1 General Information about MySQL

This is the MySQL reference manual; it documents MySQL version 3.23.11-alpha.

MySQL is a very fast, multi-threaded, multi-user and robust SQL (Structured Query Language) database server.

For Unix and OS/2 platforms, MySQL is basically free; for Microsoft platforms you must get a MySQL license after a trial time of 30 days. See Chapter 3 [Licensing and Support], page 24.

The MySQL home page (http://www.mysql.com/) provides the latest information about MySQL.

For a discussion of MySQL's capabilities, see Section 1.5 [Features], page 5.

For installation instructions, see Chapter 4 [Installing], page 34. For tips on porting MySQL to new machines or operating systems, see Appendix G [Porting], page 505.

For information about upgrading from a 3.21 release, see Section 4.16.2 [Upgrading-from-3.21], page 93.

For a tutorial introduction to MySQL, see Chapter 9 [Tutorial], page 238.

For examples of SQL and benchmarking information, see the benchmarking directory (‘sql-bench’ in the distribution).

For a history of new features and bug fixes, see Appendix D [News], page 452.

For a list of currently known bugs and misfeatures, see Appendix E [Bugs], page 499.

For future plans, see Appendix F [TODO], page 501.

For a list of all the contributors to this project, see Appendix C [Credits], page 446.

IMPORTANT:

Send error (often called bugs) reports, questions and comments to the mailing list at mysql@lists.mysql.com. See Section 2.3 [Bug reports], page 19.

For source distributions, the mysqlbug script can be found in the ‘scripts’ directory. For binary distributions, mysqlbug can be found in the ‘bin’ directory.

If you have any suggestions concerning additions or corrections to this manual, please send them to the manual team at (docs@mysql.com).

1.1 What is MySQL?

MySQL is a true multi-user, multi-threaded SQL database server. SQL (Structured Query Language) is the most popular and standardized database language in the world. MySQL is a client/server implementation that consists of a server daemon mysqld and many different client programs and libraries.

SQL is a standardized language that makes it easy to store, update and access information. For example, you can use SQL to retrieve product information and store customer information for a web site. MySQL is also fast and flexible enough to allow you to store logs and pictures in it.
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The main goals of MySQL are speed, robustness and ease of use. MySQL was originally developed because we needed a SQL server that could handle very large databases an order of magnitude faster than what any database vendor could offer to us on inexpensive hardware. We have now been using MySQL since 1996 in an environment with more than 40 databases containing 10,000 tables, of which more than 500 have more than 7 million rows. This is about 100 gigabytes of mission-critical data.

The base upon which MySQL is built is a set of routines that have been used in a highly demanding production environment for many years. Although MySQL is still under development, it already offers a rich and highly useful function set.

The official way to pronounce MySQL is “My Ess Que Ell” (Not MY-SEQUEL).

1.2 About this manual

This manual is currently available in Texinfo, plain text, Info, HTML, PostScript and PDF versions. Because of their size, PostScript and PDF versions are not included with the main MySQL distribution, but are available for separate download at http://www.mysql.com.

The primary document is the Texinfo file. The HTML version is produced automatically with a modified version of texi2html. The plain text and Info versions are produced with makeinfo. The Postscript version is produced using texi2dvi and dvips. The PDF version is produced with pdftex.

This manual is written and maintained by David Axmark, Michael (Monty) Widenius and Paul DuBois. For other contributors, see Appendix C [Credits], page 446.

1.2.1 Conventions used in this manual

This manual uses certain typographical conventions:

- **constant** Constant-width font is used for command names and options; SQL statements; database, table and column names; C and Perl code; and environment variables. Example: “To see how mysqladmin works, invoke it with the --help option.”

- ‘filename’ Constant-width font with surrounding quotes is used for filenames and pathnames. Example: “The distribution is installed under the '/usr/local/' directory.”

- ‘c’ Constant-width font with surrounding quotes is also used to indicate character sequences. Example: “To specify a wildcard, use the ‘%’ character.”

- **italic** Italic font is used for emphasis, like this.

- **boldface** Boldface font is used for access privilege names (e.g., “do not grant the process privilege lightly”) and to convey especially strong emphasis.

When commands are shown that are meant to be executed by a particular program, the program is indicated by the prompt shown with the command. For example, `shell>` indicates a command that you execute from your login shell, and `mysql>` indicates a command that you execute from the mysql client:

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Shell commands are shown using Bourne shell syntax. If you are using a csh-style shell, you may need to issue commands slightly differently. For example, the sequence to set an environment variable and run a command looks like this in Bourne shell syntax:

```shell
shell> VARNAME=value some_command
```

For csh, you would execute the sequence like this:

```shell
shell> setenv VARNAME value
shell> some_command
```

Database, table and column names often must be substituted into commands. To indicate that such substitution is necessary, this manual uses `db_name`, `tbl_name` and `col_name`. For example, you might see a statement like this:

```mysql
mysql> SELECT col_name FROM db_name.tbl_name;
```

This means that if you were to enter a similar statement, you would supply your own database, table and column names, perhaps like this:

```mysql
mysql> SELECT author_name FROM biblio_db.author_list;
```

SQL statements may be written in uppercase or lowercase. When this manual shows a SQL statement, uppercase is used for particular keywords if those keywords are under discussion (to emphasize them) and lowercase is used for the rest of the statement. So you might see the following in a discussion of the `SELECT` statement:

```mysql
mysql> SELECT count(*) FROM tbl_name;
```

On the other hand, in a discussion of the `COUNT()` function, the statement would be written like this:

```mysql
mysql> select COUNT(*) from tbl_name;
```

If no particular emphasis is intended, all keywords are written uniformly in uppercase.

In syntax descriptions, square brackets (‘[’ and ‘]’) are used to indicate optional words or clauses:

```sql
DROP TABLE [IF EXISTS] tbl_name
```

When a syntax element consists of a number of alternatives, the alternatives are separated by vertical bars (‘|’). When one member from a set of choices may be chosen, the alternatives are listed within square brackets. When one member from a set of choices must be chosen, the alternatives are listed within braces (‘{’ and ‘}’):

```sql
TRIM([^BOTH | LEADING | TRAILING] [remstr] FROM] str)
{DESCRIBE | DESC} tbl_name {col_name | wild}
```

1.3 History of MySQL

We once started off with the intention of using mSQL to connect to our tables using our own fast low-level (ISAM) routines. However, after some testing we came to the conclusion that mSQL was not fast enough or flexible enough for our needs. This resulted in a new SQL interface to our database but with almost the same API interface as mSQL. This API was chosen to ease porting of third-party code.
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The derivation of the name **MySQL** is not perfectly clear. Our base directory and a large number of our libraries and tools have had the prefix “my” for well over 10 years. However, Monty’s daughter (some years younger) is also named My. So which of the two gave its name to MySQL is still a mystery, even for us.

### 1.4 Books about MySQL

While this manual is still the right place for up to date technical information, its primary goal is to contain everything there is to know about **MySQL**. And it is sometimes nice to have a bound book to read in bed or while you travel. Here are a list of books about MySQL (in English).

<table>
<thead>
<tr>
<th>Title</th>
<th>MySQL (<a href="http://www2.newriders.com/cfm/prod_book.cfm?RecordID=584">http://www2.newriders.com/cfm/prod_book.cfm?RecordID=584</a>)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Publisher</td>
<td>New Riders</td>
</tr>
<tr>
<td>Author</td>
<td>Paul DuBois</td>
</tr>
<tr>
<td>Pub Date</td>
<td>1st Edition December 1999</td>
</tr>
<tr>
<td>ISBN</td>
<td>0735709211</td>
</tr>
<tr>
<td>Pages</td>
<td>800</td>
</tr>
<tr>
<td>Price</td>
<td>$49.99 US</td>
</tr>
<tr>
<td>Downloadable examples</td>
<td>samp_db.tar.gz (<a href="http://www.mysql.com/Contrib/Examples/samp_db.tar.gz">http://www.mysql.com/Contrib/Examples/samp_db.tar.gz</a>)</td>
</tr>
</tbody>
</table>

Foreword by Michael "Monty" Widenius, MySQL Moderator

In MySQL, Paul DuBois provides you with a comprehensive guide to one of the most popular relational database systems. Paul has contributed to the online documentation for MySQL, and is an active member of the MySQL community. The principal MySQL developer, Monty Widenius, and a network of his fellow developers reviewed the manuscript, providing Paul with the kind of insight no one else could supply.

Instead of merely giving you a general overview of MySQL, Paul teaches you how to make the most of its capabilities. Through two sample database applications that run throughout the book, he gives you solutions to problems you’re sure to face. He helps you integrate MySQL efficiently with third-party tools, such as PHP and Perl, enabling you to generate dynamic Web pages through database queries. He teaches you to write programs that access MySQL databases, and also provides a comprehensive set of references to column types, operators, functions, SQL syntax, MySQL programming, C API, Perl DBI, and PHP API. MySQL simply gives you the kind of information you won’t find anywhere else.

If you use MySQL, this book provides you with:

- An introduction to MySQL and SQL
- Coverage of MySQL’s data types and how to use them
- Thorough treatment of how to write client programs in C
- A guide to using the Perl DBI and PHP APIs for developing command-line and Web-based applications
- Tips on administrative issues such as user accounts, backup, crash recovery, and security
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- Help in choosing an ISP for MySQL access
- A comprehensive reference for MySQL’s data types, operators, functions, and SQL statements and utilities
- Complete reference guides for MySQL’s C API, the Perl DBI API, and PHP’s MySQL-related functions

Title MySQL & mSQL (http://www.oreilly.com/catalog/msql/noframes.html)
Publisher O’Reilly
Authors Randy Jay Yarger, George Reese & Tim King
Pub Date 1st Edition July 1999
ISBN 1-56592-434-7, Order Number: 4347
Pages 506
Price $34.95

This book teaches you how to use MySQL and mSQL, two popular and robust database products that support key subsets of SQL on both Linux and UNIX systems. Anyone who knows basic C, Java, Perl, or Python can write a program to interact with a database, either as a stand-alone application or through a Web page. This book takes you through the whole process, from installation and configuration to programming interfaces and basic administration. Includes ample tutorial material.

1.5 The main features of MySQL

The following list describes some of the important characteristics of MySQL:

- Fully multi-threaded using kernel threads. That means it easily can use multiple CPUs if available.
- C, C++, Eiffel, Java, Perl, PHP, Python and TCL APIs. See Chapter 21 [Clients], page 371.
- Works on many different platforms. See Section 4.2 [Which OS], page 36.
- Many column types: signed/unsigned integers 1, 2, 3, 4 and 8 bytes long, FLOAT, DOUBLE, CHAR, VARCHAR, TEXT, BLOB, DATE, TIME, DATETIME, TIMESTAMP, YEAR, SET and ENUM types. See Section 7.3 [Column types], page 134.
- Very fast joins using an optimized one-sweep multi-join.
- Full operator and function support in the SELECT and WHERE parts of queries. Example:
  
  ```sql
  mysql> SELECT CONCAT(first_name, " ", last_name) FROM tbl_name
           WHERE income/dependents > 10000 AND age > 30;
  ```

- SQL functions are implemented through a highly-optimized class library and should be as fast as they can get! Usually there shouldn’t be any memory allocation at all after query initialization.
- Full support for SQL GROUP BY and ORDER BY clauses. Support for group functions (COUNT(), COUNT(DISTINCT), AVG(), STD(), SUM(), MAX() and MIN()).
- Support for LEFT OUTER JOIN with ANSI SQL and ODBC syntax.
- You can mix tables from different databases in the same query (as of version 3.22).

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• A privilege and password system which is very flexible and secure, and which allows host-based verification. Passwords are secure since all password traffic when connecting to a server is encrypted.

• ODBC (Open-DataBase-Connectivity) for Windows95 (with source). All ODBC 2.5 functions and many others. You can, for example, use Access to connect to your MySQL server. See Chapter 17 [ODBC], page 345.

• Very fast B-tree disk tables with index compression.

• 16 indexes per table are allowed. Each index may consist of 1 to 16 columns or parts of columns. The maximum index length is 256 bytes (this may be changed when compiling MySQL). An index may use a prefix of a CHAR or VARCHAR field.

• Fixed-length and variable-length records.

• In-memory hash tables which are used as temporary tables.

• Handles large databases. We are using MySQL with some databases that contain 50,000,000 records.

• All columns have default values. You can use INSERT to insert a subset of a table's columns; those columns that are not explicitly given values are set to their default values.

• Uses GNU Automake, Autoconf, and libtool for portability.

• Written in C and C++. Tested with a broad range of different compilers.

• A very fast thread-based memory allocation system.

• No memory leaks. Tested with a commercial memory leakage detector (purify).

• Includes myisamchk, a very fast utility for table checking, optimization and repair. See Chapter 14 [Maintenance], page 323.

• Full support for the ISO-8859-1 Latin1 character set. For example, the Scandinavian characters å, ä and ö are allowed in table and column names.

• All data are saved in ISO-8859-1 Latin1 format. All comparisons for normal string columns are case insensitive.

• Sorting is done according to the ISO-8859-1 Latin1 character set (the Swedish way at the moment). It is possible to change this in the source by adding new sort order arrays. To see an example of very advanced sorting, look at the Czech sorting code. MySQL supports many different character sets that can be specified at compile time.

• Aliases on tables and columns as in the SQL92 standard.

• DELETE, INSERT, REPLACE, and UPDATE return how many rows were changed (affected).

• Function names do not clash with table or column names. For example, ABS is a valid column name. The only restriction is that for a function call, no spaces are allowed between the function name and the ‘(’ that follows it. See Section 7.31 [Reserved words], page 229.

• All MySQL programs can be invoked with the --help or -? options to obtain online assistance.

• The server can provide error messages to clients in many languages. See Section 10.1 [Languages], page 271.
Clients connect to the MySQL server using TCP/IP connections or Unix sockets, or named pipes under NT.

The MySQL-specific SHOW command can be used to retrieve information about databases, tables and indexes. The EXPLAIN command can be used to determine how the optimizer resolves a query.

1.6 How stable is MySQL?

This section addresses the questions, “how stable is MySQL?” and, “can I depend on MySQL in this project?” Here we will try to clarify some issues and to answer some of the more important questions that seem to concern many people. This section has been put together from information gathered from the mailing list (which is very active in reporting bugs).

At TrX, MySQL has worked without any problems in our projects since mid-1996. When MySQL was released to a wider public, we noticed that there were some pieces of “untested code” that were quickly found by the new users who made queries in a manner different than our own. Each new release has had fewer portability problems than the previous one (even though each has had many new features), and we hope that it will be possible to label one of the next releases “stable”.

Each release of MySQL has been usable and there have been problems only when users start to use code from “the gray zones”. Naturally, outside users can’t know what the gray zones are; this section attempts to indicate those that are currently known. The descriptions deal with the 3.22.x version of MySQL. All known and reported bugs are fixed in the latest version, with the exception of the bugs listed in the bugs section, which are things that are “design”-related. See Appendix E [Bugs], page 499.

MySQL is written in multiple layers and different independent modules. These modules are listed below with an indication of how well-tested each of them is:

The ISAM table handler — Stable
This manages storage and retrieval of all data in MySQL 3.22 and earlier versions. In all MySQL releases there hasn’t been a single (reported) bug in this code. The only known way to get a corrupted table is to kill the server in the middle of an update. Even that is unlikely to destroy any data beyond rescue, because all data are flushed to disk between each query. There hasn’t been a single bug report about lost data because of bugs in MySQL, either.

The MyISAM table handler — Beta
This is new in MySQL 3.23. It’s largely based on the ISAM table code but has a lot of new very useful features.

The parser and lexical analyser — Stable
There hasn’t been a single reported bug in this system for a long time.

The C client code — Stable
No known problems. In early 3.20 releases, there were some limitations in the send/receive buffer size. As of 3.21.x, the buffer size is now dynamic up to a default of 24M.
Standard client programs — Stable
These include mysql, mysqladmin and mysqlshow, mysqldump, and mysqlimport.

Basic SQL — Stable
The basic SQL function system and string classes and dynamic memory handling. Not a single reported bug in this system.

Query optimizer — Stable
Range optimizer — Gamma
Join optimizer — Stable

Locking — Gamma
This is very system-dependent. On some systems there are big problems using standard OS locking (fcntl()). In these cases, you should run the MySQL daemon with the --skip-locking flag. Problems are known to occur on some Linux systems and on SunOS when using NFS-mounted file systems.

Linux threads — Gamma
The only problem found has been with the fcntl() call, which is fixed by using the --skip-locking option to mysqld. Some people have reported lockup problems with the 0.5 release.

Solaris 2.5+ pthreads — Stable
We use this for all our production work.

MIT-pthreads (Other systems) — Gamma
There have been no reported bugs since 3.20.15 and no known bugs since 3.20.16. On some systems, there is a “misfeature” where some operations are quite slow (a 1/20 second sleep is done between each query). Of course, MIT-pthreads may slow down everything a bit, but index-based SELECT statements are usually done in one time frame so there shouldn’t be a mutex locking/thread juggling.

Other thread implementations — Alpha - Beta
The ports to other systems are still very new and may have bugs, possibly in MySQL, but most often in the thread implementation itself.

LOAD DATA ... INSERT ... SELECT — Stable
Some people have thought they have found bugs here, but these usually have turned out to be misunderstandings. Please check the manual before reporting problems!

ALTER TABLE — Stable
Small changes in 3.22.12.

DBD — Stable
Now maintained by Jochen Wiedmann wiedmann@neckar-alb.de. Thanks!

mysqlaccess — Stable
Written and maintained by Yves Carlier Yves.Carlier@rug.ac.be. Thanks!

GRANT — Gamma
Big changes made in MySQL 3.22.12.
MyODBC (uses ODBC SDK 2.5) — Gamma

It seems to work well with some programs.

TcX provides email support for paying customers, but the MySQL mailing list usually provides answers to common questions. Bugs are usually fixed right away with a patch; for serious bugs, there is almost always a new release.

### 1.7 Year 2000 compliance

MySQL itself has no problems with Year 2000 (Y2K) compliance:

- MySQL uses Unix time functions and has no problems with dates until 2069; all 2-digit years are regarded to be in the range 1970 to 2069, which means that if you store 01 in a year column, MySQL treats it as 2001.
- All MySQL date functions are stored in one file `sql/time.cc` and coded very carefully to be year 2000-safe.
- In MySQL 3.22 and later versions, the new YEAR column type can store years 0 and 1901 to 2155 in 1 byte and display them using 2 or 4 digits.

You may run into problems with applications that use MySQL in a way that is not Y2K-safe. For example, many old applications store or manipulate years using 2-digit values (which are ambiguous) rather than 4-digit values. This problem may be compounded by applications that use values such as 00 or 99 as “missing” value indicators.

Unfortunately, these problems may be difficult to fix, since different applications may be written by different programmers, each of whom may use a different set of conventions and date-handling functions.

Here is a simple demonstration illustrating that MySQL doesn’t have any problems with dates until the year 2030!

```sql
mysql> DROP TABLE IF EXISTS y2k;
mysql> CREATE TABLE y2k (date date, date_time datetime, time_stamp timestamp);
mysql> INSERT INTO y2k VALUES ('1998-12-31','1998-12-31 23:59:59',19981231235959);
mysql> INSERT INTO y2k VALUES ('1999-01-01','1999-01-01 00:00:00',19990101000000);
mysql> INSERT INTO y2k VALUES ('1999-09-09','1999-09-09 23:59:59',19990909235959);
mysql> INSERT INTO y2k VALUES ('2000-01-01','2000-01-01 00:00:00',20000101000000);
mysql> INSERT INTO y2k VALUES ('2000-02-28','2000-02-28 00:00:00',20000228000000);
mysql> INSERT INTO y2k VALUES ('2000-02-29','2000-02-29 00:00:00',20000229000000);
mysql> INSERT INTO y2k VALUES ('2000-03-01','2000-03-01 00:00:00',20000301000000);
mysql> INSERT INTO y2k VALUES ('2000-12-31','2000-12-31 23:59:59',20001231235959);
mysql> INSERT INTO y2k VALUES ('2001-01-01','2001-01-01 00:00:00',20010101000000);
mysql> INSERT INTO y2k VALUES ('2004-12-31','2004-12-31 23:59:59',20041231235959);
mysql> INSERT INTO y2k VALUES ('2005-01-01','2005-01-01 00:00:00',20050101000000);
mysql> INSERT INTO y2k VALUES ('2030-01-01','2030-01-01 00:00:00',20300101000000);
mysql> INSERT INTO y2k VALUES ('2050-01-01','2050-01-01 00:00:00',20500101000000);
mysql> SELECT * FROM y2k;
+------------+---------------------+----------------+
<table>
<thead>
<tr>
<th>date</th>
<th>date_time</th>
<th>time_stamp</th>
</tr>
</thead>
</table>
```

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This shows that the DATE and DATETIME types are will not give any problems with future dates (they handle dates until the year 9999).

The TIMESTAMP type, that is used to store the current time, has a range up to only 2030-01-01. TIMESTAMP has a range of 1970 to 2030 on 32-bit machines (signed value). On 64-bit machines it handles times up to 2106 (unsigned value).

Even though MySQL is Y2K-compliant, it is your responsibility to provide unambiguous input. See Section 7.3.3.1 [Y2K issues], page 142 for MySQL’s rules for dealing with ambiguous date input data (data containing 2-digit year values).

1.8 General SQL information and tutorials

This book has been recommended by a several people on the MySQL mailing list:

Judith S. Bowman, Sandra L. Emerson and Marcy Darnovsky

The Practical SQL Handbook: Using Structured Query Language
Second Edition
Addison-Wesley
ISBN 0-201-62623-3
http://www.awl.com

This book has also received some recommendations by MySQL users:

Martin Gruber
Understanding SQL
ISBN 0-89588-644-8
Publisher Sybex 510 523 8233
Alameda, CA USA

A SQL tutorial is available on the net at http://www.geocities.com/SiliconValley/Vista/2207/sql1.html

SQL in 21 Tagen (online book in German language): http://www.mut.de/leseecke/buecher/sql/inhalt
1.9 Useful MySQL-related links

Tutorials

- A beginner’s tutorial of how to start using MySQL (http://www.devshed.com/resource/advanced/mysql)
- A lot of MySQL tutorials (http://www.devshed.com/Server_Side/MySQL/)
- Setting Up a MySQL Based Website (http://www.linuxplanet.com/linuxplanet/tutorials/1046/)
- Hands on tutorial for MySQL (http://www.useractive.com/)

Porting MySQL / Using MySQL on different systems

- The MacOS Xclave (http://xclave.macnn.com/MySQL/). Running MySQL on Mac.
- MySql for MacOSX Server (http://www.prnet.de/RegEx/mysql.html)
- Client libraries for the Macintosh (http://www.lilback.com/macsq/)

Perl related links

- Perl DBI with MySQL FAQ (http://haven.e-cactus.com/dbi_mysql)

MySQL discussion forums

- Examples using MySQL; (check Top 20) (http://webdev.weberdev.com/)

Commercial applications that support MySQL

- SupportWizard; Interactive helpdesk on the web (This product includes a licensed copy of MySQL) (http://www.supportwizard.com/)
- StWeb (http://www.stweb.org/) StWeb - Stratos Web and Application server - an easy-to-use, cross platform, Internet/Intranet development and deployment system for development of web-enabled applications. The standard version of StWeb has a native interface to MySQL database.
- Right Now Web; Web automation for customer service (http://www.rightnowtech.com/)
- Bazaar; Interactive Discussion Forums with web interface (http://www.icaap.org/Bazaar/)
- PhoneSweepT (http://www.phonesweep.com/) is the world’s first commercial Telephone Scanner. Many break-ins in recent years have come not through the Internet, but through unauthorized dial-up modems. PhoneSweep lets you find these modems by repeatedly placing phone calls to every phone number that your organization controls.

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PhoneSweep has a built-in expert system that can recognize more than 250 different kinds of remote-access programs, including Carbon CopyT, pcANYWHERE, and Windows NT RAS. All information is stored in the SQL database. It then generates a comprehensive report detailing which services were discovered on which dial-up numbers in your organization.

**SQL Clients/Report writers**

- KDE MySQL client ([http://www.xnot.com/kmysql](http://www.xnot.com/kmysql))
- KMySQL ([http://www.penguinpowered.com/~kmysql](http://www.penguinpowered.com/~kmysql)) KMySQL is a database client for KDE that primarily supports **MySQL**.

**Web development tools that support MySQL**

- The Midgard Application Server; a powerful Web development environment based on MySQL and PHP ([http://www.midgard-project.org](http://www.midgard-project.org))
- SmartWorker is a platform for web application development ([http://www.smartworker.org](http://www.smartworker.org))
- XSP: e(X)tendible (s)erver (p)ages and is a HTML embedded tag language written in Java (previously known as XTAGS) ([http://xsp.lentus.se/](http://xsp.lentus.se/))
- dbServ ([http://www.dbServ.de/](http://www.dbServ.de/)) is an extension to a web server to integrate databases output into your HTML code. You may use any HTML function in your output. Only the client will stop you. It works as standalone server or as JAVA servlet.
- **MySQL** + PHP demos ([http://www.wernhart.priv.at/php/](http://www.wernhart.priv.at/php/))
- ForwardSQL: HTML interface to manipulate **MySQL** databases ([http://www.dbwww.com/](http://www.dbwww.com/))
- HeiTML: A server-side extension of HTML and a 4GL language at the same time ([http://www.heitml.com/](http://www.heitml.com/))
- Hawkeye Internet Server Suite ([http://hawkeye.net/](http://hawkeye.net/))
- Network Database Connection For Linux ([http://www.fastflow.com/](http://www.fastflow.com/))
- WDBI: Web browser as a universal front end to databases which supports **MySQL** well. ([http://www.wdbi.net/](http://www.wdbi.net/))
• WebGroove Script: HTML compiler and server-side scripting language (http://www.webgroove.com/)
• A server-side web site scripting language (http://www.ihtml.com/)
• How to use MySQL with ColdFusion on Solaris (ftp://ftp.igc.apc.org/pub/myodbc/README)
• Calistra’s ODBC MySQL Administrator (http://calistra.com/MySQL/)
• Webmerger (http://www.webmerger.com) This CGI tool interprets files and generates dynamic output based on a set of simple tags. Ready-to-run drivers for MySQL and PostgreSQL through ODBC.
• PHPclub (http://phpclub.unet.ru/index_e.php3). Tips and tricks for PHP
• MySQL and Perl Scripts (http://www.penguinservices.com/scripts)
• The Widgetchuck; Web Site Tools and Gadgets (http://www.widgetchuck.com)
• AdCycle (http://www.adcycle.com/) advertising management software
• pwPage (http://www.bidsystems.com/pwPage) provides an extremely fast and simple approach to the creation of database forms. That is, if a database table exists and an HTML page has been constructed using a few simple guidelines, pwPage can be immediately used for table data selections, insertions, updates, deletions and selectable table content reviewing.

Database design tools with MySQL support

• "Dezign for databases" is a database development tool using an rick> entity relationship diagram (ERD). (http://www.heraut.demon.nl/dezign/dezign.html)

Web servers with MySQL tools

• An Apache authentication module (http://bourbon.netvision.net.il/mysql/mod_auth_mysql/)
• The Roxen Challenger Web server (http://www.roxen.com/)

Extensions for other programs

• Tmysql: A library to use MySQL with Delphi (http://www.productivity.org/projects/mysql/)
• Delphi TDataset-component (http://www.geocities.com/CapeCanaveral/2064/mysql.html)
• MySQL support for BIND (The Internet Domain Name Server) (http://www.seawood.org/mysql_bind/)
• MySQL support for Sendmail and Procmail (http://www.inet-interactive.com/sendmail)

Using MySQL with other programs

• Using MySQL with Access (http://www.iserver.com/support/addonhelp/database/mysql/msaccess)
ODBC related links

- Popular iODBC Driver Manager (libiodbc) now available in Open Source format ([http://www.iodbc.org/](http://www.iodbc.org/))
- The FreeODBC Pages ([http://users.ids.net/~bjepson/freeODBC/](http://users.ids.net/~bjepson/freeODBC/))
- unixodbc ([http://genix.net/unixODBC/](http://genix.net/unixODBC/)) The unixODBC Project goals are to develop and promote unixODBC to be the definitive standard for ODBC on the Linux platform. This is to include GUI support for KDE.

API related links

- www.jppp.com ([http://www.jppp.com](http://www.jppp.com)) Partially implemented TDataSet-compatible components for MySQL.
- qpopmysql ([http://www.riverstyx.net/qpopmysql/](http://www.riverstyx.net/qpopmysql/)) A patch to allow POP3 authentication from a MySQL database. There’s also a link to Paul Khavkine’s patch for Procmail to allow any MTA to deliver to users in a MySQL database.
- Visual Basic class generator for Active X ([http://www.pbc.ottawa.on.ca](http://www.pbc.ottawa.on.ca))
- SCMDB ([http://www.dedecker.net/jessie/scmdb/](http://www.dedecker.net/jessie/scmdb/)). SCMDB is an add-on for SCM that ports the mysql C library to scheme (SCM). With this library scheme developers can make connections to a mysql database and use embedded SQL in their programs.

Other MySQL-related links

- Registry of Web providers who support MySQL ([http://www.wix.com/mysql-hosting](http://www.wix.com/mysql-hosting))
- Job and software tracking system ([http://tomato.nvgc.vt.edu/~hroberts/mot](http://tomato.nvgc.vt.edu/~hroberts/mot))
- ExportSQL: A script to export data from Access95+ ([http://www.cynergi.net/non-secure/exportsql/](http://www.cynergi.net/non-secure/exportsql/))
- SAL (Scientific Applications on Linux) MySQL entry ([http://SAL.KachinaTech.COM/H/1/MYSQL.html](http://SAL.KachinaTech.COM/H/1/MYSQL.html))
- Airborne Early Warning Association ([http://www.aewa.org](http://www.aewa.org))
- MySQL UDF Registry ([http://abattoir.cc.ndsu.nodak.edu/~nem/mysql/udf/](http://abattoir.cc.ndsu.nodak.edu/~nem/mysql/udf/))

SQL and database interfaces

- Patch for mSQL TCL ([http://www.gagme.com/mysql](http://www.gagme.com/mysql))
Chapter 1: General Information about MySQL

- EasySQL: An ODBC-like driver manager (http://www.amsoft.ru/easysql/)
- A REXX interface to SQL databases (http://www.lightlink.com/hessling/rexxsql.html)
- TCL interface (http://www.binevolve.com/~tdarugar/tcl-sql)

Examples of MySQL use

- Little6 Inc (http://www.little6.com/about/linux/) An online contract and job finding site that is powered by MySQL, PHP3 and Linux.
- DELECis (http://www.delec.com/is/products/prep/examples/BookShelf/index.html) A tool which makes it very easy to create an automatically generated table documentation. They have used MySQL as an example.
- World Records (http://www.worldrecords.com) A search engine for information about music that uses MySQL and PHP.
- A Contact Database using MySQL and PHP (http://www.webtechniques.com/archives/1998/01/note/)
- Web based interface and Community Calendar with PHP (http://modems.rosenet.net/mysql/)
- Perl package to generate html from a SQL table structure and for generating SQL statements from an html form. (http://www.odbsoft.com/cook/sources.htm)
- Basic telephone database using DBI/DBD (http://www.gusnet.cx/proj/telsql/).
- Installing new Perl modules that require locally installed modules (http://www.iserver.com/support/perl5/modules.html)
- JDBC examples by Daniel K. Schneider (http://tecfa.unige.ch/guides/java/staf2x/ex/jdbc/cook)
- SQL BNF (http://www.spade.com/linux/howto/PostgreSQL-HOWTO-41.html)
- Object Oriented Concepts Inc; CORBA applications with examples in source (http://www.ooc.com/)
- DBWiz: Includes an example of how to manage own cursors in VB (http://www.pbc.ottawa.on.ca/)
- Pluribus (http://keilor.cs.umass.edu/pluribus/) Pluribus, is a free search engine that learns to improve the quality of its results over time. Pluribus works by recording which pages a user prefers among those returned for a query. A user votes for a page by selecting it; Pluribus then uses that knowledge to improve the quality of the results when someone else submits the same (or similar) query. Uses PHP and MySQL.
- Stopbit (http://www.stopbit.com/) A technology news site using MySQL and PHP
- FutureForum Web Discussion Software (http://futurerealm.com/forum/futureforum.cgi)
- http://www.linuxsupportline.com/~kalendar/ KDE based calendar manager The calendar manager has both single user (file based) and multi user (MySQL database) support.
- Example of storing/retrieving images with MySQL and CGI (http://tim.desert.net/~tim/imger/)
- Online shopping cart system (http://www.penguinservices.com/scripts)
- Old Photo Album (http://www.city-gallery.com/album/) The album is a collaborative popular history of photography project that generates all pages from data stored in a MySQL database. Pages are dynamically generated through a php3 interface to the database content. Users contribute images and descriptions. Contributed images are stored on the web server to avoid storing them in the database as BLOBs. All other information is stored in on the shared MySQL server.
General database links

- Database Jump Site (http://www.pcslink.com/~ej/dbweb.html)
- Homepage of the webdb-l (Web Databases) mailing list. (http://black.hole-in-the.net/guy/webdb)
- Perl DBI/DBD modules homepage (http://www.symbolstone.org/technology/perl/DBI/index.html)
- Cygwin tools. UNIX on top of Windows (http://www.student.uni-koeln.de/cygwin/)
- dbasecentral.com; Development and distribution of powerful and easy-to-use database applications and systems. (http://dbasecentral.com/)
- Tek-Tips Forums (http://www.Tek-Tips.com) Tek-Tips Forums are 800+ independent peer-to-peer non-commercial support forums for Computer Professionals. Features include automatic e-mail notification of responses, a links library, and member confidentiality guaranteed.

There are also many web pages that use MySQL. See Appendix A [Users], page 433. Send any additions to this list to webmaster@mysql.com. We now require that you show a MySQL logo somewhere (It is okay to have it on a “used tools” page or something similar) to be added.
Chapter 2: MySQL mailing lists and how to ask questions or report errors (bugs)

2 MySQL mailing lists and how to ask questions or report errors (bugs)

2.1 The MySQL mailing lists

To subscribe to the main MySQL mailing list, send a message to the electronic mail address mysql-subscribe@lists.mysql.com.

To unsubscribe from the main MySQL mailing list, send a message to the electronic mail address mysql-unsubscribe@lists.mysql.com.

Only the address to which you send your messages is significant. The subject line and the body of the message are ignored.

If your reply address is not valid, you can specify your address explicitly. Adding a hyphen to the subscribe or unsubscribe command word, followed by your address with the ‘@’ character in your address replaced by a ‘=’, For example, to subscribe john@host.domain, send a message to mysql-subscribe-john=host.domain@lists.mysql.com.

Mail to mysql-subscribe@lists.mysql.com or mysql-unsubscribe@lists.mysql.com is handled automatically by the ezmlm mailing list processor. Information about ezmlm is available at the ezmlm Website (http://www.ezmlm.org).

To post a message to the list itself, send your message to mysql@lists.mysql.com. However, please do not send mail about subscribing or unsubscribing to mysql@lists.mysql.com, since any mail sent to that address is distributed automatically to thousands of other users.

Your local site may have many subscribers to mysql@lists.mysql.com. If so, it may have a local mailing list, so that messages sent from lists.mysql.com to your site are propagated to the local list. In such cases, please contact your system administrator to be added to or dropped from the local MySQL list.

The following MySQL mailing lists exist:

- announce: This is for announcement of new versions of MySQL and related programs. This is a low volume list that we think all MySQL users should be on.

- mysql: The main list for general MySQL discussion. Please note that some topics are better discussed on the more-specialized lists. If you post to the wrong list, you may not get an answer!

- mysql-digest: The mysql list in digest form. That means you get all individual messages, sent as one large mail message once a day.

- bugs: On this list you should only post a full, repeatable bug report, using the mysqlbug script (if you are running on Windows, you should include a description of the operating system and the MySQL version). Preferably, you should test the problem using the latest stable or development version of MySQL before posting! Anyone should be able to repeat the bug by just using 'mysql test $script' on the included test case. All bugs posted on this list will be corrected...
Chapter 2: MySQL mailing lists and how to ask questions or report errors (bugs)

or documented in the next MySQL release! If there are only small code changes involved, we will also post a patch that fixes the problem.

**bugs-digest**
The bugs list in digest form

**developer**
A list for people who work on the MySQL code. On this list one can also discuss MySQL development and post patches.

**developer-digest**
A digest version of the developer list.

**java**
Discussion about MySQL and Java. Mostly about the JDBC drivers.

**java-digest**
A digest version of the java list.

**win32**
All things concerning MySQL on Microsoft operating systems such as Windows NT.

**win32-digest**
A digest version of the win32 list.

**myodbc**
All things concerning connecting to MySQL with ODBC.

**myodbc-digest**
A digest version of the myodbc list.

**msql-mysql-modules**
A list about the Perl support in MySQL.

**msql-mysql-modules-digest**
A digest version of the msql-mysql-modules list.

You subscribe or unsubscribe to all lists in the same way as described above. In your subscribe or unsubscribe message, just put the appropriate mailing list name rather than mysql. For example, to subscribe to or unsubscribe from the myodbc list, send a message to myodbc-subscribe@lists.mysql.com or myodbc-unsubscribe@lists.mysql.com.

### 2.2 Asking questions or reporting bugs

Before posting a bug report or question, please do the following:

- Start by searching the MySQL online manual at:
  We try to keep the manual up to date by updating it frequently with solutions to newly found problems!
- Search the MySQL mailing list archives:
  http://www.mysql.com/doc.html
• You can also use http://www.mysql.com/search.html to search all the web pages (including the manual) that are located at http://www.mysql.com/.

If you can’t find an answer in the manual or the archives, check with your local MySQL expert. If you still can’t find an answer to your question, go ahead and read the next section about how to send mail to mysql@lists.mysql.com.

2.3 How to report bugs or problems

Writing a good bug report takes patience, but doing it right the first time saves time for us and for you. This section will help you write your report correctly so that you don’t waste your time doing things that may not help us much or at all.

We encourage everyone to use the mysqlbug script to generate a bug report (or a report about any problem), if possible. mysqlbug can be found in the ‘scripts’ directory in the source distribution, or, for a binary distribution, in the ‘bin’ directory under your MySQL installation directory. If you are unable to use mysqlbug, you should still include all the necessary information listed in this section.

The mysqlbug script helps you generate a report by determining much of the following information automatically, but if something important is missing, please include it with your message! Please read this section carefully and make sure that all the information described here is included in your report.

If you can make a test case which clearly shows the bug, you should post it to the bugs@list.mysql.com list. Note that on this list you should only post a full, repeatable bug report, using the mysqlbug script (if you are running on Windows, you should include a description of the operating system and the MySQL version). Preferably, you should test the problem using the latest stable or development version of MySQL before posting! Anyone should be able to repeat the bug by just using 'mysql test < script' on the included test case or run the shell / perl script that is included in the bug report. All bugs posted on this list will be corrected or documented in the next MySQL release! If there are only small code changes involved, to correct this problem, we will also post a patch that fixes the problem.

Remember that it is possible to respond to a message containing too much information, but not to one containing too little. Often people omit facts because they think they know the cause of a problem and assume that some details don’t matter. A good principle is: if you are in doubt about stating something, state it! It is a thousand times faster and less troublesome to write a couple of lines more in your report than to be forced to ask again and wait for the answer because you didn’t include enough information the first time.

The most common errors are that people don’t indicate the version number of the MySQL distribution they are using, or don’t indicate what platform they have MySQL installed on (including the platform version number). This is highly relevant information and in 99 cases out of 100 the bug report is useless without it! Very often we get questions like “Why doesn’t this work for me?” and then we find that the feature requested wasn’t implemented in that MySQL version, or that a bug described in a report has been fixed already in newer MySQL versions. Sometimes the error is platform dependent; in such cases, it is next to
impossible to fix anything without knowing the operating system and the version number of the platform.

Remember also to provide information about your compiler, if it is related to the problem. Often people find bugs in compilers and think the problem is MySQL related. Most compilers are under development all the time and become better version by version, too. To determine whether or not your problem depends on your compiler, we need to know what compiler is used. Note that every compiling problem should be regarded as a bug report and reported accordingly.

It is most helpful when a good description of the problem is included in the bug report. That is, a good example of all the things you did that led to the problem and the problem itself exactly described. The best reports are those that include a full example showing how to reproduce the bug or problem.

If a program produces an error message, it is very important to include the message in your report! If we try to search for something from the archives using programs, it is better that the error message reported exactly matches the one that the program produces. (Even the case sensitivity should be observed!) You should never try to remember what the error message was; instead, copy and paste the entire message into your report!

If you have a problem with MyODBC, you should try to generate a MyODBC trace file. See Section 17.6 [MyODBC bug report], page 349.

Please remember that many of the people who will read your report will do so using an 80-column display. When generating reports or examples using the mysql command line tool, you should therefore use the --vertical option (or the \G statement terminator) for output which would exceed the available width for such a display (for example, with the EXPLAIN SELECT statement; see the example below).

Please include the following information in your report:

- The version number of the MySQL distribution you are using (for example, MySQL 3.22.22). You can find out which version you are running by executing `mysqladmin version`. `mysqladmin` can be found in the ‘bin’ directory under your MySQL installation directory.
- The manufacturer and model of the machine you are working on.
- The operating system name and version. For most operating systems, you can get this information by executing the Unix command `uname -a`.
- Sometimes the amount of memory (real and virtual) is relevant. If in doubt, include these values.
- If you are using a source distribution of MySQL, the name and version number of the compiler used is needed. If you have a binary distribution, the distribution name is needed.
- If the problem occurs during compilation, include the exact error message(s) and also a few lines of context around the offending code in the file where the error occurred.
- If any database table is related to the problem, include the output from `mysqldump --no-data db_name tbl_name1 tbl_name2 ...` This is very easy to do and is a powerful way to get information about any table in a database that will help us create a situation matching the one you have.
Chapter 2: MySQL mailing lists and21how to ask questions or report errors (bugs)

• For speed-related bugs or problems with SELECT statements, you should always include
the output of EXPLAIN SELECT ..., and at least the number of rows that the SELECT
statement produces. The more information you give about your situation, the more
likely it is that someone can help you! For example, the following is an example of a
very good bug report (it should of course be posted with the mysqlbug script):
Example run using the mysql command line tool (note the use of the \G statement
terminator for statements whose output width would otherwise exceed that of an 80column display device):
mysql> SHOW VARIABLES;
mysql> SHOW COLUMNS FROM ...\G
<output-from-SHOW-COLUMNS>
mysql> EXPLAIN SELECT ...\G
<output-from-EXPLAIN>
mysql> FLUSH STATUS;
mysql> SELECT ...;
<A short version of the output from SELECT,
including the time taken to run the query>
mysql> SHOW STATUS;
<output from SHOW STATUS>
• If a bug or problem occurs while running MySQL, try to provide an input script that
will reproduce the anomaly. This script should include any necessary source files. The
more closely the script can reproduce your situation, the better.
If you can’t provide a script, you should at least include the output from mysqladmin
variables extended-status processlist in your mail to provide some information
of how your system is performing!
• If you think that MySQL produces a strange result from a query, include not only the
result, but also your opinion of what the result should be and an account describing
the basis for your opinion.
• When giving an example of the problem, it’s better to use the variable names, table
names, etc., that exist in your actual situation than to come up with new names. The
problem could be related to the name of a variable, table, etc.! These cases are rare,
perhaps, but it is better to be safe than sorry. After all, it should be easier for you to
provide an example that uses your actual situation and it is by all means better for us.
In case you have data you don’t want to show to others, you can use ftp to transfer it
to ftp://www.mysql.com/pub/mysql/secret/. If the data are really top secret and
you don’t want to show them even to us, then go ahead and provide an example using
other names, but please regard this as the last choice.
• Include all the options given to the relevant programs, if possible. For example, indicate
the options that you use when you start the mysqld daemon and that you use to run
any MySQL client programs. The options to programs like mysqld and mysql, and to
the configure script are often keys to answers and very relevant! It is never a bad idea
to include them anyway! If you use any modules, such as Perl or PHP, please include
the version number(s) of those as well.
• If you can’t produce a test case in a few rows, or if the test table is too big to be mailed
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to the mailing list (more than 10 rows), you should dump your tables using mysqldump and create a ‘README’ file that describes your problem. Create a compressed archive of your files using tar and gzip or zip, and use ftp to transfer the archive to ftp://www.mysql.com/pub/mysql/secret/. Then send a short description of the problem to mysql@lists.mysql.com.

- If your question is related to the privilege system, please include the output of mysqlaccess, the output of mysqladmin reload and all the error messages you get when trying to connect! When you test your privileges, you should first run mysqlaccess. After this, execute mysqladmin reload version, and last you should try to connect with the program that gives you trouble. mysqlaccess can be found in the ‘bin’ directory under your MySQL installation directory.

- If you have a patch for a bug, that is good. But don’t assume the patch is all we need or that we will use it even if you don’t provide some necessary information such as test cases showing the bug that your patch fixes. We might find problems with your patch or we might not understand it at all; if so, we can’t use it. If we can’t verify exactly what the patch is meant for, we won’t use it. Test cases will help us here. Show that the patch will handle all the situations that may occur. If we find a borderline case (even a rare one) where the patch won’t work, the patch may be useless.

- Guesses about what the bug is, why it occurs, or what it depends on, are usually wrong. Even we can’t guess such things without first using a debugger to determine the real cause of a bug.

- Indicate in your mail message that you have checked the reference manual and mail archive so others know that you have tried to solve your problem yourself.

- If you get a parse error, please check your syntax closely! If you can’t find something wrong with it, it’s extremely likely that your current version of MySQL doesn’t support the query you are using. If you are using the current version and the manual at http://www.mysql.com/doc.html doesn’t cover the syntax you are using, MySQL doesn’t support your query. In this case, your only options are to implement the syntax yourself or email mysql-licensing@mysql.com and ask for an offer to implement it! If the manual covers the syntax you are using, but you have an older version of MySQL, you should check the MySQL change history to see when the syntax was implemented. See Appendix D [News], page 452. In this case, you have the option of upgrading to a newer version of MySQL.

- If you have a problem such that your data appears corrupt or you get errors when you access some particular table, you should first check and then try repairing your tables with myisamchk. See Chapter 14 [Maintenance], page 323.

- If you often get corrupted tables you should try to find out when and why this happens! In this case, the ‘mysql-data-directory/hostname’.err’ file may contain some information about what happened. Please include any relevant information from this file in your bug report! Normally mysqld should NEVER crash a table if nothing killed it in the middle of an update! If you can find the source of why mysqld dies, it’s much easier for us to provide you with a fix for the problem!
• If possible, download the most recent version of MySQL and check whether or not it solves your problem. All versions of MySQL are thoroughly tested and should work without problems! We believe in making everything as backward compatible as possible and you should be able to switch MySQL versions in minutes! See Section 4.3 [Which version], page 37.

If you are a support customer, please cross-post the bug report to mysql-support@mysql.com for higher priority treatment, as well as to the appropriate mailing list to see if someone else has experienced (and perhaps solved) the problem.

For information on reporting bugs in MyODBC, see Section 17.3 [ODBC Problems], page 346.

For solutions to some common problems, see See Chapter 19 [Problems], page 352.

When answers are sent to you individually and not to the mailing list, it is considered good etiquette to summarize the answers and send the summary to the mailing list so that others may have the benefit of responses you received that helped you solve your problem!

2.4 Guidelines for answering questions on the mailing list

If you consider your answer to have broad interest, you may want to post it to the mailing list instead of replying directly to the individual who asked. Try to make your answer general enough that people other than the original poster may benefit from it. When you post to the list, please make sure that your answer is not a duplication of a previous answer. Try to summarize the essential part of the question in your reply; don’t feel obliged to quote the entire original message.

Please don’t post mail messages from your browser with HTML mode turned on! Many users doesn’t read mail with a browser!
Chapter 3: MySQL licensing and support

This chapter describes MySQL licensing and support arrangements, including:

- Our licensing policies for non-Microsoft and Microsoft operating systems
- The copyrights under which MySQL is distributed (see Section 3.2 [Copyright], page 25)
- Sample situations illustrating when a license is required (see Section 3.4 [Licensing examples], page 27)
- Licensing and support costs (see Section 3.5 [Cost], page 28), and support benefits (see Section 3.6 [Support], page 30)

3.1 MySQL licensing policy

The formal terms of the license for non-Microsoft operating systems such as Unix or OS/2 are specified in Appendix J [Public license], page 516. Basically, our licensing policy is as follows:

- For normal internal use, MySQL generally costs nothing. You do not have to pay us if you do not want to.
- A license is required if:
  - You sell the MySQL server directly or as a part of another product or service
  - You charge for installing and maintaining a MySQL server at some client site
  - You include MySQL in a distribution that is non redistributable and you charge for some part of that distribution
- For circumstances under which a MySQL license is required, you need a license per machine that runs the mysqld server. However, a multiple-CPU machine counts as a single machine, and there is no restriction on the number of MySQL servers that run on one machine, or on the number of clients concurrently connected to a server running on that machine!
- You do not need a license to include client code in commercial programs. The client access part of MySQL is in the public domain. The mysql command line client includes code from the readline library that is under the GNU Public License.
- For customers who have purchased 1 license or MySQL support, we provide additional functionality. Currently, this means we provide the myisampack utility for creating fast compressed read-only databases. (The server includes support for reading such databases but not the packing tool used to create them.) When support agreements generate sufficient revenue, we will release this tool under the same license as the MySQL server.
- If your use of MySQL does not require a license, but you like MySQL and want to encourage further development, you are certainly welcome to purchase a license anyway.
• If you use MySQL in a commercial context such that you profit by its use, we ask that you further the development of MySQL by purchasing some level of support. We feel that if MySQL helps your business, it is reasonable to ask that you help MySQL. (Otherwise, if you ask us support questions, you are not only using for free something into which we've put a lot of work, you're asking us to provide free support, too.)

For use under Microsoft operating systems (Win95/Win98/WinNT), you need a MySQL license after a trial period of 30 days, with the exception that licenses may be obtained upon request at no cost for educational use or for university- or government-sponsored research settings. See Appendix K [Win license], page 520. A shareware version of MySQL-Win32 that you can try before buying is available at http://www.mysql.com/mysql_w32.htm. After you have paid, you will get a password that will enable you to access the newest MySQL-Win32 version.

If you have any questions as to whether or not a license is required for your particular use of MySQL, please contact us. See Section 3.5.2 [Contact information], page 30.

If you require a MySQL license, the easiest way to pay for it is to use the license form at TcX's secure server at https://www.mysql.com/license.htm. Other forms of payment are discussed in Section 3.5.1 [Payment information], page 29.

3.2 Copyrights used by MySQL

There are several different copyrights on the MySQL distribution:

1. The MySQL-specific source needed to build the mysqlclient library and programs in the 'client' directory is in the public domain. Each file that is in the public domain has a header which clearly states so. This includes everything in the 'client' directory and some parts of the msys, mystring and dbug libraries.

2. Some small parts of the source (GNU getopt) are covered by the “GNU LIBRARY LIBRARY GENERAL PUBLIC LICENSE”. See the 'mysys/COPYING.LIB' file.

3. Some small parts of the source (GNU readline) are covered by the “GNU GENERAL PUBLIC LICENSE”. See the 'readline/COPYING' file.

4. Some parts of the source (the regexp library) are covered by a Berkeley style copyright.

5. The other source needed for the MySQL server on non-Microsoft platforms is covered by the “MySQL FREE PUBLIC LICENSE”, which is based on the “Aladdin FREE PUBLIC LICENSE.” See Appendix J [Public license], page 516. When running MySQL on any Microsoft operating system, other licensing applies.

The following points set forth the philosophy behind our copyright policy:

• The SQL client library should be totally free so that it can be included in commercial products without limitations.

• People who want free access to the software into which we have put a lot of work can have it, so long as they do not try to make money directly by distributing it for profit.

• People who want the right to keep their own software proprietary, but also want the value from our work, can pay for the privilege.

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That means normal in-house use is FREE. But if you use MySQL for something important to you, you may want to help further its development by purchasing a license or a support contract. See Section 3.6 [Support], page 30.

3.2.1 Possible future copyright changes

We may choose to distribute older versions of MySQL with the GPL in the future. However, these versions will be identified as GNU MySQL. Also, all copyright notices in the relevant files will be changed to the GPL.

3.3 Distributing MySQL commercially

This section is a clarification of the license terms that are set forth in the “MySQL FREE PUBLIC LICENSE” (FPL). See Appendix J [Public license], page 516.

MySQL may be used freely, including by commercial entities for evaluation or unsupported internal use. However, distribution for commercial purposes of MySQL, or anything containing or derived from MySQL in whole or in part, requires a written commercial license from TcX AB, the sole entity authorized to grant such licenses.

You may not include MySQL “free” in a package containing anything for which a charge is being made, except as noted below.

The intent of the exception provided in the second clause of the license is to allow commercial organizations operating an FTP server or a bulletin board to distribute MySQL freely from it, provided that:

1. The organization complies with the other provisions of the FPL, which include among other things a requirement to distribute the full source code of MySQL and of any derived work, and to distribute the FPL itself along with MySQL;
2. The only charge for downloading MySQL is a charge based on the distribution service and not one based on the content of the information being retrieved (i.e., the charge would be the same for retrieving a random collection of bits of the same size);
3. The server or BBS is accessible to the general public, i.e., the phone number or IP address is not kept secret, and anyone may obtain access to the information (possibly by paying a subscription or access fee that is not dependent on or related to purchasing anything else).

If you want to distribute software in a commercial context that incorporates MySQL and you do not want to meet these conditions, you should contact TcX AB to find out about commercial licensing, which involves a payment. The only ways you legally can distribute MySQL or anything containing MySQL are by distributing MySQL under the requirements of the FPL, or by getting a commercial license from TcX AB.
3.4 Example licensing situations

This section describes some situations illustrating whether or not you must license the MySQL server. Generally these examples involve providing MySQL as part of a product or service that you are selling to a customer, or requiring that MySQL be used in conjunction with your product. In such cases, it is your responsibility to obtain a license for the customer if one is necessary. (This requirement is waived if your customer already has a MySQL license. But the seller must send customer information and the license number to TcX, and the license must be a full license, not an OEM license.)

Note that a single MySQL license covers any number of CPUs/users/customers/mysqld servers on a machine!

3.4.1 Selling products that use MySQL

To determine whether or not you need a MySQL license when selling your application, you should ask whether the proper functioning of your application is contingent on the use of MySQL and whether you include MySQL with your product. There are several cases to consider:

- Does your application require MySQL to function properly?
  If your product requires MySQL, you need a license for any machine that runs the mysqld server. For example, if you’ve designed your application around MySQL, then you’ve really made a commercial product that requires the engine, so you need a license.
  If your application does not require MySQL, you need not obtain a license. For example, if MySQL just added some new optional features to your product (such as adding logging to a database if MySQL is used rather than logging to a text file), it should fall within normal use, and a license would not be required.

In other words, you need a license if you sell a product designed specifically for use with MySQL or that requires the MySQL server to function at all. This is true whether or not you provide MySQL for your client as part of your product distribution.

It also depends on what you’re doing for the client. Do you plan to provide your client with detailed instructions on installing MySQL with your software? Then your product may be contingent on the use of MySQL; if so, you need to buy a license. If you are simply tying into a database that you expect already to have been installed by the time your software is purchased, then you probably don’t need a license.

- Do you include MySQL in a distribution and charge for that distribution?
  If you include MySQL with a distribution that you sell to customers, you will need a license for any machine that runs the mysqld server, because in this case you are selling a system that includes MySQL.
  This is true whether the use of MySQL with your product is required or optional.

- Do you neither require for your product nor include MySQL with it?
  Suppose you want to sell a product that is designed generally to use “some database” and that can be configured to use any of several supported alternative database systems
(MySQL, PostgreSQL, or something else). That is, your product does not require MySQL, but can support any database with a base level of functionality, and you don’t rely on anything that only MySQL supports. Does one of you owe us money if your customer actually does choose to use MySQL?

In this case, if you don’t provide, obtain or set up MySQL for the customer should the customer decide to use it, neither of you need a license. If you do perform that service, see Section 3.4.2 [MySQL services], page 28.

3.4.2 Selling MySQL-related services

If you perform MySQL installation on a client’s machine and any money changes hands for the service (directly or indirectly), then you must buy a MySQL license.

If you sell an application for which MySQL is not strictly required but can be used, a license may be indicated, depending on how MySQL is set up. Suppose your product neither requires MySQL nor includes it in your product distribution, but can be configured to use MySQL for those customers who so desire. (This would be the case, for example, if your product can use any of a number of database engines.)

If the customer obtains and installs MySQL, no license is needed. If you perform that service for your customer, then a license is needed because then you are selling a service that includes MySQL.

3.4.3 ISP MySQL services

Internet Service Providers (ISPs) often host MySQL servers for their customers.

If you are an ISP that allows customers to install and administer MySQL for themselves on your machine with no assistance from you, neither you nor your customer need a MySQL license.

If you charge for MySQL installation and administrative support as part of your customer service, then you need a license because you are selling a service that includes MySQL.

3.4.4 Running a web server using MySQL

If you use MySQL in conjunction with a web server, you don’t have to pay for a license. This is true even if you run a commercial web server that uses MySQL, since you are not selling MySQL itself. However, in this case we would like you to purchase MySQL support, because MySQL is helping your enterprise.

3.5 MySQL licensing and support costs

Our current license prices are shown below. All prices are in US Dollars. If you pay by credit card, the currency is EURO (European Union Euro) so the prices will differ slightly.
Chapter 3: MySQL licensing and support

### MySQL Licensing

<table>
<thead>
<tr>
<th>Number of licenses</th>
<th>Price per copy</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>US $200</td>
<td>US $200</td>
</tr>
<tr>
<td>10 pack</td>
<td>US $150</td>
<td>US $1500</td>
</tr>
<tr>
<td>50 pack</td>
<td>US $120</td>
<td>US $6000</td>
</tr>
</tbody>
</table>

For high volume (OEM) purchases, the following prices apply:

<table>
<thead>
<tr>
<th>Number of licenses</th>
<th>Price per copy</th>
<th>Minimum at one time</th>
<th>Minimum payment</th>
</tr>
</thead>
<tbody>
<tr>
<td>100-999</td>
<td>US $40</td>
<td>100</td>
<td>US $4000</td>
</tr>
<tr>
<td>1000-2499</td>
<td>US $25</td>
<td>200</td>
<td>US $5000</td>
</tr>
<tr>
<td>2500-4999</td>
<td>US $20</td>
<td>400</td>
<td>US $8000</td>
</tr>
</tbody>
</table>

For OEM purchases, you must act as the middle-man for eventual problems or extension requests from your users. We also require that OEM customers have at least an extended email support contract.

If you have a low-margin high-volume product, you can always talk to us about other terms (for example, a percent of the sale price). If you do, please be informative about your product, pricing, market and any other information that may be relevant.

After buying 1 MySQL license, you will get a personal copy of the myisampack utility. You are not allowed to redistribute this utility but you can distribute tables packed with it.

A full-price license is not a support agreement and includes very minimal support. This means that we try to answer any relevant question. If the answer is in the documentation, we will direct you to the appropriate section. If you have not purchased a license or support, we probably will not answer at all.

If you discover what we consider a real bug, we are likely to fix it in any case. But if you pay for support we will notify you about the fix status instead of just fixing it in a later release.

More comprehensive support is sold separately. Descriptions of what each level of support includes are given in Section 3.6 [Support], page 30. Costs for the various types of commercial support are shown below. Support level prices are in EURO (European Union Euro). One EURO is about 1.17 USD.

<table>
<thead>
<tr>
<th>Type of support</th>
<th>Cost per year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic email support</td>
<td>EURO 170</td>
</tr>
<tr>
<td>Extended email support</td>
<td>EURO 1000</td>
</tr>
<tr>
<td>Login support</td>
<td>EURO 2000</td>
</tr>
<tr>
<td>Extended login support</td>
<td>EURO 5000</td>
</tr>
</tbody>
</table>

You may upgrade from any lower level of support to a higher level of support for the difference between the prices of the two support levels.

### Payment Information

Currently we can take SWIFT payments, cheques or credit cards.

Payment should be made to:

Postgirot Bank AB  
105 06 STOCKHOLM, SWEDEN
Specify: license and/or support and your name and email address.

In Europe and Japan you can use EuroGiro (that should be less expensive) to the same account.

If you want to pay by cheque, make it payable to “Monty Program KB” and mail it to the address below:

TCX DataKonsult AB  
BOX 6434  
11382 STOCKHOLM, SWEDEN

SWIFT address: PGSI SESS  
Account number: 96 77 06 - 3

If you want to pay by credit card over the Internet, you can use TcX’s secure license form (https://www.mysql.com/license.htm).

You can also print a copy of the license form, fill it in and send it by fax to:

+46-8-729 69 05

If you want us to bill you, you can use the license form and write “bill us” in the comment field. You can also mail a message to sales@mysql.com (not mysql@lists.mysql.com!)

3.5.2 Contact information

For commercial licensing, or if you have any questions about any of the information in this section, please contact the MySQL licensing team. The much preferred method is by E-Mail to mysql-licensing@mysql.com. Fax is also possible but handling of these may take much longer (Fax +46-8-729 69 05).

David Axmark  
Detron HB  
Kungsgatan 65 B  
753 21 UPPSALA  
SWEDEN  
Voice Phone +46-18-10 22 80 (Timezone GMT+1. Swedish and English spoken)

3.6 Types of commercial support

3.6.1 Basic email support
Basic email support is a very inexpensive support option and should be thought of more as a way to support our development of MySQL than as a real support option.

At this support level, the MySQL mailing lists are the preferred means of communication. Questions normally should be mailed to the primary mailing list (mysql@lists.mysql.com) or one of the other regular lists (for example, mysql-win32@lists.mysql.com for Windows-related MySQL questions), as someone else already may have experienced and solved the problem you have. See Section 2.2 [Asking questions], page 18.

However, by purchasing basic email support, you also have access to the support address mysql-support@mysql.com, which is not available as part of the minimal support that you get by purchasing a MySQL license. This means that for especially critical questions, you can cross-post your message to mysql-support@mysql.com. (If the message contains sensitive data, you should post only to mysql-support@mysql.com.)

REMEMBER! to ALWAYS include your registration number and expiration date when you send a message to mysql-support@mysql.com.

Basic email support includes the following types of service:

- If your question is already answered in the manual, we will inform you of the correct section in which you can find the answer. If the answer is not in the manual, we will point you in the right direction to solve your problem.
- We guarantee a timely answer for your email messages. We can’t guarantee that we can solve any problem, but at least you will receive an answer if we can contact you by email.
- We will help with unexpected problems when you install MySQL from a binary distribution on supported platforms. This level of support does not cover installing MySQL from a source distribution. “Supported” platforms are those for which MySQL is known to work. See Section 4.2 [Which OS], page 36.
- We will help you with bugs and missing features. Any bugs that are found are fixed for the next MySQL release. If the bug is critical for you, we will mail you a patch for it as soon the bug is fixed. Critical bugs always have the highest priority for us, to ensure that they are fixed as soon as possible.
- Your suggestions for the further development of MySQL will be taken into consideration. By taking email support you have already helped the further development of MySQL. If you want to have more input, upgrade to a higher level of support.
- If you want us to help optimize your system, you must upgrade to a higher level of support.
- We include a binary version of the myisampack packing tool for creating fast compressed read-only databases. The current server includes support for reading such databases but not the packing tool used to create them.

### 3.6.2 Extended email support

Extended email support includes everything in basic email support with these additions:
• Your email will be dealt with before mail from basic email support users and non-registered users.

• Your suggestions for the further development of MySQL will receive strong consideration. Simple extensions that suit the basic goals of MySQL are implemented in a matter of days. By taking extended email support you have already helped the further development of MySQL.

• Typical questions that are covered by extended email support are:
  − We will answer and (within reason) solve questions that relate to possible bugs in MySQL. As soon as the bug is found and corrected, we will mail a patch for it.
  − We will help with unexpected problems when you install MySQL from a source or binary distribution on supported platforms.
  − We will answer questions about missing features and offer hints how to work around them.
  − We will provide hints on optimizing mysqld for your situation.

• You are allowed to influence the priority of items on the MySQL TODO. This will ensure that the features you really need will be implemented sooner than they might be otherwise.

### 3.6.3 Login support

Login support includes everything in extended email support with these additions:

• Your email will be dealt with even before mail from extended email support users.

• Your suggestions for the further development of MySQL will be taken into very high consideration. Realistic extensions that can be implemented in a couple of hours and that suit the basic goals of MySQL will be implemented as soon as possible.

• If you have a very specific problem, we can try to log in on your system to solve the problem “in place.”

• Like any database vendor, we can’t guarantee that we can rescue any data from crashed tables, but if the worst happens we will help you rescue as much as possible. MySQL has proven itself very reliable, but anything is possible due to circumstances beyond our control (for example, if your system crashes or someone kills the server by executing a kill -9 command).

• We will provide hints on optimizing your system and your queries.

• You are allowed to call a MySQL developer (in moderation) and discuss your MySQL-related problems.

### 3.6.4 Extended login support

Extended login support includes everything in login support with these additions:

• Your email has the highest possible priority.
- We will actively examine your system and help you optimize it and your queries. We may also optimize and/or extend MySQL to better suit your needs.
- You may also request special extensions just for you. For example:
  ```sql
  mysql> select MY_CALCULATION(col_name1,col_name2) from tbl_name;
  ```
- We will provide a binary distribution of all important MySQL releases for your system, as long as we can get an account on a similar system. In the worst case, we may require access to your system to be able to create a binary distribution.
- If you can provide accommodations and pay for traveler fares, you can even get a MySQL developer to visit you and offer you help with your troubles. Extended login support entitles you to one personal encounter per year, but we are as always very flexible towards our customers!
4 Installing MySQL

This chapter describes how to obtain and install MySQL:

- For a list of sites from which you can obtain MySQL, see Section 4.1 [Getting MySQL], page 34.
- To see which platforms are supported, see Section 4.2 [Which OS], page 36.
- Several versions of MySQL are available, in both binary and source distributions. To determine which version and type of distribution you should use, see Section 4.4 [Many versions], page 39.
- Installation instructions for binary and source distributions are described in Section 4.6 [Installing binary], page 40, and Section 4.7 [Installing source], page 45. Each set of instructions includes a section on system-specific problems you may run into.
- For post-installation procedures, see Section 4.15 [Post-installation], page 81. These procedures apply whether you install MySQL using a binary or source distribution.

4.1 How to get MySQL

Check the MySQL home page (http://www.mysql.com/) for information about the current version and for downloading instructions. However, the Internet connection at TcX is not so fast; we would prefer that you do the actual downloading from one of the mirror sites listed below.

Please report bad or out of date mirrors to webmaster@mysql.com.

Europe:

- Austria [Univ. of Technology/Vienna] WWW (http://gd.tuwien.ac.at/db/mysql/)
  FTP (ftp://gd.tuwien.ac.at/db/mysql/)
- Denmark [Borsen] WWW (http://mysql.borsen.dk/)
- Denmark [SunSITE] WWW (http://SunSITE.auc.dk/mysql/) FTP (ftp://SunSITE.auc.dk/pub/databases/mysql/)
- Estonia [OKinteractive] WWW (http://mysql.mirror.ok.ee)
- France [minet] WWW (http://www.minet.net/devel/mysql/)
- Finland [EUnet] WWW (http://mysql.eunet.fi/)
- Germany [Bonn University, Bonn] WWW (http://www.wipol.uni-bonn.de/MySQL/)
  FTP (ftp://ftp.wipol.uni-bonn.de/pub/mirror/MySQL/)
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- Island [GM] WWW (http://mysql.gm.is/) WWW (ftp://ftp.gm.is/pub/mysql)
- Italy [Teta Srl] WWW (http://www.teta.it/mysql/) FTP (ftp://ftp.teta.it/pub/mysql/)
- Russia [DirectNet] WWW (http://mysql.directnet.ru)
- Spain [MasterD] WWW (http://mysql.masterd.es)
- Switzerland [Sunsite] WWW (http://sunsite.cnlab-switch.ch/ftp/mirror/mysql/) FTP (ftp://sunsite.cnlab-switch.ch/mirror/mysql/)
- UK [SunSITE] WWW (http://sunsite.org.uk/packages/mysql/) FTP (ftp://sunsite.org.uk/packages/mysql)
- Ukraine [PACO] WWW (http://mysql.paco.net.ua) FTP (ftp://mysql.paco.net.ua)

North America:
- Canada [Tryc] WWW (http://web.tryc.on.ca/mysql/)
- Canada [Cyberus] WWW (http://mysql.cyberus.ca/) FTP (ftp://mysql.cyberus.ca/)
- USA [Hurricane Electric/San Jose] WWW (http://mysql.he.net)
- USA [Circle Net/North Carolina] WWW (http://www.mysql.net)
- USA [Gina net/Florida] WWW (http://www.gina.net/mysql/)
- USA [Wisconsin University/Wisconsin] WWW (http://mirror.sit.wisc.edu/mysql/) FTP (ftp://mirror.sit.wisc.edu/mirrors/mysql/)

South America:
- Brazil [Matrix] WWW (http://mysql.matrix.com.br)
- Chile [Vision] WWW (http://mysql.vision.cl)

Asia:
Chapter 4: Installing MySQL

- China [Netfirm] WWW (http://mysql.netfirm.net)
- Korea [KREONet] WWW (http://linux.kreonet.re.kr/mysql/)
- Japan [Soft Agency] WWW (http://www.softagency.co.jp/MySQL)
- Japan [Nagoya Syouka University] WWW (http://mirror.nucba.ac.jp/mirror/mysql) FTP (ftp://mirror.nucba.ac.jp/mirror/mysql)
- Taiwan [HT] WWW (http://mysql.ht.net.tw)

Australia:
- Australia [Blue Planet/Melbourne] WWW (http://mysql.bluep.com/)

Africa:
- South-Africa [Mweb/] WWW (http://www.mysql.mweb.co.za)
- South-Africa [The Internet Solution/Johannesburg] FTP (ftp://ftp.is.co.za/linux/mysql/)

4.2 Operating systems supported by MySQL

We use GNU Autoconf so it is possible to port MySQL to all modern systems with working Posix threads and a C++ compiler. (To compile only the client code, a C++ compiler is required but not threads.) We use and develop the software ourselves primarily on Sun Solaris (versions 2.5 & 2.6) and to a lesser extent on RedHat Linux 5.0.

MySQL has been reported to compile sucessfully on the following operating system/thread package combinations. Note that for many operating systems, the native thread support works only in the latest versions.
- AIX 4.x with native threads
- BSDI 2.x with the included MIT-pthreads package
- BSDI 3.0, 3.1 and 4.x with native threads
- DEC UNIX 4.x with native threads
- FreeBSD 2.x with the included MIT-pthreads package
- FreeBSD 3.x with native threads
- HP-UX 10.20 with the included MIT-pthreads package
- HP-UX 11.x with the native threads.
- Linux 2.0+ with LinuxThreads 0.7.1 or glibc 2.0.7
- MacOS X Server
- NetBSD 1.3/1.4 Intel and NetBSD 1.3 Alpha (Requires GNU make)
- OpenBSD > 2.5 with native therads. OpenBSD < 2.5 with the included MIT-pthreads package
• OS/2 Warp 3, FixPack 29 and OS/2 Warp 4, FixPack 4
• SGI Irix 6.x with native threads
• Solaris 2.5, 2.6 and 2.7 with native threads on SPARC and x86
• SunOS 4.x with the included MIT-pthreads package
• SCO OpenServer with a recent port of the FSU Pthreads package
• SCO UnixWare 7.0.1
• Tru64 Unix
• Win95, Win98 and NT (the newest version is currently available only for users with a MySQL license or MySQL email support). For those who wish to test before they buy, we have released MySQL 3.22.30 (http://www.mysql.com/mysql_w32.htm) (an older stable version) as shareware.

4.3 Which MySQL version to use

The first decision to make is whether you want to use the latest development release or the last stable release:

• Normally, if you are beginning to use MySQL for the first time or trying to port it to some system for which there is no binary distribution, we recommend going with the development release (currently 3.22.x). This is because there are usually no really serious bugs in the development release, and you can easily test it on your machine with the crash-me and benchmark tests. See Section 11.7 [Benchmarks], page 300.
• Otherwise, if you are running an old system and want to upgrade, but don’t want to take chances with 3.22, you should upgrade to 3.21.33. We have tried to fix only fatal bugs and make small, relatively safe changes to that version.

The second decision to make is whether you want to use a source distribution or a binary distribution:

• If you want to run MySQL on a platform for which a current binary distribution exists, use that. Generally, it will be easier to install than a source distribution.
• If you want to read (and/or modify) the C and C++ code that makes up MySQL, you should get a source distribution. The source code is always the ultimate manual. Source distributions also contain more tests and examples than binary distributions.

The MySQL naming scheme uses release numbers that consist of three numbers and a suffix. For example, a release name like mysql-3.21.17-beta is interpreted like this:

• The first number (3) describes the file format. All version 3 releases have the same file format. When a version 4 appears, every table will have to be converted to the new format (nice tools for this will be included, of course).
• The second number (21) is the release level. Normally there are two to choose from. One is the release/stable branch (currently 21) and the other is the development branch (currently 22) . Normally both are stable, but the development version may have quirks, missing documentation on new features or may fail to compile on some systems.
• The third number (17) is the version number within the release level. This is incremented for each new distribution. Usually you want the latest version for the release level you have chosen.

• The suffix (beta) indicates the stability level of the release. The possible suffixes are:
  – alpha indicates that the release contains some large section of new code that hasn’t been 100% tested. Known bugs (usually there are none) should be documented in the News section. See Appendix D [News], page 452. There are also new commands and extensions in most alpha releases. Active development, that may involve major code changes, can occur on an alpha release, but everything will be tested before doing a release. There should be no known bugs in any MySQL release.
  – beta means that all new code has been tested. No major new features that could cause corruption on old code are added. There should be no known bugs. A version changes from alpha to beta when there haven’t been any reported fatal bugs within an alpha version for at least a month and we don’t plan to add any features that could make any old command more unreliable.
  – gamma is a beta that has been around a while and seems to work fine. Only minor fixes are added. This is what many other companies call a release.
  – If there is no suffix, it means that the version has been run for a while at many different sites with no reports of bugs other than platform-specific bugs. Only critical bug fixes are applied to the release. This is what we call a stable release.

All versions of MySQL are run through our standard tests and benchmarks to ensure that they are relatively safe to use. Since the standard tests are extended over time to check for all previously found bugs, the test suite keeps getting better.

Note that all releases have been tested at least with:

An internal test suite
  This is part of a production system for a customer. It has many tables with hundreds of megabytes of data.

The MySQL benchmark suite
  This runs a range of common queries. It is also a test to see whether the latest batch of optimizations actually made the code faster. See Section 11.7 [Benchmarks], page 300.

The crash-me test
  This tries to determine what features the database supports and what its capabilities and limitations are. See Section 11.7 [Benchmarks], page 300.

Another test is that we use the newest MySQL version in our internal production environment, on at least one machine. We have more than 100 gigabytes of data to work with.

4.4 How and when updates are released
MySQL is evolving quite rapidly here at TcX and we want to share this with other MySQL users. We try to make a release when we have very useful features that others seem to have a need for.

We also try to help out users who request features that are easy to implement. We also take note of what our licensed users want to have and we especially take note of what our extended email supported customers want and try to help them out.

No one has to download a new release. The News section will tell you if the new release has something you really want. See Appendix D [News], page 452.

We use the following policy when updating MySQL:

- For each minor update, the last number in the version string is incremented. When there are major new features or minor incompatibilities with previous versions, the second number in the version string is incremented. When the file format changes, the first number is increased.
- Stable tested releases are meant to appear about 1-2 times a year, but if small bugs are found, a release with only bug-fixes will be released.
- Working releases are meant to appear about every 1-8 weeks.
- Binary distributions for some platforms will be made by us for major releases. Other people may make binary distributions for other systems but probably less frequently.
- We usually make patches available as soon as we have located and fixed small bugs.
- For non-critical but annoying bugs, we will make patches available if they are sent to us. Otherwise we will combine many of them into a larger patch.
- If there is, by any chance, a fatal bug in a release we will make a new release as soon as possible. We would like other companies to do this, too. :)

The current stable release is 3.22; We have already moved active development to 3.23. Bugs will still be fixed in the stable version. We don’t believe in a complete freeze, as this also leaves out bug fixes and things that “must be done”. “Somewhat frozen” means that we may add small things that “almost surely will not affect anything that’s already working”.

### 4.5 Installation layouts

This section describes the default layout of the directories created by installing binary and source distributions.

A binary distribution is installed by unpacking it at the installation location you choose (typically ‘/usr/local/mysql’) and creates the following directories in that location:

<table>
<thead>
<tr>
<th>Directory</th>
<th>Contents of directory</th>
</tr>
</thead>
<tbody>
<tr>
<td>‘bin’</td>
<td>Client programs and the mysql server</td>
</tr>
<tr>
<td>‘data’</td>
<td>Log files, databases</td>
</tr>
<tr>
<td>‘include’</td>
<td>Include (header) files</td>
</tr>
<tr>
<td>‘lib’</td>
<td>Libraries</td>
</tr>
<tr>
<td>‘scripts’</td>
<td>mysql_install_db</td>
</tr>
</tbody>
</table>

Version: 3.23.11-alpha Printed: 25 February 2000
A source distribution is installed after you configure and compile it. By default, the installation step installs files under ‘/usr/local’, in the following subdirectories:

<table>
<thead>
<tr>
<th>Directory</th>
<th>Contents of directory</th>
</tr>
</thead>
<tbody>
<tr>
<td>‘bin’</td>
<td>Client programs and scripts</td>
</tr>
<tr>
<td>‘include/mysql’</td>
<td>Include (header) files</td>
</tr>
<tr>
<td>‘info’</td>
<td>Documentation in Info format</td>
</tr>
<tr>
<td>‘lib/mysql’</td>
<td>Libraries</td>
</tr>
<tr>
<td>‘libexec’</td>
<td>The mysql server</td>
</tr>
<tr>
<td>‘share/mysql’</td>
<td>Error message files</td>
</tr>
<tr>
<td>‘sql-bench’</td>
<td>Benchmarks</td>
</tr>
<tr>
<td>‘crash-me’</td>
<td>Test</td>
</tr>
<tr>
<td>‘var’</td>
<td>Databases and log files.</td>
</tr>
</tbody>
</table>

Within an installation directory, the layout of a source installation differs from that of a binary installation in the following ways:

- The mysql server is installed in the ‘libexec’ directory rather than in the ‘bin’ directory.
- The data directory is ‘var’ rather than ‘data’.
- mysql_install.db is installed in the ‘/usr/local/bin’ directory rather than in ‘/usr/local/mysql/scripts’.
- The header file and library directories are ‘include/mysql’ and ‘lib/mysql’ rather than ‘include’ and ‘lib’.

### 4.6 Installing a MySQL binary distribution

You need the following tools to install a MySQL binary distribution:

- GNU gunzip to uncompress the distribution.
- A reasonable tar to unpack the distribution. GNU tar is known to work.

An alternative installation method under Linux is to use RPM (RedHat Package Manager) distributions. See Section 4.6.1 [Linux-RPM], page 42.

If you run into problems, PLEASE ALWAYS USE mysqlbug when posting questions to mysql@lists.mysql.com. Even if the problem isn’t a bug, mysqlbug gathers system information that will help others solve your problem. By not using mysqlbug, you lessen the likelihood of getting a solution to your problem! You will find mysqlbug in the ‘bin’ directory after you unpack the distribution. See Section 2.3 [Bug reports], page 19.

The basic commands you must execute to install and use a MySQL binary distribution are:

```
shell> gunzip < mysql-VERSION-OS.tar.gz | tar xvf -
shell> ln -s mysql-VERSION-OS mysql
shell> cd mysql
shell> scripts/mysql_install_db
shell> bin/safe_mysqld &
```
You can add new users using the `bin/mysql_setpermission` script if you install the DBI and Msql-Mysql-modules Perl modules.

Here follows a more detailed description:

To install a binary distribution, follow the steps below, then proceed to Section 4.15 [Post-installation], page 81, for post-installation setup and testing:

1. Pick the directory under which you want to unpack the distribution, and move into it. In the example below, we unpack the distribution under `/usr/local` and create a directory `/usr/local/mysql` into which MySQL is installed. (The following instructions therefore assume you have permission to create files in `/usr/local`. If that directory is protected, you will need to perform the installation as root.)

2. Obtain a distribution file from one of the sites listed in Section 4.1 [Getting MySQL], page 34.

MySQL binary distributions are provided as compressed tar archives and have names like `mysql-VERSION-OS.tar.gz`, where VERSION is a number (e.g., 3.21.15), and OS indicates the type of operating system for which the distribution is intended (e.g., pc-linux-gnu-i586).

3. Unpack the distribution and create the installation directory:

   ```shell
   shell> gunzip < mysql-VERSION-OS.tar.gz | tar xvf -
   shell> ln -s mysql-VERSION-OS mysql
   ```

The first command creates a directory named `mysql-VERSION-OS`. The second command makes a symbolic link to that directory. This lets you refer more easily to the installation directory as `/usr/local/mysql`.

4. Change into the installation directory:

   ```shell
   shell> cd mysql
   ```

You will find several files and subdirectories in the `mysql` directory. The most important for installation purposes are the `bin` and `scripts` subdirectories.

   `bin`  This directory contains client programs and the server. You should add the full pathname of this directory to your PATH environment variable so that your shell finds the MySQL programs properly.

   `scripts`  This directory contains the `mysql_install_db` script used to initialize the server access permissions.

5. If you would like to use `mysqlaccess` and have the MySQL distribution in some non-standard place, you must change the location where `mysqlaccess` expects to find the mysql client. Edit the `bin/mysqlaccess` script at approximately line 18. Search for a line that looks like this:

   ```bash
   $MYSQL = '/usr/local/bin/mysql';  # path to mysql executable
   ```

Change the path to reflect the location where mysql actually is stored on your system. If you do not do this, you will get a broken pipe error when you run `mysqlaccess`.

6. Create the MySQL grant tables (necessary only if you haven’t installed MySQL before):

   ```shell
   shell> scripts/mysql_install_db
   ```

Note that MySQL versions older than 3.22.10 started the MySQL server when you run `mysql_install_db`. This is no longer true!
7. If you want to install support for the Perl DBI/DBD interface, see Section 4.10 [Perl support], page 53.

8. If you would like MySQL to start automatically when you boot your machine, you can copy support-files/mysql.server to the location where your system has its startup files. More information can be found in the support-files/mysql.server script itself, and in Section 4.15.3 [Automatic start], page 88.

After everything has been unpacked and installed, you should initialize and test your distribution.

You can start the MySQL server with the following command:

```
shell> bin/safe_mysqld &
```

See Section 4.15 [Post-installation], page 81.

### 4.6.1 Linux RPM notes

The recommended way to install MySQL on Linux is by using an RPM file. The MySQL RPMs are currently being built on a RedHat 5.2 system but should work on other versions of Linux that support rpm and use glibc.

If you have problems with an RPM file, for example Sorry, the host 'xxxx' could not be looked up, see Section 4.6.3.1 [Binary notes-Linux], page 43.

The RPM files you may want to use are:

- MySQL-VERSION.i386.rpm
  - The MySQL server. You will need this unless you only want to connect to another MySQL server running on another machine.
- MySQL-client-VERSION.i386.rpm
  - The standard MySQL client programs. You probably always want to install this package.
- MySQL-bench-VERSION.i386.rpm
  - Tests and benchmarks. Requires Perl and msql-mysql-modules RPMs.
- MySQL-devel-VERSION.i386.rpm
  - Libraries and include files needed if you want to compile other MySQL clients, such as the Perl modules.
- MySQL-VERSION.src.rpm
  - This contains the source code for all of the above packages. It can also be used to try to build RPMs for other architectures (for example, Alpha or SPARC).

To see all files in an RPM package:

```
shell> rpm -ql MySQL-VERSION.i386.rpm
```

To perform a standard minimal installation, run this command:

```
shell> rpm -i MySQL-VERSION.i386.rpm MySQL-client-VERSION.i386.rpm
```

To install just the client package:
shell> rpm -i MySQL-client-VERSION.i386.rpm

The RPM places data in '/var/lib/mysql'. The RPM also creates the appropriate entries in '/etc/rc.d/' to start the server automatically at boot time. (This means that if you have performed a previous installation, you may want to make a copy of your previously-installed MySQL startup file if you made any changes to it, so you don’t lose your changes.)

After installing the RPM file(s), the 'mysqld' demon should be running and you should now be able to start using MySQL. See Section 4.15 [Post-installation], page 81.

If something goes wrong, can find more information in the binary installation chapter. See Section 4.6 [Installing binary], page 40.

4.6.2 Building client programs

If you compile MySQL clients that you’ve written yourself or that you obtain from a third party, they must be linked using the -lmysqlclient option on the link command. You may also need to specify a -L option to tell the linker where to find the library. For example, if the library is installed in '/usr/local/mysql/lib', use -L/usr/local/mysql/lib -lmysqlclient on the link command.

For clients that use MySQL header files, you may need to specify a -I option when you compile them (for example, -I/usr/local/mysql/include), so the compiler can find the header files.

4.6.3 System-specific issues

The following sections indicate some of the issues that have been observed to occur on particular systems when installing MySQL from a binary distribution.

4.6.3.1 Linux notes

MySQL needs at least Linux 2.0.

The binary release is linked with -static, which means you not normally need not worry about which version of the system libraries you have. You need not install LinuxThreads, either. A program linked with -static is slightly bigger than a dynamically-linked program but also slightly faster (3-5%). One problem however is that you can’t use user definable functions (UDFs) with a statically-linked program. If you are going to write or use UDF functions (this is something only for C or C++ programmers) you must compile MySQL yourself, using dynamic linking.

If you are using a libc-based system (instead of a glibc2 system), you will probably get some problems with hostname resolving and getpwnam() with the binary release. (This is because glibc unfortunately depends on some external libraries to resolve hostnames and getpwent(), even when compiled with -static). In this case you probably get the following error message when you run mysql_install_db:
Sorry, the host 'xxxx' could not be looked up or the following error when you try to run mysqld with the --user option:

getpwnam: No such file or directory

You can solve this problem one of the following ways:

- Get a MySQL source distribution (an RPM or the tar distribution) and install this instead.
- Execute mysql_install_db --force; This will not execute the resolveip test in mysql_install_db. The downside is that you can't use host names in the grant tables; you must use IP numbers instead (except for localhost). If you are using an old MySQL release that doesn't support --force you have to remove the resolveip test in mysql_install with an editor.
- Start mysqld with su instead of using --user.

The Linux-Intel binary and RPM releases of MySQL are configured for the highest possible speed. We are always trying to use the fastest stable compiler available.

MySQL Perl support requires Perl 5.004_03 or newer.

4.6.3.2 HP-UX notes

Some of the binary distributions of MySQL for HP-UX is distributed as an HP depot file and as a tar file. To use the depot file you must be running at least HP-UX 10.x to have access to HP's software depot tools.

The HP version of MySQL was compiled on an HP 9000/8xx server under HP-UX 10.20, and uses MIT-pthreads. It is known to work well under this configuration. MySQL 3.22.26 and newer can also be built with HP’s native thread package.

Other configurations that may work:
- HP 9000/7xx running HP-UX 10.20+
- HP 9000/8xx running HP-UX 10.30

The following configurations almost definitely won't work:
- HP 9000/7xx or 8xx running HP-UX 10.x where x < 2
- HP 9000/7xx or 8xx running HP-UX 9.x

To install the distribution, use one of the commands below, where /path/to/depot is the full pathname of the depot file:

- To install everything, including the server, client and development tools:
  
  shell> /usr/sbin/swinstall -s /path/to/depot mysql.full

- To install only the server:

  shell> /usr/sbin/swinstall -s /path/to/depot mysql.server

- To install only the client package:

  shell> /usr/sbin/swinstall -s /path/to/depot mysql.client

- To install only the development tools:
shell> /usr/sbin/swinstall -s /path/to/depot mysql.developer

The depot places binaries and libraries in ‘/opt/mysql’ and data in ‘/var/opt/mysql’. The depot also creates the appropriate entries in ‘/sbin/init.d’ and ‘/sbin/rc2.d’ to start the server automatically at boot time. Obviously, this entails being root to install.

To install the HP-UX tar distribution, you must have a copy of GNU tar.

### 4.7 Installing a MySQL source distribution

You need the following tools to build and install MySQL from source:

- GNU gunzip to uncompress the distribution.
- A reasonable tar to unpack the distribution. GNU tar is known to work.
- A working ANSI C++ compiler. gcc >= 2.8.1, egcs >= 1.0.2, SGI C++ and SunPro C++ are some of the compilers that are known to work. libg++ is not needed when using gcc. gcc 2.7.x has a bug that makes it impossible to compile some perfectly legal C++ files, such as ‘sql/sql_base.cc’. If you only have gcc 2.7.x, you must upgrade your gcc to be able to compile MySQL.
- A good make program. GNU make is always recommended and is sometimes required. If you have problems, we recommend trying GNU make 3.75 or newer.

If you run into problems, PLEASE ALWAYS USE mysqlbug when posting questions to mysql@lists.mysql.com. Even if the problem isn’t a bug, mysqlbug gathers system information that will help others solve your problem. By not using mysqlbug, you lessen the likelihood of getting a solution to your problem! You will find mysqlbug in the ‘scripts’ directory after you unpack the distribution. See Section 2.3 [Bug reports], page 19.

#### 4.7.1 Quick installation overview

The basic commands you must execute to install a MySQL source distribution are (from an unpacked tar file):

```shell
shell> configure
shell> make
shell> make install
shell> scripts/mysql_install_db
shell> /usr/local/mysql/bin/safe_mysqld &
```

If you start from a source RPM, then do the following.

```shell
shell> rpm --rebuild MySQL-VERSION.src.rpm
```

This will make a binary RPM that you can install.

You can add new users using the `bin/mysql_setpermission` script if you install the DBI and Msql-Mysql-modules Perl modules.

Here follows a more detailed description:

To install a source distribution, follow the steps below, then proceed to Section 4.15 [Post-installation], page 81, for post-installation initialization and testing.
1. Pick the directory under which you want to unpack the distribution, and move into it.

2. Obtain a distribution file from one of the sites listed in Section 4.1 [Getting MySQL], page 34.

MySQL source distributions are provided as compressed tar archives and have names like ‘mysql-VERSION.tar.gz’, where VERSION is a number like 3.23.11-alpha.

3. Unpack the distribution into the current directory:

   shell> gunzip < mysql-VERSION.tar.gz | tar xvf -

   This command creates a directory named ‘mysql-VERSION’.

4. Change into the top-level directory of the unpacked distribution:

   shell> cd mysql-VERSION

5. Configure the release and compile everything:

   shell> ./configure --prefix=/usr/local/mysql

   When you run configure, you might want to specify some options. Run ./configure --help for a list of options. Section 4.7.3 [configure options], page 47, discusses some of the more useful options.

   If configure fails, and you are going to send mail to mysql@lists.mysql.com to ask for assistance, please include any lines from ‘config.log’ that you think can help solve the problem. Also include the last couple of lines of output from configure if configure aborts. Post the bug report using the mysqlbug script. See Section 2.3 [Bug reports], page 19.

   If the compile fails, see Section 4.8 [Compilation problems], page 49, for help with a number of common problems.

6. Install everything:

   shell> make install

   You might need to run this command as root.

7. Create the MySQL grant tables (necessary only if you haven’t installed MySQL before):

   shell> scripts/mysql_install_db

   Note that MySQL versions older than 3.22.10 started the MySQL server when you run mysql_install_db. This is no longer true!

8. If you want to install support for the Perl DBI/DBD interface, see Section 4.10 [Perl support], page 53.

9. If you would like MySQL to start automatically when you boot your machine, you can copy support-files/mysql.server to the location where your system has its startup files. More information can be found in the support-files/mysql.server script itself, and in Section 4.15.3 [Automatic start], page 88.

After everything has been installed, you should initialize and test your distribution.

You can start the MySQL server with the following command, where BINDIR is the directory in which safe_mysqld is installed (‘/usr/local/bin’ by default):

   shell> BINDIR/safe_mysqld &
If that command fails immediately with `mysqld daemon ended` then you can find some information in the file `mysql-data-directory/hostname.err`. The likely reason is that you already have another `mysqld` server running. See Section 20.3 [Multiple servers], page 369.

See Section 4.15 [Post-installation], page 81.

### 4.7.2 Applying patches

Sometimes patches appear on the mailing list or are placed in the patches area ([ftp://www.mysql.com/pub/mysql/Downloads/Patches](ftp://www.mysql.com/pub/mysql/Downloads/Patches)) of the MySQL FTP site.

To apply a patch from the mailing list, save the message in which the patch appears in a file, change into the top-level directory of your MySQL source tree and run these commands:

```
shell> patch -p1 < patch-file-name
shell> rm config.cache
shell> make clean
```

Patches from the FTP site are distributed as plain text files or as files compressed with gzip files. Apply a plain patch as shown above for mailing list patches. To apply a compressed patch, change into the top-level directory of your MySQL source tree and run these commands:

```
shell> gunzip < patch-file-name.gz | patch -p1
shell> rm config.cache
shell> make clean
```

After applying a patch, follow the instructions for a normal source install, beginning with the `./configure` step. After running the `make install` step, restart your MySQL server.

You may need to bring down any currently running server before you run `make install`. (Use `mysqladmin shutdown` to do this.) Some systems do not allow you to install a new version of a program if it replaces the version that is currently executing.

### 4.7.3 Typical configure options

The configure script gives you a great deal of control over how you configure your MySQL distribution. Typically you do this using options on the `configure` command line. You can also affect `configure` using certain environment variables. For a list of options supported by `configure`, run this command:

```
shell> ./configure --help
```

Some of the more commonly-used `configure` options are described below:

- To compile just the MySQL client libraries and client programs and not the server, use the `--without-server` option:

```
shell> ./configure --without-server
```

If you don’t have a C++ compiler, `mysql` will not compile (it is the one client program that requires C++). In this case, you can remove the code in `configure` that tests

Version: 3.23.11-alpha Printed: 25 February 2000
for the C++ compiler and then run `./configure` with the `--without-server` option. The compile step will still try to build `mysql`, but you can ignore any warnings about `mysql.cc`. (If `make` stops, try `make -k` to tell it to continue with the rest of the build even if errors occur.)

- If you don’t want your log files and database directories located under ‘/usr/local/var’, use a `configure` command something like one of these:

  ```shell
  shell> ./configure --prefix=/usr/local/mysql
  shell> ./configure --prefix=/usr/local \
  --localstatedir=/usr/local/mysql/data
  ```

  The first command changes the installation prefix so that everything is installed under ‘/usr/local/mysql’ rather than the default of ‘/usr/local’. The second command preserves the default installation prefix, but overrides the default location for database directories (normally ‘/usr/local/var’) and changes it to /usr/local/mysql/data.

- If you are using Unix and you want the MySQL socket located somewhere other than the default location (normally in the directory ‘/tmp’ or ‘/var/run’), use a `configure` command like this:

  ```shell
  shell> ./configure --with-unix-socket-path=/usr/local/mysql/tmp/mysql.sock
  ```

  Note that the given file must be an absolute pathname!

- If you want to compile statically-linked programs (e.g., to make a binary distribution, to get more speed or to work around problems with some RedHat distributions), run `configure` like this:

  ```shell
  shell> ./configure --with-client-ldflags=-all-static \
  --with-mysqld-ldflags=-all-static
  ```

- If you are using gcc and don’t have libg++ or libstdc++ installed, you can tell `configure` to use gcc as your C++ compiler:

  ```shell
  shell> CC=gcc CXX=gcc ./configure
  ```

  When you use gcc as your C++ compiler, it will not attempt to link in libg++ or libstdc++.

  If the build fails and produces errors about your compiler or linker not being able to create the shared library ‘libmysqlclient.so.#’ (‘#’ is a version number), you can work around this problem by giving the `--disable-shared` option to `configure`. In this case, `configure` will not build a shared libmysqlclient.so.# library.

- You can configure MySQL not to use DEFAULT column values for non-NULL columns (i.e., columns that are not allowed to be NULL). This causes INSERT statements to generate an error unless you explicitly specify values for all columns that require a non-NULL value. To suppress use of default values, run `configure` like this:

  ```shell
  shell> CXXFLAGS=-DDONT_USE_DEFAULT_FIELDS ./configure
  ```

- By default, MySQL uses the ISO-8859-1 (Latin1) character set. To change the default set, use the `--with.charset` option:

  ```shell
  shell> ./configure --with.charset=CHARSET
  ```

  CHARSET may be one of big5, cp1251, cp1257, czech, danish,dec8, dos, euc_kr, gb2312 gbk, german1, hebrew, hp8, hungarian, koi8_ru, koi8_ukr, latin1, latin2.
sjis, swe7, tis620, ujis, usa7, win1251 or win1251ukr. See Section 10.1.1 [Character sets], page 271.

Note that if you want to change the character set, you must do a `make distclean` between configurations!

If you want to convert characters between the server and the client, you should take a look at the `SET OPTION CHARACTER SET` command. See Section 7.25 [SET OPTION], page 222.

**Warning:** If you change character sets after having created any tables, you will have to run `myisamchk -r -q` on every table. Your indexes may be sorted incorrectly otherwise. (This can happen if you install MySQL, create some tables, then reconfigure MySQL to use a different character set and reinstall it.)

- To configure MySQL with debugging code, use the `--with-debug` option:
  ```
  shell> ./configure --with-debug
  ```
  This causes a safe memory allocator to be included that can find some errors and that provides output about what is happening. See Section G.1 [Debugging server], page 506.

- If your client programs are using threads, you need to compile the MySQL client library to be thread safe with `--with-thread-safe-client`; this forces the library to use thread safe functions calls for some functions that are not thread safe by default. You pay a very small performance penalty by doing this, but generally it’s quite safe to use this option.

- Options that pertain to particular systems can be found in the system-specific sections later in this chapter. See Section 4.11 [Source install system issues], page 56.

### 4.8 Problems compiling?

All MySQL programs compile cleanly for us with no warnings on Solaris using gcc. On other systems, warnings may occur due to differences in system include files. See Section 4.9 [MIT-pthreads], page 52, for warnings that may occur when using MIT-pthreads. For other problems, check the list below.

The solution to many problems involves reconfiguring. If you do need to reconfigure, take note of the following:

- If `configure` is run after it already has been run, it may use information that was gathered during its previous invocation. This information is stored in `config.cache`. When `configure` starts up, it looks for that file and reads its contents if it exists, on the assumption that the information is still correct. That assumption is invalid when you reconfigure.

- Each time you run `configure`, you must run `make` again to recompile. However, you may want to remove old object files from previous builds first, since they were compiled using different configuration options.

To prevent old configuration information or object files from being used, run these commands before rerunning `configure`:
shell> rm config.cache
shell> make clean
Alternatively, you can run make distclean.

The list below describes some of the problems compiling MySQL that have been found to occur most often:

- If you get errors when compiling ‘sql_yacc.cc’ such as the ones shown below, you have probably run out of memory or swap space:

  Internal compiler error: program cc1plus got fatal signal 11
  or
  Out of virtual memory
  or
  Virtual memory exhausted

  The problem is that gcc requires huge amounts of memory to compile ‘sql_yacc.cc’ with inline functions. Try running configure with the --with-low-memory option:

  shell> ./configure --with-low-memory

  This option causes -fno-inline to be added to the compile line if you are using gcc and -O0 if you are using something else. You should try the --with-low-memory option even if you have so much memory and swap space that you think you can’t possibly have run out. This problem has been observed to occur even on systems with generous hardware configurations, and the --with-low-memory option usually fixes it.

- By default, configure picks c++ as the compiler name and GNU c++ links with -lg++. If you are using gcc, that behavior can cause problems during configuration such as this:

  configure: error: installation or configuration problem:
  C++ compiler cannot create executables.

  You might also observe problems during compilation related to g++, libg++ or libstdc++.

  One cause of these problems is that you may not have g++, or you may have g++ but not libg++ or libstdc++. Take a look at the ‘config.log’ file. It should contain the exact reason why your c++ compiler didn’t work! To work around these problems, you can use gcc as your C++ compiler. Try setting the environment variable CXX to "gcc -O3". For example:

  shell> CXX="gcc -O3" ./configure

  This works because gcc compiles C++ sources as well as g++ does, but does not link in libg++ or libstdc++ by default.

  Another way to fix these problems, of course, is to install g++, libg++ and libstdc++.

- If your compile fails with errors such as any of the following, you must upgrade your version of make to GNU make:

  making all in mit-pthreads
  make: Fatal error in reader: Makefile, line 18:
  Badly formed macro assignment
  or
  make: file ‘Makefile’ line 18: Must be a separator (:
Solaris and FreeBSD are known to have troublesome make programs.

GNU make version 3.75 is known to work.

- If you want to define flags to be used by your C or C++ compilers, do so by adding the flags to the CFLAGS and CXXFLAGS environment variables. You can also specify the compiler names this way using CC and CXX. For example:

  ```
  shell> CC=gcc
  shell> CFLAGS=-O6
  shell> CXX=gcc
  shell> CXXFLAGS=-O6
  shell> export CC CFLAGS CXX CXXFLAGS
  ```

  See Section 4.14 [TeX binaries], page 80, for a list of flag definitions that have been found to be useful on various systems.

- If you get an error message like this, you need to upgrade your gcc compiler:

  ```
  client/libmysql.c:273: parse error before '__attribute__'
  gcc 2.8.1 is known to work, but we recommend using egcs 1.0.3a or newer instead.
  ```

- If you get errors such as those shown below when compiling mysqld, configure didn’t correctly detect the type of the last argument to accept(), getsockname() or getpeername():

  ```
  cxx: Error: mysqld.cc, line 645: In this statement, the referenced type of the pointer value "&length" is "unsigned long", which is not compatible with "int".
  new_sock = accept(sock, (struct sockaddr *)&cAddr, &length);
  ```

  To fix this, edit the ‘config.h’ file (which is generated by configure). Look for these lines:

  ```
  /* Define as the base type of the last arg to accept */
  #define SOCKET_SIZE_TYPE XXX
  ```

  Change XXX to size_t or int, depending on your operating system. (Note that you will have to do this each time you run configure, since configure regenerates ‘config.h’.)

- The ‘sql_yacc.cc’ file is generated from ‘sql_yacc.yy’. Normally the build process doesn’t need to create ‘sql_yacc.cc’, because MySQL comes with an already-generated copy. However, if you do need to recreate it, you might encounter this error:

  ```
  "sql_yacc.yy", line xxx fatal: default action causes potential...
  ```

  This is a sign that your version of yacc is deficient. You probably need to install bison (the GNU version of yacc) and use that instead.

- If you need to debug mysqld or a MySQL client, run configure with the --with-debug option, then recompile and link your clients with the new client library. See Section G.2 [Debugging client], page 508.

### 4.9 MIT-pthreads notes
This section describes some of the issues involved in using MIT-pthreads.

Note that on Linux you should NOT use MIT-pthreads but install LinuxThreads! See Section 4.11.5 [Linux], page 59.

If your system does not provide native thread support, you will need to build MySQL using the MIT-pthreads package. This includes most FreeBSD systems, SunOS 4.x, Solaris 2.4 and earlier, and some others. See Section 4.2 [Which OS], page 36.

- On most systems, you can force MIT-pthreads to be used by running configure with the --with-mit-threads option:
  
  ```shell> ./configure --with-mit-threads```

Building in a non-source directory is not supported when using MIT-pthreads, because we want to minimize our changes to this code.

- MIT-pthreads doesn't support the AF_UNIX protocol used to implement Unix sockets. This means that if you compile using MIT-pthreads, all connections must be made using TCP/IP (which is a little slower). If you find after building MySQL that you cannot connect to the local server, it may be that your client is attempting to connect to localhost using a Unix socket as the default. Try making a TCP/IP connection with mysql by using a host option (-h or --host) to specify the local host name explicitly.

- The checks that determine whether or not to use MIT-pthreads occur only during the part of the configuration process that deals with the server code. If you have configured the distribution using --without-server to build only the client code, clients will not know whether or not MIT-pthreads is being used and will use Unix socket connections by default. Since Unix sockets do not work under MIT-pthreads, this means you will need to use -h or --host when you run client programs.

- When MySQL is compiled using MIT-pthreads, system locking is disabled by default for performance reasons. You can tell the server to use system locking with the --use-locking option.

- Sometimes the pthread bind() command fails to bind to a socket without any error message (at least on Solaris). The result is that all connections to the server fail. For example:
  
  ```shell> mysqladmin version
  mysqladmin: connect to server at 'localhost' failed;
  error: 'Can't connect to mysql server on localhost (146)'```

  The solution to this is to kill the mysql server and restart it. This has only happened to us when we have forced the server down and done a restart immediately.

- With MIT-pthreads, the sleep() system call isn't interruptible with SIGINT (break). This is only noticeable when you run mysqladmin --sleep. You must wait for the sleep() call to terminate before the interrupt is served and the process stops.

- When linking you may receive warning messages like these (at least on Solaris); they can be ignored:
  
  ```ld: warning: symbol '_iob' has differing sizes:
  (file /my/local/pthreads/lib/libpthread.a(findfp.o) value=0x4;
  file /usr/lib/libc.so value=0x140);```
4.10 Perl installation comments

4.10.1 Installing Perl on Unix

Perl support for MySQL is provided by means of the DBI/DBD client interface. See Section 21.5 [Perl], page 416. The Perl DBD/DBI client code requires Perl 5.004 or later. The interface will not work if you have an older version of Perl.

MySQL Perl support also requires that you’ve installed MySQL client programming support. If you installed MySQL from RPM files, client programs are in the client RPM, but client programming support is in the developer RPM. Make sure you’ve installed the latter RPM.

As of release 3.22.8, Perl support is distributed separately from the main MySQL distribution. If you want to install Perl support, the files you will need can be obtained from http://www.mysql.com/Contrib.

The Perl distributions are provided as compressed tar archives and have names like ‘MODULE-VERSION.tar.gz’, where MODULE is the module name and VERSION is the version number. You should get the Data-Dumper, DBI, and Msql-Mysql-modules distributions and install them in that order. The installation procedure is shown below. The example shown is for the Data-Dumper module, but the procedure is the same for all three distributions.

1. Unpack the distribution into the current directory:
   
   shell> gunzip < Data-Dumper-VERSION.tar.gz | tar xvf -
   
   This command creates a directory named ‘Data-Dumper-VERSION’.

2. Change into the top-level directory of the unpacked distribution:

   shell> cd Data-Dumper-VERSION

3. Build the distribution and compile everything:

   shell> perl Makefile.PL
   shell> make
   shell> make test
   shell> make install

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The `make test` command is important, because it verifies that the module is working. Note that when you run that command during the `Mysql-Mysql-modules` installation to exercise the interface code, the MySQL server must be running or the test will fail.

It is a good idea to rebuild and reinstall the `Mysql-Mysql-modules` distribution whenever you install a new release of MySQL, particularly if you notice symptoms such as all your DBI scripts dumping core after you upgrade MySQL.

If you don’t have the right to install Perl modules in the system directory or if you to install local Perl modules, the following reference may help you:


Look under the heading Installing New Modules that Require Locally Installed Modules.

### 4.10.2 Installing ActiveState Perl on Win32

To install the MySQL DBD module with ActiveState Perl on Win32, you should do the following:

- Open a DOS shell.
- If required, set the HTTP_proxy variable. For example, you might try: `set HTTP_proxy=my.proxy.com:3128`.
- Start the PPM program: `C:\perl\bin\ppm.pl`
- If you have not already done so, install DBI: `install DBI`
- If this succeeds, install `DBD::mysql`: http://www.mysql.com/Contrib/ppd/DBD-mysql.ppd

If you can’t get the above to work, you should instead install the MyODBC driver and connect to MySQL server through ODBC.

```perl
use DBI;
$dbh = DBI->connect("DBI:ODBC:$dsn","$user","$password") ||
   die "Got error $DBI::errstr when connecting to $dsn\n";
```

### 4.10.3 Installing the MySQL Perl distribution on Win32

The MySQL Perl distribution contains DBI, DBD:MySQL and DBD:ODBC.

- Unzip the distribution in C: so that you get a ‘C:\PERL’ directory.
- Add the directory ‘C:\PERL\BIN’ to your path.
- Add the directory ‘C:\PERL\BIN\MSWin32-x86-thread’ or ‘C:\PERL\BIN\MSWin32-x86’ to your path.
- Test that perl works by executing perl -v in a DOS shell.
4.10.4 Problems using the Perl DBI/DBD interface

If Perl reports that it can’t find the ../mysql/mysql.so module, then the problem is probably that Perl can’t locate the shared library ‘libmysqlclient.so’. You can fix this by any of the following methods:

- Compile the Msql-Mysql-modules distribution with perl Makefile.PL -static -config rather than perl Makefile.PL
- Copy libmysqlclient.so to the directory where your other shared libraries are located (probably ‘/usr/lib’ or ‘/lib’).
- On Linux you can add the pathname of the directory where libmysqlclient.so is located to the ‘/etc/ld.so.conf’ file.
- Add the pathname of the directory where libmysqlclient.so is located to the LD_RUN_PATH environment variable.

If you get the following errors from DBD-mysql, you are probably using gcc (or using an old binary compiled with gcc):

/usr/bin/perl: can’t resolve symbol ‘__moddi3’
/usr/bin/perl: can’t resolve symbol ‘__divdi3’

Add -L/usr/lib/gcc-lib/... -lgcc to the link command when the ‘mysql.so’ library gets built (check the output from make for ‘mysql.so’ when you compile the Perl client). The -L option should specify the pathname of the directory where ‘libgcc.a’ is located on your system.

Another cause of this problem may be that Perl and MySQL aren’t both compiled with gcc. In this case, you can solve the mismatch by compiling both with gcc.

If you want to use the Perl module on a system that doesn’t support dynamic linking (like SCO) you can generate a static version of Perl that includes DBI and DBD-mysql. The way this works is that you generate a version of Perl with the DBI code linked in and install it on top of your current Perl. Then you use that to build a version of Perl that additionally has the DBD code linked in, and install that.

On SCO, you must have the following environment variables set:

```
shell> LD_LIBRARY_PATH=/lib:/usr/lib:/usr/local/lib:/usr/progressive/lib
or
shell> LD_LIBRARY_PATH=/usr/lib:/lib:/usr/local/lib:/usr/ccs/lib:/usr/progressive/lib:
shell> LIBPATH=/usr/lib:/lib:/usr/local/lib:/usr/ccs/lib:/usr/progressive/lib:/usr/sbin:
shell> MANPATH= scohelp:/usr/man:/usr/local1/man:/usr/local/man:/usr/skunk/man:
```

First, create a Perl that includes a statically-linked DBI by running these commands in the directory where your DBI distribution is located:

```
shell> perl Makefile.PL -static -config
shell> make
shell> make install
shell> make perl
```

Then you must install the new Perl. The output of make perl will indicate the exact make command you will need to execute to perform the installation. On SCO, this is make -f Makefile.aperl inst_perl MAP_TARGET=perl.

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Next, use the just-created Perl to create another Perl that also includes a statically-linked DBD::mysql by running these commands in the directory where your Msql-Mysql-modules distribution is located:

```
shell> perl Makefile.PL -static -config
shell> make
shell> make install
shell> make perl
```

Finally, you should install this new Perl. Again, the output of `make perl` indicates the command to use.

### 4.11 System-specific issues

The following sections indicate some of the issues that have been observed to occur on particular systems when installing MySQL from a source distribution.

#### 4.11.1 Solaris notes

On Solaris, you may run into trouble even before you get the MySQL distribution unpacked! Solaris `tar` can’t handle long file names, so you may see an error like this when you unpack MySQL:

```
x mysql-3.22.12-beta/bench/Results/ATIS-mysql_odbc-NT_4.0-cmp-db2,informix,ms-sql,mysql,oracle,solid,sybase, 0 bytes, 0 tape blocks
tar: directory checksum error
```

In this case, you must use GNU `tar` (`gtar`) to unpack the distribution. You can find a precompiled copy for Solaris at [http://www.mysql.com/Downloads/](http://www.mysql.com/Downloads/).

Sun native threads work only on Solaris 2.5 and higher. For 2.4 and earlier versions, MySQL will automatically use MIT-pthreads. See Section 4.9 [MIT-pthreads], page 52.

If you get the following error from configure:

```
checking for restartable system calls... configure: error can not run test programs while cross compiling
```

This means that you have something wrong with your compiler installation! In this case you should upgrade your compiler to a newer version. You may also be able to solve this problem by inserting the following row into the `config.cache` file:

```
ac_cv_sys_restartable_syscalls=${ac_cv_sys_restartable_syscalls='no'}
```

If you are using Solaris on a SPARC, the recommended compiler is `egcs` 1.1.2 or newer. You can find this at [http://egcs.cygnus.com/](http://egcs.cygnus.com/). Note that `egs` 1.1.1 and `gcc` 2.8.1 don’t work reliably on SPARC!

The recommended `configure` line when using `egcs` 1.1.2 is:

```
shell> CC=egcs CFLAGS="-O6" CXX=egcs CXXFLAGS="-O6 -felide-constructors -fno-exceptions -fno-rtti" /configure --prefix=/usr/local/mysql --with-low-memory
```

If you have the Sun Workshop 4.2 compiler, you can run `configure` like this:

```
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```
CC=cc CFLAGS="-xstrconst -Xa -xO4 -native -mt" CXX=CC CXXFLAGS="-xO4 -native -noex -mt" ./configure --prefix=/usr/local/mysql

shell> CC=cc CFLAGS="-Xa -fast -xO4 -native -xstrconst -mt" \CXX=CC CXXFLAGS="-noex -XO4 -mt" ./configure

You may also have to edit the configure script to change this line:

```
#if !defined(__STDC__) || __STDC__ != 1
```

to this:

```
#if !defined(__STDC__)
```

If you turn on `__STDC__` with the `-Xc` option, the Sun compiler can’t compile with the Solaris `pthread.h` header file. This is a Sun bug (broken compiler or broken include file).

If mysqlld issues the error message shown below when you run it, you have tried to compile MySQL with the Sun compiler without enabling the multi-thread option (`-mt`):

```
libc internal error: _rmutex_unlock: rmutex not held
```

Add `-mt` to CFLAGS and CXXFLAGS and try again.

If you get the following error when compiling MySQL with gcc, it means that your gcc is not configured for your version of Solaris!

```
shell> gcc -O3 -g -O2 -DDBUG_OFF -o thr_alarm ... ./thr_alarm.c: In function ‘signal_hand’:
../thr_alarm.c:556: too many arguments to function ‘sigwait’
```

The proper thing to do in this case is to get the newest version of egcs and compile it with your current gcc compiler! At least for Solaris 2.5, almost all binary versions of gcc have old, unusable include files that will break all programs that use threads (and possibly other programs)!

Solaris doesn’t provide static versions of all system libraries (`libpthreads` and `libdl`), so you can’t compile MySQL with `--static`. If you try to do so, you will get the error:

```
ld: fatal: library -ldl: not found
```

If too many processes try to connect very rapidly to mysqlld, you will see this error in the MySQL log:

```
Error in accept: Protocol error
```

You might try starting the server with the `--set-variable back_log=50` option as a workaround for this.

If you are linking your own MySQL client, you might get the following error when you try to execute it:

```
ld.so.1: ./my: fatal: libmysqlclient.so.: open failed: No such file or directory
```

The problem can be avoided by one of the following methods:

- Link the client with the following flag (instead of `-Lpath`): `-Wl,r/full-path-to-libmysqlclient.so.
- Copy `libmysqlclient.so` to `'/usr/lib'`.
- Add the path name of the directory where `libmysqlclient.so` is located to the `LD_RUN_PATH` environment variable before running your client.
When using the `--with-libwrap` configure option, you must also include the libraries that `libwrap.a` needs:

```
--with-libwrap="/opt/NUtcpwrapper-7.6/lib/libwrap.a -lnsl -lsocket
```

### 4.11.2 Solaris 2.7 notes

You can normally use a Solaris 2.6 binary on Solaris 2.7. Most of the Solaris 2.6 issues also apply for Solaris 2.7.

Note that MySQL 3.23.4 and above should be able to autodetect Solaris 2.7 and enable workarounds for the following problems!

Solaris 2.7 has some bugs in the include files. You may see the following error when you use `gcc`:

```
/usr/include/widec.h:42: warning: 'getwc' redefined
/usr/include/wchar.h:326: warning: this is the location of the previous definition
```

If this occurs, you can do the following to fix the problem:

Copy `/usr/include/widec.h` to `.../lib/gcc-lib/os/gcc-version/include` and change line 41 from:

```
#define !defined(lint) && !defined(__lint)
```

to

```
#define !defined(lint) && !defined(__lint) && !defined(getwc)
```

Alternatively, you can edit `'/usr/include/widec.h'` directly. Either way, after you make the fix, you should remove `config.cache` and run `configure` again!

If you get errors like this when you run `make`, it’s because `configure` didn’t detect the `curses.h` file (probably because of the error in `/usr/include/widec.h`):

```
In file included from mysql.cc:50:
/usr/include/term.h:1060: syntax error before ',',
/usr/include/term.h:1081: syntax error before ';
```

The solution to this is to do one of the following steps:

- Edit `'/usr/include/widec.h'` as indicted above and rerun configure
- Remove the `#define HAVE_TERM` line from `config.h` file and run `make` again.
- Configure with `CFLAGS=-DHAVE_CURSES CXXFLAGS=-DHAVE_CURSES ./configure`

### 4.11.3 Solaris x86 notes

If you are using `gcc` or `egcs` on Solaris x86 and you experience problems with core dumps under load, you should use the following `configure` command:

```
shell> CC=gcc CFLAGS="-O6 -fomit-frame-pointer" \
    CXX=gcc \
    CXXFLAGS="-O6 -fomit-frame-pointer -felide-constructors -fno-exceptions -fno-rtti"
```

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./configure --prefix=/usr/local/mysql

This will avoid problems with the libstdc++ library and with C++ exceptions.
If this doesn’t help, you should compile a debug version and run it with a trace file or under gdb. See Section G.1 [Debugging server], page 506.

4.11.4 SunOS 4 notes

On SunOS 4, MIT-pthreads is needed to compile MySQL, which in turn means you will need GNU make.

Some SunOS 4 systems have problems with dynamic libraries and libtool. You can use the following configure line to avoid this problem:

shell> ./configure --disable-shared --with-mysqld-ldflags=-all-static

When compiling readline, you may get warnings about duplicate defines. These may be ignored.

When compiling mysqld, there will be some implicit declaration of function warnings. These may be ignored.

4.11.5 Linux notes (all Linux versions)

MySQL uses LinuxThreads on Linux. If you are using an old Linux version that doesn’t have glibc2, you must install LinuxThreads before trying to compile MySQL. http://www.mysql.com/Downloads/Linux

Note that glibc versions before and including 2.1.1 has a fatal bug in pthread_mutex_timedwait handling, which is used when you do INSERT DELAYED. If you are using INSERT DELAYED, you MUST add the following patch to your glibc library: http://www.mysql.com/Downloads/Patches/glibc-pthread_cond_timedwait.patch. MySQL 3.23.7 contains a temporary workaround for this bug.

If you can’t start mysqld or if mysql_install_db doesn’t work, please continue reading! This only happens on Linux system with problems in the LinuxThreads or libc/glibc libraries. There are a lot of simple workarounds to get MySQL to work! The simplest is to use the binary version of MySQL (not the RPM) for Linux x86. One nice aspect of this version is that it’s probably 10% faster than any version you would compile yourself! See Section 11.2.1 [Compile and link options], page 276.

One known problem with the binary distribution is that with older Linux systems that use libc (like RedHat 4.x or Slackware), you will get some non-fatal problems with hostname resolution See Section 4.6.3.1 [Binary notes-Linux], page 43.

myisamchk hangs with libc.so.5.3.12. Upgrading to the newest libc fixes this problem.

When using LinuxThreads you will see a minimum of three processes running. These are in fact threads. There will be one thread for the LinuxThreads manager, one thread to handle connections, and one thread to handle alarms and signals.

If you see a dead mysqld daemon process with ps, this usually means that you have found a bug in MySQL or you have got a corrupted table. See Section 19.1 [Crashing], page 352.
If you are using LinuxThreads and `mysqladmin shutdown` doesn’t work, you must upgrade to LinuxThreads 0.7.1 or newer.

If you are using RedHat, you might get errors like this:

```
/usr/bin/perl is needed...
/usr/sh is needed...
/usr/sh is needed...
```

So, you should upgrade your version of `rpm` to `rpm-2.4.11-1.i386.rpm` and `rpm-devel-2.4.11-1.i386.rpm` (or later).


If you are linking your own MySQL client and get the error:

```
ld.so.1: ./my: fatal: libmysqlclient.so.4: open failed: No such file or directory
```

When executing them, the problem can be avoided by one of the following methods:

- Link the client with the following flag (instead of `-Lpath`): `-Wl,r/path-libmysqlclient.so`.
- Copy `libmysqclient.so` to `/usr/lib`.
- Add the pathname of the directory where `libmysqlclient.so` is located to the `LD_RUN_PATH` environment variable before running your client.

If you are using the Fujitsu compiler (fcc / FCC) you will have some problems compiling MySQL because the Linux header files are very gcc oriented.

The following `configure` line should work with fcc/FCC:

```
CC=fcc CFLAGS="-O -K fast -K lib -K omitfp -Kpreex -D_GNU_SOURCE -DCONST=const -DNO_STRTOLL_PROTO" CXX=FCC CXXFLAGS="...
```

### 4.11.5.1 Linux-x86 notes

MySQL requires libc version 5.4.12 or newer. It’s known to work with libc 5.4.46. glibc version 2.0.6 and later should also work. There have been some problems with the glibc RPMs from RedHat so if you have problems, check whether or not there are any updates! The glibc 2.0.7-19 and 2.0.7-29 RPMs are known to work.

On some older Linux distributions, configure may produce an error like this:

```
Syntax error in sched.h. Change _P to __P in the /usr/include/sched.h file.
```

See the Installation chapter in the Reference Manual.

Just do what the error message says and add an extra underscore to the _P macro that has only one underscore, then try again.

You may get some warnings when compiling; those shown below can be ignored:

```
mysqld.cc -o objs-thread/mysqld.o
mysqld.cc: In function ‘void init_signals()’: 
mysqld.cc:315: warning: assignment of negative value ‘-1’ to ‘long unsigned int’
mysqld.cc: In function ‘void * signal_hand(void *)’: 
mysqld.cc:346: warning: assignment of negative value ‘-1’ to ‘long unsigned int’
```

In Debian GNU/Linux, if you want MySQL to start automatically when the system boots, do the following:
shell> cp support-files/mysql.server /etc/init.d/mysql.server
shell> /usr/sbin/update-rc.d mysql.server defaults 99

mysql.server can be found in the ‘share/mysql’ directory under the MySQL installation directory, or in the ‘support-files’ directory of the MySQL source tree.

If mysqld always core dumps when it starts up, the problem may be that you have an old ‘/lib/libc.a’. Try renaming it, then remove ‘sql/mysqld’ and do a new make install and try again. This problem has been reported on some Slackware installations. RedHat 5.0 has also a similar problem with some new glibc versions. See Section 4.11.5.2 [Linux-RedHat50], page 61.

If you get the following error when linking mysqld, it means that your ‘libg++.a’ is not installed correctly:

/usr/lib/libc.a(putc.o): In function ‘_IO_putc’:
putc.o(.text+0x0): multiple definition of ‘_IO_putc’

You can avoid using ‘libg++.a’ by running configure like this:

shell> CXX=gcc ./configure

4.11.5.2 RedHat 5.0 notes

If you have any problems with MySQL on RedHat, you should start by upgrading glibc to the newest possible version!

If you install all the official RedHat patches (including glibc-2.0.7-19 and glibc-devel-2.0.7-19), both the binary and source distributions of MySQL should work without any trouble!

The updates are needed since there is a bug in glibc 2.0.5 in how pthread_key_create variables are freed. With glibc 2.0.5, you must use a statically-linked MySQL binary distribution. If you want to compile from source, you must install the corrected version of LinuxThreads from http://www.mysql.com/Downloads/Linux or upgrade your glibc.

If you have an incorrect version of glibc or LinuxThreads, the symptom is that mysqld crashes after each connection. For example, mysqladmin version will crash mysqld when it finishes!

Another symptom of incorrect libraries is that mysqld crashes at once when it starts. On some Linux systems, this can be fixed by configuring like this:

shell> ./configure --with-mysqld-ldflags=-all-static

On RedHat 5.0, the easy way out is to install the glibc 2.0.7-19 RPM and run configure without the --with-mysqld-ldflags=-all-static option.

For the source distribution of glibc 2.0.7, a patch that is easy to apply and is tested with MySQL may be found at:

http://www.mysql.com/Download/Linux/glibc-2.0.7-total-patch.tar.gz

If you experience crashes like these when you build MySQL, you can always download the newest binary version of MySQL. This is statically-linked to avoid library conflicts and should work on all Linux systems!

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MySQL comes with an internal debugger that can generate trace files with a lot of information that can be used to find and solve a wide range of different problems. See Section G.1 [Debugging server], page 506.

4.11.5.3 RedHat 5.1 notes

The glibc of RedHat 5.1 (glibc 2.0.7-13) has a memory leak, so to get a stable MySQL version, you must upgrade glibc to 2.0.7-19, downgrade glibc or use a binary version of mysqld. If you don’t do this, you will encounter memory problems (out of memory, etc., etc.). The most common error in this case is:

```
Can’t create a new thread (errno 11). If you are not out of available memory, you can consult the manual for any possible OS dependent bug
```

After you have upgraded to glibc 2.0.7-19, you can configure MySQL with dynamic linking (the default), but you cannot run configure with the `--with-mysqld-ldflags=-all-static` option until you have installed glibc 2.0.7-19 from source!

You can check which version of glibc you have with `rpm -q glibc`.

4.11.5.4 Linux-SPARC notes

In some implementations, readdir_r() is broken. The symptom is that SHOW DATABASES always returns an empty set. This can be fixed by removing HAVE_READDIR_R from ‘config.h’ after configuring and before compiling.

Some problems will require patching your Linux installation. The patch can be found at http://www.mysql.com/patches/Linux-sparc-2.0.30.diff. This patch is against the Linux distribution ‘sparclinux-2.0.30.tar.gz’ that is available at vger.rutgers.edu (a version of Linux that was never merged with the official 2.0.30). You must also install LinuxThreads 0.6 or newer.

Thanks to jacques@solucorp.qc.ca for this information.

4.11.5.5 Linux-Alpha notes

The big problem on Linux-Alpha is that there are still some problems with threads in glibc on this platform. You should start by getting the newest glibc version you can find.

Note that before you run any programs that use threads (like mysqld, thr_alarm or thr_lock), you should raise the shared memory limit (with ulimit). The MySQL benchmarks are known to fail if you forget to do this!

Configure MySQL with the following command:

```
shell> CC=gcc CCFLAGS="-Dalpha_linux_port" CXX=gcc CXXFLAGS="-O3 -Dalpha_linux_port -felide-constructors -fno-exceptions" ./configure --prefix=/usr/local/mysql
```

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Try to compile `mysys/thr_lock` and `mysys/thr_alarm`. Test that these programs work! (Invoke each one with no arguments. Each should end with `test_succeeded` if everything was okay.)

After installing MySQL, uncomment the `ulimit` command in `safe_mysqld` and add options to increase shared memory.

Note that Linux-Alpha is still an alpha-quality platform for MySQL. With the newest glibc, you have a very good chance of it working.

If you have problems with signals (MySQL dies unexpectedly under high load) you may have found an OS bug with threads and signals. In this case you can tell MySQL not to use signals by configuring with:

```shell
shell> CFLAGS=-DDONT_USE_THR_ALARM \ 
     CXXFLAGS=-DDONT_USE_THR_ALARM \ 
     ./configure ...
```

This doesn’t affect the performance of MySQL, but has the side effect that you can’t kill clients that are “sleeping” on a connection with `mysqladmin kill` or `mysqladmin shutdown`. Instead, the client will die when it issues its next command.

### 4.11.5.6 MkLinux notes

MySQL should work on MkLinux with the newest glibc package (tested with glibc 2.0.7).

### 4.11.5.7 Qube2 Linux notes

To get MySQL to work on Qube2, (Linux Mips), you need the newest glibc libraries (glibc-2.0.7-29C2 is known to work). You must also use the egcs C++ compiler (egcs-1.0.2-9 or newer).

### 4.11.6 Alpha-DEC-Unix notes

When compiling threaded programs under Digital UNIX, the documentation recommends using the `-pthread` option for `cc` and `cxx` and the libraries `-lmach -lexc` (in addition to `-lpthread`). You should run `configure` something like this:

```shell
shell> CC="cc -pthread" CXX="cxx -pthread -O" \ 
     ./configure --with-named-thread-libs="-lpthread -lmach -lexc -lc"
```

When compiling `mysqld`, you may see a couple of warnings like this:

```shell
mysqld.cc: In function void handle_connections()':
mysqld.cc:626: passing long unsigned int *' as argument 3 of
accept(int,sockaddr *, int *)'
```

You can safely ignore these warnings. They occur because `configure` can detect only errors, not warnings.
If you start the server directly from the command line, you may have problems with it dying when you log out. (When you log out, your outstanding processes receive a SIGHUP signal.) If so, try starting the server like this:

```
shell> nohup mysqld [options] &
```

*nohup* causes the command following it to ignore any SIGHUP signal sent from the terminal. Alternatively, start the server by running `safe_mysqld`, which invokes `mysqld` using `nohup` for you.

### 4.11.7 Alpha-DEC-OSF1 notes

If you have problems compiling and have DEC CC and gcc installed, try running `configure` like this:

```
shell> CC=cc CFLAGS=-0 CXX=gcc CXXFLAGS=-O3 .
```

If you get problems with the `c_asm.h` file, you can create and use a 'dummy' `c_asm.h` file with:

```
shell> touch include/c_asm.h
shell> CC=gcc CFLAGS=-I./include CXX=gcc CXXFLAGS=-O3 ./configure --prefix=/usr/local/mysql
```

On OSF1 V4.0D and compiler "DEC C V5.6-071 on Digital UNIX V4.0 (Rev. 878)" the compiler had some strange behavior (undefined *asm* symbols). `bin/ld` also appears to be broken (problems with `_exit` undefined errors occurring while linking `mysqld`). On this system, we have managed to compile MySQL with the following `configure` line, after replacing `/bin/ld` with the version from OSF 4.0C:

```
shell> CC=gcc CXX=gcc CXXFLAGS=-O3 ./configure --prefix=/usr/local/mysql
```

With the Digital compiler "C++ V6.1-029", the following should work:

```
CC=cc -pthread
CFLAGS=-04 -ansi_alias -ansi_args -fast -inline speed -speculate all -arch host
CXX=ccx -pthread
CXXFLAGS=-04 -ansi_alias -ansi_args -fast -inline speed -speculate all -arch host
export CC CFLAGS CXX CXXFLAGS
./configure --prefix=/usr/mysql/mysql --with-low-memory --enable-large-files --with-mysqld-ldflags=-all-static --disable-shared --with-named-thread-libs="-lpthread -lmach -lexc -lc"
```

In some versions of OSF1, the `alloca()` function is broken. Fix this by removing the line in `config.h` that defines `HAVE_ALLOCA`.

The `alloca()` function also may have an incorrect prototype in `/usr/include/alloca.h`. This warning resulting from this can be ignored.

`configure` will use the following thread libraries automatically: `--with-named-thread-libs=-lpthread -lmach -lexc -lc`.

When using gcc, you can also try running `configure` like this:

```
shell> CFLAGS=-D_PTHREAD_USE_D4 CXX=gcc CXXFLAGS=-O3 ./configure ....
```
If you have problems with signals (MySQL dies unexpectedly under high load) you may have found an OS bug with threads and signals. In this case you can tell MySQL not to use signals by configuring with:

```
shell> CFLAGS=-DDONT_USE_THR_ALARM 
    CXXFLAGS=-DDONT_USE_THR_ALARM 
    ./configure ...
```

This doesn’t affect the performance of MySQL, but has the side effect that you can’t kill clients that are “sleeping” on a connection with `mysqladmin kill` or `mysqladmin shutdown`. Instead, the client will die when it issues its next command.

With gcc 2.95.2, you will probably run into the following compile error:

```
sql_acl.cc:1456: Internal compiler error in 'scan_region', at except.c:2566
Please submit a full bug report.
```

To fix this you should change to the sql directory and do a ’cut and paste’ of the last gcc line, but change -O3 to -00 (or add -00 immediately after gcc if you don’t have any -O option on your compile line. After this is done you can just change back to the top level directly and run `make` again.

### 4.11.8 SGI-Irix notes

If you are using Irix 6.5.3 or newer mysqld will only be able to create threads if you run it as a user with CAP_SCHED_MGT privileges (like root) or give the mysqld server this privilege with the following shell command:

```
shell> chcap "CAP_SCHED_MGT+epi" /opt/mysql/libexec/mysqld
```

You may have to undefine some things in ‘config.h’ after running configure and before compiling.

In some Irix implementations, the `alloca()` function is broken. If the mysqld server dies on some SELECT statements, remove the lines from ‘config.h’ that define HAVE_ALLOC and HAVE_ALLOCA_H. If mysqladmin create doesn’t work, remove the line from ‘config.h’ that defines HAVE_READDIR_R. You may have to remove the HAVE_TERM_H line as well.

SGI recommends that you install all of the patches on this page as a set: http://support.sgi.com/surfzone/patches/patchset/6.2

At the very minimum, you should install the latest kernel rollup, the latest rld rollup, and the latest libc rollup.

You definately need all the POSIX patches on this page, for pthreads support: http://support.sgi.com/surfzone/patches/patchset/6.2.posix.rps.html

If you get the something like the following error when compiling `mysql.cc`:

```
"/usr/include/curses.h", line 82: error(1084): invalid combination of type
```

Then type the following in the top-level directory of your MySQL source tree:

```
shell> extra/replace bool curses_bool < /usr/include/curses.h > include/curses.h
shell> make
```

There have also been reports of scheduling problems. If only one thread is running, things go slow. Avoid this by starting another client. This may lead to a 2-to-10-fold increase in

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execution speed thereafter for the other thread. This is a poorly-understood problem with
Irix threads; you may have to improvise to find solutions until this can be fixed.
If you are compiling with gcc, you can use the following configure command:

```
shell> CC=gcc CXX=gcc CXXFLAGS=-O3 \
       ./configure --prefix=/usr/local/mysql --with-thread-safe-client --with-named-
```

4.11.9 FreeBSD notes

FreeBSD 3.x is recommended for running MySQL since it the thread package is much more
integrated.
The easiest and therefor the preferred way to install is to use the mysql-server and mysql-
client ports available on http://www.freebsd.org
Using these gives you:
- A working MySQL with all optimizations known to work on your version of FreeBSD
  enabled.
- Automatic configuration and build.
- Startup scripts installed in /usr/local/etc/rc.d
- Ability to see which files that are installed with pkg_info -L. And to remove them all
  with pkg_delete if you no longer want MySQL on that machine.
It is recomended to use MIT-pthreads on FreeBSD 2.x and native threads on versions 3 and
up. It is possible to run with with native threads on some late 2.2.x versions but you may
encounter problems shutting down mysqld.
Be sure to have your name resolver setup correct. Otherwise you may experience resolver
delays or failures when connecting to mysqld.
Make sure that the localhost entry in the ‘/etc/hosts’ file is correct (otherwise you will
have problems connecting to the database). The ‘/etc/hosts’ file should start with a line:

```
127.0.0.1 localhost localhost.your.domain
```
If you notice that configure will use MIT-pthreads, you should read the MIT-pthreads
notes. See Section 4.9 [MIT-pthreads], page 52.
If you get an error from make install that it can’t find ‘/usr/include/pthreads’,
configure didn’t detect that you need MIT-pthreads. This is fixed by executing these
commands:

```
shell> rm config.cache
shell> ./configure --with-mit-threads
```
The behavior of FreeBSD make is slightly different from that of GNU make. If you have
make-related problems, you should install GNU make.
FreeBSD is also known to have a very low default file handle limit. See Section 19.11 [Not
enough file handles], page 362. Uncomment the ulimit -n section in safe_mysqld or raise the
limits for the mysqld user in /etc/login.conf (and rebuild it witg cap_mkdb /etc/login.conf)
also be sure you set the appropriate Class for this user in the password file if you are not
using the default (use: chpass mysqld-user-name)
If you have a problem with `SELECT NOW()` returning values in GMT and not your local time, you have to set the `TZ` environment variable to your current timezone. This should be done for the environment in which the server runs, for example, in `safe_mysqld` or `mysql.server`.

To get a secure and stable system you should only use FreeBSD kernels that are marked `-STABLE`.

### 4.11.10 NetBSD notes

To compile on NetBSD you need GNU `make`. Otherwise the compile will crash when `make` tries to run `lint` on C++ files.

### 4.11.11 OpenBSD 2.5 notes

On OpenBSD 2.5, you can compile MySQL with native threads with the following options:

```
CFLAGS=-pthread CXXFLAGS=-pthread ./configure --with-mit-threads=no
```

### 4.11.12 BSD/OS notes

#### 4.11.12.1 BSD/OS 2.x notes

If you get the following error when compiling MySQL, your `ulimit` value for virtual memory is too low:

```
item_func.h: In method ‘Item_func_ge::Item_func_ge(const Item_func_ge &):’
item_func.h:28: virtual memory exhausted
make[2]: *** [item_func.o] Error 1
```

Try using `ulimit -v 80000` and run `make` again. If this doesn’t work and you are using `bash`, try switching to `csh` or `sh`; some BSDI users have reported problems with `bash` and `ulimit`.

If you are using `gcc`, you may also use have to use the `--with-low-memory` flag for `configure` to be able to compile `sql_yacc.cc`.

If you have a problem with `SELECT NOW()` returning values in GMT and not your local time, you have to set the `TZ` environment variable to your current timezone. This should be done for the environment in which the server runs, for example in `safe_mysqld` or `mysql.server`.

#### 4.11.12.2 BSD/OS 3.x notes

Upgrade to BSD/OS 3.1. If that is not possible, install BSDIpatch M300-038.

Use the following command when configuring MySQL:

```
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```
```
shell> env CXX=shlicc++ CC=shlicc2 \
   ./configure \
   --prefix=/usr/local/mysql \
   --localstatedir=/var/mysql \
   --without-perl \
   --with-unix-socket-path=/var/mysql/mysql.sock
```

The following is also known to work:
```
shell> env CC=gcc CXX=gcc CXXFLAGS=-O3 \
   ./configure \
   --prefix=/usr/local/mysql \
   --with-unix-socket-path=/var/mysql/mysql.sock
```

You can change the directory locations if you wish, or just use the defaults by not specifying any locations.

If you have problems with performance under heavy load, try using the `--skip-thread-priority` option to `safe_mysqld`! This will run all threads with the same priority; on BSDI 3.1, this gives better performance (at least until BSDI fixes their thread scheduler).

If you get the error `virtual memory exhausted` while compiling, you should try using `ulimit -v 80000` and run `make` again. If this doesn’t work and you are using `bash`, try switching to `csh` or `sh`; some BSDI users have reported problems with `bash` and `ulimit`.

### 4.11.12.3 BSD/OS 4.x notes

BSDI 4.x has some thread related bugs. If you want to use MySQL on this, you should install all thread related patches. At least M400-023 should be installed.

On some BSDI 4.x systems, you may get problems with shared libraries. The symptom is that you can’t execute any client programs, like for example `mysqladmin`. In this case you need to reconfigure not to use shared libraries with the `--disable-shared` option to configure.

### 4.11.13 SCO notes

The current port is tested only on a “sco3.2v5.0.4” and “sco3.2v5.0.5” system. There has also been a lot of progress on a port to “sco 3.2v4.2”.

For the moment the recommended compiler on OpenServer is gcc 2.95.2. With this you should be able to compile MySQL with just:

```
CC=gcc CXX=gcc ./configure ... (options)
```

1. For OpenServer 5.0.X you need to use GDS in Skunkware 95 (95q4c). This is necessary because GNU gcc 2.7.2 in Skunkware 97 does not have GNU as. You can also use egcs 1.1.2 or newer [http://www.egcs.com/](http://www.egcs.com/). If you are using egcs 1.1.2 you have to execute the following command:

   ```
   shell> cp -p /usr/include/pthread/stdtypes.h /usr/local/lib/gcc-lib/i386-pc-sco3
   ```
2. You need the port of GCC 2.5.3 for this product and the Development system. They are required on this version of SCO UNIX. You cannot just use the GCC Dev system.

3. You should get the FSU Pthreads package and install it first. This can be found at http://www.cs.wustl.edu/~schmidt/ACE_wrappers/FSU-threads.tar.gz. You can also get a precompiled package from ftp://www.mysql.com/pub/mysql/Downloads/SCO/FSU-threads-3.5c.tar.gz.

4. FSU Pthreads can be compiled with SCO UNIX 4.2 with tcpip. Or OpenServer 3.0 or Open Desktop 3.0 (OS 3.0 ODT 3.0), with the SCO Development System installed using a good port of GCC 2.5.X ODT or OS 3.0 you will need a good port of GCC 2.5.3. There are a lot of problems without a good port. The port for this product requires the SCO UNIX Development system. Without it, you are missing the libraries and the linker that is needed.

5. To build FSU Pthreads on your system, do the following:
   1. Run `./configure` in the `threads/src` directory and select the SCO OpenServer option. This command copies `Makefile.SCO5` to `Makefile`.
   2. Run `make`.
   3. To install in the default `/usr/include` directory, login as root, then `cd` to the `thread/src` directory, and run `make install`.

6. Remember to use GNU make when making MySQL.

7. On OSR 5.0.5, you should use the following configure line:
   ```shell
   shell> CC="gcc -belf" CXX="gcc -belf" ./configure
   ```
   The `belf` is needed to help configure detect some thread functions properly. If you forget `-belf`, you will get the following error message while compiling:
   ```c
   my_pthread.c: In function 'my_pthread_mutex_init':
   my_pthread.c:374: 'pthread_mutexattr_default' undeclared (first use this function)
   ```

8. If you don’t start `safe_mysqld` as root, you probably will get only the default 110 open files per process. `mysqld` will write a note about this in the log file.

9. With SCO 3.2V5.0.5, you should use a FSU Pthreads version 3.5c or newer. The following configure command should work:
   ```shell
   shell> CC="gcc -belf" ./configure --prefix=/usr/local/mysql --disable-shared
   ```

10. With SCO 3.2V4.2, you should use a FSU Pthreads version 3.5c or newer. The following configure command should work:
    ```shell
    shell> CFLAGS="-D_XOPEN_XPG4" CXX=gcc CXXFLAGS="-D_XOPEN_XPG4" \ 
    ./configure \ 
    --with-debug --prefix=/usr/local/mysql \ 
    --with-named-thread-libs="-lgthreads -lsocket -lgen -lgthreads" \ 
    --with-named-curses-libs="-lcurses"
    ```
    You may get some problems with some include files. In this case, you can find new SCO-specific include files at ftp://www.mysql.com/pub/mysql/Downloads/SCO/SCO-3.2v4.2-includes.tar.gz. You should unpack this file in the ‘include’ directory of your MySQL source tree.

SCO development notes:
- MySQL should automatically detect FSU Pthreads and link mysqld with `-lgthreads` `-lsocket` `-lgthreads`.

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• The SCO development libraries are reentrant in FSU Pthreads. SCO claims that its libraries' functions are reentrant, so they must be reentrant with FSU Pthreads. FSU Pthreads on OpenServer tries to use the SCO scheme to make reentrant library.

• FSU Pthreads (at least the version at www.mysql.com) comes linked with GNU malloc. If you encounter problems with memory usage, make sure that 'gmalloc.o' is included in 'libgthreads.a' and 'libgthreads.so'.

• In FSU Pthreads, the following system calls are pthreads-aware: read(), write(), getmsg(), connect(), accept(), select() and wait().

If you want to install DBI on SCO, you have to edit the 'Makefiles' in DBI-xxx and each subdirectory:

OLD:
CC = cc
CCCDLFLAGS = -KPIC -W1,-Bexport
CCDLFLAGS = -w1,-Bexport
LD = ld
LD = ld
LD = ld
OPTIMISE = -Od
OLD:
CCCFLAGS = -belf -dy -w0 -U M_XENIX -DPERL_SCO5 -I/usr/local/include

NEW:
CC = gcc -belf
CCCDLFLAGS = -fpic
CCDLFLAGS = -fpic
LD = gcc -belf -G -fpic
LD = gcc -belf -G -fpic
LD = gcc -belf -G -fpic
OPTIMISE = -O1

NEW:
CCFLAGS = -U M_XENIX -DPERL_SCO5 -I/usr/local/include

This is because the Perl dynaloader will not load the DBI modules if they were compiled with icc or cc.

Perl works best when compiled with cc.

4.11.14 SCO Unixware 7.0 notes

You must use a version of MySQL at least as recent as 3.22.13, since that version fixes some portability problems under Unixware.

We have been able to compile MySQL with the following configure command on UnixWare 7.0.1:

shell> CC=cc CXX=CC ./configure --prefix=/usr/local/mysql

If you want to use gcc, you must use gcc 2.95.2 or newer.

4.11.15 IBM-AIX notes

Automatic detection of xlC is missing from Autoconf, so a configure command something like this is needed when using the IBM compiler:
If you change the -O3 to -O2 in the above configure line, you must also remove the -qstrict option (this is a limitation in the IBM C compiler).

If you are using egcs to compile MySQL, you MUST use the -fno-exceptions flag, as the exception handling in egcs is not thread-safe! (This is tested with egcs 1.1.) We recommend the following configure line with egcs and gcc on AIX:

    shell> CXX=gcc \
        CXXFLAGS="-felide-constructors -fno-exceptions -fno-rtti" \
        ./configure --prefix=/usr/local/mysql --with-debug --with-low-memory

If you have problems with signals (MySQL dies unexpectedly under high load) you may have found an OS bug with threads and signals. In this case you can tell MySQL not to use signals by configuring with:

    shell> CFLAGS="-DDONT_USE_THR_ALARM" CXX=gcc \
        CXXFLAGS="-felide-constructors -fno-exceptions -fno-rtti -DDONT_USE_THR_ALARM" \
        ./configure --prefix=/usr/local/mysql --with-pthread --with-named-thread-libs='-ldce' --prefix=/usr/local/mysql --disable-shared

This doesn't affect the performance of MySQL, but has the side effect that you can't kill clients that are “sleeping” on a connection with mysqladmin kill or mysqladmin shutdown. Instead, the client will die when it issues its next command.

On some versions of AIX, linking with libbind.a makes getservbyname core dump. This is an AIX bug and should be reported to IBM.

### 4.11.16 HP-UX 10.20 notes

There are a couple of “small” problems when compiling MySQL on HP-UX. We recommend that you use gcc instead of the HP-UX native compiler, because gcc produces better code!

We recommend one to use gcc 2.95 on HP-UX. Don’t use high optimization flags (like -O6) as this may not be safe on HP-UX.

Note that MIT-pthreads can’t be compiled with the HP-UX compiler, because it can’t compile .S (assembler) files.

The following configure line should work:

    CFLAGS="-D_HPUX -I/opt/dce/include" CXXFLAGS="-D_HPUX -I/opt/dce/include -felide-constructors -fno-exceptions -fno-rtti -DDONT_USE_THR_ALARM" CXX=gcc \
    ./configure --prefix=/usr/local/mysql --with-debug --with-low-memory

If you are compiling gcc 2.95 yourself, you should NOT link it with the DCE libraries (libdce.a or libcma.a) if you want to compile MySQL with MIT-pthreads. If you mix the DCE and MIT-pthreads packages you will get a mysqld to which you cannot connect.

Remove the DCE libraries while you compile gcc 2.95!

### 4.11.17 HP-UX 11.x notes

Here is some information that a HP-UX 11.x user sent us:

Note that some of these things are already fixed in MySQL 3.23.
Note: binary distribution for hp-ux 10.20 pa1.1 dumps core on hp-ux 11.0 pa2.0 during scripts/mysql_install_db. As such, I feel it necessary to build from scratch. This was a mildly painful process so I am sharing my work so others may benefit.

- Environment:
  - proper compilers.
  - setenv CC cc
  - setenv CXX aCC
  - flags
    - setenv CFLAGS -D_REENTRANT
    - setenv CXXFLAGS -D_REENTRANT
    - setenv CPPFLAGS -D_REENTRANT
  - % aCC -V
  - aCC: HP ANSI C++ B3910B X.03.14.06
  - % cc -V /tmp/empty.c
  - cpp.ansi: HP92453-01 A.11.02.00 HP C Preprocessor (ANSI)
  - ccom: HP92453-01 A.11.01.00 HP C Compiler

- configuration:
  - ./configure --with-pthread \\--prefix=/source-control/mysql \\--with-named-thread-libs=-lpthread \\--with-low-memory
  - added '#define _CTYPE_INCLUDED' to include/mctype.h. This symbol is the one defined in HP’s /usr/include/ctype.h:
    /* Don’t include std ctype.h when this is included */
    #define _CTYPE_H
    #define ___CTYPE_INCLUDED
    #define ___CTYPE_INCLUDED
    #define ___CTYPE_USING /* Don’t put names in global namespace. */
  - I had to use the compile-time flag -D_REENTRANT to get the compiler to recognize the prototype for localtime_r. Alternatively I could have supplied the prototype for localtime_r. But I wanted to catch other bugs without needing to run into them. I wasn’t sure where I needed it so I added it to all flags.
  - The optimization flags used by MySQL (-O3) are not recognized by HP’s compilers. I did not change the flags.
  - MySQL uses implicit conversion of string literals to char *. This is a deprecated feature. I did not change the behaviour.

Comments from another user that built MySQL with gcc 2.95.1:

If you get the error:

In file included from /usr/include/unistd.h:11,
    from ../include/global.h:125,
    from mysql_priv.h:15,
from item.cc:19:
/usr/include/sys/unistd.h:184: declaration of C function ‘int pthread_atfork(void (*)(...), void (*)(...), void (*)(...))’ conflicts with
/usr/include/sys/pthread.h:440: previous declaration ‘int pthread_atfork(void (*)(...), void (*)(...), void (*)(...))’ here
In file included from item.h:306, from mysql_priv.h:158, from item.cc:19:

The problem is that HP-UX doesn’t define pthreads_atfork() consistently. It has conflicting prototypes in ‘/usr/include/sys/unistd.h’:184 and ‘/usr/include/sys/pthread.h’:440 (I post the details below).

My solution was to copy ‘/usr/include/sys/unistd.h’ into ‘mysql/include’ and edit ‘unistd.h’ and change it to match the definition in ‘pthread.h’. Here’s the diff:

```diff
183,184c183,184
< extern int pthread_atfork(void (*prepare)(), void (*parent)(),
< void (*child)(),
---
> extern int pthread_atfork(void (*prepare)(void), void (*parent)(void),
> void (*child)(void),
```

4.11.18 MacOS X notes

You can get MySQL to work on MacOS X by following the links to the MacOS X ports. See Section 1.9 [Useful Links], page 11.

MySQL 3.23.7 should include all patches necessary to configure it on MacOSX. You must however first install the pthread package from MySql for MacOSX Server (http://www.prnet.de/RegEx/mysql.html) before configuring MySQL.

You might want to also add aliases to your shell’s resource file to access mysql and mysqladmin from the command line.

```bash
alias mysql '/usr/local/mysql/bin/mysql'
alias mysqladmin '/usr/local/mysql/libexec/mysqladmin'
```

4.12 Win32 notes

This section describes installation and use of MySQL on Win32. This is also described in the ‘README’ file that comes with the MySQL Win32 distribution.

4.12.1 Installing MySQL on Win32

If you don’t have a registered version of MySQL, you should first download the shareware version from:

MySQL 3.22.30 (http://www.mysql.com/mysql_w32.html)
If you plan to connect to MySQL from some other program, you will probably also need the MyODBC driver. You can find this at the MySQL download page (http://www.mysql.com/download.html).

To install either distribution, unzip it in some empty directory and run the Setup.exe program.

By default, MySQL-Win32 is configured to be installed in ‘C:\mysql’. If you want to install MySQL elsewhere, install it in ‘C:\mysql’, then move the installation to where you want it. If you do move MySQL, you must tell mysqld where everything is by supplying options to mysqld. Use C:\mysql\bin\mysqld --help to display all options! For example, if you have moved the MySQL distribution to ‘D:\programs\mysql’, you must start mysqld with:

D:\programs\mysql\bin\mysqld --basedir D:\programs\mysql

With the registered version of MySQL, you can also create a ‘C:\my.cnf’ file that holds any default options for the MySQL server. Copy the file ‘\mysql\my-example.cnf’ to ‘C:\my.cnf’ and edit this to suit your setup. Note that you should specify all paths with / instead of \. If you use \, you need to specify this twice, as \ is the escape character in MySQL. See Section 4.15.4 [Option files], page 89.

4.12.2 Starting MySQL on Win95 / Win98

MySQL uses TCP/IP to connect a client to a server. (This will allow any machine on your network to connect to your MySQL server). Because of this, you must install TCP/IP on your machine before starting MySQL. You can find TCP/IP on your Windows CD-ROM.

Note that if you are using an old Win95 release (for example OSR2), it’s likely that you have an old Winsock package! MySQL requires Winsock 2! You can get the newest Winsock from Microsoft (http://www.microsoft.com). Win98 has as default the new Winsock 2 library, so the above doesn’t apply for Win98.

There are 2 different MySQL servers you can use:

- mysqld Compiled with full debugging and automatic memory allocation checking
- mysqld-opt Optimized for a Pentium processor.

Both of the above should work on any Intel processor >= i386.

To start the mysqld server, you should start a MS-DOS window and type:

C:\mysql\bin\mysqld

This will start mysqld in the background without a window.

You can kill the MySQL server by executing:

C:\mysql\bin\mysqladmin -u root shutdown

Note that Win95/Win98 don’t support creation of named pipes. On Win95/Win98, you can only use named pipes to connect to a remote MySQL running on an NT server.

If mysqld doesn’t start please check whether or not the ‘\mysql\mysql.err’ file contains any reason for this. You can also try to start it with mysqld --standalone: In this case you may get some useful information on the screen that may help solve this.

The last option is to start mysqld with --debug. In this case mysqld will write a log file in ‘\mysqld.trace’ that should contain the reason why mysqld doesn’t start. If you make a bug report about this, please only send the lines where something seams to go wrong to the mailing list!
4.12.3 Starting MySQL on NT

The Win95/Win98 section also applies to MySQL on NT, with the following differences:

To get MySQL to work with TCP/IP, you must install service pack 3 (or newer)!

For NT, the server name is mysqld-nt. Normally you should install MySQL as a service on NT:

\[ \text{C:\mysql\bin\mysqld-nt --install} \]

(You could use the mysqld or mysqld-opt servers on NT, but those cannot be started as a service or use named pipes.)

You can start and stop the MySQL service with:

\[ \text{NET START mysql} \]
\[ \text{NET STOP mysql} \]

Note that in this case you can’t use any other options for mysqld-nt!

You can also run mysqld-nt as a standalone program on NT if you need to start mysqld-nt with any options! If you start mysqld-nt without options on NT, mysqld-nt tries to starts itself as a service with the default service options. If you have stopped mysqld-nt, you have to start it with NET START mysql.

The service is installed with the name MySql. Once installed, it must be started using Services Control Manager (SCM) Utility (found in Control Panel) or by using the NET START MySQL command. If any options are desired, they must be specified as "Startup parameters" in the SCM utility before you start the MySQL service. Once running, mysqld-nt can be stopped using mysqladmin or from the SCM utility or by using the command NET STOP MySQL. If you use SCM to stop mysqld-nt, there is a strange message from SCM about mysqld shutdown normally. When run as a service, mysqld-nt has no access to a console and so no messages can be seen.

On NT you can get the following service error messages:

Permission Denied         Means that it cannot find mysqld-nt.exe
Cannot Register          Means that the path is incorrect

If you have problems installing mysqld-nt as a service, try starting it with the full path:

\[ \text{C:\mysql\bin\mysqld-nt --install} \]

If this doesn’t work, you can get mysqld-nt to start properly by fixing the path in the registry!

If you don’t want to start mysqld-nt as a service, you can start it as follows:

\[ \text{C:\mysql\bin\mysqld-nt --standalone} \]

or

\[ \text{C:\mysql\bin\mysqld --standalone --debug} \]

The last version gives you a debug trace in ‘C:\mysqld.trace’.

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4.12.4 Running MySQL on Win32

MySQL supports TCP/IP on all Win32 platforms and named pipes on NT. The default is to use named pipes for local connections on NT and TCP/IP for all other cases if the client has TCP/IP installed. The host name specifies which protocol is used:

<table>
<thead>
<tr>
<th>Host name</th>
<th>protocol</th>
</tr>
</thead>
<tbody>
<tr>
<td>NULL (none)</td>
<td>On NT, try named pipes first; if that doesn’t work, use TCP/IP. On Win95/Win98, TCP/IP is used.</td>
</tr>
<tr>
<td>localhost</td>
<td>TCP/IP to current host</td>
</tr>
<tr>
<td>hostname</td>
<td>TCP/IP</td>
</tr>
</tbody>
</table>

You can force a MySQL client to use named pipes by specifying the --pipe option. Use the --socket option to specify the name of the pipe.

You can test whether or not MySQL is working by executing the following commands:

C:\mysql\bin\mysqlshow
C:\mysql\bin\mysqlshow -u root mysql
C:\mysql\bin\mysqladmin version status proc
C:\mysql\bin\mysql test

If mysqld is slow to answer to connections on Win95/Win98, there is probably a problem with your DNS. In this case, start mysqld with --skip-name-resolve and use only localhost and IP numbers in the MySQL grant tables. You can also avoid DNS when connecting to a mysqld-nt MySQL server running on NT by using the --pipe argument to specify use of named pipes. This works for most MySQL clients.

There are two versions of the MySQL command line tool:

mysql  Compiled on native Win32, which offers very limited text editing capabilities.
mysqlc Compiled with the Cygnus GNU compiler and libraries, which offers readline editing.

If you want to use mysqlc.exe, you must copy `C:\mysql\lib\cygwinb19.dll` to `\windows\system` (or similar place).

The default privileges on Win32 give all local users full privileges to all databases. To make MySQL more secure, you should set a password for all users and remove the row in the mysql.user table that has Host='localhost' and User=''.

You should also add a password for the root user: (The following example starts by removing the anonymous user, that allows anyone to access the 'test' database)

C:\mysql\bin\mysql mysql
mysql> DELETE FROM user WHERE Host='localhost' AND User='';
mysql> QUIT
C:\mysql\bin\mysqladmin reload
C:\mysql\bin\mysqladmin -u root password your_password

After you’ve set the password, if you want to take down the mysqld server, you can do so using this command:
If you are using the old shareware version of MySQL 3.21 under Windows, the above command will fail with an error: *parse error near 'SET OPTION password'*. This is because the old shareware version, which is based on MySQL 3.21, doesn’t have the *SET PASSWORD* command. The fix is in this case is to upgrade to the 3.22 shareware version.

With the registered MySQL version you can easily add new users and change privileges with *GRANT* and *REVOKE* commands. See Section 7.26 [GRANT], page 224. With the Windows shareware version one has to use *INSERT*, *UPDATE* and *DELETE* one the tables in the *mysql* database to manage users and their privileges. See Section 6.15 [Access denied], page 126.

4.12.5 Connecting to a remote MySQL from Win32 with SSH

Here is a note about how to connect to get a secure connection to remote MySQL server with SSH (by David Carlson).

- Install SSH client on your windows machine - I used a free SSH client from http://www.doc.ic.ac.uk/~ci2/ssh/.
- Start SSH. Set Host Name = yourmysqlserver name or IP address. Set userid=your userid to login to your server
- Click on "local forwards". Set local port: 3306, host: localhost, remote port: 3306
- Save everything, otherwise you’ll have to redo it the next time.
- Log in to your server with SSH.
- Start some ODBC application (for example Access)
- Create a new file and link to mysql using the ODBC driver the same way you normally do except for server, user "localhost".

That’s it. It works very well with a direct Internet connection. I’m having problems with SSH conflicting with my Win95 network and Wingate - but that’ll be the topic of a posting on another software company’s usegroup!

4.12.6 MySQL-Win32 compared to Unix MySQL

MySQL-Win32 has by now proven itself to be very stable. This version of MySQL has the same features as the corresponding Unix version with the following exceptions:

**Win95 and threads**

Win95 leaks about 200 bytes of main memory for each thread creation. Because of this, you shouldn’t run *mysqld* for an extended time on Win95 if you do many connections, since each connection in MySQL creates a new thread! WinNT and Win98 don’t suffer from this bug.

**Blocking read**

MySQL uses a blocking read for each connection. This means that:
• A connection will not be disconnected automatically after 8 hours, as happens with the Unix version of MySQL.
• If a connection “hangs,” it’s impossible to break it without killing MySQL.
• mysqladmin kill will not work on a sleeping connection.
• mysqladmin shutdown can’t abort as long as there are sleeping connections.

We plan to fix this in the near future.

UDF functions
For the moment, MySQL-Win32 does not support user definable functions.

DROP DATABASE
You can’t drop a database that is in use by some thread.

Killing MySQL from the task manager
You can’t kill MySQL from the task manager or with the shutdown utility in Windows95. You must take it down with mysqladmin shutdown.

Case-insensitive names
Filenames are case insensitive on Win32, so database and table names are also case insensitive in MySQL for Win32. The only restriction is that database and table names must be given in the same case throughout a given statement. The following query would not work because it refers to a table both as my_table and as MY_TABLE:

```
SELECT * FROM my_table WHERE MY_TABLE.col=1;
```

The ‘\’ directory character
Pathname components in Win95 are separated by ‘\’ characters, which is also the escape character in MySQL. If you are using LOAD DATA INFILE or SELECT ... INTO OUTFILE, you must double the ‘\’ character or use Unix style filenames ‘/’ characters:

```
LOAD DATA INFILE "C:\tmp\skr.txt" INTO TABLE skr;
SELECT * FROM skr INTO OUTFILE 'C:/tmp/skr.txt';
```

Can’t open named pipe error
If you use the shareware version of MySQL-Win32 on NT with the newest mysql-clients you will get the following error:

```
error 2017: can’t open named pipe to host: . pipe...
```

This is because the release version of MySQL uses named pipes on NT by default. You can avoid this error by using the --host=localhost option to the new MySQL clients or create a file ‘C:\my.cnf’ that contains the following information:

```
[client]
host = localhost
```

Access denied for user error
If you get the error Access denied for user: ’some-user@unknown’ to database ‘mysql’ when accessing a MySQL server on the same machine, this means that MySQL can’t resolve your host name properly.
To fix this, you should create a file `\windows\hosts` with the following information:

127.0.0.1 localhost

Here are some open issues for anyone who might want to help us with the Win32 release:

- Make a single user MySQL.DLL server. This should include everything in a standard MySQL server, except thread creation. This will make MySQL much easier to use in applications that don’t need a true client/server and don’t need to access the server from other hosts.

- Add some nice “start” and “shutdown” icons to the MySQL installation.

- Create a tool to manage registry entries for the MySQL startup options. The registry entry reading is already coded into mysqld.cc, but it should be recoded to be more “parameter” oriented. The tool should also be able to update the ‘\my.cnf’ file if the user would prefer to use this instead of the registry.

- When registering mysqld as a service with --install (on NT) it would be nice if you could also add default options on the command line. For the moment, the workaround is to update the ‘C:\my.cnf’ file instead.

- When you suspend a laptop running Win95, the mysqld daemon doesn’t accept new connections when the laptop is resumed. We don’t know if this is a problem with Win95, TCP/IP or MySQL.

- It would be real nice to be able to kill mysqld from the task manager. For the moment, you must use mysqladmin shutdown.

- Port readline to Win32 for use in the mysql command line tool.

- GUI versions of the standard MySQL clients (mysql, mysqlshow, mysqladmin, and mysqldump) would be nice.

- It would be nice if the socket “read” and “write” functions in ‘net.c’ were interruptible. This would make it possible to kill open threads with mysqladmin kill on Win32.

- Documentation of which Windows programs work with MySQL-Win32/MyODBC and what must be done to get them working.

- mysqld always starts in the "C" locale and not in the default locale. We would like to have mysqld use the current locale for the sort order.

- Port sqlclient to Win32 (almost done) and add more features to it!

- Add more options to MysqlManager.

- Change the communication protocol between the server and client to use Windows internal communication instead of sockets and TCP/IP.

- Implement UDF functions with .DLLs.

- Add macros to use the faster thread-safe increment/decrement methods provided by Win32.

Other Win32-specific issues are described in the ‘README’ file that comes with the MySQL-Win32 distribution.
4.13 OS/2 notes

MySQL uses quite a few open files. Because of this, you should add something like the following to your ‘CONFIG.SYS’ file:

```
SET EMXOPT=-c -n -h1024
```

If you don’t do this, you will probably run into the following error:

```
File 'xxxx' not found (Errcode: 24)
```

When using MySQL with OS/2 Warp 3, FixPack 29 or above is required. With OS/2 Warp 4, FixPack 4 or above is required. This is a requirement of the Pthreads library. MySQL must be installed in a partition that supports long file names such as HPFS, FAT32, etc.

The ‘INSTALL.CMD’ script must be run from OS/2’s own ‘CMD.EXE’ and may not work with replacement shells such as ‘4OS2.EXE’.

The ‘scripts/mysql-install-db’ script has been renamed: it is now called ‘install.cmd’ and is a REXX script which will set up the default MySQL security settings and create the WorkPlace Shell icons for MySQL.

dynamic module support is compiled in but not fully tested. Dynamic modules should be compiled using the Pthreads runtime library.

```
gcc -Zdll -Zmt -Zcrtdll=pthrdrtl -I../include -I../regex -I.. \-o example udf_example.cc -L../lib -lmysqlclient udf_example.def
mv example.dll example.udf
```

Note: Due to limitations in OS/2, UDF module name stems must not exceed 8 characters. Modules are stored in the ‘/mysql2/udf’ directory; the safe-mysqld.cmd script will put this directory in the `BEGINLIBPATH` environment variable. When using UDF modules, specified extensions are ignored — it is assumed to be ‘.udf’. For example, in Unix, the shared module might be named ‘example.so’ and you would load a function from it like this:

```
CREATE FUNCTION metaphon RETURNS STRING SONAME "example.so";
```

In OS/2, the module would be named ‘example.udf’, but you would not specify the module extension:

```
CREATE FUNCTION metaphon RETURNS STRING SONAME "example";
```

4.14 TcX binaries

As a service, TcX provides a set of binary distributions of MySQL that are compiled at TcX or at sites where customers kindly have given us access to their machines.

These distributions are generated with scripts/make_binary_distribution and are configured with the following compilers and options:

```
SunOS 4.1.4 2 sun4c with gcc 2.7.2.1
    CC=gcc CXX=gcc CXXFLAGS=-O3 ./configure --prefix=/usr/local/mysql -
    -disable-shared
```

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SunOS 5.5.1 sun4u with egcs 1.0.3a
   CC=gcc CFLAGS="-O6 -fomit-frame-pointer" CXX=gcc CXXFLAGS="-O6 -fomit-frame-pointer -felide-constructors -fno-exceptions -fno-rtti" ./configure --prefix=/usr/local/mysql --with-low-memory

SunOS 5.6 sun4u with egcs 2.90.27
   CC=gcc CFLAGS="-O6 -fomit-frame-pointer" CXX=gcc CXXFLAGS="-O6 -fomit-frame-pointer -felide-constructors -fno-exceptions -fno-rtti" ./configure --prefix=/usr/local/mysql --with-low-memory

SunOS 5.6 i86pc with gcc 2.8.1
   CC=gcc CXX=gcc CXXFLAGS=-O3 ./configure --prefix=/usr/local/mysql --with-low-memory

Linux 2.0.33 i386 with pgcc 2.90.29 (egcs 1.0.3a)

SCO 3.2v5.0.4 i386 with gcc 2.7-95q4
   CC=gcc CXX=gcc CXXFLAGS=-O3 ./configure --prefix=/usr/local/mysql

AIX 2.4 with gcc 2.7.2.2
   CC=gcc CXX=gcc CXXFLAGS=-O3 ./configure --prefix=/usr/local/mysql

OSF1 V4.0 564 alpha with gcc 2.8.1
   CC=gcc CFLAGS=-O CXX=gcc CXXFLAGS=-O3 ./configure --prefix=/usr/local/mysql --with-low-memory

Irix 6.3 IP32 with gcc 2.8.0
   CC=gcc CXX=gcc CXXFLAGS=-O3 ./configure --prefix=/usr/local/mysql

BSDI BSD/OS 3.1 i386 with gcc 2.7.2.1
   CC=gcc CXX=gcc CXXFLAGS=-O ./configure --prefix=/usr/local/mysql

BSDI BSD/OS 2.1 i386 with gcc 2.7.2
   CC=gcc CXX=gcc CXXFLAGS=-O3 ./configure --prefix=/usr/local/mysql

Anyone who has more optimal options for any of the configurations listed above can always mail them to the developer’s mailing list at developer@lists.mysql.com.

RPM distributions prior to MySQL 3.22 are user-contributed. Beginning with 3.22, some RPMs are TeX-generated.

### 4.15 Post-installation setup and testing

Once you’ve installed MySQL (from either a binary or source distribution), you need to initialize the grant tables, start the server and make sure that the server works okay. You may also wish to arrange for the server to be started and stopped automatically when your system starts up and shuts down.
Normally you install the grant tables and start the server like this for installation from a source distribution:

```
shell> ./scripts/mysql_install_db
shell> cd mysql_installation_directory
shell> ./bin/safe_mysqld &
```

For a binary distribution, do this:

```
shell> cd mysql_installation_directory
shell> ./bin/mysql_install_db
shell> ./bin/safe_mysqld &
```

Testing is most easily done from the top-level directory of the MySQL distribution. For a binary distribution, this is your installation directory (typically something like `/usr/local/mysql`). For a source distribution, this is the main directory of your MySQL source tree.

In the commands shown below in this section and in the following subsections, **BINDIR** is the path to the location in which programs like `mysqladmin` and `safe_mysqld` are installed. For a binary distribution, this is the `bin` directory within the distribution. For a source distribution, **BINDIR** is probably `/usr/local/bin`, unless you specified an installation directory other than `/usr/local` when you ran configure. **EXECDIR** is the location in which the mysqld server is installed. For a binary distribution, this is the same as **BINDIR**. For a source distribution, **EXECDIR** is probably `/usr/local/libexec`.

Testing is described in detail below:

1. If necessary, start the mysqld server and set up the initial MySQL grant tables containing the privileges that determine how users are allowed to connect to the server. This is normally done with the `mysql_install_db` script:

   ```
   shell> scripts/mysql_install_db
   ```

   Typically, `mysql_install_db` needs to be run only the first time you install MySQL. Therefore, if you are upgrading an existing installation, you can skip this step. (However, `mysql_install_db` is quite safe to use and will not update any tables that already exist, so if you are unsure what to do, you can always run `mysql_install_db`.)

   `mysql_install_db` creates six tables (`user`, `db`, `host`, `tables_priv`, `columns_priv` and `func`) in the `mysql` database. A description of the initial privileges is given in [Section 6.12 Default privileges], page 122. Briefly, these privileges allow the MySQL root user to do anything, and allow anybody to create or use databases with a name of ‘test’ or starting with ‘test_’.

   If you don’t set up the grant tables, the following error will appear in the log file when you start the server:

   ```
   mysqld: Can’t find file: ‘host.frm’
   ```

   The above may also happens with a binary MySQL distribution if you don’t start MySQL by executing exactly `./bin/safe_mysqld`!

   You might need to run `mysql_install_db` as root. However, if you prefer, you can run the MySQL server as an unprivileged (non-root) user, provided that user can read and write files in the database directory. Instructions for running MySQL as an unprivileged user are given in [Changing MySQL user], page (undefined).
If you have problems with `mysql_install_db`, see Section 4.15.1 [mysql_install_db], page 85.

There are some alternatives to running the `mysql_install_db` script as it is provided in the MySQL distribution:

- You may want to edit `mysql_install_db` before running it, to change the initial privileges that are installed into the grant tables. This is useful if you want to install MySQL on a lot of machines with the same privileges. In this case you probably should need only to add a few extra `INSERT` statements to the `mysql.user` and `mysql.db` tables!

- If you want to change things in the grant tables after installing them, you can run `mysql_install_db`, then use `mysql -u root mysql` to connect to the grant tables as the MySQL root user and issue SQL statements to modify the grant tables directly.

- It is possible to recreate the grant tables completely after they have already been created. You might want to do this if you’ve already installed the tables but then want to recreate them after editing `mysql_install_db`.

For more information about these alternatives, see Section 6.12 [Default privileges], page 122.

2. Start the MySQL server like this:
   ```
   shell> cd mysql_installation_directory
   shell> bin/safe_mysqld &
   ```
   If you have problems starting the server, see Section 4.15.2 [Starting server], page 86.

3. Use `mysqladmin` to verify that the server is running. The following commands provide a simple test to check that the server is up and responding to connections:
   ```
   shell> BINDIR/mysqladmin version
   shell> BINDIR/mysqladmin variables
   ```
   The output from `mysqladmin version` varies slightly depending on your platform and version of MySQL, but should be similar to that shown below:
   ```
   shell> BINDIR/mysqladmin version
   mysqladmin Ver 6.3 Distrib 3.22.9-beta, for pc-linux-gnu on i686
   TCX Datakonsult AB, by Monty
   Server version        3.22.9-beta
   Protocol version      10
   Connection            Localhost via UNIX socket
   TCP port              3306
   UNIX socket           /tmp/mysql.sock
   Uptime:               16 sec
   ```
   Running threads: 1  Questions: 20  Reloads: 2  Open tables: 3
   To get a feeling for what else you can do with `BINDIR/mysqladmin`, invoke it with the `--help` option.

4. Verify that you can shut down the server:
shell> BINDIR/mysqladmin -u root shutdown

5. Verify that you can restart the server. Do this using safe_mysqld or by invoking mysqld directly. For example:

    shell> BINDIR/safe_mysqld --log &

If safe_mysqld fails, try running it from the MySQL installation directory (if you are not already there). If that doesn’t work, see Section 4.15.2 [Starting server], page 86.

6. Run some simple tests to verify that the server is working. The output should be similar to what is shown below:

    shell> BINDIR/mysqlshow
    +-----------+
    | Databases |
    +-----------+
    | mysql     |
    +-----------+

    shell> BINDIR/mysqlshow mysql
    Database: mysql
    +-----------+
    | Tables    |
    +-----------+
    | columns_priv |
    | db         |
    | func       |
    | host       |
    | tables_priv |
    | user       |
    +-----------+

    shell> BINDIR/mysql -e "select host,db,user from db" mysql
    +-----------+----------+----------+
    | host      | db       | user     |
    +-----------+----------+----------+
    | %          | test     |          |
    | %          | test_%   |          |
    +-----------+----------+----------+

There is also a benchmark suite in the ‘sql-bench’ directory (under the MySQL installation directory) that you can use to compare how MySQL performs on different platforms. The ‘sql-bench/Results’ directory contains the results from many runs against different databases and platforms. To run all tests, execute these commands:

    shell> cd sql-bench
    shell> run-all-tests

If you don’t have the ‘sql-bench’ directory, you are probably using an RPM for a binary distribution. (Source distribution RPMs include the benchmark directory.) In this case, you must first install the benchmark suite before you can use it. Beginning with MySQL 3.22, there are benchmark RPM files named ‘mysql-bench-VERSION-i386.rpm’ that contain benchmark code and data.

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If you have a source distribution, you can also run the tests in the `tests` subdirectory. For example, to run `auto_increment.tst`, do this:

```bash
shell> BINDIR/mysql -vvf test < ./tests/auto_increment.tst
```
The expected results are shown in the `./tests/auto_increment.res` file.

### 4.15.1 Problems running `mysql_install_db`

This section lists problems you might encounter when you run `mysql_install_db`:

**mysql_install_db doesn’t install the grant tables**

You may find that `mysql_install_db` fails to install the grant tables and terminates after displaying the following messages:

```
starting mysqld daemon with databases from XXXXXX
mysqld daemon ended
```

In this case, you should examine the log file very carefully! The log should be located in the directory `XXXXXX` named by the error message, and should indicate why `mysqld` didn’t start. If you don’t understand what happened, include the log when you post a bug report using `mysqlbug`! See Section 2.3 [Bug reports], page 19.

**There is already a mysqld daemon running**

In this case, you have probably don’t have to run `mysql_install_db` at all. You have to run `mysql_install_db` only once, when you install MySQL the first time.

**Installing a second mysqld daemon doesn’t work when one daemon is running**

This can happen when you already have an existing MySQL installation, but want to put a new installation in a different place (e.g., for testing, or perhaps you simply want to run two installations at the same time). Generally the problem that occurs when you try to run the second server is that it tries to use the same socket and port as the old one. In this case you will get the error message: *Can’t start server: Bind on TCP/IP port: Address already in use* or *Can’t start server: Bind on unix socket...* You can start the new server with a different socket and port as follows:

```
shell> MYSQL_UNIX_PORT=/tmp/mysqld-new.sock
shell> MYSQL_TCP_PORT=3307
shell> export MYSQL_UNIX_PORT MYSQL_TCP_PORT
shell> scripts/mysql_install_db
shell> bin/safe_mysqld &
```

After this, you should edit your server boot script to start both daemons with different sockets and ports. For example, it could invoke `safe_mysqld` twice, but with different `--socket`, `--port` and `--basedir` options for each invocation.
You don’t have write access to ‘/tmp’

If you don’t have write access to create a socket file at the default place (in ‘/tmp’) or permission to create temporary files in ‘/tmp,’ you will get an error when running `mysql_install_db` or when starting or using `mysqld`.

You can specify a different socket and temporary directory as follows:

```
shell> TMPDIR=/some_tmp_dir/
shell> MYSQL_UNIX_PORT=/some_tmp_dir/mysqld.sock
shell> export TMPDIR MYSQL_UNIX_PORT
```

‘some_tmp_dir’ should be the path to some directory for which you have write permission.

After this you should be able to run `mysql_install_db` and start the server with these commands:

```
shell> scripts/mysql_install_db
shell> BINDIR/safe_mysqld &
```

`mysqld` crashes immediately

If you are running RedHat 5.0 with a version of glibc older than 2.0.7-5, you should make sure you have installed all glibc patches! There is a lot of information about this in the MySQL mail archives. Links to the mail archives are available at the online MySQL documentation page (http://www.mysql.com/doc.html). Also, see Section 4.11.5 [Linux], page 59.

You can also start `mysqld` manually using the `--skip-grant-tables` option and add the privilege information yourself using `mysql`:

```
shell> BINDIR/safe_mysqld --skip-grant-tables &
shell> BINDIR/mysql -u root mysql
```

From `mysql`, manually execute the SQL commands in `mysql_install_db`. Make sure you run `mysqladmin flush-privileges` or `mysqladmin reload` afterward to tell the server to reload the grant tables.

### 4.15.2 Problems starting the MySQL server

Generally, you start the `mysqld` server in one of three ways:

- By invoking `mysql.server`. This script is used primarily at system startup and shutdown, and is described more fully in Section 4.15.3 [Automatic start], page 88.
- By invoking `safe_mysqld`, which tries to determine the proper options for `mysqld` and then runs it with those options.
- On NT you should install `mysqld` as a service as follows:

```
bin\mysqld-nt --install # Install MySQL as a service
```

You can now start/stop `mysqld` as follows:

```
NET START mysql
NET STOP mysql
```

Note that in this case you can’t use any other options for `mysqld`!

You can remove the service as follows:
By invoking `mysqld` directly.

Whichever method you use to start the server, if it fails to start up correctly, check the log file to see if you can find out why. Log files are located in the data directory (typically ‘/usr/local/mysql/data’ for a binary distribution, ‘/usr/local/var’ for a source distribution), ‘mysql/mysql.err’ on Windows. Look in the data directory for files with names of the form ‘host_name.err’ and ‘host_name.log’ where `host_name` is the name of your server host. Then check the last few lines of these files:

```
shell> tail host_name.err
shell> tail host_name.log
```

When the `mysqld` daemon starts up, it changes directory to the data directory. This is where it expects to write log files and the pid (process ID) file, and where it expects to find databases.

The data directory location is hardwired in when the distribution is compiled. However, if `mysqld` expects to find the data directory somewhere other than where it really is on your system, it will not work properly. If you have problems with incorrect paths, you can find out what options `mysqld` allows and what the default path settings are by invoking `mysqld` with the `--help` option. You can override the defaults by specifying the correct pathnames as command-line arguments to `mysqld`. (These options can be used with `safe_mysqld` as well.)

Normally you should need to tell `mysqld` only the base directory under which MySQL is installed. You can do this with the `--basedir` option. You can also use `--help` to check the effect of changing path options (note that `--help must be the final option of the mysqld command). For example:

```
shell> EXECDIR/mysqld --basedir=/usr/local --help
```

Once you determine the path settings you want, start the server without the `--help` option.

If you get the following error, it means that some other program (or another `mysqld` server) is already using the TCP/IP port or socket `mysqld` is trying to use:

```
Can't start server: Bind on TCP/IP port: Address already in use
or
Can't start server: Bind on unix socket...
```

Use `ps` to make sure that you don’t have another `mysqld` server running. If you can’t find another server running, you can try to execute the command `telnet your-host-name tcp-ip-port-number` and press RETURN a couple of times. If you don’t get a error message like `telnet: Unable to connect to remote host: Connection refused`, something is using the TCP/IP port `mysqld` is trying to use. See Section 4.15.1 [mysql_install_db], page 85, and Section 20.3 [Multiple servers], page 369.

The `safe_mysqld` script is written so that it normally is able to start a server that was installed from either a source or a binary version of MySQL, even if these install the server in slightly different locations. `safe_mysqld` expects one of these conditions to be true:

- The server and databases can be found relative to the directory from which `safe_mysqld` is invoked. `safe_mysqld` looks under its working directory for ‘bin’ and ‘data’ directories (for binary distributions) or for ‘libexec’ and ‘var’ directories (for source
distributions). This condition should be met if you execute `safe_mysqld` from your MySQL installation directory (for example, `/usr/local/mysql` for a binary distribution).

- If the server and databases cannot be found relative to its working directory, `safe_mysqld` attempts to locate them by absolute pathnames. Typical locations are `/usr/local/libexec` and `/usr/local/var`. The actual locations are determined when the distribution was built from which `safe_mysqld` comes. They should be correct if MySQL was installed in a standard location.

Since `safe_mysqld` will try to find the server and databases relative to its own working directory, you can install a binary distribution of MySQL anywhere, as long as you start `safe_mysqld` from the MySQL installation directory:

```
shell> cd mysql_installation_directory
shell> bin/safe_mysqld &
```

If `safe_mysqld` fails, even when invoked from the MySQL installation directory, you can modify it to use the path to `mysqld` and the pathname options that are correct for your system. Note that if you upgrade MySQL in the future, your modified version of `safe_mysqld` will be overwritten, so you should make a copy of your edited version that you can reinstall.

If `mysqld` is currently running, you can find out what path settings it is using by executing this command:

```
shell> mysqladmin variables
```

or

```
shell> mysqladmin -h 'your-host-name' variables
```

If `safe_mysqld` starts the server but you can’t connect to it, you should make sure you have an entry in `/etc/hosts` that looks like this:

```
127.0.0.1 localhost
```

This problem occurs only on systems that don’t have a working thread library and for which MySQL must be configured to use MIT-pthreads.

On Windows, you can try to start `mysqld` as follows:

```
C:\mysql\bin\mysqld --standalone --debug
```

This will not run in the background and it should also write a trace in `\mysqld.trace`, which may help you determine the source of your problems. See Section 4.12 [Win32], page 73.

### 4.15.3 Starting and stopping MySQL automatically

The `mysql.server` script can be used to start or stop the server, by invoking it with start or stop arguments:

```
shell> mysql.server start
shell> mysql.server stop
```
mysql.server can be found in the ‘share/mysql’ directory under the MySQL installation directory, or in the ‘support-files’ directory of the MySQL source tree.

Before mysql.server starts the server, it changes directory to the MySQL installation directory, then invokes safe_mysqld. You might need to edit mysql.server if you have a binary distribution that you’ve installed in a non-standard location. Modify it to cd into the proper directory before it runs safe_mysqld. If you want the server to run as some specific user, you can change the mysql_daemon_user=root line to use another user. You can also modify mysql.server to pass other options to safe_mysqld.

mysql.server stop brings down server by sending a signal to it. You can take down the server manually by executing mysqladmin shutdown.

You might want to add these start and stop commands to the appropriate places in your ‘/etc/rc*’ files when you start using MySQL for production applications. Note that if you modify mysql.server, then if you upgrade MySQL sometime, your modified version will be overwritten, so you should make a copy of your edited version that you can reinstall.

If your system uses ‘/etc/rc.local’ to start external scripts, you should append the following to it:

```
/bin/sh -c 'cd /usr/local/mysql ; ./bin/safe_mysqld &'
```

You can also add options for mysql.server in a global ‘/etc/my.cnf’ file. A typical ‘/etc/my.cnf’ file might look like this:

```
[mysqld]
  datadir=/usr/local/mysql/var
  socket=/tmp/mysqld.sock
  port=3306

[mysql.server]
  user=mysql
  basedir=/usr/local/mysql
```

The mysql.server script uses the following variables: user, datadir, basedir, bindir and pid-file.

See Section 4.15.4 [Option files], page 89.

### 4.15.4 Option files

MySQL 3.22 can read default startup options for the server and for clients from option files. MySQL reads default options from the following files on Unix:

<table>
<thead>
<tr>
<th>Filename</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>/etc/my.cnf</td>
<td>Global options</td>
</tr>
<tr>
<td>DATADIR/my.cnf</td>
<td>Server-specific options</td>
</tr>
<tr>
<td>~/.my.cnf</td>
<td>User-specific options</td>
</tr>
</tbody>
</table>

DATADIR is the MySQL data directory (typically ‘/usr/local/mysql/data’ for a binary installation, or ‘/usr/local/var’ for a source installation). Note that this is the directory that was specified at configuration time, not the one specified with --datadir when mysqld
starts up! (--datadir has no effect on where the server looks for option files, because it looks for them before it processes any command-line arguments.)

MySQL reads default options from the following files on Win32:

<table>
<thead>
<tr>
<th>Filename</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>windows-system-directory\my.ini</td>
<td>Global options</td>
</tr>
<tr>
<td>C:\my.cnf</td>
<td>Server-specific options</td>
</tr>
<tr>
<td>C:\mysql\data\my.cnf</td>
<td></td>
</tr>
</tbody>
</table>

Note that you on Win32 should specify all paths with / instead of \. If you use \, you need to specify this twice, as \ is the escape character in MySQL.

MySQL tries to read option files in the order listed above. If multiple option files exist, an option specified in a file read later takes precedence over the same option specified in a file read earlier. Options specified on the command line take precedence over options specified in any option file. Some options can be specified using environment variables. Options specified on the command line or in option files take precedence over environment variable values.

The following programs support option files: mysql, mysqladmin, mysqld, mysqldump, mysqlimport, mysql.server, myisamchk and myisampack.

You can use option files to specify any long option that a program supports! Run the program with --help to get a list of available options.

An option file can contain lines of the following forms:

- **#comment** Comment lines start with ‘#’ or ‘;’. Empty lines are ignored.
- **[group]** group is the name of the program or group for which you want to set options. After a group line, any option or set-variable lines apply to the named group until the end of the option file or another group line is given.
- **option** This is equivalent to --option on the command line.
- **option=value** This is equivalent to --option=value on the command line.
- **set-variable = variable=value** This is equivalent to --set-variable variable=value on the command line. This syntax must be used to set a mysqld variable.

The client group allows you to specify options that apply to all MySQL clients (not mysqld). This is the perfect group to use to specify the password you use to connect to the server. (But make sure the option file is readable and writable only to yourself.)

Note that for options and values, all leading and trailing blanks are automatically deleted. You may use the escape sequences \b, \t, \n, \r, \ and \s in your value string (\s == blank).

Here is a typical global option file:

```plaintext
[client]
port=3306
socket=/tmp/mysql.sock
```

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[mysqld]
port=3306
socket=/tmp/mysql.sock
set-variable = key_buffer=16M
set-variable = max_allowed_packet=1M

[mysqldump]
quick

Here is typical user option file:

[client]
# The following password will be sent to all standard MySQL clients
password=my_password

[mysql]
no-auto-rehash

If you have a source distribution, you will find a sample configuration file named ‘my-example.cnf’ in the ‘support-files’ directory. If you have a binary distribution, look in the ‘DIR/share/mysql’ directory, where DIR is the pathname to the MySQL installation directory (typically ‘/usr/local/mysql’). You can copy ‘my-example.cnf’ to your home directory (rename the copy to ‘.my.cnf’) to experiment with.

To tell a MySQL program not to read any option files, specify --no-defaults as the first option on the command line. This MUST be the first option or it will have no effect! If you want to check which options are used, you can give the option --print-defaults as the first option.

If you want to force the use of a specific config file, you can use the option --defaults-file=full-path-to-default-file. If you do this, only the specified file will be read.

Note for developers: Option file handling is implemented simply by processing all matching options (i.e., options in the appropriate group) before any command line arguments. This works nicely for programs that use the last instance of an option that is specified multiple times. If you have an old program that handles multiply-specified options this way but doesn’t read option files, you need add only two lines to give it that capability. Check the source code of any of the standard MySQL clients to see how to do this.

4.16 Is there anything special to do when upgrading/downgrading MySQL?

You can always move the MySQL form and data files between different versions on the same architecture as long as you have the same base version of MySQL. The current base version is 3. If you change the character set by recompiling MySQL (which may also change the sort order), you must run myisamchk -r -q on all tables. Otherwise your indexes may not be ordered correctly.
If you are paranoid and/or afraid of new versions, you can always rename your old `mysqld` to something like `mysqld-old-version-number`. If your new `mysqld` then does something unexpected, you can simply shut it down and restart with your old `mysqld`!

When you do an upgrade you should also backup your old databases, of course. Sometimes it’s good to be a little paranoid!

After an upgrade, if you experience problems with recompiled client programs, like `Commands out of sync` or unexpected core dumps, you probably have used an old header or library file when compiling your programs. In this case you should check the date for your `mysqld.h` file and `libmysqlclient.a` library to verify that they are from the new MySQL distribution. If not, please recompile your programs!

If you get some problems that the new `mysqld` server doesn’t want to start or that you can’t connect without a password, check that you don’t have some old `my.cnf` file from your old installation! You can check this with: `program-name --print-defaults`. If this outputs anything other than the program name, you have a active `my.cnf` file that will may affect things!

It is a good idea to rebuild and reinstall the `Msql-Mysql-modules` distribution whenever you install a new release of MySQL, particularly if you notice symptoms such as all your DBI scripts dumping core after you upgrade MySQL.

### 4.16.1 Upgrading from a 3.22 version to 3.23

MySQL 3.23 supports tables of the new MyISAM type and the old ISAM type. You don’t have to convert your old tables to use these with 3.23. By default, all new tables will be created with type MyISAM (unless you start `mysqld` with the `--default-table-type=isam` option. You can change an ISAM table to a MyISAM table with `ALTER TABLE` or the Perl script `mysql_convert_table_format`.

3.22 and 3.21 clients will work without any problems with a 3.23 server.

The following lists what you have to watch out for when upgrading to 3.23:

- **INNER** and **DELAYED** are now reserved words.
- **FLOAT(X)** is now a true floating point types.
- When declaring `DECIMAL(length,dec)` the length argument no longer includes a place for the sign or the decimal point.
- A **TIME** string must now be of one of the following formats: `[[[DAYS] [H]:]MM:]SS[.fraction]` or `[[[[[H]H][H]H][H][H]]MM]SS[.fraction]`
- **LIKE** now compares strings using the same character comparison rules as ‘='. If you require the old behavior, you can compile MySQL with the `CXXFLAGS=-DLIKE_CMP_TOUNPPER` flag.
- **REGEXP** is now case insensitive for normal (not binary) strings.
- When you check/repair tables you should use `myisamchk` for MyISAM tables (`.MYI`) and `isamchk` for ISAM (`.ISM`) tables.
- If you want your `mysqldump`s to be compatible between MySQL 3.22 and 3.23, you should not use the `--opt` or `--full` option to `mysqldump`.
• Check all your calls to `DATE_FORMAT()` to make sure there is a ‘%’ before each format character.
• `mysql_fetch_fields_direct` is now a function (it was a macro) and it returns a pointer to a `MYSQL_FIELD` instead of a `MYSQL_FIELD`.
• `mysql_num_fields()` can no longer be used on a `MYSQL` object (it’s now a function that takes `MYSQL_RES` as an argument. You should now use `mysql_field_count()` instead.
• In MySQL 3.22, the output of `SELECT DISTINCT ...` was almost always sorted. In 3.23, you must use `GROUP BY` or `ORDER BY` to obtain sorted output.
• `SUM()` now returns `NULL`, instead of 0, if there is no matching rows. This is according to ANSI SQL.
• New restricted words: `CASE`, `THEN`, `WHEN`, `ELSE` and `END`.

4.16.2 Upgrading from a 3.21 version to 3.22

Nothing that affects compatibility has changed between 3.21 and 3.22. The only pitfall is that new tables that are created with `DATE` type columns will use the new way to store the date. You can’t access these new fields from an old version of `mysqld`.

After installing MySQL 3.22, you should start the new server and then run the `mysql_fix_privilege_tables` script. This will add the new privileges that you need to use the `GRANT` command. If you forget this, you will get `Access denied` when you try to use `ALTER TABLE`, `CREATE INDEX` or `DROP INDEX`. If your MySQL root user requires a password, you should give this as an argument to `mysql_fix_privilege_tables`.

The C API interface to `mysql_real_connect()` has changed. If you have an old client program that calls this function, you must place a 0 for the new `db` argument (or recode the client to send the `db` element for faster connections). You must also call `mysql_init()` before calling `mysql_real_connect()`! This change was done to allow the new `mysql_options()` function to save options in the `MYSQL` handler structure.

4.16.3 Upgrading from a 3.20 version to 3.21

If you are running a version older than 3.20.28 and want to switch to 3.21.x, you need to do the following:

You can start the `mysqld` 3.21 server with `safe_mysqld --old-protocol` to use it with clients from the 3.20 distribution. In this case, the new client function `mysql_errno()` will not return any server error, only `CR_UNKNOWN_ERROR`, (but it works for client errors) and the server uses the old password() checking rather than the new one.

If you are NOT using the `--old-protocol` option to `mysqld`, you will need to make the following changes:

• All client code must be recompiled. If you are using ODBC, you must get the new `MyODBC` 2.x driver.
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- The script `scripts/add_long_password` must be run to convert the `Password` field in the `mysql.user` table to `CHAR(16)`.
- All passwords must be reassigned in the `mysql.user` table (to get 62-bit rather than 31-bit passwords).
- The table format hasn’t changed, so you don’t have to convert any tables.

MySQL 3.20.28 and above can handle the new `user` table format without affecting clients. If you have a MySQL version earlier than 3.20.28, passwords will no longer work with it if you convert the `user` table. So to be safe, you should first upgrade to at least 3.20.28 and then upgrade to 3.21.x.

The new client code works with a 3.20.x `mysqld` server, so if you experience problems with 3.21.x, you can use the old 3.20.x server without having to recompile the clients again.

If you are not using the `--old-protocol` option to `mysqld`, old clients will issue the error message:

```
```

The new Perl DBI/DBD interface also supports the old `mysqlperl` interface. The only change you have to make if you use `mysqlperl` is to change the arguments to the `connect()` function. The new arguments are: `host, database, user, password` (the `user` and `password` arguments have changed places). See Section 21.5.2 [Perl DBI Class], page 417.

The following changes may affect queries in old applications:

- `HAVING` must now be specified before any `ORDER BY` clause.
- The parameters to `LOCATE()` have been swapped.
- There are some new reserved words. The most notable are `DATE`, `TIME` and `TIMESTAMP`.

### 4.16.4 Upgrading to another architecture

If you are using MySQL 3.23, you can copy the `.frm`, the `.MYI` and the `.MYD` files between different architectures that support the same floating point format. (MySQL takes care of any byte swapping issues).

The MySQL ISAM data `*.ISD` and the index files `*.ISM` files) are architecture-dependent and in some case OS-dependent. If you want to move your applications to another machine that has a different architecture or OS than your current machine, you should not try to move a database by simply copying the files to the other machine. Use `mysqldump` instead.

By default, `mysqldump` will create a file full of SQL statements. You can then transfer the file to the other machine and feed it as input to the `mysql` client.

Try `mysqldump --help` to see what options are available. If you are moving the data to a newer version of MySQL, you should use `mysqldump --opt` with the newer version to get a fast, compact dump.

The easiest (although not the fastest) way to move a database between two machines is to run the following commands on the machine on which the database is located:

```bash
shell> mysqladmin -h 'other hostname' create db_name
shell> mysqldump --opt db_name \
```

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| mysql -h 'other hostname' db_name
If you want to copy a database from a remote machine over a slow network, you can use:

```
shell> mysqladmin create db_name
shell> mysqldump -h 'other hostname' --opt --compress db_name |
    mysql db_name
```

You can also store the result in a file, then transfer the file to the target machine and load the file into the database there. For example, you can dump a database to a file on the source machine like this:

```
shell> mysqldump --quick db_name | gzip > db_name.contents.gz
```

(The file created in this example is compressed.) Transfer the file containing the database contents to the target machine and run these commands there:

```
shell> mysqladmin create db_name
shell> gunzip < db_name.contents.gz | mysql db_name
```

You can also use `mysqldump` and `mysqlimport` to accomplish the database transfer. For big tables, this is much faster than simply using `mysqldump`. In the commands shown below, `DUMPDIR` represents the full pathname of the directory you use to store the output from `mysqldump`.

First, create the directory for the output files and dump the database:

```
shell> mkdir DUMPDIR
shell> mysqldump --tab=DUMPDIR db_name
```

Then transfer the files in the `DUMPDIR` directory to some corresponding directory on the target machine and load the files into MySQL there:

```
shell> mysqladmin create db_name        # create database
shell> cat DUMPDIR/*.sql | mysql db_name  # create tables in database
shell> mysqlimport db_name DUMPDIR/*.txt  # load data into tables
```

Also, don’t forget to copy the `mysql` database, since that’s where the grant tables (`user`, `db`, `host`) are stored. You may have to run commands as the MySQL root user on the new machine until you have the `mysql` database in place.

After you import the `mysql` database on the new machine, execute `mysqladmin flush-privileges` so that the server reloads the grant table information.
5 How standards-compatible is MySQL?

5.1 MySQL extensions to ANSI SQL92

MySQL includes some extensions that you probably will not find in other SQL databases. Be warned that if you use them, your code will not be portable to other SQL servers. In some cases, you can write code that includes MySQL extensions, but is still portable, by using comments of the form /*! ... */. In this case, MySQL will parse and execute the code within the comment as it would any other MySQL statement, but other SQL servers will ignore the extensions. For example:

```sql
SELECT /*! STRAIGHT_JOIN */ col_name FROM table1,table2 WHERE ...
```

If you add a version number after the '!', the syntax will only be executed if the MySQL version is equal or newer than the used version number:

```sql
CREATE /*!32302 TEMPORARY */ TABLE (a int);
```

The above means that if you have 3.23.02 or newer, then MySQL will use the TEMPORARY keyword.

MySQL extensions are listed below:

- The field types MEDIUMINT, SET, ENUM and the different BLOB and TEXT types.
- The field attributes AUTO_INCREMENT, BINARY, UNSIGNED and ZEROFILL.
- All string comparisons are case insensitive by default, with sort ordering determined by the current character set (ISO-8859-1 Latin1 by default). If you don’t like this, you should declare your columns with the BINARY attribute or use the BINARY cast, which causes comparisons to be done according to the ASCII order used on the MySQL server host.
- MySQL maps each database to a directory under the MySQL data directory, and tables within a database to filenames in the database directory. This has two implications:
  - Database names and table names are case sensitive in MySQL on operating systems that have case sensitive filenames (like most Unix systems). If you have a problem remembering table names, adopt a consistent convention, such as always creating databases and tables using lowercase names.
  - Database, table, index, column or alias names may begin with a digit (but may not consist solely of digits).
  - You can use standard system commands to backup, rename, move, delete and copy tables. For example, to rename a table, rename the `.MYD`, `.MYI` and `.frm` files to which the table corresponds.
- In SQL statements, you can access tables from different databases with the `db_name.tbl_name` syntax. Some SQL servers provide the same functionality but call this User space. MySQL doesn’t support tablespaces like in: `create table ralph.my_table...IN my_tablespace`.

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• LIKE is allowed on numeric columns.
• Use of INTO OUTFILE and STRAIGHT_JOIN in a SELECT statement. See Section 7.12 [SELECT], page 196.
• The SQL_SMALL_RESULT option in a SELECT statement.
• EXPLAIN SELECT to get a description on how tables are joined.
• Use of index names, indexes on a prefix of a field, and use of INDEX or KEY in a CREATE TABLE statement. See Section 7.7 [CREATE TABLE], page 187.
• Use of TEMPORARY or IF NOT EXISTS with CREATE TABLE.
• Use of COUNT(DISTINCT list) where 'list' is more than one element.
• Use of CHANGE col_name, DROP col_name or DROP INDEX in an ALTER TABLE statement. See Section 7.8 [ALTER TABLE], page 193.
• Use of IGNORE in an ALTER TABLE statement.
• Use of multiple ADD, ALTER, DROP or CHANGE clauses in an ALTER TABLE statement.
• Use of DROP TABLE with the keywords IF EXISTS.
• You can drop multiple tables with a single DROP TABLE statement.
• The LIMIT clause of the DELETE statement.
• The DELAYED clause of the INSERT and REPLACE statements.
• The LOW_PRIORITY clause of the INSERT, REPLACE, DELETE and UPDATE statements.
• Use of LOAD DATA INFILE. In many cases, this syntax is compatible with Oracle’s LOAD DATA INFILE. See Section 7.16 [LOAD DATA], page 204.
• The OPTIMIZE TABLE statement. See Section 7.9 [OPTIMIZE TABLE], page 195.
• The SHOW statement. See Section 7.21 [SHOW], page 211.
• Strings may be enclosed by either 'n' or ' ', not just by ' '.
• Use of the escape ‘ \ ’ character.
• The SET OPTION statement. See Section 7.25 [SET OPTION], page 222.
• You don’t need to name all selected columns in the GROUP BY part. This gives better performance for some very specific, but quite normal queries. See Section 7.4.13 [Group by functions], page 184.
• To make it easier for users that come from other SQL environments, MySQL supports aliases for many functions. For example, all string functions support both ANSI SQL syntax and ODBC syntax.
• MySQL understands the || and && operators to mean logical OR and AND, as in the C programming language. In MySQL, || and OR are synonyms, as are && and AND. Because of this nice syntax, MySQL doesn’t support the ANSI SQL || operator for string concatenation; use CONCAT() instead. Since CONCAT() takes any number of arguments, it’s easy to convert use of the || operator to MySQL.
• CREATE DATABASE or DROP DATABASE. See Section 7.5 [CREATE DATABASE], page 186.
• The % operator is a synonym for MOD(). That is, N % M is equivalent to MOD(N,M). % is supported for C programmers and for compatibility with PostgreSQL.
• The =, <>, <=, , >, >=, , <>, >, <>, AND, OR or LIKE operators may be used in column comparisons to the left of the FROM in SELECT statements. For example:
mysql> SELECT col1=1 AND col2=2 FROM tbl_name;

- The `LAST_INSERT_ID()` function. See Section 21.4.29 `[mysql_insert_id()]`, page 397.
- The `REEXP` and `NOT REEXP` extended regular expression operators.
- `CONCAT()` or `CHAR()` with one argument or more than two arguments. (In MySQL, these functions can take any number of arguments.)
- The `BIT_COUNT()`, `CASE`, `ELT()`, `FROM_DAYS()`, `FORMAT()`, `IF()`, `PASSWORD()`, `ENCRYPT()`, `md5()`, `ENCODE()`, `DECODE()`, `PERIOD_ADD()`, `PERIOD_DIFF()`, `TO_DAYS()`, or `WEEKDAY()` functions.
- Use of `TRIM()` to trim substrings. ANSI SQL only supports removal of single characters.
- The `GROUP BY` functions `STD()`, `BIT_OR()` and `BIT_AND()`.
- Use of `REPLACE` instead of `DELETE + INSERT`. See Section 7.15 `[REPLACE]`, page 204.
- The `FLUSH flush_option` statement.
- The possibility to set variables in a statement with `:=`:
  
  SELECT @a:=SUM(total),@b=COUNT(*),@a/@b AS avg FROM test_table;
  SELECT @t1:=(@t2:=1)+@t3:=4,@t1,@t2,@t3;

### 5.2 Running MySQL in ANSI mode

If you start mysqld with the `--ansi` option, the following behaviour of MySQL changes.

- `||` is string concatenation instead of `OR`.
- One can have any number of spaces between a function name and the `´` ('). This makes also all function names reserved words.
- `"` will be a identifier quote character (like the MySQL `´` quote character) and not a string quote character.
- `REAL` will be a synonym for `FLOAT` instead of a synonym of `DOUBLE`.

### 5.3 MySQL differences compared to ANSI SQL92

We try to make MySQL follow the ANSI SQL standard and the ODBC SQL standard, but in some cases MySQL does some things differently:

- `--` is only a comment if followed by a white space. See Section 5.4.7 [Missing comments], page 103.
- For `VARCHAR` columns, trailing spaces are removed when the value is stored. See Appendix E [Bugs], page 499.
- In some cases, `CHAR` columns are silently changed to `VARCHAR` columns. See Section 7.7.1 [Silent column changes], page 192.
- Privileges for a table is not automatically revoked when you delete a table. You must explicitly issue a `REVOKE` to revoke privileges for a table. See Section 7.26 [GRANT], page 224.
• `NULL AND FALSE` will evaluate to `NULL` and not to `FALSE`. This is because we don’t think it’s good to have to evaluate a lot of extra conditions in this case.

5.4 Functionality missing from MySQL

The following functionality is missing in the current version of MySQL. For a prioritized list indicating when new extensions may be added to MySQL, you should consult the online MySQL TODO list (http://www.mysql.com/Manual_chapter/manual_Todo.html). That is the latest version of the TODO list in this manual. See Appendix F [TODO], page 501.

5.4.1 Sub-selects

The following will not yet work in MySQL:

```sql
SELECT * FROM table1 WHERE id IN (SELECT id FROM table2);
SELECT * FROM table1 WHERE id NOT IN (SELECT id FROM table2);
```

However, in many cases you can rewrite the query without a sub select:

```sql
SELECT table1.* FROM table1,table2 WHERE table1.id=table2.id;
SELECT table1.* FROM table1 LEFT JOIN table2 ON table1.id=table2.id WHERE table2.id IS NULL
```

For more complicated subqueries you can often create temporary tables to hold the sub-query. In some cases, however this option will not work. The most frequently encountered of these cases arises with `DELETE` statements, for which standard SQL does not support joins (except in sub-selects). For this situation there are two options available until subqueries are supported by MySQL.

The first option is to use a procedural programming language (such as Perl or PHP) to submit a `SELECT` query to obtain the primary keys for the records to be deleted, and then use these values to construct the `DELETE` statement (`DELETE FROM ... WHERE ... IN (key1, key2, ...)`).

The second option is to use interactive SQL to construct a set of `DELETE` statements automatically, using the MySQL extension `CONCAT()` (in lieu of the standard `||` operator). For example:

```sql
SELECT CONCAT('DELETE FROM tab1 WHERE pkid = ', tab1.pkid, ',')
FROM tab1, tab2
WHERE tab1.col1 = tab2.col2;
```

You can place this query in a script file and redirect input from it to the `mysql` command-line interpreter, piping its output back to a second instance of the interpreter:

```bash
prompt> mysql --skip-column-names mydb < myscript.sql | mysql mydb
```

MySQL only supports `INSERT ... SELECT ...` and `REPLACE ... SELECT ...` Independent sub-selects will be probably be available in 3.24.0. You can now use the function `IN()` in other contexts, however.
5.4.2 SELECT INTO TABLE

MySQL doesn’t yet support the Oracle SQL extension: `SELECT ... INTO TABLE ...`
MySQL supports instead the ANSI SQL syntax `INSERT INTO ... SELECT ...`, which is basically the same thing.
Alternatively, you can use `SELECT INTO OUTFILE...` or `CREATE TABLE ... SELECT` to solve your problem.

5.4.3 Transactions

The question is often asked, by the curious and the critical, “Why is MySQL not a transactional database?” or “Why does MySQL not support transactions?”

MySQL has made a conscious decision to support another paradigm for data integrity, “atomic operations.” It is our thinking and experience that atomic operations offer equal or even better integrity with much better performance. We, nonetheless, appreciate and understand the transactional database paradigm and plan, within the next few releases, to introduce transaction safe tables on a per table basis. We will be giving our users the possibility to decide if they need the speed of atomic operations or if they need to use transactional features in their applications.

How does one use the features of MySQL to maintain rigorous integrity and how do these features compare with the transactional paradigm?

First, in the transactional paradigm, if your applications are written in a way that is dependent on the calling of “rollback” instead of “commit” in critical situations, then transactions are more convenient. Moreover, transactions ensure that unfinished updates or corrupting activities are not committed to the database; the server is given the opportunity to do an automatic rollback and your database is saved.

MySQL, in almost all cases, allows you to solve for potential problems by including simple checks before updates and by running simple scripts that check the databases for inconsistencies and automatically repair or warn if such occurs. Note that just by using the MySQL log or even adding one extra log, one can normally fix tables perfectly with no data integrity loss.

Moreover, “fatal” transactional updates can be rewritten to be atomic. In fact, we will go so far as to say that all integrity problems that transactions solve can be done with `LOCK TABLES` or atomic updates, ensuring that you never will get an automatic abort from the database, which is a common problem with transactional databases.

Not even transactions can prevent all loss if the server goes down. In such cases even a transactional system can lose data. The difference between different systems lies in just how small the time-lapse is where they could lose data. No system is 100% secure, only “secure enough.” Even Oracle, reputed to be the safest of transactional databases, is reported to sometimes lose data in such situations.

To be safe with MySQL, you only need to have backups and have the update logging turned on. With this you can recover from any situation that you could with any transactional
database. It is, of course, always good to have backups, independent of which database you use.

The transactional paradigm has its benefits and its drawbacks. Many users and application developers depend on the ease with which they can code around problems where an “abort” appears or is necessary, and they may have to do a little more work with MySQL to either think differently or write more. If you are new to the atomic operations paradigm, or more familiar or more comfortable with transactions, do not jump to the conclusion that MySQL has not addressed these issues. Reliability and integrity are foremost in our minds. Recent estimates are that there are more than 1,000,000 mysqld servers currently running, many of which are in production environments. We hear very, very seldom from our users that they have lost any data, and in almost all of those cases user error is involved. This is in our opinion the best proof of MySQL’s stability and reliability.

Lastly, in situations where integrity is of highest importance, MySQL’s current features allow for transaction-level or better reliability and integrity. If you lock tables with LOCK TABLES, all updates will stall until any integrity checks are made. If you only obtain a read lock (as opposed to a write lock), then reads and inserts are still allowed to happen. The new inserted records will not be seen by any of the clients that have a READ lock until they release their read locks. With INSERT DELAYED you can queue inserts into a local queue, until the locks are released, without having to have the client wait for the insert to complete. “Atomic,” in the sense that we mean it, is nothing magical. It only means that you can be sure that while each specific update is running no other user can interfere with it and that there will never be an automatic rollback (which can happen on transaction based systems if you are not very careful). MySQL also guarantees that there will not be any dirty reads.

We have thought quite a bit about integrity and performance and we believe that our atomic operations paradigm allows for both high reliability and extremely high performance, on the order of three to five times the speed of the fastest and most optimally tuned of transactional databases. We didn’t leave out transactions because they are hard to do; The main reason we went with atomic operations as opposed to transactions is that by doing this we could apply many speed optimizations that would not otherwise have been possible.

Many of our users who have speed foremost in their minds are not at all concerned about transactions. For them transactions are not an issue. For those of our users who are concerned with or have wondered about transactions vis a vis MySQL, there is a “MySQL way” as we have outlined above.

One final note: we are currently working on a safe replication schema that we believe to be better than any commercial replication system we know of. This system will work most reliably under the atomic operations, non-transactional, paradigm. Stay tuned.

5.4.4 Stored procedures and triggers

A stored procedure is a set of SQL commands that can be compiled and stored in the server. Once this has been done, clients don’t need to keep reissuing the entire query but can refer to the stored procedure. This provides better performance because the query has to be parsed only once and less information needs to be sent between the server and the client. You can also raise the conceptual level by having libraries of functions in the server.
A trigger is a stored procedure that is invoked when a particular event occurs. For example, you can install a stored procedure that is triggered each time a record is deleted from a transaction table and that automatically deletes the corresponding customer from a customer table when all his transactions are deleted.

The planned update language will be able to handle stored procedures, but without triggers. Triggers usually slow down everything, even queries for which they are not needed.

To see when MySQL might get stored procedures, see Appendix F [TODO], page 501.

5.4.5 Foreign Keys

Note that foreign keys in SQL are not used to join tables, but are used mostly for checking referential integrity. If you want to get results from multiple tables from a SELECT statement, you do this by joining tables!

```
SELECT * from table1,table2 where table1.id = table2.id;
```

See Section 7.13 [JOIN], page 199. See Section 9.3.5 [example-Foreign keys], page 245.

The FOREIGN KEY syntax in MySQL exists only for compatibility with other SQL vendors’ CREATE TABLE commands; it doesn’t do anything. The FOREIGN KEY syntax without ON DELETE ... is mostly used for documentation purposes. Some ODBC applications may use this to produce automatic WHERE clauses, but this is usually easy to override. FOREIGN KEY is sometimes used as a constraint check, but this check is unnecessary in practice if rows are inserted into the tables in the right order. MySQL only supports these clauses because some applications require them to exist (regardless of whether or not they work!).

In MySQL, you can work around the problem of ON DELETE ... not being implemented by adding the appropriate DELETE statement to an application when you delete records from a table that has a foreign key. In practice this is as quick (in some cases quicker) and much more portable than using foreign keys.

In the near future we will extend the FOREIGN KEY implementation so that at least the information will be saved in the table specification file and may be retrieved by mysqldump and ODBC.

5.4.5.1 Reasons NOT to use foreign keys

There are so many problems with FOREIGN KEYs that we don’t know where to start:

- Foreign keys make life very complicated, because the foreign key definitions must be stored in a database and implementing them would destroy the whole “nice approach” of using files that can be moved, copied and removed.
- The speed impact is terrible for INSERT and UPDATE statements, and in this case almost all FOREIGN KEY checks are useless because you usually insert records in the right tables in the right order, anyway.
- There is also a need to hold locks on many more tables when updating one table, because the side effects can cascade through the entire database. It’s MUCH faster to delete records from one table first and subsequently delete them from the other tables.
• You can no longer restore a table by doing a full delete from the table and then restoring all records (from a new source or from a backup).
• If you have foreign keys you can’t dump and restore tables unless you do so in a very specific order.
• It’s very easy to do “allowed” circular definitions that make the tables impossible to recreate each table with a single create statement, even if the definition works and is usable.

The only nice aspect of FOREIGN KEY is that it gives ODBC and some other client programs the ability to see how a table is connected and to use this to show connection diagrams and to help in building applications.

MySQL will soon store FOREIGN KEY definitions so that a client can ask for and receive an answer how the original connection was made. The current ‘.frm’ file format does not have any place for it.

5.4.6 Views

MySQL doesn’t support views, but this is on the TODO.

5.4.7 ‘--’ as the start of a comment

Some other SQL databases use ‘--’ to start comments. MySQL has ‘#’ as the start comment character, even if the mysql command line tool removes all lines that start with ‘--’. You can also use the C comment style /* this is a comment */ with MySQL. See Section 7.29 [Comments], page 228.

MySQL 3.23.3 and above supports the ‘--’ comment style only if the comment is followed by a space. This is because this degenerate comment style has caused many problems with automatically generated SQL queries that have used something like the following code, where we automatically insert the value of the payment for !payment!:

```
UPDATE tbl_name SET credit=credit-!payment!
```

What do you think will happen when the value of payment is negative?

Because 1--1 is legal in SQL, we think it is terrible that ‘--’ means start comment.

In MySQL 3.23 you can however use:

```
-- This is a comment
```

The following discussing only concerns you if you are running an MySQL version earlier than 3.23:

If you have a SQL program in a text file that contains ‘--’ comments you should use:

```
shell> replace " --" " #" < text-file-with-funny-comments.sql \
| mysql database
```

instead of the usual:

```
shell> mysql database < text-file-with-funny-comments.sql
```

You can also edit the command file “in place” to change the ‘--’ comments to ‘#’ comments:


shell> replace " --" " #" -- text-file-with-funny-comments.sql
Change them back with this command:

shell> replace " #" " --" -- text-file-with-funny-comments.sql

5.5 What standards does MySQL follow?

Entry level SQL92. ODBC level 0-2.

5.6 How to cope without COMMIT/ROLLBACK

MySQL doesn’t support COMMIT-ROLLBACK. The problem is that handling COMMIT-ROLLBACK efficiently would require a completely different table layout than MySQL uses today. MySQL would also need extra threads that do automatic cleanups on the tables and the disk usage would be much higher. This would make MySQL about 2-4 times slower than it is today. MySQL is much faster than almost all other SQL databases (typically at least 2-3 times faster). One of the reasons for this is the lack of COMMIT-ROLLBACK.

For the moment, we are much more for implementing the SQL server language (something like stored procedures). With this you would very seldom really need COMMIT-ROLLBACK. This would also give much better performance.

Loops that need transactions normally can be coded with the help of LOCK TABLES, and you don’t need cursors when you can update records on the fly.

We have transactions and cursors on the TODO but not quite prioritized. If we implement these, it will be as an option to CREATE TABLE. That means that COMMIT-ROLLBACK will work only on those tables, so that a speed penalty will be imposed on those table only.

We at TcX have a greater need for a real fast database than a 100% general database. Whenever we find a way to implement these features without any speed loss, we will probably do it. For the moment, there are many more important things to do. Check the TODO for how we prioritize things at the moment. (Customers with higher levels of support can alter this, so things may be reprioritized.)

The current problem is actually ROLLBACK. Without ROLLBACK, you can do any kind of COMMIT action with LOCK TABLES. To support ROLLBACK, MySQL would have to be changed to store all old records that were updated and revert everything back to the starting point if ROLLBACK was issued. For simple cases, this isn’t that hard to do (the current isamlog could be used for this purpose), but it would be much more difficult to implement ROLLBACK for ALTER/DROP/CREATE TABLE.

To avoid using ROLLBACK, you can use the following strategy:

1. Use LOCK TABLES ... to lock all the tables you want to access.
2. Test conditions.
3. Update if everything is okay.
4. Use UNLOCK TABLES to release your locks.
This is usually a much faster method than using transactions with possible ROLLBACKs, although not always. The only situation this solution doesn’t handle is when someone kills the threads in the middle of an update. In this case, all locks will be released but some of the updates may not have been executed.

You can also use functions to update records in a single operation. You can get a very efficient application by using the following techniques:

- Modify fields relative to their current value
- Update only those fields that actually have changed

For example, when we are doing updates to some customer information, we update only the customer data that have changed and test only that none of the changed data, or data that depend on the changed data, have changed compared to the original row. The test for changed data is done with the WHERE clause in the UPDATE statement. If the record wasn’t updated, we give the client a message: "Some of the data you have changed have been changed by another user". Then we show the old row versus the new row in a window, so the user can decide which version of the customer record he should use.

This gives us something that is similar to “column locking” but is actually even better, because we only update some of the columns, using values that are relative to their current values. This means that typical UPDATE statements look something like these:

```
UPDATE tablename SET pay_back=pay_back+'relative change';
```

```
UPDATE customer
  SET
    customer_date='current_date',
    address='new address',
    phone='new phone',
    money_he_owes_us=money_he_owes_us+'new_money'
WHERE
  customer_id=id AND address='old address' AND phone='old phone';
```

As you can see, this is very efficient and works even if another client has changed the values in the pay_back or money_he_owes_us columns.

In many cases, users have wanted ROLLBACK and/or LOCK TABLES for the purpose of managing unique identifiers for some tables. This can be handled much more efficiently by using an AUTO_INCREMENT column and either the SQL function LAST_INSERT_ID() or the C API function mysql_insert_id(). See Section 21.4.29 [mysql_insert_id()], page 397.

At TcX, we have never had any need for row-level locking because we have always been able to code around it. Some cases really need row locking, but they are very few. If you want row-level locking, you can use a flag column in the table and do something like this:

```
UPDATE tbl_name SET row_flag=1 WHERE id=ID;
```

MySQL returns 1 for the number of affected rows if the row was found and row_flag wasn’t already 1 in the original row.

You can think of it as MySQL changed the above query to:

```
UPDATE tbl_name SET row_flag=1 WHERE id=ID and row_flag <> 1;
```
6 The MySQL access privilege system

MySQL has an advanced but non-standard security/privilege system. This section describes how it works.

6.1 General security

Anyone using MySQL on a computer connected to the Internet should read this chapter to avoid mistakes people do.

Under "security" we mean that our site, not only MySQL is protected against all types of applicable attacks: eavesdropping, altering, playback and Denial of Service. We do not cover all aspects of availability and fault tolerance here.

There are some security logic in MySQL: Access control lists (ACL-s) and SSL encrypted connections but much more is depending on overall usage of MySQL. Also most of this chapter isn’t MySQL dependant at all. Same rules apply for most applications.

When you running a site, designing software or just doing something with MySQL then try to follow these rules:

- Try to understand MySQL ACL system. The GRANT/REVOKE commands are for restricting access to MySQL. Do not grant anyone for more than is must. Never grant all hosts to do something.
  
  Checklist:
  - Do mysql -u root. If you granted a connection without asking password, then this is bad.
  - Use command SHOW GRANTS and check who is having access and to what.

- Do not keep any plain passwords in tables when possible. When your computer gets compromised, intruder can take full list of passwords and use them in somewhere else place. Instead use MD5() or other one-way hashing function.

- Do not use passwords from dictionaries. There are special programs to break them. Even passwords like: "xfish98" are very bad. Much better is "duag" which is same word "fish" but typed one key left on keyboard. Another method is to use "Mhall" which is taken from first characters of sentence "Mary had a little lamb". Easy to type when you know the system but hard to guess from side.

- Invest in firewall. This protects for at least 50% of all types of exploits in any software. Put MySQL behind the firewall or in demilitarized zone (DMZ).
  
  Checklist:
  - Try to scan your ports from Internet. MySQL uses port 3306 by default. This port should be unaccessible for most cases.
  - Do not trust any data entered from user. Users can enter special symbols from webforms, URL-s or your custom application. Are you sure that your application remains secure if user enters something like ; DROP ALL DATABASES ; into form?
  
  Checklist:
Chapter 6: The MySQL access privilege system

- All WWW applications:
  - Try to enter ' and " in all forms on your WWW. If you get any kind of MySQL error, better take your site down.
  - Try to modify any types of dynamic URL-s by adding %22 (*), %23 (#) and %27 (') in your URL.
  - Try to modify datatypes in dynamic URL-s from numeric ones to character ones containing characters from previous example. Your application should be safe against this.
  - Try to enter characters, spaces, special symbols instead of numbers in numeric fields. Application should remove them before passing to MySQL or your application should generate error. Passing wrong things to MySQL is dangerous!
  - Check data sizes before passing them to MySQL.

- Users of PHP3:
  - Check out the addslashes() function.

- Users of MySQL C API:
  - Check out the mysql_escape() API call.

- Users of MySQL++:
  - Check out the escape and quote modifiers (?) for query streams.

- Do not transmit plain data over the net. This data is accessible to everyone who have interest to trap this information and reuse it somewhere. If you really need this, use encrypted communications like SSL. MySQL supports internal SSL connections beginning from version 3.23.9.

- Learn to use utilities "tcpdump" and "strings". For most cases you can see unencrypted MySQL data streams issuing command:

  tcpdump -i -i eth0 -w - src or dst port 3306 | strings

  (This works under linux and should work with small modifications under another systems). Warning: If you do not see data this doesn’t actually always mean that it is encrypted. If you need high security you should consult with security expert.

6.2 How to make MySQL secure against crackers

When you connect to a MySQL server, you should normally use a password. The password is not transmitted in clear text over the connection.

All other information is transferred as text that can be read by anyone that is able to watch the connection. If you are concerned about this, you can use the compressed protocol (in MySQL 3.22 and above) to make things much harder. To make things even more secure you should install ssh (see http://www.cs.hut.fi/ssh). With this, you can get an encrypted TCP/IP connection between a MySQL server and a MySQL client.

To make a MySQL system secure, you should strongly consider the following suggestions:
• Use passwords for all MySQL users. Remember that anyone can log in as any other person as simply as mysql -u other_user db_name if other_user has no password. It is common behavior with client/server applications that the client may specify any user name. You can change the password of all users by editing the mysql_install_db script before you run it, or only the password for the MySQL root user like this:

```
shell> mysql -u root mysql
mysql> UPDATE user SET Password=PASSWORD('new_password')
    WHERE user='root';
mysql> FLUSH PRIVILEGES;
```

• Don’t run the MySQL daemon as the Unix root user. mysqld can be run as any user. You can also create a new Unix user mysql to make everything even more secure. If you run mysqld as another Unix user, you don’t need to change the root user name in the user table, because MySQL user names have nothing to do with Unix user names. You can edit the mysql.server script to start mysqld as another Unix user. Normally this is done with the su command. For more details, see [software] [Changing MySQL user], page (undefined).

• If you put a password for the Unix root user in the mysql.server script, make sure this script is readable only by root.

• Check that the Unix user that mysqld runs as is the only user with read/write privileges in the database directories.

• Don’t give the process privilege to all users. The output of mysqladmin processlist shows the text of the currently executing queries, so any user who is allowed to execute that command might be able to see if another user issues an UPDATE user SET password=PASSWORD('not_secure') query.

mysqld saves an extra connection for users who have the process privilege, so that a MySQL root user can log in and check things even if all normal connections are in use.

• Don’t give the file privilege to all users. Any user that has this privilege can write a file anywhere in the file system with the privileges of the mysqld daemon! To make this a bit safer, all files generated with SELECT ... INTO OUTFILE are readable to everyone, and you can’t overwrite existing files.

The file privilege may also be used to read any file accessible to the Unix user that the server runs as. This could be abused, for example, by using LOAD DATA to load '/etc/passwd' into a table, which can then be read with SELECT.

• If you don’t trust your DNS, you should use IP numbers instead of hostnames in the grant tables. In principle, the --secure option to mysqld should make hostnames safe. In any case, you should be very careful about using hostname values that contain wildcards.

The following mysqld options affect security:

```
--secure   IP numbers returned by the gethostbyname() system call are checked to make sure they resolve back to the original hostname. This makes it harder for someone on the outside to get access by simulating another host. This option also adds some sanity checks of hostnames. The option is turned off by default in MySQL 3.21 since it sometimes takes a long time to perform backward resolutions. MySQL 3.22 caches hostnames and has this option enabled by default.
```

Version: 3.23.11-alpha Printed: 25 February 2000
--skip-grant-tables

This option causes the server not to use the privilege system at all. This gives everyone full access to all databases! (You can tell a running server to start using the grant tables again by executing mysqladmin reload.)

--skip-name-resolve

Hostnames are not resolved. All Host column values in the grant tables must be IP numbers or localhost.

--skip-networking

Don’t allow TCP/IP connections over the network. All connections to mysqld must be made via Unix sockets. This option is unsuitable for systems that use MIT-pthreads, because the MIT-pthreads package doesn’t support Unix sockets.

6.3 What the privilege system does

The primary function of the MySQL privilege system is to authenticate a user connecting from a given host, and to associate that user with select, insert, update and delete privileges on a database.

Additional functionality includes the ability to have an anonymous user and to grant privileges for MySQL-specific functions such as LOAD DATA INFILE and administrative operations.

6.4 MySQL user names and passwords

There are several distinctions between the way user names and passwords are used by MySQL, and the way they are used by Unix or Windows:

- User names, as used by MySQL for authentication purposes, have nothing to do with Unix user names (login names) or Windows user names. Most MySQL clients by default try to log in using the current Unix user name as the MySQL user name, but that is for convenience only. Client programs allow a different name to be specified with the -u or --user options. This means that you can’t make a database secure in any way unless all MySQL user names have passwords. Anyone may attempt to connect to the server using any name, and they will succeed if they specify any name that doesn’t have a password.

- MySQL user names can be up to 16 characters long; Unix user names typically are limited to 8 characters.

- MySQL passwords have nothing to do with Unix passwords. There is no necessary connection between the password you use to log in to a Unix machine and the password you use to access a database on that machine.

- MySQL encrypts passwords using a different algorithm than the one used during the Unix login process. See the descriptions of the PASSWORD() and ENCRYPT() functions in Section 7.4.12 [Miscellaneous functions], page 181.
6.5 Connecting to the MySQL server

MySQL client programs generally require that you specify connection parameters when you want to access a MySQL server: the host you want to connect to, your user name and your password. For example, the mysql client can be started like this (optional arguments are enclosed between ‘[’ and ‘]’):

```
shell> mysql [-h host_name] [-u user_name] [-pyour_pass]
```

Alternate forms of the -h, -u and -p options are --host=host_name, --user=user_name and --password=your_pass. Note that there is no space between -p or --password= and the password following it.

*Note:* Specifying a password on the command line is not secure! Any user on your system may then find out your password by typing a command like: `ps auxww`. See Section 4.15.4 [Option files], page 89.

mysql uses default values for connection parameters that are missing from the command line:

- The default hostname is localhost.
- The default user name is your Unix login name.
- No password is supplied if -p is missing.

Thus, for a Unix user joe, the following commands are equivalent:

```
shell> mysql -h localhost -u joe
shell> mysql -h localhost
shell> mysql -u joe
shell> mysql
```

Other MySQL clients behave similarly.

On Unix systems, you can specify different default values to be used when you make a connection, so that you need not enter them on the command line each time you invoke a client program. This can be done in a couple of ways:

- You can specify connection parameters in the [client] section of the ‘.my.cnf’ configuration file in your home directory. The relevant section of the file might look like this:

  ```
  [client]
  host=host_name
  user=user_name
  password=your_pass
  ```

  See Section 4.15.4 [Option files], page 89.

- You can specify connection parameters using environment values. The host can be specified using MYSQL_HOST. The MySQL user name can be specified using USER (this is for Windows only). The password can be specified using MYSQL_PWD (but this is insecure; see next section).

If connection parameters are specified in multiple ways, values specified on the command line take precedence over values specified in configuration files and environment variables, and values in configuration files take precedence over values in environment variables.
6.6 Keeping your password secure

It is inadvisable to specify your password in a way that exposes it to discovery by other users. The methods you can use to specify your password when you run client programs are listed below, along with an assessment of the risks of each method:

- Use a `-pyour_pass` or `--password=your_pass` option on the command line. This is convenient but insecure, since your password becomes visible to system status programs (such as `ps`) that may be invoked by other users to display command lines. (MySQL clients typically overwrite the command line argument with zeroes during their initialization sequence, but there is still a brief interval during which the value is visible.)

- Use a `-p` or `--password` option (with no `your_pass` value specified). In this case, the client program solicits the password from the terminal:

  ```shell
  shell> mysql -u user_name -p
  Enter password: ********
  ```

  The client echoes ‘*’ characters to the terminal as you enter your password so that onlookers cannot see it.

  It is more secure to enter your password this way than to specify it on the command line because it is not visible to other users. However, this method of entering a password is suitable only for programs that you run interactively. If you want to invoke a client from a script that runs non-interactively, there is no opportunity to enter the password from the terminal.

- Store your password in a configuration file. For example, you can list your password in the `[client]` section of the `.my.cnf` file in your home directory:

  ```conf
  [client]
  password=your_pass
  ```

  If you store your password in `.my.cnf`, the file should not be group or world readable or writable. Make sure the file’s access mode is 400 or 600. See Section 4.15.4 [Option files], page 89.

- You can store your password in the `MYSQL_PWD` environment variable, but this method must be considered extremely insecure and should not be used. Some versions of `ps` include an option to display the environment of running processes; your password will be in plain sight for all to see if you set `MYSQL_PWD`. Even on systems without such a version of `ps`, it is unwise to assume there is no other method to observe process environments.

All in all, the safest methods are to have the client program prompt for the password or to specify the password in a properly-protected `.my.cnf` file.

6.7 Privileges provided by MySQL

Privilege information is stored in the `user`, `db`, `host`, `tables_priv` and `columns_priv` tables in the `mysql` database (that is, in the database named `mysql`). The MySQL server
reads the contents of these tables when it starts up and under the circumstances indicated in Section 6.11 [Privilege changes], page 121.

The names used in this manual to refer to the privileges provided by MySQL are shown below, along with the table column name associated with each privilege in the grant tables and the context in which the privilege applies:

<table>
<thead>
<tr>
<th>Privilege</th>
<th>Column</th>
<th>Context</th>
</tr>
</thead>
<tbody>
<tr>
<td>select</td>
<td>Select_priv</td>
<td>tables</td>
</tr>
<tr>
<td>insert</td>
<td>Insert_priv</td>
<td>tables</td>
</tr>
<tr>
<td>update</td>
<td>Update_priv</td>
<td>tables</td>
</tr>
<tr>
<td>delete</td>
<td>Delete_priv</td>
<td>tables</td>
</tr>
<tr>
<td>index</td>
<td>Index_priv</td>
<td>tables</td>
</tr>
<tr>
<td>alter</td>
<td>Alter_priv</td>
<td>tables</td>
</tr>
<tr>
<td>create</td>
<td>Create_priv</td>
<td>databases, tables or indexes</td>
</tr>
<tr>
<td>drop</td>
<td>Drop_priv</td>
<td>databases or tables</td>
</tr>
<tr>
<td>grant</td>
<td>Grant_priv</td>
<td>databases or tables</td>
</tr>
<tr>
<td>references</td>
<td>References_priv</td>
<td>databases or tables</td>
</tr>
<tr>
<td>reload</td>
<td>Reload_priv</td>
<td>server administration</td>
</tr>
<tr>
<td>shutdown</td>
<td>Shutdown_priv</td>
<td>server administration</td>
</tr>
<tr>
<td>process</td>
<td>Process_priv</td>
<td>server administration</td>
</tr>
<tr>
<td>file</td>
<td>File_priv</td>
<td>file access on server</td>
</tr>
</tbody>
</table>

The select, insert, update and delete privileges allow you to perform operations on rows in existing tables in a database.

SELECT statements require the select privilege only if they actually retrieve rows from a table. You can execute certain SELECT statements even without permission to access any of the databases on the server. For example, you could use the mysql client as a simple calculator:

```
mysql> SELECT 1+1;
```
```
mysql> SELECT PI()*2;
```

The index privilege allows you to create or drop (remove) indexes.

The alter privilege allows you to use ALTER TABLE.

The create and drop privileges allow you to create new databases and tables, or to drop (remove) existing databases and tables.

Note that if you grant the drop privilege for the mysql database to a user, that user can drop the database in which the MySQL access privileges are stored!

The grant privilege allows you to give to other users those privileges you yourself possess.

The file privilege gives you permission to read and write files on the server using the LOAD DATA INFILE and SELECT ... INTO OUTFILE statements. Any user to whom this privilege is granted can read or write any file that the MySQL server can read or write.

The remaining privileges are used for administrative operations, which are performed using the mysqladmin program. The table below shows which mysqladmin commands each administrative privilege allows you to execute:

<table>
<thead>
<tr>
<th>Privilege</th>
<th>Commands permitted to privilege holders</th>
</tr>
</thead>
</table>

Version: 3.23.11-alpha Printed: 25 February 2000
The `reload` command tells the server to reread the grant tables. The `refresh` command flushes all tables and opens and closes the log files. `flush-privileges` is a synonym for `reload`. The other `flush-*` commands perform functions similar to `refresh` but are more limited in scope, and may be preferable in some instances. For example, if you want to flush just the log files, `flush-logs` is a better choice than `refresh`.

The `shutdown` command shuts down the server.

The `processlist` command displays information about the threads executing within the server. The `kill` command kills server threads. You can always display or kill your own threads, but you need the `process` privilege to display or kill threads initiated by other users.

It is a good idea in general to grant privileges only to those users who need them, but you should exercise particular caution in granting certain privileges:

- The `grant` privilege allows users to give away their privileges to other users. Two users with different privileges and with the `grant` privilege are able to combine privileges.
- The `alter` privilege may be used to subvert the privilege system by renaming tables.
- The `file` privilege can be abused to read any world-readable file on the server into a database table, the contents of which can then be accessed using `SELECT`.
- The `shutdown` privilege can be abused to deny service to other users entirely, by terminating the server.
- The `process` privilege can be used to view the plain text of currently executing queries, including queries that set or change passwords.
- Privileges on the `mysql` database can be used to change passwords and other access privilege information. (Passwords are stored encrypted, so a malicious user cannot simply read them. However, with sufficient privileges, that same user can replace a password with a different one.)

There are some things that you cannot do with the MySQL privilege system:

- You cannot explicitly specify that a given user should be denied access. That is, you cannot explicitly match a user and then refuse the connection.
- You cannot specify that a user has privileges to create or drop tables in a database but not to create or drop the database itself.

### 6.8 How the privilege system works

The MySQL privilege system ensures that all users may do exactly the things that they are supposed to be allowed to do. When you connect to a MySQL server, your identity is determined by the host from which you connect and the user name you specify. The system grants privileges according to your identity and what you want to do.
MySQL considers both your hostname and user name in identifying you because there is little reason to assume that a given user name belongs to the same person everywhere on the Internet. For example, the user bill who connects from whitehouse.gov need not be the same person as the user bill who connects from microsoft.com. MySQL handles this by allowing you to distinguish users on different hosts that happen to have the same name: you can grant bill one set of privileges for connections from whitehouse.gov, and a different set of privileges for connections from microsoft.com.

MySQL access control involves two stages:

- Stage 1: The server checks whether or not you are even allowed to connect.
- Stage 2: Assuming you can connect, the server checks each request you issue to see whether or not you have sufficient privileges to perform it. For example, if you try to select rows from a table in a database or drop a table from the database, the server makes sure you have the select privilege for the table or the drop privilege for the database.

The server uses the user, db and host tables in the mysql database at both stages of access control. The fields in these grant tables are shown below:

<table>
<thead>
<tr>
<th>Table name</th>
<th>user</th>
<th>db</th>
<th>host</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scope fields</td>
<td>Host</td>
<td>Host</td>
<td>Host</td>
</tr>
<tr>
<td>User</td>
<td>Db</td>
<td>Db</td>
<td></td>
</tr>
<tr>
<td>Password</td>
<td>User</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Privilege fields</td>
<td>Select_priv</td>
<td>Select_priv</td>
<td>Select_priv</td>
</tr>
<tr>
<td>Insert_priv</td>
<td>Insert_priv</td>
<td>Insert_priv</td>
<td></td>
</tr>
<tr>
<td>Update_priv</td>
<td>Update_priv</td>
<td>Update_priv</td>
<td></td>
</tr>
<tr>
<td>Delete_priv</td>
<td>Delete_priv</td>
<td>Delete_priv</td>
<td></td>
</tr>
<tr>
<td>Index_priv</td>
<td>Index_priv</td>
<td>Index_priv</td>
<td></td>
</tr>
<tr>
<td>Alter_priv</td>
<td>Alter_priv</td>
<td>Alter_priv</td>
<td></td>
</tr>
<tr>
<td>Create_priv</td>
<td>Create_priv</td>
<td>Create_priv</td>
<td></td>
</tr>
<tr>
<td>Drop_priv</td>
<td>Drop_priv</td>
<td>Drop_priv</td>
<td></td>
</tr>
<tr>
<td>Grant_priv</td>
<td>Grant_priv</td>
<td>Grant_priv</td>
<td></td>
</tr>
<tr>
<td>References_priv</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reload_priv</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shutdown_priv</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Process_priv</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>File_priv</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

For the second stage of access control (request verification), the server may, if the request involves tables, additionally consult the tables_priv and columns_priv tables. The fields in these tables are shown below:

<table>
<thead>
<tr>
<th>Table name</th>
<th>tables_priv</th>
<th>columns_priv</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scope fields</td>
<td>Host</td>
<td>Host</td>
</tr>
<tr>
<td>Db</td>
<td>Db</td>
<td></td>
</tr>
<tr>
<td>User</td>
<td>User</td>
<td></td>
</tr>
<tr>
<td>Table_name</td>
<td>Table_name</td>
<td></td>
</tr>
</tbody>
</table>
Chapter 6: The MySQL access privilege system

Each grant table contains scope fields and privilege fields.

Scope fields determine the scope of each entry in the tables, i.e., the context in which the entry applies. For example, a user table entry with Host and User values of 'thomas.loc.gov' and 'bob' would be used for authenticating connections made to the server by bob from the host thomas.loc.gov. Similarly, a db table entry with Host, User and Db fields of 'thomas.loc.gov', 'bob' and 'reports' would be used when bob connects from the host thomas.loc.gov to access the reports database. The tables_priv and columns_priv tables contain scope fields indicating tables or table/column combinations to which each entry applies.

For access-checking purposes, comparisons of Host values are case insensitive. User, Password, Db and Table_name values are case sensitive. Column_name values are case insensitive in MySQL 3.22.12 or later.

Privilege fields indicate the privileges granted by a table entry, that is, what operations can be performed. The server combines the information in the various grant tables to form a complete description of a user’s privileges. The rules used to do this are described in Section 6.10 [Request access], page 119.

Scope fields are strings, declared as shown below; the default value for each is the empty string:

<table>
<thead>
<tr>
<th>Field name</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Host</td>
<td>CHAR(60)</td>
</tr>
<tr>
<td>User</td>
<td>CHAR(16)</td>
</tr>
<tr>
<td>Password</td>
<td>CHAR(16)</td>
</tr>
<tr>
<td>Db</td>
<td>CHAR(64)</td>
</tr>
<tr>
<td></td>
<td>(CHAR(60) for the tables_priv and columns_priv tables)</td>
</tr>
</tbody>
</table>

In the user, db and host tables, all privilege fields are declared as ENUM(‘N’, ’Y’) — each can have a value of ’N’ or ’Y’, and the default value is ’N’.

In the tables_priv and columns_priv tables, the privilege fields are declared as SET fields:

<table>
<thead>
<tr>
<th>Table name</th>
<th>Field name</th>
<th>Possible set elements</th>
</tr>
</thead>
<tbody>
<tr>
<td>tables_priv</td>
<td>Table_priv</td>
<td>'Select', 'Insert', 'Update', 'Delete', 'Create', 'Drop', 'Grant', 'References', 'Index', 'Alter'</td>
</tr>
<tr>
<td>tables_priv</td>
<td>Column_priv</td>
<td>'Select', 'Insert', 'Update', 'References'</td>
</tr>
<tr>
<td>columns_priv</td>
<td>Column_priv</td>
<td>'Select', 'Insert', 'Update', 'References'</td>
</tr>
</tbody>
</table>

Briefly, the server uses the grant tables like this:

- The user table scope fields determine whether to allow or reject incoming connections. For allowed connections, the privilege fields indicate the user’s global (superuser) privileges.
- The db and host tables are used together:
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- The db table scope fields determine which users can access which databases from which hosts. The privilege fields determine which operations are allowed.
- The host table is used as an extension of the db table when you want a given db table entry to apply to several hosts. For example, if you want a user to be able to use a database from several hosts in your network, leave the host value empty in the user's db table entry, then populate the host table with an entry for each of those hosts. This mechanism is described more detail in Section 6.10 [Request access], page 119.

- The tables_priv and columns_priv tables are similar to the db table, but are more fine-grained: they apply at the table and column level rather than at the database level.

Note that administrative privileges (reload, shutdown, etc.) are specified only in the user table. This is because administrative operations are operations on the server itself and are not database-specific, so there is no reason to list such privileges in the other grant tables. In fact, only the user table need be consulted to determine whether or not you can perform an administrative operation.

The file privilege is specified only in the user table, too. It is not an administrative privilege as such, but your ability to read or write files on the server host is independent of the database you are accessing.

The mysql server reads the contents of the grant tables once, when it starts up. Changes to the grant tables take effect as indicated in Section 6.11 [Privilege changes], page 121.

When you modify the contents of the grant tables, it is a good idea to make sure that your changes set up privileges the way you want. For help in diagnosing problems, see Section 6.15 [Access denied], page 126. For advice on security issues, Section 6.2 [Security], page 107.

A useful diagnostic tool is the mysqlaccess script, which Yves Carlier has provided for the MySQL distribution. Invoke mysqlaccess with the --help option to find out how it works. Note that mysqlaccess checks access using only the user, db and host tables. It does not check table- or column-level privileges.

6.9 Access control, stage 1: Connection verification

When you attempt to connect to a MySQL server, the server accepts or rejects the connection based on your identity and whether or not you can verify your identity by supplying the correct password. If not, the server denies access to you completely. Otherwise, the server accepts the connection, then enters stage 2 and waits for requests.

Your identity is based on two pieces of information:

- The host from which you connect
- Your MySQL user name

Identity checking is performed using the three user table scope fields (Host, User and Password). The server accepts the connection only if a user table entry matches your hostname and user name, and you supply the correct password.
Values in the user table scope fields may be specified as follows:

- A Host value may be a hostname or an IP number, or 'localhost' to indicate the local host.
- You can use the wildcard characters '%' and '_' in the Host field.
- A Host value of '%' matches any hostname. A blank Host value is equivalent to '%'. Note that these values match any host that can create a connection to your server!
- Wildcard characters are not allowed in the User field, but you can specify a blank value, which matches any name. If the user table entry that matches an incoming connection has a blank user name, the user is considered to be the anonymous user (the user with no name), rather than the name that the client actually specified. This means that a blank user name is used for all further access checking for the duration of the connection (that is, during stage 2).
- The Password field can be blank. This does not mean that any password matches, it means the user must connect without specifying a password.

Non-blank Password values represent encrypted passwords. MySQL does not store passwords in plaintext form for anyone to see. Rather, the password supplied by a user who is attempting to connect is encrypted (using the PASSWORD() function) and compared to the already-encrypted version stored in the user table. If they match, the password is correct.

The examples below show how various combinations of Host and User values in user table entries apply to incoming connections:

<table>
<thead>
<tr>
<th>Host value</th>
<th>User value</th>
<th>Connections matched by entry</th>
</tr>
</thead>
<tbody>
<tr>
<td>'thomas.loc.gov'</td>
<td>'fred'</td>
<td>fred, connecting from thomas.loc.gov</td>
</tr>
<tr>
<td>'thomas.loc.gov'</td>
<td>''</td>
<td>Any user, connecting from thomas.loc.gov</td>
</tr>
<tr>
<td>'%'</td>
<td>'fred'</td>
<td>fred, connecting from any host</td>
</tr>
<tr>
<td>'%'</td>
<td>''</td>
<td>Any user, connecting from any host</td>
</tr>
<tr>
<td>'%.loc.gov'</td>
<td>'fred'</td>
<td>fred, connecting from any host in the loc.gov domain</td>
</tr>
<tr>
<td>'x.y.%'</td>
<td>'fred'</td>
<td>fred, connecting from x.y.net, x.y.com.x.y.edu, etc. (this is probably not useful)</td>
</tr>
<tr>
<td>'144.155.166.177'</td>
<td>'fred'</td>
<td>fred, connecting from the host with IP address 144.155.166.177</td>
</tr>
<tr>
<td>'144.155.166.%'</td>
<td>'fred'</td>
<td>fred, connecting from any host in the 144.155.166 class C subnet</td>
</tr>
</tbody>
</table>

Since you can use IP wildcard values in the Host field (e.g., '144.155.166.%' to match every host on a subnet), there is the possibility that someone might try to exploit this capability by naming a host 144.155.166.somewhere.com. To foil such attempts, MySQL disallows matching on hostnames that start with digits and a dot. Thus, if you have a host named something like 1.2.foo.com, its name will never match the Host column of the grant tables. Only an IP number can match an IP wildcard value.

An incoming connection may be matched by more than one entry in the user table. For example, a connection from thomas.loc.gov by fred would be matched by several of the entries just shown above. How does the server choose which entry to use if more than one matches? The server resolves this question by sorting the user table after reading it...
at startup time, then looking through the entries in sorted order when a user attempts to connect. The first matching entry is the one that is used.

`user` table sorting works as follows. Suppose the `user` table looks like this:

```
+-----------+----------+-----+
| Host      | User     | ... |
+-----------+----------+-----+
| %         | root     | ... |
| %         | jeffrey  | ... |
| localhost | root     |     |
| localhost |          |     |
+-----------+----------+-----+
```

When the server reads in the table, it orders the entries with the most-specific `Host` values first (’%’ in the `Host` column means “any host” and is least specific). Entries with the same `Host` value are ordered with the most-specific `User` values first (a blank `User` value means “any user” and is least specific). The resulting sorted `user` table looks like this:

```
+-----------+----------+-----+
| Host      | User     |     |
+-----------+----------+-----+
| localhost | root     |     |
| localhost |          |     |
| %         | jeffrey  |     |
| %         | root     |     |
+-----------+----------+-----+
```

When a connection is attempted, the server looks through the sorted entries and uses the first match found. For a connection from `localhost` by `jeffrey`, the entries with ‘localhost’ in the `Host` column match first. Of those, the entry with the blank user name matches both the connecting hostname and user name. (The ‘%/’’jeffrey’ entry would have matched, too, but it is not the first match in the table.)

Here is another example. Suppose the `user` table looks like this:

```
+----------------+----------+-----+
| Host           | User     |     |
+----------------+----------+-----+
| thomas.loc.gov |          |     |
| %              | jeffrey  |     |
+----------------+----------+-----+
```

The sorted table looks like this:

```
+----------------+----------+-----+
| Host           | User     |     |
+----------------+----------+-----+
| thomas.loc.gov |          |     |
| %              | jeffrey  |     |
+----------------+----------+-----+
```

A connection from `thomas.loc.gov` by `jeffrey` is matched by the first entry, whereas a connection from `whitehouse.gov` by `jeffrey` is matched by the second.
A common misconception is to think that for a given user name, all entries that explicitly name that user will be used first when the server attempts to find a match for the connection. This is simply not true. The previous example illustrates this, where a connection from thomas.loc.gov by jeffrey is first matched not by the entry containing 'jeffrey' as the User field value, but by the entry with no user name!

If you have problems connecting to the server, print out the user table and sort it by hand to see where the first match is being made.

6.10 Access control, stage 2: Request verification

Once you establish a connection, the server enters stage 2. For each request that comes in on the connection, the server checks whether you have sufficient privileges to perform it, based on the type of operation you wish to perform. This is where the privilege fields in the grant tables come into play. These privileges can come from any of the user, db, host, tables_priv or columns_priv tables. The grant tables are manipulated with GRANT and REVOKE commands. See Section 7.26 [GRANT], page 224. (You may find it helpful to refer to Section 6.8 [Privileges], page 113, which lists the fields present in each of the grant tables.)

The user table grants privileges that are assigned to you on a global basis and that apply no matter what the current database is. For example, if the user table grants you the delete privilege, you can delete rows from any database on the server host! In other words, user table privileges are superuser privileges. It is wise to grant privileges in the user table only to superusers such as server or database administrators. For other users, you should leave the privileges in the user table set to 'N' and grant privileges on a database-specific basis only, using the db and host tables.

The db and host tables grant database-specific privileges. Values in the scope fields may be specified as follows:

- The wildcard characters '%' and '_' can be used in the Host and Db fields of either table.
- A '%' Host value in the db table means “any host.” A blank Host value in the db table means “consult the host table for further information.”
- A '%' or blank Host value in the host table means “any host.”
- A '%' or blank Db value in either table means “any database.”
- A blank User value in either table matches the anonymous user.

The db and host tables are read in and sorted when the server starts up (at the same time that it reads the user table). The db table is sorted on the Host, Db and User scope fields, and the host table is sorted on the Host and Db scope fields. As with the user table, sorting puts the most-specific values first and least-specific values last, and when the server looks for matching entries, it uses the first match that it finds.

The tables_priv and columns_priv tables grant table- and column-specific privileges. Values in the scope fields may be specified as follows:

- The wildcard characters '%' and '_' can be used in the Host field of either table.
- A '%' or blank Host value in either table means “any host.”
The Db, Table_name and Column_name fields cannot contain wildcards or be blank in either table.

The tables_priv and columns_priv tables are sorted on the Host, Db and User fields. This is similar to db table sorting, although since only the Host field may contain wildcards, the sorting is simpler.

The request verification process is described below. (If you are familiar with the access-checking source code, you will notice that the description here differs slightly from the algorithm used in the code. The description is equivalent to what the code actually does; it differs only to make the explanation simpler.)

For administrative requests (shutdown, reload, etc.), the server checks only the user table entry, since that is the only table that specifies administrative privileges. Access is granted if the entry allows the requested operation and denied otherwise. For example, if you want to execute mysqladmin shutdown but your user table entry doesn’t grant the shutdown privilege to you, access is denied without even checking the db or host tables. (Since they contain no Shutdown_priv column, there is no need to do so.)

For database-related requests (insert, update, etc.), the server first checks the user’s global (superuser) privileges by looking in the user table entry. If the entry allows the requested operation, access is granted. If the global privileges in the user table are insufficient, the server determines the user’s database-specific privileges by checking the db and host tables:

1. The server looks in the db table for a match on the Host, Db and User fields. Host and User are matched to the connecting user’s hostname and MySQL user name. The Db field is matched to the database the user wants to access. If there is no entry for the Host and User, access is denied.
2. If there is a matching db table entry and its Host field is not blank, that entry defines the user’s database-specific privileges.
3. If the matching db table entry’s Host field is blank, it signifies that the host table enumerates which hosts should be allowed access to the database. In this case, a further lookup is done in the host table to find a match on the Host and Db fields. If no host table entry matches, access is denied. If there is a match, the user’s database-specific privileges are computed as the intersection (not the union!) of the privileges in the db and host table entries, i.e., the privileges that are ‘Y’ in both entries. (This way you can grant general privileges in the db table entry and then selectively restrict them on a host-by-host basis using the host table entries.)

After determining the database-specific privileges granted by the db and host table entries, the server adds them to the global privileges granted by the user table. If the result allows the requested operation, access is granted. Otherwise, the server checks the user’s table and column privileges in the tables_priv and columns_priv tables and adds those to the user’s privileges. Access is allowed or denied based on the result.

Expressed in boolean terms, the preceding description of how a user’s privileges are calculated may be summarized like this:

\[
global\ privileges \ OR \ (database\ privileges \ AND \ host\ privileges) \ OR \ table\ privileges
\]
It may not be apparent why, if the global user entry privileges are initially found to be insufficient for the requested operation, the server adds those privileges to the database-, table- and column-specific privileges later. The reason is that a request might require more than one type of privilege. For example, if you execute an `INSERT ... SELECT` statement, you need both `insert` and `select` privileges. Your privileges might be such that the user table entry grants one privilege and the db table entry grants the other. In this case, you have the necessary privileges to perform the request, but the server cannot tell that from either table by itself; the privileges granted by both entries must be combined.

The host table can be used to maintain a list of “secure” servers. At TcX, the host table contains a list of all machines on the local network. These are granted all privileges.

You can also use the host table to indicate hosts that are not secure. Suppose you have a machine `public.your.domain` that is located in a public area that you do not consider secure. You can allow access to all hosts on your network except that machine by using host table entries like this:

+--------------------+----+---
| Host               | Db | ...
+--------------------+----+---
| public.your.domain | %  | ... (all privileges set to 'N')
| %.your.domain      | %  | ... (all privileges set to 'Y')
+--------------------+---+

Naturally, you should always test your entries in the grant tables (e.g., using `mysqlaccess`) to make sure your access privileges are actually set up the way you think they are.

### 6.11 When privilege changes take effect

When `mysqld` starts, all grant table contents are read into memory and become effective at that point.

Modifications to the grant tables that you perform using `GRANT`, `REVOKE`, or `SET PASSWORD` are noticed by the server immediately.

If you modify the grant tables manually (using `INSERT`, `UPDATE`, etc.), you should execute a `FLUSH PRIVILEGES` statement or run `mysqladmin flush-privileges` to tell the server to reload the grant tables. Otherwise your changes will have no effect until you restart the server.

When the server notices that the grant tables have been changed, existing client connections are affected as follows:

- Table and column privilege changes take effect with the client’s next request.
- Database privilege changes take effect at the next `USE db_name` command.

Global privilege changes and password changes take effect the next time the client connects.
6.12 Setting up the initial MySQL privileges

After installing MySQL, you set up the initial access privileges by running scripts/mysql_install_db. See Section 4.7.1 [Quick install], page 45. The scripts/mysql_install_db script starts up the mysqld server, then initializes the grant tables to contain the following set of privileges:

- The MySQL root user is created as a superuser who can do anything. Connections must be made from the local host.
  
  **Note:** The initial root password is empty, so anyone can connect as root *without a password* and be granted all privileges.

- An anonymous user is created that can do anything with databases that have a name of 'test' or starting with 'test_'. Connections must be made from the local host. This means any local user can connect and be treated as the anonymous user.

- Other privileges are denied. For example, normal users can’t use mysqladmin shutdown or mysqladmin processlist.

**Note:** The default privileges are different for Win32. See Section 4.12.4 [Win32 running], page 76.

Since your installation is initially wide open, one of the first things you should do is specify a password for the MySQL root user. You can do this as follows (note that you specify the password using the PASSWORD() function):

shell> mysql -u root mysql
mysql> UPDATE user SET Password=PASSWORD('new_password')
WHERE user='root';
mysql> FLUSH PRIVILEGES;

You can in MySQL 3.22 and above use the SET PASSWORD statement:

shell> mysql -u root mysql
mysql> SET PASSWORD FOR root=PASSWORD('new_password');

Another way to set the password is by using the mysqladmin command:

shell> mysqladmin -u root password new_password

Note that if you update the password in the user table directly using the first method, you must tell the server to reread the grant tables (with FLUSH PRIVILEGES), since the change will go unnoticed otherwise.

Once the root password has been set, thereafter you must supply that password when you connect to the server as root.

You may wish to leave the root password blank so that you don’t need to specify it while you perform additional setup or testing, but be sure to set it before using your installation for any real production work.

See the scripts/mysql_install_db script to see how it sets up the default privileges. You can use this as a basis to see how to add other users.

If you want the initial privileges to be different than those just described above, you can modify mysql_install_db before you run it.
To recreate the grant tables completely, remove all the '*.frm', '*.MYI' and '*.MYD' files in the directory containing the mysql database. (This is the directory named 'mysql' under the database directory, which is listed when you run mysqld --help.) Then run the mysql_install_db script, possibly after editing it first to have the privileges you want.

**NOTE:** For MySQL versions older than 3.22.10, you should NOT delete the '*.frm' files. If you accidentally do this, you should copy them back from your MySQL distribution before running mysql_install_db.

### 6.13 Adding new user privileges to MySQL

You can add users two different ways: by using GRANT statements or by manipulating the MySQL grant tables directly. The preferred method is to use GRANT statements, because they are more concise and less error-prone.

The examples below show how to use the mysql client to set up new users. These examples assume that privileges are set up according to the defaults described in the previous section. This means that to make changes, you must be on the same machine where mysqld is running, you must connect as the MySQL root user, and the root user must have the **insert** privilege for the mysql database and the **reload** administrative privilege. Also, if you have changed the root user password, you must specify it for the mysql commands below.

You can add new users by issuing GRANT statements:

```
shell> mysql --user=root mysql
mysql> GRANT ALL PRIVILEGES ON *.* TO monty@localhost
     IDENTIFIED BY 'something' WITH GRANT OPTION;
mysql> GRANT ALL PRIVILEGES ON *.* TO monty@"%"
     IDENTIFIED BY 'something' WITH GRANT OPTION;
mysql> GRANT RELOAD,PROCESS ON *.* TO admin@localhost;
mysql> GRANT USAGE ON *.* TO dummy@localhost;
```

These GRANT statements set up three new users:

- **monty**  
  A full superuser who can connect to the server from anywhere, but who must use a password 'something' to do so. Note that we must issue GRANT statements for both monty@localhost and monty@"%". If we don't add the entry with localhost, the anonymous user entry for localhost that is created by mysql_install_db will take precedence when we connect from the local host, because it has a more specific Host field value and thus comes earlier in the user table sort order.

- **admin**  
  A user who can connect from localhost without a password and who is granted the **reload** and **process** administrative privileges. This allows the user to execute the mysqladmin reload, mysqladmin refresh and mysqladmin flush-commands, as well as mysqladmin processlist. No database-related privileges are granted. They can be granted later by issuing additional GRANT statements.

- **dummy**  
  A user who can connect without a password, but only from the local host. The global privileges are all set to 'N' — the USAGE privilege type allows you to set
up a user with no privileges. It is assumed that you will grant database-specific privileges later.

You can also add the same user access information directly by issuing `INSERT` statements and then telling the server to reload the grant tables:

```shell
shell> mysql --user=root mysql
mysql> INSERT INTO user VALUES('localhost','monty',PASSWORD('something'),
   'Y','Y','Y','Y','Y','Y','Y','Y','Y','Y','Y','Y','Y','Y','Y')
mysql> INSERT INTO user VALUES('%','monty',PASSWORD('something'),
   'Y','Y','Y','Y','Y','Y','Y','Y','Y','Y','Y','Y','Y','Y','Y','Y')
mysql> INSERT INTO user SET Host='localhost',User='admin',
   Reload_priv='Y', Process_priv='Y';
mysql> INSERT INTO user (Host,User,Password)
   VALUES('localhost','dummy','');
mysql> FLUSH PRIVILEGES;
```

Depending on your MySQL version, you may have to use a different number of 'Y' values above (versions prior to 3.22.11 had fewer privilege columns). For the `admin` user, the more readable extended `INSERT` syntax that is available starting with 3.22.11 is used.

Note that to set up a superuser, you need only create a `user` table entry with the privilege fields set to 'Y'. No `db` or `host` table entries are necessary.

The privilege columns in the `user` table were not set explicitly in the last `INSERT` statement (for the `dummy` user), so those columns are assigned the default value of 'N'. This is the same thing that `GRANT USAGE` does.

The following example adds a user `custom` who can connect from hosts `localhost`, `server.domain` and `whitehouse.gov`. He wants to access the `bankaccount` database only from `localhost`, the `expenses` database only from `whitehouse.gov` and the `customer` database from all three hosts. He wants to use the password `stupid` from all three hosts.

To set up this user’s privileges using `GRANT` statements, run these commands:

```shell
shell> mysql --user=root mysql
mysql> GRANT SELECT,INSERT,UPDATE,DELETE,CREATE,DROP
   ON bankaccount.*
   TO custom@localhost
   IDENTIFIED BY 'stupid';
mysql> GRANT SELECT,INSERT,UPDATE,DELETE,CREATE,DROP
   ON expenses.*
   TO custom@whitehouse.gov
   IDENTIFIED BY 'stupid';
mysql> GRANT SELECT,INSERT,UPDATE,DELETE,CREATE,DROP
   ON customer.*
   TO custom@'%
   IDENTIFIED BY 'stupid';
```

To set up the user’s privileges by modifying the grant tables directly, run these commands (note the `FLUSH PRIVILEGES` at the end):

```shell
shell> mysql --user=root mysql
mysql> INSERT INTO user (Host,User,Password)
   VALUES('localhost','custom',PASSWORD('stupid'));
```
mysql> INSERT INTO user (Host, User, Password)
VALUES ('server.domain', 'custom', PASSWORD('stupid'));

mysql> INSERT INTO user (Host, User, Password)
VALUES ('whitehouse.gov', 'custom', PASSWORD('stupid'));

mysql> INSERT INTO db
(Host, Db, User, Select_priv, Insert_priv, Update_priv, Delete_priv,
Create_priv, Drop_priv)
VALUES
('localhost', 'bankaccount', 'custom', 'Y', 'Y', 'Y', 'Y', 'Y', 'Y');

mysql> INSERT INTO db
(Host, Db, User, Select_priv, Insert_priv, Update_priv, Delete_priv,
Create_priv, Drop_priv)
VALUES
('whitehouse.gov', 'expenses', 'custom', 'Y', 'Y', 'Y', 'Y', 'Y', 'Y');

mysql> INSERT INTO db
(Host, Db, User, Select_priv, Insert_priv, Update_priv, Delete_priv,
Create_priv, Drop_priv)
VALUES ('%', 'customer', 'custom', 'Y', 'Y', 'Y', 'Y', 'Y', 'Y');

mysql> FLUSH PRIVILEGES;

The first three INSERT statements add user table entries that allow user custom to connect from the various hosts with the given password, but grant no permissions to him (all privileges are set to the default value of 'N'). The next three INSERT statements add db table entries that grant privileges to custom for the bankaccount, expenses and customer databases, but only when accessed from the proper hosts. As usual, when the grant tables are modified directly, the server must be told to reload them (with FLUSH PRIVILEGES) so that the privilege changes take effect.

If you want to give a specific user access from any machine in a given domain, you can issue a GRANT statement like the following:

```
mysql> GRANT ... ON *.*
    TO myusername@"%.mydomainname.com"
    IDENTIFIED BY 'mypassword';
```

To do the same thing by modifying the grant tables directly, do this:

```
mysql> INSERT INTO user VALUES ('%.mydomainname.com', 'myusername',
    PASSWORD('mypassword'),...);

mysql> FLUSH PRIVILEGES;
```

You can also use xmysqladmin, mysql_webadmin and even xmysql to insert, change and update values in the grant tables. You can find these utilities at the MySQL Contrib directory (http://www.mysql.com/Contrib/).

### 6.14 How to set up passwords

The examples in the preceding sections illustrate an important principle: when you store a non-empty password using INSERT or UPDATE statements, you must use the PASSWORD()
function to encrypt it. This is because the `user` table stores passwords in encrypted form, not as plaintext. If you forget that fact, you are likely to attempt to set passwords like this:

```
shell> mysql -u root mysql
mysql> INSERT INTO user (Host,User,Password)
    VALUES('%','jeffrey','biscuit');
mysql> FLUSH PRIVILEGES;
```

The result is that the plaintext value `biscuit` is stored as the password in the `user` table. When the user `jeffrey` attempts to connect to the server using this password, the `mysql` client encrypts it with `PASSWORD()` and sends the result to the server. The server compares the value in the `user` table (which is the plaintext value `biscuit`) to the encrypted password (which is not `biscuit`). The comparison fails and the server rejects the connection:

```
shell> mysql -u jeffrey -pbiscuit test
Access denied
```

Since passwords must be encrypted when they are inserted in the `user` table, the `INSERT` statement should have been specified like this instead:

```
mysql> INSERT INTO user (Host,User,Password)
    VALUES('%','jeffrey',PASSWORD('biscuit'));
```

You must also use the `PASSWORD()` function when you use `SET PASSWORD` statements:

```
mysql> SET PASSWORD FOR jeffrey@"%" = PASSWORD('biscuit');
```

If you set passwords using the `GRANT ... IDENTIFIED BY` statement or the `mysqladmin password` command, the `PASSWORD()` function is unnecessary. They both take care of encrypting the password for you, so you would specify a password of `biscuit` like this:

```
mysql> GRANT USAGE ON *.* TO jeffrey@"%" IDENTIFIED BY 'biscuit';
```

or

```
shell> mysqladmin -u jeffrey password biscuit
```

Note: `PASSWORD()` does not perform password encryption in the same way that Unix passwords are encrypted. You should not assume that if your Unix password and your MySQL password are the same, `PASSWORD()` will result in the same encrypted value as is stored in the Unix password file. See Section 6.4 [User names], page 109.

### 6.15 Causes of Access denied errors

If you encounter `Access denied` errors when you try to connect to the MySQL server, the list below indicates some courses of action you can take to correct the problem:

- Did you run the `mysql_install_db` script after installing MySQL, to set up the initial grant table contents? If not, do so. See Section 6.12 [Default privileges], page 122.

Test the initial privileges by executing this command:

```
shell> mysql -u root test
```

The server should let you connect without error. You should also make sure you have a file `user.MYD` in the MySQL database directory. Ordinarily, this is `PATH/var/mysql/user.MYD`, where `PATH` is the pathname to the MySQL installation root.
After a fresh installation, you should connect to the server and set up your users and their access permissions:

```
shell> mysql -u root mysql
```

The server should let you connect because the MySQL root user has no password initially. Since that is also a security risk, setting the root password is something you should do while you’re setting up your other MySQL users.

If you try to connect as root and get this error:

```
Access denied for user: '@unknown' to database mysql
```

this means that you don’t have an entry in the user table with a User column value of ‘root’ and that mysqld cannot resolve the hostname for your client. In this case, you must restart the server with the --skip-grant-tables option and edit your ‘/etc/hosts’ or ‘\windows\hosts’ file to add a entry for your host.

- If you updated an existing MySQL installation from a pre-3.22.11 version to 3.22.11 or later, did you run the mysql_fix_privilege_tables script? If not, do so. The structure of the grant tables changed with MySQL 3.22.11 when the GRANT statement became functional.

- If you make changes to the grant tables directly (using INSERT or UPDATE statement) and your changes seem to be ignored, remember that you must issue a FLUSH PRIVILEGES statement or execute a mysqladmin flush-privileges command to cause the server to reread the tables. Otherwise your changes have no effect until the next time the server is restarted. Remember that after you set the root password, you won’t need to specify it until after you flush the privileges, because the server still won’t know you’ve changed the password yet!

- If your privileges seem to have changed in the middle of a session, it may be that a superuser has changed them. Reloading the grant tables affects new client connections, but it also affects existing connections as indicated in Section 6.11 [Privilege changes], page 121.

- For testing, start the mysqld daemon with the --skip-grant-tables option. Then you can change the MySQL grant tables and use the mysqlaccess script to check whether or not your modifications have the desired effect. When you are satisfied with your changes, execute mysqladmin flush-privileges to tell the mysqld server to start using the new grant tables. Note: Reloading the grant tables overrides the --skip-grant-tables option. This allows you to tell the server to begin using the grant tables again without bringing it down and restarting it.

- If you have access problems with a Perl, Python or ODBC program, try to connect to the server with mysql -u user_name db_name or mysql -u user_name -pyour_pass db_name. If you are able to connect using the mysql client, there is a problem with your program and not with the access privileges. (Notice that there is no space between -p and the password; you can also use the --password=your_pass syntax to specify the password.)

- If you can’t get your password to work, remember that you must use the PASSWORD() function if you set the password with the INSERT, UPDATE or SET PASSWORD statements. The PASSWORD() function is unnecessary if you specify the password using the
Chapter 6: The MySQL access privilege system

GRANT ... IDENTIFIED BY statement or the mysqladmin password command. See Section 6.14 [Passwords], page 125.

- localhost is a synonym for your local hostname, and is also the default host to which clients try to connect if you specify no host explicitly. However, connections to localhost do not work if you are running on a system that uses MIT-pthreads (localhost connections are made using Unix sockets, which are not supported by MIT-pthreads). To avoid this problem on such systems, you should use the --host option to name the server host explicitly. This will make a TCP/IP connection to the mysqld server. In this case, you must have your real hostname in user table entries on the server host. (This is true even if you are running a client program on the same host as the server.)

- If you get an Access denied error when trying to connect to the database with mysql -u user_name db_name, you may have a problem with the user table. Check this by executing mysql -u root mysql and issuing this SQL statement:

  mysql> SELECT * FROM user;

  The result should include an entry with the Host and User columns matching your computer’s hostname and your MySQL user name.

- The Access denied error message will tell you who you are trying to log in as, the host from which you are trying to connect, and whether or not you were using a password. Normally, you should have one entry in the user table that exactly matches the hostname and user name that were given in the error message.

- If you get the following error when you try to connect from a different host than the one on which the MySQL server is running, then there is no row in the user table that matches that host:

  Host ... is not allowed to connect to this MySQL server

  You can fix this by using the command line tool mysql (on the server host!) to add a row to the user table for the user/hostname combination from which you are trying to connect. If you are not running MySQL 3.22 and you don’t know the IP number or hostname of the machine from which you are connecting, you should put an entry with '%' as the Host column value in the user table and restart mysqld with the --log option on the server machine. After trying to connect from the client machine, the information in the MySQL log will indicate how you really did connect. (Then replace the '%' in the user table entry with the actual hostname that shows up in the log. Otherwise, you’ll have a system that is insecure.)

- If mysql -u root test works but mysql -h your_hostname -u root test results in Access denied, then you may not have the correct name for your host in the user table. A common problem here is that the Host value in the user table entry specifies an unqualified hostname, but your system’s name resolution routines return a fully-qualified domain name (or vice-versa). For example, if you have an entry with host ’tcx’ in the user table, but your DNS tells MySQL that your hostname is ’tcx.subnet.se’, the entry will not work. Try adding an entry to the user table that contains the IP number of your host as the Host column value. (Alternatively, you could add an entry to the user table with a Host value that contains a wildcard—for example, ’tcx.%’). However, use of hostnames ending with ’%’ is insecure and is not recommended!)

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• If `mysql -u user_name test` works but `mysql -u user_name other_db_name` doesn’t work, you don’t have an entry for `other_db_name` listed in the `db` table.

• If `mysql -u user_name db_name` works when executed on the server machine, but `mysql -u host_name -u user_name db_name` doesn’t work when executed on another client machine, you don’t have the client machine listed in the `user` table or the `db` table.

• If you can’t figure out why you get `Access denied`, remove from the `user` table all entries that have `Host` values containing wildcards (entries that contain `%` or `_`). A very common error is to insert a new entry with `Host='%'` and `User='some user'`, thinking that this will allow you to specify `localhost` to connect from the same machine. The reason that this doesn’t work is that the default privileges include an entry with `Host='localhost'` and `User=''.` Since that entry has a `Host` value `localhost` that is more specific than `%`, it is used in preference to the new entry when connecting from `localhost`! The correct procedure is to insert a second entry with `Host='localhost'` and `User='some_user'`, or to remove the entry with with `Host='localhost'` and `User=''.`

• If you get the following error, you may have a problem with the `db` or `host` table:

```
Access to database denied
```

If the entry selected from the `db` table has an empty value in the `Host` column, make sure there are one or more corresponding entries in the `host` table specifying which hosts the `db` table entry applies to.

If you get the error when using the SQL commands `SELECT ... INTO OUTFILE` or `LOAD DATA INFILE`, your entry in the `user` table probably doesn’t have the `file` privilege enabled.

• Remember that client programs will use connection parameters specified in configuration files or environment variables. If a client seems to be sending the wrong default connection parameters when you don’t specify them on the command line, check your environment and the `.my.cnf` file in your home directory. You might also check the system-wide MySQL configuration files, though it is far less likely that client connection parameters will be specified there. See Section 4.15.4 [Option files], page 89. If you get `Access denied` when you run a client without any options, make sure you haven’t specified an old password in any of your option files! See Section 4.15.4 [Option files], page 89.

• If everything else fails, start the `mysqld` daemon with a debugging option (for example, `--debug=d,general,query`). This will print host and user information about attempted connections, as well as information about each command issued. See Section G.1 [Debugging server], page 506.

• If you have any other problems with the MySQL grant tables and feel you must post the problem to the mailing list, always provide a dump of the MySQL grant tables. You can dump the tables with the `mysqldump mysql` command. As always, post your problem using the `mysqlbug` script. In some cases you may restart `mysqld` with `--skip-grant-tables` to be able to run `mysqldump`.
Chapter 7: MySQL language reference

7.1 Literals: how to write strings and numbers

7.1.1 Strings

A string is a sequence of characters, surrounded by either single quote (‘’’) or double quote (‘“’’) characters (the later only if you don’t run in ANSI mode). Examples:

'"a string"
"another string"

Within a string, certain sequences have special meaning. Each of these sequences begins with a backslash (‘\’), known as the escape character. MySQL recognizes the following escape sequences:

\0 An ASCII 0 (NUL) character.
\n A newline character.
\t A tab character.
\r A carriage return character.
\b A backspace character.
\' A single quote (‘’’) character.
\" A double quote (‘“’’) character.
\\ A backslash (‘\’) character.
\% A ‘%’ character. This is used to search for literal instances of ‘%’ in contexts where ‘%’ would otherwise be interpreted as a wildcard character.
\_ A ‘_’ character. This is used to search for literal instances of ‘_’ in contexts where ‘_’ would otherwise be interpreted as a wildcard character.

Note that if you use ‘\%' or ‘\%_’ in some string contexts, these will return the strings ‘\%’ and ‘\_’ and not ‘%’ and ‘_’.

There are several ways to include quotes within a string:

- A ‘’’ inside a string quoted with ‘’’ may be written as ‘’’’.’’.
- A ‘“” inside a string quoted with ‘“”’ may be written as ‘“”’.
- You can precede the quote character with an escape character (‘\’).
- A ‘’’ inside a string quoted with ‘“”’ needs no special treatment and need not be doubled or escaped. In the same way, ‘“” inside a string quoted with ‘’’ needs no special treatment.
The SELECT statements shown below demonstrate how quoting and escaping work:

```sql
mysql> SELECT 'hello', "hello", ""hello"", 'hel''lo', '\hello';
+-------+---------+-----------+--------+--------+
| hello | "hello" | ""hello"" | hel'lo | "hello |
+-------+---------+-----------+--------+--------+
mysql> SELECT "hello", 'hello', "'hello'", "hel"lo", "\hello";
+-------+---------+-----------+--------+--------+
| hello | 'hello' | ''hello'' | hel"lo | "hello |
+-------+---------+-----------+--------+--------+
mysql> SELECT "This
Is
Four
lines";
| This
Is
Four
lines |
+--------------------+
```

If you want to insert binary data into a BLOB column, the following characters must be represented by escape sequences:

```
NUL    ASCII 0. You should represent this by '\0' (a backslash and an ASCII '0' character).
\      ASCII 92, backslash. Represent this by '\\'.
'      ASCII 39, single quote. Represent this by '\'.
"      ASCII 34, double quote. Represent this by '"'.
```

If you write C code, you can use the C API function `mysql_escape_string()` to escape characters for the INSERT statement. See Section 21.3 [C API function overview], page 374. In Perl, you can use the `quote` method of the DBI package to convert special characters to the proper escape sequences. See Section 21.5.2 [Perl DBI Class], page 417.

You should use an escape function on any string that might contain any of the special characters listed above!

### 7.1.2 Numbers

Integers are represented as a sequence of digits. Floats use '.' as a decimal separator. Either type of number may be preceded by '-' to indicate a negative value.

Examples of valid integers:

```
1221
0
-32
```

Examples of valid floating-point numbers:
An integer may be used in a floating-point context; it is interpreted as the equivalent floating-point number.

### 7.1.3 Hexadecimal values

MySQL supports hexadecimal values. In number context these acts like an integer (64 bit precision). In string context these acts like a binary string where each pair of hex digits is converted to a character.

```sql
mysql> SELECT 0xa+0
    -> 10
mysql> SELECT 0x5061756c;
    -> Paul
```

Hexadecimal strings is often used by ODBC to give values for BLOB columns.

### 7.1.4 NULL values

The NULL value means “no data” and is different from values such as 0 for numeric types or the empty string for string types. See Section 19.15 [Problems with NULL], page 364. NULL may be represented by \N when using the text file import or export formats (LOAD DATA INFILE, SELECT ... INTO OUTFILE). See Section 7.16 [LOAD DATA], page 204.

### 7.1.5 Database, table, index, column and alias names

Database, table, index, column and alias names all follow the same rules in MySQL:

Note that the rules changed starting with MySQL 3.23.6 when we introduced quoting of identifiers (database, table and column names) with ‘ (" will also work to quote identifiers if you run in ANSI mode).

<table>
<thead>
<tr>
<th>Identifier</th>
<th>max length</th>
<th>Allowed characters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Database</td>
<td>64</td>
<td>Any character that is allowed</td>
</tr>
<tr>
<td>Table</td>
<td>64</td>
<td>Any character that is allowed</td>
</tr>
<tr>
<td>Column</td>
<td>64</td>
<td>All characters</td>
</tr>
<tr>
<td>Alias</td>
<td>255</td>
<td>All characters</td>
</tr>
</tbody>
</table>

Note that in addition to the above, you can’t have ASCII(0) or ASCII(255) in an identifier.

Note that if the identifier is a restricted word or contains special character you must always quote it with ‘ when you use it:

```
SELECT * from 'select' where 'select'.id > 100;
```

In previous versions of MySQL, the name rules are as follows:

Version: 3.23.11-alpha Printed: 25 February 2000
• A name may consist of alphanumeric characters from the current character set and also ‘_’ and ‘$’. The default character set is ISO-8859-1 Latin1; this may be changed by recompiling MySQL. See Section 10.1.1 [Character sets], page 271.

• A name may start with any character that is legal in a name. In particular, a name may start with a number (this differs from many other database systems!). However, a name cannot consist only of numbers.

• You cannot use the ‘.’ character in names because it is used to extend the format by which you can refer to columns (see immediately below).

It is recommended that you do not use names like 1e, because an expression like 1e+1 is ambiguous. It may be interpreted as the expression 1e + 1 or as the number 1e+1.

In MySQL you can refer to a column using any of the following forms:

<table>
<thead>
<tr>
<th>Column reference</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>col_name</td>
<td>Column col_name from whichever table used in the query contains a column of that name</td>
</tr>
<tr>
<td>tbl_name.col_name</td>
<td>Column col_name from table tbl_name of the current database</td>
</tr>
<tr>
<td>db_name.tbl_name.col_name</td>
<td>Column col_name from table tbl_name of the database db_name. This form is available in MySQL 3.22 or later.</td>
</tr>
<tr>
<td>‘column_name’</td>
<td>A column that is a keyword or contains special characters.</td>
</tr>
</tbody>
</table>

You need not specify a tbl_name or db_name.tbl_name prefix for a column reference in a statement unless the reference would be ambiguous. For example, suppose tables t1 and t2 each contain a column c, and you retrieve c in a SELECT statement that uses both t1 and t2. In this case, c is ambiguous because it is not unique among the tables used in the statement, so you must indicate which table you mean by writing t1.c or t2.c. Similarly, if you are retrieving from a table t in database db1 and from a table t in database db2, you must refer to columns in those tables as db1.t.col_name and db2.t.col_name.

The syntax .tbl_name means the table tbl_name in the current database. This syntax is accepted for ODBC compatibility, because some ODBC programs prefix table names with a ‘.’ character.

7.1.5.1 Case sensitivity in names

In MySQL, databases and tables correspond to directories and files within those directories. Consequently, the case sensitivity of the underlying operating system determines the case sensitivity of database and table names. This means database and table names are case sensitive in Unix and case insensitive in Win32.

Note: Although database and table names are case insensitive for Win32, you should not refer to a given database or table using different cases within the same query. The following query would not work because it refers to a table both as my_table and as MY_TABLE:

```sql
mysql> SELECT * FROM my_table WHERE MY_TABLE.col=1;
```

Column names are case insensitive in all cases.
Aliases on tables are case sensitive. The following query would not work because it refers to the alias both as a and as A:

```sql
mysql> SELECT col_name FROM tbl_name AS a
    > WHERE a.col_name = 1 OR A.col_name = 2;
```

Aliases on columns are case insensitive.

### 7.2 User variables

MySQL supports thread specific variables with the `@variablename` syntax. A variable name may consist of alphanumeric characters from the current character set and also ‘_’, ‘$’, and ‘.’. The default character set is ISO-8859-1 Latin1; this may be changed by recompiling MySQL. See Section 10.1.1 [Character sets], page 271.

Variables don’t have to be initialized. They contain `NULL` by default and can store an integer, real or string value. All variables for a thread are automatically freed when the thread exits.

You can set a variable with the `SET` syntax:

```sql
SET @variable= { integer expression | real expression | string expression } [, @variable= ... ].
```

You can also set a variable in an expression with the `@variable:=expr` syntax:

```sql
select @t1:=(@t2:=1)+@t3:=4, @t1, @t2, @t3;
```

<table>
<thead>
<tr>
<th>@t1:=(@t2:=1)+@t3:=4</th>
<th>@t1</th>
<th>@t2</th>
<th>@t3</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>5</td>
<td>1</td>
<td>4</td>
</tr>
</tbody>
</table>

(We had to use the `:=` syntax here, because `=` was reserved for comparisons.)

User variables may be used where expressions are allowed. Note that this does not currently include use in contexts where a number is explicitly required, such as in the `LIMIT` clause of a `SELECT` statement, or the `IGNORE number LINES` clause of a `LOAD DATA` statement.

### 7.3 Column types

MySQL supports a number of column types, which may be grouped into three categories: numeric types, date and time types, and string (character) types. This section first gives an overview of the types available and summarizes the storage requirements for each column type, then provides a more detailed description of the properties of the types in each category. The overview is intentionally brief. The more detailed descriptions should be consulted for additional information about particular column types, such as the allowable formats in which you can specify values.

The column types supported by MySQL are listed below. The following code letters are used in the descriptions:
Indicates the maximum display size. The maximum legal display size is 255.

Applies to floating-point types and indicates the number of digits following the decimal point. The maximum possible value is 30, but should be no greater than 4 - 2.

Square brackets (‘[’ and ‘]’) indicate parts of type specifiers that are optional.

Note that if you specify ZEROFILL for a column, MySQL will automatically add the UNSIGNED attribute to the column.

TINYINT[(M)] [UNSIGNED] [ZEROFILL]
A very small integer. The signed range is -128 to 127. The unsigned range is 0 to 255.

SMALLINT[(M)] [UNSIGNED] [ZEROFILL]
A small integer. The signed range is -32768 to 32767. The unsigned range is 0 to 65535.

MEDIUMINT[(M)] [UNSIGNED] [ZEROFILL]
A medium-size integer. The signed range is -8388608 to 8388607. The unsigned range is 0 to 16777215.

INT[(M)] [UNSIGNED] [ZEROFILL]
A normal-size integer. The signed range is -2147483648 to 2147483647. The unsigned range is 0 to 4294967295.

INTEGER[(M)] [UNSIGNED] [ZEROFILL]
This is a synonym for INT.

BIGINT[(M)] [UNSIGNED] [ZEROFILL]
A large integer. The signed range is -9223372036854775808 to 9223372036854775807. The unsigned range is 0 to 18446744073709551615. Note that all arithmetic is done using signed BIGINT or DOUBLE values, so you shouldn’t use unsigned big integers larger than 9223372036854775807 (63 bits) except with bit functions! Note that -, *, and + will use BIGINT arithmetic when both arguments are INTEGER values! This means that if you multiply two big integers (or results from functions that return integers) you may get unexpected results if the result is larger than 9223372036854775807.

FLOAT(precision) [ZEROFILL]
A floating-point number. Cannot be unsigned. precision can be <=24 for a single precision floating point number and between 25 and 53 for a double precision floating point number. These types are like the FLOAT and DOUBLE types described immediately below. FLOAT(X) have the same ranges as the corresponding FLOAT and DOUBLE types, but the display size and number of decimals is undefined.

In MySQL 3.23, this is a true floating point value. In earlier MySQL versions, FLOAT(precision) always has 2 decimals.

This syntax is provided for ODBC compatibility.
FLOAT[(M,D)] [ZEROFILL]
A small (single-precision) floating-point number. Cannot be unsigned. Allowable values are \(-3.402823466E+38\) to \(-1.175494351E-38\), 0 and \(1.175494351E-38\) to \(3.402823466E+38\). The M is the display width and D is the number of decimals. FLOAT without an argument or with an argument of \(\leq 24\) stands for a single-precision floating point number.

DOUBLE[(M,D)] [ZEROFILL]
A normal-size (double-precision) floating-point number. Cannot be unsigned. Allowable values are \(-1.7976931348623157E+308\) to \(-2.2250738585072014E-308\), 0 and \(2.2250738585072014E-308\) to \(1.7976931348623157E+308\). The M is the display width and D is the number of decimals. DOUBLE without an argument or FLOAT(X) where \(25 \leq X \leq 53\) stands for a double-precision floating point number.

DOUBLE PRECISION[(M,D)] [ZEROFILL]
REAL[(M,D)] [ZEROFILL]
These are synonyms for DOUBLE.

DECIMAL[(M[,D])] [ZEROFILL]
An unpacked floating-point number. Cannot be unsigned. Behaves like a CHAR column: “unpacked” means the number is stored as a string, using one character for each digit of the value. The decimal point, and, for negative numbers, the ‘-’ sign is not counted in M. If D is 0, values will have no decimal point or fractional part. The maximum range of DECIMAL values is the same as for DOUBLE, but the actual range for a given DECIMAL column may be constrained by the choice of M and D.

If D is left out it’s set to 0. If M is left out it’s set to 10.

Note that in MySQL 3.22 the M argument includes the sign and the decimal point.

NUMERIC(M,D) [ZEROFILL]
This is a synonym for DECIMAL.

DATE
A date. The supported range is '1000-01-01' to '9999-12-31'. MySQL displays DATE values in 'YYYY-MM-DD' format, but allows you to assign values to DATE columns using either strings or numbers.

DATETIME
A date and time combination. The supported range is '1000-01-01 00:00:00' to '9999-12-31 23:59:59'. MySQL displays DATETIME values in 'YYYY-MM-DD HH:MM:SS' format, but allows you to assign values to DATETIME columns using either strings or numbers.

TIMESTAMP[(M)]
A timestamp. The range is '1970-01-01 00:00:00' to sometime in the year 2037. MySQL displays TIMESTAMP values in YYYYMMDDHHMMSS, YYMMDHHMMSS, YYYYMMDD or YYMMDD format, depending on whether M is 14 (or missing), 12, 8

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or 6, but allows you to assign values to TIMESTAMP columns using either strings or numbers. A TIMESTAMP column is useful for recording the date and time of an INSERT or UPDATE operation because it is automatically set to the date and time of the most recent operation if you don’t give it a value yourself. You can also set it to the current date and time by assigning it a NULL value. See Section 7.3.3 [Date and time types], page 141.

TIME
A time. The range is ’-838:59:59’ to ’838:59:59’. MySQL displays TIME values in ’HH:MM:SS’ format, but allows you to assign values to TIME columns using either strings or numbers.

YEAR[(2|4)]
A year in 2- or 4- digit formats (default is 4-digit). The allowable values are 1901 to 2155, and 0000 in the 4 year format and 1970-2069 if you use the 2 digit format (70-69). MySQL displays YEAR values in YYYY format, but allows you to assign values to YEAR columns using either strings or numbers. (The YEAR type is new in MySQL 3.22.)

CHAR(M) [BINARY]
A fixed-length string that is always right-padded with spaces to the specified length when stored. The range of M is 1 to 255 characters. Trailing spaces are removed when the value is retrieved. CHAR values are sorted and compared in case-insensitive fashion according to the default character set unless the BINARY keyword is given.

NATIONAL CHAR (short form NCHAR) is the ANSI SQL way to define that a CHAR column should use the default CHARACTER set. This is default in MySQL. CHAR is a shorthand for CHARACTER. MySQL allows you to create a column of type CHAR(0). This is mainly useful when you have to be compliant with some old applications that depend on the existence of a column but that do not actually use the value. This is also quite nice when you need a column that only can take 2 values: A CHAR(0), that is not defined as NOT NULL, will only occupy one bit and can only take 2 values: NULL or "".

[NATIONAL] VARCHAR(M) [BINARY]
A variable-length string. Note: Trailing spaces are removed when the value is stored (this differs from the ANSI SQL specification). The range of M is 1 to 255 characters. VARCHAR values are sorted and compared in case-insensitive fashion unless the BINARY keyword is given. See Section 7.7.1 [Silent column changes], page 192.

VARCHAR is a shorthand for CHARACTER VARYING.

TINYBLOB

TINYTEXT
A BLOB or TEXT column with a maximum length of 255 (2^8 - 1) characters. See Section 7.7.1 [Silent column changes], page 192.
BLOB
TEXT
A BLOB or TEXT column with a maximum length of 65535 \(2^{16} - 1\) characters. See Section 7.7.1 [Silent column changes], page 192.

MEDIUMBLOB
MEDIUMTEXT
A BLOB or TEXT column with a maximum length of 16777215 \(2^{24} - 1\) characters. See Section 7.7.1 [Silent column changes], page 192.

LONGBLOB
LONGTEXT
A BLOB or TEXT column with a maximum length of 4294967295 \(2^{32} - 1\) characters. See Section 7.7.1 [Silent column changes], page 192.

ENUM('value1','value2',...)
An enumeration. A string object that can have only one value, chosen from the list of values 'value1', 'value2', ..., or NULL. An ENUM can have a maximum of 65535 distinct values.

SET('value1','value2',...)
A set. A string object that can have zero or more values, each of which must be chosen from the list of values 'value1', 'value2', .... A SET can have a maximum of 64 members.

7.3.1 Column type storage requirements

The storage requirements for each of the column types supported by MySQL are listed below by category.

Numeric types

<table>
<thead>
<tr>
<th>Column type</th>
<th>Storage required</th>
</tr>
</thead>
<tbody>
<tr>
<td>TINYINT</td>
<td>1 byte</td>
</tr>
<tr>
<td>SMALLINT</td>
<td>2 bytes</td>
</tr>
<tr>
<td>MEDIUMINT</td>
<td>3 bytes</td>
</tr>
<tr>
<td>INT</td>
<td>4 bytes</td>
</tr>
<tr>
<td>INTEGER</td>
<td>4 bytes</td>
</tr>
<tr>
<td>BIGINT</td>
<td>8 bytes</td>
</tr>
<tr>
<td>FLOAT(X)</td>
<td>4 if (X \leq 24) or 8 if (25 \leq X \leq 53)</td>
</tr>
<tr>
<td>FLOAT</td>
<td>4 bytes</td>
</tr>
<tr>
<td>DOUBLE</td>
<td>8 bytes</td>
</tr>
<tr>
<td>DOUBLE PRECISION</td>
<td>8 bytes</td>
</tr>
<tr>
<td>REAL</td>
<td>8 bytes</td>
</tr>
<tr>
<td>DECIMAL(M,D)</td>
<td>(M) bytes ((D+2, \text{if } M &lt; D))</td>
</tr>
<tr>
<td>NUMERIC(M,D)</td>
<td>(M) bytes ((D+2, \text{if } M &lt; D))</td>
</tr>
</tbody>
</table>
Date and time types

<table>
<thead>
<tr>
<th>Column type</th>
<th>Storage required</th>
</tr>
</thead>
<tbody>
<tr>
<td>DATE</td>
<td>3 bytes</td>
</tr>
<tr>
<td>DATETIME</td>
<td>8 bytes</td>
</tr>
<tr>
<td>TIMESTAMP</td>
<td>4 bytes</td>
</tr>
<tr>
<td>TIME</td>
<td>3 bytes</td>
</tr>
<tr>
<td>YEAR</td>
<td>1 byte</td>
</tr>
</tbody>
</table>

String types

<table>
<thead>
<tr>
<th>Column type</th>
<th>Storage required</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHAR(M)</td>
<td>M bytes, 1 &lt;= M &lt;= 255</td>
</tr>
<tr>
<td>VARCHAR(M)</td>
<td>L+1 bytes, where L &lt;= M and 1 &lt;= M &lt;= 255</td>
</tr>
<tr>
<td>TINYBLOB, TINYTEXT</td>
<td>L+1 bytes, where L &lt; 2^8</td>
</tr>
<tr>
<td>BLOB, TEXT</td>
<td>L+2 bytes, where L &lt; 2^16</td>
</tr>
<tr>
<td>MEDIUMBLOB, MEDIUMTEXT</td>
<td>L+3 bytes, where L &lt; 2^24</td>
</tr>
<tr>
<td>LONGBLOB, LONGTEXT</td>
<td>L+4 bytes, where L &lt; 2^32</td>
</tr>
<tr>
<td>ENUM('value1','value2',...)</td>
<td>1 or 2 bytes, depending on the number of enumeration values (65535 values maximum)</td>
</tr>
<tr>
<td>SET('value1','value2',...)</td>
<td>1, 2, 3, 4 or 8 bytes, depending on the number of set members (64 members maximum)</td>
</tr>
</tbody>
</table>

VARCHAR and the BLOB and TEXT types are variable-length types, for which the storage requirements depend on the actual length of column values (represented by L in the preceding table), rather than on the type’s maximum possible size. For example, a VARCHAR(10) column can hold a string with a maximum length of 10 characters. The actual storage required is the length of the string (L), plus 1 byte to record the length of the string. For the string ‘abcd’, L is 4 and the storage requirement is 5 bytes.

The BLOB and TEXT types require 1, 2, 3 or 4 bytes to record the length of the column value, depending on the maximum possible length of the type.

If a table includes any variable-length column types, the record format will also be variable-length. Note that when a table is created, MySQL may under certain conditions change a column from a variable-length type to a fixed-length type, or vice-versa. See Section 7.7.1 [Silent column changes], page 192.

The size of an ENUM object is determined by the number of different enumeration values. 1 byte is used for enumerations with up to 255 possible values. 2 bytes are used for enumerations with up to 65535 values.

The size of a SET object is determined by the number of different set members. If the set size is N, the object occupies (N+7)/8 bytes, rounded up to 1, 2, 3, 4 or 8 bytes. A SET can have a maximum of 64 members.

7.3.2 Numeric types

MySQL supports all of the ANSI/ISO SQL92 numeric types. These types include the exact numeric data types (NUMERIC, DECIMAL, INTEGER, and SMALLINT), as well as the approximate
numeric data types (FLOAT, REAL, and DOUBLE PRECISION). The keyword INT is a synonym for INTEGER, and the keyword DEC is a synonym for DECIMAL.

The NUMERIC and DECIMAL types are implemented as the same type by MySQL, as permitted by the SQL92 standard. They are used for values for which it is important to preserve exact precision, for example with monetary data. When declaring a column of one of these types the precision and scale can be (and usually is) specified; for example:

```
salary DECIMAL(9,2)
```

In this example, 9 (precision) represents the number of significant decimal digits which will be stored for values, and 2 (scale) represents the number of digits which will be stored following the decimal point. In this case, therefore, the range of values which can be stored in the salary column is from -9999999.99 to 9999999.99. In ANSI/ISO SQL92, the syntax DECIMAL(p) is equivalent to DECIMAL(p,0). Similarly, the syntax DECIMAL is equivalent to DECIMAL(p,0), where the implementation is allowed to decide the value of p.

MySQL does not currently support either of these variant forms of the DECIMAL/NUMERIC data types. This is not generally a serious problem, as the principal benefits of these types derive from the ability to control both precision and scale explicitly.

DECIMAL and NUMERIC values are stored as strings, rather than as binary floating point numbers, in order to preserve the decimal precision of those values. One character is used for each digit of the value, the decimal point (if scale > 0) and the ‘-’ sign (for negative numbers). If scale is 0, DECIMAL and NUMERIC values contain no decimal point or fractional part.

The maximum range of DECIMAL and NUMERIC values is the same as for DOUBLE, but the actual range for a given DECIMAL or NUMERIC column can be constrained by the precision or scale for a given column. When such a column is assigned a value with more digits following the decimal point than are allowed by the specified scale, the value is rounded to that scale. When a DECIMAL or NUMERIC column is assigned a value whose magnitude exceeds the range implied by the specified (or defaulted) precision and scale, MySQL stores the value representing the corresponding end point of that range.

As an extension to the ANSI/ISO SQL92 standard, MySQL also supports the integral types TINYINT, MEDIUMINT, and BIGINT as listed in the tables above. Another extension is supported by MySQL for optionally specifying the display width of an integral value in parentheses following the base keyword for the type (for example, INT(4)). This optional width specification is used to left-pad the display of values whose width is less than the width specified for the column, but does not constrain the range of values which can be stored in the column, nor the number of digits which will be displayed for values whose width exceeds that specified for the column. When used in conjunction with the optional extension attribute ZEROFILL the default padding of spaces is replaced with zeroes. For example, for a column declared as INT(5) ZEROFILL, a value of 4 is retrieved as 00004. Note that if you store larger values than the display width in an integral column, you may experience problems when MySQL generates temporary tables for some complicated joins as in these case MySQL trust that the data did fit into the original column width.

All integral types can have an optional (non-standard) attribute UNSIGNED. Unsigned values can be used when you want to allow only positive numbers in a column and you need a little bigger numeric range for the column.
The `FLOAT` type is used to represent approximate numeric data types. The ANSI/ISO SQL92 standard allows an optional specification of the precision (but not the range of the exponent) in bits following the keyword `FLOAT` in parentheses. The MySQL implementation also supports this optional precision specification. When the keyword `FLOAT` is used for a column type without a precision specification, MySQL uses four bytes to store the values. A variant syntax is also supported, with two numbers given in parentheses following the `FLOAT` keyword. With this option, the first number continues to represent the storage requirements for the value in bytes, and the second number specifies the number of digits to be stored and displayed following the decimal point (as with `DECIMAL` and `NUMERIC`). When MySQL is asked to store a number for such a column with more decimal digits following the decimal point than specified for the column, the value is rounded to eliminate the extra digits when the value is stored.

The `REAL` and `DOUBLE PRECISION` types do not accept precision specifications. As an extension to the ANSI/ISO SQL92 standard, MySQL recognizes `DOUBLE` as a synonym for the `DOUBLE PRECISION` type. In contrast with the standard’s requirement that the precision for `REAL` be smaller than that used for `DOUBLE PRECISION`, MySQL implements both as 8-byte double-precision floating point values (when running in not "Ansi mode"). For maximum portability, code requiring storage of approximate numeric data values should use `FLOAT` or `DOUBLE PRECISION` with no specification of precision or number of decimal points.

When asked to store a value in a numeric column that is outside the column type’s allowable range, MySQL clips the value to the appropriate endpoint of the range and stores the resulting value instead.

For example, the range of an `INT` column is -2147483648 to 2147483647. If you try to insert -9999999999 into an `INT` column, the value is clipped to the lower endpoint of the range, and -2147483648 is stored instead. Similarly, if you try to insert 9999999999, 2147483647 is stored instead.

If the `INT` column is `UNSIGNED`, the size of the column’s range is the same but its endpoints shift up to 0 and 4294967295. If you try to store -9999999999 and 9999999999, the values stored in the column become 0 and 4294967296.

Conversions that occur due to clipping are reported as “warnings” for `ALTER TABLE`, `LOAD DATA INFILE`, `UPDATE` and multi-row `INSERT` statements.

### 7.3.3 Date and time types

The date and time types are `DATETIME`, `DATE`, `TIMESTAMP`, `TIME` and `YEAR`. Each of these has a range of legal values, as well as a “zero” value that is used when you specify a really illegal value. Note that MySQL allows you to store certain ‘not strictly’ legal date values, for example 1999-11-31. The reason for this is that we think it’s the responsibility of the application to handle date checking, not the SQL servers. To make the date checking ‘fast’, MySQL only checks that the month is in the range of 0-12 and the day is in the range of 0-31. The above ranges are defined this way because MySQL allows you to store, in a `DATE` or `DATETIME` column, dates where the day or month-day are zero. This is extremely useful for applications that need to store a birth-date for which you don’t know the exact date. In this case you simply store the date like 1999-00-00 or 1999-01-00. (You can of course
not expect to get a correct value from functions like DATE_SUB() or DATE_ADD for dates like these).

Here are some general considerations to keep in mind when working with date and time types:

- **MySQL** retrieves values for a given date or time type in a standard format, but it attempts to interpret a variety of formats for values that you supply (e.g., when you specify a value to be assigned to or compared to a date or time type). Nevertheless, only the formats described in the following sections are supported. It is expected that you will supply legal values, and unpredictable results may occur if you use values in other formats.

- Although **MySQL** tries to interpret values in several formats, it always expects the year part of date values to be leftmost. Dates must be given in year-month-day order (e.g., '98-09-04'), rather than in the month-day-year or day-month-year orders commonly used elsewhere (e.g., '09-04-98', '04-09-98').

- **MySQL** automatically converts a date or time type value to a number if the value is used in a numeric context, and vice versa.

- When **MySQL** encounters a value for a date or time type that is out of range or otherwise illegal for the type (see start of this section), it converts the value to the “zero” value for that type. (The exception is that out-of-range TIME values are clipped to the appropriate endpoint of the TIME range.) The table below shows the format of the “zero” value for each type:

<table>
<thead>
<tr>
<th>Column type</th>
<th>“Zero” value</th>
</tr>
</thead>
<tbody>
<tr>
<td>DATETIME</td>
<td>'0000-00-00 00:00:00'</td>
</tr>
<tr>
<td>DATE</td>
<td>'0000-00-00'</td>
</tr>
<tr>
<td>TIMESTAMP</td>
<td>0000000000000000 (length depends on display size)</td>
</tr>
<tr>
<td>TIME</td>
<td>'00:00:00'</td>
</tr>
<tr>
<td>YEAR</td>
<td>0000</td>
</tr>
</tbody>
</table>

- The “zero” values are special, but you can store or refer to them explicitly using the values shown in the table. You can also do this using the values '0' or 0, which are easier to write.

- “Zero” date or time values used through **MyODBC** are converted automatically to NULL in **MyODBC** 2.50.12 and above, because ODBC can’t handle such values.

### 7.3.3.1 Y2K issues and date types

**MySQL** itself is Y2K-safe (see Section 1.7 [Year 2000 compliance], page 9), but input values presented to **MySQL** may not be. Any input containing 2-digit year values is ambiguous, since the century is unknown. Such values must be interpreted into 4-digit form since **MySQL** stores years internally using four digits.

For **DATETIME**, **DATE**, **TIMESTAMP** and **YEAR** types, **MySQL** interprets dates with ambiguous year values using the following rules:

- Year values in the range 00-69 are converted to 2000-2069.
• Year values in the range 70–99 are converted to 1970–1999. Remember that these rules provide only reasonable guesses as to what your data mean. If the heuristics used by MySQL don’t produce the correct values, you should provide unambiguous input containing 4-digit year values. ORDER BY will sort 2 digit YEAR/DATE/DATETIME types properly.

Note also that some functions like MIN() and MAX() will convert a TIMESTAMP/DATE to a number. This means that a timestamp with a 2 digit year will not work properly with these functions. The fix in this case is to convert the TIMESTAMP/DATE to 4 digit year format or use something like MIN(DATE_ADD(timestamp,INTERVAL 0 DAYS)).

7.3.3.2 The DATETIME, DATE and TIMESTAMP types

The DATETIME, DATE and TIMESTAMP types are related. This section describes their characteristics, how they are similar and how they differ.

The DATETIME type is used when you need values that contain both date and time information. MySQL retrieves and displays DATETIME values in 'YYYY-MM-DD HH:MM:SS' format. The supported range is '1000-01-01 00:00:00' to '9999-12-31 23:59:59'. ("Supported" means that although earlier values might work, there is no guarantee that they will.)

The DATE type is used when you need only a date value, without a time part. MySQL retrieves and displays DATE values in 'YYYY-MM-DD' format. The supported range is '1000-01-01' to '9999-12-31'.

The TIMESTAMP column type provides a type that you can use to automatically mark INSERT or UPDATE operations with the current date and time. If you have multiple TIMESTAMP columns, only the first one is updated automatically.

Automatic updating of the first TIMESTAMP column occurs under any of the following conditions:

• The column is not specified explicitly in an INSERT or LOAD DATA INFILE statement.
• The column is not specified explicitly in an UPDATE statement and some other column changes value. (Note that an UPDATE that sets a column to the value it already has will not cause the TIMESTAMP column to be updated, because if you set a column to its current value, MySQL ignores the update for efficiency.)
• You explicitly set the TIMESTAMP column to NULL.

TIMESTAMP columns other than the first may also be set to the current date and time. Just set the column to NULL, or to NOW().

You can set any TIMESTAMP column to a value different than the current date and time by setting it explicitly to the desired value. This is true even for the first TIMESTAMP column. You can use this property if, for example, you want a TIMESTAMP to be set to the current date and time when you create a row, but not to be changed whenever the row is updated later:

• Let MySQL set the column when the row is created. This will initialize it to the current date and time.
• When you perform subsequent updates to other columns in the row, set the **TIMESTAMP** column explicitly to its current value.

On the other hand, you may find it just as easy to use a **DATETIME** column that you initialize to `NOW()` when the row is created and leave alone for subsequent updates.

**TIMESTAMP** values may range from the beginning of 1970 to sometime in the year 2037, with a resolution of one second. Values are displayed as numbers.

The format in which **MySQL** retrieves and displays **TIMESTAMP** values depends on the display size, as illustrated by the table below. The ‘full’ **TIMESTAMP** format is 14 digits, but **TIMESTAMP** columns may be created with shorter display sizes:

<table>
<thead>
<tr>
<th>Column type</th>
<th>Display format</th>
</tr>
</thead>
<tbody>
<tr>
<td>TIMESTAMP (14)</td>
<td>YYYYMMDDHHMMSS</td>
</tr>
<tr>
<td>TIMESTAMP (12)</td>
<td>YYYYMMDDHHMMSS</td>
</tr>
<tr>
<td>TIMESTAMP (10)</td>
<td>YYYYMMDDHHMM</td>
</tr>
<tr>
<td>TIMESTAMP (8)</td>
<td>YYYYMMDD</td>
</tr>
<tr>
<td>TIMESTAMP (6)</td>
<td>YYMMDD</td>
</tr>
<tr>
<td>TIMESTAMP (4)</td>
<td>YYMM</td>
</tr>
<tr>
<td>TIMESTAMP (2)</td>
<td>YY</td>
</tr>
</tbody>
</table>

All **TIMESTAMP** columns have the same storage size, regardless of display size. The most common display sizes are 6, 8, 12, and 14. You can specify an arbitrary display size at table creation time, but values of 0 or greater than 14 are coerced to 14. Odd-valued sizes in the range from 1 to 13 are coerced to the next higher even number.

You can specify **DATETIME**, **DATE** and **TIMESTAMP** values using any of a common set of formats:

- As a string in either ‘YYYY-MM-DD HH:MM:SS’ or ‘YY-MM-DD HH:MM:SS’ format. A “relaxed” syntax is allowed—any punctuation character may be used as the delimiter between date parts or time parts. For example, ‘98-12-31 11:30:45’, ‘98.12.31 11+30+45’, ‘98/12/31 11*30*45’ and ‘98@12@31 11^30^45’ are equivalent.
- As a string in either ‘YYYY-MM-DD’ or ‘YY-MM-DD’ format. A “relaxed” syntax is allowed here, too. For example, ‘98-12-31’, ‘98.12.31’, ‘98/12/31’ and ‘98@12@31’ are equivalent.
- As a string with no delimiters in either ‘YYYYMMDDHHMMSS’ or ‘YYMMDDHHMMSS’ format, provided that the string makes sense as a date. For example, ‘19970523091528’ and ‘970523091528’ are interpreted as ‘1997-05-23 09:15:28’ and ‘971122129015’ is illegal (it has a nonsensical minute part) and becomes ‘0000-00-00 00:00:00’.
- As a string with no delimiters in either ‘YYYYMMDD’ or ‘YYMMDD’ format, provided that the string makes sense as a date. For example, ‘19970523’ and ‘970523’ are interpreted as ‘1997-05-23’, but ’971332’ is illegal (it has nonsensical month and day parts) and becomes ‘0000-00-00’.
- As a number in either YYYYMMDDHHMMSS or YYMMDDHHMMSS format, provided that the number makes sense as a date. For example, 19830905132800 and 830905132800 are interpreted as ‘1983-09-05 13:28:00’.
- As a number in either YYYYMMDD or YYMMDD format, provided that the number makes sense as a date. For example, 19830905 and 830905 are interpreted as ’1983-09-05’.

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• As the result of a function that returns a value that is acceptable in a DATETIME, DATE or TIMESTAMP context, such as NOW() or CURRENT_DATE.

Illegal DATETIME, DATE or TIMESTAMP values are converted to the “zero” value of the appropriate type ('0000-00-00 00:00:00', '0000-00-00' or 00000000000000).

For values specified as strings that include date part delimiters, it is not necessary to specify two digits for month or day values that are less than 10. '1979-6-9' is the same as '1979-06-09'. Similarly, for values specified as strings that include time part delimiters, it is not necessary to specify two digits for hour, month or second values that are less than 10. '1979-10-30 1:2:3' is the same as '1979-10-30 01:02:03'.

Values specified as numbers should be 6, 8, 12 or 14 digits long. If the number is 8 or 14 digits long, it is assumed to be in YYYYMMDD or YYYYMMDDHHMMSS format and that the year is given by the first 4 digits. If the number is 6 or 12 digits long, it is assumed to be in YYMMDD or YYMMDDHHMMSS format and that the year is given by the first 2 digits. Numbers that are not one of these lengths are interpreted as though padded with leading zeros to the closest length.

Values specified as non-delimited strings are interpreted using their length as given. If the string is 8 or 14 characters long, the year is assumed to be given by the first 4 characters. Otherwise the year is assumed to be given by the first 2 characters. The string is interpreted from left to right to find year, month, day, hour, minute and second values, for as many parts as are present in the string. This means you should not use strings that have fewer than 6 characters. For example, if you specify '9903', thinking that will represent March, 1999, you will find that MySQL inserts a “zero” date into your table. This is because the year and month values are 99 and 03, but the day part is missing (zero), so the value is not a legal date.

TIMESTAMP columns store legal values using the full precision with which the value was specified, regardless of the display size. This has several implications:

• Always specify year, month, and day, even if your column types are TIMESTAMP(4) or TIMESTAMP(2). Otherwise, the value will not be a legal date and 0 will be stored.

• If you use ALTER TABLE to widen a narrow TIMESTAMP column, information will be displayed that previously was “hidden”.

• Similarly, narrowing a TIMESTAMP column does not cause information to be lost, except in the sense that less information is shown when the values are displayed.

• Although TIMESTAMP values are stored to full precision, the only function that operates directly on the underlying stored value is UNIX_TIMESTAMP(). Other functions operate on the formatted retrieved value. This means you cannot use functions such as HOUR() or SECOND() unless the relevant part of the TIMESTAMP value is included in the formatted value. For example, the HH part of a TIMESTAMP column is not displayed unless the display size is at least 10, so trying to use HOUR() on shorter TIMESTAMP values produces a meaningless result.

You can to some extent assign values of one date type to an object of a different date type. However, there may be some alteration of the value or loss of information:

• If you assign a DATE value to a DATETIME or TIMESTAMP object, the time part of the resulting value is set to '00:00:00', because the DATE value contains no time information.
• If you assign a DATETIME or TIMESTAMP value to a DATE object, the time part of the resulting value is deleted, because the DATE type stores no time information.

• Remember that although DATETIME, DATE and TIMESTAMP values all can be specified using the same set of formats, the types do not all have the same range of values. For example, TIMESTAMP values cannot be earlier than 1970 or later than 2037. This means that a date such as '1968-01-01', while legal as a DATETIME or DATE value, is not a valid TIMESTAMP value and will be converted to 0 if assigned to such an object.

Be aware of certain pitfalls when specifying date values:

• The relaxed format allowed for values specified as strings can be deceiving. For example, a value such as '10:11:12' might look like a time value because of the ':' delimiter, but if used in a date context will be interpreted as the year '2010-11-12'. The value '10:45:15' will be converted to '0000-00-00' because '45' is not a legal month.

• Year values specified as two digits are ambiguous, since the century is unknown. MySQL interprets 2-digit year values using the following rules:
  - Year values in the range 00-69 are converted to 2000-2069.
  - Year values in the range 70-99 are converted to 1970-1999.

7.3.3.3 The TIME type

MySQL retrieves and displays TIME values in 'HH:MM:SS' format (or 'HHH:MM:SS' format for large hours values). TIME values may range from '-838:59:59' to '838:59:59'. The reason the hours part may be so large is that the TIME type may be used not only to represent a time of day (which must be less than 24 hours), but also elapsed time or a time interval between two events (which may be much greater than 24 hours, or even negative).

You can specify TIME values in a variety of formats:

• As a string in 'HH:MM:SS' format. A "relaxed" syntax is allowed—any punctuation character may be used as the delimiter between time parts. For example, '10:11:12' and '10.11.12' are equivalent.

• As a string with no delimiters in 'HHMMSS' format, provided that it makes sense as a time. For example, '101112' is understood as '10:11:12', but '109712' is illegal (it has a nonsensical minute part) and becomes '00:00:00'.

• As a number in HHMMSS format, provided that it makes sense as a time. For example, 101112 is understood as '10:11:12'.

• As the result of a function that returns a value that is acceptable in a TIME context, such as CURRENT_TIME.

For TIME values specified as strings that include a time part delimiter, it is not necessary to specify two digits for hours, minutes or seconds values that are less than 10. '8:3:2' is the same as '08:03:02'.

Be careful about assigning “short” TIME values to a TIME column. MySQL interprets values using the assumption that the rightmost digits represent seconds. (MySQL interprets TIME values as elapsed time, rather than as time of day.) For example, you might think of
'11:12', '1112' and 1112 as meaning '11:12:00' (12 minutes after 11 o'clock), but MySQL interprets them as '00:11:12' (11 minutes, 12 seconds). Similarly, '12' and 12 are interpreted as '00:00:12'.

Values that lie outside the TIME range but are otherwise legal are clipped to the appropriate endpoint of the range. For example, '-850:00:00' and '850:00:00' are converted to '-838:59:59' and '838:59:59'.

Illegal TIME values are converted to '00:00:00'. Note that since '00:00:00' is itself a legal TIME value, there is no way to tell, from a value of '00:00:00' stored in a table, whether the original value was specified as '00:00:00' or whether it was illegal.

### 7.3.3.4 The YEAR type

The YEAR type is a 1-byte type used for representing years.

MySQL retrieves and displays YEAR values in YYYY format. The range is 1901 to 2155.

You can specify YEAR values in a variety of formats:

- As a four-digit string in the range '1901' to '2155'.
- As a four-digit number in the range 1901 to 2155.
- As a two-digit string in the range '00' to '99'. Values in the ranges '00' to '69' and '70' to '99' are converted to YEAR values in the ranges 2000 to 2069 and 1970 to 1999.
- As a two-digit number in the range 1 to 99. Values in the ranges 1 to 69 and 70 to 99 are converted to YEAR values in the ranges 2001 to 2069 and 1970 to 1999. Note that the range for two-digit numbers is slightly different than the range for two-digit strings, since you cannot specify zero directly as a number and have it be interpreted as 2000. You must specify it as a string '0' or '00' or it will be interpreted as 0000.
- As the result of a function that returns a value that is acceptable in a YEAR context, such as NOW().

Illegal YEAR values are converted to 0000.

### 7.3.4 String types

The string types are CHAR, VARCHAR, BLOB, TEXT, ENUM and SET.

#### 7.3.4.1 The CHAR and VARCHAR types

The CHAR and VARCHAR types are similar, but differ in the way they are stored and retrieved. The length of a CHAR column is fixed to the length that you declare when you create the table. The length can be any value between 1 and 255. (As of MySQL 3.23, the length of CHAR may be 0 to 255.) When CHAR values are stored, they are right-padded with spaces to the specified length. When CHAR values are retrieved, trailing spaces are removed.
Values in VARCHAR columns are variable-length strings. You can declare a VARCHAR column to be any length between 1 and 255, just as for CHAR columns. However, in contrast to CHAR, VARCHAR values are stored using only as many characters as are needed, plus one byte to record the length. Values are not padded; instead, trailing spaces are removed when values are stored. (This space removal differs from the ANSI SQL specification.)

If you assign a value to a CHAR or VARCHAR column that exceeds the column’s maximum length, the value is truncated to fit.

The table below illustrates the differences between the two types of columns by showing the result of storing various string values into CHAR(4) and VARCHAR(4) columns:

<table>
<thead>
<tr>
<th>Value</th>
<th>CHAR(4) Storage required</th>
<th>VARCHAR(4) Storage required</th>
</tr>
</thead>
<tbody>
<tr>
<td>’ ’</td>
<td>4 bytes</td>
<td>’ ’</td>
</tr>
<tr>
<td>’ab’</td>
<td>4 bytes</td>
<td>’ab’</td>
</tr>
<tr>
<td>’abcd’</td>
<td>4 bytes</td>
<td>’abcd’</td>
</tr>
<tr>
<td>’abcdefg’</td>
<td>4 bytes</td>
<td>’abcd’</td>
</tr>
</tbody>
</table>

The values retrieved from the CHAR(4) and VARCHAR(4) columns will be the same in each case, because trailing spaces are removed from CHAR columns upon retrieval.

Values in CHAR and VARCHAR columns are sorted and compared in case-insensitive fashion, unless the BINARY attribute was specified when the table was created. The BINARY attribute means that column values are sorted and compared in case-sensitive fashion according to the ASCII order of the machine where the MySQL server is running.

The BINARY attribute is “sticky”. This means that if a column marked BINARY is used in an expression, the whole expression is compared as a BINARY value.

MySQL may silently change the type of a CHAR or VARCHAR column at table creation time. See Section 7.7.1 [Silent column changes], page 192.

7.3.4.2 The BLOB and TEXT types

A BLOB is a binary large object that can hold a variable amount of data. The four BLOB types TINYBLOB, BLOB, MEDIUMBLOB and LONGBLOB differ only in the maximum length of the values they can hold. See Section 7.3.1 [Storage requirements], page 138.

The four TEXT types TINYTEXT, TEXT, MEDIUMTEXT and LONGTEXT correspond to the four BLOB types and have the same maximum lengths and storage requirements. The only difference between BLOB and TEXT types is that sorting and comparison is performed in case-sensitive fashion for BLOB values and case-insensitive fashion for TEXT values. In other words, a TEXT is a case-insensitive BLOB.

If you assign a value to a BLOB or TEXT column that exceeds the column type’s maximum length, the value is truncated to fit.

In most respects, you can regard a TEXT column as a VARCHAR column that can be as big as you like. Similarly, you can regard a BLOB column as a VARCHAR BINARY column. The differences are:

- You can have indexes on BLOB and TEXT columns with MySQL versions 3.23.2 and newer. Older versions of MySQL did not support this.
• There is no trailing-space removal for BLOB and TEXT columns when values are stored, as there is for VARCHAR columns.

• BLOB and TEXT columns cannot have DEFAULT values.

MyODBC defines BLOB values as LONGVARBINARY and TEXT values as LONGVARCHAR. Because BLOB and TEXT values may be extremely long, you may run up against some constraints when using them:

• If you want to use GROUP BY or ORDER BY on a BLOB or TEXT column, you must convert the column value into a fixed-length object. The standard way to do this is with the SUBSTRING function. For example:

```
mysql> select comment from tbl_name,substring(comment,20) as substr
ORDER BY substr;
```

If you don’t do this, only the first max_sort_length bytes of the column are used when sorting. The default value of max_sort_length is 1024; this value can be changed using the -O option when starting the mysqld server. You can group on an expression involving BLOB or TEXT values by specifying the column position or by using an alias:

```
mysql> select id,substring(blob_col,1,100) from tbl_name
GROUP BY 2;

mysql> select id,substring(blob_col,1,100) as b from tbl_name
GROUP BY b;
```

• The maximum size of a BLOB or TEXT object is determined by its type, but the largest value you can actually transmit between the client and server is determined by the amount of available memory and the size of the communications buffers. You can change the message buffer size, but you must do so on both the server and client ends. See Section 11.2.3 [Server parameters], page 278.

Note that each BLOB or TEXT value is represented internally by a separately-allocated object. This is in contrast to all other column types, for which storage is allocated once per column when the table is opened.

### 7.3.4.3 The ENUM type

An ENUM is a string object whose value normally is chosen from a list of allowed values that are enumerated explicitly in the column specification at table creation time.

The value may also be the empty string ("") or NULL under certain circumstances:

• If you insert an invalid value into an ENUM (that is, a string not present in the list of allowed values), the empty string is inserted instead as a special error value.

• If an ENUM is declared NULL, NULL is also a legal value for the column, and the default value is NULL. If an ENUM is declared NOT NULL, the default value is the first element of the list of allowed values.

Each enumeration value has an index:

• Values from the list of allowable elements in the column specification are numbered beginning with 1.
• The index value of the empty string error value is 0. This means that you can use the following `SELECT` statement to find rows into which invalid `ENUM` values were assigned:

```sql
mysql> SELECT * FROM tbl_name WHERE enum_col=0;
```
• The index of the NULL value is NULL.

For example, a column specified as `ENUM("one", "two", "three")` can have any of the values shown below. The index of each value is also shown:

<table>
<thead>
<tr>
<th>Value</th>
<th>Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>NULL</td>
<td>NULL</td>
</tr>
<tr>
<td>&quot;&quot;</td>
<td>0</td>
</tr>
<tr>
<td>&quot;one&quot;</td>
<td>1</td>
</tr>
<tr>
<td>&quot;two&quot;</td>
<td>2</td>
</tr>
<tr>
<td>&quot;three&quot;</td>
<td>3</td>
</tr>
</tbody>
</table>

An enumeration can have a maximum of 65535 elements.

Lettercase is irrelevant when you assign values to an `ENUM` column. However, values retrieved from the column later have lettercase matching the values that were used to specify the allowable values at table creation time.

If you retrieve an `ENUM` in a numeric context, the column value’s index is returned. If you store a number into an `ENUM`, the number is treated as an index, and the the value stored is the enumeration member with that index. (However, this will not work with `LOAD DATA`, which treats all input as strings.)

`ENUM` values are sorted according to the order in which the enumeration members were listed in the column specification. (In other words, `ENUM` values are sorted according to their index numbers.) For example, "a" sorts before "b" for `ENUM("a", "b")`, but "b" sorts before "a" for `ENUM("b", "a")`. The empty string sorts before non-empty strings, and NULL values sort before all other enumeration values.

If you want to get all possible values for an `ENUM` column, you should use: `SHOW COLUMNS FROM table_name LIKE enum_column_name` and parse the `ENUM` definition in the second column.

### 7.3.4.4 The SET type

A `SET` is a string object that can have zero or more values, each of which must be chosen from a list of allowed values specified when the table is created. `SET` column values that consist of multiple set members are specified with members separated by commas (','). A consequence of this is that `SET` member values cannot themselves contain commas.

For example, a column specified as `SET("one", "two") NOT NULL` can have any of these values:

- ""
- "one"
- "two"
- "one,two"

A `SET` can have a maximum of 64 different members.
MySQL stores SET values numerically, with the low-order bit of the stored value corresponding to the first set member. If you retrieve a SET value in a numeric context, the value retrieved has bits set corresponding to the set members that make up the column value. If a number is stored into a SET column, the bits that are set in the binary representation of the number determine the set members in the column value. Suppose a column is specified as SET("a","b","c","d"). Then the members have the following bit values:

<table>
<thead>
<tr>
<th>SET member</th>
<th>Decimal value</th>
<th>Binary value</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>1</td>
<td>0001</td>
</tr>
<tr>
<td>b</td>
<td>2</td>
<td>0010</td>
</tr>
<tr>
<td>c</td>
<td>4</td>
<td>0100</td>
</tr>
<tr>
<td>d</td>
<td>8</td>
<td>1000</td>
</tr>
</tbody>
</table>

If you assign a value of 9 to this column, that is 1001 in binary, so the first and fourth SET value members "a" and "d" are selected and the resulting value is "a,d".

For a value containing more than one SET element, it does not matter what order the elements are listed in when you insert the value. It also does not matter how many times a given element is listed in the value. When the value is retrieved later, each element in the value will appear once, with elements listed according to the order in which they were specified at table creation time. For example, if a column is specified as SET("a","b","c","d"), then "a,d", "d,a" and "d,a,a,d,d" will all appear as "a,d" when retrieved.

SET values are sorted numerically. NULL values sort before non-NULL SET values.

Normally, you perform a SELECT on a SET column using the LIKE operator or the FIND_IN_SET() function:

```sql
mysql> SELECT * FROM tbl_name WHERE set_col LIKE '%value%';
mysql> SELECT * FROM tbl_name WHERE FIND_IN_SET('value',set_col)>0;
```

But the following will also work:

```sql
mysql> SELECT * FROM tbl_name WHERE set_col = 'val1,val2';
mysql> SELECT * FROM tbl_name WHERE set_col & 1;
```

The first of these statements looks for an exact match. The second looks for values containing the first set member.

If you want to get all possible values for an SET column, you should use: SHOW COLUMNS FROM table_name LIKE set_column_name and parse the SET definition in the second column.

7.3.5 Choosing the right type for a column

For the most efficient use of storage, try to use the most precise type in all cases. For example, if an integer column will be used for values in the range between 1 and 99999, MEDIUMINT UNSIGNED is the best type.

Accurate representation of monetary values is a common problem. In MySQL, you should use the DECIMAL type. This is stored as a string, so no loss of accuracy should occur. If accuracy is not too important, the DOUBLE type may also be good enough.

For high precision, you can always convert to a fixed-point type stored in a BIGINT. This allows you to do all calculations with integers and convert results back to floating-point values only when necessary.
7.3.6 Column indexes

All MySQL column types can be indexed. Use of indexes on the relevant columns is the best way to improve the performance of SELECT operations.

A table may have up to 16 indexes. The maximum index length is 256 bytes, although this may be changed when compiling MySQL.

For CHAR and VARCHAR columns, you can index a prefix of a column. This is much faster and requires less disk space than indexing the whole column. The syntax to use in the CREATE TABLE statement to index a column prefix looks like this:

```
KEY index_name (col_name(length))
```

The example below creates an index for the first 10 characters of the name column:

```
mysql> CREATE TABLE test (
    name CHAR(200) NOT NULL,
    KEY index_name (name(10)));
```

For BLOB and TEXT columns, you must index a prefix of the column, you cannot index the entire thing.

7.3.7 Multiple-column indexes

MySQL can create indexes on multiple columns. An index may consist of up to 15 columns. (On CHAR and VARCHAR columns you can also use a prefix of the column as a part of an index).

A multiple-column index can be considered a sorted array containing values that are created by concatenating the values of the indexed columns.

MySQL uses multiple-column indexes in such a way that queries are fast when you specify a known quantity for the first column of the index in a WHERE clause, even if you don’t specify values for the other columns.

Suppose a table is created using the following specification:

```
mysql> CREATE TABLE test (
    id INT NOT NULL,
    last_name CHAR(30) NOT NULL,
    first_name CHAR(30) NOT NULL,
    PRIMARY KEY (id),
    INDEX name (last_name,first_name));
```

Then the index name is an index over last_name and first_name. The index will be used for queries that specify values in a known range for last_name, or for both last_name and first_name. Therefore, the name index will be used in the following queries:

```
mysql> SELECT * FROM test WHERE last_name="Widenius";

mysql> SELECT * FROM test WHERE last_name="Widenius" AND first_name="Michael";
```
mysql> SELECT * FROM test WHERE last_name="Widenius"
    AND (first_name="Michael" OR first_name="Monty");

mysql> SELECT * FROM test WHERE last_name="Widenius"
    AND first_name >="M" AND first_name < "N";

However, the name index will NOT be used in the following queries:

mysql> SELECT * FROM test WHERE first_name="Michael";

mysql> SELECT * FROM test WHERE last_name="Widenius"
    OR first_name="Michael";

For more information on the manner in which MySQL uses indexes to improve query performance, see Section 11.4 [MySQL indexes], page 289.

7.3.8 Using column types from other database engines

To make it easier to use code written for SQL implementations from other vendors, MySQL maps column types as shown in the table below. These mappings make it easier to move table definitions from other database engines to MySQL:

<table>
<thead>
<tr>
<th>Other vendor type</th>
<th>MySQL type</th>
</tr>
</thead>
<tbody>
<tr>
<td>BINARY(NUM)</td>
<td>CHAR(NUM) BINARY</td>
</tr>
<tr>
<td>CHAR VARYING(NUM)</td>
<td>VARCHAR(NUM)</td>
</tr>
<tr>
<td>FLOAT4</td>
<td>FLOAT</td>
</tr>
<tr>
<td>FLOAT8</td>
<td>DOUBLE</td>
</tr>
<tr>
<td>INT1</td>
<td>TINYINT</td>
</tr>
<tr>
<td>INT2</td>
<td>SMALLINT</td>
</tr>
<tr>
<td>INT3</td>
<td>MEDIUMINT</td>
</tr>
<tr>
<td>INT4</td>
<td>INT</td>
</tr>
<tr>
<td>INT8</td>
<td>BIGINT</td>
</tr>
<tr>
<td>LONG VARBINARY</td>
<td>MEDIUMBLOB</td>
</tr>
<tr>
<td>LONG VARCHAR</td>
<td>MEDIUMTEXT</td>
</tr>
<tr>
<td>MIDDLEINT</td>
<td>MEDIUMINT</td>
</tr>
<tr>
<td>VARBINARY(NUM)</td>
<td>VARCHAR(NUM) BINARY</td>
</tr>
</tbody>
</table>

Column type mapping occurs at table creation time. If you create a table with types used by other vendors and then issue a DESCRIBE tbl_name statement, MySQL reports the table structure using the equivalent MySQL types.

7.4 Functions for use in SELECT and WHERE clauses

A select_expression or where_definition in a SQL statement can consist of any expression using the functions described below.

An expression that contains NULL always produces a NULL value unless otherwise indicated in the documentation for the operators and functions involved in the expression.
Note: There must be no whitespace between a function name and the parenthesis following it. This helps the MySQL parser distinguish between function calls and references to tables or columns that happen to have the same name as a function. Spaces around arguments are permitted, though.

For the sake of brevity, examples display the output from the mysql program in abbreviated form. So this:

```sql
mysql> select MOD(29,9);
+-----------+
| mod(29,9) |
+-----------+
| 2         |
```

Is displayed like this:

```sql
mysql> select MOD(29,9);
-> 2
```

### 7.4.1 Grouping functions

( ... ) Parentheses. Use these to force the order of evaluation in an expression.

```sql
mysql> select 1+2*3;
-> 7
mysql> select (1+2)*3;
-> 9
```

### 7.4.2 Normal arithmetic operations

The usual arithmetic operators are available. Note that in the case of -, + and *, the result is calculated with BIGINT (64-bit) precision if both arguments are integers!

* Addition
  ```sql
  mysql> select 3+5;
  -> 8
  ```

- Subtraction
  ```sql
  mysql> select 3-5;
  -> -2
  ```

* Multiplication
  ```sql
  mysql> select 18014398509481984*18014398509481984.0;
  -> 324518553658426726783156020576256.0
  ```

Version: 3.23.11-alpha Printed: 25 February 2000
mysql> select 18014398509481984*18014398509481984;
-> 0
The result of the last expression is incorrect because the result of the integer multiplication exceeds the 64-bit range of `BIGINT` calculations.

/ Division
mysql> select 3/5;
-> 0.60
Division by zero produces a NULL result:
mysql> select 102/(1-1);
-> NULL
A division will be calculated with `BIGINT` arithmetic only if performed in a context where its result is converted to an integer!

7.4.3 Bit functions

`MySQL` uses `BIGINT` (64-bit) arithmetic for bit operations, so these operators have a maximum range of 64 bits.

<table>
<thead>
<tr>
<th>Bitwise OR</th>
</tr>
</thead>
</table>
| mysql> select 29 | 15;
  -> 31 |

<table>
<thead>
<tr>
<th>Bitwise AND</th>
</tr>
</thead>
</table>
| mysql> select 29 & 15;
  -> 13 |

<< Shifts a longlong (BIGINT) number to the left.
mysql> select 1 << 2
  -> 4

>> Shifts a longlong (BIGINT) number to the right.
mysql> select 4 >> 2
  -> 1

~ Invert all bits.
mysql> select 5 & ~1
  -> 4

`BIT_COUNT(N)`
Returns the number of bits that are set in the argument N.
mysql> select BIT_COUNT(29);
  -> 4
7.4.4 Logical operations

All logical functions return 1 (TRUE) or 0 (FALSE).

**NOT**

\(!\)

Logical NOT. Returns 1 if the argument is 0, otherwise returns 0. Exception: NOT NULL returns NULL.

```
mysql> select NOT 1;
-> 0

mysql> select NOT NULL;
-> NULL

mysql> select ! (1+1);
-> 0

mysql> select ! 1+1;
-> 1
```

The last example returns 1 because the expression evaluates the same way as (!1)+1.

**OR**

\(||\)

Logical OR. Returns 1 if either argument is not 0 and not NULL.

```
mysql> select 1 || 0;
-> 1

mysql> select 0 || 0;
-> 0

mysql> select 1 || NULL;
-> 1
```

**AND**

\(&&\)

Logical AND. Returns 0 if either argument is 0 or NULL, otherwise returns 1.

```
mysql> select 1 && NULL;
-> 0

mysql> select 1 && 0;
-> 0

mysql> select 1 && NULL;
-> 1
```

7.4.5 Comparison operators

Comparison operations result in a value of 1 (TRUE), 0 (FALSE) or NULL. These functions work for both numbers and strings. Strings are automatically converted to numbers and numbers to strings as needed (as in Perl).

MySQL performs comparisons using the following rules:

- If one or both arguments are NULL, the result of the comparison is NULL, except for the \(<=\>\) operator.
- If both arguments in a comparison operation are strings, they are compared as strings.
• If both arguments are integers, they are compared as integers.
• Hexadecimal values are treated as binary strings if not compared to a number.
• If one of the arguments is a TIMESTAMP or DATETIME column and the other argument is a constant, the constant is converted to a timestamp before the comparison is performed. This is done to be more ODBC-friendly.
• In all other cases, the arguments are compared as floating-point (real) numbers.

By default, string comparisons are done in case-independent fashion using the current character set (ISO-8859-1 Latin1 by default, which also works excellently for English).

The examples below illustrate conversion of strings to numbers for comparison operations:

```
mysql> SELECT 1 > '6x';
   -> 0
mysql> SELECT 7 > '6x';
   -> 1
mysql> SELECT 0 > 'x6';
   -> 0
mysql> SELECT 0 = 'x6';
   -> 1
```

=  
```
mysql> select 1 = 0;
   -> 0
mysql> select '0' = 0;
   -> 1
mysql> select '0.0' = 0;
   -> 1
mysql> select '0.01' = 0;
   -> 0
mysql> select '.01' = 0.01;
   -> 1
```

<>  
```
mysql> select '.01' <> '0.01';
   -> 1
mysql> select .01 <> '0.01';
   -> 0
mysql> select 'zapp' <> 'zappp';
   -> 1
```

<=  
```
mysql> select 0.1 <= 2;
   -> 1
```

<  
```
mysql> select 2 <= 2;
   -> 1
```

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Greater than or equal

```sql
mysql> select 2 >= 2;
-> 1
```

Greater than

```sql
mysql> select 2 > 2;
-> 0
```

Null safe equal

```sql
mysql> select 1 <=> 1, NULL <=> NULL, 1 <=> NULL;
-> 1 1 0
```

**IS NULL**

Test whether or not a value is or is not NULL

```sql
mysql> select 1 IS NULL, 0 IS NULL, NULL IS NULL;
-> 0 0 1
mysql> select 1 IS NOT NULL, 0 IS NOT NULL, NULL IS NOT NULL;
-> 1 1 0
```

**expr BETWEEN min AND max**

If `expr` is greater than or equal to `min` and `expr` is less than or equal to `max`, `BETWEEN` returns 1, otherwise it returns 0. This is equivalent to the expression `(min <= expr AND expr <= max)` if all the arguments are of the same type. The first argument (`expr`) determines how the comparison is performed as follows:

- If `expr` is a `TIMESTAMP`, `DATE` or `DATETIME` column, `min` and `max` are formatted to the same format if they are constants.
- If `expr` is a case-insensitive string expression, a case-insensitive string comparison is done.
- If `expr` is a case-sensitive string expression, a case-sensitive string comparison is done.
- If `expr` is an integer expression, an integer comparison is done.
- Otherwise, a floating-point (real) comparison is done.

```sql
mysql> select 1 BETWEEN 2 AND 3;
-> 0
mysql> select 'b' BETWEEN 'a' AND 'c';
-> 1
mysql> select 2 BETWEEN 2 AND '3';
-> 1
mysql> select 2 BETWEEN 2 AND 'x-3';
-> 0
```

**expr IN (value,...)**

Returns 1 if `expr` is any of the values in the `IN` list, else returns 0. If all values are constants, then all values are evaluated according to the type of `expr` and sorted. The search for the item is then done using a binary search. This means `IN` is very quick if the `IN` value list consists entirely of constants. If `expr` is
a case-sensitive string expression, the string comparison is performed in case-sensitive fashion.

```sql
mysql> select 2 IN (0,3,5,'wefwf');
--> 0
mysql> select 'wefwf' IN (0,3,5,'wefwf');
--> 1
```

**expr NOT IN (value,...)**
Same as NOT (expr IN (value,...)).

**ISNULL(expr)**
If `expr` is NULL, `ISNULL()` returns 1, otherwise it returns 0.

```sql
mysql> select ISNULL(1+1);
--> 0
mysql> select ISNULL(1/0);
--> 1
```

Note that a comparison of NULL values using `=` will always be false!

**COALESCE(list)**
Returns first non-NULL element in list.

```sql
mysql> select COALESCE(NULL,1);
--> 1
mysql> select COALESCE(NULL,NULL,NULL);
--> NULL
```

**INTERVAL(N,N1,N2,N3,...)**
Returns 0 if `N < N1`, 1 if `N < N2` and so on. All arguments are treated as integers.

It is required that `N1 < N2 < N3 < ... < Nn` for this function to work correctly.

```sql
mysql> select INTERVAL(23, 1, 15, 17, 30, 44, 200);
--> 3
mysql> select INTERVAL(10, 1, 10, 100, 1000);
--> 2
mysql> select INTERVAL(22, 23, 30, 44, 200);
--> 0
```

### 7.4.6 String comparison functions

Normally, if any expression in a string comparison is case sensitive, the comparison is performed in case-sensitive fashion.

**expr LIKE pat [ESCAPE 'escape-char']**
Pattern matching using SQL simple regular expression comparison. Returns 1 (TRUE) or 0 (FALSE). With LIKE you can use the following two wildcard characters in the pattern:

- `%` Matches any number of characters, even zero characters
- `_` Matches exactly one character
To test for literal instances of a wildcard character, precede the character with the escape character. If you don’t specify the ESCAPE character, ‘\’ is assumed:

```
\%  Matches one % character
\_  Matches one _ character
```

mysql> select 'David!' LIKE 'David\_';
-> 0

mysql> select 'David_' LIKE 'David\_';
-> 1

To specify a different escape character, use the ESCAPE clause:

```
mysql> select 'David_' LIKE 'David\_|_' ESCAPE '|';
-> 1
```

LIKE is allowed on numeric expressions! (This is a MySQL extension to the ANSI SQL LIKE.)

```
mysql> select 10 LIKE '1%';
-> 1
```

Note: Because MySQL uses the C escape syntax in strings (e.g., ‘\n’), you must double any ‘\’ that you use in your LIKE strings. For example, to search for ‘\n’, specify it as ‘\\n’. To search for ‘\’, specify it as ‘\\\’ (the backslashes are stripped once by the parser, and another time when the pattern match is done, leaving a single backslash to be matched).

```
expr NOT LIKE pat [ESCAPE 'escape-char']
```

Same as NOT (expr LIKE pat [ESCAPE 'escape-char']).

```
expr REGEXP pat
```

```
expr RLIKE pat
```

Performs a pattern match of a string expression expr against a pattern pat. The pattern can be an extended regular expression. See Appendix H [Regexp], page 512. Returns 1 if expr matches pat, otherwise returns 0. RLIKE is a synonym for REGEXP, provided for mSQL compatibility. Note: Because MySQL uses the C escape syntax in strings (e.g., ‘\n’), you must double any ‘\’ that you use in your REGEXP strings. In MySQL 3.23.4 REGEXP is case insensitive for normal (not binary) strings.

```
mysql> select 'Monty!' REGEXP 'm%y%%';
-> 0
```

```
mysql> select 'Monty!' REGEXP '.*';
-> 1
```

```
mysql> select 'new\n*line' REGEXP 'new\.*\n*line';
-> 1
```

```
mysql> select "a" REGEXP "A", "a" REGEXP BINARY "A";
-> 1 0
```
REGEXP and RLIKE use the current character set (ISO-8859-1 Latin1 by default) when deciding the type of a character.

expr NOT REGEXP pat
expr NOT RLIKE pat
Same as NOT (expr REGEXP pat).

STRCMP(expr1,expr2)
STRCMP() returns 0 if the strings are the same, -1 if the first argument is smaller than the second according to the current sort order, and 1 otherwise.

mysql> select STRCMP('text', 'text2');
-> -1
mysql> select STRCMP('text2', 'text');
-> 1
mysql> select STRCMP('text', 'text');
-> 0

7.4.7 Cast operators

BINARY The BINARY operator casts the string following it to a binary string. This is an easy way to force a column comparison to be case sensitive even if the column isn’t defined as BINARY or BLOB.

mysql> select "a" = "A";
-> 1
mysql> select BINARY "a" = "A";
-> 0

BINARY was introduced in MySQL 3.23.0

7.4.8 Control flow functions

IFNULL(expr1,expr2)
If expr1 is not NULL, IFNULL() returns expr1, else it returns expr2. IFNULL() returns a numeric or string value, depending on the context in which it is used.

mysql> select IFNULL(1,0);
-> 1
mysql> select IFNULL(0,10);
-> 0
mysql> select IFNULL(1/0,10);
-> 10
mysql> select IFNULL(1/0,'yes');
-> 'yes'
IF(expr1,expr2,expr3)

If expr1 is TRUE (expr1 <> 0 and expr1 <> NULL) then IF() returns expr2, else it returns expr3. IF() returns a numeric or string value, depending on the context in which it is used.

```sql
mysql> select IF(1>2,2,3);
-> 3
mysql> select IF(1<2,'yes','no');
-> 'yes'
mysql> select IF(strcmp('test','test1'),'yes','no');
-> 'no'
```

expr1 is evaluated as an integer value, which means that if you are testing floating-point or string values, you should do so using a comparison operation.

```sql
mysql> select IF(0.1,1,0);
-> 0
mysql> select IF(0.1<>0,1,0);
-> 1
```

In the first case above, IF(0.1) returns 0 because 0.1 is converted to an integer value, resulting in a test of IF(0). This may not be what you expect. In the second case, the comparison tests the original floating-point value to see whether it is non-zero. The result of the comparison is used as an integer.

```sql
mysql> SELECT CASE 1 WHEN 1 THEN "one" WHEN 2 THEN "two" ELSE "more" END;
-> "one"
mysql> SELECT CASE WHEN 1>0 THEN "true" ELSE "false" END;
-> "true"
mysql> SELECT CASE BINARY "B" when "a" then 1 when "b" then 2 END;
-> NULL
```

7.4.9 Mathematical functions

All mathematical functions return NULL in case of an error.

- Unary minus. Changes the sign of the argument.

```sql
mysql> select - 2;
-> -2
```

Note that if this operator is used with a BIGINT, the return value is a BIGINT! This means that you should avoid using - on integers that may have the value of -2^63!
### ABS(X)

Returns the absolute value of X.

```sql
mysql> select ABS(2);
-> 2
mysql> select ABS(-32);
-> 32
```

This function is safe to use with `BIGINT` values.

### SIGN(X)

Returns the sign of the argument as -1, 0 or 1, depending on whether X is negative, zero, or positive.

```sql
mysql> select SIGN(-32);
-> -1
mysql> select SIGN(0);
-> 0
mysql> select SIGN(234);
-> 1
```

### MOD(N,M)

Returns the remainder of N divided by M.

```sql
mysql> select MOD(234, 10);
-> 4
mysql> select 253 % 7;
-> 1
mysql> select MOD(29,9);
-> 2
```

This function is safe to use with `BIGINT` values.

### FLOOR(X)

Returns the largest integer value not greater than X.

```sql
mysql> select FLOOR(1.23);
-> 1
mysql> select FLOOR(-1.23);
-> -2
```

Note that the return value is converted to a `BIGINT`!

### CEILING(X)

Returns the smallest integer value not less than X.

```sql
mysql> select CEILING(1.23);
-> 2
mysql> select CEILING(-1.23);
-> -1
```

Note that the return value is converted to a `BIGINT`!

### ROUND(X)

Returns the argument X, rounded to the nearest integer.

```sql
mysql> select ROUND(-1.23);
-> -1
mysql> select ROUND(-1.58);
-> -2
mysql> select ROUND(1.58);
-> 2
```
**ROUND**(X,D)

Returns the argument X, rounded to a number with D decimals. If D is 0, the result will have no decimal point or fractional part.

```sql
mysql> select ROUND(1.298, 1);
-> 1.3
mysql> select ROUND(1.298, 0);
-> 1
```

**EXP**(X)

Returns the value of e (the base of natural logarithms) raised to the power of X.

```sql
mysql> select EXP(2);
-> 7.389056
mysql> select EXP(-2);
-> 0.135335
```

**LOG**(X)

Returns the natural logarithm of X.

```sql
mysql> select LOG(2);
-> 0.693147
mysql> select LOG(-2);
-> NULL
```

If you want the log of a number X to some arbitrary base B, use the formula `LOG(X)/LOG(B)`.

**LOG10**(X)

Returns the base-10 logarithm of X.

```sql
mysql> select LOG10(2);
-> 0.301030
mysql> select LOG10(100);
-> 2.000000
mysql> select LOG10(-100);
-> NULL
```

**POW**(X,Y)

**POWER**(X,Y)

Returns the value of X raised to the power of Y.

```sql
mysql> select POW(2,2);
-> 4.000000
mysql> select POW(2,-2);
-> 0.250000
```

**SQRT**(X)

Returns the non-negative square root of X.

```sql
mysql> select SQRT(4);
-> 2.000000
mysql> select SQRT(20);
-> 4.472136
```

**PI()**

Returns the value of PI.

```sql
mysql> select PI();
-> 3.141593
```

**COS**(X)

Returns the cosine of X, where X is given in radians.
mysql> select COS(PI());
-> -1.000000

SIN(X) Returns the sine of X, where X is given in radians.
mysql> select SIN(PI());
-> 0.000000

TAN(X) Returns the tangent of X, where X is given in radians.
mysql> select TAN(PI()+1);
-> 1.557408

ACOS(X) Returns the arc cosine of X, that is, the value whose cosine is X. Returns NULL if X is not in the range -1 to 1.
mysql> select ACOS(1);
-> 0.000000
mysql> select ACOS(1.0001);
-> NULL
mysql> select ACOS(0);
-> 1.570796

ASIN(X) Returns the arc sine of X, that is, the value whose sine is X. Returns NULL if X is not in the range -1 to 1.
mysql> select ASIN(0.2);
-> 0.201358
mysql> select ASIN('foo');
-> 0.000000

ATAN(X) Returns the arc tangent of X, that is, the value whose tangent is X.
mysql> select ATAN(2);
-> 1.107149
mysql> select ATAN(-2);
-> -1.107149

ATAN2(X,Y) Returns the arc tangent of the two variables X and Y. It is similar to calculating the arc tangent of Y / X, except that the signs of both arguments are used to determine the quadrant of the result.
mysql> select ATAN(-2,2);
-> -0.785398
mysql> select ATAN(PI(),0);
-> 1.570796

COT(X) Returns the cotangent of X.
mysql> select COT(12);
-> -1.57267341
mysql> select COT(0);
-> NULL

RAND() Returns a random floating-point value in the range 0 to 1.0. If an integer argument N is specified, it is used as the seed value.

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You can't use a column with RAND() values in an ORDER BY clause, because ORDER BY would evaluate the column multiple times. In MySQL 3.23, you can however do: SELECT * FROM table_name ORDER BY RAND()

This is useful to get a random sample of a set SELECT * FROM table1,table2 WHERE a=b AND c<d ORDER BY RAND() LIMIT 1000.

Note that a RAND() in a WHERE clause will be re-evaluated every time the WHERE is executed.

LEAST(X,Y,...)

With two or more arguments, returns the smallest (minimum-valued) argument. The arguments are compared using the following rules:

- If the return value is used in an INTEGER context, or all arguments are integer-valued, they are compared as integers.
- If the return value is used in a REAL context, or all arguments are real-valued, they are compared as reals.
- If any argument is a case-sensitive string, the arguments are compared as case-sensitive strings.
- In other cases, the arguments are compared as case-insensitive strings.

```sql
mysql> select LEAST(2,0);
-> 0
mysql> select LEAST(34.0,3.0,5.0,767.0);
-> 3.0
mysql> select LEAST("B","A","C");
-> "A"
```

In MySQL versions prior to 3.22.5, you can use MIN() instead of LEAST.

GREATEST(X,Y,...)

Returns the largest (maximum-valued) argument. The arguments are compared using the same rules as for LEAST.

```sql
mysql> select GREATEST(2,0);
-> 2
mysql> select GREATEST(34.0,3.0,5.0,767.0);
-> 767.0
mysql> select GREATEST("B","A","C");
-> "C"
```

In MySQL versions prior to 3.22.5, you can use MAX() instead of GREATEST.
DEGREES(X)
Returns the argument X, converted from radians to degrees.

```sql
mysql> select DEGREES(PI());
-> 180.000000
```

RADIANS(X)
Returns the argument X, converted from degrees to radians.

```sql
mysql> select RADIANS(90);
-> 1.570796
```

TRUNCATE(X,D)
Returns the number X, truncated to D decimals. If D is 0, the result will have no decimal point or fractional part.

```sql
mysql> select TRUNCATE(1.223,1);
-> 1.2
mysql> select TRUNCATE(1.999,1);
-> 1.9
mysql> select TRUNCATE(1.999,0);
-> 1
```

### 7.4.10 String functions

String-valued functions return NULL if the length of the result would be greater than the `max_allowed_packet` server parameter. See Section 11.2.3 [Server parameters], page 278.

For functions that operate on string positions, the first position is numbered 1.

ASCII(str)
Returns the ASCII code value of the leftmost character of the string str. Returns 0 if str is the empty string. Returns NULL if str is NULL.

```sql
mysql> select ASCII('2');
-> 50
mysql> select ASCII(2);
-> 50
mysql> select ASCII('dx');
-> 100
```

See also the ORD() function.

ORD(str) If the leftmost character of the string str is a multi-byte character, returns the code of multi-byte character by returning the ASCII code value of the character in the format of: `((first byte ASCII code)*256+(second byte ASCII code))[*256+third byte ASCII code...].` If the leftmost character is not a multi-byte character, returns the same value as the like ASCII() function does.

```sql
mysql> select ORD('2');
-> 50
```
CONV(N,from_base,to_base)
Converts numbers between different number bases. Returns a string representation of the number N, converted from base from_base to base to_base. Returns NULL if any argument is NULL. The argument N is interpreted as an integer, but may be specified as an integer or a string. The minimum base is 2 and the maximum base is 36. If to_base is a negative number, N is regarded as a signed number. Otherwise, N is treated as unsigned. CONV works with 64-bit precision.

```
mysql> select CONV("a",16,2); -> '1010'
mysql> select CONV("6E",18,8); -> '172'
mysql> select CONV(-17,10,-18); -> '-H'
mysql> select CONV(10+"10"+0xa,10,10); -> '40'
```

BIN(N)
Returns a string representation of the binary value of N, where N is a longlong (BIGINT) number. This is equivalent to CONV(N,10,2). Returns NULL if N is NULL.

```
mysql> select BIN(12); -> '1100'
```

OCT(N)
Returns a string representation of the octal value of N, where N is a longlong number. This is equivalent to CONV(N,10,8). Returns NULL if N is NULL.

```
mysql> select OCT(12); -> '14'
```

HEX(N)
Returns a string representation of the hexadecimal value of N, where N is a longlong (BIGINT) number. This is equivalent to CONV(N,10,16). Returns NULL if N is NULL.

```
mysql> select HEX(255); -> 'FF'
```

CHAR(N,...)
CHAR() interprets the arguments as integers and returns a string consisting of the characters given by the ASCII code values of those integers. NULL values are skipped.

```
mysql> select CHAR(77,121,83,81,'76'); -> 'MySQL'
mysql> select CHAR(77,77.3,'77.3'); -> 'MMM'
```

CONCAT(str1,str2,...)
Returns the string that results from concatenating the arguments. Returns NULL if any argument is NULL. May have more than 2 arguments. A numeric argument is converted to the equivalent string form.

```
mysql> select CONCAT('My', 'S', 'QL');
```
-> 'MySQL'
mysql> select CONCAT('My', NULL, 'QL');
  -> NULL
mysql> select CONCAT(14.3);
  -> '14.3'

LENGTH(str)
OCTET_LENGTH(str)
CHAR_LENGTH(str)
CHARACTER_LENGTH(str)

Returns the length of the string str.

mysql> select LENGTH('text');
  -> 4
mysql> select OCTET_LENGTH('text');
  -> 4

Note that for CHAR_LENGTH(), multi-byte characters are only counted once.

LOCATE(substr,str)
POSITION(substr IN str)

Returns the position of the first occurrence of substring substr in string str.
Returns 0 if substr is not in str.

mysql> select LOCATE('bar', 'foobarbar');
  -> 4
mysql> select LOCATE('xbar', 'foobar');
  -> 0

This function is multi-byte safe.

LOCATE(substr,str,pos)

Returns the position of the first occurrence of substring substr in string str, starting at position pos. Returns 0 if substr is not in str.

mysql> select LOCATE('bar', 'foobarbar',5);
  -> 7

This function is multi-byte safe.

INSTR(str,substr)

Returns the position of the first occurrence of substring substr in string str. This is the same as the two-argument form of LOCATE(), except that the arguments are swapped.

mysql> select INSTR('foobarbar', 'bar');
  -> 4
mysql> select INSTR('xbar', 'foobar');
  -> 0

This function is multi-byte safe.

LPAD(str,len,padstr)

Returns the string str, left-padded with the string padstr until str is len characters long.
mysql> select LPAD('hi',4,'??');
-> '??hi'

RPAD(str,len,padstr)
Returns the string str, right-padded with the string padstr until str is len characters long.
mysql> select RPAD('hi',5,'?');
-> 'hi???'

LEFT(str,len)
Returns the leftmost len characters from the string str.
mysql> select LEFT('foobarbar', 5);
-> 'fooba'
This function is multi-byte safe.

RIGHT(str,len)
Returns the rightmost len characters from the string str.
mysql> select RIGHT('foobarbar', 4);
-> 'rbar'
This function is multi-byte safe.

SUBSTRING(str,pos,len)
SUBSTRING(str FROM pos FOR len)
MID(str,pos,len)
Returns a substring len characters long from string str, starting at position pos. The variant form that uses FROM is ANSI SQL92 syntax.
mysql> select SUBSTRING('Quadratically',5,6);
-> 'ratica'
This function is multi-byte safe.

SUBSTRING(str,pos)
SUBSTRING(str FROM pos)
Returns a substring from string str starting at position pos.
mysql> select SUBSTRING('Quadratically',5);
-> 'ratically'
mysql> select SUBSTRING('foobarbar' FROM 4);
-> 'barbar'
This function is multi-byte safe.

SUBSTRING_INDEX(str,delim,count)
Returns the substring from string str before count occurrences of the delimiter delim. If count is positive, everything to the left of the final delimiter (counting from the left) is returned. If count is negative, everything to the right of the final delimiter (counting from the right) is returned.
mysql> select SUBSTRING_INDEX('www.mysql.com', '.', 2);
-> 'www.mysql'
mysql> select SUBSTRING_INDEX('www.mysql.com', '.', -2);
-> 'mysql.com'

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This function is multi-byte safe.

**LTRIM**(str)

Returns the string str with leading space characters removed.

```sql
mysql> select LTRIM('barbar');
-> 'barbar'
```

**RTRIM**(str)

Returns the string str with trailing space characters removed.

```sql
mysql> select RTRIM('barbar');
-> 'barbar'
```

This function is multi-byte safe.

**TRIM([BOTH | LEADING | TRAILING] [remstr] FROM) str**

Returns the string str with all remstr prefixes and/or suffixes removed. If none of the specifiers BOTH, LEADING or TRAILING are given, BOTH is assumed. If remstr is not specified, spaces are removed.

```sql
mysql> select TRIM('bar');
-> 'bar'

mysql> select TRIM(LEADING 'x' FROM 'xxxbarxxx');
-> 'barxxx'

mysql> select TRIM(BOTH 'x' FROM 'xxxbarxxx');
-> 'bar'

mysql> select TRIM(TRAILING 'xyz' FROM 'barxyz');
-> 'barx'
```

This function is multi-byte safe.

**SOUNDEX**(str)

Returns a soundex string from str. Two strings that sound “about the same” should have identical soundex strings. A “standard” soundex string is 4 characters long, but the SOUNDEX() function returns an arbitrarily long string. You can use SUBSTRING() on the result to get a “standard” soundex string. All non-alphanumeric characters are ignored in the given string. All international alpha characters outside the A-Z range are treated as vowels.

```sql
mysql> select SOUNDEX('Hello');
-> 'H400'

mysql> select SOUNDEX('Quadratically');
-> 'Q36324'
```

**SPACE**(N)

Returns a string consisting of N space characters.

```sql
mysql> select SPACE(6);
-> ' ' 
```

**REPLACE**(str,from_str,to_str)

Returns the string str with all all occurrences of the string from_str replaced by the string to_str.

```sql
mysql> select REPLACE('www.mysql.com', 'w', 'Ww');
-> 'Wwww.mysql.com'
```

This function is multi-byte safe.
REPEAT(str, count)
Returns a string consisting of the string str repeated count times. If count <= 0, returns an empty string. Returns NULL if str or count are NULL.
   mysql> select REPEAT('MySQL', 3);
   -> 'MySQLMySQLMySQL'

REVERSE(str)
Returns the string str with the order of the characters reversed.
   mysql> select REVERSE('abc');
   -> 'cba'
   This function is multi-byte safe.

INSERT(str, pos, len, newstr)
Returns the string str, with the substring beginning at position pos and len characters long replaced by the string newstr.
   mysql> select INSERT('Quadratic', 3, 4, 'What');
   -> 'QuWhattic'
   This function is multi-byte safe.

ELT(N, str1, str2, str3, ...)
Returns str1 if N = 1, str2 if N = 2, and so on. Returns NULL if N is less than 1 or greater than the number of arguments. ELT() is the complement of FIELD().
   mysql> select ELT(1, 'ej', 'Heja', 'hej', 'foo');
   -> 'ej'
   mysql> select ELT(4, 'ej', 'Heja', 'hej', 'foo');
   -> 'foo'

FIELD(str, str1, str2, str3, ...)
Returns the index of str in the str1, str2, str3, ... list. Returns 0 if str is not found. FIELD() is the complement of ELT().
   mysql> select FIELD('ej', 'Hej', 'ej', 'Heja', 'hej', 'foo');
   -> 2
   mysql> select FIELD('fo', 'Hej', 'ej', 'Heja', 'hej', 'foo');
   -> 0

FIND_IN_SET(str, strlist)
Returns a value 1 to N if the string str is in the list strlist consisting of N substrings. A string list is a string composed of substrings separated by ‘,’ characters. If the first argument is a constant string and the second is a column of type SET, the FIND_IN_SET() function is optimized to use bit arithmetic! Returns 0 if str is not in strlist or if strlist is the empty string. Returns NULL if either argument is NULL. This function will not work properly if the first argument contains a ‘,’.
   mysql> SELECT FIND_IN_SET('b', 'a,b,c,d');
   -> 2
MAKE_SET(bits,str1,str2,...)
Returns a set (a string containing substrings separated by ‘,’ characters) consisting of the strings that have the corresponding bit in bits set. str1 corresponds to bit 0, str2 to bit 1, etc. NULL strings in str1, str2, ... are not appended to the result.

mysql> SELECT MAKE_SET(1,'a','b','c');
-> 'a'
mysql> SELECT MAKE_SET(1 | 4,'hello','nice','world');
-> 'hello,world'
mysql> SELECT MAKE_SET(0,'a','b','c');
-> ''

EXPORT_SET(bits,on,off,[separator,[number_of_bits]])
Returns a string where for every bit set in 'bit', you get a 'on' string and for every reset bit you get an 'off' string. Each string is separated with 'separator' (default ',') and only 'number_of_bits' (default 64) of 'bits' is used.

mysql> select EXPORT_SET(5,'Y','N',',',4)
-> Y,N,Y,N

LCASE(str)
LOWER(str)
Returns the string str with all characters changed to lowercase according to the current character set mapping (the default is ISO-8859-1 Latin1).
This function is multi-byte safe.

mysql> select LCASE('QUADRATICALLY');
-> 'quadratically'

UCASE(str)
UPPER(str)
Returns the string str with all characters changed to uppercase according to the current character set mapping (the default is ISO-8859-1 Latin1).

mysql> select UCASE('Hej');
-> 'HEJ'
This function is multi-byte safe.

LOAD_FILE(file_name)
Reads the file and returns the file contents as a string. The file must be on the server, you must specify the full pathname to the file, and you must have the file privilege. The file must be readable by all and be smaller than max_allowed_packet.
If the file doesn’t exist or can’t be read due to one of the above reasons, the function returns NULL.

mysql> UPDATE table_name
    SET blob_column=LOAD_FILE("/tmp/picture")
    WHERE id=1;

MySQL automatically converts numbers to strings as necessary, and vice versa:
mysql> SELECT 1+"1";
   -> 2
mysql> SELECT CONCAT(2,' test');
   -> '2 test'

If you want to convert a number to a string explicitly, pass it as the argument to `CONCAT()`.
If a string function is given a binary string as an argument, the resulting string is also a binary string. A number converted to a string is treated as a binary string. This only affects comparisons.

### 7.4.11 Date and time functions

See [Section 7.3.3 (Date and time types)](page 141) for a description of the range of values each type has, and the valid formats in which date and time values may be specified.

Here is an example that uses date functions. The query below selects all records with a `date_col` value from within the last 30 days:

```sql
mysql> SELECT something FROM table
WHERE TO_DAYS(NOW()) - TO_DAYS(date_col) <= 30;
```

**DAYOFWEEK(date)**

Returns the weekday index for `date` (1 = Sunday, 2 = Monday, ... 7 = Saturday). These index values correspond to the ODBC standard.

```sql
mysql> select DAYOFWEEK('1998-02-03');
   -> 3
```

**WEEKDAY(date)**

Returns the weekday index for `date` (0 = Monday, 1 = Tuesday, ... 6 = Sunday).

```sql
mysql> select WEEKDAY('1997-10-04 22:23:00');
   -> 5
mysql> select WEEKDAY('1997-11-05');
   -> 2
```

**DAYOFMONTH(date)**

Returns the day of the month for `date`, in the range 1 to 31.

```sql
mysql> select DAYOFMONTH('1998-02-03');
   -> 3
```

**DAYOFYEAR(date)**

Returns the day of the year for `date`, in the range 1 to 366.

```sql
mysql> select DAYOFYEAR('1998-02-03');
   -> 34
```

**MONTH(date)**

Returns the month for `date`, in the range 1 to 12.

```sql
mysql> select MONTH('1998-02-03');
   -> 2
```
DAYNAME(date)
Returns the name of the weekday for date.
  mysql> select DAYNAME("1998-02-05");
     -> 'Thursday'

MONTHNAME(date)
Returns the name of the month for date.
  mysql> select MONTHNAME("1998-02-05");
     -> 'February'

QUARTER(date)
Returns the quarter of the year for date, in the range 1 to 4.
  mysql> select QUARTER('98-04-01');
      -> 2

WEEK(date)
  With a single argument, returns the week for date, in the range 0 to 53 (yes, there may be the beginnings of a week 53), for locations where Sunday is the first day of the week. The two-argument form of WEEK() allows you to specify whether the week starts on Sunday or Monday. The week starts on Sunday if the second argument is 0, on Monday if the second argument is 1.
  mysql> select WEEK('1998-02-20');
       -> 7
  mysql> select WEEK('1998-02-20',0);
       -> 7
  mysql> select WEEK('1998-02-20',1);
       -> 8
  mysql> select WEEK('1998-12-31',1);
       -> 53

YEAR(date)
Returns the year for date, in the range 1000 to 9999.
  mysql> select YEAR('98-02-03');
      -> 1998

YEARWEEK(date)
YEARWEEK(date,first)
Returns year and week for a date. The second arguments works exactly like the second argument to WEEK(). Note that the year may be different from the year in the date argument for the first and the last week of the year!
  mysql> select YEARWEEK('1987-01-01');
      -> 198653

HOUR(time)
Returns the hour for time, in the range 0 to 23.
  mysql> select HOUR('10:05:03');
     -> 10
MINUTE(time)
Returns the minute for time, in the range 0 to 59.
```
mysql> select MINUTE('98-02-03 10:05:03');
-> 5
```

SECOND(time)
Returns the second for time, in the range 0 to 59.
```
mysql> select SECOND('10:05:03');
-> 3
```

PERIOD_ADD(P,N)
Adds N months to period P (in the format YYMM or YYYYMM). Returns a value in the format YYYYMM.
Note that the period argument P is not a date value.
```
mysql> select PERIOD_ADD('9801',2); 
-> 199803
```

PERIOD_DIFF(P1,P2)
Returns the number of months between periods P1 and P2. P1 and P2 should be in the format YYMM or YYYYMM.
Note that the period arguments P1 and P2 are not date values.
```
mysql> select PERIOD_DIFF('9802','199703'); 
-> 11
```

DATE_ADD(date,INTERVAL expr type)
DATE_SUB(date,INTERVAL expr type)
ADDDATE(date,INTERVAL expr type)
SUBDATE(date,INTERVAL expr type)
These functions perform date arithmetic. They are new for MySQL 3.22. ADDDATE() and SUBDATE() are synonyms for DATE_ADD() and DATE_SUB().
In MySQL 3.23, you can use + and - instead of DATE_ADD() and DATE_SUB(). (See example)
```
date is a DATETIME or DATE value specifying the starting date. expr is an expression specifying the interval value to be added or substracted from the starting date. expr is a string; it may start with a '-' for negative intervals. type is a keyword indicating how the expression should be interpreted.
The EXTRACT(type FROM date) function returns the 'type' interval from the date.
The following table shows how the type and expr arguments are related:

<table>
<thead>
<tr>
<th>type</th>
<th>Meaning</th>
<th>Expected expr format</th>
</tr>
</thead>
<tbody>
<tr>
<td>SECOND</td>
<td>Seconds</td>
<td>SECONDS</td>
</tr>
<tr>
<td>MINUTE</td>
<td>Minutes</td>
<td>MINUTES</td>
</tr>
<tr>
<td>HOUR</td>
<td>Hours</td>
<td>HOURS</td>
</tr>
<tr>
<td>DAY</td>
<td>Days</td>
<td>DAYS</td>
</tr>
<tr>
<td>MONTH</td>
<td>Months</td>
<td>MONTHS</td>
</tr>
<tr>
<td>YEAR</td>
<td>Years</td>
<td>YEARS</td>
</tr>
</tbody>
</table>

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MySQL allows any punctuation delimiter in the expr format. The ones shown in the table are the suggested delimiters. If the date argument is a DATE value and your calculations involve only YEAR, MONTH and DAY parts (that is, no time parts), the result is a DATE value. Otherwise the result is a DATETIME value.

If you specify an interval value that is too short (does not include all the interval parts that would be expected from the type keyword), MySQL assumes you have left out the leftmost parts of the interval value. For example, if you specify a type of DAY_SECOND, the value of expr is expected to have days, hours, minutes and seconds parts. If you specify a value like "1:10", MySQL assumes that the days and hours parts are missing and the value represents...
minutes and seconds. In other words, "1:10" DAY_SECOND is interpreted in such a way that it is equivalent to "1:10" MINUTE_SECOND. This is analogous to the way that MySQL interprets TIME values as representing elapsed time rather than as time of day.

If you use really incorrect dates, the result is NULL. If you add MONTH, YEAR_MONTH or YEAR and the resulting date has a day that is larger than the maximum day for the new month, the day is adjusted to the maximum days in the new month.

```sql
mysql> select DATE_ADD('1998-01-30', Interval 1 month);
-> 1998-02-28
```

Note from the preceding example that the word INTERVAL and the type keyword are not case sensitive.

**TO_DAYS(date)**

Given a date date, returns a daynumber (the number of days since year 0).

```sql
mysql> select TO_DAYS(950501);
-> 728779
mysql> select TO_DAYS('1997-10-07');
-> 729669
```

TO_DAYS() is not intended for use with values that precede the advent of the Gregorian calendar (1582), because it doesn’t take into account the days that were lost when the calendar was changed.

**FROM_DAYS(N)**

Given a daynumber N, returns a DATE value.

```sql
mysql> select FROM_DAYS(729669);
-> '1997-10-07'
```

FROM_DAYS() is not intended for use with values that precede the advent of the Gregorian calendar (1582), because it doesn’t take into account the days that were lost when the calendar was changed.

**DATE_FORMAT(date,format)**

Formats the date value according to the format string. The following specifiers may be used in the format string:

- `%M` Month name (January..December)
- `%W` Weekday name (Sunday..Saturday)
- `%D` Day of the month with english suffix (1st, 2nd, 3rd, etc.)
- `%Y` Year, numeric, 4 digits
- `%y` Year, numeric, 2 digits
- `%X` Year for the week where Sunday is the first day of the week, numeric, 4 digits, used with `%V`
- `%x` Year for the week, where Monday is the first day of the week, numeric, 4 digits, used with `%v`
- `%a` Abbreviated weekday name (Sun..Sat)
- `%d` Day of the month, numeric (00..31)
- `%e` Day of the month, numeric (0..31)
%m  Month, numeric (01..12)
%c  Month, numeric (1..12)
%b  Abbreviated month name (Jan..Dec)
%j  Day of year (001..366)
%H  Hour (00..23)
%k  Hour (0..23)
%h  Hour (01..12)
%I  Hour (01..12)
%l  Hour (1..12)
%i  Minutes, numeric (00..59)
%x  Time, 12-hour (hh:mm:ss [AP]M)
%T  Time, 24-hour (hh:mm:ss)
%S  Seconds (00..59)
%s  Seconds (00..59)
%p  AM or PM
%w  Day of the week (0=Sunday..6=Saturday)
%U  Week (0..53), where Sunday is the first day of the week
%w  Week (0..53), where Monday is the first day of the week
%V  Week (1..53), where Sunday is the first day of the week. Used with '%X'
%v  Week (1..53), where Monday is the first day of the week. Used with '%x'
%%  A literal '%'.

All other characters are just copied to the result without interpretation.

```mysql
mysql> select DATE_FORMAT('1997-10-04 22:23:00', '%W %M %Y');
    -> 'Saturday October 1997'
mysql> select DATE_FORMAT('1997-10-04 22:23:00', '%H:%i:%s');
    -> '22:23:00'
mysql> select DATE_FORMAT('1997-10-04 22:23:00', '%D %y %a %d %m %b %j');
    -> '4th 97 Sat 04 10 Oct 277'
mysql> select DATE_FORMAT('1997-10-04 22:23:00', '%H %k %I %r %T %S %w');
    -> '22 22 10 10:23:00 PM 22:23:00 00 6'
mysql> select DATE_FORMAT('1999-01-01', '%X %V');
    -> '1998 52'
```

As of MySQL 3.23, the % character is required before format specifier characters. In earlier versions of MySQL, % was optional.

```
TIME_FORMAT(time,format)
```

This is used like the `DATE_FORMAT()` function above, but the format string may contain only those format specifiers that handle hours, minutes and seconds. Other specifiers produce a NULL value or 0.

```
CURDATE()
CURRENT_DATE
```

Returns today’s date as a value in ‘YYYY-MM-DD’ or YYYYMMDD format, depending on whether the function is used in a string or numeric context.

```mysql
mysql> select CURDATE();
```

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CURTIME()
CURRENT_TIME

Returns the current time as a value in 'HH:MM:SS' or 'HHMMSS' format, depending on whether the function is used in a string or numeric context.

mysql> select CURTIME();
-> '23:50:26'

mysql> select CURTIME() + 0;
-> 235026

NOW()
SYSDATE()
CURRENT_TIMESTAMP

Returns the current date and time as a value in 'YYYY-MM-DD HH:MM:SS' or 'YYYYMMDDHHMMSS' format, depending on whether the function is used in a string or numeric context.

mysql> select NOW();
-> '1997-12-15 23:50:26'

mysql> select NOW() + 0;
-> 19971215235026

UNIX_TIMESTAMP()
UNIX_TIMESTAMP(date)

If called with no argument, returns a Unix timestamp (seconds since '1970-01-01 00:00:00' GMT). If UNIX_TIMESTAMP() is called with a date argument, it returns the value of the argument as seconds since '1970-01-01 00:00:00' GMT. date may be a DATE string, a DATETIME string, a TIMESTAMP, or a number in the format YYYYMMDD or YYYYMMDD in local time.

mysql> select UNIX_TIMESTAMP();
-> 882226357

mysql> select UNIX_TIMESTAMP('1997-10-04 22:23:00');
-> 875996580

When UNIX_TIMESTAMP is used on a TIMESTAMP column, the function will receive the value directly, with no implicit "string-to-unix-timestamp" conversion.

FROM_UNIXTIME(unix_timestamp)

Returns a representation of the unix_timestamp argument as a value in 'YYYY-MM-DD HH:MM:SS' or 'YYYYMMDDHHMMSS' format, depending on whether the function is used in a string or numeric context.

mysql> select FROM_UNIXTIME(875996580);
-> '1997-10-04 22:23:00'

mysql> select FROM_UNIXTIME(875996580) + 0;
-> 19971004222300

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FROM_UNIXTIME(unix_timestamp, format)
Returns a string representation of the Unix timestamp, formatted according to
the format string. format may contain the same specifiers as those listed in
the entry for the DATE_FORMAT() function.

```sql
mysql> select FROM_UNIXTIME(UNIX_TIMESTAMP(), 'YY MM DD HH:MI:SS %x');
-> '1997 23rd December 03:43:30 x'
```

SEC_TO_TIME(seconds)
Returns the seconds argument, converted to hours, minutes and seconds, as a
value in 'HH:MM:SS' or HHMMSS format, depending on whether the function is
used in a string or numeric context.

```sql
mysql> select SEC_TO_TIME(2378);
-> '00:39:38'

mysql> select SEC_TO_TIME(2378) + 0;
-> 3938
```

TIME_TO_SEC(time)
Returns the time argument, converted to seconds.

```sql
mysql> select TIME_TO_SEC('22:23:00');
-> 80580

mysql> select TIME_TO_SEC('00:39:38');
-> 2378
```

### 7.4.12 Miscellaneous functions

DATABASE()
Returns the current database name.

```sql
mysql> select DATABASE();
-> 'test'
```

If there is no current database, DATABASE() returns the empty string.

USER()

SYSTEM_USER()

SESSION_USER()
Returns the current MySQL user name.

```sql
mysql> select USER();
-> 'davida@localhost'
```

In MySQL 3.22.11 or later, this includes the client hostname as well as the user-
name. You can extract just the username part like this (which works whether
or not the value includes a hostname part):

```sql
mysql> select substring_index(USER(),"@",1);
-> 'davida'
```
PASSWORD(str)
Calculates a password string from the plaintext password str. This is the function that is used for encrypting MySQL passwords for storage in the Password column of the user grant table.

```
mysql> select PASSWORD('badpwd');
-> '7f84554057dd964b'
```

PASSWORD() encryption is non-reversible.
PASSWORD() does not perform password encryption in the same way that Unix passwords are encrypted. You should not assume that if your Unix password and your MySQL password are the same, PASSWORD() will result in the same encrypted value as is stored in the Unix password file. See ENCRYPT().

ENCRYPT(str[,salt])
Encrypt str using the Unix crypt() system call. The salt argument should be a string with two characters. (As of MySQL 3.22.16, salt may be longer than two characters.)

```
mysql> select ENCRYPT("hello");
-> 'VxuFAJXVARROc'
```

If crypt() is not available on your system, ENCRYPT() always returns NULL.
ENCRYPT() ignores all but the first 8 characters of str, at least on some systems. This will be determined by the behavior of the underlying crypt() system call.

ENCODE(str,pass_str)
Encrypt str using pass_str as the password. To decrypt the result, use DECODE().
The results is a binary string. If you want to save it in a column, use a BLOB column type.

DECODE(crypt_str,pass_str)
Descrypts the encrypted string crypt_str using pass_str as the password.
crypt_str should be a string returned from ENCODE().

MD5(string)
Calculates a MD5 checksum for the string. Value is returned as a 32 long hex number that may, for example, be used as a hash key.

```
mysql> select MD5("testing");
-> 'ae2b1fca5159f49e5d54fb22b8ed95675'
```

This is a "RSA Data Security, Inc. MD5 Message-Digest Algorithm".

LAST_INSERT_ID([expr])
Returns the last automatically generated value that was inserted into an AUTO_INCREMENT column. See Section 21.4.29 [mysql_insert_id()], page 397.

```
mysql> select LAST_INSERT_ID();
-> 195
```

The last ID that was generated is maintained in the server on a per-connection basis. It will not be changed by another client. It will not even be changed if
you update another \texttt{AUTO_INCREMENT} column with a non-magic value (that is, a value that is not \texttt{NULL} and not 0).

If \texttt{expr} is given as an argument to \texttt{LAST_INSERT_ID()} in an \texttt{UPDATE} clause, then the value of the argument is returned as a \texttt{LAST_INSERT_ID()} value. This can be used to simulate sequences:

First create the table:

\begin{verbatim}
mysql> create table sequence (id int not null);
mysql> insert into sequence values (0);
\end{verbatim}

Then the table can be used to generate sequence numbers like this:

\begin{verbatim}
mysql> update sequence set id=LAST_INSERT_ID(id+1);
\end{verbatim}

You can generate sequences without calling \texttt{LAST_INSERT_ID()}, but the utility of using the function this way is that the ID value is maintained in the server as the last automatically generated value. You can retrieve the new ID as you would read any normal \texttt{AUTO_INCREMENT} value in MySQL. For example, \texttt{LAST_INSERT_ID()} (without an argument) will return the new ID. The C API function \texttt{mysql_insert_id()} can also be used to get the value.

\textbf{FORMAT(X,D)}

Formats the number \texttt{X} to a format like ‘##,###,###.##’, rounded to \texttt{D} decimals. If \texttt{D} is 0, the result will have no decimal point or fractional part.

\begin{verbatim}
mysql> select FORMAT(12332.123456, 4);
-> '12,332.1235'
mysql> select FORMAT(12332.1,4);
-> '12,332.1000'
mysql> select FORMAT(12332.2,0);
-> '12,332'
\end{verbatim}

\textbf{VERSION()}

Returns a string indicating the MySQL server version.

\begin{verbatim}
mysql> select VERSION();
-> '3.22.19b-log'
\end{verbatim}

\textbf{GET_LOCK(str,timeout)}

Tries to obtain a lock with a name given by the string \texttt{str}, with a timeout of \texttt{timeout} seconds. Returns 1 if the lock was obtained successfully, 0 if the attempt timed out, or NULL if an error occurred (such as running out of memory or the thread was killed with \texttt{mysqladmin kill}). A lock is released when you execute \texttt{RELEASE_LOCK()}, execute a new \texttt{GET_LOCK()} or the thread terminates. This function can be used to implement application locks or to simulate record locks. It blocks requests by other clients for locks with the same name; clients that agree on a given lock string name can use the string to perform cooperative advisory locking.

\begin{verbatim}
mysql> select GET_LOCK("lock1",10);
-> 1
mysql> select GET_LOCK("lock2",10);
-> 1
\end{verbatim}
mysql> select RELEASE_LOCK("lock2");
  -> 1
mysql> select RELEASE_LOCK("lock1");
  -> NULL

Note that the second \texttt{RELEASE\_LOCK()} call returns \texttt{NULL} because the lock "lock1" was automatically released by the second \texttt{GET\_LOCK()} call.

\textbf{RELEASE\_LOCK}(str)

Releases the lock named by the string \texttt{str} that was obtained with \texttt{GET\_LOCK()}. Returns 1 if the lock was released, 0 if the lock wasn’t locked by this thread (in which case the lock is not released) and \texttt{NULL} if the named lock didn’t exist. The lock will not exist if it was never obtained by a call to \texttt{GET\_LOCK()} or if it already has been released.

\textbf{BENCHMARK}(count,expr)

The \texttt{BENCHMARK()} function executes the expression \texttt{expr} repeatedly \texttt{count} times. It may be used to time how fast MySQL processes the expression. The result value is always 0. The intended use is in the \texttt{mysql} client, which reports query execution times.

mysql> select student.student_name,COUNT(*)
    from student,course
    where student.student_id=course.student_id
    GROUP BY student_name;

\textbf{COUNT(expr)}

Returns a count of the number of non-NULL values in the rows retrieved by a \texttt{SELECT} statement.

mysql> select student.student_name,COUNT(*)
    from student,course
    where student.student_id=course.student_id
    GROUP BY student_name;

\textbf{7.4.13 Functions for use with GROUP BY clauses}

If you use a group function in a statement containing no \texttt{GROUP BY} clause, it is equivalent to grouping on all rows.

\textbf{COUNT(expr)}

Returns a count of the number of non-NULL values in the rows retrieved by a \texttt{SELECT} statement.

mysql> select student.student_name,COUNT(*)
    from student,course
    where student.student_id=course.student_id
    GROUP BY student_name;

\textbf{COUNT(*)} is somewhat different in that it returns a count of the number of rows retrieved, whether or not they contain NULL values.
COUNT(*) is optimized to return very quickly if the SELECT retrieves from one table, no other columns are retrieved and there is no WHERE clause. For example:

```
mysql> select COUNT(*) from student;
```

`COUNT(DISTINCT expr,[expr...] )`

Returns a count of the number of different values.

```
mysql> select COUNT(DISTINCT results) from student;
```

In MySQL you can get the number of distinct expressions combinations by giving a list of expressions. In ANSI SQL you would have to do a concatenation of all expressions inside `CODE(DISTINCT ..)`.

`AVG(expr)`

Returns the average value of expr.

```
mysql> select student_name, AVG(test_score)
    from student
    GROUP BY student_name;
```

`MIN(expr)`

`MAX(expr)`

Returns the minimum or maximum value of expr. `MIN()` and `MAX()` may take a string argument; in such cases they return the minimum or maximum string value.

```
mysql> select student_name, MIN(test_score), MAX(test_score)
    from student
    GROUP BY student_name;
```

`SUM(expr)`

Returns the sum of expr. Note that if the return set has no rows, it returns NULL!

`STD(expr)`

`STDDEV(expr)`

Returns the standard deviation of expr. This is an extension to ANSI SQL. The `STDDEV()` form of this function is provided for Oracle compatibility.

`BIT_OR(expr)`

Returns the bitwise OR of all bits in expr. The calculation is performed with 64-bit (`BIGINT` precision).

`BIT_AND(expr)`

Returns the bitwise AND of all bits in expr. The calculation is performed with 64-bit (`BIGINT` precision).

MySQL has extended the use of `GROUP BY`. You can use columns or calculations in the `SELECT` expressions which don’t appear in the `GROUP BY` part. This stands for any possible value for this group. You can use this to get better performance by avoiding sorting and grouping on unnecessary items. For example, you don’t need to group on `customer.name` in the following query:

```
mysql> select order.custid,customer.name,max(payments)
    from order,customer
```

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WHERE order.custid = customer.custid
GROUP BY order.custid;

In ANSI SQL, you would have to add customer.name to the GROUP BY clause. In MySQL, the name is redundant.

Don’t use this feature if the columns you omit from the GROUP BY part aren’t unique in the group!

In some cases, you can use MIN() and MAX() to obtain a specific column value even if it isn’t unique. The following gives the value of column from the row containing the smallest value in the sort column:

```
substr(MIN(concat(sort, space(6-length(sort)), column),7,length(column)))
```

Note that if you are using MySQL 3.22 (or earlier) or if you are trying to follow ANSI SQL, you can’t use expressions in GROUP BY or ORDER BY clauses. You can work around this limitation by using an alias for the expression:

```
mysql> SELECT id,FLOOR(value/100) AS val FROM tbl_name
GROUP BY id,val ORDER BY val;
```

In MySQL 3.23 you can do:

```
mysql> SELECT id,FLOOR(value/100) FROM tbl_name ORDER BY RAND();
```

### 7.5 CREATE DATABASE syntax

**CREATE DATABASE** creates a database with the given name. Rules for allowable database names are given in Section 7.1.5 [Legal names], page 132. An error occurs if the database already exists.

Databases in MySQL are implemented as directories containing files that correspond to tables in the database. Since there are no tables in a database when it is initially created, the CREATE DATABASE statement only creates a directory under the MySQL data directory.

You can also create databases with mysqladmin. See Section 13.1 [Programs], page 305.

### 7.6 DROP DATABASE syntax

**DROP DATABASE** drops all tables in the database and deletes the database. Be VERY careful with this command!

DROP DATABASE returns the number of files that were removed from the database directory. Normally, this is three times the number of tables, since each table corresponds to a `.MYD` file, a `.MYI` file and a `.frm` file.

In MySQL 3.22 or later, you can use the keywords IF EXISTS to prevent an error from occurring if the database doesn’t exist.

You can also drop databases with mysqladmin. See Section 13.1 [Programs], page 305.
7.7 CREATE TABLE syntax

CREATE [TEMPORARY] TABLE [IF NOT EXISTS] tbl_name [(create_definition,...)]
[table_options] [select_statement]

create_definition:
   col_name type [NOT NULL | NULL] [DEFAULT default_value] [AUTO_INCREMENT]
   [PRIMARY KEY] [reference_definition]
   or PRIMARY KEY (index_col_name,...)
   or KEY [index_name] (index_col_name,...)
   or INDEX [index_name] (index_col_name,...)
   or UNIQUE [INDEX] [index_name] (index_col_name,...)
   or [CONSTRAINT symbol] FOREIGN KEY index_name (index_col_name,...)
   [reference_definition]
   or CHECK (expr)

type:
   TINYINT[(length)] [UNSIGNED] [ZEROFILL]
   or SMALLINT[(length)] [UNSIGNED] [ZEROFILL]
   or MEDIUMINT[(length)] [UNSIGNED] [ZEROFILL]
   or INT[(length)] [UNSIGNED] [ZEROFILL]
   or INTEGER[(length)] [UNSIGNED] [ZEROFILL]
   or BIGINT[(length)] [UNSIGNED] [ZEROFILL]
   or REAL[(length,decimals)] [UNSIGNED] [ZEROFILL]
   or DOUBLE[(length,decimals)] [UNSIGNED] [ZEROFILL]
   or FLOAT[(length,decimals)] [UNSIGNED] [ZEROFILL]
   or DECIMAL(length,decimals) [UNSIGNED] [ZEROFILL]
   or NUMERIC(length,decimals) [UNSIGNED] [ZEROFILL]
   or CHAR(length) [BINARY]
   or VARCHAR(length) [BINARY]
   or DATE
   or TIME
   or TIMESTAMP
   or DATETIME
   or TINYBLOB
   or BLOB
   or MEDIUMBLOB
   or LONGBLOB
   or TINYTEXT
   or TEXT
   or MEDIUMTEXT
   or LONGBlob
   or ENUM(value1,value2,value3,...)
   or SET(value1,value2,value3,...)

index_col_name:
   col_name [(length)]
CREATE TABLE creates a table with the given name in the current database. Rules for allowable table names are given in Section 7.1.5 [Legal names], page 132. An error occurs if there is no current database or if the table already exists.

In MySQL 3.22 or later, the table name can be specified as db_name.tbl_name. This works whether or not there is a current database.

In MySQL 3.23, you can use the TEMPORARY keyword when you create a table. A temporary table will automatically be deleted if a connection dies and the name is per connection. This means that two different connections can both use the same temporary table name without conflicting with each other or with an existing table of the same name. (The existing table is hidden until the temporary table is deleted).

In MySQL 3.23 or later, you can use the keywords IF NOT EXISTS so that an error does not occur if the table already exists. Note that there is no verification that the table structures are identical.

Each table tbl_name is represented by some files in the database directory. In the case of MyISAM-type tables you will get:

<table>
<thead>
<tr>
<th>File</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>tbl_name.frm</td>
<td>Table definition (form) file</td>
</tr>
<tr>
<td>tbl_name.MYD</td>
<td>Data file</td>
</tr>
<tr>
<td>tbl_name.MYI</td>
<td>Index file</td>
</tr>
</tbody>
</table>

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For more information on the properties of the various column types, see Section 7.3 [Column types], page 134.

- If neither NULL nor NOT NULL is specified, the column is treated as though NULL had been specified.

- An integer column may have the additional attribute AUTO_INCREMENT. When you insert a value of NULL (recommended) or 0 into an AUTO_INCREMENT column, the column is set to \( \text{value}+1 \), where \( \text{value} \) is the largest value for the column currently in the table. AUTO_INCREMENT sequences begin with 1. See Section 21.4.29 [mysql_insert_id()], page 397.

If you delete the row containing the maximum value for an AUTO_INCREMENT column, the value will be reused with an ISAM table but not with a MyISAM table. If you delete all rows in the table with DELETE FROM TABLE (without a WHERE), the sequence starts over for both table types.

**Note:** There can be only one AUTO_INCREMENT column per table, and it must be indexed.

To make MySQL compatible with some ODBC applications, you can find the last inserted row with the following query:

```sql
SELECT * FROM tbl_name WHERE auto_col IS NULL
```

- NULL values are handled differently for TIMESTAMP columns than for other column types. You cannot store a literal NULL in a TIMESTAMP column; setting the column to NULL sets it to the current date and time. Because TIMESTAMP columns behave this way, the NULL and NOT NULL attributes do not apply in the normal way and are ignored if you specify them.

On the other hand, to make it easier for MySQL clients to use TIMESTAMP columns, the server reports that such columns may be assigned NULL values (which is true), even though TIMESTAMP never actually will contain a NULL value. You can see this when you use DESCRIBE tbl_name to get a description of your table.

Note that setting a TIMESTAMP column to 0 is not the same as setting it to NULL, because 0 is a valid TIMESTAMP value.

- If no DEFAULT value is specified for a column, MySQL automatically assigns one.

If the column may take NULL as a value, the default value is NULL.

If the column is declared as NOT NULL, the default value depends on the column type:

- For numeric types other than those declared with the AUTO_INCREMENT attribute, the default is 0. For an AUTO_INCREMENT column, the default value is the next value in the sequence.

- For date and time types other than TIMESTAMP, the default is the appropriate “zero” value for the type. For the first TIMESTAMP column in a table, the default value is the current date and time. See Section 7.3.3 [Date and time types], page 141.

- For string types other than ENUM, the default is the empty string. For ENUM, the default is the first enumeration value.

- KEY is a synonym for INDEX.
• In MySQL, a UNIQUE key can have only distinct values. An error occurs if you try to add a new row with a key that matches an existing row.

• A PRIMARY KEY is an unique key with the extra constraint that all key columns must be defined as NOT NULL. In MySQL the key is named PRIMARY. A table can have only one PRIMARY KEY. If you don’t have a PRIMARY KEY and some applications ask for the PRIMARY KEY in your tables, MySQL will return the first UNIQUE key, which doesn’t have any NULL columns, as the PRIMARY KEY.

• A PRIMARY KEY can be a multiple-column index. However, you cannot create a multiple-column index using the PRIMARY KEY key attribute in a column specification. Doing so will mark only that single column as primary. You must use the PRIMARY KEY(index_col_name, ...) syntax.

• If the PRIMARY or UNIQUE key consists of only one column and this is of type integer, you can also refer to it as _rowid (new in 3.23.11).

• If you don’t assign a name to an index, the index will be assigned the same name as the first index_col_name, with an optional suffix (_2, _3, ...) to make it unique. You can see index names for a table using SHOW INDEX FROM tbl_name. See Section 7.21 [SHOW], page 211.

• Only the MyISAM table type supports indexes on columns that can have NULL values. In other cases you must declare such columns NOT NULL or an error results.

• With col_name(length) syntax, you can specify an index which uses only a part of a CHAR or VARCHAR column. This can make the index file much smaller. See Section 7.3.6 [Indexes], page 152.

• Only the MyISAM table type supports indexing on BLOB and TEXT columns. When putting an index on a BLOB or TEXT column you MUST always specify the length of the index:

  CREATE TABLE test (blob_col BLOB, index(blob_col(10)));

• When you use ORDER BY or GROUP BY with a TEXT or BLOB column, only the first max_sort_length bytes are used. See Section 7.3.4.2 [BLOB], page 148.

• The FOREIGN KEY, CHECK and REFERENCES clauses don’t actually do anything. The syntax for them is provided only for compatibility, to make it easier to port code from other SQL servers and to run applications that create tables with references. See Section 5.4 [Missing functions], page 99.

• Each NULL column takes one bit extra, rounded up to the nearest byte.

• The maximum record length in bytes can be calculated as follows:

  row length = 1
  + (sum of column lengths)
  + (number of NULL columns + 7)/8
  + (number of variable-length columns)

• The table_options and SELECT options is only implemented in MySQL 3.23 and above.

  The different table types are:

  ISAM   The original table handler. See Section 8.2 [ISAM], page 236.
MyISAM is the new binary portable table handler. See Section 8.1 [MyISAM], page 232.

HEAP The data for this table is only stored in memory. See Section 8.3 [HEAP], page 236.

See Chapter 8 [Table types], page 232.

The other table options are used to optimize the behavior of the table. In most cases, you don’t have to specify any of them. The options work for all table types, if not otherwise indicated.

- **AUTO_INCREMENT** The next auto_increment value you want to set for your table (MyISAM)
- **AVG_ROW_LENGTH** An approximation of the average row length for your table. You only need to set this for tables with variable size records.
- **CHECKSUM** Set this to 1 if you want MySQL to maintain a checksum for all rows (makes the table a little slower to update but makes it easier to find corrupted tables) (MyISAM)
- **COMMENT** A 60 character comment for your table
- **MAX_ROWS** Max number of rows you plan to store in the table
- **MIN_ROWS** Minimum number of rows you plan to store in the table
- **PACK_KEYS** Set this to 1 if you want to have smaller index. This usually makes updates slower and reads faster (MyISAM, ISAM).
- **PASSWORD** Encrypt the .frm file with a password. This option doesn’t do anything in the standard MySQL version.
- **DELAY_KEY_WRITE** Set this to 1 if want to delay key table updates until the table is closed (MyISAM).
- **ROW_FORMAT** Defines how the rows should be stored (for the future).

When you use a MyISAM table, MySQL uses the product of `max_rows * avg_row_length` to decide how big the resulting table will be. If you don’t specify any of the above options, the maximum size for a table will be 4G (or 2G if your operating systems only supports 2G tables).

If you don’t use PACK_KEYS, the default is to only pack strings, not numbers. If you use PACK_KEYS=1, numbers will be packed as well.

When packing binary number keys, MySQL will use prefix compression. This means that you will only get a big benefit of this if you have many numbers that are the same. Prefix compression means that every key needs one extra byte to indicate how many bytes of the previous key are the same for the next key (note that the pointer to the row is stored in high-byte-first-order directly after the key, to improve compression. This means that if you have many equal keys on two rows in a row, all following ‘same’ keys will usually only take 2 bytes (including the pointer to the row). Compare this to the ordinary case where the following keys will take ‘storage_size_for_key’ + pointer_size (usually 4). On the other hand, if all keys are totally different, you will lose 1 byte per key, if the key isn’t a key that can have NULL values (In this case the packed key length will be stored in the same byte that is used to mark if a key is NULL).

- If you specify a SELECT after the CREATE STATEMENT, MySQL will create new fields for all elements in the SELECT. For example:
mysql> CREATE TABLE test (a int not null auto_increment,
primary key (a), key(b))
TYPE=HEAP SELECT b,c from test2;

This will create a HEAP table with 3 columns. Note that the table will automatically be deleted if any errors occur while copying data into the table.

- The RAID_TYPE option will help you to break the 2G/4G limit on OS that doesn’t support big files. You can get also more speed from IO bottleneck by putting RAID dirs on different physical disks. RAID_TYPE will work on any OS, as long as you have configured MySQL with --with-raid. For now the only allowed RAID_TYPE is STRIPED (1 and RAID0 are alias for this).

If you specify RAID_TYPE=STRIPED for a MyISAM table, MyISAM will create RAID_CHUNKS sub-directories named 00, 01, 02 in the database directory. In each of these directories MyISAM will create an table_name.MYD. When writing data to the data file, the RAID handler will map the first RAID_CHUNKSIZE bytes to the first file, the next RAID_CHUNKSIZE bytes to the next file and so on.

### 7.7.1 Silent column specification changes

In some cases, MySQL silently changes a column specification from that given in a CREATE TABLE statement. (This may also occur with ALTER TABLE.)

- VARCHAR columns with a length less than four are changed to CHAR.

- If any column in a table has a variable length, the entire row is variable-length as a result. Therefore, if a table contains any variable-length columns (VARCHAR, TEXT or BLOB), all CHAR columns longer than three characters are changed to VARCHAR columns. This doesn’t affect how you use the columns in any way; in MySQL, VARCHAR is just a different way to store characters. MySQL performs this conversion because it saves space and makes table operations faster. See Chapter 8 [Table types], page 232.

- TIMESTAMP display sizes must be even and in the range from 2 to 14. If you specify a display size of 0 or greater than 14, the size is coerced to 14. Odd-valued sizes in the range from 1 to 13 are coerced to the next higher even number.

- You cannot store a literal NULL in a TIMESTAMP column; setting it to NULL sets it to the current date and time. Because TIMESTAMP columns behave this way, the NULL and NOT NULL attributes do not apply in the normal way and are ignored if you specify them. DESCRIBE tbl_name always reports that a TIMESTAMP column may be assigned NULL values.

- MySQL maps certain column types used by other SQL database vendors to MySQL types. See Section 7.3.8 [Other-vendor column types], page 153.

If you want to see whether or not MySQL used a column type other than the one you specified, issue a DESCRIBE tbl_name statement after creating or altering your table.

Certain other column type changes may occur if you compress a table using myisampack. See Section 8.1.2.3 [Compressed format], page 235.
### 7.8 ALTER TABLE syntax

`ALTER [IGNORE] TABLE tbl_name alter_spec [, alter_spec ...]`

**alter_specification:**
- `ADD [COLUMN] create_definition [FIRST | AFTER column_name ]`
- `or ADD [COLUMN] (create_definition, create_definition,...)`
- `or ADD INDEX [index_name] (index_col_name,...)`
- `or ADD PRIMARY KEY (index_col_name,...)`
- `or ADD UNIQUE [index_name] (index_col_name,...)`
- `or ALTER [COLUMN] col_name {SET DEFAULT literal | DROP DEFAULT}`
- `or CHANGE [COLUMN] old_col_name create_definition`
- `or MODIFY [COLUMN] create_definition`
- `or DROP [COLUMN] col_name`
- `or DROP PRIMARY KEY`
- `or DROP INDEX index_name`
- `or RENAME [AS] new_tbl_name`
- `or table_options`

**ALTER TABLE** allows you to change the structure of an existing table. For example, you can add or delete columns, create or destroy indexes, change the type of existing columns, or rename columns or the table itself. You can also change the comment for the table and type of the table. See Section 7.7 [CREATE TABLE], page 187.

If you use **ALTER TABLE** to change a column specification but **DESCRIBE tbl_name** indicates that your column was not changed, it is possible that MySQL ignored your modification for one of the reasons described in Section 7.7.1 [Silent column changes], page 192. For example, if you try to change a VARCHAR column to CHAR, MySQL will still use VARCHAR if the table contains other variable-length columns.

**ALTER TABLE** works by making a temporary copy of the original table. The alteration is performed on the copy, then the original table is deleted and the new one is renamed. This is done in such a way that all updates are automatically redirected to the new table without any failed updates. While **ALTER TABLE** is executing, the original table is readable by other clients. Updates and writes to the table are stalled until the new table is ready.

- To use **ALTER TABLE**, you need **select**, **insert**, **delete**, **update**, **create** and **drop** privileges on the table.
- **IGNORE** is a MySQL extension to ANSI SQL92. It controls how **ALTER TABLE** works if there are duplicates on unique keys in the new table. If **IGNORE** isn’t specified, the copy is aborted and rolled back. If **IGNORE** is specified, then for rows with duplicates on a unique key, only the first row is used; the others are deleted.
- You can issue multiple **ADD**, **ALTER**, **DROP** and **CHANGE** clauses in a single **ALTER TABLE** statement. This is a MySQL extension to ANSI SQL92, which allows only one of each clause per **ALTER TABLE** statement.
- **CHANGE col_name**, **DROP col_name** and **DROP INDEX** are MySQL extensions to ANSI SQL92.
- **MODIFY** is an Oracle extension to **ALTER TABLE**.
• The optional word COLUMN is a pure noise word and can be omitted.
• If you use ALTER TABLE tbl_name RENAME AS new_name without any other options, MySQL simply renames the files that correspond to the table tbl_name. There is no need to create the temporary table.
• create_definition clauses use the same syntax for ADD and CHANGE as for CREATE TABLE. Note that this syntax includes the column name, not just the column type. See Section 7.7 [CREATE TABLE], page 187.
• You can rename a column using a CHANGE old_col_name create_definition clause. To do so, specify the old and new column names and the type that the column currently has. For example, to rename an INTEGER column from a to b, you can do this:

```sql
mysql> ALTER TABLE t1 CHANGE a b INTEGER;
```

If you want to change a column’s type but not the name, CHANGE syntax still requires two column names even if they are the same. For example:

```sql
mysql> ALTER TABLE t1 CHANGE b b BIGINT NOT NULL;
```

However, as of MySQL 3.22.16a, you can also use MODIFY to change a column’s type without renaming it:

```sql
mysql> ALTER TABLE t1 MODIFY b BIGINT NOT NULL;
```

• If you use CHANGE or MODIFY to shorten a column for which an index exists on part of the column (for instance, if you have an index on the first 10 characters of a VARCHAR column), you cannot make the column shorter than the number of characters that are indexed.

• When you change a column type using CHANGE or MODIFY, MySQL tries to convert data to the new type as well as possible.

• In MySQL 3.22 or later, you can use FIRST or ADD ... AFTER col_name to add a column at a specific position within a table row. The default is to add the column last.

• ALTER COLUMN specifies a new default value for a column or removes the old default value. If the old default is removed and the column can be NULL, MySQL assigns a default value. Default value assignment is described in Section 7.7 [CREATE TABLE], page 187.

• DROP PRIMARY KEY drops the primary index. If no such index exists, it drops the first UNIQUE index in the table. (MySQL marks the first UNIQUE key as the PRIMARY KEY if no PRIMARY KEY was specified explicitly.)

• With the C API function mysql_info(), you can find out how many records were copied, and (when IGNORE is used) how many records were deleted due to duplication of unique key values.

• The FOREIGN KEY, CHECK and REFERENCES clauses don’t actually do anything. The syntax for them is provided only for compatibility, to make it easier to port code from other SQL servers and to run applications that create tables with references. See Section 5.4 [Missing functions], page 99.
Here is an example that shows some of the uses of ALTER TABLE. We begin with a table t1 that is created as shown below:

```sql
mysql> CREATE TABLE t1 (a INTEGER,b CHAR(10));
```

To rename the table from t1 to t2:

```sql
mysql> ALTER TABLE t1 RENAME t2;
```

To change column a from INTEGER to TINYINT NOT NULL (leaving the name the same), and to change column b from CHAR(10) to CHAR(20) as well as renaming it from b to c:

```sql
mysql> ALTER TABLE t2 MODIFY a TINYINT NOT NULL, CHANGE b c CHAR(20);
```

To add a new TIMESTAMP column named d:

```sql
mysql> ALTER TABLE t2 ADD d TIMESTAMP;
```

To add an index on column d, and make column a the primary key:

```sql
mysql> ALTER TABLE t2 ADD INDEX (d), ADD PRIMARY KEY (a);
```

To remove column c:

```sql
mysql> ALTER TABLE t2 DROP COLUMN c;
```

To add a new AUTO_INCREMENT integer column named c:

```sql
mysql> ALTER TABLE t2 ADD c INT UNSIGNED NOT NULL AUTO_INCREMENT, ADD INDEX (c);
```

Note that we indexed c, because AUTO_INCREMENT columns must be indexed, and also that we declare c as NOT NULL, because indexed columns cannot be NULL.

When you add an AUTO_INCREMENT column, column values are filled in with sequence numbers for you automatically.

See also See Section 19.19 [ALTER TABLE problems], page 366.

7.9 OPTIMIZE TABLE syntax

OPTIMIZE TABLE tbl_name

OPTIMIZE TABLE should be used if you have deleted a large part of a table or if you have made many changes to a table with variable-length rows (tables that have VARCHAR, BLOB or TEXT columns). Deleted records are maintained in a linked list and subsequent INSERT operations reuse old record positions. You can use OPTIMIZE TABLE to reclaim the unused space.

OPTIMIZE TABLE works by making a temporary copy of the original table; The old table is copied to the new table (without the unused rows), then the original table is deleted and the new one is renamed. While OPTIMIZE TABLE is executing, the original table is readable by other clients. Updates and writes to the table are stalled until the new table is ready. This is done in such a way that all updates are automatically redirected to the new table without any failed updates.
7.10 DROP TABLE syntax

```
DROP TABLE [IF EXISTS] tbl_name [, tbl_name,...]
```

DROP TABLE removes one or more tables. All table data and the table definition are removed, so be careful with this command!

In MySQL 3.22 or later, you can use the keywords IF EXISTS to prevent an error from occurring for tables that don’t exist.

7.11 DELETE syntax

```
DELETE [LOW_PRIORITY] FROM tbl_name
    [WHERE where_definition] [LIMIT rows]
```

DELETE deletes rows from tbl_name that satisfy the condition given by where_definition, and returns the number of records deleted.

If you issue a DELETE with no WHERE clause, all rows are deleted. MySQL does this by recreating the table as an empty table, which is much faster than deleting each row. In this case, DELETE returns zero as the number of affected records. (MySQL can’t return the number of rows that were actually deleted, since the recreate is done without opening the data files. As long as the table definition file ‘tbl_name.frm’ is valid, the table can be recreated this way, even if the data or index files have become corrupted.).

If you really want to know how many records are deleted when you are deleting all rows, and are willing to suffer a speed penalty, you can use a DELETE statement of this form:

```
mysql> DELETE FROM tbl_name WHERE 1>0;
```

Note that this is MUCH slower than DELETE FROM tbl_name with no WHERE clause, because it deletes rows one at a time.

If you specify the keyword LOW_PRIORITY, execution of the DELETE is delayed until no other clients are reading from the table.

Deleted records are maintained in a linked list and subsequent INSERT operations reuse old record positions. To reclaim unused space and reduce file sizes, use the OPTIMIZE TABLE statement or the myisamchk utility to reorganize tables. OPTIMIZE TABLE is easier, but myisamchk is faster. See Section 7.9 [OPTIMIZE TABLE], page 195, and Section 14.4.3 [Optimization], page 335.

The MySQL-specific LIMIT rows option to DELETE tells the server the maximum number of rows to be deleted before control is returned to the client. This can be used to ensure that a specific DELETE command doesn’t take too much time. You can simply repeat the DELETE command until the number of affected rows is less than the LIMIT value.

7.12 SELECT syntax
SELECT [STRAIGHT_JOIN] [SQL_SMALL_RESULT] [SQL_BIG_RESULT] [HIGH_PRIORITY] [DISTINCT | DISTINCTROW | ALL] select_expression,... [INTO {OUTFILE | DUMPFILE} 'file_name' export_options] [FROM table_references [WHERE where_definition] [GROUP BY col_name,...] [HAVING where_definition] [ORDER BY {unsigned_integer | col_name | formula} [ASC | DESC] ,...] [LIMIT [offset,] rows] [PROCEDURE procedure_name] ]

SELECT is used to retrieve rows selected from one or more tables. select_expression indicates the columns you want to retrieve. SELECT may also be used to retrieve rows computed without reference to any table. For example:

```sql
mysql> SELECT 1 + 1;
-> 2
```

All keywords used must be given in exactly the order shown above. For example, a HAVING clause must come after any GROUP BY clause and before any ORDER BY clause.

- A SELECT expression may be given an alias using AS. The alias is used as the expression’s column name and can be used with ORDER BY or HAVING clauses. For example:

```sql
mysql> select concat(last_name,', ',first_name) AS full_name from mytable ORDER BY full_name;
```

- The FROM table_references clause indicates the tables from which to retrieve rows. If you name more than one table, you are performing a join. For information on join syntax, see Section 7.13 [JOIN], page 199.

- You can refer to a column as col_name, tbl_name.col_name or db_name.tbl_name.col_name. You need not specify a tbl_name or db_name.tbl_name prefix for a column reference in a SELECT statement unless the reference would be ambiguous. See Section 7.1.5 [Legal names], page 132, for examples of ambiguity that require the more explicit column reference forms.

- A table reference may be aliased using tbl_name [AS] alias_name.

```sql
mysql> select t1.name, t2.salary from employee AS t1, info AS t2 where t1.name = t2.name;
```

- Columns selected for output may be referred to in ORDER BY and GROUP BY clauses using column names, column aliases or column positions. Column positions begin with 1.

```sql
mysql> select college, region, seed from tournament ORDER BY region, seed;
mysql> select college, region AS r, seed AS s from tournament ORDER BY r, s;
mysql> select college, region, seed from tournament ORDER BY 2, 3;
```
To sort in reverse order, add the `DESC` (descending) keyword to the name of the column in the `ORDER BY` clause that you are sorting by. The default is ascending order; this may be specified explicitly using the `ASC` keyword.

- The `HAVING` clause can refer to any column or alias named in the `select_expression`. It is applied last, just before items are sent to the client, with no optimization. Don’t use `HAVING` for items that should be in the `WHERE` clause. For example, do not write this:

  ```sql
  mysql> select col_name from tbl_name HAVING col_name > 0;
  ```
  
  Write this instead:

  ```sql
  mysql> select col_name from tbl_name WHERE col_name > 0;
  ```

  In MySQL 3.22.5 or later, you can also write queries like this:

  ```sql
  mysql> select user,max(salary) from users
       group by user HAVING max(salary)>10;
  ```

  In older MySQL versions, you can write this instead:

  ```sql
  mysql> select user,max(salary) AS sum from users
       group by user HAVING sum>10;
  ```

- `SQL_SMALL_RESULT`, `SQL_BIG_RESULT`, `STRAIGHT_JOIN` and `HIGH_PRIORITY` are MySQL extensions to ANSI SQL92.

- `STRAIGHT_JOIN` forces the optimizer to join the tables in the order in which they are listed in the `FROM` clause. You can use this to speed up a query if the optimizer joins the tables in non-optimal order. See Section 7.22 [EXPLAIN], page 216.

- `SQL_SMALL_RESULT`, an MySQL specific option, can be used with `GROUP BY` or `DISTINCT` to tell the optimizer that the result set will be small. In this case, MySQL will use fast temporary tables to store the resulting table instead of using sorting. In MySQL 3.23 this shouldn’t normally be needed.

- `SQL_BIG_RESULT` can be used with `GROUP BY` or `DISTINCT` to tell the optimizer that the result set will have many rows. In this case, MySQL will directly use disk based temporary tables if needed. MySQL in this case will prefer to do a sort instead doing a temporary table with a key on the `GROUP BY` elements.

- `HIGH_PRIORITY` will give the `SELECT` higher priority than a statement that updates a table. You should only use this for queries that are very fast and must be done at once. A `SELECT HIGH_PRIORITY` query will run if the table is locked for read even if there is an update statement that is waiting for the table to be free.

- The `LIMIT` clause can be used to constrain the number of rows returned by the `SELECT` statement. `LIMIT` takes one or two numeric arguments.

  If two arguments are given, the first specifies the offset of the first row to return, the second specifies the maximum number of rows to return. The offset of the initial row is 0 (not 1).

  ```sql
  mysql> select * from table LIMIT 5,10;  # Retrieve rows 6-15
  ```

  If one argument is given, it indicates the maximum number of rows to return.

  ```sql
  mysql> select * from table LIMIT 5;     # Retrieve first 5 rows
  ```

  In other words, `LIMIT n` is equivalent to `LIMIT 0,n`.
• The SELECT ... INTO OUTFILE 'file_name' form of SELECT writes the selected rows to a file. The file is created on the server host, and cannot already exist (among other things, this prevents database tables and files such as '/etc/passwd' from being destroyed). You must have the file privilege on the server host to use this form of SELECT.

SELECT ... INTO OUTFILE is the complement of LOAD DATA INFILE; the syntax for the export_options part of the statement consists of the same FIELDS and LINES clauses that are used with the LOAD DATA INFILE statement. See Section 7.16 [LOAD DATA], page 204.

In the resulting text file, only the following characters are escaped by the ESCAPED BY character:
• The ESCAPED BY character
• The first character in FIELDS TERMINATED BY
• The first character in LINES TERMINATED BY

Additionally, ASCII 0 is converted to ESCAPED BY followed by 0 (ASCII 48).

The reason for the above is that you MUST escape any FIELDS TERMINATED BY, ESCAPED BY or LINES TERMINATED BY characters to reliably be able to read the file back. ASCII 0 is escaped to make it easier to view with some pagers.

As the resulting file doesn’t have to conform to the SQL syntax, nothing else need be escaped.

If you use INTO DUMPFILE instead of INTO OUTFILE MySQL will only write one row into the file, without any column or line terminations and without any escaping. This is useful if you want to store a blob in a file.

7.13 JOIN syntax

MySQL supports the following JOIN syntaxes for use in SELECT statements:

```sql
  table_reference, table_reference
  table_reference [CROSS] JOIN table_reference
  table_reference INNER JOIN table_reference
  table_reference STRAIGHT_JOIN table_reference
  table_reference LEFT [OUTER] JOIN table_reference ON conditional_expr
  table_reference LEFT [OUTER] JOIN table_reference USING (column_list)
  table_reference NATURAL LEFT [OUTER] JOIN table_reference
  { oj table_reference LEFT OUTER JOIN table_reference ON conditional_expr }
```

Where table_reference is defined as

```sql
  table_name [[AS] alias] [USE INDEX (key_list)] [IGNORE INDEX (key_list)]
```

The last LEFT OUTER JOIN syntax shown above exists only for compatibility with ODBC.

• A table reference may be aliased using tbl_name AS alias_name or tbl_name alias_ name.

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INNER JOIN and , (comma) are semantically equivalent. Both do a full join between the tables used. Normally, you specify how the tables should be linked in the WHERE condition.

The ON conditional is any conditional of the form that may be used in a WHERE clause.

If there is no matching record for the right table in a LEFT JOIN, a row with all columns set to NULL is used for the right table. You can use this fact to find records in a table that have no counterpart in another table:

```sql
mysql> select table1.* from table1
       LEFT JOIN table2 ON table1.id=table2.id
       where table2.id is NULL;
```

This example finds all rows in `table1` with an id value that is not present in `table2` (i.e., all rows in `table1` with no corresponding row in `table2`). This assumes that `table2.id` is declared NOT NULL, of course.

The USING (column_list) clause names a list of columns that must exist in both tables. A USING clause such as:

```sql
A LEFT JOIN B USING (C1,C2,C3,...)
```

is defined to be semantically identical to an ON expression like this:

```sql
A.C1=B.C1 AND A.C2=B.C2 AND A.C3=B.C3,...
```

The NATURAL LEFT JOIN of two tables is defined to be semantically equivalent to a LEFT JOIN with a USING clause that names all columns that exist in both tables.

STRAIGHT_JOIN is identical to JOIN, except that the left table is always read before the right table. This can be used for those (few) cases where the join optimizer puts the tables in the wrong order.

Starting from MySQL 3.23.12 one can give hints about which index MySQL should use when retrieving information from a table. This is useful if EXPLAIN shows that MySQL is using the wrong index. By specifying USE INDEX (key_list) one can say to MySQL to only use one of the specified indexes to find rows in the table. The alternative syntax IGNORE INDEX (key_list) can be used to tell MySQL to not use some particular index.

Some examples:

```sql
mysql> select * from table1,table2 where table1.id=table2.id;
mysql> select * from table1 LEFT JOIN table2 ON table1.id=table2.id;
mysql> select * from table1 LEFT JOIN table2 USING (id);
mysql> select * from table1 LEFT JOIN table2 ON table1.id=table2.id
       LEFT JOIN table3 ON table2.id=table3.id;
mysql> select * from table1 USE INDEX (key1,key2) WHERE key1=1 and key2=2 AND key3=3;
mysql> select * from table1 IGNORE INDEX (key3) WHERE key1=1 and key2=2 AND key3=3;
```

See Section 11.5.4 [LEFT JOIN optimization], page 294.
7.14 INSERT syntax

```
INSERT [LOW_PRIORITY | DELAYED] [IGNORE]
[INTO] tbl_name [(col_name,...)]
VALUES (expression,...),(...),...
or INSERT [LOW_PRIORITY | DELAYED] [IGNORE]
[INTO] tbl_name [(col_name,...)]
SELECT ...
or INSERT [LOW_PRIORITY | DELAYED] [IGNORE]
[INTO] tbl_name
SET col_name=expression, col_name=expression, ...
```

INSERT inserts new rows into an existing table. The INSERT ... VALUES form of the statement inserts rows based on explicitly-specified values. The INSERT ... SELECT form inserts rows selected from another table or tables. The INSERT ... VALUES form with multiple value lists is supported in MySQL 3.22.5 or later. The col_name=expression syntax is supported in MySQL 3.22.10 or later.

tbl_name is the table into which rows should be inserted. The column name list or the SET clause indicates which columns the statement specifies values for.

- If you specify no column list for INSERT ... VALUES or INSERT ... SELECT, values for all columns must be provided in the VALUES() list or by the SELECT. If you don’t know the order of the columns in the table, use DESCRIBE tbl_name to find out.

- Any column not explicitly given a value is set to its default value. For example, if you specify a column list that doesn’t name all the columns in the table, unnamed columns are set to their default values. Default value assignment is described in Section 7.7 [CREATE TABLE], page 187.

- An expression may refer to any column that was set earlier in a value list. For example, you can say this:

  ```
  mysql> INSERT INTO tbl_name (col1,col2) VALUES(15,col1*2);
  ```

  But not this:

  ```
  mysql> INSERT INTO tbl_name (col1,col2) VALUES(col2*2,15);
  ```

- If you specify the keyword LOW_PRIORITY, execution of the INSERT is delayed until no other clients are reading from the table. In this case the client has to wait until the insert statement is completed, which may take a long time if the table is in heavy use. This is in contrast to INSERT DELAYED which lets the client continue at once.

- If you specify the keyword IGNORE in an INSERT with many value rows, any rows which duplicate an existing PRIMARY or UNIQUE key in the table are ignored and are not inserted. If you do not specify IGNORE, the insert is aborted if there is any row that duplicates an existing key value. You can check with the C API function mysql_info() how many rows were inserted into the table.

- If MySQL was configured using the DONT_USE_DEFAULT_FIELDS option, INSERT statements generate an error unless you explicitly specify values for all columns that require a non-NULL value. See Section 4.7.3 [configure options], page 47.

- The following conditions hold for a INSERT INTO ... SELECT statement:
– The query cannot contain an ORDER BY clause.
– The target table of the INSERT statement cannot appear in the FROM clause of the SELECT part of the query, because it’s forbidden in ANSI SQL to SELECT from the same table into which you are INSERTing. (The problem is that the SELECT possibly would find records that were inserted earlier during the same run. When using sub-select clauses, the situation could easily be very confusing!)
– AUTO_INCREMENT columns work as usual.

If you use INSERT ... SELECT or a INSERT ... VALUES statement with multiple value lists, you can use the C API function mysql_info() to get information about the query. The format of the information string is shown below:

Records: 100 Duplicates: 0 Warnings: 0

Duplicates indicates the number of rows that couldn’t be inserted because they would duplicate some existing unique index value. Warnings indicates the number of attempts to insert column values that were problematic in some way. Warnings can occur under any of the following conditions:

- Inserting NULL into a column that has been declared NOT NULL. The column is set to its default value.
- Setting a numeric column to a value that lies outside the column’s range. The value is clipped to the appropriate endpoint of the range.
- Setting a numeric column to a value such as ‘10.34 a’. The trailing garbage is stripped and the remaining numeric part is inserted. If the value doesn’t make sense as a number at all, the column is set to 0.
- Inserting a string into a CHAR, VARCHAR, TEXT or BLOB column that exceeds the column’s maximum length. The value is truncated to the column’s maximum length.
- Inserting a value into a date or time column that is illegal for the column type. The column is set to the appropriate “zero” value for the type.

The DELAYED option for the INSERT statement is a MySQL-specific option that is very useful if you have clients that can’t wait for the INSERT to complete. This is a common problem when you use MySQL for logging and you also periodically run SELECT statements that take a long time to complete. DELAYED was introduced in MySQL 3.22.15. It is a MySQL extension to ANSI SQL92.

When you use INSERT DELAYED, the client will get an ok at once and the row will be inserted when the table is not in use by any other thread.

Another major benefit of using INSERT DELAYED is that inserts from many clients are bundled together and written in one block. This is much faster than doing many separate inserts.

Note that currently the queued rows are only stored in memory until they are inserted into the table. This means that if you kill mysql the hard way (kill -9) or if mysql dies unexpectedly, any queued rows that weren’t written to disk are lost!

The following describes in detail what happens when you use the DELAYED option to INSERT or REPLACE. In this description, the “thread” is the thread that received an INSERT DELAYED
command and “handler” is the thread that handles all INSERT DELAYED statements for a particular table.

- When a thread executes a DELAYED statement for a table, a handler thread is created to process all DELAYED statements for the table, if no such handler already exists.

- The thread checks whether or not the handler has acquired a DELAYED lock already; if not, it tells the handler thread to do so. The DELAYED lock can be obtained even if other threads have a READ or WRITE lock on the table. However, the handler will wait for all ALTER TABLE locks or FLUSH TABLES to ensure that the table structure is up to date.

- The thread executes the INSERT statement but instead of writing the row to the table it puts a copy of the final row into a queue that is managed by the handler thread. Any syntax errors are noticed by the thread and reported to the client program.

- The thread checks whether the handler has acquired a DELAYED lock already; if not, it tells the handler thread to do so. The DELAYED lock can be obtained even if other threads have a READ or WRITE lock on the table. However, the handler will wait for all ALTER TABLE locks or FLUSH TABLES to ensure that the table structure is up to date.

- The thread executes the INSERT statement but instead of writing the row to the table it puts a copy of the final row into a queue that is managed by the handler thread. Any syntax errors are noticed by the thread and reported to the client program.

- The client can’t report the number of duplicates or the AUTO_INCREMENT value for the resulting row; it can’t obtain them from the server, because the INSERT returns before the insert operation has been completed. If you use the C API, the mysql_info() function doesn’t return anything meaningful, for the same reason.

- The update log is updated by the handler thread when the row is inserted into the table. In case of multiple-row inserts, the update log is updated when the first row is inserted.

- After every delayed_insert_limit rows are written, the handler checks whether or not any SELECT statements are still pending. If so, it allows these to execute before continuing.

- When the handler has no more rows in its queue, the table is unlocked. If no new INSERT DELAYED commands are received within delayed_insert_timeout seconds, the handler terminates.

- If more than delayed_queue_size rows are pending already in a specific handler queue, the thread waits until there is room in the queue. This is useful to ensure that the mysqld server doesn’t use all memory for the delayed memory queue.

- The handler thread will show up in the MySQL process list with delayed_insert in the Command column. It will be killed if you execute a FLUSH TABLES command or kill it with KILL thread_id. However, it will first store all queued rows into the table before exiting. During this time it will not accept any new INSERT commands from another thread. If you execute an INSERT DELAYED command after this, a new handler thread will be created.

- Note that the above means that INSERT DELAYED commands have higher priority than normal INSERT commands if there is an INSERT DELAYED handler already running! Other update commands will have to wait until the INSERT DELAY queue is empty, someone kills the handler thread (with KILL thread_id) or someone executes FLUSH TABLES.

- The following status variables provide information about INSERT DELAYED commands:
  
<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delayed_insert_threads</td>
<td>Number of handler threads</td>
</tr>
<tr>
<td>Delayed_writes</td>
<td>Number of rows written with INSERT DELAYED</td>
</tr>
<tr>
<td>Not_flushed_delayed_rows</td>
<td>Number of rows waiting to be written</td>
</tr>
</tbody>
</table>
You can view these variables by issuing a `SHOW STATUS` statement or by executing a `mysqladmin extended-status` command.

Note that `INSERT DELAYED` is slower than a normal `INSERT` if the table is not in use. There is also the additional overhead for the server to handle a separate thread for each table on which you use `INSERT DELAYED`. This means that you should only use `INSERT DELAYED` when you are really sure you need it!

### 7.15 REPLACE syntax

```
REPLACE [LOW_PRIORITY | DELAYED]
    [INTO] tbl_name [(col_name,...)]
    VALUES (expression,...)
```

or

```
REPLACE [LOW_PRIORITY | DELAYED]
    [INTO] tbl_name [(col_name,...)]
    SELECT ...
```

or

```
REPLACE [LOW_PRIORITY | DELAYED]
    [INTO] tbl_name
    SET col_name=expression, col_name=expression,...
```

`REPLACE` works exactly like `INSERT`, except that if an old record in the table has the same value as a new record on a unique index, the old record is deleted before the new record is inserted. See Section 7.14 [INSERT], page 201.

### 7.16 LOAD DATA INFILE syntax

```
LOAD DATA [LOW_PRIORITY] [LOCAL] INFILE 'file_name.txt' [REPLACE | IGNORE]
    INTO TABLE tbl_name
    [FIELDS
        [TERMINATED BY '\t']
        [OPTIONALLY] ENCLOSED BY ' ']
        [ESCAPED BY '\']]
    [LINES TERMINATED BY '\n']
    [IGNORE number LINES]
    [(col_name,...)]
```

The `LOAD DATA INFILE` statement reads rows from a text file into a table at a very high speed. If the `LOCAL` keyword is specified, the file is read from the client host. If `LOCAL` is not specified, the file must be located on the server. (`LOCAL` is available in MySQL 3.22.6 or later.)

For security reasons, when reading text files located on the server, the files must either reside in the database directory or be readable by all. Also, to use `LOAD DATA INFILE` on server files, you must have the `file` privilege on the server host. See Section 6.7 [Privileges provided], page 111.

If you specify the keyword `LOW_PRIORITY`, execution of the `LOAD DATA` statement is delayed until no other clients are reading from the table.
Using `LOCAL` will be a bit slower than letting the server access the files directly, since the contents of the file must travel from the client host to the server host. On the other hand, you do not need the `file` privilege to load local files.

You can also load data files by using the `mysqlimport` utility; it operates by sending a `LOAD DATA INFILE` command to the server. The `--local` option causes `mysqlimport` to read data files from the client host. You can specify the `--compress` option to get better performance over slow networks if the client and server support the compressed protocol.

When locating files on the server host, the server uses the following rules:

- If an absolute pathname is given, the server uses the pathname as is.
- If a relative pathname with one or more leading components is given, the server searches for the file relative to the server’s data directory.
- If a filename with no leading components is given, the server looks for the file in the database directory of the current database.

Note that these rules mean a file given as `./myfile.txt` is read from the server’s data directory, whereas a file given as `myfile.txt` is read from the database directory of the current database. For example, the following `LOAD DATA` statement reads the file `data.txt` from the database directory for `db1` because `db1` is the current database, even though the statement explicitly loads the file into a table in the `db2` database:

```
mysql> USE db1;
mysql> LOAD DATA INFILE "data.txt" INTO TABLE db2.my_table;
```

The `REPLACE` and `IGNORE` keywords control handling of input records that duplicate existing records on unique key values. If you specify `REPLACE`, new rows replace existing rows that have the same unique key value. If you specify `IGNORE`, input rows that duplicate an existing row on a unique key value are skipped. If you don’t specify either option, an error occurs when a duplicate key value is found, and the rest of the text file is ignored.

If you load data from a local file using the `LOCAL` keyword, the server has no way to stop transmission of the file in the middle of the operation, so the default behavior is the same as if `IGNORE` is specified.

`LOAD DATA INFILE` is the complement of `SELECT ... INTO OUTFILE`. See Section 7.12 [SELECT], page 196. To write data from a database to a file, use `SELECT ... INTO OUTFILE`. To read the file back into the database, use `LOAD DATA INFILE`. The syntax of the `FIELDS` and `LINES` clauses is the same for both commands. Both clauses are optional, but `FIELDS` must precede `LINES` if both are specified.

If you specify a `FIELDS` clause, each of its subclauses (`TERMINATED BY`, `[OPTIONALLY] ENCLOSED BY` and `ESCAPED BY`) is also optional, except that you must specify at least one of them.

If you don’t specify a `FIELDS` clause, the defaults are the same as if you had written this:

```
FIELDS TERMINATED BY '\t' ENCLOSED BY '"' ESCAPED BY '\\\'
```

If you don’t specify a `LINES` clause, the default is the same as if you had written this:

```
LINES TERMINATED BY '\n'
```

In other words, the defaults cause `LOAD DATA INFILE` to act as follows when reading input:

- Look for line boundaries at newlines
• Break lines into fields at tabs
• Do not expect fields to be enclosed within any quoting characters
• Interpret occurrences of tab, newline or ‘\’ preceded by ‘\’ as literal characters that are part of field values

Conversely, the defaults cause SELECT ... INTO OUTFILE to act as follows when writing output:
• Write tabs between fields
• Do not enclose fields within any quoting characters
• Use ‘\’ to escape instances of tab, newline or ‘\’ that occur within field values
• Write newlines at the ends of lines

Note that to write FIELDS ESCAPED BY ‘\\’, you must specify two backslashes for the value to be read as a single backslash.

The IGNORE number LINES option can be used to ignore a header of column names at the start of the file:

```sql
mysql> LOAD DATA INFILE "/tmp/file_name" into table test IGNORE 1 LINES;
```

When you use SELECT ... INTO OUTFILE in tandem with LOAD DATA INFILE to write data from a database into a file and then read the file back into the database later, the field and line handling options for both commands must match. Otherwise, LOAD DATA INFILE will not interpret the contents of the file properly. Suppose you use SELECT ... INTO OUTFILE to write a file with fields delimited by commas:

```sql
mysql> SELECT * FROM table1 INTO OUTFILE 'data.txt'
    FIELDS TERMINATED BY ','
    FROM ...;
```

To read the comma-delimited file back in, the correct statement would be:

```sql
mysql> LOAD DATA INFILE 'data.txt' INTO TABLE table2
    FIELDS TERMINATED BY ',';
```

If instead you tried to read in the file with the statement shown below, it wouldn’t work because it instructs LOAD DATA INFILE to look for tabs between fields:

```sql
mysql> LOAD DATA INFILE 'data.txt' INTO TABLE table2
    FIELDS TERMINATED BY '\t';
```

The likely result is that each input line would be interpreted as a single field.

LOAD DATA INFILE can be used to read files obtained from external sources, too. For example, a file in dBASE format will have fields separated by commas and enclosed in double quotes. If lines in the file are terminated by newlines, the command shown below illustrates the field and line handling options you would use to load the file:

```sql
mysql> LOAD DATA INFILE 'data.txt' INTO TABLE tbl_name
    FIELDS TERMINATED BY ',' ENCLOSED BY '"'
    LINES TERMINATED BY '
';
```

Any of the field or line handling options may specify an empty string (’’). If not empty, the FIELDS [OPTIONALLY] ENCLOSED BY and FIELDS ESCAPED BY values must be a single character. The FIELDS TERMINATED BY and LINES TERMINATED BY values may be more than
one character. For example, to write lines that are terminated by carriage return-linefeed pairs, or to read a file containing such lines, specify a LINES TERMINATED BY ‘\r\n’ clause. FIELDS [OPTIONALLY] ENCLOSED BY controls quoting of fields. For output (SELECT ... INTO OUTFILE), if you omit the word OPTIONALLY, all fields are enclosed by the ENCLOSED BY character. An example of such output (using a comma as the field delimiter) is shown below:

"1","a string","100.20"
"2","a string containing a , comma","102.20"
"3","a string containing a \" quote","102.20"
"4","a string containing a ", quote and comma","102.20"

If you specify OPTIONALLY, the ENCLOSED BY character is used only to enclose CHAR and VARCHAR fields:

1,"a string",100.20
2,"a string containing a , comma",102.20
3,"a string containing a \" quote",102.20
4,"a string containing a ", quote and comma",102.20

Note that occurrences of the ENCLOSED BY character within a field value are escaped by prefixing them with the ESCAPED BY character. Also note that if you specify an empty ESCAPED BY value, it is possible to generate output that cannot be read properly by LOAD DATA INFILE. For example, the output just shown above would appear as shown below if the escape character is empty. Observe that the second field in the fourth line contains a comma following the quote, which (erroneously) appears to terminate the field:

1,"a string",100.20
2,"a string containing a , comma",102.20
3,"a string containing a \" quote",102.20
4,"a string containing a ", quote and comma",102.20

For input, the ENCLOSED BY character, if present, is stripped from the ends of field values. (This is true whether or not OPTIONALLY is specified; OPTIONALLY has no effect on input interpretation.) Occurrences of the ENCLOSED BY character preceded by the ESCAPED BY character are interpreted as part of the current field value. In addition, duplicated ENCLOSED BY characters occurring within fields are interpreted as single ENCLOSED BY characters if the field itself starts with that character. For example, if ENCLOSED BY ‘”’ is specified, quotes are handled as shown below:

"The ""BIG"" boss" -> The "BIG" boss
The "BIG" boss -> The "BIG" boss
The ""BIG"" boss -> The ""BIG"" boss

FIELDS ESCAPED BY controls how to write or read special characters. If the FIELDS ESCAPED BY character is not empty, it is used to prefix the following characters on output:

- The FIELDS ESCAPED BY character
- The FIELDS [OPTIONALLY] ENCLOSED BY character
- The first character of the FIELDS TERMINATED BY and LINES TERMINATED BY values
- ASCII 0 (what is actually written following the escape character is ASCII '0', not a zero-valued byte)
If the \texttt{FIELDS ESCAPED BY} character is empty, no characters are escaped. It is probably not a good idea to specify an empty escape character, particularly if field values in your data contain any of the characters in the list just given.

For input, if the \texttt{FIELDS ESCAPED BY} character is not empty, occurrences of that character are stripped and the following character is taken literally as part of a field value. The exceptions are an escaped ‘0’ or ‘N’ (e.g., \texttt{\0} or \texttt{\N} if the escape character is ‘\’). These sequences are interpreted as ASCII 0 (a zero-valued byte) and \texttt{NULL}. See below for the rules on NULL handling.

For more information about ‘\’-escape syntax, see Section\ 7.1 [Literals], page 130.

In certain cases, field and line handling options interact:

- If \texttt{LINES TERMINATED BY} is an empty string and \texttt{FIELDS TERMINATED BY} is non-empty, lines are also terminated with \texttt{FIELDS TERMINATED BY}.

- If the \texttt{FIELDS TERMINATED BY} and \texttt{FIELDS ENCLOSED BY} values are both empty (’’), a fixed-row (non-delimited) format is used. With fixed-row format, no delimiters are used between fields. Instead, column values are written and read using the “display” widths of the columns. For example, if a column is declared as \texttt{INT(7)}, values for the column are written using 7-character fields. On input, values for the column are obtained by reading 7 characters. Fixed-row format also affects handling of NULL values; see below. Note that fixed size format will not work if you are using a multi-byte character set.

Handling of NULL values varies, depending on the \texttt{FIELDS} and \texttt{LINES} options you use:

- For the default \texttt{FIELDS} and \texttt{LINES} values, \texttt{NULL} is written as \texttt{\N} for output and \texttt{\N} is read as \texttt{NULL} for input (assuming the \texttt{ESCAPED BY} character is ‘\’).

- If \texttt{FIELDS ENCLOSED BY} is not empty, a field containing the literal word \texttt{NULL} as its value is read as a \texttt{NULL} value (this differs from the word \texttt{NULL} enclosed within \texttt{FIELDS ENCLOSED BY} characters, which is read as the string ‘\texttt{NULL}’).

- If \texttt{FIELDS ESCAPED BY} is empty, \texttt{NULL} is written as the word \texttt{NULL}.

- With fixed-row format (which happens when \texttt{FIELDS TERMINATED BY} and \texttt{FIELDS ENCLOSED BY} are both empty), \texttt{NULL} is written as an empty string. Note that this causes both \texttt{NULL} values and empty strings in the table to be indistinguishable when written to the file since they are both written as empty strings. If you need to be able to tell the two apart when reading the file back in, you should not use fixed-row format.

Some cases are not supported by \texttt{LOAD DATA INFILE}:

- Fixed-size rows (\texttt{FIELDS TERMINATED BY} and \texttt{FIELDS ENCLOSED BY} both empty) and \texttt{BLOB} or \texttt{TEXT} columns.

- If you specify one separator that is the same as or a prefix of another, \texttt{LOAD DATA INFILE} won’t be able to interpret the input properly. For example, the following \texttt{FIELDS} clause would cause problems:

  \begin{verbatim}
  FIELDS TERMINATED BY \"\" ENCLOSED BY \"\"
  \end{verbatim}

- If \texttt{FIELDS ESCAPED BY} is empty, a field value that contains an occurrence of \texttt{FIELDS ENCLOSED BY} or \texttt{LINES TERMINATED BY} followed by the \texttt{FIELDS TERMINATED BY} value will cause \texttt{LOAD DATA INFILE} to stop reading a field or line too early. This happens
because \texttt{LOAD DATA INFILE} cannot properly determine where the field or line value
ends.

The following example loads all columns of the \texttt{persondata} table:

\begin{verbatim}
mysql> LOAD DATA INFILE 'persondata.txt' INTO TABLE persondata;
\end{verbatim}

No field list is specified, so \texttt{LOAD DATA INFILE} expects input rows to contain a field for each
table column. The default \texttt{FIELDS} and \texttt{LINES} values are used.

If you wish to load only some of a table’s columns, specify a field list:

\begin{verbatim}
mysql> LOAD DATA INFILE 'persondata.txt'
        INTO TABLE persondata (col1,col2,...);
\end{verbatim}

You must also specify a field list if the order of the fields in the input file differs from the
order of the columns in the table. Otherwise, \texttt{MySQL} cannot tell how to match up input
fields with table columns.

If a row has too few fields, the columns for which no input field is present are set to default
values. Default value assignment is described in Section 7.7 \texttt{[CREATE TABLE]}, page 187.

An empty field value is interpreted differently than if the field value is missing:

- For string types, the column is set to the empty string.
- For numeric types, the column is set to 0.
- For date and time types, the column is set to the appropriate “zero” value for the type.
  See Section 7.3.3 \texttt{[Date and time types]}, page 141.

\texttt{TIMESTAMP} columns are only set to the current date and time if there is a \texttt{NULL}
value for the column, or (for the first \texttt{TIMESTAMP} column only) if the \texttt{TIMESTAMP}
column is left out from the field list when a field list is specified.

If an input row has too many fields, the extra fields are ignored and the number of warnings
is incremented.

\texttt{LOAD DATA INFILE} regards all input as strings, so you can’t use numeric values for \texttt{ENUM}
or \texttt{SET} columns the way you can with \texttt{INSERT} statements. All \texttt{ENUM} and \texttt{SET} values must be
specified as strings!

If you are using the C API, you can get information about the query by calling the API
function \texttt{mysql_info()} when the \texttt{LOAD DATA INFILE} query finishes. The format of the
information string is shown below:

\begin{verbatim}
Records: 1 Deleted: 0 Skipped: 0 Warnings: 0
\end{verbatim}

Warnings occur under the same circumstances as when values are inserted via the \texttt{INSERT}
statement (see Section 7.14 \texttt{[INSERT]}, page 201), except that \texttt{LOAD DATA INFILE} also generates
warnings when there are too few or too many fields in the input row. The warnings are
not stored anywhere; the number of warnings can only be used as an indication if everything
went well. If you get warnings and want to know exactly why you got them, one way to do
this is to use \texttt{SELECT . . . INTO OUTFILE} into another file and compare this to your original
input file.

For more information about the efficiency of \texttt{INSERT} versus \texttt{LOAD DATA INFILE} and speeding
up \texttt{LOAD DATA INFILE}, See Section 11.5.6 \texttt{[Insert speed]}, page 295.
7.17 UPDATE syntax

```
UPDATE [LOW_PRIORITY] tbl_name SET col_name1=expr1,col_name2=expr2,...
    [WHERE where_definition] [LIMIT #]
```

UPDATE updates columns in existing table rows with new values. The SET clause indicates which columns to modify and the values they should be given. The WHERE clause, if given, specifies which rows should be updated. Otherwise all rows are updated.

If you specify the keyword LOW_PRIORITY, execution of the UPDATE is delayed until no other clients are reading from the table.

If you access a column from tbl_name in an expression, UPDATE uses the current value of the column. For example, the following statement sets the age column to one more than its current value:

```
mysql> UPDATE persondata SET age=age+1;
```

UPDATE assignments are evaluated from left to right. For example, the following statement doubles the age column, then increments it:

```
mysql> UPDATE persondata SET age=age*2, age=age+1;
```

If you set a column to the value it currently has, MySQL notices this and doesn’t update it.

UPDATE returns the number of rows that were actually changed. In MySQL 3.22 or later, the C API function mysql_info() returns the number of rows that were matched and updated and the number of warnings that occurred during the UPDATE.

In MySQL 3.23 you can use LIMIT # to ensure that only a given number of rows are changed.

7.18 USE syntax

```
USE db_name
```

The USE db_name statement tells MySQL to use the db_name database as the default database for subsequent queries. The database remains current until the end of the session, or until another USE statement is issued:

```
mysql> USE db1;
mysql> SELECT count(*) FROM mytable;   # selects from db1.mytable
mysql> USE db2;
mysql> SELECT count(*) FROM mytable;   # selects from db2.mytable
```

Making a particular database current by means of the USE statement does not preclude you from accessing tables in other databases. The example below accesses the author table from the db1 database and the editor table from the db2 database:

```
mysql> USE db1;
mysql> SELECT author_name,editor_name FROM author,db2.editor
    WHERE author.editor_id = db2.editor.editor_id;
```

The USE statement is provided for Sybase compatibility.
7.19 FLUSH syntax (clearing caches)

    FLUSH flush_option [,flush_option]

You should use the FLUSH command if you want to clear some of the internal caches MySQL uses. To execute FLUSH, you must have the reload privilege.

flush_option can be any of the following:

**HOSTS**
Empties the host cache tables. You should flush the host tables if some of your hosts change IP number or if you get the error message Host ... is blocked. When more than `max_connect_errors` errors occur in a row for a given host while connection to the MySQL server, MySQL assumes something is wrong and blocks the host from further connection requests. Flushing the host tables allows the host to attempt to connect again. See Section 19.2.3 [Blocked host], page 356.) You can start mysqld with `-O max_connection_errors=999999999` to avoid this error message.

**LOGS**
Closes and reopens the standard and update log files. If you have specified the update log file without an extension, the extension number of the new update log file will be incremented by one relative to the previous file. If you have used an extension in the file name, MySQL will close and reopen the update log file. On Unix you can use this behaviour to your advantage by first moving the file to another name and then issue FLUSH LOGS.

**PRIVILEGES**
Reloads the privileges from the grant tables in the mysql database.

**TABLES**
Closes all open tables.

**STATUS**
Resets most status variables to zero.

You can also access each of the commands shown above with the mysqladmin utility, using the flush-hosts, flush-logs, reload or flush-tables commands.

7.20 KILL syntax

    KILL thread_id

Each connection to mysqld runs in a separate thread. You can see which threads are running with the SHOW PROCESSLIST command, and kill a thread with the KILL thread_id command.

If you have the process privilege, you can see and kill all threads. Otherwise, you can see and kill only your own threads.

You can also use the mysqladmin processlist and mysqladmin kill commands to examine and kill threads.

7.21 SHOW syntax (Get information about tables, columns,...)
SHOW DATABASES [LIKE wild]
or SHOW TABLES [FROM db_name] [LIKE wild]
or SHOW COLUMNS FROM tbl_name [FROM db_name] [LIKE wild]
or SHOW INDEX FROM tbl_name [FROM db_name]
or SHOW STATUS [LIKE wild]
or SHOW VARIABLES [LIKE wild]
or SHOW [FULL] PROCESSLIST
or SHOW TABLE STATUS [FROM db_name] [LIKE wild]
or SHOW GRANTS FOR user

SHOW provides information about databases, tables, columns or the server. If the LIKE wild part is used, the wild string can be a string that uses the SQL ‘%’ and ‘_’ wildcard characters.

You can use db_name.tbl_name as an alternative to the tbl_name FROM db_name syntax. These two statements are equivalent:

```
mysql> SHOW INDEX FROM mytable FROM mydb;
mysql> SHOW INDEX FROM mydb.mytable;
```

SHOW DATABASES lists the databases on the MySQL server host. You can also get this list using the mysqlshow command.

SHOW TABLES lists the tables in a given database. You can also get this list using the mysqlshow db_name command.

**Note:** If a user doesn’t have any privileges for a table, the table will not show up in the output from SHOW TABLES or mysqlshow db_name.

SHOW COLUMNS lists the columns in a given table. If the column types are different than you expect them to be based on a CREATE TABLE statement, note that MySQL sometimes changes column types. See Section 7.7.1 [Silent column changes], page 192.

The DESCRIBE statement provides information similar to SHOW COLUMNS. See Section 7.23 [DESCRIBE], page 220.

SHOW TABLE STATUS (new in version 3.23) works like SHOW STATUS, but provides a lot of information about each table. You can also get this list using the mysqlshow --status db_name command. The following columns are returned:

<table>
<thead>
<tr>
<th>Column</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
<td>Name of the table</td>
</tr>
<tr>
<td>Type</td>
<td>Type of table (ISAM, MyISAM or HEAP)</td>
</tr>
<tr>
<td>Row_format</td>
<td>The row storage format (Fixed, Dynamic, or Compressed)</td>
</tr>
<tr>
<td>Rows</td>
<td>Number of rows</td>
</tr>
<tr>
<td>Avg_row_length</td>
<td>Average row length</td>
</tr>
<tr>
<td>Data_length</td>
<td>Length of the data file</td>
</tr>
<tr>
<td>Max_data_length</td>
<td>Max length of the data file</td>
</tr>
<tr>
<td>Index_length</td>
<td>Length of the index file</td>
</tr>
<tr>
<td>Data_free</td>
<td>Number of allocated but not used bytes</td>
</tr>
<tr>
<td>Auto_increment</td>
<td>Next autoincrement value</td>
</tr>
<tr>
<td>Create_time</td>
<td>When the table was created</td>
</tr>
<tr>
<td>Update_time</td>
<td>When the data file was last updated</td>
</tr>
<tr>
<td>Check_time</td>
<td>When one last run a check on the table</td>
</tr>
</tbody>
</table>
Create_options Extra options used with CREATE TABLE
Comment The comment used when creating the table (or some information why MySQL couldn’t access the table information).

SHOW FIELDS is a synonym for SHOW COLUMNS and SHOW KEYS is a synonym for SHOW INDEX. You can also list a table’s columns or indexes with mysqlshow db_name tbl_name or mysqlshow -k db_name tbl_name.

SHOW INDEX returns the index information in a format that closely resembles the SQLStatistics call in ODBC. The following columns are returned:

<table>
<thead>
<tr>
<th>Column</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Table</td>
<td>Name of the table</td>
</tr>
<tr>
<td>Non_unique</td>
<td>0 if the index can’t contain duplicates.</td>
</tr>
<tr>
<td>Key_name</td>
<td>Name of the index</td>
</tr>
<tr>
<td>Seq_in_index</td>
<td>Column sequence number in index, starting with 1.</td>
</tr>
<tr>
<td>Column_name</td>
<td>Column name.</td>
</tr>
<tr>
<td>Collation</td>
<td>How the column is sorted in the index. In MySQL, this can have values A (Ascending) or NULL (Not sorted).</td>
</tr>
<tr>
<td>Cardinality</td>
<td>Number of unique values in the index. This is updated by running isamchk -a.</td>
</tr>
<tr>
<td>Sub_part</td>
<td>Number of indexed characters if the column is only partly indexed. NULL if the entire key is indexed.</td>
</tr>
</tbody>
</table>

SHOW STATUS provides server status information (like mysqladmin extended-status). The output resembles that shown below, though the format and numbers may differ somewhat:

```
+--------------------------+--------+
| Variable_name            | Value  |
|--------------------------+--------+
| Aborted_clients          | 0      |
| Aborted_connects         | 0      |
| Connections              | 17     |
| Created_tmp_tables       | 0      |
| Delayed_insert_threads   | 0      |
| Delayed_writes           | 0      |
| Delayed_errors           | 0      |
| Flush_commands           | 2      |
| Handler_delete           | 2      |
| Handler_read_first       | 0      |
| Handler_read_key         | 1      |
| Handler_read_next        | 0      |
| Handler_read_rnd         | 35     |
| Handler_update           | 0      |
| Handler_write            | 2      |
| Key_blocks_used          | 0      |
| Key_read_requests        | 0      |
| Key_reads                | 0      |
| Key_write_requests       | 0      |
| Key_writes               | 0      |
| Max_used_connections     | 1      |
```
### Chapter 7: MySQL language reference

<table>
<thead>
<tr>
<th>Not_flushed_key_blocks</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not_flushed_delayed_rows</td>
<td>0</td>
</tr>
<tr>
<td>Open_tables</td>
<td>1</td>
</tr>
<tr>
<td>Open_files</td>
<td>2</td>
</tr>
<tr>
<td>Open_streams</td>
<td>0</td>
</tr>
<tr>
<td>Opened_tables</td>
<td>11</td>
</tr>
<tr>
<td>Questions</td>
<td>14</td>
</tr>
<tr>
<td>Slow_queriers</td>
<td>0</td>
</tr>
<tr>
<td>Threads_connected</td>
<td>1</td>
</tr>
<tr>
<td>Threads_running</td>
<td>1</td>
</tr>
<tr>
<td>Uptime</td>
<td>149111</td>
</tr>
</tbody>
</table>

The status variables listed above have the following meaning:

- **Aborted_clients**: Number of connections that has been aborted because the client has died without closing the connection properly.
- **Aborted_connects**: Number of tries to connect to the MySQL server that has failed.
- **Connections**: Number of connection attempts to the MySQL server.
- **Created_tmp_tables**: Number of implicit temporary tables that has been created while executing statements.
- **Delayed_insert_threads**: Number of delayed insert handler threads in use.
- **Delayed_writes**: Number of rows written with `INSERT DELAYED`.
- **Delayed_errors**: Number of rows written with `INSERT DELAYED` for which some error occurred (probably `duplicate key`).
- **Flush_commands**: Number of executed `FLUSH` commands.
- **Handler_delete**: Number of requests to delete a row from a table.
- **Handler_read_first**: Number of requests to read the first row in a table.
- **Handler_read_key**: Number of requests to read a row based on a key.
- **Handler_read_next**: Number of requests to read next row in key order.
- **Handler_read_rnd**: Number of requests to read a row based on a fixed position.
- **Handler_update**: Number of requests to update a row in a table.
- **Handler_write**: Number of requests to insert a row in a table.
- **Key_blocks_used**: The number of used blocks in the key cache.
- **Key_read_requests**: The number of requests to read a key block from the cache.
- **Key_reads**: The number of physical reads of a key block from disk.
- **Key_write_requests**: The number of requests to write a key block to the cache.
- **Key_writes**: The number of physical writes of a key block to disk.
- **Max_used_connections**: The maximum number of connections that has been in use simultaneously.
- **Not_flushed_key_blocks**: Keys blocks in the key cache that has changed but hasn’t yet been flushed to disk.
- **Not_flushed_delayed_rows**: Number of rows waiting to be written in `INSERT DELAYED` queues.
Open_tables Number of tables that are open.
Open_files Number of files that are open.
Open_streams Number of streams that are open (used mainly for logging)
Opened_tables Number of tables that has been opened.
Questions Number of queries sent to the server.
Slow_queries Number of queries that has taken more than long_query_time
Threads_connected Number of currently open connections.
Threads_running Number of threads that are not sleeping.
Uptime How many seconds the server has been up.

Some comments about the above:

- If Opened_tables is big, then your table_cache variable is probably too small.
- If key_reads is big, then your key_cache is probably too small. The cache hit rate can be calculated with key_reads/key_read_requests.
- If Handler_read_rnd is big, then you have a probably a lot of queries that requires MySQL to scan whole tables or you have joins that doesn’t use keys properly.

SHOW VARIABLES shows the values of the some of MySQL system variables. You can also get this information using the mysqladmin variables command. If the default values are unsuitable, you can set most of these variables using command-line options when mysqld starts up. The output resembles that shown below, though the format and numbers may differ somewhat:

```
+------------------------+--------------------------+
| Variable_name          | Value                    |
+------------------------+--------------------------+
| back_log               | 5                        |
| connect_timeout        | 5                        |
| basedir               | /my/monty/               |
| datadir               | /my/monty/data/          |
| delayed_insert_limit   | 100                      |
| delayed_insert_timeout | 300                      |
| delayed_queue_size    | 1000                     |
| join_buffer_size      | 131072                   |
| flush_time             | 0                        |
| interactive_timeout   | 28800                    |
| key_buffer_size       | 1048540                  |
| language              | /my/monty/share/english/ |
| log                   | OFF                      |
| log_update            | OFF                      |
| long_query_time       | 10                       |
| low_priority_updates  | OFF                      |
| max_allowed_packet    | 1048576                  |
| max_connections       | 100                      |
| max_connect_errors    | 10                       |
| max_delayed_threads   | 20                       |
```
### Chapter 7: MySQL language reference

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>max_heap_table_size</td>
<td>16777216</td>
</tr>
<tr>
<td>max_join_size</td>
<td>4294967295</td>
</tr>
<tr>
<td>max_sort_length</td>
<td>1024</td>
</tr>
<tr>
<td>max_tmp_tables</td>
<td>32</td>
</tr>
<tr>
<td>net_buffer_length</td>
<td>16384</td>
</tr>
<tr>
<td>port</td>
<td>3306</td>
</tr>
<tr>
<td>protocol_version</td>
<td>10</td>
</tr>
<tr>
<td>record_buffer</td>
<td>131072</td>
</tr>
<tr>
<td>skip_locking</td>
<td>ON</td>
</tr>
<tr>
<td>socket</td>
<td>/tmp/mysql.sock</td>
</tr>
<tr>
<td>sort_buffer</td>
<td>2097116</td>
</tr>
<tr>
<td>table_cache</td>
<td>64</td>
</tr>
<tr>
<td>thread_stack</td>
<td>131072</td>
</tr>
<tr>
<td>tmp_table_size</td>
<td>1048576</td>
</tr>
<tr>
<td>tmpdir</td>
<td>/machine/tmp/</td>
</tr>
<tr>
<td>version</td>
<td>3.23.0-alpha-debug</td>
</tr>
<tr>
<td>wait_timeout</td>
<td>28800</td>
</tr>
</tbody>
</table>

See Section 11.2.3 [Server parameters], page 278.

SHOW PROCESSLIST shows you which threads are running. You can also get this information using the `mysqladmin processlist` command. If you have the process privilege, you can see all threads. Otherwise, you can see only your own threads. See Section 7.20 [KILL], page 211. If you don’t use the FULL option, then only the first 100 characters of each query will be shown.

SHOW GRANTS FOR user lists the grant commands that must be issued to duplicate the grants for a user.

```sql
mysql> SHOW GRANTS FOR root@localhost;
+---------------------------------------------------------------------+
| Grants for root@localhost                                          |
| GRANT ALL PRIVILEGES ON *.* TO 'root'@'localhost' WITH GRANT OPTION |
+---------------------------------------------------------------------+
```

### 7.22 EXPLAIN syntax (Get information about a SELECT)

```sql
EXPLAIN tbl_name
or EXPLAIN SELECT select_options
```

EXPLAIN `tbl_name` is a synonym for `DESCRIBE tbl_name` or `SHOW COLUMNS FROM tbl_name`. When you precede a SELECT statement with the keyword EXPLAIN, MySQL explains how it would process the SELECT, providing information about how tables are joined and in which order.

With the help of EXPLAIN, you can see when you must add indexes to tables to get a faster SELECT that uses indexes to find the records. You can also see if the optimizer joins the
tables in an optimal order. To force the optimizer to use a specific join order for a `SELECT` statement, add a `STRAIGHT_JOIN` clause.

For non-simple joins, `EXPLAIN` returns a row of information for each table used in the `SELECT` statement. The tables are listed in the order they would be read. MySQL resolves all joins using a single-sweep multi-join method. This means that MySQL reads a row from the first table, then finds a matching row in the second table, then in the third table and so on. When all tables are processed, it outputs the selected columns and backtracks through the table list until a table is found for which there are more matching rows. The next row is read from this table and the process continues with the next table.

Output from `EXPLAIN` includes the following columns:

- **table**: The table to which the row of output refers.
- **type**: The join type. Information about the various types is given below.
- **possible_keys**: The `possible_keys` column indicates which indexes MySQL could use to find the rows in this table. Note that this column is totally independent on the order of the tables. That means that some of the keys in `possible_keys` may not be usable in practice with the generated table order.

  If this column is empty, there are no relevant indexes. In this case, you may be able to improve the performance of your query by examining the `WHERE` clause to see if it refers to some column or columns that would be suitable for indexing. If so, create an appropriate index and check the query with `EXPLAIN` again. See Section 7.8 [ALTER TABLE], page 193.

  To see what indexes a table has, use `SHOW INDEX FROM tbl_name`.

- **key**: The `key` column indicates the key that MySQL actually decided to use. The key is `NULL` if no index was chosen. If MySQL chooses the wrong index, you can probably force MySQL to use another index by using `myisamchk --analyze`, See Section 14.1.1 [myisamchk syntax], page 323, or using `USE INDEX/IGNORE INDEX`. See Section 7.13 [JOIN], page 199.

- **key_len**: The `key_len` column indicates the length of the key that MySQL decided to use. The length is `NULL` if the `key` is `NULL`. Note that this tell us how many parts of a multi part key MySQL will actually use.

- **ref**: The `ref` column shows which columns or constants are used with the `key` to select rows from the table.

- **rows**: The `rows` column indicates the number of rows MySQL believe it must examine to execute the query.

- **Extra**: If the `Extra` column includes the text `Only index`, this means that information is retrieved from the table using only information in the index tree. Normally, this is much faster than scanning the entire table.

  If the `Extra` column includes the text `where used`, it means that a `WHERE` clause will be used to restrict which rows will be matched against the next table or sent to the client.
The different join types are listed below, ordered from best to worst type:

- **system**: The table has only one row (= system table). This is a special case of the const join type.
- **const**: The table has at most one matching row, which will be read at the start of the query. Since there is only one row, values from the column in this row can be regarded as constants by the rest of the optimizer. const tables are very fast as they are read only once!
- **eq_ref**: One row will be read from this table for each combination of rows from the previous tables. This the best possible join type, other than the const types. It is used when all parts of an index are used by the join and the index is UNIQUE or a PRIMARY KEY.
- **ref**: All rows with matching index values will be read from this table for each combination of rows from the previous tables. ref is used if the join uses only a leftmost prefix of the key, or if the key is not UNIQUE or a PRIMARY KEY (in other words, if the join cannot select a single row based on the key value). If the key that is used matches only a few rows, this join type is good.
- **range**: Only rows that are in a given range will be retrieved, using an index to select the rows. The ref column indicates which index is used.
- **index**: This is the same as ALL, except that only the index tree is scanned. This is usually faster than ALL, as the index file is usually smaller than the data file.
- **ALL**: A full table scan will be done for each combination of rows from the previous tables. This is normally not good if the table is the first table not marked const, and usually very bad in all other cases. You normally can avoid ALL by adding more indexes, so that the row can be retrieved based on constant values or column values from earlier tables.

You can get a good indication of how good a join is by multiplying all values in the rows column of the EXPLAIN output. This should tell you roughly how many rows MySQL must examine to execute the query. This number is also used when you restrict queries with the max_join_size variable. See Section 11.2.3 [Server parameters], page 278.

The following example shows how a JOIN can be optimized progressively using the information provided by EXPLAIN.

Suppose you have the SELECT statement shown below, that you examine using EXPLAIN:

```sql
FROM tt, et, et AS et_1, do
WHERE tt.SubmitTime IS NULL
AND tt.ActualPC = et.EMPLOYID
```

Version: 3.23.11-alpha Printed: 25 February 2000
AND tt.AssignedPC = et.1.EMPLOYID
AND tt.ClientID = do.CUSTNMBR;

For this example, assume that:

- The columns being compared have been declared as follows:

<table>
<thead>
<tr>
<th>Table</th>
<th>Column</th>
<th>Column type</th>
</tr>
</thead>
<tbody>
<tr>
<td>tt</td>
<td>ActualPC</td>
<td>CHAR(10)</td>
</tr>
<tr>
<td>tt</td>
<td>AssignedPC</td>
<td>CHAR(10)</td>
</tr>
<tr>
<td>tt</td>
<td>ClientID</td>
<td>CHAR(10)</td>
</tr>
<tr>
<td>et</td>
<td>EMPLOYID</td>
<td>CHAR(15)</td>
</tr>
<tr>
<td>do</td>
<td>CUSTNMBR</td>
<td>CHAR(15)</td>
</tr>
</tbody>
</table>

- The tables have the indexes shown below:

<table>
<thead>
<tr>
<th>Table</th>
<th>Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>tt</td>
<td>ActualPC</td>
</tr>
<tr>
<td>tt</td>
<td>AssignedPC</td>
</tr>
<tr>
<td>tt</td>
<td>ClientID</td>
</tr>
<tr>
<td>et</td>
<td>EMPLOYID (primary key)</td>
</tr>
<tr>
<td>do</td>
<td>CUSTNMBR (primary key)</td>
</tr>
</tbody>
</table>

- The tt.ActualPC values aren’t evenly distributed.

Initially, before any optimizations have been performed, the EXPLAIN statement produces the following information:

<table>
<thead>
<tr>
<th>table type possible_keys</th>
<th>key</th>
<th>key_len</th>
<th>ref</th>
<th>rows</th>
<th>Extra</th>
</tr>
</thead>
<tbody>
<tr>
<td>et</td>
<td>ALL</td>
<td>PRIMARY</td>
<td>NULL</td>
<td>NULL</td>
<td>74</td>
</tr>
<tr>
<td>do</td>
<td>ALL</td>
<td>PRIMARY</td>
<td>NULL</td>
<td>NULL</td>
<td>2135</td>
</tr>
<tr>
<td>et_1</td>
<td>ALL</td>
<td>PRIMARY</td>
<td>NULL</td>
<td>NULL</td>
<td>74</td>
</tr>
<tr>
<td>tt</td>
<td>ALL</td>
<td>AssignedPC,ClientID,ActualPC</td>
<td>NULL</td>
<td>NULL</td>
<td>3872</td>
</tr>
</tbody>
</table>

range checked for each record (key map: 35)

Since type is ALL for each table, this output indicates that MySQL is doing a full join for all tables! This will take quite a long time, as the product of the number of rows in each table must be examined! For the case at hand, this is $74 \times 2135 \times 74 \times 3872 = 45,268,558,720$ rows. If the tables were bigger, you can only imagine how long it would take...

One problem here is that MySQL can’t (yet) use indexes on columns efficiently if they are declared differently. In this context, VARCHAR and CHAR are the same unless they are declared as different lengths. Since tt.ActualPC is declared as CHAR(10) and et.EMPLOYID is declared as CHAR(15), there is a length mismatch.

To fix this disparity between column lengths, use ALTER TABLE to lengthen ActualPC from 10 characters to 15 characters:

```sql
mysql> ALTER TABLE tt MODIFY ActualPC VARCHAR(15);
```

Now tt.ActualPC and et.EMPLOYID are both VARCHAR(15). Executing the EXPLAIN statement again produces this result:

<table>
<thead>
<tr>
<th>table type possible_keys</th>
<th>key</th>
<th>key_len</th>
<th>ref</th>
<th>rows</th>
<th>Extra</th>
</tr>
</thead>
<tbody>
<tr>
<td>tt</td>
<td>ALL</td>
<td>AssignedPC,ClientID,ActualPC</td>
<td>NULL</td>
<td>NULL</td>
<td>3872</td>
</tr>
<tr>
<td>do</td>
<td>ALL</td>
<td>PRIMARY</td>
<td>NULL</td>
<td>NULL</td>
<td>2135</td>
</tr>
</tbody>
</table>

range checked for each record (key map: 1)
et_1    ALL    PRIMARY    NULL    NULL    NULL    74
         range checked for each record (key map: 1)
et    eq_ref    PRIMARY    PRIMARY    15    tt.ActualPC    1

This is not perfect, but is much better (the product of the rows values is now less by a factor of 74). This version is executed in a couple of seconds.

A second alteration can be made to eliminate the column length mismatches for the tt.AssignedPC = et_1.EMPLOYID and tt.ClientID = do.CUSTNMBR comparisons:

```
mysql> ALTER TABLE tt MODIFY AssignedPC VARCHAR(15),
            MODIFY ClientID VARCHAR(15);
```

Now EXPLAIN produces the output shown below:

```
table type possible_keys      key key_len ref   rows Extra
et    ALL    PRIMARY    NULL    NULL    NULL    74
         AssignedPC,ClientID,ActualPC ActualPC 15 et.EMPLOYID 52 where used
et_1 eq_ref PRIMARY PRIMARY 15 tt.AssignedPC 1
do eq_ref PRIMARY PRIMARY 15 tt.ClientID 1
```

This is “almost” as good as it can get.

The remaining problem is that, by default, MySQL assumes that values in the tt.ActualPC column are evenly distributed, and that isn’t the case for the tt table. Fortunately, it is easy to tell MySQL about this:

```
shell> myisamchk --analyze PATH_TO_MYSQL_DATABASE/tt
shell> mysqladmin refresh
```

Now the join is “perfect”, and EXPLAIN produces this result:

```
table type possible_keys key key_len ref   rows Extra
            AssignedPC,ClientID,ActualPC NULL NULL NULL 3872 where used
et_1 eq_ref PRIMARY PRIMARY 15 tt.AssignedPC 1
do eq_ref PRIMARY PRIMARY 15 tt.ClientID 1
```

Note that the rows column in the output from EXPLAIN is an “educated guess” from the MySQL join optimizer; To optimize a query, you should check if the numbers are even close to the truth. If not, you may get better performance by using STRAIGHT_JOIN in your SELECT statement and trying to list the tables in a different order in the FROM clause.

### 7.23 DESCRIBE syntax (Get information about columns)

```
{DESCRIBE | DESC} tbl_name {col_name | wild}
```

DESCRIBE provides information about a table’s columns. col_name may be a column name or a string containing the SQL ‘%’ and ‘_’ wildcard characters.

If the column types are different than you expect them to be based on a CREATE TABLE statement, note that MySQL sometimes changes column types. See Section 7.7.1 [Silent column changes], page 192.

This statement is provided for Oracle compatibility.

The SHOW statement provides similar information. See Section 7.21 [SHOW], page 211.

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7.24 LOCK TABLES/UNLOCK TABLES syntax

```
LOCK TABLES tbl_name [AS alias] {READ | [READ LOCAL] | [LOW_PRIORITY] WRITE}
[, tbl_name {READ | [LOW_PRIORITY] WRITE} ...]
...

UNLOCK TABLES
```

LOCK TABLES locks tables for the current thread. UNLOCK TABLES releases any locks held by the current thread. All tables that are locked by the current thread are automatically unlocked when the thread issues another LOCK TABLES, or when the connection to the server is closed.

If a thread obtains a READ lock on a table, that thread (and all other threads) can only read from the table. If a thread obtains a WRITE lock on a table, then only the thread holding the lock can READ from or WRITE to the table. Other threads are blocked.

The difference between READ LOCAL and READ is that READ LOCAL allows non-conflicting INSERT statements to execute while the lock is held. This can’t however be used if you are going to manipulate the database files outside MySQL while you hold the lock.

Each thread waits (without timing out) until it obtains all the locks it has requested.

WRITE locks normally have higher priority than READ locks, to ensure that updates are processed as soon as possible. This means that if one thread obtains a READ lock and then another thread requests a WRITE lock, subsequent READ lock requests will wait until the WRITE thread has gotten the lock and released it. You can use LOW_PRIORITY WRITE locks to allow other threads to obtain READ locks while the thread is waiting for the WRITE lock.

You should only use LOW_PRIORITY WRITE locks if you are sure that there will eventually be a time when no threads will have a READ lock.

When you use LOCK TABLES, you must lock all tables that you are going to use and you must use the same alias that you are going to use in your queries! If you are using a table multiple times in a query (with aliases), you must get a lock for each alias! This policy ensures that table locking is deadlock free.

Note that you should NOT lock any tables that you are using with INSERT DELAYED. This is because that in this case the INSERT is done by a separate thread.

Normally, you don’t have to lock tables, as all single UPDATE statements are atomic; no other thread can interfere with any other currently executing SQL statement. There are a few cases when you would like to lock tables anyway:

- If you are going to run many operations on a bunch of tables, it’s much faster to lock the tables you are going to use. The downside is, of course, that no other thread can update a READ-locked table and no other thread can read a WRITE-locked table.

- MySQL doesn’t support a transaction environment, so you must use LOCK TABLES if you want to ensure that no other thread comes between a SELECT and an UPDATE. The example shown below requires LOCK TABLES in order to execute safely:

  ```
  mysql> LOCK TABLES trans READ, customer WRITE;
  mysql> select sum(value) from trans where customer_id= some_id;
  mysql> update customer set total_value=sum_from_previous_statement
  where customer_id=some_id;
  ```

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Without `LOCK TABLES`, there is a chance that another thread might insert a new row in the `trans` table between execution of the `SELECT` and `UPDATE` statements.

By using incremental updates (UPDATE `customer` SET `value` = `value` + `new_value`) or the `LAST_INSERT_ID()` function, you can avoid using `LOCK TABLES` in many cases.

You can also solve some cases by using the user-level lock functions `GET_LOCK()` and `RELEASE_LOCK()`. These locks are saved in a hash table in the server and implemented with `pthread_mutex_lock()` and `pthread_mutex_unlock()` for high speed. See Section 7.4.12 [Miscellaneous functions], page 181.

See Section 11.2.8 [Internal locking], page 286, for more information on locking policy.

### 7.25 SET syntax

```
SET [OPTION] SQL_VALUE_OPTION=value, ...
```

`SET OPTION` sets various options that affect the operation of the server or your client. Any option you set remains in effect until the current session ends, or until you set the option to a different value.

```
CHARACTER SET character_set_name | DEFAULT
```

This maps all strings from and to the client with the given mapping. Currently the only option for `character_set_name` is `cp1251_koi8`, but you can easily add new mappings by editing the `sql/convert.cc` file in the MySQL source distribution. The default mapping can be restored by using a `character_set_name` value of `DEFAULT`.

Note that the syntax for setting the `CHARACTER SET` option differs from the syntax for setting the other options.

```
PASSWORD = PASSWORD('some password')
```

Set the password for the current user. Any non-anonymous user can change his own password!

```
PASSWORD FOR user = PASSWORD('some password')
```

Set the password for a specific user on the current server host. Only a user with access to the `mysql` database can do this. The user should be given in `user@hostname` format, where `user` and `hostname` are exactly as they are listed in the `User` and `Host` columns of the `mysql.user` table entry. For example, if you had an entry with `User` and `Host` fields of `bob` and `%.loc.gov`, you would write:

```
mysql> SET PASSWORD FOR bob@"%.loc.gov" = PASSWORD("newpass");
```

or

```
mysql> UPDATE mysql.user SET password=PASSWORD("newpass") where user="bob"
```

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SQL_AUTO_IS_NULL = 0 | 1
If set to 1 (default) then one can find the last inserted row for a table with an auto_increment row with the following construct: WHERE auto_increment_column IS NULL. This is used by some ODBC programs like Access.

SQL_BIG_TABLES = 0 | 1
If set to 1, all temporary tables are stored on disk rather than in memory. This will be a little slower, but you will not get the error The table tbl_name is full for big SELECT operations that require a large temporary table. The default value for a new connection is 0 (i.e., use in-memory temporary tables).

SQL_BIG_SELECTS = 0 | 1
If set to 0, MySQL will abort if a SELECT is attempted that probably will take a very long time. This is useful when an inadvisable WHERE statement has been issued. A big query is defined as a SELECT that probably will have to examine more than max_join_size rows. The default value for a new connection is 1 (which will allow all SELECT statements).

SQL_LOW_PRIORITY_UPDATES = 0 | 1
If set to 1, all INSERT, UPDATE, DELETE and and LOCK TABLE WRITE statements wait until there is no pending SELECT or LOCK TABLE READ on the affected table.

SQL_MAX_JOIN_SIZE = value | DEFAULT
Don’t allow SELECT’s that will probably need to examine more than value row combinations. By setting this value, you can catch SELECT’s where keys are not used properly and that would probably take a long time. Setting this to a value other than DEFAULT will reset the SQL_BIG_SELECTS flag. If you set the SQL_BIG_SELECTS flag again, the SQL_MAX_JOIN_SIZE variable will be ignored. You can set a default value for this variable by starting mysqld with -O max_join_size=#.

SQL_SAFE_MODE = 0 | 1
If set to 1, MySQL will abort if a UPDATE or DELETE is attempted that doesn’t use a key or LIMIT in the WHERE clause. This makes it possible to catch wrong updates when creating SQL commands by hand.

SQL_SELECT_LIMIT = value | DEFAULT
The maximum number of records to return from SELECT statements. If a SELECT has a LIMIT clause, the LIMIT takes precedence over the value of SQL_SELECT_LIMIT. The default value for a new connection is “unlimited”. If you have changed the limit, the default value can be restored by using a SQL_SELECT_LIMIT value of DEFAULT.

SQL_LOG_OFF = 0 | 1
If set to 1, no logging will be done to the standard log for this client, if the client has the process privilege. This does not affect the update log!

SQL_LOG_UPDATE = 0 | 1
If set to 0, no logging will be done to the update log for the client, if the client has the process privilege. This does not affect the standard log!
TIMESTAMP = timestamp_value | DEFAULT
    Set the time for this client. This is used to get the original timestamp if you
    use the update log to restore rows.

LAST_INSERT_ID = #
    Set the value to be returned from LAST_INSERT_ID(). This is stored in the
    update log when you use LAST_INSERT_ID() in a command that updates a
    table.

INSERT_ID = #
    Set the value to be used by the following INSERT command when inserting an
    AUTO_INCREMENT value. This is mainly used with the update log.

7.26 GRANT and REVOKE syntax

GRANT priv_type [(column_list)] [, priv_type [(column_list)] ...]
    ON {tbl_name | * | *.* | db_name.*}
    TO user_name [IDENTIFIED BY 'password']
    [, user_name [IDENTIFIED BY 'password'] ...]
    [WITH GRANT OPTION]

REVOKE priv_type [(column_list)] [, priv_type [(column_list)] ...]
    ON {tbl_name | * | *.* | db_name.*}
    FROM user_name [, user_name ...]

GRANT is implemented in MySQL 3.22.11 or later. For earlier MySQL versions, the GRANT
statement does nothing.

The GRANT and REVOKE commands allow system administrators to grant and revoke rights
to MySQL users at four privilege levels:

Global level
    Global privileges apply to all databases on a given server. These privileges are
    stored in the mysql.user table.

Database level
    Database privileges apply to all tables in a given database. These privileges are
    stored in the mysql.db and mysql.host tables.

Table level
    Table privileges apply to all columns in a given table. These privileges are
    stored in the mysql.tables_priv table.

Column level
    Column privileges apply to single columns in a given table. These privileges
    are stored in the mysql.columns_priv table.

For examples of how GRANT works, see Section 6.13 [Adding users], page 123.
For the GRANT and REVOKE statements, priv_type may be specified as any of the following:
ALL PRIVILEGES FILE RELOAD
ALTER INDEX SELECT
CREATE INSERT SHUTDOWN
DELETE PROCESS UPDATE
DROP REFERENCES USAGE

ALL is a synonym for ALL PRIVILEGES. REFERENCES is not yet implemented. USAGE is currently a synonym for “no privileges”. It can be used when you want to create a user that has no privileges.

To revoke the grant privilege from a user, use a priv_type value of GRANT OPTION:

\texttt{REVOKE GRANT OPTION ON ... FROM ...;}

The only priv_type values you can specify for a table are SELECT, INSERT, UPDATE, DELETE, CREATE, DROP, GRANT, INDEX and ALTER.

The only priv_type values you can specify for a column (that is, when you use a column_list clause) are SELECT, INSERT and UPDATE.

You can set global privileges by using ON *.* syntax. You can set database privileges by using ON db_name.* syntax. If you specify ON * and you have a current database, you will set the privileges for that database. (Warning: If you specify ON * and you don’t have a current database, you will affect the global privileges!)

In order to accommodate granting rights to users from arbitrary hosts, MySQL supports specifying the user_name value in the form user@host. If you want to specify a user string containing special characters (such as ‘-’), or a host string containing special characters or wildcard characters (such as ‘%’), you can quote the user or host name (e.g., ’test-user’@’test-hostname’).

You can specify wildcards in the hostname. For example, user@%.loc.gov applies to user for any host in the loc.gov domain, and user@"144.155.166.%" applies to user for any host in the 144.155.166 class C subnet.

The simple form user is a synonym for user@"%". Note: If you allow anonymous users to connect to the MySQL server (which is the default), you should also add all local users as user@localhost because otherwise the anonymous user entry for the local host in the mysql.user table will be used when the user tries to log into the MySQL server from the local machine! Anonymous users are defined by inserting entries with User='' into the mysql.user table. You can verify if this applies to you by executing this query:

\texttt{mysql> SELECT Host,User FROM mysql.user WHERE User='';}

For the moment, GRANT only supports host, table, database and column names up to 60 characters long. A user name can be up to 16 characters long.

The privileges for a table or column are formed from the logical OR of the privileges at each of the four privilege levels. For example, if the mysql.user table specifies that a user has a global select privilege, this can’t be denied by an entry at the database, table or column level.

The privileges for a column can be calculated as follows:

\begin{align*}
\text{global privileges} \\
\text{OR} \ (\text{database privileges AND host privileges}) \\
\text{OR table privileges}
\end{align*}
OR column privileges

In most cases, you grant rights to a user at only one of the privilege levels, so life isn't normally as complicated as above. :) The details of the privilege-checking procedure are presented in Chapter 6 [Privilege system], page 106.

If you grant privileges for a user/hostname combination that does not exist in the mysql.user table, an entry is added and remains there until deleted with a DELETE command. In other words, GRANT may create user table entries, but REVOKE will not remove them; you must do that explicitly using DELETE.

In MySQL 3.22.12 or later, if a new user is created or if you have global grant privileges, the user's password will be set to the password specified by the IDENTIFIED BY clause, if one is given. If the user already had a password, it is replaced by the new one.

**Warning:** If you create a new user but do not specify an IDENTIFIED BY clause, the user has no password. This is insecure.

Passwords can also be set with the SET PASSWORD command. See Section 7.25 [SET OPTION], page 222.

If you grant privileges for a database, an entry in the mysql.db table is created if needed. When all privileges for the database have been removed with REVOKE, this entry is deleted.

If a user doesn't have any privileges on a table, the table is not displayed when the user requests a list of tables (e.g., with a SHOW TABLES statement).

The WITH GRANT OPTION clause gives the user the ability to give to other users any privileges the user has at the specified privilege level. You should be careful to whom you give the grant privilege, as two users with different privileges may be able to join privileges!

You cannot grant another user a privilege you don't have yourself; the grant privilege allows you to give away only those privileges you possess.

Be aware that when you grant a user the grant privilege at a particular privilege level, any privileges the user already possesses (or is given in the future!) at that level are also grantable by that user. Suppose you grant a user the insert privilege on a database. If you then grant the select privilege on the database and specify WITH GRANT OPTION, the user can give away not only the select privilege, but also insert. If you then grant the update privilege to the user on the database, the user can give away the insert, select and update.

You should not grant alter privileges to a normal user. If you do that, the user can try to subvert the privilege system by renaming tables!

Note that if you are using table or column privileges for even one user, the server examines table and column privileges for all users and this will slow down MySQL a bit.

When mysql starts, all privileges are read into memory. Database, table and column privileges take effect at once and user-level privileges take effect the next time the user connects. Modifications to the grant tables that you perform using GRANT or REVOKE are noticed by the server immediately. If you modify the grant tables manually (using INSERT, UPDATE, etc.), you should execute a FLUSH PRIVILEGES statement or run mysqladmin flush-privileges to tell the server to reload the grant tables. See Section 6.11 [Privilege changes], page 121.

The biggest differences between the ANSI SQL and MySQL versions of GRANT are:

- ANSI SQL doesn't have global or database-level privileges and ANSI SQL doesn't support all privilege types that MySQL supports.
When you drop a table in ANSI SQL, all privileges for the table are revoked. If you
revoke a privilege in ANSI SQL, all privileges that were granted based on this privilege
are also revoked. In MySQL, privileges can be dropped only with explicit \texttt{REVOKE}
commands or by manipulating the MySQL grant tables.

\textbf{7.27 CREATE INDEX syntax}

\texttt{CREATE [UNIQUE] INDEX index\_name ON tbl\_name (col\_name[(length)],... )}

The \texttt{CREATE INDEX} statement doesn’t do anything in MySQL prior to version 3.22. In 3.22
or later, \texttt{CREATE INDEX} is mapped to an \texttt{ALTER TABLE} statement to create indexes. See
\textbf{Section 7.8 \texttt{[ALTER TABLE]}}, page 193.

Normally, you create all indexes on a table at the time the table itself is created with \texttt{CREATE TABLE}. See \textbf{Section 7.7 \texttt{[CREATE TABLE]}}, page 187. \texttt{CREATE INDEX} allows you to add indexes
to existing tables.

A column list of the form \texttt{(col1,col2,...)} creates a multiple-column index. Index values
are formed by concatenating the values of the given columns.

For \texttt{CHAR} and \texttt{VARCHAR} columns, indexes can be created that use only part of a column,
using \texttt{col\_name(length)} syntax. (On \texttt{BLOB} and \texttt{TEXT} columns the length is required). The
statement shown below creates an index using the first 10 characters of the \texttt{name} column:

\begin{verbatim}
mysql> CREATE INDEX part\_of\_name ON customer (name(10));
\end{verbatim}

Since most names usually differ in the first 10 characters, this index should not be much
slower than an index created from the entire \texttt{name} column. Also, using partial columns
for indexes can make the index file much smaller, which could save a lot of disk space and
might also speed up \texttt{INSERT} operations!

Note that you can only add a index on a column that can have \texttt{NULL} values or on a \texttt{BLOB/TEXT}
column if you are using MySQL version 3.23.2 or newer and are using the \texttt{MyISAM} table
type.

For more information about how MySQL uses indexes, see \textbf{Section 11.4 \texttt{[MySQL indexes]}},
page 289.

\textbf{7.28 DROP INDEX syntax}

\texttt{DROP INDEX index\_name ON tbl\_name}

\texttt{DROP INDEX} drops the index named \texttt{index\_name} from the table \texttt{tbl\_name}. \texttt{DROP INDEX}
doesn’t do anything in MySQL prior to version 3.22. In 3.22 or later, \texttt{DROP INDEX} is mapped
to an \texttt{ALTER TABLE} statement to drop the index. See \textbf{Section 7.8 \texttt{[ALTER TABLE]}}, page 193.
### 7.29 Comment syntax

The MySQL server supports the `#` to end of line, `--` to end of line and `/*` in-line or multiple-line `*/` comment styles:

```sql
mysql> select 1+1;  # This comment continues to the end of line
mysql> select 1+1;  -- This comment continues to the end of line
mysql> select 1 /* this is an in-line comment */ + 1;
mysql> select 1+
   /*
   this is a multiple-line comment
*/
   1;
```

Note that the `--` comment style requires you to have at least one space after the `--`

Although the server understands the comment syntax just described, there are some limitations on the way that the `mysql` client parses `/* ... */` comments:

- Single-quote and double-quote characters are taken to indicate the beginning of a quoted string, even within a comment. If the quote is not matched by a second quote within the comment, the parser doesn’t realize the comment has ended. If you are running `mysql` interactively, you can tell that it has gotten confused like this because the prompt changes from `mysql>` to `'>` or `'>`.

- A semicolon is taken to indicate the end of the current SQL statement and anything following it to indicate the beginning of the next statement.

These limitations apply both when you run `mysql` interactively and when you put commands in a file and tell `mysql` to read its input from that file with `mysql < some-file`.

MySQL doesn’t support the `‘--’` ANSI SQL comment style. See Section 5.4.7 [Missing comments], page 103.

### 7.30 CREATE FUNCTION/DROP FUNCTION syntax

```sql
CREATE [AGGREGATE] FUNCTION function_name RETURNS {STRING|REAL|INTEGER}
   SONAME shared_library_name

DROP FUNCTION function_name
```

A user-definable function (UDF) is a way to extend MySQL with a new function that works like native (built in) MySQL functions such as `ABS()` and `CONCAT()`.

`AGGREGATE` is a new option for MySQL 3.23. An `AGGREGATE` function works exactly like a native MySQL `GROUP` function like `SUM` or `COUNT()`.

`CREATE FUNCTION` saves the function’s name, type and shared library name in the `mysql.func` system table. You must have the `insert` and `delete` privileges for the `mysql` database to create and drop functions.
All active functions are reloaded each time the server starts, unless you start mysqld with the --skip-grant-tables option. In this case, UDF initialization is skipped and UDFs are unavailable. (An active function is one that has been loaded with CREATE FUNCTION and not removed with DROP FUNCTION.)

For instructions on writing user-definable functions, see Chapter 15 [Adding functions], page 337. For the UDF mechanism to work, functions must be written in C or C++, your operating system must support dynamic loading and you must have compiled mysqld dynamically (not static).

7.31 Is MySQL picky about reserved words?

A common problem stems from trying to create a table with column names that use the names of datatypes or functions built into MySQL, such as TIMESTAMP or GROUP. You’re allowed to do it (for example, ABS is an allowed column name), but whitespace is not allowed between a function name and the ‘C when using functions whose names are also column names.

The following words are explicitly reserved in MySQL. Most of them are forbidden by ANSI SQL92 as column and/or table names (for example, group). A few are reserved because MySQL needs them and is (currently) using a yacc parser:

<table>
<thead>
<tr>
<th>action</th>
<th>add</th>
<th>aggregate</th>
<th>all</th>
</tr>
</thead>
<tbody>
<tr>
<td>alter</td>
<td>after</td>
<td>and</td>
<td>as</td>
</tr>
<tr>
<td>asc</td>
<td>avg</td>
<td>avg_row_length</td>
<td>auto_increment</td>
</tr>
<tr>
<td>between</td>
<td>bigint</td>
<td>bit</td>
<td>binary</td>
</tr>
<tr>
<td>blob</td>
<td>bool</td>
<td>both</td>
<td>by</td>
</tr>
<tr>
<td>cascade</td>
<td>case</td>
<td>char</td>
<td>character</td>
</tr>
<tr>
<td>change</td>
<td>check</td>
<td>checksum</td>
<td>column</td>
</tr>
<tr>
<td>columns</td>
<td>comment</td>
<td>constraint</td>
<td>create</td>
</tr>
<tr>
<td>cross</td>
<td>current_date</td>
<td>current_time</td>
<td>current_timestamp</td>
</tr>
<tr>
<td>data</td>
<td>database</td>
<td>databases</td>
<td>date</td>
</tr>
<tr>
<td>datetime</td>
<td>day</td>
<td>day_hour</td>
<td>day_minute</td>
</tr>
<tr>
<td>day_second</td>
<td>dayofmonth</td>
<td>dayofweek</td>
<td>dayofyear</td>
</tr>
<tr>
<td>dec</td>
<td>decimal</td>
<td>default</td>
<td>delayed</td>
</tr>
<tr>
<td>delay_key_write</td>
<td>delete</td>
<td>desc</td>
<td>describe</td>
</tr>
<tr>
<td>distinct</td>
<td>distinctrow</td>
<td>double</td>
<td>drop</td>
</tr>
<tr>
<td>end</td>
<td>else</td>
<td>escape</td>
<td>escaped</td>
</tr>
<tr>
<td>enclosed</td>
<td>enum</td>
<td>explain</td>
<td>exists</td>
</tr>
<tr>
<td>fields</td>
<td>file</td>
<td>first</td>
<td>float</td>
</tr>
<tr>
<td>float4</td>
<td>float8</td>
<td>flush</td>
<td>foreign</td>
</tr>
<tr>
<td>from</td>
<td>for</td>
<td>full</td>
<td>function</td>
</tr>
<tr>
<td>global</td>
<td>grant</td>
<td>grants</td>
<td>group</td>
</tr>
<tr>
<td>having</td>
<td>heap</td>
<td>high_priority</td>
<td>hour</td>
</tr>
<tr>
<td>hour_minute</td>
<td>hour_second</td>
<td>hosts</td>
<td>identified</td>
</tr>
<tr>
<td>ignore</td>
<td>in</td>
<td>index</td>
<td>infile</td>
</tr>
<tr>
<td>inner</td>
<td>insert</td>
<td>insert_id</td>
<td>int</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td>integer</td>
<td>integer</td>
<td>int1</td>
<td></td>
</tr>
<tr>
<td>int3</td>
<td>int4</td>
<td>int8</td>
<td></td>
</tr>
<tr>
<td>if</td>
<td>is</td>
<td>isam</td>
<td></td>
</tr>
<tr>
<td>key</td>
<td>keys</td>
<td>kill</td>
<td></td>
</tr>
<tr>
<td>leading</td>
<td>left</td>
<td>length</td>
<td></td>
</tr>
<tr>
<td>lines</td>
<td>limit</td>
<td>load</td>
<td></td>
</tr>
<tr>
<td>lock</td>
<td>logs</td>
<td>long</td>
<td></td>
</tr>
<tr>
<td>longtext</td>
<td>low_priority</td>
<td>max</td>
<td></td>
</tr>
<tr>
<td>match</td>
<td>mediumblob</td>
<td>mediumtext</td>
<td></td>
</tr>
<tr>
<td>middleint</td>
<td>min_rows</td>
<td>minute</td>
<td></td>
</tr>
<tr>
<td>modify</td>
<td>month</td>
<td>monthname</td>
<td></td>
</tr>
<tr>
<td>natural</td>
<td>numeric</td>
<td>no</td>
<td></td>
</tr>
<tr>
<td>null</td>
<td>on</td>
<td>optimize</td>
<td></td>
</tr>
<tr>
<td>optionally</td>
<td>or</td>
<td>order</td>
<td></td>
</tr>
<tr>
<td>outfile</td>
<td>pack_keys</td>
<td>partial</td>
<td></td>
</tr>
<tr>
<td>precision</td>
<td>primary</td>
<td>procedure</td>
<td></td>
</tr>
<tr>
<td>processlist</td>
<td>privileges</td>
<td>read</td>
<td></td>
</tr>
<tr>
<td>references</td>
<td>reload</td>
<td>regexp</td>
<td></td>
</tr>
<tr>
<td>replace</td>
<td>restrict</td>
<td>returns</td>
<td></td>
</tr>
<tr>
<td>rlike</td>
<td>row</td>
<td>rows</td>
<td></td>
</tr>
<tr>
<td>select</td>
<td>set</td>
<td>show</td>
<td></td>
</tr>
<tr>
<td>smallint</td>
<td>soname</td>
<td>sql_big_tables</td>
<td></td>
</tr>
<tr>
<td>sql_low_priority_updates</td>
<td>sql_log_off</td>
<td>sql_log_update</td>
<td></td>
</tr>
<tr>
<td>sql_small_result</td>
<td>sql_warnings</td>
<td>straight_join</td>
<td></td>
</tr>
<tr>
<td>starting</td>
<td>status</td>
<td>string</td>
<td></td>
</tr>
<tr>
<td>tables</td>
<td>temporary</td>
<td>terminated</td>
<td></td>
</tr>
<tr>
<td>then</td>
<td>time</td>
<td>timestamp</td>
<td></td>
</tr>
<tr>
<td>tinytext</td>
<td>tinyint</td>
<td>trailing</td>
<td></td>
</tr>
<tr>
<td>type</td>
<td>use</td>
<td>using</td>
<td></td>
</tr>
<tr>
<td>unlock</td>
<td>unsigned</td>
<td>update</td>
<td></td>
</tr>
<tr>
<td>values</td>
<td>varchar</td>
<td>variables</td>
<td></td>
</tr>
<tr>
<td>varbinary</td>
<td>with</td>
<td>write</td>
<td></td>
</tr>
<tr>
<td>where</td>
<td>year</td>
<td>year_month</td>
<td></td>
</tr>
</tbody>
</table>

The following symbols (from the table above) are disallowed by ANSI SQL but allowed by MySQL as column/table names. This is because some of these names are very natural names and a lot of people have already used them.

- ACTION
- BIT
- DATE
- ENUM
- NO
- TEXT
- TIME
• TIMESTAMP
8 MySQL table types

As of MySQL 3.23.6, you can choose between three basic table formats. When you create a new table, you can tell MySQL which table type it should use for the table. MySQL will always create a .frm file to hold the table and column definitions. Depending on the table type the index and data will be stored in other files.

You can convert tables between different types with the `ALTER TABLE` statement. See Section 7.8 [ALTER TABLE], page 193.

8.1 MyISAM tables

MyISAM is the default table type in MySQL 3.23. It's based on the ISAM code and has a lot of useful extensions.

The index is stored in a file with the .MYI (MYindex) extension and the data is stored in file with the .MYD (MYData) extension. You can check/repair MyISAM tables with the `myisamchk` utility. See Section 14.4 [Crash recovery], page 332.

The following is new in MyISAM:

- You can `INSERT` new rows in a table without deleted rows, while other threads are reading from the table.
- Support for big files (63-bit) on filesystems/operating systems that support big files.
- All data are stored with the low byte first. This makes the data machine and OS independent. The only requirement is that the machine uses twos-complement signed integers (as every machine for the last 20 years has) and IEEE floating point format (also totally dominant among mainstream machines). The only area of machines that may not support binary compatibility are embedded systems (since they sometimes have peculiar processors).
- All number keys are stored with high byte first to give better index compression.
- Internal handling of one `AUTO_INCREMENT` column. MyISAM will automatically update this on `INSERT/UPDATE`. The `AUTO_INCREMENT` value can be reset with `myisamchk`. This will make `AUTO_INCREMENT` columns faster and old numbers will not be reused as with the old ISAM. Note that when a `AUTO_INCREMENT` is defined on the end of a multi-part-key the old behavior is still present.
- `BLOB` and `TEXT` columns can be indexed.
- `NULL` values are allowed in indexed columns. This takes 0-1 bytes/key.
- Maximum key length is now 500 bytes by default. In cases of keys longer than 250 bytes, a bigger key block size than the default of 1024 bytes is used for this key.
- Maximum number of keys/table enlarged to 32 as default. This can be enlarged to 64 without having to recompile `myisamchk`.
- There is a flag in the MyISAM file that indicates whether or not the table was closed correctly. This will soon be used for automatic repair in the MySQL server.
• myisamchk will now mark tables as checked. myisamchk --fast will only check those tables that don’t have this mark.

• myisamchk -a stores statistics for key parts (and not only for whole keys as in ISAM).

• Dynamic size rows will now be much less fragmented when mixing deletes with updates and inserts. This is done by automatically combining adjacent deleted blocks and by extending blocks if the next block is deleted.

• myisampack can pack BLOB and VARCHAR columns.

MyISAM also supports the following things, which MySQL will be able to use in the near future.

• Support for a true VARCHAR type; A VARCHAR column starts with a length stored in 2 bytes.

• Tables with VARCHAR may have fixed or dynamic record length.

• VARCHAR and CHAR may be up to 64K. All key segments have their own language definition. This will enable MySQL to have different language definitions per column.

• A hashed computed index can be used for UNIQUE; This will allow you to have UNIQUE on any combination of columns in a table. (You can’t search on a UNIQUE computed index, however.)

8.1.1 Space needed for keys

MySQL can support different index types, but the normal type is ISAM or MyISAM. These uses B-tree index and you can roughly calculate the size for the index file as (key_length+4)/0.67, summed over all keys. (This is for the worst case when all keys are inserted in sorted order and we don’t have any compressed keys.).

String indexes are space compressed. If the first index part is a string, it will also be prefix compressed. Space compression makes the index file smaller than the above figures if the string column has a lot of trailing space or is a VARCHAR column that is not always used to the full length. Prefix compression is used on keys that start with a string. Prefix compression helps if there are many strings with an identical prefix.

In MyISAM tables, you can also prefix compress numbers by specifying PACK_KEYS=1 when you create the table. This helps when you have many integer keys which have an identical prefix when the numbers are stored high-byte first.

8.1.2 MyISAM table formats

MyISAM supports 3 different table types. 2 of them are chosen automatically depending on the type of columns you are using. The third, compressed tables, can only be created with the myisampack tool.
8.1.2.1 Static (Fixed-length) table characteristics

This is the default format. It’s used when the table contains no VARCHAR, BLOB or TEXT columns.
This format is the simplest and most secure format. It is also the fastest of the on-disk formats. The speed comes from the easy way data can be found on disk. When looking up something with a index and static format it very simple, just multiply the row number with the row length.
Also when scanning a table it is very easy to read a constant number of records with each disk read.
The security comes from if your computer crashes when writing to a static MyISAM file, myisamchk can easily figure out where each row starts and ends. So it can usually reclaim all records except the partially written one. Note that in MySQL all indexes can always be reconstructed.

- All CHAR, NUMERIC and DECIMAL columns are space-padded to the column width.
- Very quick.
- Easy to cache.
- Easy to reconstruct after a crash, because records are located in fixed positions.
- Doesn’t have to be reorganized (with myisamchk) unless a huge number of records are deleted and you want to return free disk space to the operating system.
- Usually requires more disk space than dynamic tables.

8.1.2.2 Dynamic table characteristics

This format is used if the table contains any VARCHAR, BLOB or TEXT columns or if the table was created with ROW_FORMAT=dynamic.
This format is a little more complex since each row has to have a header that says how long it is. One record can also end up at more than one location when it is made longer at an update.
You can use OPTIMIZE table or myisamchk to defragment a table. If you have static data that you access/change a lot in the same table as some VARCHAR or BLOB columns, it might be a good idea to move the dynamic columns to other tables just to avoid fragmentation.

- All string columns are dynamic (except those with a length less than 4).
- Each record is preceded by a bitmap indicating which columns are empty ("") for string columns, or zero for numeric columns (this isn’t the same as columns containing NULL values). If a string column has a length of zero after removal of trailing spaces, or a numeric column has a value of zero, it is marked in the bit map and not saved to disk. Non-empty strings are saved as a length byte plus the string contents.
- Usually takes much less disk space than fixed-length tables.
- Each record uses only as much space as is required. If a record becomes larger, it is split into as many pieces as required. This results in record fragmentation.
• If you update a row with information that extends the row length, the row will be fragmented. In this case, you may have to run `myisamchk -r` from time to time to get better performance. Use `myisamchk -ei tbl_name` for some statistics.

• Not as easy to reconstruct after a crash, because a record may be fragmented into many pieces and a link (fragment) may be missing.

• The expected row length for dynamic sized records is:

\[
3 + \frac{(\text{number of columns} + 7)}{8} + \text{packed size of numeric columns} + \text{length of strings} + \frac{(\text{number of NULL columns} + 7)}{8}
\]

There is a penalty of 6 bytes for each link. A dynamic record is linked whenever an update causes an enlargement of the record. Each new link will be at least 20 bytes, so the next enlargement will probably go in the same link. If not, there will be another link. You may check how many links there are with `myisamchk -ed`. All links may be removed with `myisamchk -r`.

8.1.2.3 Compressed table characteristics

This is a read only type that is generated with the optional `myisampack` tool (`pack_isam` for ISAM tables).

`myisampack` and `pack_isam` are available to all customers that have bought a MySQL license or MySQL support for their internal use.

• The uncompress code exists in all MySQL distributions so that even customers who don’t have `myisampack` can read tables that were compressed with `myisampack`.

• Compressed tables takes very little disk space. This minimizes disk usage which is very nice when using slow disks (like CD-ROMs).

• Each record is compressed separately (very little access overhead). The header for a record is fixed (1-3 bytes) depending on the biggest record in the table. Each column is compressed differently. Some of the compression types are:
  – There is usually a different Huffman table for each column.
  – Suffix space compression.
  – Prefix space compression.
  – Numbers with value 0 are stored using 1 bit.
  – If values in an integer column have a small range, the column is stored using the smallest possible type. For example, a BIGINT column (8 bytes) may be stored as a TINYINT column (1 byte) if all values are in the range 0 to 255.
  – If a column has only a small set of possible values, the column type is converted to ENUM.
  – A column may use a combination of the above compressions.

• Can handle fixed or dynamic length records, but not BLOB or TEXT columns.
Can be uncompressed with `myisamchk`.

### 8.2 ISAM tables

You can also use the deprecated ISAM table type. This will disappear rather soon since MyISAM is a better implementation of the same thing. ISAM uses a B-tree index. The index is stored in a file with the `.ISM` extension and the data is stored in file with the `.ISD` extension. You can check/repair ISAM tables with the `isamchk` utility. See Section 14.4 [Crash recovery], page 332.

**ISAM** has the following features/properties:

- Compressed and fixed length keys
- Fixed and dynamic record length
- 16 keys with 16 key parts / key
- Max key length 256 (default)
- Data is stored in machine format; this is fast, but is machine/OS dependent.

Most of the things for MyISAM tables are also true for ISAM tables. See Section 8.1 [MyISAM], page 232. The major differences compared to MyISAM tables are:

- ISAM tables are not binary portable across OS/Platforms.
- Can’t handle tables > 4G.
- Only support prefix compression on strings
- Smaller key limits.
- Dynamic tables gets more fragmented.
- Tables are compressed with `pack_isam` rather than with `myisampack`.

### 8.3 HEAP tables

HEAP tables use a hashed index and are stored in memory. This makes them very fast, but if MySQL crashes you will lose all data stored in them. HEAP is very useful for temporary tables!

The MySQL internal HEAP tables uses 100% dynamic hashing without overflow areas. There is no extra space needed for free lists. HEAP tables also don’t have problems with delete + inserts, which normally is common with hashed tables..

```sql
mysql> CREATE TABLE test TYPE=HEAP SELECT ip,SUM(downloads) as down
FROM log_table GROUP BY ip;
mysql> SELECT COUNT(ip),AVG(down) FROM test;
mysql> DROP TABLE test;
```

Here are some things you should consider when you use HEAP tables:

- You should always use specify `MAX_ROWS` in the `CREATE` statement to ensure that you accidently do not use all memory.
- Indexes will only be used with `=` and `<>` (but are VERY fast).
- **HEAP** tables can only use whole keys to search for a row; compare this to **MyISAM** tables where any prefix of the key can be used to find rows.
- **HEAP** tables use a fixed record length format.
- **HEAP** doesn't support **BLOB/TEXT** columns.
- **HEAP** doesn't support **AUTO_INCREMENT** columns.
- **HEAP** doesn't support an index on a **NULL** column.
- You can have non-unique keys in a **HEAP** table (this isn't common for hashed tables).
- **HEAP** tables are shared between all clients (just like any other table).
- You can't search for the next entry in order (that is to use the index to do a **ORDER BY**).
- Data for **HEAP** tables are allocated in small blocks. The tables are 100% dynamic (on inserting). No overflow areas and no extra key space is needed. Deleted rows are put in a linked list and are reused when you insert new data into the table.
- You need enough extra memory for all **HEAP** tables that you want to use at the same time.
- To free memory, you should execute **DELETE FROM heap_table** or **DROP TABLE heap_table**.
- **MySQL** cannot find out how approximately many rows there are between two values (this is used by the range optimizer to decide which index to use). This may affect some queries if you change a **MyISAM** table to a **HEAP** table.
- To ensure that you accidentally don’t do anything stupid, you can’t create **HEAP** tables bigger than **max_heap_table_size**.

Memory needed for one row in a **HEAP** table is:

\[
\text{SUM\_OVER\_ALL\_KEYS(max\_length\_of\_key + sizeof(char*)*2) + ALIGN(length\_of\_row+1,}\quad \text{sizeof(char*)}}
\]

`sizeof(char*)` is 4 on 32 bit machines and 8 on 64 bit machines.
9 MySQL Tutorial

This chapter provides a tutorial introduction to MySQL by showing how to use the mysql client program to create and use a simple database. mysql (sometimes referred to as the “terminal monitor” or just “monitor”) is an interactive program that allows you to connect to a MySQL server, run queries and view the results. mysql may also be used in batch mode: you place your queries in a file beforehand, then tell mysql to execute the contents of the file. Both ways of using mysql are covered here.

To see a list of options provided by mysql, invoke it with the --help option:

```shell
shell> mysql --help
```

This chapter assumes that mysql is installed on your machine, and that a MySQL server is available to which you can connect. If this is not true, contact your MySQL administrator. (If you are the administrator, you will need to consult other sections of this manual.)

The chapter describes the entire process of setting up and using a database. If you are interested only in accessing an already-existing database, you may want to skip over the sections that describe how to create the database and the tables it contains.

Since this chapter is tutorial in nature, many details are necessarily left out. Consult the relevant sections of the manual for more information on the topics covered here.

9.1 Connecting to and disconnecting from the server

To connect to the server, you'll usually need to provide a MySQL user name when you invoke mysql and, most likely, a password. If the server runs on a machine other than the one where you log in, you'll also need to specify a hostname. Contact your administrator to find out what connection parameters you should use to connect (i.e., what host, user name and password to use). Once you know the proper parameters, you should be able to connect like this:

```shell
shell> mysql -h host -u user -p
Enter password: ********
```

The ******** represents your password; enter it when mysql displays the Enter password: prompt.

If that works, you should see some introductory information followed by a mysql> prompt:

```shell
shell> mysql -h host -u user -p
Enter password: ********
Welcome to the MySQL monitor. Commands end with ; or \g.
Your MySQL connection id is 459 to server version: 3.22.20a-log
Type 'help' for help.

mysql>
```

The prompt tells you that mysql is ready for you to enter commands.
Some MySQL installations allow users to connect as the “anonymous” (unnamed) user to the server running on the local host. If this is the case on your machine, you should be able to connect to that server by invoking mysql without any options:

   shell> mysql

After you have connected successfully, you can disconnect any time by typing QUIT at the mysql> prompt:

   mysql> QUIT
   Bye

You can also disconnect by typing control-D.

Most examples in the following sections assume you are connected to the server. They indicate this by the mysql> prompt.

9.2 Entering queries

Make sure you are connected to the server, as discussed in the previous section. Doing so will not in itself select any database to work with, but that’s okay. At this point, it’s more important to find out a little about how to issue queries than to jump right in creating tables, loading data into them and retrieving data from them. This section describes the basic principles of entering commands, using several queries you can try out to familiarize yourself with how mysql works.

Here’s a simple command that asks the server to tell you its version number and the current date. Type it in as shown below following the mysql> prompt and hit the RETURN key:

   mysql> SELECT VERSION(), CURRENT_DATE;
   +--------------+--------------+
   | version()    | CURRENT_DATE |
   |-------------+--------------|
   | 3.22.20a-log | 1999-03-19   |
   +--------------+--------------+
   1 row in set (0.01 sec)
   mysql>

This query illustrates several things about mysql:

- A command normally consists of a SQL statement followed by a semicolon. (There are some exceptions where a semicolon is not needed. QUIT, mentioned earlier, is one of them. We’ll get to others later.)

- When you issue a command, mysql sends it to the server for execution and displays the results, then prints another mysql> to indicate that it is ready for another command.

- mysql displays query output as a table (rows and columns). The first row contains labels for the columns. The rows following are the query results. Normally, column labels are the names of the columns you fetch from database tables. If you’re retrieving the value of an expression rather than a table column (as in the example just shown), mysql labels the column using the expression itself.
• **mysql** shows how many rows were returned, and how long the query took to execute, which gives you a rough idea of server performance. These values are imprecise because they represent wall clock time (not CPU or machine time), and because they are affected by factors such as server load and network latency. (For brevity, the “rows in set” line is not shown in the remaining examples in this chapter.)

Keywords may be entered in any lettercase. The following queries are equivalent:

```
mysql> SELECT VERSION(), CURRENT_DATE;
mysql> select version(), current_date;
mysql> SeLeCt vErSiOn(), current_DATE;
```

Here’s another query. It demonstrates that you can use **mysql** as a simple calculator:

```
mysql> SELECT SIN(PI()/4), (4+1)*5;
+-------------+---------+
| SIN(PI()/4) | (4+1)*5 |
|-------------+---------|
| 0.707107    | 25      |
+-------------+---------+
```

The commands shown thus far have been relatively short, single-line statements. You can even enter multiple statements on a single line. Just end each one with a semicolon:

```
mysql> SELECT VERSION(); SELECT NOW();
+--------------+
<table>
<thead>
<tr>
<th>version()</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.22.20a-log</td>
</tr>
</tbody>
</table>
+--------------+
```

A command need not be given all on a single line, so lengthy commands that require several lines are not a problem. **mysql** determines where your statement ends by looking for the terminating semicolon, not by looking for the end of the input line. (In other words, **mysql** accepts free-format input: it collects input lines but does not execute them until it sees the semicolon.)

Here’s a simple multiple-line statement:

```
mysql> SELECT
      -> USER()
      -> ,
      -> CURRENT_DATE;
+---------------------+--------------+
| USER()              | CURRENT_DATE |
| joesmith@localhost  | 1999-03-18   |
+---------------------+--------------+
```
In this example, notice how the prompt changes from `mysql>` to `->` after you enter the first line of a multiple-line query. This is how `mysql` indicates that it hasn’t seen a complete statement and is waiting for the rest. The prompt is your friend, because it provides valuable feedback. If you use that feedback, you will always be aware of what `mysql` is waiting for.

If you decide you don’t want to execute a command that you are in the process of entering, cancel it by typing `\c`:

```
mysql> SELECT
-> USER()
-> \c
mysql>
```

Here, too, notice the prompt. It switches back to `mysql>` after you type `\c`, providing feedback to indicate that `mysql` is ready for a new command.

The following table shows each of the prompts you may see and summarizes what they mean about the state that `mysql` is in:

<table>
<thead>
<tr>
<th>Prompt</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>mysql&gt;</code></td>
<td>Ready for new command</td>
</tr>
<tr>
<td><code>-&gt;</code></td>
<td>Waiting for next line of multiple-line command</td>
</tr>
<tr>
<td><code>'&gt;</code></td>
<td>Waiting for next line, collecting a string that begins with a single quote (<strong>’’</strong>)</td>
</tr>
<tr>
<td><code>”&gt;</code></td>
<td>Waiting for next line, collecting a string that begins with a double quote (<strong>””</strong>)</td>
</tr>
</tbody>
</table>

Multiple-line statements commonly occur “by accident” when you intend to issue a command on a single line, but forget the terminating semicolon. In this case, `mysql` waits for more input:

```
mysql> SELECT USER()
->
```

If this happens to you (you think you’ve entered a statement but the only response is a `->` prompt), most likely `mysql` is waiting for the semicolon. If you don’t notice what the prompt is telling you, you might sit there for a while before realizing what you need to do. Enter a semicolon to complete the statement, and `mysql` will execute it:

```
mysql> SELECT USER()
-> ;
```

The `'>` and `”>` prompts occur during string collection. In MySQL, you can write strings surrounded by either `'` or `"` characters (for example, 'hello' or "goodbye"), and `mysql` lets you enter strings that span multiple lines. When you see a `'>` or `">` prompt, it means that you’ve entered a line containing a string that begins with a `'` or `"` quote character, but have not yet entered the matching quote that terminates the string. That’s fine if you really are entering a multiple-line string, but how likely is that? Not very. More often, the `'>` and `”>` prompts indicate that you’ve inadvertently left out a quote character. For example:

```
mysql> SELECT * FROM my_table WHERE name = "Smith AND age < 30;
```
If you enter this SELECT statement, then hit RETURN and wait for the result, nothing will happen. Instead of wondering, “why does this query take so long?,” notice the clue provided by the ""> prompt. It tells you that MySQL expects to see the rest of an unterminated string. (Do you see the error in the statement? The string "Smith is missing the second quote.)

At this point, what do you do? The simplest thing is to cancel the command. However, you cannot just type \c in this case, because MySQL interprets it as part of the string that it is collecting! Instead, enter the closing quote character (so MySQL knows you’ve finished the string), then type "c:

```
mysql> SELECT * FROM my_table WHERE name = "Smith AND age < 30;
"c
mysql>
```

The prompt changes back to mysql>, indicating that MySQL is ready for a new command. It’s important to know what the ‘>’ and ">" prompts signify, because if you mistakenly enter an unterminated string, any further lines you type will appear to be ignored by MySQL — including a line containing QUIT! This can be quite confusing, especially if you don’t know that you need to supply the terminating quote before you can cancel the current command.

### 9.3 Examples of common queries

Here follows examples of how to solve some common problems with MySQL.

Some of the examples use the table shop to hold the price of each article (item number) for certain traders (dealers). Supposing that each trader has a single fixed price per article, then (item, trader) is a primary key for the records.

You can create the example table as:

```
CREATE TABLE shop (
    article INT(4) UNSIGNED ZEROFILL DEFAULT '0000' NOT NULL,
    dealer CHAR(20) DEFAULT '' NOT NULL,
    price DOUBLE(16,2) DEFAULT '0.00' NOT NULL,
    PRIMARY KEY(article, dealer));
```

```
INSERT INTO shop VALUES
    (1,'A',3.45),(1,'B',3.99),(2,'A',10.99),(3,'B',1.45),(3,'C',1.69),
    (3,'D',1.25),(4,'D',19.95);
```

Okay, so the example data is:

```
SELECT * FROM shop
```

<table>
<thead>
<tr>
<th>article</th>
<th>dealer</th>
<th>price</th>
</tr>
</thead>
<tbody>
<tr>
<td>0001</td>
<td>A</td>
<td>3.45</td>
</tr>
<tr>
<td>0001</td>
<td>B</td>
<td>3.99</td>
</tr>
<tr>
<td>0002</td>
<td>A</td>
<td>10.99</td>
</tr>
</tbody>
</table>
9.3.1 The maximum value for column

“What’s the highest item number?”

```sql
SELECT MAX(article) AS article FROM shop
```

```
+---------+
| article |
+---------+
| 4       |
```

9.3.2 The row holding the maximum of a certain column

“Find number, dealer, and price of the most expensive article.”

In ANSI SQL this is easily done with a sub-query:

```sql
SELECT article, dealer, price
FROM shop
WHERE price=(SELECT MAX(price) FROM shop)
```

In MySQL (which does not yet have sub-selects), just do it in two steps:

1. Get the maximum price value from the table with a `SELECT` statement.
2. Using this value compile the actual query:

```sql
SELECT article, dealer, price
FROM shop
WHERE price=19.95
```

Another solution is to sort all rows descending by price and only get the first row using the MySQL specific `LIMIT` clause:

```sql
SELECT article, dealer, price
FROM shop
ORDER BY price DESC
LIMIT 1
```

**Note:** If there are several most expensive articles (e.g. each 19.95) the LIMIT solution shows only one of them!

9.3.3 Maximum of column: per group: only the values

“What’s the highest price per article?”
SELECT article, MAX(price) AS price
FROM shop
GROUP BY article

+--------+-------+
| article | price |
+--------+-------+
| 0001   | 3.99  |
| 0002   | 10.99 |
| 0003   | 1.69  |
| 0004   | 19.95 |
+--------+-------+

9.3.4 The rows holding the group-wise maximum of a certain field

“For each article, find the dealer(s) with the most expensive price.”

In ANSI SQL, I’d do it with a sub-query like this:

SELECT article, dealer, price
FROM shop s1
WHERE price=(SELECT MAX(s2.price)
            FROM shop s2
            WHERE s1.article = s2.article)

In MySQL it’s best do it in several steps:

1. Get the list of (article,maxprice). See Section 9.3.4 [example-Maximum-column-group-row], page 244.
2. For each article get the corresponding rows which have the stored maximum price.

This can easily be done with a temporary table:

CREATE TEMPORARY TABLE tmp (
    article INT(4) UNSIGNED ZEROFILL DEFAULT '0000' NOT NULL,
    price DOUBLE(16,2) DEFAULT '0.00' NOT NULL);

LOCK TABLES article read;

INSERT INTO tmp SELECT article, MAX(price) FROM shop GROUP BY article;

SELECT article, dealer, price FROM shop, tmp
WHERE shop.article=tmp.article AND shop.price=tmp.price;

UNLOCK TABLES;

DROP TABLE tmp;

If you don’t use a TEMPORARY table, you must also lock the 'tmp' table.

“Can it be done with a single query?”

Yes, but only by using a quite inefficient trick that I call the “MAX-CONCAT trick”:  

[Note: The SQL code is not included in the natural text provided.]
SELECT article,  
    SUBSTRING( MAX( CONCAT(LPAD(price,6,'0'),dealer) ), 7) AS dealer, 
    0.00+LEFT( MAX( CONCAT(LPAD(price,6,'0'),dealer) ), 6) AS price 
FROM shop 
GROUP BY article;

<table>
<thead>
<tr>
<th>article</th>
<th>dealer</th>
<th>price</th>
</tr>
</thead>
<tbody>
<tr>
<td>0001</td>
<td>B</td>
<td>3.99</td>
</tr>
<tr>
<td>0002</td>
<td>A</td>
<td>10.99</td>
</tr>
<tr>
<td>0003</td>
<td>C</td>
<td>1.69</td>
</tr>
<tr>
<td>0004</td>
<td>D</td>
<td>19.95</td>
</tr>
</tbody>
</table>

The last example can of course be made a bit more efficient by doing the splitting of the concatenated column in the client.

### 9.3.5 Using foreign keys

You don’t need foreign keys to join 2 tables.

The only thing MySQL doesn’t do is CHECK to make sure that the keys you use really exist in the table(s) you’re referencing and it doesn’t automatically delete rows from table with a foreign key definition. If you use your keys like normal, it’ll work just fine!

```
CREATE TABLE persons (  
    id SMALLINT UNSIGNED NOT NULL AUTO_INCREMENT,  
    name CHAR(60) NOT NULL,  
    PRIMARY KEY (id)  
);

CREATE TABLE shirts (  
    id SMALLINT UNSIGNED NOT NULL AUTO_INCREMENT,  
    style ENUM('t-shirt', 'polo', 'dress') NOT NULL,  
    color ENUM('red', 'blue', 'orange', 'white', 'black') NOT NULL,  
    owner SMALLINT UNSIGNED NOT NULL REFERENCES persons,  
    PRIMARY KEY (id)  
);

INSERT INTO persons VALUES (NULL, 'Antonio Paz');

INSERT INTO shirts VALUES  
    (NULL, 'polo', 'blue', LAST_INSERT_ID()),  
    (NULL, 'dress', 'white', LAST_INSERT_ID()),  
    (NULL, 't-shirt', 'blue', LAST_INSERT_ID());
```
INSERT INTO persons VALUES (NULL, 'Lilliana Angelovska');

INSERT INTO shirts VALUES
(NULL, 'dress', 'orange', LAST_INSERT_ID()),
(NULL, 'polo', 'red', LAST_INSERT_ID()),
(NULL, 'dress', 'blue', LAST_INSERT_ID()),
(NULL, 't-shirt', 'white', LAST_INSERT_ID());

SELECT * FROM persons;
+----+---------------------+
| id | name |
+----+---------------------+
| 1 | Antonio Paz |
| 2 | Lilliana Angelovska |
+----+---------------------+

SELECT * FROM shirts;
+----+---------+--------+-------+
| id | style | color | owner |
+----+---------+--------+-------+
| 1 | polo | blue | 1 |
| 2 | dress | white | 1 |
| 3 | t-shirt | blue | 1 |
| 4 | dress | orange | 2 |
| 5 | polo | red | 2 |
| 6 | dress | blue | 2 |
| 7 | t-shirt | white | 2 |
+----+---------+--------+-------+

SELECT s.* FROM persons p, shirts s
WHERE p.name LIKE 'Lilliana%'
AND s.owner = p.id
AND s.color <> 'white';

+----+-------+--------+-------+
| id | style | color | owner |
+----+-------+--------+-------+
| 4 | dress | orange | 2 |
| 5 | polo | red | 2 |
| 6 | dress | blue | 2 |
+----+-------+--------+-------+

9.4 Creating and using a database

Now that you know how to enter commands, it’s time to access a database.
Suppose you have several pets in your home (your “menagerie”) and you’d like to keep track of various types of information about them. You can do so by creating tables to hold your data and loading them with the desired information. Then you can answer different sorts of questions about your animals by retrieving data from the tables. This section shows how to do all that:

• How to create a database
• How to create a table
• How to load data into the table
• How to retrieve data from the table in various ways
• How to use multiple tables

The menagerie database will be simple (deliberately), but it is not difficult to think of real-world situations in which a similar type of database might be used. For example, a database like this could be used by a farmer to keep track of livestock, or by a veterinarian to keep track of patient records.

Use the `SHOW` statement to find out what databases currently exist on the server:

```
mysql> SHOW DATABASES;
+----------+
| Database |
+----------+
| mysql    |
| test     |
| tmp      |
+----------+
```

The list of databases is probably different on your machine, but the `mysql` and `test` databases are likely to be among them. The `mysql` database is required because it describes user access privileges. The `test` database is often provided as a workspace for users to try things out.

If the `test` database exists, try to access it:

```
mysql> USE test
Database changed
```

Note that `USE`, like `QUIT`, does not require a semicolon. (You can terminate such statements with a semicolon if you like; it does no harm.) The `USE` statement is special in another way, too: it must be given on a single line.

You can use the `test` database (if you have access to it) for the examples that follow, but anything you create in that database can be removed by anyone else with access to it. For this reason, you should probably ask your MySQL administrator for permission to use a database of your own. Suppose you want to call yours `menagerie`. The administrator needs to execute a command like this:

```
mysql> GRANT ALL ON menagerie.* TO your_mysql_name;
```

where `your_mysql_name` is the MySQL user name assigned to you.
9.4.1 Creating and selecting a database

If the administrator creates your database for you when setting up your permissions, you can begin using it. Otherwise, you need to create it yourself:

```sql
mysql> CREATE DATABASE menagerie;
```

Under Unix, database names are case sensitive (unlike SQL keywords), so you must always refer to your database as `menagerie`, not as `Menagerie`, `MENAGERIE` or some other variant. This is also true for table names. (Under Windows, this restriction does not apply, although you must refer to databases and tables using the same lettercase throughout a given query.) Creating a database does not select it for use, you must do that explicitly. To make `menagerie` the current database, use this command:

```sql
mysql> USE menagerie
    Database changed
```

Your database needs to be created only once, but you must select it for use each time you begin a `mysql` session. You can do this by issuing a `USE` statement as shown above. Alternatively, you can select the database on the command line when you invoke `mysql`. Just specify its name after any connection parameters that you might need to provide. For example:

```sh
shell> mysql -h host -u user -p menagerie
Enter password: ********
```

Note that `menagerie` is not your password on the command just shown. If you want to supply your password on the command line after the `-p` option, you must do so with no intervening space (e.g., as `-p mypassword`, not as `-p mypassword`). However, putting your password on the command line is not recommended, because doing so exposes it to snooping by other users logged in on your machine.

9.4.2 Creating a table

Creating the database is the easy part, but at this point it’s empty, as `SHOW TABLES` will tell you:

```sql
mysql> SHOW TABLES;
    Empty set (0.00 sec)
```

The harder part is deciding what the structure of your database should be: what tables you will need, and what columns will be in each of them.

You’ll want a table that contains a record for each of your pets. This can be called the `pet` table, and it should contain, as a bare minimum, each animal’s name. Since the name by itself is not very interesting, the table should contain other information. For example, if more than one person in your family keeps pets, you might want to list each animal’s owner. You might also want to record some basic descriptive information such as species and sex.

How about age? That might be of interest, but it’s not a good thing to store in a database. Age changes as time passes, which means you’d have to update your records often. Instead,
it’s better to store a fixed value such as date of birth. Then, whenever you need age, you can calculate it as the difference between the current date and the birth date. **MySQL** provides functions for doing date arithmetic, so this is not difficult. Storing birth date rather than age has other advantages, too:

- You can use the database for tasks such as generating reminders for upcoming pet birthdays. (If you think this type of query is somewhat silly, note that it is the same question you might ask in the context of a business database to identify clients to whom you’ll soon need to send out birthday greetings, for that computer-assisted personal touch.)
- You can calculate age in relation to dates other than the current date. For example, if you store death date in the database, you can easily calculate how old a pet was when it died.

You can probably think of other types of information that would be useful in the pet table, but the ones identified so far are sufficient for now: name, owner, species, sex, birth and death.

Use a CREATE TABLE statement to specify the layout of your table:

```
mysql> CREATE TABLE pet (name VARCHAR(20), owner VARCHAR(20),
-> species VARCHAR(20), sex CHAR(1), birth DATE, death DATE);
```

VARCHAR is a good choice for the name, owner and species columns since the column values will vary in length. The lengths of those columns need not all be the same, and need not be 20. You can pick any length from 1 to 255, whatever seems most reasonable to you. (If you make a poor choice and it turns out later that you need a longer field, **MySQL** provides an ALTER TABLE statement.)

Animal sex can be represented in a variety of ways, for example, "m" and "f", or perhaps "male" and "female". It’s simplest to use the single characters "m" and "f".

The use of the DATE data type for the birth and death columns is a fairly obvious choice. Now that you have created a table, SHOW TABLES should produce some output:

```
mysql> SHOW TABLES;
+---------------------+
| Tables in menagerie |
+---------------------+
| pet                 |
+---------------------+
```

To verify that your table was created the way you expected, use a DESCRIBE statement:

```
mysql> DESCRIBE pet;
+---------+-------------+------+-----+---------+-------+
| Field   | Type        | Null | Key | Default | Extra |
|---------+-------------+------+-----+---------+-------|
| name    | varchar(20) | YES  |     | NULL    |       |
| owner   | varchar(20) | YES  |     | NULL    |       |
| species | varchar(20) | YES  |     | NULL    |       |
| sex     | char(1)     | YES  |     | NULL    |       |
| birth   | date        | YES  |     | NULL    |       |
| death   | date        | YES  |     | NULL    |       |
+---------+-------------+------+-----+---------+-------+
```

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You can use `DESCRIBE` any time, for example, if you forget the names of the columns in your table or what types they are.

### 9.4.3 Loading data into a table

After creating your table, you need to populate it. The `LOAD DATA` and `INSERT` statements are useful for this.

Suppose your pet records can be described as shown below. (Observe that MySQL expects dates in `YYYY-MM-DD` format; this may be different than what you are used to.)

<table>
<thead>
<tr>
<th>name</th>
<th>owner</th>
<th>species</th>
<th>sex</th>
<th>birth</th>
<th>death</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluffy</td>
<td>Harold</td>
<td>cat</td>
<td>f</td>
<td>1993-02-04</td>
<td></td>
</tr>
<tr>
<td>Claws</td>
<td>Gwen</td>
<td>cat</td>
<td>m</td>
<td>1994-03-17</td>
<td></td>
</tr>
<tr>
<td>Buffy</td>
<td>Harold</td>
<td>dog</td>
<td>f</td>
<td>1989-05-13</td>
<td></td>
</tr>
<tr>
<td>Fang</td>
<td>Benny</td>
<td>dog</td>
<td>m</td>
<td>1990-08-27</td>
<td></td>
</tr>
<tr>
<td>Bowser</td>
<td>Diane</td>
<td>dog</td>
<td>m</td>
<td>1998-08-31</td>
<td>1995-07-29</td>
</tr>
<tr>
<td>Chirpy</td>
<td>Gwen</td>
<td>bird</td>
<td>f</td>
<td>1997-12-09</td>
<td></td>
</tr>
<tr>
<td>Whistler</td>
<td>Diane</td>
<td>bird</td>
<td>m</td>
<td>1996-04-29</td>
<td></td>
</tr>
</tbody>
</table>

Since you are beginning with an empty table, an easy way to populate it is to create a text file containing a row for each of your animals, then load the contents of the file into the table with a single statement.

You could create a text file `pet.txt` containing one record per line, with values separated by tabs, and given in the order in which the columns were listed in the `CREATE TABLE` statement. For missing values (such as unknown sexes, or death dates for animals that are still living), you can use `NULL` values. To represent these in your text file, use `\N`. For example, the record for Whistler the bird would look like this (where the whitespace between values is a single tab character):

```
Whistler Gwen bird \N 1997-12-09 \N
```

To load the text file `pet.txt` into the `pet` table, use this command:

```
mysql> LOAD DATA LOCAL INFILE "pet.txt" INTO TABLE pet;
```

You can specify the column value separator and end of line marker explicitly in the `LOAD DATA` statement if you wish, but the defaults are tab and linefeed. These are sufficient for the statement to read the file `pet.txt` properly.

When you want to add new records one at a time, the `INSERT` statement is useful. In its simplest form, you supply values for each column, in the order in which the columns were listed in the `CREATE TABLE` statement. Suppose Diane gets a new hamster named Puffball. You could add a new record using an `INSERT` statement like this:

```
mysql> INSERT INTO pet
    -> VALUES ('Puffball', 'Diane', 'hamster', 'f', '1999-03-30', NULL);
```

Note that string and date values are specified as quoted strings here. Also, with `INSERT`, you can insert `NULL` directly to represent a missing value. You do not use `\N` like you do with `LOAD DATA`.

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From this example, you should be able to see that there would be a lot more typing involved to load your records initially using several `INSERT` statements rather than a single `LOAD DATA` statement.

### 9.4.4 Retrieving information from a table

The `SELECT` statement is used to pull information from a table. The general form of the statement is:

```
SELECT what_to_select
FROM which_table
WHERE conditions_to_satisfy
```

`what_to_select` indicates what you want to see. This can be a list of columns, or `*` to indicate “all columns.” `which_table` indicates the table from which you want to retrieve data. The `WHERE` clause is optional. If it’s present, `conditions_to_satisfy` specifies conditions that rows must satisfy to qualify for retrieval.

#### 9.4.4.1 Selecting all data

The simplest form of `SELECT` retrieves everything from a table:

```sql
mysql> SELECT * FROM pet;
```

<table>
<thead>
<tr>
<th>name</th>
<th>owner</th>
<th>species</th>
<th>sex</th>
<th>birth</th>
<th>death</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluffy</td>
<td>Harold</td>
<td>cat</td>
<td>f</td>
<td>1993-02-04</td>
<td>NULL</td>
</tr>
<tr>
<td>Claws</td>
<td>Gwen</td>
<td>cat</td>
<td>m</td>
<td>1994-03-17</td>
<td>NULL</td>
</tr>
<tr>
<td>Buffy</td>
<td>Harold</td>
<td>dog</td>
<td>f</td>
<td>1989-05-13</td>
<td>NULL</td>
</tr>
<tr>
<td>Fang</td>
<td>Benny</td>
<td>dog</td>
<td>m</td>
<td>1990-08-27</td>
<td>NULL</td>
</tr>
<tr>
<td>Bowser</td>
<td>Diane</td>
<td>dog</td>
<td>m</td>
<td>1998-08-31</td>
<td>1995-07-29</td>
</tr>
<tr>
<td>Chirpy</td>
<td>Gwen</td>
<td>bird</td>
<td>f</td>
<td>1998-09-11</td>
<td>NULL</td>
</tr>
<tr>
<td>Whistler</td>
<td>Gwen</td>
<td>bird</td>
<td>NULL</td>
<td>1997-12-09</td>
<td>NULL</td>
</tr>
<tr>
<td>Slim</td>
<td>Benny</td>
<td>snake</td>
<td>m</td>
<td>1996-04-29</td>
<td>NULL</td>
</tr>
<tr>
<td>Puffball</td>
<td>Diane</td>
<td>hamster</td>
<td>f</td>
<td>1999-03-30</td>
<td>NULL</td>
</tr>
</tbody>
</table>

This form of `SELECT` is useful if you want to review your entire table, for instance, after you’ve just loaded it with your initial dataset. As it happens, the output just shown reveals an error in your data file: Bowser appears to have been born after he died! Consulting your original pedigree papers, you find that the correct birth year is 1989, not 1998.

There are at least a couple of ways to fix this:

- Edit the file `pet.txt` to correct the error, then empty the table and reload it using `DELETE` and `LOAD DATA`:
  ```sql
  mysql> DELETE FROM pet;
  mysql> LOAD DATA LOCAL INFILE "pet.txt" INTO TABLE pet;
  ```
  However, if you do this, you must also re-enter the record for Puffball.
• Fix only the erroneous record with an UPDATE statement:

    mysql> UPDATE pet SET birth = "1989-08-31" WHERE name = "Bowser";

As shown above, it is easy to retrieve an entire table. But typically you don’t want to do
that, particularly when the table becomes large. Instead, you’re usually more interested in
answering a particular question, in which case you specify some constraints on the informa-
tion you want. Let’s look at some selection queries in terms of questions about your pets
that they answer.

### 9.4.4.2 Selecting particular rows

You can select only particular rows from your table. For example, if you want to verify the
change that you made to Bowser’s birth date, select Bowser’s record like this:

    mysql> SELECT * FROM pet WHERE name = "Bowser";

<table>
<thead>
<tr>
<th>name</th>
<th>owner</th>
<th>species</th>
<th>sex</th>
<th>birth</th>
<th>death</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bowser</td>
<td>Diane</td>
<td>dog</td>
<td>m</td>
<td>1989-08-31</td>
<td>1995-07-29</td>
</tr>
</tbody>
</table>

The output confirms that the year is correctly recorded now as 1989, not 1998.

String comparisons are normally case-insensitive, so you can specify the name as "bowser",
"BOWSER", etc. The query result will be the same.

You can specify conditions on any column, not just name. For example, if you want to know
which animals were born after 1998, test the birth column:

    mysql> SELECT * FROM pet WHERE birth >= "1998-1-1";

<table>
<thead>
<tr>
<th>name</th>
<th>owner</th>
<th>species</th>
<th>sex</th>
<th>birth</th>
<th>death</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chirpy</td>
<td>Gwen</td>
<td>bird</td>
<td>f</td>
<td>1998-09-11</td>
<td>NULL</td>
</tr>
<tr>
<td>Puffball</td>
<td>Diane</td>
<td>hamster</td>
<td>f</td>
<td>1999-03-30</td>
<td>NULL</td>
</tr>
</tbody>
</table>

You can combine conditions, for example, to locate female dogs:

    mysql> SELECT * FROM pet WHERE species = "dog" AND sex = "f";

<table>
<thead>
<tr>
<th>name</th>
<th>owner</th>
<th>species</th>
<th>sex</th>
<th>birth</th>
<th>death</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buffy</td>
<td>Harold</td>
<td>dog</td>
<td>f</td>
<td>1989-05-13</td>
<td>NULL</td>
</tr>
</tbody>
</table>

The preceding query uses the AND logical operator. There is also an OR operator:

    mysql> SELECT * FROM pet WHERE species = "snake" OR species = "bird";

<table>
<thead>
<tr>
<th>name</th>
<th>owner</th>
<th>species</th>
<th>sex</th>
<th>birth</th>
<th>death</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chirpy</td>
<td>Gwen</td>
<td>bird</td>
<td>f</td>
<td>1998-09-11</td>
<td>NULL</td>
</tr>
</tbody>
</table>
AND and OR may be intermixed. If you do that, it’s a good idea to use parentheses to indicate how conditions should be grouped:

```sql
mysql> SELECT * FROM pet WHERE (species = "cat" AND sex = "m")
   -> OR (species = "dog" AND sex = "f");
```

9.4.4.3 Selecting particular columns

If you don’t want to see entire rows from your table, just name the columns in which you’re interested, separated by commas. For example, if you want to know when your animals were born, select the `name` and `birth` columns:

```sql
mysql> SELECT name, birth FROM pet;
```

To find out who owns pets, use this query:

```sql
mysql> SELECT owner FROM pet;
```
However, notice that the query simply retrieves the **owner** field from each record, and some of them appear more than once. To minimize the output, retrieve each unique output record just once by adding the keyword **DISTINCT**:

```
mysql> SELECT DISTINCT owner FROM pet;
```

<table>
<thead>
<tr>
<th>owner</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benny</td>
</tr>
<tr>
<td>Diane</td>
</tr>
<tr>
<td>Gwen</td>
</tr>
<tr>
<td>Harold</td>
</tr>
</tbody>
</table>

You can use a **WHERE** clause to combine row selection with column selection. For example, to get birth dates for dogs and cats only, use this query:

```
mysql> SELECT name, species, birth FROM pet
    -> WHERE species = "dog" OR species = "cat";
```

```
<table>
<thead>
<tr>
<th>name</th>
<th>species</th>
<th>birth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluffy</td>
<td>cat</td>
<td>1993-02-04</td>
</tr>
<tr>
<td>Claws</td>
<td>cat</td>
<td>1994-03-17</td>
</tr>
<tr>
<td>Buffy</td>
<td>dog</td>
<td>1989-05-13</td>
</tr>
<tr>
<td>Fang</td>
<td>dog</td>
<td>1990-08-27</td>
</tr>
<tr>
<td>Bowser</td>
<td>dog</td>
<td>1989-08-31</td>
</tr>
</tbody>
</table>
```

### 9.4.4.4 Sorting rows

You may have noticed in the preceding examples that the result rows are displayed in no particular order. However, it’s often easier to examine query output when the rows are sorted in some meaningful way. To sort a result, use an **ORDER BY** clause.

Here are animal birthdays, sorted by date:

```
mysql> SELECT name, birth FROM pet ORDER BY birth;
```

```
<table>
<thead>
<tr>
<th>name</th>
<th>birth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buffy</td>
<td>1989-05-13</td>
</tr>
<tr>
<td>Bowser</td>
<td>1989-08-31</td>
</tr>
<tr>
<td>Fang</td>
<td>1990-08-27</td>
</tr>
<tr>
<td>Fluffy</td>
<td>1993-02-04</td>
</tr>
<tr>
<td>Claws</td>
<td>1994-03-17</td>
</tr>
<tr>
<td>Slim</td>
<td>1996-04-29</td>
</tr>
<tr>
<td>Whistler</td>
<td>1997-12-09</td>
</tr>
</tbody>
</table>
```
To sort in reverse order, add the `DESC` (descending) keyword to the name of the column you are sorting by:

```
mysql> SELECT name, birth FROM pet ORDER BY birth DESC;
+----------+------------+
| name     | birth      |
+----------+------------+
| Puffball | 1999-03-30 |
| Chirpy   | 1998-09-11 |
| Whistler | 1997-12-09 |
| Slim     | 1996-04-29 |
| Claws    | 1994-03-17 |
| Fluffy   | 1993-02-04 |
| Fang     | 1990-08-27 |
| Bowser   | 1989-08-31 |
| Buffy    | 1989-05-13 |
+----------+------------+
```

You can sort on multiple columns. For example, to sort by type of animal, then by birth date within animal type with youngest animals first, use the following query:

```
mysql> SELECT name, species, birth FROM pet ORDER BY species, birth DESC;
+----------+---------+------------+
| name     | species | birth      |
+----------+---------+------------+
| Chirpy   | bird    | 1998-09-11 |
| Whistler | bird    | 1997-12-09 |
| Claws    | cat     | 1994-03-17 |
| Fluffy   | cat     | 1993-02-04 |
| Fang     | dog     | 1990-08-27 |
| Bowser   | dog     | 1989-08-31 |
| Buffy    | dog     | 1989-05-13 |
| Puffball | hamster | 1999-03-30 |
| Slim     | snake   | 1996-04-29 |
+----------+---------+------------+
```

Note that the `DESC` keyword applies only to the column name immediately preceding it (birth); `species` values are still sorted in ascending order.

### 9.4.4.5 Date calculations

`MySQL` provides several functions that you can use to perform calculations on dates, for example, to calculate ages or extract parts of dates.

To determine how many years old each of your pets is, compute age as the difference between the birth date and the current date. Do this by converting the two dates to days, take the difference, and divide by 365 (the number of days in a year):
### MySQL Tutorial

```sql
mysql> SELECT name, (TO_DAYS(NOW())-TO_DAYS(birth))/365 FROM pet;
+----------+-------------------------------------+
| name | (TO_DAYS(NOW())-TO_DAYS(birth))/365 |
+----------+-------------------------------------+
| Fluffy | 6.15 |
| Claws | 5.04 |
| Buffy | 9.88 |
| Fang | 8.59 |
| Bowser | 9.58 |
| Chirpy | 0.55 |
| Whistler | 1.30 |
| Slim | 2.92 |
| Puffball | 0.00 |
+----------+-------------------------------------+
```

Although the query works, there are some things about it that could be improved. First, the result could be scanned more easily if the rows were presented in some order. Second, the heading for the age column isn’t very meaningful.

The first problem can be handled by adding an `ORDER BY name` clause to sort the output by name. To deal with the column heading, provide a name for the column so that a different label appears in the output (this is called a column alias):

```sql
mysql> SELECT name, (TO_DAYS(NOW())-TO_DAYS(birth))/365 AS age
    > FROM pet ORDER BY name;
+----------+------+
| name | age |
+----------+------+
| Bowser | 9.58 |
| Buffy | 9.88 |
| Chirpy | 0.55 |
| Claws | 5.04 |
| Fang | 8.59 |
| Fluffy | 6.15 |
| Puffball | 0.00 |
| Slim | 2.92 |
| Whistler | 1.30 |
+----------+------+
```

To sort the output by `age` rather than `name`, just use a different `ORDER BY` clause:

```sql
mysql> SELECT name, (TO_DAYS(NOW())-TO_DAYS(birth))/365 AS age
    > FROM pet ORDER BY age;
+----------+------+
| name | age |
+----------+------+
| Puffball | 0.00 |
| Chirpy | 0.55 |
| Whistler | 1.30 |
| Slim | 2.92 |
| Claws | 5.04 |
| Fluffy | 6.15 |
+----------+------+
```

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A similar query can be used to determine age at death for animals that have died. You determine which animals these are by checking whether or not the death value is NULL. Then, for those with non-NULL values, compute the difference between the death and birth values:

```sql
mysql> SELECT name, birth, death, (TO_DAYS(death)-TO_DAYS(birth))/365 AS age
    -> FROM pet WHERE death IS NOT NULL ORDER BY age;
```

<table>
<thead>
<tr>
<th>name</th>
<th>birth</th>
<th>death</th>
<th>age</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bowser</td>
<td>1989-08-31</td>
<td>1995-07-29</td>
<td>5.91</td>
</tr>
</tbody>
</table>

The query uses death IS NOT NULL rather than death != NULL because NULL is a special value. This is explained later. See Section 9.4.4.6 [Working with NULL], page 258.

What if you want to know which animals have birthdays next month? For this type of calculation, year and day are irrelevant, you simply want to extract the month part of the birth column. MySQL provides several date-part extraction functions, such as YEAR(), MONTH() and DAYOFMONTH(). MONTH() is the appropriate function here. To see how it works, run a simple query that displays the value of both birth and MONTH(birth):

```sql
mysql> SELECT name, birth, MONTH(birth) FROM pet;
```

<table>
<thead>
<tr>
<th>name</th>
<th>birth</th>
<th>MONTH(birth)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluffy</td>
<td>1993-02-04</td>
<td>2</td>
</tr>
<tr>
<td>Claws</td>
<td>1994-03-17</td>
<td>3</td>
</tr>
<tr>
<td>Buffy</td>
<td>1989-05-13</td>
<td>5</td>
</tr>
<tr>
<td>Fang</td>
<td>1990-08-27</td>
<td>8</td>
</tr>
<tr>
<td>Bowser</td>
<td>1989-08-31</td>
<td>8</td>
</tr>
<tr>
<td>Chirpy</td>
<td>1998-09-11</td>
<td>9</td>
</tr>
<tr>
<td>Whistler</td>
<td>1997-12-09</td>
<td>12</td>
</tr>
<tr>
<td>Slim</td>
<td>1996-04-29</td>
<td>4</td>
</tr>
<tr>
<td>Puffball</td>
<td>1999-03-30</td>
<td>3</td>
</tr>
</tbody>
</table>

Finding animals with birthdays in the upcoming month is easy, too. Suppose the current month is April. Then the month value is 4 and you look for animals born in May (month 5) like this:

```sql
mysql> SELECT name, birth FROM pet WHERE MONTH(birth) = 5;
```

<table>
<thead>
<tr>
<th>name</th>
<th>birth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buffy</td>
<td>1989-05-13</td>
</tr>
</tbody>
</table>
There is a small complication if the current month is December, of course. You don’t just
add one to the month number (12) and look for animals born in month 13, because there
is no such month. Instead, you look for animals born in January (month 1).

You can even write the query so that it works no matter what the current month is. That
way you don’t have to use a particular month number in the query. \texttt{DATE\_ADD()} allows
you to add a time interval to a given date. If you add a month to the value of \texttt{NOW()}, then
extract the month part with \texttt{MONTH()}, the result produces the month in which to look for
birthdays:

\begin{verbatim}
mysql> SELECT name, birth FROM pet
    -> WHERE MONTH(birth) = MONTH(DATE\_ADD(NOW(), INTERVAL 1 MONTH));
\end{verbatim}

A different way to accomplish the same task is to add 1 to get the next month after the
current one (after using the modulo function (\texttt{MOD}) to “wrap around” the month value to 0
if it is currently 12):

\begin{verbatim}
mysql> SELECT name, birth FROM pet
    -> WHERE MONTH(birth) = MOD(MONTH(NOW()), 12) + 1;
\end{verbatim}

Note that \texttt{MONTH} return a number between 1 and 12. And \texttt{MOD(something,12)} returns a
number between 0 and 11. So the addition has to be after the \texttt{MOD()} otherwise we would go
from November (11) to January (1).

\subsection*{9.4.4.6 Working with NULL values}

The \texttt{NULL} value can be surprising until you get used to it. Conceptually, \texttt{NULL}
means “missing value” or “unknown value” and it is treated somewhat differently than other
values. To test for \texttt{NULL}, you cannot use the arithmetic comparison operators such as =, <
or \texttt{!=}. To demonstrate this for yourself, try the following query:

\begin{verbatim}
mysql> SELECT 1 = NULL, 1 != NULL, 1 < NULL, 1 > NULL;
| 1 = NULL | 1 != NULL | 1 < NULL | 1 > NULL |
+--------------------+-------------------+-----------+-----------+
| NULL | NULL | NULL | NULL |
+--------------------+-------------------+-----------+-----------+
\end{verbatim}

Clearly you get no meaningful results from these comparisons. Use the \texttt{IS NULL} and \texttt{IS NOT
NULL} operators instead:

\begin{verbatim}
mysql> SELECT 1 IS NULL, 1 IS NOT NULL;
| 1 IS NULL | 1 IS NOT NULL |
+-------------------+-------------------+
| 0 | 1 |
+-------------------+-------------------+
\end{verbatim}

In MySQL, 0 means false and 1 means true.

This special treatment of \texttt{NULL} is why, in the previous section, it was necessary to determine
which animals are no longer alive using \texttt{death IS NOT NULL} instead of \texttt{death != NULL}.
9.4.4.7 Pattern matching

MySQL provides standard SQL pattern matching as well as a form of pattern matching based on extended regular expressions similar to those used by Unix utilities such as vi, grep and sed.

SQL pattern matching allows you to use '_' to match any single character, and '%' to match an arbitrary number of characters (including zero characters). In MySQL, SQL patterns are case insensitive by default. Some examples are shown below. Note that you do not use = or != when you use SQL patterns; use the LIKE or NOT LIKE comparison operators instead.

To find names beginning with 'b':

```sql
mysql> SELECT * FROM pet WHERE name LIKE "b\%";
+--------+--------+---------+------+------------+------------+
| name   | owner  | species | sex  | birth      | death      |
+--------+--------+---------+------+------------+------------+
| Buffy   | Harold | dog     | f    | 1989-05-13 | NULL       |
| Bowser  | Diane  | dog     | m    | 1989-08-31 | 1995-07-29 |
+--------+--------+---------+------+------------+------------+
```

To find names ending with 'fy':

```sql
mysql> SELECT * FROM pet WHERE name LIKE "%fy";
+--------+--------+---------+------+------------+-------+
| name   | owner  | species | sex  | birth      | death |
+--------+--------+---------+------+------------+-------+
| Fluffy  | Harold | cat     | f    | 1993-02-04 | NULL  |
| Buffy   | Harold | dog     | f    | 1989-05-13 | NULL  |
+--------+--------+---------+------+------------+-------+
```

To find names containing a 'w':

```sql
mysql> SELECT * FROM pet WHERE name LIKE "%w\%";
+----------+-------+---------+------+------------+------------+
| name     | owner | species | sex  | birth      | death      |
+----------+-------+---------+------+------------+------------+
| Claws    | Gwen  | cat     | m    | 1994-03-17 | NULL       |
| Bowser   | Diane | dog     | m    | 1989-08-31 | 1995-07-29 |
| Whistler | Gwen  | bird    | NULL | 1997-12-09 | NULL       |
+----------+-------+---------+------+------------+------------+
```

To find names containing exactly five characters, use the '_' pattern character:

```sql
mysql> SELECT * FROM pet WHERE name LIKE "_____";
+-------+--------+---------+------+------------+-------+
| name  | owner  | species | sex  | birth      | death |
+-------+--------+---------+------+------------+-------+
| Claws | Gwen   | cat     | m    | 1994-03-17 | NULL  |
| Buffy | Harold | dog     | f    | 1989-05-13 | NULL  |
+-------+--------+---------+------+------------+-------+
```

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The other type of pattern matching provided by MySQL uses extended regular expressions. When you test for a match for this type of pattern, use the REGEXP and NOT REGEXP operators (or RLIKE and NOT RLIKE, which are synonyms).

Some characteristics of extended regular expressions are:

- `.` matches any single character.
- A character class `'[...]'` matches any character within the brackets. For example, `'[abc]'` matches ‘a’, ‘b’ or ‘c’. To name a range of characters, use a dash. ‘[a-z]’ matches any lowercase letter, whereas ‘[0-9]’ matches any digit.
- `'*'` matches zero or more instances of the thing preceding it. For example, ‘x*’ matches any number of ‘x’ characters, ‘[0-9]*’ matches any number of digits, and ‘.*’ matches any number of anything.
- Regular expressions are case sensitive, but you can use a character class to match both lettercases if you wish. For example, ‘[aA]’ matches lowercase or uppercase ‘a’ and ‘[a-zA-Z]’ matches any letter in either case.
- The pattern matches if it occurs anywhere in the value being tested (SQL patterns match only if they match the entire value).
- To anchor a pattern so that it must match the beginning or end of the value being tested, use ‘^’ at the beginning or ‘$’ at the end of the pattern.

To demonstrate how extended regular expressions work, the LIKE queries shown above are rewritten below to use REGEXP:

To find names beginning with ‘b’, use ‘~’ to match the beginning of the name and ‘[bB]’ to match either lowercase or uppercase ‘b’:

```
mysql> SELECT * FROM pet WHERE name REGEXP "^\[bB\]";
+--------+--------+---------+------+------------+------------+
| name | owner | species | sex | birth | death |
+--------+--------+---------+------+------------+------------+
| Buffy | Harold | dog | f | 1989-05-13 | NULL |
| Bowser | Diane | dog | m | 1989-08-31 | 1995-07-29 |
+--------+--------+---------+------+------------+------------+
```

To find names ending with ‘fy’, use ‘$’ to match the end of the name:

```
mysql> SELECT * FROM pet WHERE name REGEXP "fy$";
+--------+--------+---------+------+------------+-------+
| name | owner | species | sex | birth | death |
+--------+--------+---------+------+------------+-------+
| Fluffy | Harold | cat | f | 1993-02-04 | NULL |
| Buffy | Harold | dog | f | 1989-05-13 | NULL |
+--------+--------+---------+------+------------+-------+
```

To find names containing a ‘w’, use ‘[wW]’ to match either lowercase or uppercase ‘w’:

```
mysql> SELECT * FROM pet WHERE name REGEXP "[wW]";
+----------+-------+---------+------+------------+------------+
| name | owner | species | sex | birth | death |
+----------+-------+---------+------+------------+------------+
| Claws | Gwen | cat | m | 1994-03-17 | NULL |
| Bowser | Diane | dog | m | 1989-08-31 | 1995-07-29 |
+----------+-------+---------+------+------------+------------+
```
Since a regular expression pattern matches if it occurs anywhere in the value, it is not necessary in the previous query to put a wildcard on either side of the pattern to get it to match the entire value like it would be if you used an SQL pattern.

To find names containing exactly five characters, use '\^' and '\$' to match the beginning and end of the name, and five instances of '\.' in between:

```sql
mysql> SELECT * FROM pet WHERE name REGEXP "^.....$";
```

You could also write the previous query using the '{n}' “repeat-n-times” operator:

```sql
mysql> SELECT * FROM pet WHERE name REGEXP "^.{5}$";
```

### 9.4.4.8 Counting rows

Databases are often used to answer the question, “how often does a certain type of data occur in a table?” For example, you might want to know how many pets you have, or how many pets each owner has, or you might want to perform various kinds of censuses on your animals.

Counting the total number of animals you have is the same question as “how many rows are in the pet table?,” since there is one record per pet. The `COUNT()` function counts the number of non-NULL results, so the query to count your animals looks like this:

```sql
mysql> SELECT COUNT(*) FROM pet;
```

Earlier, you retrieved the names of the people who owned pets. You can use `COUNT()` if you want to find out how many pets each owner has:

```sql
mysql> SELECT owner, COUNT(*) FROM pet GROUP BY owner;
```
Note the use of `GROUP BY` to group together all records for each **owner**. Without it, all you get is an error message:

```
mysql> SELECT owner, COUNT(owner) FROM pet;
ERROR 1140 at line 1: Mixing of GROUP columns (MIN(),MAX(),COUNT()...) with no GROUP columns is illegal if there is no GROUP BY clause
```

`COUNT()` and `GROUP BY` are useful for characterizing your data in various ways. The following examples show different ways to perform animal census operations.

**Number of animals per species:**
```
mysql> SELECT species, COUNT(*) FROM pet GROUP BY species;
```

```
+---------+----------+
| species | COUNT(*) |
+---------+----------+
| bird    | 2        |
| cat     | 2        |
| dog     | 3        |
| hamster | 1        |
| snake   | 1        |
+---------+----------+
```

**Number of animals per sex:**
```
mysql> SELECT sex, COUNT(*) FROM pet GROUP BY sex;
```

```
+------+----------+
| sex  | COUNT(*) |
+------+----------+
| NULL | 1        |
| f    | 4        |
| m    | 4        |
+------+----------+
```

(In this output, **NULL** indicates “sex unknown.”)

**Number of animals per combination of species and sex:**
```
mysql> SELECT species, sex, COUNT(*) FROM pet GROUP BY species, sex;
```

```
+---------+------+----------+
| species | sex  | COUNT(*) |
+---------+------+----------+
| bird    | NULL | 1        |
| bird    | f    | 1        |
| cat     | f    | 1        |
| cat     | m    | 1        |
| dog     | f    | 1        |
| dog     | m    | 2        |
| hamster | f    | 1        |
| snake   | m    | 1        |
+---------+------+----------+
```
You need not retrieve an entire table when you use \texttt{COUNT()}. For example, the previous query, when performed just on dogs and cats, looks like this:

\begin{verbatim}
mysql> SELECT species, sex, COUNT(*) FROM pet
    -> WHERE species = "dog" OR species = "cat"
    -> GROUP BY species, sex;
\end{verbatim}

| species | sex | COUNT(*) |
|---------+-----+----------|
| cat     | f   | 1        |
| cat     | m   | 1        |
| dog     | f   | 1        |
| dog     | m   | 2        |

Or, if you wanted the number of animals per sex only for known-sex animals:

\begin{verbatim}
mysql> SELECT species, sex, COUNT(*) FROM pet
    -> WHERE sex IS NOT NULL
    -> GROUP BY species, sex;
\end{verbatim}

| species | sex | COUNT(*) |
|---------+-----+----------|
| bird    | f   | 1        |
| cat     | f   | 1        |
| cat     | m   | 1        |
| dog     | f   | 1        |
| dog     | m   | 2        |
| hamster | f   | 1        |
| snake   | m   | 1        |

\subsection*{9.4.5 Using more than one table}

The \texttt{pet} table keeps track of which pets you have. If you want to record other information about them, such as events in their lives like visits to the vet or when litters are born, you need another table. What should this table look like?

- It needs to contain the pet name so you know which animal each event pertains to.
- It needs a date so you know when the event occurred.
- It needs a field to describe the event.
- If you want to be able to categorize events, it would be useful to have an event type field.

Given these considerations, the \texttt{CREATE TABLE} statement for the \texttt{event} table might look like this:

\begin{verbatim}
mysql> CREATE TABLE event (name VARCHAR(20), date DATE,
    -> type VARCHAR(15), remark VARCHAR(255));
\end{verbatim}
As with the pet table, it’s easiest to load the initial records by creating a tab-delimited text file containing the information:

- Fluffy 1995-05-15 litter 4 kittens, 3 female, 1 male
- Buffy 1993-06-23 litter 5 puppies, 2 female, 3 male
- Buffy 1994-06-19 litter 3 puppies, 3 female
- Chirpy 1999-03-21 vet needed beak straightened
- Slim 1997-08-03 vet broken rib
- Bowser 1991-10-12 kennel
- Fang 1991-10-12 kennel
- Fang 1998-08-28 birthday Gave him a new chew toy
- Claws 1998-03-17 birthday Gave him a new flea collar
- Whistler 1998-12-09 birthday First birthday

Load the records like this:

```
mysql> LOAD DATA LOCAL INFILE "event.txt" INTO TABLE event;
```

Based on what you’ve learned from the queries you’ve run on the pet table, you should be able to perform retrievals on the records in the event table; the principles are the same. But when is the event table by itself insufficient to answer questions you might ask?

Suppose you want to find out the ages of each pet when they had their litters. The event table indicates when this occurred, but to calculate age of the mother, you need her birth date. Since that is stored in the pet table, you need both tables for the query:

```
mysql> SELECT pet.name, (TO_DAYS(date) - TO_DAYS(birth))/365 AS age, remark
      -> FROM pet, event
      -> WHERE pet.name = event.name AND type = "litter";
```

<table>
<thead>
<tr>
<th>name</th>
<th>age</th>
<th>remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluffy</td>
<td>2.27</td>
<td>4 kittens, 3 female, 1 male</td>
</tr>
<tr>
<td>Buffy</td>
<td>4.12</td>
<td>5 puppies, 2 female, 3 male</td>
</tr>
<tr>
<td>Buffy</td>
<td>5.10</td>
<td>3 puppies, 3 female</td>
</tr>
</tbody>
</table>

There are several things to note about this query:

- The FROM clause lists two tables since the query needs to pull information from both of them.
- When combining (joining) information from multiple tables, you need to specify how records in one table can be matched to records in the other. This is easy since they both have a name column. The query uses WHERE clause to match up records in the two tables based on the name values.
- Since the name column occurs in both tables, you must be specific about which table you mean when referring to the column. This is done by prepending the table name to the column name.

You need not have two different tables to perform a join. Sometimes it is useful to join a table to itself, if you want to compare records in a table to other records in that same table. For example, to find breeding pairs among your pets, you can join the pet table with itself to pair up males and females of like species:

```
mysql> SELECT pet.name, (TO_DAYS(date) - TO_DAYS(birth))/365 AS age, remark
      -> FROM pet, pet
      -> WHERE pet.name = pet2.name AND type = "litter";
```

<table>
<thead>
<tr>
<th>name</th>
<th>age</th>
<th>remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluffy</td>
<td>2.27</td>
<td>4 kittens, 3 female, 1 male</td>
</tr>
<tr>
<td>Buffy</td>
<td>4.12</td>
<td>5 puppies, 2 female, 3 male</td>
</tr>
<tr>
<td>Buffy</td>
<td>5.10</td>
<td>3 puppies, 3 female</td>
</tr>
</tbody>
</table>

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```sql
mysql> SELECT p1.name, p1.sex, p2.name, p2.sex, p1.species
-> FROM pet AS p1, pet AS p2
-> WHERE p1.species = p2.species AND p1.sex = "f" AND p2.sex = "m";

<table>
<thead>
<tr>
<th>name</th>
<th>sex</th>
<th>name</th>
<th>sex</th>
<th>species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluffy</td>
<td>f</td>
<td>Claws</td>
<td>m</td>
<td>cat</td>
</tr>
<tr>
<td>Buffy</td>
<td>f</td>
<td>Fang</td>
<td>m</td>
<td>dog</td>
</tr>
<tr>
<td>Buffy</td>
<td>f</td>
<td>Bowser</td>
<td>m</td>
<td>dog</td>
</tr>
</tbody>
</table>
```

In this query, we specify aliases for the table name in order to be able to refer to the columns and keep straight which instance of the table each column reference is associated with.

### 9.5 Getting information about databases and tables

What if you forget the name of a database or table, or what the structure of a given table is (e.g., what its columns are called)? MySQL addresses this problem through several statements that provide information about the databases and tables it supports.

You have already seen `SHOW DATABASES`, which lists the databases managed by the server. To find out which database is currently selected, use the `DATABASE()` function:

```sql
mysql> SELECT DATABASE();
+------------+
| DATABASE() |
+------------+
| menagerie  |
+------------+
```

If you haven’t selected any database yet, the result is blank.

To find out what tables the current database contains (for example, when you’re not sure about the name of a table), use this command:

```sql
mysql> SHOW TABLES;
+---------------------+
| Tables in menagerie |
+---------------------+
| event               |
| pet                 |
+---------------------+
```

If you want to find out about the structure of a table, the `DESCRIBE` command is useful; it displays information about each of a table’s columns:

```sql
mysql> DESCRIBE pet;
+---------+-------------+------+-----+---------+-------+
<table>
<thead>
<tr>
<th>Field</th>
<th>Type</th>
<th>Null</th>
<th>Key</th>
<th>Default</th>
<th>Extra</th>
</tr>
</thead>
<tbody>
<tr>
<td>name</td>
<td>varchar(20)</td>
<td>YES</td>
<td></td>
<td>NULL</td>
<td></td>
</tr>
<tr>
<td>owner</td>
<td>varchar(20)</td>
<td>YES</td>
<td></td>
<td>NULL</td>
<td></td>
</tr>
</tbody>
</table>
```

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### Field indicates the column name, **Type** is the data type for the column, **Null** indicates whether or not the column can contain NULL values, **Key** indicates whether or not the column is indexed and **Default** specifies the column’s default value.

If you have indexes on a table, `SHOW INDEX FROM tbl_name` produces information about them.

#### 9.6 Using mysql in batch mode

In the previous sections, you used `mysql` interactively to enter queries and view the results. You can also run `mysql` in batch mode. To do this, put the commands you want to run in a file, then tell `mysql` to read its input from the file:

```
shell> mysql < batch-file
```

If you need to specify connection parameters on the command line, the command might look like this:

```
shell> mysql -h host -u user -p < batch-file
Enter password: ********
```

When you use `mysql` this way, you are creating a script file, then executing the script.

**Why use a script?** Here are a few reasons:

- If you run a query repeatedly (say, every day or every week), making it a script allows you to avoid retyping it each time you execute it.
- You can generate new queries from existing ones that are similar by copying and editing script files.
- Batch mode can also be useful while you’re developing a query, particularly for multiple-line commands or multiple-statement sequences of commands. If you make a mistake, you don’t have to retype everything. Just edit your script to correct the error, then tell `mysql` to execute it again.
- If you have a query that produces a lot of output, you can run the output through a pager rather than watching it scroll off the top of your screen:
  ```
  shell> mysql < batch-file | more
  ```
- You can catch the output in a file for further processing:
  ```
  shell> mysql < batch-file > mysql.out
  ```
- You can distribute your script to other people so they can run the commands, too.
- Some situations do not allow for interactive use, for example, when you run a query from a `cron` job. In this case, you must use batch mode.

The default output format is different (more concise) when you run `mysql` in batch mode than when you use it interactively. For example, the output of `SELECT DISTINCT species FROM pet` looks like this when run interactively:

<table>
<thead>
<tr>
<th>Field</th>
<th>Type</th>
<th>Null</th>
<th>Default</th>
</tr>
</thead>
<tbody>
<tr>
<td>species</td>
<td>varchar(20)</td>
<td>YES</td>
<td>NULL</td>
</tr>
<tr>
<td>sex</td>
<td>char(1)</td>
<td>YES</td>
<td>NULL</td>
</tr>
<tr>
<td>birth</td>
<td>date</td>
<td>YES</td>
<td>NULL</td>
</tr>
<tr>
<td>death</td>
<td>date</td>
<td>YES</td>
<td>NULL</td>
</tr>
</tbody>
</table>
But like this when run in batch mode:

```
species
bird
cat
dog
hamster
snake
```

If you want to get the interactive output format in batch mode, use `mysql -t`. To echo to the output the commands that are executed, use `mysql -vvv`.

### 9.7 Queries from twin project

At Analytikerna and Lentus, we have been doing the systems and field work for a big research project. This project is a collaboration between the Institute of Environmental Medicine at Karolinska Institutet Stockholm and the Section on Clinical Research in Aging and Psychology at the University of Southern California.

The project involves a screening part where all twins in Sweden older than 65 years are interviewed by telephone. Twins who meet certain criteria are passed on to the next stage. In this latter stage, twins who want to participate are visited by a doctor/nurse team. Some of the examinations include physical and neuropsychological examination, laboratory testing, neuroimaging, psychological status assessment, and family history collection. In addition, data are collected on medical and environmental risk factors.

More information about Twin studies can be found at:

```
http://www.imm.ki.se/TWIN/TWINUKW.HTM
```

The latter part of the project is administered with a web interface written using Perl and MySQL.

Each night all data from the interviews are moved into a MySQL database.

#### 9.7.1 Find all non-distributed twins

The following query is used to determine who goes into the second part of the project:

```sql
select
    concat(p1.id, p1.tvab) + 0 as tvid,
    concat(p1.christian_name, " ", p1.surname) as Name,
```

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p1.postal_code as Code,
p1.city as City,
pg.abrev as Area,
if (td.participation = "Aborted", "A", "") as A,
p1.dead as dead1,
l.event as event1,
td.suspect as tsuspect1,
id.suspect as isuspect1,
td.severe as tsevere1,
id.severe as isevere1,
p2.dead as dead2,
l2.event as event2,
h2.nurse as nurse2,
h2.doctor as doctor2,
td2.suspect as tsuspect2,
id2.suspect as isuspect2,
td2.severe as tsevere2,
id2.severe as isevere2,
l.finish_date
from
twin_project as tp
  /* For Twin 1 */
  left join twin_data as td on tp.id = td.id and tp.tvab = td.tvab
  left join informant_data as id on tp.id = id.id and tp.tvab = id.tvab
  left join harmony as h on tp.id = h.id and tp.tvab = h.tvab
  left join lentus as l on tp.id = l.id and tp.tvab = l.tvab
  /* For Twin 2 */
  left join twin_data as td2 on p2.id = td2.id and p2.tvab = td2.tvab
  left join informant_data as id2 on p2.id = id2.id and p2.tvab = id2.tvab
  left join harmony as h2 on p2.id = h2.id and p2.tvab = h2.tvab
  left join lentus as l2 on p2.id = l2.id and p2.tvab = l2.tvab,
  person_data as p1,
  person_data as p2,
  postal_groups as pg
where
  /* p1 gets main twin and p2 gets his/her twin. */
  /* ptvab is a field inverted from tvab */
p1.id = tp.id and p1.tvab = tp.tvab and
p2.id = p1.id and p2.ptvab = p1.tvab and
  /* Just the screening survey */
  tp.survey_no = 5 and
  /* Skip if partner died before 65 but allow emigration (dead=9) */
  (p2.dead = 0 or p2.dead = 9 or
   (p2.dead = 1 and
    (p2.death_date = 0 or
     (((to_days(p2.death_date) - to_days(p2.birthday)) / 365) >= 65))))
and
/* Twin is suspect */
(td.future_contact = 'Yes' and td.suspect = 2) or
/* Twin is suspect - Informant is Blessed */
(td.future_contact = 'Yes' and td.suspect = 1 and id.suspect = 1) or
/* No twin - Informant is Blessed */
(ISNULL(td.suspect) and id.suspect = 1 and id.future_contact = 'Yes') or
/* Twin broken off - Informant is Blessed */
(td.participation = 'Aborted'
    and id.suspect = 1 and id.future_contact = 'Yes') or
/* Twin broken off - No inform - Have partner */
(td.participation = 'Aborted' and ISNULL(id.suspect) and p2.dead = 0))
and
l.event = 'Finished'
/* Get at area code */
and substring(p1.postal_code, 1, 2) = pg.code
/* Not already distributed */
and (h.nurse is NULL or h.nurse=00 or h.doctor=00)
/* Has not refused or been aborted */
and not (h.status = 'Refused' or h.status = 'Aborted'
or h.status = 'Died' or h.status = 'Other')
order by
tvid;

Some explanations:

`concat(p1.id, p1.tvab) + 0` as tvid
We want to sort on the concatenated id and tvab in numerical order. Adding
0 to the result causes MySQL to treat the result as a number.

column id  This identifies a pair of twins. It is a key in all tables.

column tvab
This identifies a twin in a pair. It has a value of 1 or 2.

column ptvab
This is an inverse of tvab. When tvab is 1 this is 2, and vice versa. It exists
to save typing and to make it easier for MySQL to optimize the query.

This query demonstrates, among other things, how to do lookups on a table from the same
table with a join (p1 and p2). In the example, this is used to check whether a twin’s partner
died before the age of 65. If so, the row is not returned.

All of the above exist in all tables with twin-related information. We have a key on both
id, tvab (all tables) and id, ptvab (person_data) to make queries faster.

On our production machine (A 200MHz UltraSPARC), this query returns about 150-200
rows and takes less than one second.

The current number of records in the tables used above:

<table>
<thead>
<tr>
<th>Table</th>
<th>Rows</th>
</tr>
</thead>
<tbody>
<tr>
<td>person_data</td>
<td>71074</td>
</tr>
<tr>
<td>lentus</td>
<td>5291</td>
</tr>
</tbody>
</table>

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9.7.2 Show a table on twin pair status

Each interview ends with a status code called `event`. The query shown below is used to display a table over all twin pairs combined by event. This indicates in how many pairs both twins are finished, in how many pairs one twin is finished and the other refused, and so on.

```sql
select
t1.event,
t2.event,
count(*)
from
lentus as t1,
lentus as t2,
twin_project as tp
where
/* We are looking at one pair at a time */
t1.id = tp.id
and t1.tvab=tp.tvab
and t1.id = t2.id
/* Just the screening survey */
and tp.survey_no = 5
/* This makes each pair only appear once */
and t1.tvab='1' and t2.tvab='2'
group by
t1.event, t2.event;
```
10 MySQL server functions

10.1 What languages are supported by MySQL?

`mysqld` can issue error messages in the following languages: Czech, Dutch, English (the default), Estonia, French, German, Hungarian, Italian, Norwegian, Norwegian-ny, Polish, Portuguese, Spanish and Swedish.

To start `mysqld` with a particular language, use either the `--language=lang` or `-L lang` options. For example:

```
shell> mysqld --language=swedish
```
or:

```
shell> mysqld --language=/usr/local/share/swedish
```

Note that all language names are specified in lowercase.

The language files are located (by default) in `mysql_base_dir/share/LANGUAGE/`.

To update the error message file, you should edit the `errmsg.txt` file and execute the following command to generate the `errmsg.sys` file:

```
shell> comp_err errmsg.txt errmsg.sys
```

If you upgrade to a newer version of MySQL, remember to repeat your changes with the new `errmsg.txt` file.

10.1.1 The character set used for data and sorting

By default, MySQL uses the ISO-8859-1 (Latin1) character set. This is the character set used in the USA and western Europe.

The character set determines what characters are allowed in names and how things are sorted by the `ORDER BY` and `GROUP BY` clauses of the `SELECT` statement.

You can change the character set at compile time by using the `--with-charset=charset` option to `configure`. See Section 4.7.1 [Quick install], page 45.

To add another character set to MySQL, use the following procedure:

10.1.2 Adding a new character set

1. Choose a name for the character set, denoted `MYSET` below.
2. Create the file `strings/ctype-MYSET.c` in the MySQL source distribution.
3. Look at one of the existing `ctype-*.c` files to see what needs to be defined. Note that the arrays in your file must have names like `ctype_MYSET`, `to_lower_MYSET` and so on.
to_lower[] and to_upper[] are simple arrays that hold the lowercase and uppercase characters corresponding to each member of the character set. For example:

- `to_lower['A']` should contain 'a'
- `to_upper['a']` should contain 'A'

sort_order[] is a map indicating how characters should be ordered for comparison and sorting purposes. For many character sets, this is the same as to_upper[] (which means sorting will be case insensitive). MySQL will sort characters based on the value of sort_order[character].

cctype[] is an array of bit values, with one element for one character. (Note that to_lower[], to_upper[] and sort_order[] are indexed by character value, but cctype[] is indexed by character value + 1. This is an old legacy to be able to handle EOF.)

You can find the following bitmask definitions in 'm ctype.h':

```c
#define _U 01 /* Upper case */
#define _L 02 /* Lower case */
#define _N 04 /* Numeral (digit) */
#define _S 010 /* Spacing character */
#define _P 020 /* Punctuation */
#define _C 040 /* Control character */
#define _B 0100 /* Blank */
#define _X 0200 /* hexadecimal digit */
```

The cctype[] entry for each character should be the union of the applicable bitmask values that describe the character. For example, 'A' is an uppercase character (_U) as well as a hexadecimal digit (_X), so cctype['A'+1] should contain the value:

```
_U + _X = 01 + 0200 = 0201
```

4. Add a unique number for your character set to 'include/m ctype.h.in'.
5. Add the character set name to the CHARSETS AVAILABLE list in configure.in.

### 10.1.3 Multi-byte character support

If you are creating a multi-byte character set, you can use the _MB macros. In 'include/m ctype.h.in', add:

```c
#define MY_CHARSET_MYSET X
#if MY_CHARSET_CURRENT == MY_CHARSET_MYSET
#define USE_MB
#define USE_MB_IDENT
#define ismbchar(p, end) (...)
#define ismbhead(c) (...)
#define mbcharlen(c) (...)
#define MBMAXLEN N
#endif
```

Where:

**MY_CHARSET_MYSET** A unique character set value.
USE_MB

This character set has multi-byte characters, handled by ismbhead() and mbcharlen()

USE_MB_IDENT

(optional) If defined, you can use table and column names that use multi-byte characters

ismbchar(p, e)

return 0 if p is not a multi-byte character string, or the size of the character (in bytes) if it is. p and e point to the beginning and end of the string. Check from (char*)p to (char*)e-1.

ismbhead(c)

True if c is the first character of a multi-byte character string

mbcharlen(c)

Size of a multi-byte character string if c is the first character of such a string

MBMAXLEN

Size in bytes of the largest character in the set

10.2 The update log

When started with the --log-update=file_name option, mysqld writes a log file containing all SQL commands that update data. The file is written in the data directory and has a name of file_name.#, where # is a number that is incremented each time you execute mysqladmin refresh or mysqladmin flush-logs, the FLUSH LOGS statement, or restart the server.

If you use the --log or -l options, mysqld writes a general log with a filename of ‘hostname.log’, and restarts and refreshes do not cause a new log file to be generated (although it is closed and reopened). By default, the mysql.server script starts the MySQL server with the -l option. If you need better performance when you start using MySQL in a production environment, you can remove the -l option from mysql.server.

Update logging is smart since it logs only statements that really update data. So an UPDATE or a DELETE with a WHERE that finds no rows is not written to the log. It even skips UPDATE statements that set a column to the value it already has.

If you want to update a database from update log files, you could do the following (assuming your update logs have names of the form ‘file_name.#’):

shell> ls -l -t -r file_name.[0-9]* | xargs cat | mysql

ls is used to get all the log files in the right order.

This can be useful if you have to revert to backup files after a crash and you want to redo the updates that occurred between the time of the backup and the crash.

You can also use the update logs when you have a mirrored database on another host and you want to replicate the changes that have been made to the master database.

10.3 How big MySQL tables can be

MySQL 3.22 has a 4G limit on table size. With the new MyISAM in MySQL 3.23 the maximum table size is pushed up to 8 million terabytes (2 \(^63\) bytes).
Note however that operating systems have their own file size limits. On Linux, the current limit is 2G; on Solaris 2.5.1, the limit is 4G; on Solaris 2.6, the limit is 1000G. This means that the table size for MySQL is normally limited by the operating system.

By default, MySQL tables have a maximum size of about 4G. You can check the maximum table size for a table with the `SHOW TABLE STATUS` command or with the `myisamchk --dv table_name`. See Section 7.21 [SHOW], page 211.

If you need bigger tables than 4G (and your operating system supports this), you should set the `AVG_ROW_LENGTH` and `MAX_ROWS` parameter when you create your table. See Section 7.7 [CREATE TABLE], page 187. You can also set these later with `ALTER TABLE`. See Section 7.8 [ALTER TABLE], page 193.

If your big table is going to be read-only, you could use `myisampack` to merge and compress many tables to one. `myisampack` usually compresses a table by at least 50%, so you can have, in effect, much bigger tables. See Section 13.7 [myisampack], page 316.

Another solution can be the included MERGE library, which allows you to handle a collection of identical tables as one. (Identical in this case means that all tables are created with identical column information.) Currently MERGE can only be used to scan a collection of tables because it doesn’t support indexes. We will add indexes to this in the near future.
11 Getting maximum performance from MySQL

Optimization is a complicated task since it ultimately requires understanding of the whole system. While it may be possible to do some local optimizations with small knowledge of your system/application, the more optimal you want your system to become the more you will have to know about it.

So this chapter will try to explain and give some examples of different ways to optimize MySQL. But remember that there are always some (increasingly harder) ways to make the system even faster left to do.

11.1 Optimization overview

The most important part for getting a system fast is of course the basic design. You also need to know that kinds of things your system will be doing. That is your bottlenecks are.

The most common bottlenecks are.

- Disk seeks It takes time for the disk to find a piece of data. With modern disk in 1999 the mean time for this is usually lower than 10ms. So we can in theory do about 1000 seeks a second. This time improves slowly with new disks and is very hard to optimize for a single table. The way to optimize this is to spread the data on more than one disk.

- Disk reading/writing When the disk is at the correct position we need to read the data. With modern disks in 1999 one disk delivers something like 10-20Mb/s. This is easier to optimize than seeks since you can read in parallel from multiple disks.

- CPU cycles When we have got the data into main memory (or if it already where there) we need to process it to get to our result. When we have small tables compared to the memory this is the most common limiting factor. But then with small tables speed is usually not the problem.

- Memory bandwidth When the CPU needs more data than that fits in the cpu cache the main memory bandwidth becomes a bottleneck. This is a uncommon bottleneck for most systems but one should be aware of it.

11.2 System/Compile time and startup parameter tuning

We start with the system level things sine some of these decisions have to be made very early. In other cases a fast look at this part may suffice since it not that important for the big gains. But it is always nice to have a feeling about how much one could gain by chancing things at this level.

The default OS to use is really important! To get the most use of multiple CPU machines one should use Solaris (because the threads works really nice) or Linux (because the 2.2
kernel has really good SMP support). Also on 32bit machines Linux has a 2G file size limit by default. Hopefully this will be fixed soon when new filesystems is released (XFS).

Since we have not run production MySQL on that many platforms we advice you to test your intended platform before choosing it if possible.

Other tips:

- If you have enough ram, you could remove all swap devices. Some operating systems will use a SWAP device in some contexts even if you have free memory.
- Use the --skip-locking MySQL option to avoid external locking. Note that this will not impact MySQL functionality as long that only run one server. Just remember to take down the server (or lock relevant parts) before you run myisamchk. On some system this switch is mandatory since the external locking does not work in any case.
- The --skip-locking option is on by default when compiling with MIT-pthreads, because flock() isn’t fully supported by MIT-pthreads on all platforms.
- The only case when you can’t use --skip-locking is if you run multiple MySQL SERVERS (not clients) on the same data. Or run myisamchk on the table without first flushing and locking the mysqld server tables first.
- You can still use LOCK TABLES / UNLOCK TABLES even if you are using --skip-locking

### 11.2.1 How compiling and linking affects the speed of MySQL

Most of the following tests are done on Linux and with the MySQL benchmarks, but they should give some indication for other operating systems and workloads.

You get the fastest executable when you link with -static. Using Unix sockets rather than TCP/IP to connect to a database also gives better performance.

On Linux, you will get the fastest code when compiling with pgcc and -O6. To compile ‘sql_yacc.cc’ with these options, you need about 200M memory because gcc/pgcc needs a lot of memory to make all functions inline. You should also set CXX=gcc when configuring MySQL to avoid inclusion of the libstdc++ library (it is not needed).

By just using a better compiler and/or better compiler options you can get a 10-30% speed increase in your application. This is particularly important if you compile the SQL server yourselves!

On Intel you should for example use pgcc or the Cygnus CodeFusion compiler to get maximum speed. We have tested the new Fujitsu compiler but it is not yet bug free enough to compile MySQL with optimizations on.

Here is a list of some measurements that we have done:

- If you use pgcc and compile everything with -O6, the mysqld server is 11% faster than with gcc versions older than gcc 2.95.2.
- If you link dynamically (without -static), the result is 13% slower. Note that you still can use a dynamic linked MySQL library. It is only the server that is critical for performance.
- If you connect using TCP/IP rather than Unix sockets, the result is 7.5% slower.
• On a Sun SPARCstation 10, gcc 2.7.3 is 13% faster than Sun Pro C++ 4.2.
• On Solaris 2.5.1, MIT-pthreads is 8-12% slower than Solaris native threads on a single processor. With more load/cpus the difference should get bigger.

The MySQL-Linux distribution provided by TcX is compiled with pgcc and linked statically.

11.2.2 Disk issues

• As mentioned before disks seeks are a big performance bottleneck. This problems gets more and more apparent when the data starts to grow so large that effective caching becomes impossible. For large databases, where you access data more or less random, you can count on that you will need at least one disk seek to read and a couple of disk seeks to write things. To minimize this problem use disks with low seek times.

• To increase the number of available disk spindles (and thereby reduce the seek overhead) it is possible to either symlink files to different disks or stripe the disks.

Using symbolic links
This means that you symlink the index or/and data file(s) from the normal data directory to another disk (that may also be striped). This makes both the seek and read times better (if the disk are not used for other things). See Section 11.2.2.1 [Symbolic links], page 278.

Striping
Striping means that you have many disks and put the first block on the first disk, the second block on the second disk, and the Nth on the (Nth mod number_of_disks) disk, and so on. This means if your normal data size is less than the stripe size (or perfectly aligned) you will get much better performance. Note that striping if very dependent on the OS and stripe-size. So benchmark your application with different stripe-sizes. See Section 11.7 [Benchmarks], page 300.

Note that the speed difference for striping is very dependent on the parameters. Depending on how you set the striping parameters and number of disks you may get difference in orders of magnitude. Note that you have to choose to optimize for random or sequential access.

• For reliability you may want to use RAID 0+1 (striping + mirroring), but in this case you will need 2*N drives to hold N drives of data. This is probably the best option if you have the money for it! You may however also have to invest in some volume management software to handle it efficiently.

• A good option is to have semi-important data (that can be re-generated) on RAID 0 disk while store really important data (like host information and logs) on a RAID 0+1 or RAID N disks. RAID N can be a problem if you have many writes because of the time to update the parity bits.

• You may also set the parameters for the file system that the database uses. One easy change is to mount the file system with the noatime option. That makes it skip the updating of the last access time in the inode and by this will avoid some disk seeks.
11.2.2.1 Using symbolic links for databases and tables

You can move tables and databases from the database directory to other locations and replace them with symbolic links to the new locations. You might want to do this, for example, to move a database to a file system with more free space.

If MySQL notices that a table is a symbolically-linked, it will resolve the symlink and use the table it points to instead. This works on all systems that support the `realpath()` call (at least Linux and Solaris support `realpath()`)! On systems that don't support `realpath()`, you should not access the table through the real path and through the symlink at the same time! If you do, the table will be inconsistent after any update.

MySQL doesn’t support linking of databases by default. Things will work fine as long as you don’t make a symbolic link between databases. Suppose you have a database `db1` under the MySQL data directory, and then make a symlink `db2` that points to `db1`:

```
shell> cd /path/to/datadir
shell> ln -s db1 db2
```

Now, for any table `tbl_a` in `db1`, there also appears to be a table `tbl_a` in `db2`. If one thread updates `db1.tbl_a` and another thread updates `db2.tbl_a`, there will be problems.

If you really need this, you must change the following code in `mysys/mf_format.c`:

```c
if (!lstat(to,&stat_buff)) /* Check if it's a symbolic link */
  if (S_ISLNK(stat_buff.st_mode) && realpath(to,buff))
```

Change the code to this:

```c
if (realpath(to,buff))
```

11.2.3 Tuning server parameters

You can get the default buffer sizes used by the `mysqld` server with this command:

```
shell> mysqld --help
```

This command produces a list of all `mysqld` options and configurable variables. The output includes the default values and looks something like this:

```
Possible variables for option --set-variable (-O) are:
back_log current value: 5
connect_timeout current value: 5
delayed_insert_timeout current value: 300
delayed_insert_limit current value: 100
delayed_queue_size current value: 1000
flush_time current value: 0
interactive_timeout current value: 28800
join_buffer_size current value: 131072
key_buffer_size current value: 1048540
lower_case_table_names current value: 0
long_query_time current value: 10
max_allowed_packet current value: 1048576
```
Chapter 11: Getting maximum performance from MySQL

max_connections  current value: 100
max_connect_errors current value: 10
max_delayed_threads current value: 20
max_heap_table_size current value: 16777216
max_join_size current value: 4294967295
max_sort_length current value: 1024
max_tmp_tables current value: 32
max_write_lock_count current value: 4294967295
net_buffer_length current value: 16384
query_buffer_size  current value: 0
record_buffer current value: 131072
sort_buffer current value: 2097116
table_cache current value: 64
thread_concurrency current value: 10
tmp_table_size current value: 1048576
thread_stack current value: 131072
wait_timeout current value: 28800

If there is a mysqld server currently running, you can see what values it actually is using for the variables by executing this command:

shell> mysqladmin variables

Each option is described below. Values for buffer sizes, lengths and stack sizes are given in bytes. You can specify values with a suffix of ‘K’ or ‘M’ to indicate kilobytes or megabytes. For example, 16M indicates 16 megabytes. Case of suffix letters does not matter; 16M and 16m are equivalent.

You can also see some statistics from a running server by the command SHOW STATUS. See Section 7.21 [SHOW], page 211.

ansi_mode
Is ON if mysqld was started with --ansi. See Section 5.2 [Ansi mode], page 98.

back_log  The number of outstanding connection requests MySQL can have. This comes into play when the main MySQL thread gets very many connection requests in a very short time. It then takes some time (although very little) for the main thread to check the connection and start a new thread. The back_log value indicates how many requests can be stacked during this short time before MySQL momentarily stops answering new requests. You need to increase this only if you expect a large number of connections in a short period of time.

In other words, this value is the size of the listen queue for incoming TCP/IP connections. Your operating system has its own limit on the size of this queue. The manual page for the Unix listen(2) system call should have more details. Check your OS documentation for the maximum value for this variable. Attempting to set back_log higher than your operating system limit will be ineffective.

concurrent_inserts
If ON (the default), MySQL will allow you to use INSERT on MyISAM tables at the same time as you run SELECT queries on them. You can turn this option off by starting mysqld with --safe or --skip-new.
connect_timeout
The number of seconds the mysqld server is waiting for a connect packet before responding with Bad handshake.

delayed_insert_timeout
How long a INSERT DELAYED thread should wait for INSERT statements before terminating.

delayed_insert_limit
After inserting delayed_insert_limit rows, the INSERT DELAYED handler will check if there are any SELECT statements pending. If so, it allows these to execute before continuing.

delay_key_write
If enabled (is on by default), MySQL will honor the delay_key_write option CREATE TABLE. This means that the key buffer for tables with this option will not get flushed on every index update, but only when a table is closed. This will speed up writes on keys a lot but you should add automatic checking of all tables with myisamchk --fast --force if you use this. Note that if you start mysqld with the --delay-key-write-for-all-tables option this means that all tables will be treated as if they were created with the delay_key_write option. You can clear this flag by starting mysqld with --skip-new or --safe-mode.

delayed_queue_size
How big a queue (in rows) should be allocated for handling INSERT DELAYED. If the queue becomes full, any client that does INSERT DELAYED will wait until there is room in the queue again.

flush_time
If this is set to a non-zero value, then every flush_time seconds all tables will be closed (to free up resources and sync things to disk).

init_file
The name of the file specified with the --init-file option when you start the server. This is a file of SQL statements you want the server to execute when it starts.

interactive_timeout
The number of seconds the server waits for activity on a interactive connection before closing it. An interactive client is defined as a client that uses the CLIENT_INTERACTIVE option to mysql_real_connect(). See also wait_timeout.

join_buffer_size
The size of the buffer that is used for full joins (joins that do not use indexes). The buffer is allocated one time for each full join between two tables. Increase this value to get a faster full join when adding indexes is not possible. (Normally the best way to get fast joins is to add indexes.)
**key_buffer_size**

Index blocks are buffered and are shared by all threads. `key_buffer_size` is the size of the buffer used for index blocks.

Increase this get better index handling (for all reads and multiple writes) to as much as you can afford; 64M on a 256M machine that mainly runs MySQL is quite common. If you however make this too big (more than 50% of your total memory?) your system may start to page and go REAL slow. Remember that since MySQL does not cache data read that you will have to leave some room for the OS filesystem cache.

You can check the performance of the key buffer by doing `show status` and examine the variables `Key_read_requests`, `Key_reads`, `Key_write_requests` and `Key_writes`. The `Key_reads/Key_read_request` ratio should normally be < 0.01. The `Key_write/Key_write_requests` is usually near 1 if you are using mostly updates/deletes but may be much smaller if you tend to do updates that affects a lot of rows at the same time or if you are using `delay_key_write`. See Section 7.21 [SHOW], page 211.

To get even more speed when writing many rows at the same time use `LOCK TABLES`. See Section 7.24 [LOCK TABLES], page 221.

**lower_case_table_names**

Change all table names to lower case on disk.

**long_query_time**

If a query takes longer than this (in seconds), the `Slow_queries` counter will be incremented.

**max_allowed_packet**

The maximum size of one packet. The message buffer is initialized to `net_buffer_length` bytes, but can grow up to `max_allowed_packet` bytes when needed. This value by default is small to catch big (possibly wrong) packets. You must increase this value if you are using big BLOB columns. It should be as big as the biggest BLOB you want to use.

**max_connections**

The number of simultaneous clients allowed. Increasing this value increases the number of file descriptors that `mysqld` requires. See below for comments on file descriptor limits. See Section 19.2.4 [Too many connections], page 356.

**max_connect_errors**

If there is more than this number of interrupted connections from a host this host will be blocked for further connections. You can unblock a host with the command `FLUSH HOSTS`.

**max_delayed_threads**

Don’t start more than this number of threads to handle `INSERT DELAYED` statements. If you try to insert data in a new table after all `INSERT DELAYED` threads are in use, the row will be inserted as if the `DELAYED` attribute wasn’t specified.
max_join_size
Joins that are probably going to read more than max_join_size records return an error. Set this value if your users tend to perform joins without a WHERE clause that take a long time and return millions of rows.

max_heap_table_size
Don’t allow creation of heap tables bigger than this.

max_sort_length
The number of bytes to use when sorting BLOB or TEXT values (only the first max_sort_length bytes of each value are used; the rest are ignored).

max_tmp_tables
(This option doesn’t yet do anything). Maximum number of temporary tables a client can keep open at the same time.

max_write_lock_count
After this many write locks, allow some read locks to run in between.

net_buffer_length
The communication buffer is reset to this size between queries. This should not normally be changed, but if you have very little memory, you can set it to the expected size of a query. (That is, the expected length of SQL statements sent by clients. If statements exceed this length, the buffer is automatically enlarged, up to max_allowed_packet bytes.)

net_retry_count
If a read on a communication port is interrupted, retry this many times before giving up. This value should be quite high on FreeBSD as internal interrupts is sent to all threads.

record_buffer
Each thread that does a sequential scan allocates a buffer of this size for each table it scans. If you do many sequential scans, you may want to increase this value.

query_buffer_size
The initial allocation of the query buffer. If most of your queries are long (like when inserting blobs), you should increase this!

skip_show_databases
This prevents people from doing SHOW DATABASES, if they don’t have the PROCESS_PRIV privilege. This can improve security if you’re concerned about people being able to see what databases and tables other users have.

sort_buffer
Each thread that needs to do a sort allocates a buffer of this size. Increase this value for faster ORDER BY or GROUP BY operations. See Section 19.5 [Temporary files], page 359.

table_cache
The number of open tables for all threads. Increasing this value increases the number of file descriptors that mysql requires. MySQL needs two file descrip-
tors for each unique open table. See below for comments on file descriptor limits. You can check if you need to increase the table cache by checking the `Opened_tables` variables. See Section 7.21 [SHOW], page 211. If this variable is big and you don’t do `FLUSH TABLES` a lot (which just forces all tables to be closed and reopened), then you should increase the value of this variable.

For information about how the table cache works, see Section 11.2.4 [Table cache], page 284.

tmp_table_size

If a temporary table exceeds this size, MySQL generates an error of the form `The table tbl_name is full`. Increase the value of `tmp_table_size` if you do many advanced `GROUP BY` queries.

thread_concurrency

On Solaris, mysqld will call `thr_setconcurrency()` with this value. `thr_setconcurrency()` permits the application to give the threads system a hint, for the desired number of threads that should be run at the same time.

thread_stack

The stack size for each thread. Many of the limits detected by the crash-me test are dependent on this value. The default is large enough for normal operation. See Section 11.7 [Benchmarks], page 300.

wait_timeout

The number of seconds the server waits for activity on a connection before closing it. See also `interactive_timeout`.

MySQL uses algorithms that are very scalable, so you can usually run with very little memory or give MySQL more memory to get better performance.

The 2 most important variables to use when tuning a MySQL server is `key_buffer` and `table_cache`. You should first feel confident that you have got these right before trying to change any of the other variables.

If you have much memory (\(\geq 256\)M) and many tables and want maximum performance with a moderate number of clients, you should use something like this:

```
shell> safe_mysqld -O key_buffer=64M -O table_cache=256 -O sort_buffer=4M -O record_buffer=1M &
```

If you have only 128M, and only a few tables but you still do a lot of sorting, you can use something like:

```
shell> safe_mysqld -O key_buffer=16M -O sort_buffer=1M
```

If you have little memory and lots of connections, use something like this:

```
shell> safe_mysqld -O key_buffer=512k -O sort_buffer=100k -O record_buffer=100k &
```

or even:

```
shell> safe_mysqld -O key_buffer=512k -O sort_buffer=16k -O table_cache=32 -O record_buffer=8k -O net_buffer=1K &
```
If there are very many connections, “swapping problems” may occur unless `mysqld` has been configured to use very little memory for each connection. `mysqld` performs better if you have enough memory for all connections, of course.

Note that if you change an option to `mysqld`, it remains in effect only for that instance of the server.

To see the effects of a parameter change, do something like this:

```
shell> mysqld -O key_buffer=32m --help
```

Make sure that the `--help` option is last; otherwise, the effect of any options listed after it on the command line will not be reflected in the output.

### 11.2.4 How MySQL opens and closes tables

`table_cache`, `max_connections` and `max_tmp_tables` affect the maximum number of files the server keeps open. If you increase one or both of these values, you may run up against a limit imposed by your operating system on the per-process number of open file descriptors. However, you can increase the limit on many systems. Consult your OS documentation to find out how to do this, because the method for changing the limit varies widely from system to system.

`table_cache` is related to `max_connections`. For example, for 200 open connections, you should have a table cache of at least $200 \times n$, where $n$ is the maximum number of tables in a join.

The cache of open tables can grow to a maximum of `table_cache` (default 64; this can be changed with the `-O table_cache=#` option to `mysqld`). A table is never closed, except when the cache is full and no tables can be released, but a new table needs to be opened, the cache is temporarily extended as necessary.

When the table cache fills up, the server uses the following procedure to locate a cache entry to use:

- Tables that are not currently in use are released, in least-recently-used order.
- If the cache is full and no tables can be released, but a new table needs to be opened, the cache is temporarily extended as necessary.
- If the cache is in a temporarily-extended state and a table goes from in-use to not-in-use state, it is closed and released from the cache.

A table is opened for each concurrent access. This means that if you have two threads accessing the same table or access the table twice in the same query (with `AS`) the table needs to be opened twice. The first open of any table takes two file descriptors; each additional use of the table takes only one file descriptor. The extra descriptor for the first open is used for the index file; this descriptor is shared among all threads.

### 11.2.5 Drawbacks of creating large numbers of tables in the same database
If you have many files in a directory, open, close and create operations will be slow. If you execute `SELECT` statements on many different tables, there will be a little overhead when the table cache is full, because for every table that has to be opened, another must be closed. You can reduce this overhead by making the table cache larger.

### 11.2.6 Why so many open tables?

When you run `mysqladmin status`, you’ll see something like this:

```
Uptime: 426 Running threads: 1 Questions: 11082 Reloads: 1 Open tables: 12
```

This can be somewhat perplexing if you only have 6 tables. MySQL is multithreaded, so it may have many queries on the same table simultaneously. To minimize the problem with two threads having different states on the same file, the table is opened independently by each concurrent thread. This takes some memory and one extra file descriptor for the data file. The index file descriptor is shared between all threads.

### 11.2.7 How MySQL uses memory

The list below indicates some of the ways that the `mysqld` server uses memory. Where applicable, the name of the server variable relevant to the memory use is given.

- The key buffer (variable `key_buffer_size`) is shared by all threads; Other buffers used by the server are allocated as needed. See Section 11.2.3 [Server parameters], page 278.
- Each connection uses some thread specific space; A stack (default 64K, variable `thread_stack`) a connection buffer (variable `net_buffer_length`), and a result buffer (variable `net_buffer_length`). The connection buffer and result buffer are dynamically enlarged up to `max_allowed_packet` when needed. When a query is running a copy of the current query string is also allocated.
- All threads share the same base memory.
- Nothing is memory-mapped yet (except compressed tables, but that’s another story). This is because the 32-bit memory space of 4GB is not large enough for most large tables. When systems with a 64-bit address-space become more common we may add general support for memory-mapping.
- Each request doing a sequential scan over a table allocates a read buffer (variable `record_buffer`).
- All joins are done in one pass and most joins can be done without even using a temporary table. Most temporary tables are memory-based (HEAP) tables. Temporary tables with a big record length (calculated as the sum of all column lengths) or that contain `BLOB` columns are stored on disk.

One problem in MySQL versions before 3.23.2 is that if a HEAP table exceeds the size of `tmp_table_size`, you get the error `The table tbl_name is full`. In newer versions this is handled by automatically changing the in-memory (HEAP) table to
a disk-based (MyISAM) table as necessary. To work around this problem, you can increase the temporary table size by setting the `tmp_table_size` option to `mysqld`, or by setting the SQL option `SQL_BIG_TABLES` in the client program. See Section 7.25 [SET OPTION], page 222. In MySQL 3.20, the maximum size of the temporary table was `record_buffer*16`, so if you are using this version, you have to increase the value of `record_buffer`. You can also start `mysqld` with the `--big-tables` option to always store temporary tables on disk, however, this will affect the speed of many complicated queries.

- Most requests doing a sort allocate a sort buffer and one or two temporary files. See Section 19.5 [Temporary files], page 359.

- Almost all parsing and calculating is done in a local memory store. No memory overhead is needed for small items and the normal slow memory allocation and freeing is avoided. Memory is allocated only for unexpectedly large strings (this is done with `malloc()` and `free()`).

- Each index file is opened once and the data file is opened once for each concurrently-running thread. For each concurrent thread, a table structure, column structures for each column, and a buffer of size $3 \times n$ is allocated (where $n$ is the maximum row length, not counting BLOB columns). A BLOB uses 5 to 8 bytes plus the length of the BLOB data.

- For each table having BLOB columns, a buffer is enlarged dynamically to read in larger BLOB values. If you scan a table, a buffer as large as the largest BLOB value is allocated.

- Table handlers for all in-use tables are saved in a cache and managed as a FIFO. Normally the cache has 64 entries. If a table has been used by two running threads at the same time, the cache contains two entries for the table. See Section 11.2.4 [Table cache], page 284.

- A `mysqladmin flush-tables` command closes all tables that are not in use and marks all in-use tables to be closed when the currently executing thread finishes. This will effectively free most in-use memory.

`ps` and other system status programs may report that `mysqld` uses a lot of memory. This may be caused by thread-stacks on different memory addresses. For example, the Solaris version of `ps` counts the unused memory between stacks as used memory. You can verify this by checking available swap with `swap -s`. We have tested `mysqld` with commercial memory-leakage detectors, so there should be no memory leaks.

11.2.8 How MySQL locks tables

All locking in MySQL is deadlock-free. This is managed by always requesting all needed locks at once at the beginning of a query and always locking the tables in the same order. The locking method MySQL uses for WRITE locks works as follows:

- If there are no locks on the table, put a write lock on it.
- Otherwise, put the lock request in the write lock queue.

The locking method MySQL uses for READ locks works as follows:
• If there are no write locks on the table, put a read lock on it.
• Otherwise, put the lock request in the read lock queue.

When a lock is released, the lock is made available to the threads in the write lock queue, then to the threads in the read lock queue.

This means that if you have many updates on a table, SELECT statements will wait until there are no more updates.

To work around this for the case where you want to do many INSERT and SELECT operations on a table, you can insert rows in a temporary table and update the real table with the records from the temporary table once in a while.

This can be done with the following code:
"mysql> LOCK TABLES real_table WRITE, insert_table WRITE;
mysql> insert into real_table select * from insert_table;
mysql> delete from insert_table;
mysql> UNLOCK TABLES;
"

You can use the LOW_PRIORITY options with INSERT if you want to prioritize retrieval in some specific cases. See Section 7.14 [INSERT], page 201.

You could also change the locking code in ‘mysys/thr_lock.c’ to use a single queue. In this case, write locks and read locks would have the same priority, which might help some applications.

11.2.9 Table locking issues

The table locking code in MySQL is deadlock free.

MySQL uses table locking (instead of row locking or column locking) to achieve a very high lock speed. For large tables, table locking is for most applications MUCH better than row locking, but there are of course some pitfalls.

In MySQL 3.23.7 and above, you can insert rows into MyISAM tables at the same time as other threads are reading from the table. Note that currently this only works if there are no deleted rows in the table.

Table locking enables many threads to read from a table at the same time, but if a thread wants to write to a table, it must first get exclusive access. During the update all others threads that want to access this particular table will wait until the update is ready.

As updates of databases normally are considered to be more important than SELECT, all statements that update a table have higher priority than statements that retrieve information from a table. This should ensure that updates are not 'starved' because one issues a lot of heavy queries against a specific table.

Starting from MySQL 3.23.7 one can use the max_write_lock_count variable to force MySQL to issue a SELECT after a specific number of inserts on a table.

One main problem with this is the following:
• A client issues a SELECT that takes a long time to run.
• Another client then issues an UPDATE on a used table; This client will wait until the SELECT is finished
• Another client issues another SELECT statement on the same table; As UPDATE has higher priority than SELECT, this SELECT will wait for the UPDATE to finish. It will also wait for the first SELECT to finish!

Some possible solutions to this problem are:
• Try to get the SELECT statements to run faster; You may have to create some summary tables to do this.
• Start mysqld with --low-priority-updates. This will give all statements that update (modify) a table lower priority than a SELECT statement. In this case the last SELECT statement in the previous scenario would execute before the INSERT statement.
• You can give a specific INSERT,UPDATE or DELETE statement lower priority with the LOW_PRIORITY attribute.
• Start mysqld with a low value for max_write_lock_count to give READ locks after a certain number of WRITE locks.
• You can specify that all updates from a specific thread should be done with low priority by using the SQL command: SET SQL_LOW_PRIORITY_UPDATES=1. See Section 7.25 [SET OPTION], page 222.
• You can specify that a specific SELECT is very important with the HIGH_PRIORITY attribute. See Section 7.12 [SELECT], page 196.
• If you have problems with INSERT combined with SELECT, switch to use the new MyISAM tables as these supports concurrent SELECTs and INSERTs.
• If you mainly mix INSERT and SELECT statements, the DELAYED attribute to INSERT will probably solve your problems. See Section 7.14 [INSERT], page 201.
• If you have problems with SELECT and DELETE, the LIMIT option to DELETE may help. See Section 7.11 [DELETE], page 196.

11.3 Get your data as small as possible

One of the most basic optimization is to get your data (and indexes) to take as little space on the disk (and in memory) as possible. This can give huge improvements since disk reads are faster and normally less main memory will also be used. Indexing also takes less resources if done on smaller columns.

MySQL supports a lot of different table types and row formats. Choosing the right table format may give you a big performance gain. See Chapter 8 [Table types], page 232.

You can get better performance on a table and minimize storage space using the techniques listed below:
• Use the most efficient (smallest) types possible. MySQL has a many specialized types that save disk space and memory.
• Use the smaller integer types if possible to get smaller tables. For example, MEDIUMINT is often better than INT.
• Declare columns to be NOT NULL if possible. It makes everything faster and you save one bit per column. Note that if you really need NULL in your application you should definitely use it. Just avoid having it on all columns by default.
• If you don’t have any variable-length columns (VARCHAR, TEXT or BLOB columns), a fixed-size record format is used. This is faster but unfortunately may waste some space. See Section 8.1.2 [MyISAM table formats], page 233.

• Each table should have as short as possible primary index. This makes identification of one row easy and efficient.

• For each table you have to decide which storage/index method to use. See Chapter 8 [Table types], page 232.

• Only create the indexes that you really need. Indexes are good for retrieval but bad when you need to store things fast. If you mostly access a table by searching on a combination of columns, make an index on them. The first index part should be the most used column. If you are ALWAYS using many columns you should use the column with more duplicates first to get better compression of the index.

• If its very likely that an index has unique prefix on the first number of characters, it’s better that only index this prefix. MySQL supports an index on a part of a character column. Shorter indexes is faster not only because they take less disk space but also because they will give you more hits in the index cache and thus fewer disk seeks. See Section 11.2.3 [Server parameters], page 278.

• In some circumstances it can be beneficial to split a table that is scanned very often into two. Especially if it is a dynamic format table and it is possible to a smaller static format table that can be used to find the relevant rows then scanning.

11.4 MySQL index use

Indexes are used to find find a row with a specific value on one column fast. Without a index MySQL has to start with the first record and then read through the whole table until it find the relevent rows. The bigger the table the more this costs. If the table has a index for the columns in question MySQL can get fast a position to seek to in the middle of the data file without having to look at all data. If a table have 1000 rows this is at least 100 times faster than reading sequentially. Note that is you need to access almost all 1000 rows it is faster to read sequentially since we when avoid disk seeks.

All MySQL indexes (PRIMARY, UNIQUE and INDEX) are stored in B-trees. Strings are automatically prefix- and end-space compressed. See Section 7.27 [CREATE INDEX], page 227.

Indexes are used to:

• Quickly find the rows that match a WHERE clause.

• Retrieve rows from other tables when performing joins.

• Find the MAX() or MIN() value for a specific indexed column.

• Sort or group a table if the sorting or grouping is done on a leftmost prefix of a usable key (e.g., ORDER BY key_part_1,key_part_2). The key is read in reverse order if all key parts are followed by DESC.

• In some cases a query can be optimized to retrieve values without consulting the data file. If all used columns for some table are numeric and form a leftmost prefix for some key, the values may be retrieved from the index tree for greater speed.
Suppose you issue the following SELECT statement:

```
mysql> SELECT * FROM tbl_name WHERE col1=val1 AND col2=val2;
```

If a multiple-column index exists on `col1` and `col2`, the appropriate rows can be fetched directly. If separate single-column indexes exist on `col1` and `col2`, the optimizer tries to find the most restrictive index by deciding which index will find fewer rows and using that index to fetch the rows.

If the table has a multiple-column index, any leftmost prefix of the index can be used by the optimizer to find rows. For example, if you have a three-column index on `(col1,col2,col3)`, you have indexed search capabilities on `(col1)`, `(col1,col2)` and `(col1,col2,col3)`. MySQL can’t use a partial index if the columns don’t form a leftmost prefix of the index.

Suppose you have the SELECT statements shown below:

```
mysql> SELECT * FROM tbl_name WHERE col1=val1;
mysql> SELECT * FROM tbl_name WHERE col2=val2;
mysql> SELECT * FROM tbl_name WHERE col2=val2 AND col3=val3;
```

If an index exists on `(col1,col2,col3)`, only the first query shown above uses the index. The second and third queries do involve indexed columns, but `(col2)` and `(col2,col3)` are not leftmost prefixes of `(col1,col2,col3)`. MySQL also uses indexes for LIKE comparisons if the argument to LIKE is a constant string that doesn’t start with a wildcard character. For example, the following SELECT statements use indexes:

```
mysql> select * from tbl_name where key_col LIKE "Patrick%";
mysql> select * from tbl_name where key_col LIKE "Pat%ck%";
```

In the first statement, only rows with "Patrick" \(<=\) key_col < "Patricl" are considered. In the second statement, only rows with "Pat" \(<=\) key_col < "Pau" are considered.

The following SELECT statements will not use indexes:

```
mysql> select * from tbl_name where key_col LIKE "%Patrick%";
mysql> select * from tbl_name where key_col LIKE other_col;
```

In the first statement, the LIKE value begins with a wildcard character. In the second statement, the LIKE value is not a constant.

Searching using `column_name IS NULL` will use indexes if `column_name` is a index.

MySQL normally uses the index that finds least number of rows. An index is used for columns that you compare with the following operators: `=, >, >=, <, <=, BETWEEN` and a LIKE with a non-wildcard prefix like 'something%'.

Any index that doesn’t span all AND levels in the WHERE clause is not used to optimize the query. In other words: To be able to use an index, a prefix of the index must be used in every AND group.

The following WHERE clauses use indexes:

```
... WHERE index_part1=1 AND index_part2=2 AND other_column=3
... WHERE index=1 OR A=10 AND index=2 /* index = 1 OR index = 2 */
... WHERE index_part1='hello' AND index_part_3=5
    /* optimized like "index_part1="hello" " */
... WHERE index1=1 and index2=2 or index1=3 and index3=3;
```
11.5 Speed of queries that access or update data

First, one thing that affects all queries: The more complex permission system setup you have, the more overhead you get.

If you do not have any GRANT statements done MySQL will optimize the permission checking somewhat. So if you have a very high volume it may be worth the time to avoid grants. Otherwise more permission check results in a larger overhead.

If your problem is with some explicit MySQL function, you can always time this in the MySQL client:

```sql
mysql> select benchmark(1000000,1+1);
+------------------------+
| benchmark(1000000,1+1) |
+------------------------+
| 0 |
+------------------------+
1 row in set (0.32 sec)
```

The above shows that MySQL can execute 1,000,000 + expressions in 0.32 seconds on a PentiumII 400MHz.

All MySQL functions should be very optimized, but there may be some exceptions and the `benchmark(loop_count,expression)` is a great tool to find if this is a problem with your query.

### 11.5.1 Estimating query performance

In most cases you can estimate the performance by counting disk seeks. For small tables you can usually find the row in 1 disk seek (as the index is probably cached). For bigger tables, you can estimate that, (using B++ tree indexes), you will need:

```
log(row_count) / log(index_block_length / 3 * 2 / (index_length + data_pointer_length)) + 1
```

seeks to find a row.

In MySQL an index block is usually 1024 bytes and the data pointer is usually 4 bytes, which gives for a 500,000 row table with a index length of 3 (medium integer) gives you:

```
log(500,000) / log(1024/3*2/(3+4)) + 1 = 4
```

As the above index would require about 500,000 * 7 * 3/2 = 5.2M, (assuming that the index buffers are filled to 2/3 (which is typical) you will probably have much of the index in memory and you will probably only need 1-2 calls to read data from the OS to find the row.
For writes you will however need 4 seek requests (as above) to find where to place the new index and normally 2 seeks to update the index and write the row.

Note that the above doesn’t mean that your application will slowly degenerate by \( N \log N \)! As long as everything is cached by the OS or SQL server things will only go marginally slower while the table gets bigger. After the data gets too big to be cached, things will start to go much slower until your applications is only bound by disk-seeks (which increase by \( N \log N \)). To avoid this increase the index cache as the data grows. See Section 11.2.3 [Server parameters], page 278.

11.5.2 Speed of SELECT queries

In general, when you want to make a slow \( \text{SELECT} \ldots \text{WHERE} \) faster, the first thing to check is whether or not you can add an index. See Section 11.4 [MySQL indexes], page 289. All references between different tables should usually be done with indexes. You can use the \texttt{EXPLAIN} command to determine which indexes are used for a \( \text{SELECT} \). See Section 7.22 [\texttt{EXPLAIN}], page 216.

Some general tips:

- To help MySQL optimize queries better, run \texttt{myisamchk \--analyze} on a table after it has been loaded with relevant data. This updates a value for each index part that indicates the average number of rows that have the same value. (For unique indexes, this is always 1, of course.) MySQL will use this to decide which index to choose when you connect two tables with ‘a not constant expression’. You can check the result from the analyze run by doing \texttt{SHOW INDEX \FROM \table\_name} and examining the \texttt{Cardinality} column.

- To sort an index and data according to an index, use \texttt{myisamchk \--sort-index \--sort-records=1} (if you want to sort on index 1). If you have a unique index from which you want to read all records in order according to that index, this is a good way to make that faster. Note however that this sorting isn’t written optimally and will take a long time for a large table!

11.5.3 How MySQL optimizes \texttt{WHERE} clauses

The where optimizes are put in the \texttt{SELECT} part here since they are mostly used there. But the same optimizations are used for there in \texttt{DELETE} and \texttt{UPDATE} statements.

Also note that this section is incomplete. MySQL does many optimizations and we have not had time to document them all.

Some of the optimizations performed by MySQL are listed below:

- Removal of unnecessary parentheses:
  \[
  ((a \text{ AND } b) \text{ AND } c \text{ OR } ((a \text{ AND } b) \text{ AND } (c \text{ AND } d)) \]
  \[
  \rightarrow (a \text{ AND } b \text{ AND } c) \text{ OR } (a \text{ AND } b \text{ AND } c \text{ AND } d)
  \]

- Constant folding:
(a<b AND b=c) AND a=5
-> b>5 AND b=c AND a=5

- Constant condition removal (needed because of constant folding):
  (B>=5 AND B=5) OR (B=6 AND 5=5) OR (B=7 AND 5=6)
-> B=5 OR B=6

- Constant expressions used by indexes are evaluated only once.
- COUNT(*) on a single table without a WHERE is retrieved directly from the table information. This is also done for any NOT NULL expression when used with only one table.
- Early detection of invalid constant expressions. MySQL quickly detects that some SELECT statements are impossible and returns no rows.
- HAVING is merged with WHERE if you don’t use GROUP BY or group functions (COUNT(), MIN()...)
- For each sub join, a simpler WHERE is constructed to get a fast WHERE evaluation for each sub join and also to skip records as soon as possible.
- All constant tables are read first, before any other tables in the query. A constant table is:
  - An empty table or a table with 1 row.
  - A table that is used with a WHERE clause on a UNIQUE index, or a PRIMARY KEY, where all index parts are used with constant expressions and the index parts are defined as NOT NULL.

All the following tables are used as constant tables:

```sql
mysql> SELECT * FROM t WHERE primary_key=1;
mysql> SELECT * FROM t1,t2
    WHERE t1.primary_key=1 AND t2.primary_key=t1.id;
```

- The best join combination to join the tables is found by trying all possibilities :(. If all columns in ORDER BY and in GROUP BY come from the same table, then this table is preferred first when joining.
- If there is an ORDER BY clause and a different GROUP BY clause, or if the ORDER BY or GROUP BY contains columns from tables other than the first table in the join queue, a temporary table is created.
- If you use SQL_SMALL_RESULT, MySQL will use an in-memory temporary table.
- As DISTINCT is converted to a GROUP BY on all columns, DISTINCT combined with ORDER BY will in many cases also need a temporary table.
- Each table index is queried and the best index that spans fewer than 30% of the rows is used. If no such index can be found, a quick table scan is used.
- In some cases, MySQL can read rows from the index without even consulting the data file. If all columns used from the index are numeric, then only the index tree is used to resolve the query.
- Before each record is output, those that do not match the HAVING clause are skipped.

Some examples of queries that are very fast:
### 11.5.4 How MySQL optimizes LEFT JOIN

A `LEFT JOIN` B is in MySQL implemented as follows:

- The table B is set to be dependent on table A and all tables that A is dependent on.
- The table A is set to be dependent on all tables (except B) that are used in the `LEFT JOIN` condition.
- All `LEFT JOIN` conditions are moved to the `WHERE` clause.
- All standard join optimizations are done, with the exception that a table is always read after all tables it is dependent on. If there is a circular dependence then MySQL will issue an error.
- All standard `WHERE` optimizations are done.
- If there is a row in A that matches the `WHERE` clause, but there wasn’t any row in B that matched the `LEFT JOIN` condition, then an extra B row is generated with all columns set to `NULL`.
- If you use `LEFT JOIN` to find rows that doesn’t exist in some table and you have the following test: `column_name IS NULL` in the `WHERE` part, where `column_name` is a column that is declared as `NOT NULL`, then MySQL will stop searching after more rows (for a particular key combination) after it has found one row that matches the `LEFT JOIN` condition.

The table read order forced by `LEFT JOIN` and `STRAIGHT JOIN` will help the join optimizer (which calculates in which order tables should be joined) to do its work much quickly as there are fewer table permutations to check.

Note that the above means that if you do a query of type:
SELECT * FROM a, b LEFT JOIN c ON (c.key=a.key) LEFT JOIN d (d.key=a.key) WHERE b.key = d.key

Then MySQL will do a full scan on b as the LEFT JOIN will force it to be read before d.

The fix in this case is to change the query to:

SELECT * FROM b, a LEFT JOIN c ON (c.key=a.key) LEFT JOIN d (d.key=a.key) WHERE b.key = d.key

11.5.5 How MySQL optimizes LIMIT

In some cases MySQL will handle the query differently when you are using LIMIT # and not using HAVING:

- If you are selecting only a few rows with LIMIT, MySQL will use indexes in some cases when it normally would prefer to do a full table scan.
- If you use LIMIT # with ORDER BY, MySQL will end the sorting as soon as it has found the first # lines instead of sorting the whole table.
- When combining LIMIT # with DISTINCT, MySQL will stop as soon as it finds # unique rows.
- In some cases a GROUP BY can be resolved by reading the key in order (or do a sort on the key) and then calculate summaries until the key value changes. In this case LIMIT # will not calculate any unnecessary GROUP's.
- As soon as MySQL has sent the first # rows to the client, it will abort the query.
- LIMIT 0 will always quickly return an empty set. This is useful to check the query and to get the column types of the result columns.
- The size of temporary tables uses the LIMIT # to calculate how much space is needed to resolve the query.

11.5.6 Speed of INSERT queries

The time to insert a record consists approximately of:

- Connect: (3)
- Sending query to server: (2)
- Parsing query: (2)
- Inserting record: (1 x size of record)
- Inserting indexes: (1 x number of indexes)
- Close: (1)

Where the numbers are somewhat proportional to the overall time. This does not take into consideration the initial overhead to open tables (which is done once for each concurrently-running query).

The size of the table slows down the insertion of indexes by N log N (B-trees).

Some ways to speed up inserts:

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• If you are inserting many rows from the same client at the same time use multiple value lists \texttt{INSERT} statements. This is much faster (many times in some cases) than using separate \texttt{INSERT} statements.

• If you are inserting a lot of rows from different clients, you can get higher speed by using the \texttt{INSERT DELAYED} statement. See Section 7.14 [\texttt{INSERT}], page 201.

• Note that with \texttt{MyISAM} you can insert rows at the same time \texttt{SELECT}s are running if there are no deleted rows in the tables.

• When loading a table from a text file, use \texttt{LOAD DATA INFILE}. This is usually 20 times faster than using a lot of \texttt{INSERT} statements. See Section 7.16 [\texttt{LOAD DATA}], page 204.

• It is possible with some extra work to make \texttt{LOAD DATA INFILE} run even faster when the table has many indexes. Use the following procedure:
  1. Optionally create the table with \texttt{CREATE TABLE}. For example using \texttt{mysql} or Perl-DBI.
  2. Execute a \texttt{FLUSH TABLES} statement or the shell command \texttt{mysqladmin flush-tables}.
  3. Use \texttt{myisamchk --keys-used=0 -rq /path/to/db/tbl_name}. This will remove all usage of all indexes from the table.
  4. Insert data into the table with \texttt{LOAD DATA INFILE}. This will not update any indexes and will therefore be very fast.
  5. If you have \texttt{myisampack} and want to compress the table, run \texttt{myisampack} on it. See Section 8.1.2.3 [Compressed format], page 235.
  6. Recreate the indexes with \texttt{myisamchk -r -q /path/to/db/tbl_name}. This will create the index tree in memory before writing it to disk, which is much faster since it avoid lots of disk seeks. The resulting index tree is also perfectly balanced.
  7. Execute a \texttt{FLUSH TABLES} statement or the shell command \texttt{mysqladmin flush-tables}.

This procedure will be built into \texttt{LOAD DATA INFILE} in some future version of MySQL.

• You can speed up insertions by locking your tables:

  \begin{verbatim}
  mysql> LOCK TABLES a WRITE;
  mysql> INSERT INTO a VALUES (1,23),(2,34),(4,33);
  mysql> INSERT INTO a VALUES (8,26),(6,29);
  mysql> UNLOCK TABLES;
  \end{verbatim}

The main speed difference is that the index buffer is flushed to disk only once, after all \texttt{INSERT} statements have completed. Normally there would be as many index buffer flushes as there are different \texttt{INSERT} statements. Locking is not needed if you can insert all rows with a single statement.

Locking will also lower the total time of multi-connection tests, but the maximum wait time for some threads will go up (because they wait for locks). For example:

  thread 1 does 1000 inserts
  thread 2, 3, and 4 does 1 insert
  thread 5 does 1000 inserts
If you don’t use locking, 2, 3 and 4 will finish before 1 and 5. If you use locking, 2, 3
and 4 probably will not finish before 1 or 5, but the total time should be about 40% faster.

As INSERT, UPDATE and DELETE operations are very fast in MySQL, you will obtain
better overall performance by adding locks around everything that does more than
about 5 inserts or updates in a row. If you do very many inserts in a row, you could do
a LOCK TABLES followed by a UNLOCK TABLES once in a while (about each 1000 rows) to
allow other threads access to the table. This would still result in a nice performance
gain.

Of course, LOAD DATA INFILE is much faster still for loading data.

To get some more speed for both LOAD DATA INFILE and INSERT, enlarge the key buffer.
See Section 11.2.3 [Server parameters], page 278.

11.5.7 Speed of UPDATE queries

Update queries are optimized as a SELECT query with the additional overhead of a write.
The speed of the write is dependent on the size of the data that are being updated and the
number of indexes that are updated. Indexes that are not changed will not be updated.
Also another way to get fast updates is to delay updates and then do many updates in a
row later. Doing many updates in a row is much quicker than doing one at a time if you
lock the table.

Not that with dynamic record format updating a record with to a longer total length may
split the record. So if you do this often it is very important to OPTIMIZE TABLE sometimes.
See Section 7.9 [OPTIMIZE TABLE], page 195.

11.5.8 Speed of DELETE queries

The time to delete a record is exactly proportional to the number of indexes. To delete
records more quickly, you can increase the size of the index cache. See Section 11.2.3 [Server
parameters], page 278.
Its also much faster to remove all rows than to remove a big part of the rows from a table.

11.6 Other optimization tips

Unsorted tips for faster systems:

- Use persistent connections to the database to avoid the connection over head.
- Always check that all your queries really uses the indexes you have created in the tables.
In MySQL you can do this with the EXPLAIN command. See Section 7.22 [Explain],
page 216.
- Try to avoid complex SELECT queries on tables that are updated a lot. This is to avoid
problems with table locking.
The new MyISAM tables can insert rows in a table without deleted rows at the same
time another table is reading from it. If this is important for you, you should consider
methods where you don’t have to delete rows or run OPTIMIZE TABLE after you have
deleted a lot of rows.

In some cases it may make sense to introduce a column that is 'hashed' based on
information from other columns. If this column is short and reasonable unique it may
be much faster than a big index on many columns. In MySQL its very easy to use
this extra column: SELECT * from table where hash='calculated hash on col1 and
col2' and col_1='constant' and col_2='constant' and ..

For tables that changes a lot you should try to avoid all VARCHAR or BLOB columns.
You will get dynamic row length as soon as you are using a single VARCHAR or BLOB
columns. See Chapter 8 [Table types], page 232.

It’s not normally useful to split a table into different tables just because the rows gets
'big'. To access a row, the biggest performance hit is the disk seek to find the first byte
of the row. After finding the data most new disks can read the whole row fast enough
for most applications. The only cases it really matters to split up a table is if its a
dynamic row size table (see above) that you can change to a fixed row size. Or if you
very often need to scan the table and don’t need most of the columns. See Chapter 8
[Table types], page 232.

If you very often need to calculate things based on information from a lot of rows
(like counts of things) it’s probably much better to introduce a new table and update
the counter in real time. An update of type UPDATE table set count=count+1 where
index_column=constant is very fast!
This is really important when you use databases like MySQL that only has table locking
(multiple readers / single writers). This will also give better performance with most
databases as the row locking manager in this case will have less to do.

If you need to collect statistics from big log tables use summary tables instead of
scanning the whole table. Maintaing the summarys should be much faster than trying
to do statistics 'live'. It’s much faster to re-generate new summary tables from the
logs when things changes (depending on business decisions) than to have to change the
running application!

If possible one should classify reports as 'live' or 'statistical', where data needed for
statistical reports are only generated based on summary tables that are generated from
the actual data.

Take advantage of the fact that columns have default values. Insert values explicitly
only when the value to be inserted differs from the default. This reduces the parsing
that MySQL need to do and improves the insert speed.

In some cases its convenient to pack and store data into a blob In this case you have
to add some extra code in your appllication to pack/unpack things in the blob but this
may save a lot of accesses at some stage. This is practical when you have data that
doesn’t conform to a static table structure.

Normally you should try to keep all data non-redundant (what is called 3rd normal
form in database theory), but you should not be afraid of duplicating things or creating
summary tables if you need these to gain more speed.
• Stored procedures or UDF (user defined functions) may be a good way to get more performance. In this case you should however always have a way to do this some other (slower) way if you use some database that doesn’t support this.

• You can always gain something by caching queries/answers in your application and try to do many inserts/updates at the same time. If your database supports lock tables (like MySQL and Oracle), this should help to ensure that the index cache is only flushed once after all updates.

• Use `INSERT /*! DELAYED */` when you do not need to know when your data is written. This speeds things up since many records can be written with a single disk write.

• Use `INSERT /*! LOW_PRIORITY */` when you want your selects are more important.

• Use `SELECT /*! HIGH_PRIORITY */` to get selects that jumps the queue. That is the select is done even if there is somebody waiting to do a write.

• Use the multi-line `INSERT` statement to store many rows with one SQL command (many SQL servers supports this)

• Use `LOAD DATA INFILE` to load bigger amounts of data. This if faster than normal inserts and will be even faster when `myisamchk` is integrated in `mysqld`

• Use `AUTO_INCREMENT` columns to make unique values.

• Use `OPTIMIZE TABLE` once in a while to avoid fragmentation when using dynamic table format. See Section 7.9 [OPTIMIZE TABLE], page 195.

• Use `HEAP` tables to get more speed when possible. See Chapter 8 [Table types], page 232.

• When using a normal Web server setup, images should be stored as files. That is store only a file reference in the database. The main reason for this is that a normal web server is much better at caching files than database contents. So it it’s much easier to get a fast system if you are using files.

• Use in memory tables for not critical data that are accessed often (like information about the last shown banner for users that doesn’t have cookies)

• Columns with identical information in different tables should be declared identical and have identical names. Before version 3.23 you got slow joins otherwise.

• Try to keep the names simple (use `name` instead of `customer_name` in the customer table). To make your names portable to other SQL servers you should keep them shorter than 18 characters.

• If you need REALLY high speed you should take a look at the low level interfaces for data storage that the different SQL servers support! For example by accessing the MySQL MyISAM directly you could get a speed increase of 2-5 times compared to using the SQL interface. The be able to do this the data must however be on the same server as the application and usually it should only be accessed by on processes (because external file locking is real slow). One could eliminate the above problems by introducing low level MyISAM commands in the MySQL server (this could be one easy way to get more performance if needed). By carefully designing the database interface it should be quite easy to support this types of optimisations.

• In many cases it’s faster to access data from a database (using a live connection) than accessing a text file, just because the database is likely to be more compact than the text file (if you are using numerical data) and this will involve fewer disk accesses.
You will also save code because you don’t have to parse your text files to find line and column boundaries.

- You can also use replication to speed things up. See Section 20.1 [Replication], page 368.
- Declaring a table with `DELAY_KEY_WRITE=1` will make the updating of indexes faster as these are not logged to disk until the file is closed. The downside is that you should run `myisamchk` on these tables before you start `mysqld` to ensure that they are ok if something killed `mysqld` in the middle. As the key information can always be generated from the data you should not lose anything by using `DELAY_KEY_WRITE`.

11.7 Using your own benchmarks

You should definitely benchmark your application and database to find out where is the bottlenecks. By fixing it (or by replacing the bottleneck with a ’dummy module’) you can then easily identify the next bottleneck (and so on). Even if the overall performance for your application is ’good enough’ you should at least make a ’plan’, for each bottleneck, how to solve it if you someday ’really need it fix it’.

For some example portable benchmark programs look at the MySQL benchmark suite. See Chapter 12 [MySQL Benchmarks], page 304. You can take any program this suite and modify it for your needs. By doing this, you can try different solutions to your problem and test which is really the fastest solution for you.

It is very common that some problems only occur then the system is very heavily loaded. And we have had many customer who contacts us then they have a (tested) system in production and have got load problems. In every on these cases so far it has been problems with basic design (table scans are NOT good at high load) or OS/Library issues. Most of this would be a LOT easier to fix if the system where not already in production.

To avoid problems like this you should put some effort into benchmarking your whole application under the worst possible load!

11.8 Design choices

MySQL keeps row data and index data in separate files. Many (almost all) other databases mix row and index data in the same file. We believe that the MySQL choice is better for a very wide range of modern systems.

Another way to store the row data is to keep the information for each column in a separate area (examples are SDBM and Focus). This will get a performance hit for every query that access more than one column. Since this degenerates so quickly when more that when one columns are accessed we believe that this model is not good for general purpose databases.

The more common case is there the index and data are stored together (like in Oracle/Sybase at all). In this case you will find the row information at the leaf page of the index. The good thing with this layout is that it in many cases (depends on how well the index is cached) saves a disk read. The bad things with this layout is:
Table scanning is much slower since you have to read through the indexes to get at the data.

- You lose a lot of space as you must duplicate indexes from the nodes (as you can’t store the row in the nodes)
- Deletes will degenerate the table over time (as indexes in nodes are usually not updated on delete).
- You can’t use only the index table to retrieve data for a query.
- The index data is harder to cache.

11.9 MySQL design limitations/tradeoffs

Since MySQL uses extremely fast table locking (multiple readers / single writers) the biggest remaining problem is a mix of a steady stream of inserts and slow selects on the same table. We believe that for a huge number of systems the extremely fast performance in other cases make this choice a win. This case is usually also possible to solve by having multiple copies of the table. But it takes more effort and hardware.

We are also working on some extension to solve this problem for some common application niches.

11.10 Portability

Since all SQL servers implement different parts of SQL it takes work to write portable SQL applications. For very simple selects/inserts it is very easy but the more you need the harder it gets. And if you want a application that is fast with many databases it becomes even harder!

To make a complex application portable you need to choose a number of SQL server that it should work with.

When you can use the MySQL crash-me program/web-page http://www.mysql.com/crash-me-choose.html to find functions, types and limits you can use with a selection of database servers. Crash-me now test a long way from everything possible but it still is comprehensive with about 450 things tested.

For example, you shouldn’t have longer column names than 18 characters if you want to be able to use Informix or DB2.

Both the MySQL benchmarks and Crash-me programs are very database independent. By taking a look of how we have handled this, you can get a feeling of what you have to do to write your application database independent. The benchmark themselves can be found in the ‘sql-bench’ directory in the MySQL source distribution. They are written in Perl with DBI database interface (which solves the access part of the problem.

See http://www.mysql.com/benchmark.html the results from this benchmark.
As you can see in these results all databases has some weak points. That is they have different design compromises that lead to different behavior.

If you strive for database independence you need to get a good feeling of each SQL servers bottlenecks. **MySQL** is VERY fast in retrieving and updating things, but will have a problem in mixing slow readers/writers on the same table. Oracle on the other hand has a big problem when you try to access rows that you have recently updated (until they are flushed to disk). Transaction databases in general are not very good in generating summary tables from log tables as in this case row locking is almost useless.

To get your application ‘really database independent’ you need to define a easy extendable interface through which you manipulate your data. As C++ is available on most systems, it makes sense to use a C++ classes interface to the databases.

If you use some specific feature for some database (like the `REPLACE` command in **MySQL**), you should code a method for the other SQL servers to implement the same feature (but slower). With **MySQL** you can use the `/*! */` syntax to add **MySQL** specific keywords to a query. The code inside `/**/` will be treated as a comment (ignored) by most other SQL servers.

If REAL high performance is more important than exactness, like in some web applications. A possibility is to create a application layer that caches all results to give you even higher performance. By just letting old results ‘expire’ after a while you can keep the cache reasonable fresh. This is quite nice in case of extremely high load, in which case you can dynamically increase the cache to be bigger and set the expire timeout higher until things gets back to normal.

In this case the table creating information should contain information of the initial size of the cache and how often the table should normally be refreshed.

### 11.11 What have we used **MySQL** for?

During **MySQL** initial development the features of **MySQL** where made to fit our largest customer. They handle data warehousing for a couple of the biggest retailers in Sweden.

We get from all stores weekly summaries of all bonus card transactions and we are expected to provide useful information for the store owners to help them find how their advertisements campaigns are affecting their customers.

The data is quite huge (about 7 million summary transactions per month) and we have data for 4-10 years that we need to present to the users. We got weekly requests from the customers that they want to get ‘instant’ access to new reports from this data.

We solved this by storing all information per month in compressed ‘transaction’ tables. We have a set of simple macros/script that generate summary tables grouped by different criterias (product group, customer id, store ...) from the transaction tables. The reports are web pages that are dynamically generated by a small Perl script that parses a web pages, executes the SQL statements in it and inserts the results. Now we would have used PHP or mod_perl instead but they where not available at that time.

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For graphical data we wrote a simple tool in C that can produce gifs based on the result of a SQL query (with some processing of the result). This is also dynamically executed from the Perl script that parses the HTML files.

In most cases a new report can simple by done by copying a existing script and modifying the SQL query in it. In some cases we will need to add more fields to an existing summary table or generate a new one, but this is also quite simply as we keep all transactions tables on disk. (Currently we have at least 50G of transactions tables and 200G of other customer data).

We also let our customers access the summary tables directly with ODBC so that the advanced users can themselves experiment with the data.

We haven’t had any problems handling this with quite modest Sun Ultra sparcstation (2x200 Mz). We recently upgrade one of our servers to a 2 CPU 400 Mz Ultra sparc and we are now planing to start handling transactions on the product level, which would mean a 10 fold increase of data. We think we can keep up with this by just adding more disk to our systems.

We are also experimenting with Intel-Linux to be able to get more cpu power cheaper. Now that we have the binary portable database format (new in 3.32) we will start to use this for some parts of the application.

Our initial feelings are that Linux will perform much better on low to medium load but Solaris will perform better when you start to get a a high load because of extrema disk IO, but we don’t yet have anything conclusive about this. After some discussion with a Linux Kernel developer this might be a side effect of Linux giving so much resources to the batch job that the interactive performance gets very low. Hopefully this will be better handled in future Linux Kernels.
12 The MySQL benchmark suite

This should contain a technical description of the MySQL benchmark suite (and crash-me) but that description is not written yet. Currently, you should look at the code and results in the ‘sql-bench’ directory in the distribution (and of course on the web page at http://www.mysql.com/crash-me-choose.html and (normally found in the ‘sql-bench’ directory in the MySQL distribution)).

It is meant to be a benchmark that will tell any user what things a given SQL implementation performs well or poorly at.

Note that this benchmark is single threaded so it measures the minimum time for the operations.

For example (run on the same NT 4.0 machine):

<table>
<thead>
<tr>
<th>Reading 2000000 rows by index</th>
<th>Seconds</th>
<th>Seconds</th>
</tr>
</thead>
<tbody>
<tr>
<td>mysql</td>
<td>367</td>
<td>249</td>
</tr>
<tr>
<td>mysql_odbc</td>
<td>464</td>
<td></td>
</tr>
<tr>
<td>db2_odbc</td>
<td>1206</td>
<td></td>
</tr>
<tr>
<td>informix_odbc</td>
<td>121126</td>
<td></td>
</tr>
<tr>
<td>ms-sql_odbc</td>
<td>1634</td>
<td></td>
</tr>
<tr>
<td>oracle_odbc</td>
<td>20800</td>
<td></td>
</tr>
<tr>
<td>solid_odbc</td>
<td>877</td>
<td></td>
</tr>
<tr>
<td>sybase_odbc</td>
<td>17614</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Inserting (350768) rows</th>
<th>Seconds</th>
<th>Seconds</th>
</tr>
</thead>
<tbody>
<tr>
<td>mysql</td>
<td>381</td>
<td>206</td>
</tr>
<tr>
<td>mysql_odbc</td>
<td>619</td>
<td></td>
</tr>
<tr>
<td>db2_odbc</td>
<td>3460</td>
<td></td>
</tr>
<tr>
<td>informix_odbc</td>
<td>2692</td>
<td></td>
</tr>
<tr>
<td>ms-sql_odbc</td>
<td>4012</td>
<td></td>
</tr>
<tr>
<td>oracle_odbc</td>
<td>11291</td>
<td></td>
</tr>
<tr>
<td>solid_odbc</td>
<td>1801</td>
<td></td>
</tr>
<tr>
<td>sybase_odbc</td>
<td>4802</td>
<td></td>
</tr>
</tbody>
</table>

In the above test MySQL was run with a 8M index cache.

Note that Oracle is not included since they asked to be removed. All Oracle benchmarks has to be passed by Oracle! We believe that makes Oracle benchmarks VERY biased since the above benchmarks are supposed to show that a standard installation can do for a single client.

crash-me tries to determine what features a database supports and what its capabilities and limitations are by actually running queries. For example, it determines:

- What column types are supported
- How many indexes are supported
- What functions are supported
- How big a query can be
- How big a VARCHAR column can be
13 MySQL Utilities

13.1 Overview of the different MySQL programs

All MySQL clients that communicate with the server using the mysqlclient library use the following environment variables:

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MYSQL_UNIX_PORT</td>
<td>The default socket; used for connections to localhost</td>
</tr>
<tr>
<td>MYSQL_TCP_PORT</td>
<td>The default TCP/IP port</td>
</tr>
<tr>
<td>MYSQL_PWD</td>
<td>The default password</td>
</tr>
<tr>
<td>MYSQL_DEBUG</td>
<td>Debug-trace options when debugging</td>
</tr>
<tr>
<td>TMPDIR</td>
<td>The directory where temporary tables/files are created</td>
</tr>
</tbody>
</table>

Use of `MYSQL_PWD` is insecure. See Section 6.5 [Connecting], page 110.

The `mysql` client uses the file named in the `MYSQL_HISTFILE` environment variable to save the command line history. The default value for the history file is `$HOME/.mysql_history`, where `$HOME` is the value of the `HOME` environment variable.

All MySQL programs take many different options. However, every MySQL program provides a `--help` option that you can use to get a full description of the program’s different options. For example, try `mysql --help`.

You can override default options for all standard client programs with an option file. See Section 4.15.4 [Option files], page 89.

The list below briefly describes the MySQL programs:

- `myisamchk` Utility to describe, check, optimize and repair MySQL tables. Because `myisamchk` has many functions, it is described in its own chapter. See Chapter 14 [Maintenance], page 323.

- `make_binary_release` Makes a binary release of a compiled MySQL. This could be sent by FTP to `/pub/mysql/Incoming` on ftp.tcx.se for the convenience of other MySQL users.

- `msql2mysql` A shell script that converts mSQL programs to MySQL. It doesn’t handle all cases, but it gives a good start when converting.

- `mysqlaccess` A script that checks the access privileges for a host, user and database combination.

- `mysqladmin` Utility for performing administrative operations, such as creating or dropping databases, reloading the grant tables, flushing tables to disk and reopening...
log files. `mysqladmin` can also be used to retrieve version, process and status information from the server. See Section 13.3 [mysqladmin], page 309.

`mysqlbug` The MySQL bug report script. This script should always be used when filing a bug report to the MySQL list.

`mysqld` The SQL daemon. This should always be running.

`mysqldump` Dumps a MySQL database into a file as SQL statements or as tab-separated text files. Enhanced freeware originally by Igor Romanenko. See Section 13.4 [mysqldump], page 310.

`mysqlimport` Imports text files into their respective tables using LOAD DATA INFILE. See Section 13.5 [mysqlimport], page 313.

`mysqlshow` Displays information about databases, tables, columns and indexes.

`mysql_install_db` Creates the MySQL grant tables with default privileges. This is usually executed only once, when first installing MySQL on a system.

`replace` A utility program that is used by `msql2mysql`, but that has more general applicability as well. `replace` changes strings in place in files or on the standard input. Uses a finite state machine to match longer strings first. Can be used to swap strings. For example, this command swaps a and b in the given files:

```
shell> replace a b b a -- file1 file2 ...
```

`safe_mysqld` A script that starts the mysqld daemon with some safety features, such as restarting the server when an error occurs and logging runtime information to a log file.

### 13.2 The command line tool

`mysql` is a simple SQL shell (with GNU `readline` capabilities). It supports interactive and non-interactive use. When used interactively, query results are presented in an ASCII-table format. When used non-interactively (e.g., as a filter), the result is presented in tab-separated format. (The output format can be changed using command-line options.) You can run scripts simply like this:

```
shell> mysql database < script.sql > output.tab
```

If you have problems due to insufficient memory in the client, use the `--quick` option! This forces `mysql` to use `mysql_use_result()` rather than `mysql_store_result()` to retrieve the result set.

Using `mysql` is very easy; Just start it as follows `mysql database` or `mysql --user=user_name --password=your_password database`. Type a SQL statement, end it with ‘;’, ‘\g’ or ‘\G’ and press return/enter.
mysql supports the following options:

-? , --help
  Display this help and exit

-A , --no-auto-rehash
  No automatic rehashing. One has to use ‘rehash’ to get table and field completion. This gives a quicker start of mysql.

-B , --batch
  Print results with a tab as separator, each row on a new line. Doesn’t use history file

-C , --compress
  Use compression in server/client protocol.

-# , --debug=[...]
  Debug log. Default is ’d:t:o:/tmp/mysql.trace’

-D , --database=..
  Database to use; This is mainly useful in the my.cnf file.

-e , --execute=...
  Execute command and quit.(Output like with -batch)

-E , --vertical
  Print the output of a query (rows) vertically. Without this option you can also force this output by ending your statements with \G.

-f , --force
  Continue even if we get an sql error.

-i , --ignore-space
  Ignore space after function names

-h , --host=...
  Connect to the given host

-H , --html
  Produce HTML output

-L , --skip-line-numbers
  Don’t write line number for errors. Useful when one want’s to compare result files that includes error messages.

-n , --unbuffered
  Flush buffer after each query

-N , --skip-column-names
  Don’t write column names in results

-O , --set-variable var=option
  Give a variable an value. --help lists variables

-o , --one-database
  Only update the default database. This is useful for skipping updates to other database in the update log.
-p[password], --password[=...]
    Password to use when connecting to server. If password is not given on the
    command line it’s asked from the tty. Note that if you use the short form -p
    you can’t have a space between the option and the password.

-P --port=...
    TCP/IP port number to use for connection.

-q, --quick
    Don’t cache result, print it row by row. This may slow down the server if the
    output is suspended. Doesn’t use history file

-r, --raw
    Write column values without escape conversion. Used with --batch

-s, --silent
    Be more silent.

-S, --socket=...
    Socket file to use for connection

-t, --table
    Output in table format. This is default in not batch mode.

-T, --debug-info
    Print some debug info at exit

-u, --user=#
    User for login if not current user

-U, --safe-updates[=#], --i-am-a-dummy[=#]
    Only allow UPDATE and DELETE that uses keys. See below for more information
    about this option. You can reset this option if you have it in your my.cnf
    file by using --safe-updates=0.

-v, --verbose
    More verbose output (-v -v -v gives the table output format)

-V, --version
    Output version information and exit

-w, --wait
    Wait and retry if connection is down instead of aborting.

If you type ‘help’ on the command line, mysql will print out the commands that it supports:
mysql> help

MySQL commands:
help  \h  Display this text
?    \h  Synonym for ‘help’
clear \c  Clear command
connect \r  Reconnect to the server. Optional arguments are db and host
edit  \e  Edit command with $EDITOR
exit  \(\texttt{\(\texttt{q}\)}\) Exit mysql. Same as quit

go  \(\texttt{\(\texttt{g}\)}\) Send command to mysql server

go  \(\texttt{\(\texttt{G}\)}\) Send command to mysql server; Display result vertically

print  \(\texttt{\(\texttt{p}\)}\) Print current command

quit  \(\texttt{\(\texttt{q}\)}\) Quit mysql

rehash  \(\texttt{\(\texttt{\#}\)}\) Rebuild completion hash

source  \(\texttt{\(\texttt{.}\)}\) Execute a SQL script file. Takes a file name as an argument

status  \(\texttt{\(\texttt{s}\)}\) Get status information from the server

use  \(\texttt{\(\texttt{u}\)}\) Use another database. Takes database name as argument

The \texttt{status} command gives you some information about the connection and the server you are using. If you are running in the --safe-updates mode, \texttt{status} will also print the values for the mysql variables that affects your queries.

A useful startup option for beginners (introduced in MySQL 3.23.11) is --safe-mode (or --i-am-a-dummy for users that has at some time done a DELETE FROM table_name but forgot the WHERE clause. When using this option, \texttt{mysql} sends the following command to the MySQL server when opening the connection:

\[
\texttt{SET SQL_SAFE_UPDATES}=1, \texttt{SQL_SELECT_LIMIT}=#select_limit#, \\
\texttt{SQL_MAX_JOIN_SIZE}=#max_join_size#
\]

where \#select_limit# and \#max_join_size# are variables that can be set from the mysql command line. See Section 7.25 [SET OPTION], page 222.

The effect of the above is:

- bullet You are not allowed to do an UPDATE or DELETE statements if you don’t have a key constraint in the WHERE part. One can however force an UPDATE/DELETE by using LIMIT:

\[
\texttt{UPDATE table_name SET not_key_column=# WHERE not_key_column=# LIMIT 1};
\]

- bullet All big results are automatically limited to \#select_limit# rows.

- bullet SELECT’s that will probably need to examine more than \#max_join_size row combinations will be aborted.

### 13.3 Administering a MySQL server

Utility for performing administrative operations. The syntax is:

\[
\texttt{shell> mysqladmin [OPTIONS] command [command-option] command ...}
\]

You can get a list of the options your version of \texttt{mysqladmin} supports by executing \texttt{mysqladmin --help}.

The current \texttt{mysqladmin} supports the following commands:

- create databasename Create a new database.
- drop databasename Delete a database and all its tables.
- extended-status Gives an extended status message from the server.
- flush-hosts Flush all cached hosts.
- flush-logs Flush all logs.
- flush-tables Flush all tables.
- flush-privileges Reload grant tables (same as reload)
Chapter 13: MySQL Utilities

kill id,id,... Kill mysql threads.
password new-password Change old password to new-password
ping Check if mysqld is alive
processlist Show list of active threads in server
reload Reload grant tables
refresh Flush all tables and close and open logfiles
shutdown Take server down
status Gives a short status message from the server
variables Prints variables available
version Get version info from server

All commands can be shortened to their unique prefix. For example:

```
shell> mysqladmin proc stat
+----+-------+-----------+----+-------------+------+-------+------+
| Id | User | Host | db | Command | Time | State | Info |
+----+-------+-----------+----+-------------+------+-------+------+
| 6  | monty | localhost |  | Processlist | 0    | | |
+----+-------+-----------+----+-------------+------+-------+------+
```

The mysqladmin status command result has the following columns:

- **Uptime**: Number of seconds the MySQL server have been up
- **Threads**: Number of active threads (clients)
- **Questions**: Number of questions from clients since mysqld was started
- **Slow queries**: Queries that has taken more than long_query_time seconds
- **Opens**: How many tables mysqld has opened.
- **Flush tables**: Number of flush . . , refresh and reload commands.
- **Open tables**: Number of tables that are open now
- **Memory in use**: Memory allocated directly by the mysqld code (only available when MySQL is compiled with --with-debug)
- **Max memory used**: Maximum memory allocated directly by the mysqld code (only available when MySQL is compiled with --with-debug)

If you do mysqladmin shutdown on a socket (in other words, on a the computer where mysqld is running), mysqladmin will wait until the MySQL pid-file is removed to ensure that the mysqld server has stopped properly.

### 13.4 Dumping the structure and data from MySQL databases and tables

Utility to dump a database or a collection of database for backup or for transferring the data to another SQL server. The dump will contain SQL statements to create the table and/or populate the table.

```
shell> mysqldump [OPTIONS] database [tables]
OR      mysqldump [OPTIONS] --databases [OPTIONS] DB1 [DB2 DB3...]
OR      mysqldump [OPTIONS] --all-databases [OPTIONS]
```

Version: 3.23.11-alpha Printed: 25 February 2000
If you don’t give any tables or use the `--databases` or `--all-databases`, the whole database(s) will be dumped.

You can get a list of the options your version of `mysqldump` supports by executing `mysqldump --help`.

Note that if you run `mysqldump` without `--quick` or `--opt`, `mysqldump` will load the whole result set into memory before dumping the result. This will probably be a problem if you are dumping a big database.

`mysqldump` supports the following options:

`--add-locks`
Add `LOCK TABLES` before and `UNLOCK TABLE` after each table dump. (To get faster inserts into MySQL).

`--add-drop-table`
Add a drop table before each create statement.

`-A, --all-databases`
Dump all the databases. This will be same as `--databases` with all databases selected.

`--allow-keywords`
Allow creation of column names that are keywords. This works by prefixing each column name with the table name.

`-c, --complete-insert`
Use complete insert statements (with column names).

`-C, --compress`
Compress all information between the client and the server if both support compression.

`-B, --databases`
To dump several databases. Note the difference in usage; In this case no tables are given. All name arguments are regarded as databases. `USE db_name;` will be included in the output before each new database.

`--delayed`
Insert rows with the `INSERT DELAYED` command.

`-e, --extended-insert`
Use the new multiline `INSERT` syntax. ( Gives more compact and faster inserts statements)

`-#, --debug[=option_string]`
Trace usage of the program (for debugging).

`--help`
Display a help message and exit.

Version: 3.23.11-alpha Printed: 25 February 2000
--fields-terminated-by=
--fields-enclosed-by=
--fields-optionally-enclosed-by=
--fields-escaped-by=
--fields-terminated-by=

These options are used with the -T option and have the same meaning as the corresponding clauses for LOAD DATA INFILE. See Section 7.16 [LOAD DATA], page 204.

-F, --flush-logs
Flush logs file in the MySQL server before starting the dump.

-f, --force,
Continue even if we get an SQL error during a table dump.

-h, --host=
Dump data from the MySQL server on the named host. The default host is localhost.

-l, --lock-tables.
Lock all tables for starting the dump. The tables are locked with READ LOCAL to allow concurrent inserts in the case of MyISAM tables.

-t, --no-create-info
Don't write table creation info (The CREATE TABLE statement)

-d, --no-data
Don't write any row information for the table. This is very useful if you just want to get a dump of the structure for a table!

--opt Same as --quick --add-drop-table --add-locks --extended-insert --lock-tables. Should give you the fastest possible dump for reading into a MySQL server.

-p your_pass, --password[=your_pass]
The password to use when connecting to the server. If you specify no "=your_pass" part, mysqldump solicits the password from the terminal.

-P port_num, --port=port_num
The TCP/IP port number to use for connecting to a host. (This is used for connections to hosts other than localhost, for which Unix sockets are used.)

-q, --quick
Don't buffer query, dump directly to stdout; Uses mysql_use_result() to do this.

-S /path/to/socket, --socket=/path/to/socket
The socket file to use when connecting to localhost (which is the default host).

-T, --tab=path-to-some-directory
Creates a table_name.sql file, that contains the SQL CREATE commands, and a table_name.txt file, that contains the data, for each give table. NOTE: This only works if mysqldump is run on the same machine as the mysqld daemon.
The format of the .txt file is made according to the --fields-xxx and --lines--xxx options.

-u user_name, --user=user_name
The MySQL user name to use when connecting to the server. The default value is your Unix login name.

-O var=option, --set-variable var=option
Set the value of a variable. The possible variables are listed below.

-v, --verbose
Verbose mode. Print out more information what the program does.

-V, --version
Print version information and exit.

-w, --where='where-condition'
Dump only selected records; Note that QUOTES are mandatory!
"--where=user='jimf'" "-wuserid>1" "-wuserid<1"

The most normal use of mysqldump is probably for making a backup of whole database:
mysqldump --opt database > backup-file.sql
But it’s also very useful to populate another MySQL server with information from a database:
mysqldump --opt database | mysql ---host=remote-host -C database

13.5 Importing data from text files

mysqlimport provides a command line interface to the LOAD DATA INFILE SQL statement. Most options to mysqlimport correspond directly to the same options to LOAD DATA INFILE. See Section 7.16 [LOAD DATA], page 204.

mysqlimport is invoked like this:
shell> mysqlimport [options] database textfile1 [textfile2....]
For each text file named on the command line, mysqlimport strips any extension from the filename and uses the result to determine which table to import the file’s contents into. For example, files named ‘patient.txt’, ‘patient.text’ and ‘patient’ would all be imported into a table named patient.

mysqlimport supports the following options:
-C, --compress
Compress all information between the client and the server if both support compression.

-, --debug=[option_string]
Trace usage of the program (for debugging).

-d, --delete
Empty the table before importing the text file.
These options have the same meaning as the corresponding clauses for LOAD DATA INFILE. See Section 7.16 [LOAD DATA], page 204.

-f, --force
Ignore errors. For example, if a table for a text file doesn’t exist, continue processing any remaining files. Without --force, mysqlimport exits if a table doesn’t exist.

--help
Display a help message and exit.

-h host_name, --host=host_name
Import data to the MySQL server on the named host. The default host is localhost.

-i, --ignore
See the description for the --replace option.

-l, --lock-tables
Lock ALL tables for writing before processing any text files. This ensures that all tables are synchronized on the server.

-L, --local
Read input files from the client. By default, text files are assumed to be on the server if you connect to localhost (which is the default host).

-p your_pass, --password[=your_pass]
The password to use when connecting to the server. If you specify no ‘=your_pass’ part, mysqlimport solicits the password from the terminal.

-P port_num, --port=port_num
The TCP/IP port number to use for connecting to a host. (This is used for connections to hosts other than localhost, for which Unix sockets are used.)

-r, --replace
The --replace and --ignore options control handling of input records that duplicate existing records on unique key values. If you specify --replace, new rows replace existing rows that have the same unique key value. If you specify --ignore, input rows that duplicate an existing row on a unique key value are skipped. If you don’t specify either option, an error occurs when a duplicate key value is found, and the rest of the text file is ignored.

-s, --silent
Silent mode. Write output only when errors occur.

-S /path/to/socket, --socket=/path/to/socket
The socket file to use when connecting to localhost (which is the default host).
-u user_name, --user=user_name

The MySQL user name to use when connecting to the server. The default value is your Unix login name.

-v, --verbose

Verbose mode. Print out more information what the program does.

-V, --version

Print version information and exit.

Here follows a sample run of using mysqlimport:

```bash
$ mysql --version
mysql Ver 9.33 Distrib 3.22.25, for pc-linux-gnu (i686)
$ uname -a
Linux xxx.com 2.2.5-15 #1 Mon Apr 19 22:21:09 EDT 1999 i586 unknown
$ mysql -e 'CREATE TABLE imptest(id INT, n VARCHAR(30))' test
$ ed
  100 Max Sydow
  101 Count Dracula
.
  w imptest.txt
  32
  q
$ od -c imptest.txt
0000000 1 0 0 \t M a x S y d o w \n 1 0
0000020 1 \t C o u n t D r a c u l a \n
$ mysqlimport --local test imptest.txt
  test.imptest: Records: 2 Deleted: 0 Skipped: 0 Warnings: 0
$ mysql -e 'SELECT * FROM imptest' test
+------+---------------+
<table>
<thead>
<tr>
<th>id</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>Max Sydow</td>
</tr>
<tr>
<td>101</td>
<td>Count Dracula</td>
</tr>
</tbody>
</table>
+------+---------------+
```

13.6 Showing databases, tables and columns

mysqlshow can be used to quickly look at which databases exist and their tables and the tables columns.

With the mysql program you can get the same information with the SHOW commands. See Section 7.21 [SHOW], page 211.

mysqlshow is invoked like this:

shell> mysqlshow [OPTIONS] [database [table [column]]]

- If no database is given then all matching databases are shown.
• If no table is given then all matching tables in database are shown
• If no column is given then all matching columns and column types in table are shown

Note that in newer MySQL versions you only see those database/tables/columns on which you have some privilege.

If last argument contains a shell or SQL wildcard (*, ?, % or _) then only what’s matched by the wildcard is shown. This may cause some confusion when you try to display the columns for a table with a _ as in this case mysqlshow only shows you the table names that matches the pattern. This is easily fixed by adding an extra % last on the command line (as a separate argument).

13.7 The MySQL compressed read-only table generator

myisampack is used to compress MyISAM tables and pack_isam is used to compress ISAM tables. Since ISAM tables are deprecated, we will only discuss myisampack here.

myisampack are an extra utility that you get when you order one MySQL licence or MySQL support. Since these are distributed only in binary form, they are available only on some platforms.

In the following we only talk about myisampack, but everything holds also for pack_isam.

myisampack works by compressing each column in the table separately. The information needed to decompress columns is read into memory when the table is opened. This results in much better performance when accessing individual records, since you only have to uncompress exactly one record, not a much larger disk block like when using Stacker on MS-DOS. Usually, myisampack packs the data file 40%-70%.

MySQL uses memory mapping (mmap()) on compressed tables and falls back to normal read/write file usage if mmap() doesn’t work.

There are currently two limitations with myisampack:

• After packing, the table is read only.
• myisampack can also pack BLOB or TEXT columns. The older pack_isam could not do this.

Fixing these limitations is on our TODO list but with low priority.

myisampack is invoked like this:

```
shell> myisampack [options] filename ...
```

Each filename should be the name of an index (’.MYI’) file. If you are not in the database directory, you should specify the pathname to the file. It is permissible to omit the ‘.MYI’ extension.

myisampack supports the following options:

- `--backup`
  Make a backup of the table as tbl_name.OLD.

- `--debug=debug_options`
  Output debug log. The debug_options string often is 'd:t:o, filename'.
-f, --force
Force packing of the table even if it becomes bigger or if the temporary file exists. (myisampack creates a temporary file named ‘tbl_name.TMD’ while it compresses the table. If you kill myisampack, the ‘.TMD’ file may not be deleted. Normally, myisampack exits with an error if it finds that ‘tbl_name.TMD’ exists. With --force, myisampack packs the table anyway.

-?, --help
Display a help message and exit.

-j big_tbl_name, --join=big_tbl_name
Join all tables named on the command line into a single table big_tbl_name. All tables that are to be combined MUST be identical (same column names and types, same indexes, etc.)

-p #, --packlength=#
Specify the record length storage size, in bytes. The value should be 1, 2 or 3. (myisampack stores all rows with length pointers of 1, 2 or 3 bytes. In most normal cases, myisampack can determine the right length value before it begins packing the file, but it may notice during the packing process that it could have used a shorter length. In this case, myisampack will print a note that the next time you pack the same file, you could use a shorter record length.)

-s, --silent
Silent mode. Write output only when errors occur.

-t, --test
Don’t pack table, only test packing it.

-T dir_name, --tmp_dir=dir_name
Use the named directory as the location in which to write the temporary table.

-v, --verbose
Verbose mode. Write info about progress and packing result.

-V, --version
Display version information and exit.

-w, --wait
Wait and retry if table is in use. If the mysql server was invoked with the --skip-locking option, it is not a good idea to invoke myisampack if the table might be updated during the packing process.

The sequence of commands shown below illustrates a typical table compression session:

```
shell> ls -l station.*
-rw-rw-r-- 1 monty my 994128 Apr 17 19:00 station.MYD
-rw-rw-r-- 1 monty my 53248 Apr 17 19:00 station.MYI
-rw-rw-r-- 1 monty my 5767 Apr 17 19:00 station.frm

shell> myisamchk -dvv station

MyISAM file: station
```

Version: 3.23.11-alpha Printed: 25 February 2000
Isam-version: 2
Creation time: 1996-03-13 10:08:58
Recover time: 1997-02-02 3:06:43
Data records: 1192 Deleted blocks: 0
Datafile: Parts: 1192 Deleted data: 0
Datafile pointer (bytes): 2 Keyfile pointer (bytes): 2
Max datafile length: 54657023 Max keyfile length: 33554431
Record length: 834
Record format: Fixed length

table description:
<table>
<thead>
<tr>
<th>Key</th>
<th>Start</th>
<th>Len</th>
<th>Index Type</th>
<th>Root</th>
<th>Blocksize</th>
<th>Rec/key</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>4</td>
<td>unique unsigned long</td>
<td>1024</td>
<td>1024</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>32</td>
<td>30</td>
<td>multip. text</td>
<td>10240</td>
<td>1024</td>
<td>1</td>
</tr>
</tbody>
</table>

Field Start Length Type
<table>
<thead>
<tr>
<th>Field</th>
<th>Start</th>
<th>Length</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>6</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>10</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>11</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>31</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>32</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>62</td>
<td>35</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>97</td>
<td>35</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>132</td>
<td>35</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>167</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>171</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>187</td>
<td>35</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>222</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>226</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>242</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>262</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>282</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>302</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>332</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>336</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>340</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>341</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>349</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>357</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>365</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>367</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>369</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>29</td>
<td>373</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>377</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>31</td>
<td>378</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>32</td>
<td>380</td>
<td>8</td>
<td></td>
</tr>
</tbody>
</table>

Version: 3.23.11-alpha Printed: 25 February 2000
shell> myisampack station.MYI
Compressing station.MYI: (1192 records)
- Calculating statistics

  normal: 20  empty-space: 16  empty-zero: 12  empty-fill: 11
  pre-space: 0  end-space: 12  table-lookup: 5  zero: 7

Original trees: 57  After join: 17
- Compressing file
87.14%

shell> ls -l station.*
-rw-rw-rw- 1 monty my 127874 Apr 17 19:00 station.MYD
-rw-rw-rw- 1 monty my 55296 Apr 17 19:04 station.MYI
-rw-rw-rw- 1 monty my 5767 Apr 17 19:00 station.frm

shell> myisamchk -dvv station

MyISAM file: station
Isam-version: 2
Creation time: 1996-03-13 10:08:58
Recover time: 1997-04-17 19:04:26
Data records: 1192  Deleted blocks: 0
Datafile: Parts: 1192 Deleted data: 0  
Datafile pointer (bytes): 3 Keyfile pointer (bytes): 1  
Max datafile length: 16777215 Max keyfile length: 131071  
Recordlength: 834  
Record format: Compressed

table description:

<table>
<thead>
<tr>
<th>Key</th>
<th>Start</th>
<th>Len</th>
<th>Index</th>
<th>Type</th>
<th>Root</th>
<th>Blocksize</th>
<th>Rec/key</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>4</td>
<td>unique</td>
<td>unsigned long</td>
<td>10240</td>
<td>1024</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>32</td>
<td>30</td>
<td>multip.</td>
<td>text</td>
<td>54272</td>
<td>1024</td>
<td>1</td>
</tr>
</tbody>
</table>

Field Start Length Type Huff tree Bits

<p>| 1   | 1    | 1   | constant | 1  | 0        |
| 2   | 2    | 4   | zerofill(1) | 2  | 9        |
| 3   | 6    | 4   | no zeros, zerofill(1) | 2  | 9        |
| 4   | 10   | 1   |          | 3  | 9        |
| 5   | 11   | 20  | table-lookup | 4  | 0        |
| 6   | 31   | 1   |          | 3  | 9        |
| 7   | 32   | 30  | no endspace, not_always | 5  | 9        |
| 8   | 62   | 35  | no endspace, not_always, no empty | 6  | 9        |
| 9   | 97   | 35  | no empty | 7  | 9        |
| 10  | 132  | 35  | no endspace, not_always, no empty | 6  | 9        |
| 11  | 167  | 4   | zerofill(1) | 2  | 9        |
| 12  | 171  | 16  | no endspace, not_always, no empty | 5  | 9        |
| 13  | 187  | 35  | no endspace, not_always, no empty | 6  | 9        |
| 14  | 222  | 4   | zerofill(1) | 2  | 9        |
| 15  | 226  | 16  | no endspace, not_always, no empty | 5  | 9        |
| 16  | 242  | 20  | no endspace, not_always | 8  | 9        |
| 17  | 262  | 20  | no endspace, no empty | 8  | 9        |
| 18  | 282  | 20  | no endspace, no empty | 5  | 9        |
| 19  | 302  | 30  | no endspace, no empty | 6  | 9        |
| 20  | 332  | 4   | always zero | 2  | 9        |
| 21  | 336  | 4   | always zero | 2  | 9        |
| 22  | 340  | 1   |          | 3  | 9        |
| 23  | 341  | 8   | table-lookup | 9  | 0        |
| 24  | 349  | 8   | table-lookup | 10 | 0        |
| 25  | 357  | 8   | always zero | 2  | 9        |
| 26  | 365  | 2   |          | 2  | 9        |
| 27  | 367  | 2   | no zeros, zerofill(1) | 2  | 9        |
| 28  | 369  | 4   | no zeros, zerofill(1) | 2  | 9        |
| 29  | 373  | 4   | table-lookup | 11 | 0        |
| 30  | 377  | 1   |          | 3  | 9        |
| 31  | 378  | 2   | no zeros, zerofill(1) | 2  | 9        |
| 32  | 380  | 8   | no zeros | 2  | 9        |
| 33  | 388  | 4   | always zero | 2  | 9        |
| 34  | 392  | 4   | table-lookup | 12 | 0        |
| 35  | 396  | 4   | no zeros, zerofill(1) | 13 | 9        |
| 36  | 400  | 4   | no zeros, zerofill(1) | 2  | 9        |</p>
<table>
<thead>
<tr>
<th></th>
<th>Column Count</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>37</td>
<td>404</td>
<td>1 no zeros</td>
</tr>
<tr>
<td>38</td>
<td>405</td>
<td>4 always zero</td>
</tr>
<tr>
<td>39</td>
<td>409</td>
<td>4 no zeros</td>
</tr>
<tr>
<td>40</td>
<td>413</td>
<td>4 always zero</td>
</tr>
<tr>
<td>41</td>
<td>417</td>
<td>4 no zeros</td>
</tr>
<tr>
<td>42</td>
<td>421</td>
<td>4 always zero</td>
</tr>
<tr>
<td>43</td>
<td>425</td>
<td>20 no empty</td>
</tr>
<tr>
<td>44</td>
<td>429</td>
<td>30 no empty</td>
</tr>
<tr>
<td>45</td>
<td>449</td>
<td>30 no empty</td>
</tr>
<tr>
<td>46</td>
<td>479</td>
<td>14 no empty</td>
</tr>
<tr>
<td>47</td>
<td>480</td>
<td>14 no empty</td>
</tr>
<tr>
<td>48</td>
<td>481</td>
<td>79 no endspace, no empty</td>
</tr>
<tr>
<td>49</td>
<td>560</td>
<td>79 no empty</td>
</tr>
<tr>
<td>50</td>
<td>639</td>
<td>79 no empty</td>
</tr>
<tr>
<td>51</td>
<td>718</td>
<td>79 no endspace</td>
</tr>
<tr>
<td>52</td>
<td>797</td>
<td>8 no empty</td>
</tr>
<tr>
<td>53</td>
<td>805</td>
<td>17 no empty</td>
</tr>
<tr>
<td>54</td>
<td>806</td>
<td>1 no empty</td>
</tr>
<tr>
<td>55</td>
<td>807</td>
<td>20 no empty</td>
</tr>
<tr>
<td>56</td>
<td>827</td>
<td>4 no zeros, zerofill(2)</td>
</tr>
<tr>
<td>57</td>
<td>831</td>
<td>4 no zeros, zerofill(1)</td>
</tr>
</tbody>
</table>

The information printed by `myisampack` is described below:

- **normal**: The number of columns for which no extra packing is used.
- **empty-space**: The number of columns containing values that are only spaces; these will occupy 1 bit.
- **empty-zero**: The number of columns containing values that are only binary 0’s; these will occupy 1 bit.
- **empty-fill**: The number of integer columns that don’t occupy the full byte range of their type; these are changed to a smaller type (for example, an `INTEGER` column may be changed to `MEDIUMINT`).
- **pre-space**: The number of decimal columns that are stored with leading space. In this case, each value will contain a count for the number of leading spaces.
- **end-space**: The number of columns that have a lot of trailing space. In this case, each value will contain a count for the number of trailing spaces.
- **table-lookup**: The column had only a small number of different values, and that were converted to an `ENUM` before Huffman compression.
- **zero**: The number of columns for which all values are zero.
Original trees
The initial number of Huffman trees.

After join
The number of distinct Huffman trees left after joining trees to save some header space.

After a table has been compressed, `myisamchk -dvv` prints additional information about each field:

**Type**
The field type may contain the following descriptors:

- **constant**  All rows have the same value.
- **no endspace**  Don’t store endspace.
- **no endspace, not always**  Don’t store endspace and don’t do end space compression for all values.
- **no endspace, no empty**  Don’t store endspace. Don’t store empty values.
- **table-lookup**  The column was converted to an `ENUM`.
- **zerofill(n)**  The most significant n bytes in the value are always 0 and are not stored.
- **no zeros**  Don’t store zeros.
- **always zero**  0 values are stored in 1 bit.

**Huff tree**
The Huffman tree associated with the field

**Bits**
The number of bits used in the Huffman tree.

After you have run `pack_isam/myisampack` you must run `isamchk/myisamchk` to recreate the index. At this time you can also sort the index blocks and create statistics that is needed for the MySQL optimizer to work more efficiently.

```
myisamchk -rq --analyze --sort-index table_name.MYI
isamchk -rq --analyze --sort-index table_name.ISM
```

After you have installed the packed table into the MySQL database directory you should do `mysqladmin flush-tables` to force `mysqld` to start using the new table.
14 Maintaining a MySQL installation

14.1 Using myisamchk for table maintenance and crash recovery

To check/repair MyISAM tables (.MYI and .MYD) you should use the myisamchk utility. To check/repair ISAM tables (.ISM and .ISD) you should use the isamchk utility. See Chapter 8 [Table types], page 232.

In the following text we will talk about myisamchk but everything also applies to the old isamchk.

You can use the myisamchk utility to get information about your database tables, check and repair them or optimize them. The following sections describe how to invoke myisamchk (including a description of its options), how to set up a table maintenance schedule, and how to use myisamchk to perform its various functions.

You can in most cases also use the command OPTIMIZE TABLES to optimize and repair tables, but this is not as fast or reliable (in case of real fatal errors) as myisamchk. On the other hand, OPTIMIZE TABLE is easier to use and you don’t have to worry about flushing tables. See Section 7.9 [OPTIMIZE TABLE], page 195.

14.1.1 myisamchk invocation syntax

myisamchk is invoked like this:

shell> myisamchk [options] tbl_name

The options specify what you want myisamchk to do. They are described below. (You can also get a list of options by invoking myisamchk --help.) With no options, myisamchk simply checks your table. To get more information or to tell myisamchk to take corrective action, specify options as described below and in the following sections.

tbl_name is the database table you want to check. If you run myisamchk somewhere other than in the database directory, you must specify the path to the file, since myisamchk has no idea where your database is located. Actually, myisamchk doesn’t care whether or not the files you are working on are located in a database directory; you can copy the files that correspond to a database table into another location and perform recovery operations on them there.

You can name several tables on the myisamchk command line if you wish. You can also specify a name as an index file name (with the ‘.MYI’ suffix), which allows you to specify all tables in a directory by using the pattern ‘*.MYI’. For example, if you are in a database directory, you can check all the tables in the directory like this:

shell> myisamchk *.MYI

If you are not in the database directory, you can check all the tables there by specifying the path to the directory:
shell> myisamchk /path/to/database_dir/*.MYI
You can even check all tables in all databases by specifying a wildcard with the path to the MySQL data directory:

shell> myisamchk /path/to/datadir/*/*.MYI

myisamchk supports the following options:

-a, --analyze
   Analyze the distribution of keys. This improves join performance by enabling the join optimizer to better choose in which order it should join the tables and which keys it should use.

-#, --debug=debug_options
   Output debug log. The debug_options string often is ‘d:t:o,filename’.

-d, --description
   Prints some information about the table.

-e, --extend-check
   Check the table VERY thoroughly. This is necessary only in extreme cases. Normally, myisamchk should find all errors even without this option.

-f, --force
   Overwrite old temporary files. If you use -f when checking tables (running myisamchk without -r), myisamchk will automatically restart with -r on any table for which an error occurs during checking.

--help
   Display a help message and exit.

-i, --information
   Print informational statistics about the table that is checked.

-k #, --keys-used=#
   Used with -r. Tell the ISAM table handler to update only the first # indexes. Higher-numbered indexes are deactivated. This can be used to get faster inserts! Deactivated indexes can be reactivated by using myisamchk -r.

-l, --no-symlinks
   Do not follow symbolic links when repairing. Normally myisamchk repairs the table a symlink points at.

-q, --quick
   Used with -r to get a faster repair. Normally, the original data file isn’t touched; you can specify a second -q to force the original data file to be used.

-r, --recover
   Recovery mode. Can fix almost anything except unique keys that aren’t unique.

-o, --safe-recover
   Recovery mode. Uses an old recovery method; this is slower than -r, but can handle a couple of cases that -r cannot handle.

-O var=option, --set-variable var=option
   Set the value of a variable. The possible variables are listed below.
-s, --silent
Silent mode. Write output only when errors occur. You can use -s twice (-ss) to make myisamchk very silent.

-S, --sort-index
Sort the index tree blocks in high-low order. This will optimize seeks and will make table scanning by key faster.

-R index_num, --sort-records=index_num
Sorts records according to an index. This makes your data much more localized and may speed up ranged SELECT and ORDER BY operations on this index. (It may be VERY slow to do a sort the first time!) To find out a table’s index numbers, use SHOW INDEX, which shows a table’s indexes in the same order that myisamchk sees them. Indexes are numbered beginning with 1.

-u, --unpack
Unpack a table that was packed with myisampack.

-v, --verbose
Verbose mode. Print more information. This can be used with -d and -e. Use -v multiple times (-vv, -vvv) for more verbosity!

-V, --version
Print the myisamchk version and exit.

-w, --wait
Wait if the table is locked.

Possible variables for the --set-variable (-O) option are:

- key_buffer_size current value: 16776192
- read_buffer_size current value: 262136
- write_buffer_size current value: 262136
- sort_buffer_size current value: 2097144
- sort_key_blocks current value: 16
- decode_bits current value: 9

14.1.2 myisamchk memory usage

Memory allocation is important when you run myisamchk. myisamchk uses no more memory than you specify with the -O options. If you are going to use myisamchk on very large files, you should first decide how much memory you want it to use. The default is to use only about 3M to fix things. By using larger values, you can get myisamchk to operate faster. For example, if you have more than 32M RAM, you could use options such as these (in addition to any other options you might specify):

```
shell> myisamchk -O sort=16M -O key=16M -O read=1M -O write=1M ...
```
Using -O sort=16M should probably be enough for most cases.

Be aware that myisamchk uses temporary files in TMPDIR. If TMPDIR points to a memory file system, you may easily get out of memory errors. If this happens, set TMPDIR to point at some directory with more space and restart myisamchk.
14.2 Setting up a table maintenance regimen

It is a good idea to perform table checks on a regular basis rather than waiting for problems to occur. For maintenance purposes, you can use `myisamchk -s` to check tables. The `-s` option causes `myisamchk` to run in silent mode, printing messages only when errors occur.

It’s a good idea to check tables when the server starts up. For example, whenever the machine has done a reboot in the middle of an update, you usually need to check all the tables that could have been affected. (This is an “expected crashed table”.) You could add a test to `safe_mysqld` that runs `myisamchk` to check all tables that have been modified during the last 24 hours if there is an old `.pid` (process ID) file left after a reboot. (The `.pid` file is created by `mysqld` when it starts up and removed when it terminates normally. The presence of a `.pid` file at system startup time indicates that `mysqld` terminated abnormally.)

An even better test would be to check any table whose last-modified time is more recent than that of the `.pid` file.

You should also check your tables regularly during normal system operation. At TcX, we run a cron job to check all our important tables once a week, using a line like this in a `crontab` file:

```
35 0 * * 0 /path/to/myisamchk -s /path/to/datadir/*//*.MYI
```

This prints out information about crashed tables so we can examine and repair them when needed.

As we haven’t had any unexpectedly crashed tables (tables that become corrupted for reasons other than hardware trouble) for a couple of years now (this is really true), once a week is more than enough for us.

We recommend that to start with, you execute `myisamchk -s` each night on all tables that have been updated during the last 24 hours, until you come to trust MySQL as much as we do.

14.3 Getting information about a table

To get a description of a table or statistics about it, use the commands shown below. We explain some of the information in more detail later.

```
myisamchk -d tbl_name
```

Runs `myisamchk` in “describe mode” to produce a description of your table. If you start the MySQL server using the `--skip-locking` option, `myisamchk` may report an error for a table that is updated while it runs. However, since `myisamchk` doesn’t change the table in describe mode, there isn’t any risk of destroying data.

```
myisamchk -d -v tbl_name
```

To produce more information about what `myisamchk` is doing, add `-v` to tell it to run in verbose mode.
myisamchk -eis tbl_name
    Shows only the most important information from a table. It is slow since it
    must read the whole table.

myisamchk -eiv tbl_name
    This is like -eis, but tells you what is being done.

Example of myisamchk -d output:

    MyISAM file: company.MYI
    Record format: Fixed length
    Data records: 1403698 Deleted blocks: 0
    Recordlength: 226

    table description:
    Key Start Len Index Type
    1  2  8   unique double 15845376 1024
    2 15 10  multip. text packed stripped 2 25062400 1024
    3 219 8  multip. double 73 40907776 1024
    4 63 10  multip. text packed stripped 5 48097280 1024
    5 167 2  multip. unsigned short 4840 55200768 1024
    6 177 4  multip. unsigned long 1346 65145856 1024
    7 155 4  multip. text 4995 75090944 1024
    8 138 4  multip. unsigned long 87 85036032 1024

Example of myisamchk -d -v output:

    MyISAM file: company
    Record format: Fixed length
    File-version: 1
    Creation time: 1999-10-30 12:12:51
    Recover time: 1999-10-31 19:13:01
    Status: checked
    Data records: 1403698 Deleted blocks: 0
    Datafile parts: 1403698 Deleted data: 0
    Datafilepointer (bytes): 3 Keyfile pointer (bytes): 3
    Max datafile length: 3791650815 Max keyfile length: 4294967294
    Recordlength: 226

    table description:
    Key Start Len Index Type    Rec/key Root Blocksize
    1  2  8   unique double 1  15845376 1024
    2 15 10  multip. text packed stripped 2  25062400 1024
    3 219 8  multip. double 73  40907776 1024
    4 63 10  multip. text packed stripped 5  48097280 1024
    5 167 2  multip. unsigned short 4840  55200768 1024
    6 177 4  multip. unsigned long 1346  65145856 1024
    7 155 4  multip. text 4995  75090944 1024
    8 138 4  multip. unsigned long 87  85036032 1024
Example of myisamchk -eis output:

Checking MyISAM file: company
Key: 1: Keyblocks used: 97% Packed: 0% Max levels: 4
Key: 2: Keyblocks used: 98% Packed: 50% Max levels: 4
Key: 3: Keyblocks used: 97% Packed: 0% Max levels: 4
Key: 4: Keyblocks used: 99% Packed: 60% Max levels: 3
Key: 5: Keyblocks used: 99% Packed: 0% Max levels: 3
Key: 6: Keyblocks used: 99% Packed: 0% Max levels: 3
Key: 7: Keyblocks used: 99% Packed: 0% Max levels: 3
Key: 8: Keyblocks used: 99% Packed: 0% Max levels: 3
Key: 9: Keyblocks used: 98% Packed: 0% Max levels: 4
Total: Keyblocks used: 98% Packed: 17%

Records: 1403698 M.recordlength: 226 Packed: 0%
Recordspace used: 100% Empty space: 0% Blocks/Record: 1.00
Record blocks: 1403698 Delete blocks: 0
Recorddata: 317235748 Deleted data: 0
Lost space: 0 Linkdata: 0

User time 1626.51, System time 232.36
Maximum resident set size 0, Integral resident set size 0
Non physical pagefaults 0, Physical pagefaults 627, Swaps 0
Blocks in 0 out 0, Messages in 0 out 0, Signals 0
Voluntary context switches 639, Involuntary context switches 28966

Example of myisamchk -eiv output:

Checking MyISAM file: company
Data records: 1403698 Deleted blocks: 0
- check file-size
- check delete-chain
block_size 1024:
index 1:
index 2:
index 3:
index 4:
index 5:
index 6:
index 7:
index 8:
index 9:
No recordlinks
- check index reference
- check data record references index: 1
Key: 1: Keyblocks used: 97% Packed: 0% Max levels: 4
- check data record references index: 2
Key: 2: Keyblocks used: 98% Packed: 50% Max levels: 4
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- check data record references index: 3
  Key: 3: Keyblocks used: 97% Packed: 0% Max levels: 4
- check data record references index: 4
  Key: 4: Keyblocks used: 99% Packed: 60% Max levels: 3
- check data record references index: 5
  Key: 5: Keyblocks used: 99% Packed: 0% Max levels: 3
- check data record references index: 6
  Key: 6: Keyblocks used: 99% Packed: 0% Max levels: 3
- check data record references index: 7
  Key: 7: Keyblocks used: 99% Packed: 0% Max levels: 3
- check data record references index: 8
  Key: 8: Keyblocks used: 99% Packed: 0% Max levels: 3
- check data record references index: 9
  Key: 9: Keyblocks used: 98% Packed: 0% Max levels: 4
Total: Keyblocks used: 9% Packed: 17%

- check records and index references
[LOTS OF ROW NUMBERS DELETED]

Records: 1403698 M.recordlength: 226 Packed: 0%
Recordspace used: 100% Empty space: 0% Blocks/Record: 1.00
Record blocks: 1403698 Delete blocks: 0
Recorddata: 317235748 Deleted data: 0
Lost space: 0 Linkdata: 0

User time 1639.63, System time 251.61
Maximum resident set size 0, Integral resident set size 0
Non physical pagefaults 0, Physical pagefaults 10580, Swaps 0
Blocks in 4 out 0, Messages in 0 out 0, Signals 0
Voluntary context switches 10604, Involuntary context switches 122798

Here are the sizes of the data and index files for the table used in the preceding examples:

- rw-rw-r-- 1 monty tcx 317235748 Jan 12 17:30 company.MYD
- rw-rw-r-- 1 davida tcx 96482304 Jan 12 18:35 company.MYM

Explanations for the types of information myisamchk produces are given below. The “key-file” is the index file. “Record” and “row” are synonymous.

**ISAM file** Name of the ISAM (index) file.

**Isam-version** Version of ISAM format. Currently always 2.

**Creation time** When the data file was created.

**Recover time** When the index/data file was last reconstructed.

**Data records** How many records are in the table.
Deleted blocks
How many deleted blocks still have reserved space. You can optimize your table to minimize this space. See Section 14.4.3 [Optimization], page 335.

Datafile: Parts
For dynamic record format, this indicates how many data blocks there are. For an optimized table without fragmented records, this is the same as Data records.

Deleted data
How many bytes of non-reclaimed deleted data there are. You can optimize your table to minimize this space. See Section 14.4.3 [Optimization], page 335.

Datafile pointer
The size of the data file pointer, in bytes. It is usually 2, 3, 4 or 5 bytes. Most tables manage with 2 bytes, but this cannot be controlled from MySQL yet. For fixed tables, this is a record address. For dynamic tables, this is a byte address.

Keyfile pointer
The size of the index file pointer, in bytes. It is usually 1, 2 or 3 bytes. Most tables manage with 2 bytes, but this is calculated automatically by MySQL. It is always a block address.

Max datafile length
How long the table’s data file (.MYD file) can become, in bytes.

Max keyfile length
How long the table’s key file (.MYI file) can become, in bytes.

Record length
How much space each record takes, in bytes.

Record format
The format used to store table rows. The examples shown above use Fixed length. Other possible values are Compressed and Packed.

Table description
A list of all keys in the table. For each key, some low-level information is presented:

Key
This key’s number.

Start
Where in the record this index part starts.

Len
How long this index part is. For packed numbers, this should always be the full length of the column. For strings, it may be shorter than the full length of the indexed column, because you can index a prefix of a string column.

Index
unique or multip. (multiple). Indicates whether or not one value can exist multiple times in this index.
### Type
What data-type this index part has. This is an ISAM data-type with the options `packed`, `stripped` or `empty`.

### Root
Address of the root index block.

### Blocksize
The size of each index block. By default this is 1024, but the value may be changed at compile time.

### Rec/key
This is a statistical value used by the optimizer. It tells how many records there are per value for this key. A unique key always has a value of 1. This may be updated after a table is loaded (or greatly changed) with `myisamchk -a`. If this is not updated at all, a default value of 30 is given.

In the first example above, the 9th key is a multi-part key with two parts.

### Keyblocks used
What percentage of the keyblocks are used. Since the table used in the examples had just been reorganized with `myisamchk`, the values are very high (very near the theoretical maximum).

### Packed
MySQL tries to pack keys with a common suffix. This can only be used for `CHAR/VARCHAR/DECIMAL` keys. For long strings like names, this can significantly reduce the space used. In the third example above, the 4th key is 10 characters long and a 60% reduction in space is achieved.

### Max levels
How deep the B-tree for this key is. Large tables with long keys get high values.

### Records
How many rows are in the table.

### M.recordlength
The average record length. For tables with fixed-length records, this is the exact record length.

### Packed
MySQL strips spaces from the end of strings. The `Packed` value indicates the percentage savings achieved by doing this.

### Recordspace used
What percentage of the data file is used.

### Empty space
What percentage of the data file is unused.

### Blocks/Record
Average number of blocks per record (i.e., how many links a fragmented record is composed of). This is always 1 for fixed-format tables. This value should stay as close to 1.0 as possible. If it gets too big, you can reorganize the table with `myisamchk`. See Section 14.4.3 [Optimization], page 335.

### Recordblocks
How many blocks (links) are used. For fixed format, this is the same as the number of records.
Deleteblocks
   How many blocks (links) are deleted.

Recorddata
   How many bytes in the data file are used.

Deleted data
   How many bytes in the data file are deleted (unused).

Lost space
   If a record is updated to a shorter length, some space is lost. This is the sum of all such losses, in bytes.

Linkdata
   When the dynamic table format is used, record fragments are linked with pointers (4 to 7 bytes each). Linkdata is the sum of the amount of storage used by all such pointers.

If a table has been compressed with `myisampack`, `myisamchk -d` prints additional information about each table column. See Section 13.7 [myisampack], page 316, for an example of this information and a description of what it means.

14.4 Using `myisamchk` for crash recovery

If you run `mysqld` with `--skip-locking` (which is the default on some systems, like Linux), you can’t reliably use `myisamchk` to check a table when `mysqld` is using the same table. If you can be sure that no one is accessing the tables through `mysqld` while you run `myisamchk`, you only have to do `mysqladmin flush-tables` before you start checking the tables. If you can’t guarantee the above, then you must take down `mysqld` while you check the tables. If you run `myisamchk` while `mysqld` is updating the tables, you may get a warning that a table is corrupt even if it isn’t.

If you are not using `--skip-locking`, you can use `myisamchk` to check tables at any time. While you do this, all clients that try to update the table will wait until `myisamchk` is ready before continuing.

If you use `myisamchk` to repair or optimize tables, you MUST always ensure that the `mysqld` server is not using the table (this also applies if you are using `--skip-locking`). If you don’t take down `mysqld` you should at least do a `mysqladmin flush-tables` before you run `myisamchk`.

The file format that MySQL uses to store data has been extensively tested, but there are always external circumstances that may cause database tables to become corrupted:

- The `mysqld` process being killed in the middle of a write
- Unexpected shutdown of the computer (for example, if the computer is turned off)
- A hardware error

This chapter describes how to check for and deal with data corruption in MySQL databases. If your tables get corrupted a lot you should try to find the reason for this! See Section G.1 [Debugging server], page 506.
When performing crash recovery, it is important to understand that each table `tbl_name` in a database corresponds to three files in the database directory:

<table>
<thead>
<tr>
<th>File</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>tbl_name.frm</code></td>
<td>Table definition (form) file</td>
</tr>
<tr>
<td><code>tbl_name.MYD</code></td>
<td>Data file</td>
</tr>
<tr>
<td><code>tbl_name.MYI</code></td>
<td>Index file</td>
</tr>
</tbody>
</table>

Each of these three file types is subject to corruption in various ways, but problems occur most often in data files and index files.

`myisamchk` works by creating a copy of the `.MYD` (data) file row by row. It ends the repair stage by removing the old `.MYD` file and renaming the new file to the original file name. If you use `--quick`, `myisamchk` does not create a temporary `.MYD` file, but instead assumes that the `.MYD` file is correct and only generates a new index file without touching the `.MYD` file. This is safe, because `myisamchk` automatically detects if the `.MYD` file is corrupt and aborts the repair in this case. You can also give two `--quick` options to `myisamchk`. In this case, `myisamchk` does not abort on some errors (like duplicate key) but instead tries to resolve them by modifying the `.MYD` file. Normally the use of two `--quick` options is useful only if you have too little free disk space to perform a normal repair. In this case you should at least make a backup before running `myisamchk`.

### 14.4.1 How to check tables for errors

To check a table, use the following commands:

- `myisamchk tbl_name`
  
  This finds 99.99% of all errors. What it can’t find is corruption that involves ONLY the data file (which is very unusual). If you want to check a table, you should normally run `myisamchk` without options or with either the `-s` or `--silent` option.

- `myisamchk -e tbl_name`
  
  This does a complete and thorough check of all data (`-e` means “extended check”). It does a check-read of every key for each row to verify that they indeed point to the correct row. This may take a LONG time on a big table with many keys. `myisamchk` will normally stop after the first error it finds. If you want to obtain more information, you can add the `--verbose (-v)` option. This causes `myisamchk` to keep going, up through a maximum of 20 errors. In normal usage, a simple `myisamchk` (with no arguments other than the table name) is sufficient.

- `myisamchk -e -i tbl_name`
  
  Like the previous command, but the `-i` option tells `myisamchk` to print some informational statistics, too.

### 14.4.2 How to repair tables

Version: 3.23.11-alpha Printed: 25 February 2000
In the following we only talk about using myisamchk on MyISAM tables (extensions .MYI and .MYD). If you are using ISAM tables (extensions .ISM and .ISD), you should use isamchk instead.

The symptoms of a corrupted table are usually that queries abort unexpectedly and that you observe errors such as these:

- 'tbl_name.frm' is locked against change
- Can't find file 'tbl_name.MYI' (Errcode: ###)
- Got error ### from table handler (Error 135 is an exception in this case)
- Unexpected end of file
- Record file is crashed

In these cases, you must repair your tables. myisamchk can usually detect and fix most things that go wrong.

The repair process involves up to four stages, described below. Before you begin, you should cd to the database directory and check the permissions of the table files. Make sure they are readable by the Unix user that mysqld runs as (and to you, since you need to access the files you are checking). If it turns out you need to modify files, they must also be writable by you.

If you are going to repair a table, you must first take down the mysqld server. Note that when you do mysqladmin shutdown, the mysqld server will still be alive for a while after mysqladmin returns until all queries are stopped and all keys have been flushed to disk.

Stage 1: Checking your tables

Run myisamchk *.MYI or (myisamchk -e *.MYI if you have more time). Use the -s (silent) option to suppress unnecessary information.

You have to repair only those tables for which myisamchk announces an error. For such tables, proceed to Stage 2.

If you get weird errors when checking (such as out of memory errors), or if myisamchk crashes, go to Stage 3.

Stage 2: Easy safe repair

First, try myisamchk -r -q tbl_name (-r -q means “quick recovery mode”). This will attempt to repair the index file without touching the data file. If the data file contains everything that it should and the delete links point at the correct locations within the data file, this should work and the table is fixed. Start repairing the next table. Otherwise, use the following procedure:

1. Make a backup of the data file before continuing.
2. Use myisamchk -r tbl_name (-r means “recovery mode”). This will remove incorrect records and deleted records from the data file and reconstruct the index file.
3. If the preceding step fails, use myisamchk --safe-recover tbl_name. Safe recovery mode uses an old recovery method that handles a few cases that regular recovery mode doesn’t (but is slower).
If you get weird errors when repairing (such as out of memory errors), or if myisamchk crashes, go to Stage 3.

**Stage 3: Difficult repair**

You should only reach this stage if the first 16K block in the index file is destroyed or contains incorrect information, or if the index file is missing. In this case, it’s necessary to create a new index file. Do so as follows:

1. Move the data file to some safe place.
2. Use the table description file to create new (empty) data and index files:
   ```shell
   shell> mysql db_name
   mysql> DELETE FROM tbl_name;
   mysql> quit
   ```
3. Copy the old data file back onto the newly created data file. (Don’t just move the old file back onto the new file; you want to retain a copy in case something goes wrong.)

Go back to Stage 2. myisamchk -r -q should work now. (This shouldn’t be an endless loop).

**Stage 4: Very difficult repair**

You should reach this stage only if the description file has also crashed. That should never happen, because the description file isn’t changed after the table is created.

1. Restore the description file from a backup and go back to Stage 3. You can also restore the index file and go back to Stage 2. In the latter case, you should start with myisamchk -r.
2. If you don’t have a backup but know exactly how the table was created, create a copy of the table in another database. Remove the new data file, then move the description and index files from the other database to your crashed database. This gives you new description and index files, but leaves the data file alone. Go back to Stage 2 and attempt to reconstruct the index file.

**14.4.3 Table optimization**

To coalesce fragmented records and eliminate wasted space resulting from deleting or updating records, run myisamchk in recovery mode:

```shell
shell> myisamchk -r tbl_name
```

You can optimize a table in the same way using the SQL OPTIMIZE TABLE statement. OPTIMIZE TABLE is easier, but myisamchk is faster. There is also no possibility of unwanted interaction between a utility and the server, because the server does all the work when you use OPTIMIZE TABLE.

myisamchk also has a number of other options you can use to improve the performance of a table:

- `-S`, `--sort-index`
- `-R index_num`, `--sort-records=index_num`
- `-a`, `--analyze`

For a full description of the option see See Section 14.1.1 [myisamchk syntax], page 323.
14.5 Log file maintenance

When using MySQL with log files, you will from time to time want to remove/backup old log files and tell MySQL to start logging on new files. See Section 10.2 [Update log], page 273. One a Linux (Redhat) installation, you can use the mysql-log-rotate script for this. If you installed MySQL from an RPM distribution, the script should have been installed automatically.

On other systems you must install a short script yourself that you start from cron to handle log files.

You can force MySQL to start using new log files by using mysqladmin flush-logs or by using the SQL command FLUSH LOGS. If you are using MySQL 3.21 you must use mysqladmin refresh.

The above command does the following:

- If standard logging (--log) is used, closes and reopens the log file. (‘mysql.log’ as default).
- If update logging (--log-update) is used, closes the update log and opens a new log file with a higher sequence number.

If you are using only an update log, you only have to flush the logs and then move away the old update log files to a backup. If you are using the normal logging, you can do something like:

```shell
shell> cd mysql-data-directory
shell> mv mysql.log mysql.old
shell> mysqladmin flush-tables
```

and then take a backup and remove ‘mysql.old’.
15 Adding new functions to MySQL

There are two ways to add new functions to MySQL:

- You can add the function through the user-definable function (UDF) interface. User-definable functions are added and removed dynamically using the `CREATE FUNCTION` and `DROP FUNCTION` statements. See Section 7.30 [CREATE FUNCTION], page 228.
- You can add the function as a native (built in) MySQL function. Native functions are compiled into the mysqld server and become available on a permanent basis.

Each method has advantages and disadvantages:

- If you write a user-definable function, you must install the object file in addition to the server itself. If you compile your function into the server, you don’t need to do that.
- You can add UDFs to a binary MySQL distribution. Native functions require you to modify a source distribution.
- If you upgrade your MySQL distribution, you can continue to use your previously-installed UDFs. For native functions, you must repeat your modifications each time you upgrade.

Whichever method you use to add new functions, they may be used just like native functions such as `ABS()` or `SOUNDEX()`.

15.1 Adding a new user-definable function

For the UDF mechanism to work, functions must be written in C or C++ and your operating system must support dynamic loading. The MySQL source distribution includes a file `sql/udf_example.cc` that defines 5 new functions. Consult this file to see how UDF calling conventions work.

For each function that you want to use in SQL statements, you should define corresponding C (or C++) functions. In the discussion below, the name “xxx” is used for an example function name. To distinguish between SQL and C/C++ usage, `XXX()` (uppercase) indicates a SQL function call, and `xxx()` (lowercase) indicates a C/C++ function call.

The C/C++ functions that you write to implement the interface for `XXX()` are:

`xxx()` (required)

The main function. This is where the function result is computed. The correspondence between the SQL type and return type of your C/C++ function is shown below:

<table>
<thead>
<tr>
<th>SQL type</th>
<th>C/C++ type</th>
</tr>
</thead>
<tbody>
<tr>
<td>STRING</td>
<td>char *</td>
</tr>
<tr>
<td>INTEGER</td>
<td>long long</td>
</tr>
<tr>
<td>REAL</td>
<td>double</td>
</tr>
</tbody>
</table>

`xxx_init()` (optional)

The initialization function for `xxx()`. It can be used to:
• Check the number of arguments to \texttt{XXX()}
• Check that the arguments are of a required type, or, alternatively, tell \texttt{MySQL} to coerce arguments to the types you want when the main function is called
• Allocate any memory required by the main function
• Specify the maximum length of the result
• Specify (for \texttt{REAL} functions) the maximum number of decimals
• Specify whether or not the result can be \texttt{NULL}

\texttt{xxx\_deinit()} (optional)

The deinitialization function for \texttt{xxx()}. It should deallocate any memory allocated by the initialization function.

When a SQL statement invokes \texttt{XXX()}, \texttt{MySQL} calls the initialization function \texttt{xxx\_init()} to let it perform any required setup, such as argument checking or memory allocation. If \texttt{xxx\_init()} returns an error, the SQL statement is aborted with an error message and the main and deinitialization functions are not called. Otherwise, the main function \texttt{xxx()} is called once for each row. After all rows have been processed, the deinitialization function \texttt{xxx\_deinit()} is called so it can perform any required cleanup.

All functions must be thread-safe (not just the main function, but the initialization and deinitialization functions as well). This means that you are not allowed to allocate any global or static variables that change! If you need memory, you should allocate it in \texttt{xxx\_init()} and free it in \texttt{xxx\_deinit()}.

\textbf{15.1.1 UDF calling sequences}

The main function should be declared as shown below. Note that the return type and parameters differ, depending on whether you will declare the SQL function \texttt{XXX()} to return \texttt{STRING}, \texttt{INTEGER} or \texttt{REAL} in the \texttt{CREATE FUNCTION} statement:

For \texttt{STRING} functions:

\begin{verbatim}
char *xxx(UDF_INIT *initid, UDF_ARGS *args,
        char *result, unsigned long *length,
        char *is_null, char *error);
\end{verbatim}

For \texttt{INTEGER} functions:

\begin{verbatim}
long long xxx(UDF_INIT *initid, UDF_ARGS *args,
             char *is_null, char *error);
\end{verbatim}

For \texttt{REAL} functions:

\begin{verbatim}
double xxx(UDF_INIT *initid, UDF_ARGS *args,
          char *is_null, char *error);
\end{verbatim}

The initialization and deinitialization functions are declared like this:

\begin{verbatim}
my_bool xxx\_init(UDF_INIT *initid, UDF_ARGS *args, char *message);
\end{verbatim}

\begin{verbatim}
void xxx\_deinit(UDF_INIT *initid);
\end{verbatim}
Chapter 15: Adding new functions to MySQL

The **initid** parameter is passed to all three functions. It points to a **UDF_INIT** structure that is used to communicate information between functions. The **UDF_INIT** structure members are listed below. The initialization function should fill in any members that it wishes to change. (To use the default for a member, leave it unchanged.)

### my_bool maybe_null

**xxx_init()** should set **maybe_null** to 1 if **xxx()** can return NULL. The default value is 1 if any of the arguments are declared **maybe_null**.

### unsigned int decimals

Number of decimals. The default value is the maximum number of decimals in the arguments passed to the main function. (For example, if the function is passed 1.34, 1.345 and 1.3, the default would be 3, since 1.345 has 3 decimals.)

### unsigned int max_length

The maximum length of the string result. The default value differs depending on the result type of the function. For string functions, the default is the length of the longest argument. For integer functions, the default is 21 digits. For real functions, the default is 13 plus the number of decimals indicated by **initid->decimals**. (For numeric functions, the length includes any sign or decimal point characters.)

### char *ptr

A pointer that the function can use for its own purposes. For example, functions can use **initid->ptr** to communicate allocated memory between functions. In **xxx_init()**, allocate the memory and assign it to this pointer:

```c
initid->ptr = allocated_memory;
```

In **xxx()** and **xxx_deinit()**, refer to **initid->ptr** to use or deallocate the memory.

### 15.1.2 Argument processing

The **args** parameter points to a **UDF_ARGS** structure which has the members listed below:

### unsigned int arg_count

The number of arguments. Check this value in the initialization function if you want your function to be called with a particular number of arguments. For example:

```c
if (args->arg_count != 2)
{
    strcpy(message,"XXX() requires two arguments");
    return 1;
}
```

### enum Item_result *arg_type

The types for each argument. The possible type values are **STRING_RESULT**, **INT_RESULT** and **REAL_RESULT**.

To make sure that arguments are of a given type and return an error if they are not, check the **arg_type** array in the initialization function. For example:
```c
if (args->arg_type[0] != STRING_RESULT
   && args->arg_type[1] != INT_RESULT)
{
    strcpy(message,"XXX() requires a string and an integer");
    return 1;
}
```

As an alternative to requiring your function’s arguments to be of particular types, you can use the initialization function to set the `arg_type` elements to the types you want. This causes MySQL to coerce arguments to those types for each call to `xxx()`. For example, to specify coercion of the first two arguments to string and integer, do this in `xxx_init()`:

```c
args->arg_type[0] = STRING_RESULT;
args->arg_type[1] = INT_RESULT;
```

`char **args` communicates information to the initialization function about the general nature of the arguments your function was called with. For a constant argument `i`, `args->args[i]` points to the argument value. (See below for instructions on how to access the value properly.) For a non-constant argument, `args->args[i]` is 0. A constant argument is an expression that uses only constants, such as 3 or 4*7-2 or `SIN(3.14)`. A non-constant argument is an expression that refers to values that may change from row to row, such as column names or functions that are called with non-constant arguments.

For each invocation of the main function, `args->args` contains the actual arguments that are passed for the row currently being processed.

Functions can refer to an argument `i` as follows:

- An argument of type `STRING_RESULT` is given as a string pointer plus a length, to allow handling of binary data or data of arbitrary length. The string contents are available as `args->args[i]` and the string length is `args->lengths[i]`. You should not assume that strings are null-terminated.
- For an argument of type `INT_RESULT`, you must cast `args->args[i]` to a `long long` value:
  ```c
  long long int_val;
  int_val = *((long long*) args->args[i]);
  ```
- For an argument of type `REAL_RESULT`, you must cast `args->args[i]` to a `double` value:
  ```c
  double real_val;
  real_val = *((double*) args->args[i]);
  ```

`unsigned long *lengths` For the initialization function, the `lengths` array indicates the maximum string length for each argument. For each invocation of the main function, `lengths` contains the actual lengths of any string arguments that are passed for the row currently being processed. For arguments of types `INT_RESULT` or `REAL_
15.1.3 Return values and error handling

The initialization function should return 0 if no error occurred and 1 otherwise. If an error occurs, xxx_init() should store a null-terminated error message in the message parameter. The message will be returned to the client. The message buffer is MySQL_ERRMSG_SIZE characters long, but you should try to keep the message to less than 80 characters so that it fits the width of a standard terminal screen.

The return value of the main function xxx() is the function value, for long long and double functions. For string functions, the string is returned in the result and length arguments. result is a buffer at least 255 bytes long. Set these to the contents and length of the return value. For example:

```c
memcpy(result, "result string", 13);
*length = 13;
```

The string function return value normally also points to the result.

To indicate a return value of NULL in the main function, set is_null to 1:

```c
*is_null = 1;
```

To indicate an error return in the main function, set the error parameter to 1:

```c
*error = 1;
```

If xxx() sets *error to 1 for any row, the function value is NULL for the current row and for any subsequent rows processed by the statement in which XXX() was invoked. (xxx() will not even be called for subsequent rows.) Note: In MySQL versions prior to 3.22.10, you should set both *error and *is_null:

```c
*error = 1;
*is_null = 1;
```

15.1.4 Compiling and installing user-definable functions

Files implementing UDFs must be compiled and installed on the host where the server runs. This process is described below for the example UDF file ‘udf_example.cc’ that is included in the MySQL source distribution. This file contains the following functions:

- `metaphon()` returns a metaphon string of the string argument. This is something like a soundex string, but it’s more tuned for English.
- `myfunc_double()` returns the sum of the ASCII values of the characters in its arguments, divided by the sum of the length of its arguments.
- `myfunc_int()` returns the sum of the length of its arguments.
- `lookup()` returns the IP number for a hostname.
- `reverse_lookup()` returns the hostname for an IP number. The function may be called with a string "xxx.xxx.xxx.xxx" or four numbers.
A dynamically-loadable file should be compiled as a sharable object file, using a command something like this:

```
shell> gcc -shared -o udf_example.so myfunc.cc
```

You can easily find out the correct compiler options for your system by running this command in the ‘sql’ directory of your MySQL source tree:

```
shell> make udf_example.o
```

You should run a compile command similar to the one that make displays, except that you should remove the -c option near the end of the line and add -o udf_example.so to the end of the line. (On some systems, you may need to leave the -c on the command.)

Once you compile a shared object containing UDFs, you must install it and tell MySQL about it. Compiling a shared object from ‘udf_example.cc’ produces a file named something like ‘udf_example.so’ (the exact name may vary from platform to platform). Copy this file to some directory searched by ld, such as ‘/usr/lib’. On many systems, you can set the LD_LIBRARY or LD_LIBRARY_PATH environment variable to point at the directory where you have your UDF function files. The dopen manual page tells you which variable you should use on your system. You should set this in mysql.server or safe_mysqld and restart mysqld.

After the library is installed, notify mysqld about the new functions with these commands:

```
mysql> CREATE FUNCTION metaphon RETURNS STRING SONAME "udf_example.so";
mysql> CREATE FUNCTION myfunc_double RETURNS REAL SONAME "udf_example.so";
mysql> CREATE FUNCTION myfunc_int RETURNS INTEGER SONAME "udf_example.so";
mysql> CREATE FUNCTION lookup RETURNS STRING SONAME "udf_example.so";
mysql> CREATE FUNCTION reverse_lookup RETURNS STRING SONAME "udf_example.so";
```

Functions can be deleted using DROP FUNCTION:

```
mysql> DROP FUNCTION metaphon;
mysql> DROP FUNCTION myfunc_double;
mysql> DROP FUNCTION myfunc_int;
mysql> DROP FUNCTION lookup;
mysql> DROP FUNCTION reverse_lookup;
```

The CREATE FUNCTION and DROP FUNCTION statements update the system table func in the mysql database. The function’s name, type and shared library name are saved in the table. You must have the insert and delete privileges for the mysql database to create and drop functions.

You should not use CREATE FUNCTION to add a function that has already been created. If you need to reinstall a function, you should remove it with DROP FUNCTION and then reinstall it with CREATE FUNCTION. You would need to do this, for example, if you recompile a new version of your function, so that mysqld gets the new version. Otherwise the server will continue to use the old version.

Active functions are reloaded each time the server starts, unless you start mysqld with the --skip-grant-tables option. In this case, UDF initialization is skipped and UDFs are unavailable. (An active function is one that has been loaded with CREATE FUNCTION and not removed with DROP FUNCTION.)
15.2 Adding a new native function

The procedure for adding a new native function is described below. Note that you cannot add native functions to a binary distribution since the procedure involves modifying MySQL source code. You must compile MySQL yourself from a source distribution. Also note that if you migrate to another version of MySQL (e.g., when a new version is released), you will need to repeat the procedure with the new version.

To add a new native MySQL function, follow these steps:

1. Add one line to ‘lex.h’ that defines the function name in the sql_functions[] array.
2. Add two lines to ‘sql_yacc.yy’. One indicates the preprocessor symbol that yacc should define (this should be added at the beginning of the file). Then define the function parameters and add an “item” with these parameters to the simple_expr parsing rule. For an example, check all occurrences of SOUNDEX in ‘sql_yacc.yy’ to see how this is done.
3. In ‘item_func.h’, declare a class inheriting from Item_num_func or Item_str_func, depending on whether your function returns a number or a string.
4. In ‘item_func.cc’, add one of the following declarations, depending on whether you are defining a numeric or string function:
   ```
   double Item_func_newname::val()
   longlong Item_func_newname::val_int()
   String *Item_func_newname::Str(String *str)
   ```
5. You should probably also define the following function:
   ```
   void Item_func_newname::fix_length_and_dec()
   ```
   This function should at least calculate max_length based on the given arguments. max_length is the maximum number of characters the function may return. This function should also set maybe_null = 0 if the main function can’t return a NULL value. The function can check if any of the function arguments can return NULL by checking the arguments maybe_null variable.

All functions must be thread-safe.

For string functions, there are some additional considerations to be aware of:

- The String *str argument provides a string buffer that may be used to hold the result.
- The function should return the string that holds the result.
- All current string functions try to avoid allocating any memory unless absolutely necessary!
16 Adding new procedures to MySQL

In MySQL, you can define a procedure in C++ that can access and modify the data in a query before it is sent to the client. The modification can be done on row by row or GROUP BY level.

We have created an example procedure in MySQL 3.23 to show you what can be done.

16.1 Procedure analyse

```c++
analyse([[max elements],[max memory]])
```

This procedure is defined in the `sql/sql_analyse.cc`. This examines the result from your query and returns an analysis of the results.

- **max elements** (default 256) is the maximum number of distinct values `analyse` will notice per column. This is used by `analyse` to check if the optimal column type should be of type ENUM.
- **max memory** (default 8192) is the maximum memory `analyse` should allocate per column while trying to find all distinct values.

```sql
SELECT ... FROM ... WHERE ... PROCEDURE ANALYSE([[max elements],[max memory]])
```

16.2 Writing a procedure.

For the moment, the only documentation for this is the source. :(

You can find all information about procedures by examining the following files:

- `sql/sql_analyse.cc`
- `sql/procedure.h`
- `sql/procedure.cc`
- `sql/sql_select.cc`
17 MySQL ODBC Support

MySQL provides support for ODBC by means of the MyODBC program.

17.1 Operating systems supported by MyODBC

MyODBC is a 32-bit ODBC (2.50) level 0 driver for connecting an ODBC-aware application to MySQL. MyODBC works on Windows95, Windows98, NT and on most Unix platforms. Normally you only need to install MyODBC on Windows machines. You only need MyODBC for Unix if you have a program like ColdFusion that is running on the Unix machine and uses ODBC to connect to the databases.

MyODBC is in public domain and you can find the newest version at http://www.mysql.com/download_myodbc.html.

If you want to install MyODBC on a Unix box, you will also need an ODBC manager. MyODBC is known to work both with most of the Unix ODBC managers. You can find a list at these in the ODBC-related links section on the MySQL useful links page. See Section 1.9 [Useful Links], page 11.

On Windows/NT you may get the following error when trying to install MyODBC:

An error occurred while copying C:\WINDOWS\SYSTEM\MFC30.DLL. Restart Windows and try installing again (before running any applications which use ODBC)

The problem in this case is that some other program is using ODBC and because of how windows is designed, one cannot in this case install new ODBC drivers with Microsoft’s ODBC setup program :( The solution to this is to reboot your computer in “safe mode” (You can choose this by pressing F8 just before your machine starts Windows during rebooting), install MyODBC and reboot to normal mode.

• To make a connection to an Unix box from a Windows box, with an ODBC application (one that doesn’t support MySQL natively), you must first install MyODBC on the Windows Machine.

• The user and Windows machine must have the access privileges to the MySQL server the Unix machine. This is set up with the GRANT command. See Section 7.26 [GRANT], page 224.

• You must create an ODBC DSN entry as follows:
  • Open the Control Panel on the Windows Machine
  • Double click the ODBC Data Sources 32 bits icon.
  • Click the tab User DSN
  • Click the button Add
  • Select MySQL in the screen Create New Data Source and click the Finish button.
  • The TCX MySQL Driver default configuration screen is shown. See Section 17.2 [ODBC administrator], page 346.
• Now start your application and select the ODBC driver with the DSN you specified in
the ODBC administrator.

Notice that there are other configuration options in the screen of MySQL (trace, don’t
prompt on connect, etc) that you can try if you run into problems.

17.2 How to fill in the various fields in the ODBC administrator program

There are three possibilities for specifying the server name on Windows95:
• Use the IP address of the server.
• Add a file ‘\windows\lmhosts’ with the following information:
  ip hostname
  For example:
    194.216.84.21 my_hostname
• Configure the PC to use DNS.

Example of how to fill in the ODBC setup

<table>
<thead>
<tr>
<th>Windows DSN name:</th>
<th>test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description:</td>
<td>This is my test database</td>
</tr>
<tr>
<td>MySql Database:</td>
<td>test</td>
</tr>
<tr>
<td>Server:</td>
<td>194.216.84.21</td>
</tr>
<tr>
<td>User:</td>
<td>monty</td>
</tr>
<tr>
<td>Password:</td>
<td>my_password</td>
</tr>
<tr>
<td>Port:</td>
<td></td>
</tr>
</tbody>
</table>

The value for the Windows DSN name field is any name that is unique in your Windows
ODBC setup.

You don’t have to specify values for the Server, User, Password or Port fields in the ODBC
setup screen. However, if you do, the values will be used as the defaults later when you
attempt to make a connection. You have the option of changing the values at that time.
If the port number is not given, the default port (3306) is used.

If you specify the option Read options from C:\my.cnf, the groups client and odbc will
be read from the ‘C:\my.cnf’ file. You can use all options that are usable by mysql_options(). See Section 21.4.37 [mysql_options], page 402.

17.3 How to report problems with MyODBC

MyODBC has been tested with Access, Admndemo.exe, C++-Builder, Borland Builder 4,
Centura Team Developer (formerly Gupta SQL/Windows), ColdFusion (on Solaris and NT
with svc pack 5), Crystal Reports, DataJunction, Delphi, ERwin, Excel, iHTML, FileMaker
Pro, FoxPro, Notes 4.5/4.6, SBSS, Perl DBD-ODBC, Paradox, Powerbuilder, Powerdesigner
32 bit, VC++ and Visual Basic.
If you know of any other applications that work with MyODBC, please mail myodbc@lists.mysql.com about this!

17.4 Programs known to work with MyODBC

Most programs should work with MyODBC, but for each of those listed below, we have tested it ourselves or gotten confirmation from some user that it works:

<table>
<thead>
<tr>
<th>Program</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Access</td>
<td>To make Access work:</td>
</tr>
<tr>
<td></td>
<td>• You should have a primary key in the table.</td>
</tr>
<tr>
<td></td>
<td>• You should have a timestamp in all tables you want to be able to update.</td>
</tr>
<tr>
<td></td>
<td>• Only use double float fields. Access fails when comparing with single floats.</td>
</tr>
<tr>
<td></td>
<td>• Set the ‘Return matching rows’ option field when connecting to MySQL.</td>
</tr>
<tr>
<td></td>
<td>• Access on NT will report BLOB columns as OLE OBJECTS. If you want to have MEMO columns instead, you should change the column to TEXT with ALTER TABLE.</td>
</tr>
<tr>
<td></td>
<td>• Access can’t always handle DATE columns properly. If you have a problem with these, change the columns to DATETIME.</td>
</tr>
<tr>
<td></td>
<td>• In some cases, Access may generate illegal SQL queries that MySQL can’t understand. You can fix this by selecting &quot;Query</td>
</tr>
<tr>
<td>Borland Builder 4</td>
<td>When you start a query you can use the property Active or use the method Open. Note that Active will start by automatically issue a SELECT * FROM ... query that may not be a good thing if your tables are big!</td>
</tr>
<tr>
<td>Coldfusion (On Unix)</td>
<td>The following information is taken from the Coldfusion documentation: Use the following information to configure ColdFusion Server for Linux to use the unixODBC driver with MyODBC for MySQL data sources. Allaire has verified that MyODBC version 2.50.26 works with MySQL version 3.22.27 and ColdFusion for Linux. (Any newer version should also work). You can download MyODBC at <a href="http://www.mysql.com/download_myodbc.html">http://www.mysql.com/download_myodbc.html</a> ColdFusion 4.5.1 allows you to us the ColdFusion Administrator to add the MySQL data source. However, the driver is not included with ColdFusion 4.5.1. Before the MySQL driver will appear in the ODBC data-sources drop-down list, you must build and copy the MyODBC driver to /opt/coldfusion/lib/libmyodbc.so.</td>
</tr>
<tr>
<td>DataJunction</td>
<td>You have to change it to output VARCHAR rather than ENUM, as it exports the latter in a manner that causes MySQL grief.</td>
</tr>
</tbody>
</table>
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Excel

Chapter 17: MySQL ODBC Support

Works. Some tips:
• If you have problems with dates, try to select them as strings using the
CONCAT() function. For example:
select CONCAT(rise_time), CONCAT(set_time)
from sunrise_sunset;
Values retrieved as strings this way should be correctly recognized as time
values by Excel97.
The purpose of CONCAT() in this example is to fool ODBC into thinking
the column is of “string type”. Without the CONCAT(), ODBC knows the
column is of time type, and Excel does not understand that.
Note that this is a bug in Excel, because it automatically converts a string
to a time. This would be great if the source was a text file, but is plain
stupid when the source is an ODBC connection that reports exact types
for each column.

odbcadmin
Test program for ODBC.
Delphi

You must use DBE 3.2 or newer. Set the ‘Don’t optimize column width’ option
field when connecting to MySQL.
Also, here is some potentially useful delphi code that sets up both an ODBC
entry and a BDE entry for MyODBC (the BDE entry requires a BDE Alias
Editor which may be had for free at a Delphi Super Page near you.): (Thanks
to Bryan Brunton bryan@flesherfab.com for this)
fReg:= TRegistry.Create;
fReg.OpenKey(’\Software\ODBC\ODBC.INI\DocumentsFab’, True);
fReg.WriteString(’Database’, ’Documents’);
fReg.WriteString(’Description’, ’ ’);
fReg.WriteString(’Driver’, ’C:\WINNT\System32\myodbc.dll’);
fReg.WriteString(’Flag’, ’1’);
fReg.WriteString(’Password’, ’’);
fReg.WriteString(’Port’, ’ ’);
fReg.WriteString(’Server’, ’xmark’);
fReg.WriteString(’User’, ’winuser’);
fReg.OpenKey(’\Software\ODBC\ODBC.INI\ODBC Data Sources’, True);
fReg.WriteString(’DocumentsFab’, ’MySQL’);
fReg.CloseKey;
fReg.Free;
Memo1.Lines.Add(’DATABASE NAME=’);
Memo1.Lines.Add(’USER NAME=’);
Memo1.Lines.Add(’ODBC DSN=DocumentsFab’);
Memo1.Lines.Add(’OPEN MODE=READ/WRITE’);
Memo1.Lines.Add(’BATCH COUNT=200’);
Memo1.Lines.Add(’LANGDRIVER=’);
Memo1.Lines.Add(’MAX ROWS=-1’);
Memo1.Lines.Add(’SCHEMA CACHE DIR=’);
Version: 3.23.11-alpha Printed: 25 February 2000


Memo1.Lines.Add('SCHEMA CACHE SIZE=8');
Memo1.Lines.Add('SCHEMA CACHE TIME=-1');
Memo1.Lines.Add('SQLPASSTHRU MODE=SHARED AUTOCOMMIT');
Memo1.Lines.Add('SQLQRYMODE=');
Memo1.Lines.Add('ENABLE SCHEMA CACHE=FALSE');
Memo1.Lines.Add('ENABLE BCD=FALSE');
Memo1.Lines.Add('ROWSET SIZE=20');
Memo1.Lines.Add('BLOBS TO CACHE=64');
Memo1.Lines.Add('BLOB SIZE=32');

AliasEditor.Add('DocumentsFab','MySQL',Memo1.Lines);

C++Builder

Tested with BDE 3.0. The only known problem is that when the table schema changes, query fields are not updated. BDE however does not seem to recognize primary keys, only the index PRIMARY, though this has not been a problem.

Visual basic

To be able to update a table, you must define a primary key for the table.

17.5 How to get the value of an AUTO_INCREMENT column in ODBC

A common problem is how to get the value of an automatically generated ID from an INSERT. With ODBC, you can do something like this (assuming that auto is an AUTO_INCREMENT field):

```
INSERT INTO foo (auto,text) VALUES(NULL,'text');
SELECT LAST_INSERT_ID();
```

Or, if you are just going to insert the ID into another table, you can do this:

```
INSERT INTO foo2 (id,text) VALUES(LAST_INSERT_ID(),'text');
```

For the benefit of some ODBC applications (at least Delphi and Access), the following query can be used to find a newly-inserted row:

```
SELECT * FROM tbl_name WHERE auto IS NULL;
```

17.6 Reporting problems with MyODBC

If you encounter difficulties with MyODBC, you should start by making a log file from the ODBC manager (the log you get when requesting logs from ODBCADMIN) and a MyODBC log. To get a MyODBC log, tag the ‘Trace MyODBC’ option flag in the MyODBC connect/configure screen. The log will be written to file ‘C:\myodbc.log’. Note that you must use MYSQL.DLL and not MYSQL2.DLL for this option to work!

Check the queries that MyODBC sends to the MySQL server; You should be able to find this by searching after the string >mysql_real_query in the ‘myodbc.log’ file.
You should also try duplicating the queries in the `mysql` monitor or `admndemo` to find out if the error is MyODBC or MySQL.

If you find out something is wrong, please only send the relevant rows (max 40 rows) to the `myodbc@lists.mysql.com`. Please never send the whole MyODBC or ODBC log file!

If you are unable to find out what’s wrong, the last option is to make a archive (tar or zip) that contains a MyODBC log file, the ODBC log file and a README file that explains the problem. You can send this to `ftp://www.mysql.com/pub/mysql/secret`. Only we at TCX will have access to the files you upload and we will be very discrete with the data!

If you can create a program that also shows this problem, please upload this too!

If the program works with some other SQL server, you should make a ODBC log file where you do exactly the same thing in the other SQL server.

Remember that the more information you can supply to us, the more likely it is that we can fix the problem!
18 Using MySQL with some common programs

18.1 Using MySQL with Apache

The contrib section includes programs that lets you authenticate your users from a MySQL database and also let you log your log files into a MySQL table. See Appendix B [Contrib], page 438.

You can change the Apache logging format to be easily readable by MySQL by putting the following into the Apache configuration file:

```
LogFormat "\"%h\",%{Y%m%d%H%M%S}t,%>s,"%b","%{Content-Type}o","%U","%{Referer}i","%{User-Agent}i\"
```

In MySQL you can now do something like this:

```
LOAD DATA INFILE '/local/access_log' INTO TABLE table_name
FIELDS TERMINATED BY ',' OPTIONALLY ENCLOSED BY '"' ESCAPED BY '\'
```
19 Problems and common errors

19.1 What to do if MySQL keeps crashing

All MySQL versions are tested on many platforms before they are released. This doesn’t mean that there isn’t any bugs in MySQL, but that if there are bugs they are very few and can be hard to find. If you have a problem, it will always help if you try to find out exactly what crashes your system as you will have a much better chance of getting this fixed quickly.

First you should try to find out whether the problem is that the mysqld daemon dies or whether your problem has to do with your client. You can check how long your mysqld server has been up by executing mysqladmin version. If mysqld has died, you may find the reason for this in the file ‘mysql-data-directory/hostname.err’.

Since it is very difficult to know why something is crashing, first try to check whether or not things that work for others crash for you. Please try the following things:

- Take down the mysqld daemon with mysqladmin shutdown, run myisamchk --silent --force */*.MYI on all tables and restart the mysqld daemon. This will ensure that you are running from a clean state. See Chapter 14 [Maintenance], page 323.
- Use mysqld --log and try to determine from the information in the log whether or not some specific query kills the server. 95% of all bugs are related to a particular query! Normally this is one of the last queries in the log file just before MySQL restarted.

You may be able to verify this using the following procedure:

- Take down the MySQL daemon (with mysqladmin shutdown)
- Make a backup of files in the MySQL database directory.
- Check the tables with myisamchk -s */*.MYI to verify that all tables are correct. If any table is corrupted, repair it with myisamchk -r path-to-table.MYI.
- Remove (or move away) any old log files from the MySQL data directory.
- Start the server with safe_mysql --log.
- If mysqld now dies, you can test if the problem is a specific query by restoring the backup and executing mysql < mysql-log-file. You can of course do the last test in some other directory than the standard MySQL database directory by starting another MySQL server with safe_mysqld --data=path-to-backup-directory.
- Have you tried the benchmarks? They should test MySQL rather well. You can also add code that simulates your application! The benchmarks can be found in the ‘bench’ directory in the source distribution, or, for a binary distribution, in the ‘sql-bench’ directory under your MySQL installation directory.
- Try fork_test.pl and fork2_test.pl.
- Check the file ‘mysql-data-directory/hostname.err’ for any errors.
• If you configure MySQL for debugging, it will be much easier to gather information about possible errors if something goes wrong. Reconfigure MySQL with the `--with-debug` option to `configure` and then recompile. See Section G.1 [Debugging server], page 506.

• Configuring MySQL for debugging causes a safe memory allocator to be included that can find some errors. It also provides a lot of output about what is happening.

• Have you applied the latest patches for your operating system?

• Use the `--skip-locking` option to `mysqld`. On some systems, the `lockd` lock manager does not work properly; the `--skip-locking` option tells `mysqld` not to use external locking. (This means that you cannot run 2 `mysqld` servers on the same data and that you must be careful if you use `myisamchk`, but it may be instructive to try the option as a test.)

• Have you tried `mysqladmin -u root processlist` when `mysqld` appears to be running but not responding? Sometimes `mysqld` is not comatose even though you might think so. The problem may be that all connections are in use, or there may be some internal lock problem. `mysqladmin processlist` will usually be able to make a connection even in these cases, and can provide useful information about the current number of connections and their status.

• Run the command `mysqladmin -i 5 status` in a separate window to produce statistics while you run your other queries.

• Try the following:
  1. Start `mysqld` from `gdb` (or another debugger).
  2. Run your test scripts.
  3. Do `back` (or the backtrace command in your debugger) when `mysqld` core dumps.

• Try to simulate your application with a Perl script to force MySQL to crash or misbehave.

• Or send a normal bug report. See Section 2.3 [Bug reports], page 19. But be even more detailed than usual. Since MySQL works for many people, it may be that the crash results from something that exists only on your computer (for example, an error that is related to your particular system libraries).

• If you have a problem with table with dynamic length rows and you are not using `BLOB/TEXT` columns (but only `VARCHAR` columns) you can try to change all `VARCHAR` to `CHAR` with `ALTER TABLE`. This will force MySQL to use fixed size rows. Fixed size rows take a little extra place, but are much more tolerant for corruption!

The current dynamic row code has been in use at TCX for at least 3 years without any problems, but by nature dynamic length rows are more prone to errors so it may be a good idea to try if the above helps!

19.2 Some common errors when using MySQL
19.2.1 MySQL server has gone away error

This section also covers the related Lost connection to server during query error.

The most common reason for the MySQL server has gone away error is that the server timed out and closed the connection. By default, the server closes the connection after 8 hours if nothing has happened. You can change the time limit with by setting the wait_timeout variable when you start mysqld.

You can check that the MySQL hasn’t died by executing mysqladmin version and examining the uptime.

If you have a script, you just have to issue the query again for the client to do an automatic reconnection.

You normally can get the following error codes in this case (which one you get is OS-dependent):

CR_SERVER_GONE_ERROR The client couldn’t send a question to the server.
CR_SERVER_LOST The client didn’t get an error when writing to the server, but it didn’t get a full answer (or any answer) to the question.

You can also get these errors if you send a query to the server that is incorrect or too large. If mysqld gets a packet that is too large or out of order, it assumes that something has gone wrong with the client and closes the connection. If you need big queries (for example, if you are working with big BLOB columns), you can increase the query limit by starting mysqld with the -O max_allowed_packet=# option (default 1M). The extra memory is allocated on demand, so mysqld will use more memory only when you issue a big query or when mysqld must return a big result row!

19.2.2 Can’t connect to [local] MySQL server error

A MySQL client on Unix can connect to the mysqld server in two different ways: Unix sockets, which connect through a file in the file system (default ’/tmp/mysqld.sock’), or TCP/IP, which connects through a port number. Unix sockets are faster than TCP/IP but can only be used when connecting to a server on the same computer. Unix sockets are used if you don’t specify a hostname or if you specify the special hostname localhost.

On Windows you can connect only with TCP/IP if the mysqld server is running on Win95/Win98. If it’s running on NT, you can also connect with named pipes. The name of the named pipe is MySQL. If you don’t give a hostname when connecting to mysqld, a MySQL client will first try to connect to the named pipe and if this doesn’t work it will connect to the TCP/IP port. You can force the use of named pipes on Windows by using . as the hostname.

The error (2002) Can’t connect to ... normally means that there isn’t a MySQL server running on the system or that you are using a wrong socket file or TCP/IP port when trying to connect to the mysqld server.
Start by checking (using `ps` or the task manager on Windows) that there is a process running named `mysqld` on your server! If there isn’t any `mysqld` process, you should start one. See Section 4.15.2 [Starting server], page 86.

If a `mysqld` process is running, you can check the server by trying these different connections (the port number and socket pathname might be different in your setup, of course):

```
shell> mysqladmin version
shell> mysqladmin variables
shell> mysqladmin -h 'hostname' version variables
shell> mysqladmin -h 'hostname' --port=3306 version
shell> mysqladmin -h 'ip for your host' version
shell> mysqladmin --socket=/tmp/mysql.sock version
```

Note the use of backquotes rather than forward quotes with the `hostname` command; these cause the output of `hostname` (i.e., the current hostname) to be substituted into the `mysqladmin` command.

Here are some reasons the `Can't connect to local MySQL server` error might occur:

- `mysqld` is not running.
- You are running on a system that uses MIT-pthreads. If you are running on a system that doesn’t have native threads, `mysqld` uses the MIT-pthreads package. See Section 4.2 [Which OS], page 36. However, MIT-pthreads doesn’t support Unix sockets, so on such a system you must always specify the hostname explicitly when connecting to the server. Try using this command to check the connection to the server:

```
shell> mysqladmin -h 'hostname' version
```

- Someone has removed the Unix socket that `mysqld` uses (default `'/tmp/mysqld.sock'`). You might have a cron job that removes the MySQL socket (e.g., a job that removes old files from the `/tmp` directory). You can always run `mysqladmin version` and check that the socket `mysqladmin` is trying to use really exists. The fix in this case is to change the cron job to not remove `mysqld.sock` or to place the socket somewhere else. You can specify a different socket location at MySQL configuration time with this command:

```
shell> ./configure --with-unix-socket-path=/path/to/socket
```

You can also start `safe_mysqld` with the `--socket=/path/to/socket` option and set the environment variable `MYSQL_UNIX_PORT` to the socket pathname before starting your MySQL clients.

- You have started the `mysqld` server with the `--socket=/path/to/socket` option. If you change the socket pathname for the server, you must also notify the MySQL clients about the new path. You can do this by setting the environment variable `MYSQL_UNIX_PORT` to the socket pathname or by providing the socket path as an argument to the clients. You can test the socket with this command:

```
shell> mysqladmin --socket=/path/to/socket version
```

- You are using Linux and one thread has died (core dumped). In this case you must kill the other `mysqld` threads (for example with the `mysql_zap` script) before you can start a new MySQL server. See Section 19.1 [Crashing], page 352.

If you get the error message `Can't connect to MySQL server on some_hostname`, you can try the following things to find out what is the problem:
• Check if the server up by doing `telnet your-host-name tcp-ip-port-number` and press `RETURN` a couple of times. If there is a MySQL server running on this port you should get a responses that includes the version number of the running MySQL server. If you get an error like `telnet: Unable to connect to remote host: Connection refused`, then there is no server running on the used port.

• Try connecting to the mysqld daemon on the local machine and check the TCP/IP port that mysqld it’s configured to use (variable `port`) with `mysqladmin variables`.

• Check that your mysqld server is not started with the `--skip-networking` option.

19.2.3 Host ‘...’ is blocked error

If you get a error like this:

```
   Host 'hostname' is blocked because of many connection errors.
   Unblock with 'mysqladmin flush-hosts'
```

This means that mysqld has gotten a lot (`max_connect_errors`) of connect requests from the host ‘hostname’ that have been interrupted in the middle. After `max_connect_errors` failed requests, mysqld assumes that something is wrong (like a attack from a cracker), and blocks the site from further connections until someone executes the command `mysqladmin flush-hosts`.

By default, mysqld blocks a host after 10 connection errors. You can easily adjust this by starting the server like this:

```
shell> safe_mysqld -O max_connect_errors=10000 &
```

Note that if you get this error message for a given host, you should first check that there isn’t anything wrong with TCP/IP connections from that host. If your TCP/IP connections aren’t working, it won’t do you any good to increase the value of the `max_connect_errors` variable!

19.2.4 Too many connections error

If you get the error `Too many connections` when you try to connect to MySQL, this means that there is already `max_connections` clients connected to the mysqld server.

If you need more connections than the default (100), then you should restart mysqld with a bigger value for the `max_connections` variable.

Note that mysqld actually allows (`max_connections+1`) clients to connect. The last connection is reserved for a user with the `process` privilege. By not giving this privilege to normal users (they shouldn’t need this), an administrator with this privilege can login and use `SHOW PROCESSLIST` to find out what could be wrong. See Section 7.21 [SHOW], page 211.

19.2.5 Out of memory error

If you issue a query and get something like the following error:

```
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```

...
mysql: Out of memory at line 42, 'malloc.c'
mysql: needed 8136 byte (8k), memory in use: 12481367 bytes (12189k)
ERROR 2008: MySQL client ran out of memory

Note that the error refers to the MySQL client mysql. The reason for this error is simply that the client does not have enough memory to store the whole result.

To remedy the problem, first check that your query is correct. Is it reasonable that it should return so many rows? If so, you can use mysql --quick, which uses `mysql_use_result()` to retrieve the result set. This places less of a load on the client (but more on the server).

### 19.2.6 Packet too large error

When a MySQL client or the mysqld server gets a packet bigger than `max_allowed_packet` bytes, it issues a Packet too large error and closes the connection.

If you are using the mysql client, you may specify a bigger buffer by starting the client with
```
mysql --set-variable=max_allowed_packet=8M
```

If you are using other clients that do not allow you to specify the maximum packet size (such as DBI), you need to set the packet size when you start the server. You can use a command-line option to `mysqld` to set `max_allowed_packet` to a larger size. For example, if you are expecting to store the full length of a BLOB into a table, you’ll need to start the server with the `--set-variable=max_allowed_packet=24M` option.

### 19.2.7 The table is full error

This error occurs when an in-memory temporary table becomes larger than `tmp_table_size` bytes. To avoid this problem, you can use the `-O tmp_table_size=#` option to `mysqld` to increase the temporary table size, or use the SQL option `SQL_BIG_TABLES` before you issue the problematic query. See Section 7.25 [SET OPTION], page 222.

You can also start `mysqld` with the `--big-tables` option. This is exactly the same as using `SQL_BIG_TABLES` for all queries.

### 19.2.8 Commands out of sync error in client

If you get Commands out of sync; You can’t run this command now in your client code, you are calling client functions in the wrong order!

This can happen, for example, if you are using `mysql_use_result()` and try to execute a new query before you have called `mysql_free_result()`. It can also happen if you try to execute two queries that return data without a `mysql_use_result()` or `mysql_store_result()` in between.
19.2.9 Ignoring user error

If you get the following error:

**Found wrong password for user: 'some_user@some_host'; Ignoring user**

This means that when `mysqld` was started or when it reloaded the permissions tables, it found an entry in the `user` table with an invalid password. As a result, the entry is simply ignored by the permission system.

Possible causes of and fixes for this problem:

- You may be running a new version of `mysqld` with an old `user` table. You can check this by executing `mysqlshow mysql user` to see if the password field is shorter than 16 characters. If so, you can correct this condition by running the `scripts/add_long_password` script.
- The user has an old password (8 characters long) and you didn’t start `mysqld` with the `--old-protocol` option. Update the user in the `user` table with a new password or restart `mysqld` with `--old-protocol`.
- You have specified a password in the `user` table without using the `PASSWORD()` function. Use `mysql` to update the user in the `user` table with a new password. Make sure to use the `PASSWORD()` function:
  ```sql
  mysql> update user set password=PASSWORD('your password')
  where user='XXX';
  ```

19.2.10 Table 'xxx' doesn’t exist error

If you get the error **Table 'xxx' doesn’t exist** or **Can’t find file: 'xxx' (errno: 2)**, this means that no table exists in the current database with the name `xxx`.

Note that as MySQL uses directories and files to store databases and tables, the database and table names are case sensitive! (On Win32 the databases and tables names are not case sensitive, but all references to a given table within a query must use the same case!)

You can check which tables you have in the current database with `SHOW TABLES`. See Section 7.21 [SHOW], page 211.

19.3 How MySQL handles a full disk

When a disk full condition occurs, MySQL does the following:

- It checks once every minute to see whether or not there is enough space to write the current row. If there is enough space, it continues as if nothing had happened.
- Every 6 minutes it writes an entry to the log file warning about the disk full condition.

To alleviate the problem, you can take the following actions:

- To continue, you only have to free enough disk space to insert all records.

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**To abort the thread, you must send a** `mysqladmin kill` **to the thread. The thread will be aborted the next time it checks the disk (in 1 minute).**

**Note that other threads may be waiting for the table that caused the “disk full” condition. If you have several “locked” threads, killing the one thread that is waiting on the disk full condition will allow the other threads to continue.**

### 19.4 How to run SQL commands from a text file

The `mysql` client typically is used interactively, like this:

```
shell> mysql database
```

However, it’s also possible to put your SQL commands in a file and tell `mysql` to read its input from that file. To do so, create a text file `text_file` that contains the commands you wish to execute. Then invoke `mysql` as shown below:

```
shell> mysql database < text_file
```

You can also start your text file with a `USE db_name` statement. In this case, it is unnecessary to specify the database name on the command line:

```
shell> mysql < text_file
```

See Section 13.1 [Programs], page 305.

### 19.5 Where MySQL stores temporary files

MySQL uses the value of the `TMPDIR` environment variable as the pathname of the directory in which to store temporary files. If you don’t have `TMPDIR` set, MySQL uses the system default, which is normally ‘/tmp’ or ‘/usr/tmp’. If the file system containing your temporary file directory is too small, you should edit `safe_mysqld` to set `TMPDIR` to point to a directory in a file system where you have enough space! You can also set the temporary directory using the `--tmpdir` option to `mysqld`.

MySQL creates all temporary files as “hidden files”. This ensures that the temporary files will be removed if `mysqld` is terminated. The disadvantage of using hidden files is that you will not see a big temporary file that fills up the file system in which the temporary file directory is located.

When sorting (ORDER BY or GROUP BY), MySQL normally uses one or two temporary files. The maximum disk-space needed is:

```
(length of what is sorted + sizeof(database pointer))
* number of matched rows
* 2
```

`sizeof(database pointer)` is usually 4, but may grow in the future for really big tables.

For some SELECT queries, MySQL also creates temporary SQL tables. These are not hidden and have names of the form ‘SQL_’.

**ALTER TABLE** and **OPTIMIZE TABLE** create a temporary table in the same directory as the original table.
19.6 How to protect ‘/tmp/mysql.sock’ from being deleted

If you have problems with the fact that anyone can delete the MySQL communication socket ‘/tmp/mysql.sock’, you can, on most versions of Unix, protect your ‘/tmp’ file system by setting the sticky bit on it. Log in as root and do the following:

   shell> chmod +t /tmp

This will protect your ‘/tmp’ file system so that files can be deleted only by their owners or the superuser (root).

You can check if the sticky bit is set by executing ls -ld /tmp. If the last permission bit is t, the bit is set.

19.7 Access denied error

See Section 6.8 [Privileges], page 113. And especially see Section 6.15 [Access denied], page 126.

19.8 How to run MySQL as a normal user

The MySQL server mysqld can be started and run by any user. In order to change mysqld to run as Unix user user_name, you must do the following:

1. Stop the server if it’s running (use mysqladmin shutdown).

2. Change the database directories and files so that user_name has privileges to read and write files in them (you may need to do this as the Unix root user):

   shell> chown -R user_name /path/to/mysql/datadir

   If directories or files within the MySQL data directory are symlinks, you’ll also need to follow those links and change the directories and files they point to. chown -R may not follow symlinks for you.

3. Start the server as user user_name, or, if you are using MySQL 3.22 or later, start mysqld as the Unix root user and use the --user=user_name option. mysqld will switch to run as Unix user user_name before accepting any connections.

4. If you are using the mysql.server script to start mysqld when the system is rebooted, you should edit mysql.server to use su to run mysqld as user user_name, or to invoke mysqld with the --user option. (No changes to safe_mysqld are necessary.)

At this point, your mysqld process should be running fine and dandy as the Unix user user_name. One thing hasn’t changed, though: the contents of the permissions tables. By default (right after running the permissions table install script mysql_install_db), the MySQL user root is the only user with permission to access the mysql database or to create or drop databases. Unless you have changed those permissions, they still hold. This shouldn’t stop you from accessing MySQL as the MySQL root user when you’re logged in as a Unix user other than root; just specify the -u root option to the client program.
Note that accessing MySQL as root, by supplying -u root on the command line, has nothing to do with MySQL running as the Unix root user, or, indeed, as other Unix user. The access permissions and user names of MySQL are completely separate from Unix user names. The only connection with Unix user names is that if you don’t provide a -u option when you invoke a client program, the client will try to connect using your Unix login name as your MySQL user name.

If your Unix box itself isn’t secured, you should probably at least put a password on the MySQL root users in the access tables. Otherwise, any user with an account on that machine can run mysql -u root db_name and do whatever he likes.

### 19.9 How to reset a forgotten password.

If you have forgotten the root user password for MySQL, you can restore it with the following procedure.

1. Take down the mysqld server by sending a kill (not kill -9) to the mysqld server.
   The pid is stored in a .pid file which is normally in the MySQL database directory:
   
   ```
   kill 'cat /mysql-data-directory/hostname.pid'
   ```

   You must be either the UNIX root user or the same user the server runs as to do this.

2. Restart mysqld with the --skip-grant-tables option.

3. Connect to the mysqld server with mysql -h hostname mysql and change the password with a GRANT command. See Section 7.26 [GRANT], page 224. You can also do this with mysqladmin -h hostname -u user password 'new password'

4. Load the privilege tables with: mysqladmin -h hostname flush-privileges or with the SQL command FLUSH PRIVILEGES.

### 19.10 Problems with file permissions

If you have problems with file permissions, for example, if mysql issues the following error message when you create a table:

ERROR: Can’t find file: 'path/with/filename.frm' (Errcode: 13)

Then the environment variable UMASK might be set incorrectly when mysqld starts up. The default umask value is 0660. You can change this behavior by starting safe_mysqld as follows:

```
shell> UMASK=384 # = 600 in octal
shell> export UMASK
shell> /path/to/safe_mysqld &
```

### 19.11 File not found
If you get `ERROR '...' not found (errno: 23). Can’t open file: ... (errno: 24)` or any other error with `errno 23` or `errno 24` from MySQL, it means that you haven’t allocated enough file descriptors for MySQL. You can use the `perror` utility to get a description of what the error number means:

```
shell> perror 23
File table overflow
shell> perror 24
Too many open files
```

The problem here is that mysqld is trying to keep open too many files simultaneously. You can either tell mysqld not to open so many files at once, or increase the number of file descriptors available to mysqld.

To tell mysqld to keep open fewer files at a time, you can make the table cache smaller by using the `-O table_cache=32` option to `safe_mysqld` (the default value is 64). Reducing the value of `max_connections` will also reduce the number of open files (the default value is 90).

To change the number of file descriptors available to mysqld, modify the `safe_mysqld` script. There is a commented-out line `ulimit -n 256` in the script. You can remove the `#` character to uncomment this line, and change the number 256 to change the number of file descriptors available to mysqld.

`ulimit` can increase the number of file descriptors, but only up to the limit imposed by the operating system. If you need to increase the OS limit on the number of file descriptors available to each process, consult the documentation for your operating system.

Note that if you run the tcsh shell, `ulimit` will not work! tcsh will also report incorrect values when you ask for the current limits! In this case you should start `safe_mysqld` with `sh`!

### 19.12 Problems using DATE columns

The format of a `DATE` value is `'YYYY-MM-DD'`. According to ANSI SQL, no other format is allowed. You should use this format in `UPDATE` expressions and in the `WHERE` clause of `SELECT` statements. For example:

```
mysql> SELECT * FROM tbl_name WHERE date >= '1997-05-05';
```

As a convenience, MySQL automatically converts a date to a number if the date is used in a numeric context (and vice versa). It is also smart enough to allow a “relaxed” string form when updating and in a `WHERE` clause that compares a date to a `TIMESTAMP`, `DATE` or a `DATETIME` column. (Relaxed form means that any punctuation character may be used as the separator between parts. For example, `'1998-08-15'` and `'1998#08#15'` are equivalent.) MySQL can also convert a string containing no separators (such as `'19980815'`), provided it makes sense as a date.

The special date `'0000-00-00'` can be stored and retrieved as `'0000-00-00'`. When using a `'0000-00-00'` date through MyODBC, it will automatically be converted to `NULL` in MyODBC 2.50.12 and above, because ODBC can’t handle this kind of date.
Since MySQL performs the conversions described above, the following statements work:

```sql
mysql> INSERT INTO tbl_name (idate) VALUES (19970505);
mysql> INSERT INTO tbl_name (idate) VALUES ('19970505');
mysql> INSERT INTO tbl_name (idate) VALUES ('97-05-05');
mysql> INSERT INTO tbl_name (idate) VALUES ('1997.05.05');
mysql> INSERT INTO tbl_name (idate) VALUES ('1997 05 05');
mysql> INSERT INTO tbl_name (idate) VALUES ('0000-00-00');
mysql> SELECT idate FROM tbl_name WHERE idate >= '1997-05-05';
mysql> SELECT idate FROM tbl_name WHERE idate >= 19970505;
mysql> SELECT mod(idate,100) FROM tbl_name WHERE idate >= 19970505;
mysql> SELECT idate FROM tbl_name WHERE idate >= '19970505';
```

However, the following will not work:

```sql
mysql> SELECT idate FROM tbl_name WHERE STRCMP(idate,'19970505')=0;
```

`STRCMP()` is a string function, so it converts `idate` to a string and performs a string comparison. It does not convert '19970505' to a date and perform a date comparison.

Note that MySQL does no checking whether or not the date is correct. If you store an incorrect date, such as '1998-2-31', the wrong date will be stored. If the date cannot be converted to any reasonable value, a 0 is stored in the DATE field. This is mainly a speed issue and we think it is up to the application to check the dates, and not the server.

### 19.13 Timezone problems

If you have a problem with `SELECT NOW()` returning values in GMT and not your local time, you have to set the `TZ` environment variable to your current timezone. This should be done for the environment in which the server runs, for example in `safe_mysqld` or `mysql.server`.

### 19.14 Case sensitivity in searches

By default, MySQL searches are case-insensitive (although there are some character sets that are never case insensitive, such as czech). That means that if you search with `col_name LIKE 'a%'`, you will get all column values that start with A or a. If you want to make this search case-sensitive, use something like `INDEX(col_name, "A")=0` to check a prefix. Or use `STRCMP(col_name, "A") = 0` if the column value must be exactly "A".

Simple comparison operations (`>=`, `>`, `=`, `<`, `<>`, sorting and grouping) are based on each character’s “sort value”. Characters with the same sort value (like E, e and ´ e) are treated as the same character!

LIKE comparisons are done on the uppercase value of each character (E == e but E <> é)

If you want a column always to be treated in case-sensitive fashion, declare it as `BINARY`. See Section 7.7 [CREATE TABLE], page 187.

If you are using Chinese data in the so-called big5 encoding, you want to make all character columns `BINARY`. This works because the sorting order of big5 encoding characters is based on the order of ASCII codes.
19.15 Problems with NULL values

The concept of the NULL value is a common source of confusion for newcomers to SQL, who often think that NULL is the same thing as an empty string ‘ ’. This is not the case! For example, the following statements are completely different:

```sql
mysql> INSERT INTO my_table (phone) VALUES (NULL);
mysql> INSERT INTO my_table (phone) VALUES ('');
```

Both statements insert a value into the `phone` column, but the first inserts a NULL value and the second inserts an empty string. The meaning of the first can be regarded as “phone number is not known” and the meaning of the second can be regarded as “she has no phone”.

In SQL, the NULL value is always false in comparison to any other value, even NULL. An expression that contains NULL always produces a NULL value unless otherwise indicated in the documentation for the operators and functions involved in the expression. All columns in the following example return NULL:

```sql
mysql> SELECT NULL,1+NULL,CONCAT('Invisible',NULL);
```

If you want to search for column values that are NULL, you cannot use the `=NULL` test. The following statement returns no rows, because `expr = NULL` is FALSE, for any expression:

```sql
mysql> SELECT * FROM my_table WHERE phone = NULL;
```

To look for NULL values, you must use the `IS NULL` test. The following shows how to find the NULL phone number and the empty phone number:

```sql
mysql> SELECT * FROM my_table WHERE phone IS NULL;
mysql> SELECT * FROM my_table WHERE phone = "";
```

In MySQL, as in many other SQL servers, you can’t index columns that can have NULL values. You must declare such columns `NOT NULL`. Conversely, you cannot insert NULL into an indexed column.

When reading data with `LOAD DATA INFILE`, empty columns are updated with ‘ ’. If you want a NULL value in a column, you should use ‘\N’ in the text file. The literal word ‘NULL’ may also be used under some circumstances. See Section 7.16 [LOAD DATA], page 204.

When using `ORDER BY`, NULL values are presented first. If you sort in descending order using `DESC`, NULL values are presented last. When using `GROUP BY`, all NULL values are regarded as equal.

To help with NULL handling, you can use the `IS NULL` and `IS NOT NULL` operators and the `IFNULL()` function.

For some column types, NULL values are handled specially. If you insert NULL into the first `TIMESTAMP` column of a table, the current date and time is inserted. If you insert NULL into an `AUTO_INCREMENT` column, the next number in the sequence is inserted.

19.16 Problems with alias

You can use alias to refer to a column in the `GROUP BY`, `ORDER BY` or in the `HAVING` part. Aliases can also be used to give columns more better names:
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```
SELECT SQRT(a*b) as rt FROM table_name GROUP BY rt HAVING rt > 0;
SELECT id,COUNT(*) AS cnt FROM table_name GROUP BY id HAVING cnt > 0;
SELECT id AS "Customer identity" FROM table_name;
```

Note that you ANSI SQL doesn’t allow you to refer to an alias in a WHERE clause. This is because that when the WHERE code is executed the column value may not yet be determined. For example the following query is illegal:

```
SELECT id,COUNT(*) AS cnt FROM table_name WHERE cnt > 0 GROUP BY id;
```

The WHERE statement is executed to determinate which rows should be included in the GROUP BY part while HAVING is used to decide which rows from the result set should be used.

19.17 Deleting rows from related tables

As MySQL doesn’t support sub-selects or use of more than one table in the DELETE statement, you should use the following approach to delete rows from 2 related tables:

1. SELECT the rows based on some WHERE condition in the main table.
2. DELETE the rows in the main table based on the same condition.
3. DELETE FROM related_table WHERE related_column IN (selected_rows)

If the total number of characters in the query with related_column is more than 1,048,576 (the default value of max_allowed_packet, you should split it into smaller parts and execute multiple DELETE statements. You will probably get the fastest DELETE by only deleting 100-1000 related_column id’s per time if the related_column is an index. If the related_column isn’t an index, the speed is independent of the number of arguments in the IN clause.

19.18 Solving problems with no matching rows

If you have a complicated query with many tables that doesn’t return any rows, you should use the following procedure to find out what is wrong with your query:

1. Test the query with EXPLAIN and check if you can find something that is obviously wrong. See Section 7.22 [EXPLAIN], page 216.
2. Select only those fields that are used in the WHERE clause.
3. Remove one table at a time from the query until it returns some rows. If the tables are big, it's a good idea to use LIMIT 10 with the query.
4. Do a SELECT for the column that should have matched a row, against the table that was last removed from the query.
5. If you are comparing FLOAT or DOUBLE columns with numbers that have decimals, you can’t use =! This problem is common in most computer languages because floating point values are not exact values.

```
mysql> SELECT * FROM table_name WHERE float_column=3.5;
```

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mysql> SELECT * FROM table_name WHERE float_column between 3.45 and 3.55;
In most cases, changing the FLOAT to a DOUBLE will fix this!

6. If you still can’t find out what’s wrong, create a minimal test that can be run with mysql test < query.sql that shows your problems. You can create a test file with mysqldump --quick database tables > query.sql. Take the file up in a editor, remove some insert lines (if there are too many of these) and add your select statement last in the file.

Test that you still have your problem by doing:

shell> mysqladmin create test2
shell> mysql test2 < query.sql

Post the test file using mysqlbug to mysql@lists.mysql.com.

19.19 Problems with ALTER TABLE.

If ALTER TABLE dies with an error like this:

   Error on rename of './database/name.frm' to './database/B-a.frm' (Errcode: 17)

The problem may be that MySQL has crashed in a previous ALTER TABLE and there is an old table named ‘A-something’ or ‘B-something’ lying around. In this case, go to the MySQL data directory and delete all files that have names starting with A- or B-. (You may want to move them elsewhere instead of deleting them).

ALTER TABLE works the following way:

- Create a new table named ‘A-xxx’ with the requested changes.
- All rows from the old table are copied to ‘A-xxx’.
- The old table is renamed ‘B-xxx’.
- ‘A-xxx’ is renamed to your old table name.
- ‘B-xxx’ is deleted.

If something goes wrong with the renaming operation, MySQL tries to undo the changes. If something goes seriously wrong (this shouldn’t happen, of course), MySQL may leave the old table as ‘B-xxx’ but a simple rename should get your data back.

19.20 How to change the order of columns in a table

The whole point of SQL is to abstract the application from the data storage format. You should always specify the order in wish you wish to retrieve your data. For example:

SELECT col_name1, col_name2, col_name3 FROM tbl_name;

will return columns in the order col_name1, col_name2, col_name3, whereas:

SELECT col_name1, col_name3, col_name2 FROM tbl_name;

will return columns in the order col_name1, col_name3, col_name2.

You should NEVER, in an application, use SELECT * and retrieve the columns based on their position, because the order in which columns are returned CANNOT be guaranteed.
over time; A simple change to your database may cause your application to fail rather dramatically.

If you want to change the order of columns anyway, you can do it as follows:

1. Create a new table with the columns in the right order.
2. Execute `INSERT INTO new_table SELECT fields-in-new_table-order FROM old_table`.
3. Drop or rename `old_table`
4. `ALTER TABLE new_table RENAME old_table`
20 Solving some common problems with MySQL

20.1 Database replication

One way replication can be used both to increase robustness and speed. For robustness you have two systems and switch to the backup if you get problems you switch to the backup. The extra speed is achieved by sending a part of the non updating queries to the replica server. Of course this only works if non updating queries dominate, but that is the normal case.

One way replication is planned for the near future. This will be implemented so that slave servers will be synchronized with low priority updates and delayed inserts up to date (this will give readers higher priority than writers).

MySQL doesn’t (yet) have database replication, but here are some info on how to do it.

The most general way to replicate a database is to use the update log. See Section 10.2 [Update log], page 273. This requires one database that acts as a master (to which data changes are made) and one or more other databases that act as slaves. To update a slave, just run mysql < update_log. Supply host, user and password options that are appropriate for the slave database, and use the update log from the master database as input.

If you never delete anything from a table, you can use a TIMESTAMP column to find out which rows have been inserted or changed in the table since the last replication (by comparing to the time when you did the replication last time) and only copy these rows to the mirror.

It is possible to make a two-way updating system using both the update log (for deletes) and timestamps (on both sides). But in that case you must be able to handle conflicts when the same data have been changed in both ends. You probably want to keep the old version to help with deciding what has been updated.

Because replication in this case is done with SQL statements, you should not use the following functions in statements that update the database; they may not return the same value as in the original database:

- DATABASE()
- GET_LOCK() and RELEASE_LOCK()
- RAND()
- USER(), SYSTEM_USER() or SESSION_USER()
- VERSION()

All time functions are safe to use, as the timestamp is sent to the mirror if needed. LAST_INSERT_ID() is also safe to use.
20.2 Database backups

Since MySQL tables are stored as files, it is easy to do a backup. To get a consistent backup, do a `LOCK TABLES` on the relevant tables. See Section 7.24 [LOCK TABLES], page 221. You only need a read lock; this allows other threads to continue to query the tables while you are making a copy of the files in the database directory. If you want to make a SQL level backup, you can use `SELECT INTO OUTFILE`.

Another way to backup a database is to use the `mysqldump` program:

1. Do a full backup of your databases:
   ```
   shell> mysqldump --tab=/path/to/some/dir --opt --full
   ```
   You can also simply copy all table files (`*.frm`, `*.MYD` and `*.MYI` files), as long as the server isn’t updating anything.

2. Stop `mysqld` if it’s running, then start it with the `--log-update` option. You will get log files with names of the form `hostname.n`, where `n` is a number that is incremented each time you execute `mysqldadmin refresh` or `mysqldadmin flush-logs`, the `FLUSH LOGS` statement, or restart the server. These log files provide you with the information you need to replicate changes to the database that are made subsequent to the point at which you executed `mysqldump`.

If you have to restore something, try to recover your tables using `myisamchk -r` first. That should work in 99.9% of all cases. If `myisamchk` fails, try the following procedure:

1. Restore the original `mysqldump` backup.
2. Execute the following command to re-run the updates in the update logs:
   ```
   shell> ls -l -t -r hostname.[0-9]* | xargs cat | mysql
   ```
   `ls` is used to get all the log files in the right order.

You can also do selective backups with `SELECT * INTO OUTFILE 'file_name' FROM tbl_name` and restore with `LOAD DATA INFILE 'file_name' REPLACE ...`. To avoid duplicate records, you need a `PRIMARY KEY` or a `UNIQUE` key in the table. The `REPLACE` keyword causes old records to be replaced with new ones when a new record duplicates an old record on a unique key value.

20.3 Running multiple MySQL servers on the same machine

There are circumstances when you might want to run multiple servers on the same machine. For example, you might want to test a new MySQL release while leaving your existing production setup undisturbed. Or you might be an Internet service provider that wants to provide independent MySQL installations for different customers.

If you want to run multiple servers, the easiest way is to compile the servers with different TCP/IP ports and socket files so they are not both listening to the same TCP/IP port or socket file.

Assume an existing server is configured for the default port number and socket file. Then configure the new server with a `configure` command something like this:
shell> ./configure --with-tcp-port=port_number \ 
  --with-unix-socket=file_name \ 
  --prefix=/usr/local/mysql-3.22.9

Here `port_number` and `file_name` should be different than the default port number and 
socket file pathname, and the `--prefix` value should specify an installation directory dif-
ferent than the one under which the existing MySQL installation is located.

You can check the socket and port used by any currently-executing MySQL server with this 
command:

    shell> mysqladmin -h hostname --port=port_number variables

If you have a MySQL server running on the port you used, you will get a list of some of the 
most important configurable variables in MySQL, including the socket name.

You should also edit the initialization script for your machine (probably `mysql.server`) 
to start and kill multiple mysqld servers.

You don’t have to recompile a new MySQL server just to start with a different port and 
socket. You can change the port and socket to be used by specifying them at runtime as 
options to `safe_mysqld`:

    shell> /path/to/safe_mysqld --socket=file_name --port=port_number

If you run the new server on the same database directory as another server with logging 
enabled, you should also specify the name of the log files to `safe_mysqld` with `--log` and 
`--log-update`. Otherwise, both servers may be trying to write to the same log file.

**Warning:** Normally you should never have two servers that update data in the same 
database! If your OS doesn’t support fault-free system locking, this may lead to unpleasant 
surprises!

If you want to use another database directory for the second server, you can use the `-- 
datadir=path` option to `safe_mysqld`.

When you want to connect to a MySQL server that is running with a different port than 
the port that is compiled into your client, you can use one of the following methods:

- Start the client with `--host 'hostname' --port=port_number` or `[--host localhost]` 
  `--socket=file_name`.

- In your C or Perl programs, you can give the port and socket arguments when con-
necting to the MySQL server.

- Set the `MYSQL_UNIX PORT` and `MYSQL_TCP_PORT` environment variables to point to the 
Unix socket and TCP/IP port before you start your clients. If you normally use a 
specific socket or port, you should place commands to set these environment variables 
in your `~/.login` file. See Section 13.1 [Programs], page 305.

- Specify the default socket and TCP/IP port in the `~/.my.cnf` file in your home directory. 
See Section 4.15.4 [Option files], page 89.
21 MySQL client tools and APIs

21.1 MySQL C API

The C API code is distributed with MySQL. It is included in the mysqlclient library and allows C programs to access a database.

Many of the clients in the MySQL source distribution are written in C. If you are looking for examples that demonstrate how to use the C API, take a look at these clients. Most of the other client APIs (all except Java) use the mysqlclient library to communicate with the MySQL server. This means that, for example, you can take advantage of many of the same environment variables that are used by other client programs, because they are referenced from the library. See Section 13.1 [Programs], page 305, for a list of these variables.

The client has a maximum communication buffer size. The size of the buffer that is allocated initially (16K bytes) is automatically increased up to the maximum size (the default maximum is 24M). Since buffer sizes are increased only as demand warrants, simply increasing the default maximum limit does not in itself cause more resources to be used. This size check is mostly a check for erroneous queries and communication packets.

The communication buffer must be large enough to contain a single SQL statement (for client-to-server traffic) and one row of returned data (for server-to-client traffic). Each thread’s communication buffer is dynamically enlarged to handle any query or row up to the maximum limit. For example, if you have BLOB values that contain up to 16M of data, you must have a communication buffer limit of at least 16M (in both server and client). The client’s default maximum is 24M, but the default maximum in the server is 1M. You can increase this by changing the value of the max_allowed_packet parameter when the server is started. See Section 11.2.3 [Server parameters], page 278.

The MySQL server shrinks each communication buffer to net_buffer_length bytes after each query. For clients, the size of the buffer associated with a connection is not decreased until the connection is closed, at which time client memory is reclaimed.

If you are programming with threads, you should compile the MySQL C API with --with-thread-safe-client. This will make the C API thread safe per connection. You can let two threads share the same connection as long as you do the following:

Two threads can’t send a query to the MySQL at the same time on the same connection. In particular you have to ensure that between a mysql_query() and mysql_store_result() no other thread is using the same connection.

Many threads can access different result sets that are retrieved with mysql_store_result().

If you use mysql_use_result, you have to ensure that no other thread is asking anything on the same connection until the result set is closed.
21.2 C API datatypes

MYSQL
This structure represents a handle to one database connection. It is used for almost all MySQL functions.

MYSQL_RES
This structure represents the result of a query that returns rows (SELECT, SHOW, DESCRIBE, EXPLAIN). The information returned from a query is called the result set in the remainder of this section.

MYSQL_ROW
This is a type-safe representation of one row of data. It is currently implemented as an array of counted byte strings. (You cannot treat these as null-terminated strings if field values may contain binary data, because such values may contain null bytes internally.) Rows are obtained by calling mysql_fetch_row().

MYSQL_FIELD
This structure contains information about a field, such as the field’s name, type and size. Its members are described in more detail below. You may obtain the MYSQL_FIELD structures for each field by calling mysql_fetch_field() repeatedly. Field values are not part of this structure; they are contained in a MYSQL_ROW structure.

MYSQL_FIELD_OFFSET
This is a type-safe representation of an offset into a MySQL field list. (Used by mysql_field_seek().) Offsets are field numbers within a row, beginning at zero.

my_ulonglong
The type used for the number of rows and for mysql_affected_rows(), mysql_num_rows() and mysql_insert_id(). This type provides a range of 0 to 1.84e19.

On some systems, attempting to print a value of type my_ulonglong will not work. To print such a value, convert it to unsigned long and use a %lu print format. Example:

```
printf (Number of rows: \%lu\n", (unsigned long) mysql_num_rows(result));
```

The MYSQL_FIELD structure contains the members listed below:

char * name
The name of the field, as a null-terminated string.

char * table
The name of the table containing this field, if it isn’t a calculated field. For calculated fields, the table value is an empty string.

char * def
The default value of this field, as a null-terminated string. This is set only if you use mysql_list_fields().
enum enum_field_types type

The type of the field. The type value may be one of the following:

<table>
<thead>
<tr>
<th>Type value</th>
<th>Type meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>FIELD_TYPE_TINY</td>
<td>TINYINT field</td>
</tr>
<tr>
<td>FIELD_TYPE_SHORT</td>
<td>SMALLINT field</td>
</tr>
<tr>
<td>FIELD_TYPE_LONG</td>
<td>INTEGER field</td>
</tr>
<tr>
<td>FIELD_TYPE_INT24</td>
<td>MEDIUMINT field</td>
</tr>
<tr>
<td>FIELD_TYPE_LONGLONG</td>
<td>BIGINT field</td>
</tr>
<tr>
<td>FIELD_TYPE_DECIMAL</td>
<td>DECIMAL or NUMERIC field</td>
</tr>
<tr>
<td>FIELD_TYPE_FLOAT</td>
<td>FLOAT field</td>
</tr>
<tr>
<td>FIELD_TYPE_DOUBLE</td>
<td>DOUBLE or REAL field</td>
</tr>
<tr>
<td>FIELD_TYPE_TIMESTAMP</td>
<td>TIMESTAMP field</td>
</tr>
<tr>
<td>FIELD_TYPE_DATE</td>
<td>DATE field</td>
</tr>
<tr>
<td>FIELD_TYPE_TIME</td>
<td>TIME field</td>
</tr>
<tr>
<td>FIELD_TYPE_DATETIME</td>
<td>DATETIME field</td>
</tr>
<tr>
<td>FIELD_TYPE_YEAR</td>
<td>YEAR field</td>
</tr>
<tr>
<td>FIELD_TYPE_STRING</td>
<td>String (CHAR or VARCHAR) field</td>
</tr>
<tr>
<td>FIELD_TYPE_BLOB</td>
<td>BLOB or TEXT field (use max_length to determine the maximum length)</td>
</tr>
<tr>
<td>FIELD_TYPE_SET</td>
<td>SET field</td>
</tr>
<tr>
<td>FIELD_TYPE_ENUM</td>
<td>ENUM field</td>
</tr>
<tr>
<td>FIELD_TYPE_NULL</td>
<td>NULL-type field</td>
</tr>
<tr>
<td>FIELD_TYPE_CHAR</td>
<td>Deprecated; use FIELD_TYPE_TINY instead</td>
</tr>
</tbody>
</table>

You can use the IS_NUM() macro to test whether or not a field has a numeric type. Pass the type value to IS_NUM() and it will evaluate to TRUE if the field is numeric:

```c
if (IS_NUM(field->type))
    printf("Field is numeric\n");
```

unsigned int length

The width of the field, as specified in the table definition.

unsigned int max_length

The maximum width of the field for the result set (the length of the longest field value for the rows actually in the result set). If you use mysql_store_result() or mysql_list_fields(), this contains the maximum length for the field. If you use mysql_use_result(), the value of this variable is zero.

unsigned int flags

Different bit-flags for the field. The flags value may have zero or more of the following bits set:

<table>
<thead>
<tr>
<th>Flag value</th>
<th>Flag meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOT_NULL_FLAG</td>
<td>Field can’t be NULL</td>
</tr>
<tr>
<td>PRI_KEY_FLAG</td>
<td>Field is part of a primary key</td>
</tr>
<tr>
<td>UNIQUE_KEY_FLAG</td>
<td>Field is part of a unique key</td>
</tr>
<tr>
<td>MULTIPLE_KEY_FLAG</td>
<td>Field is part of a non-unique key.</td>
</tr>
<tr>
<td>UNSIGNED_FLAG</td>
<td>Field has the UNSIGNED attribute</td>
</tr>
</tbody>
</table>
ZEROFILL_FLAG  Field has the ZEROFILL attribute
BINARY_FLAG   Field has the BINARY attribute
AUTO_INCREMENT_FLAG Field has the AUTO_INCREMENT attribute
ENUM_FLAG Field is an ENUM (deprecated)
BLOB_FLAG Field is a BLOB or TEXT (deprecated)
TIMESTAMP_FLAG Field is a TIMESTAMP (deprecated)

Use of the BLOB_FLAG, ENUM_FLAG and TIMESTAMP_FLAG flags is deprecated because they indicate the type of a field rather than an attribute of its type. It is preferable to test field->type against FIELD_TYPE_BLOB, FIELD_TYPE_ENUM or FIELD_TYPE_TIMESTAMP instead.

The example below illustrates a typical use of the flags value:

```c
if (field->flags & NOT_NULL_FLAG)
    printf("Field can't be null\n");
```

You may use the following convenience macros to determine the boolean status of the flags value:

- **IS_NOT_NULL(flags)**  True if this field is defined as NOT NULL
- **IS_PRI_KEY(flags)**    True if this field is a primary key
- **IS_BLOB(flags)**       True if this field is a BLOB or TEXT (deprecated; test field->type instead)

**unsigned int decimals**

The number of decimals for numeric fields.

### 21.3 C API function overview

The functions available in the C API are listed below and are described in greater detail in the next section. See Section 21.4 [C API functions], page 378.

- **mysql_affected_rows()** Returns the number of rows affected by the last UPDATE, DELETE or INSERT query.
- **mysql_close()** Closes a server connection.
- **mysql_connect()** Connects to a MySQL server. This function is deprecated; use **mysql_real_connect()** instead.
- **mysql_change_user()** Change user and database on an open connection.
- **mysql_create_db()** Creates a database. This function is deprecated; use the SQL command **CREATE DATABASE** instead.
- **mysql_data_seek()** Seeks to an arbitrary row in a query result set.
- **mysql_debug()** Does a **DBG_PUSH** with the given string.
- **mysql_drop_db()** Drops a database. This function is deprecated; use the SQL command **DROP DATABASE** instead.
- **mysql_dump_debug_info()** Makes the server write debug information to the log.
mysql_eof()  Determines whether or not the last row of a result set has been read. This function is deprecated; mysql_errno() or mysql_error() may be used instead.

mysql_errno()  Returns the error number for the most recently invoked MySQL function.

mysql_error()  Returns the error message for the most recently invoked MySQL function.

mysql_escape_string()  Escapes special characters in a string for use in a SQL statement.

mysql_fetch_field()  Returns the type of the next table field.

mysql_fetch_field_direct()  Returns the type of a table field, given a field number.

mysql_fetch_fields()  Returns an array of all field structures.

mysql_fetch_lengths()  Returns the lengths of all columns in the current row.

mysql_fetch_row()  Fetches the next row from the result set.

mysql_field_seek()  Puts the column cursor on a specified column.

mysql_field_count()  Returns the number of result columns for the most recent query.

mysql_field.tell()  Returns the position of the field cursor used for the last mysql_fetch_field().

mysql_free_result()  Frees memory used by a result set.

mysql_get_client_info()  Returns client version information.

mysql_get_host_info()  Returns a string describing the connection.

mysql_get_proto_info()  Returns the protocol version used by the connection.

mysql_get_server_info()  Returns the server version number.

mysql_info()  Returns information about the most recently executed query.

mysql_init()  Gets or initializes a MYSQL structure.

mysql_insert_id()  Returns the ID generated for an AUTO_INCREMENT column by the previous query.

mysql_kill()  Kill a given thread.

mysql_list_dbs()  Returns database names matching a simple regular expression.

mysql_list_fields()  Returns field names matching a simple regular expression.
mysql_list_processes()  Returns a list of the current server threads.
mysql_list_tables()  Returns table names matching a simple regular expression.
mysql_num_fields()  Returns the number of columns in a result set.
mysql_num_rows()  Returns the number of rows in a result set.
mysql_options()  Set connect options for mysql_connect().
mysql_ping()  Checks whether or not the connection to the server is working, reconnecting as necessary.
mysql_query()  Executes a SQL query specified as a null-terminated string.
mysql_real_connect()  Connects to a MySQL server.
mysql_real_query()  Executes a SQL query specified as a counted string.
mysql_reload()  Tells the server to reload the grant tables.
mysql_row_seek()  Seeks to a row in a result set, using value returned from mysql_row_tell().
mysql_row_tell()  Returns the row cursor position.
mysql_select_db()  Connects to a database.
mysql_shutdown()  Shuts down the database server.
mysql_stat()  Returns the server status as a string.
mysql_store_result()  Retrieves a complete result set to the client.
mysql_thread_id()  Returns the current thread ID.
mysql_use_result()  Initiates a row-by-row result set retrieval.

To connect to the server, call mysql_init() to initialize a connection handler, then call mysql_real_connect() with that handler (along with other information such as the host-name, user name and password). When you are done with the connection, call mysql_close() to terminate it.

While a connection is active, the client may send SQL queries to the server using mysql_query() or mysql_real_query(). The difference between the two is that mysql_query() expects the query to be specified as a null-terminated string whereas mysql_real_query() expects a counted string. If the string contains binary data (which may include null bytes), you must use mysql_real_query().

For each non-SELECT query (e.g., INSERT, UPDATE, DELETE), you can found out how many rows were affected (changed) by calling mysql_affected_rows().

For SELECT queries, you retrieve the selected rows as a result set. (Note that some statements are SELECT-like in that they return rows. These include SHOW, DESCRIBE and EXPLAIN. They should be treated the same way as SELECT statements.)
There are two ways for a client to process result sets. One way is to retrieve the entire result set all at once by calling `mysql_store_result()`. This function acquires from the server all the rows returned by the query and stores them in the client. The second way is for the client to initiate a row-by-row result set retrieval by calling `mysql_use_result()`. This function initializes the retrieval, but does not actually get any rows from the server.

In both cases, you access rows by calling `mysql_fetch_row()`. With `mysql_store_result()`, `mysql_fetch_row()` accesses rows that have already been fetched from the server. With `mysql_use_result()`, `mysql_fetch_row()` actually retrieves the row from the server. Information about as the size of the data values in each row is available by calling `mysql_fetch_lengths()`.

After you are done with a result set, call `mysql_free_result()` to free the memory used for it.

The two retrieval mechanisms are complementary. Client programs should choose the approach that is most appropriate for their requirements. In practice, clients tend to use `mysql_store_result()` more commonly.

An advantage of `mysql_store_result()` is that since the rows have all been fetched to the client, you not only can access rows sequentially, you can move back and forth in the result set using `mysql_data_seek()` or `mysql_row_seek()` to change the current row position within the result set. You can also find out how many rows there are by calling `mysql_num_rows()`. On the other hand, the memory requirements for `mysql_store_result()` may be very high for large result sets and you are more likely to encounter out-of-memory conditions.

An advantage of `mysql_use_result()` is that the client requires less memory for the result set since it maintains only one row at a time (and since there is less allocation overhead, `mysql_use_result()` can be faster). Disadvantages are that you must process each row quickly to avoid tying up the server, you don’t have random access to rows within the result set (you can only access rows sequentially), and you don’t know how many rows are in the result set until you have retrieved them all. Furthermore, you must retrieve all the rows even if you determine in mid-retrieval that you’ve found the information you were looking for.

The API makes it possible for clients to respond appropriately to queries (retrieving rows only as necessary) without knowing whether or not the query is a SELECT. You can do this by calling `mysql_store_result()` after each `mysql_query()` (or `mysql_real_query()`). If the result set call succeeds, the query was a SELECT and you can read the rows. If the result set call fails, call `mysql_field_count()` to determine whether or not a result was actually to be expected. If `mysql_field_count()` returns zero, the query returned no data (indicating that it was an INSERT, UPDATE, DELETE, etc.), and thus not expected to return rows. If `mysql_field_count()` is non-zero, the query should have returned rows, but didn’t. This indicates that the query was a SELECT that failed. See the description for `mysql_field_count()` for an example of how this can be done.

Both `mysql_store_result()` and `mysql_use_result()` allow you to obtain information about the fields that make up the result set (the number of fields, their names and types, etc.). You can access field information sequentially within the row by calling `mysql_fetch_field()` repeatedly, or by field number within the row by calling `mysql_fetch_field_`
direct(). The current field cursor position may be changed by calling mysql_field_seek(). Setting the field cursor affects subsequent calls to mysql_fetch_field(). You can also get information for fields all at once by calling mysql_fetch_fields().

For detecting and reporting errors, MySQL provides access to error information by means of the mysql_errno() and mysql_error() functions. These return the error code or error message for the most recently invoked function that can succeed or fail, allowing you to determine when an error occurred and what it was.

### 21.4 C API function descriptions

In the descriptions below, a parameter or return value of NULL means NULL in the sense of the C programming language, not a MySQL NULL value.

Functions that return a value generally return a pointer or an integer. Unless specified otherwise, functions returning a pointer return a non-NULL value to indicate success or a NULL value to indicate an error, and functions returning an integer return zero to indicate success or non-zero to indicate an error. Note that “non-zero” means just that. Unless the function description says otherwise, do not test against a value other than zero:

```c
if (result) /* correct */
    ... error ...
if (result < 0) /* incorrect */
    ... error ...
if (result == -1) /* incorrect */
    ... error ...
```

When a function returns an error, the Errors subsection of the function description lists the possible types of errors. You can find out which of these occurred by calling mysql_errno(). A string representation of the error may be obtained by calling mysql_error().

#### 21.4.1 mysql_affected_rows()

```c
my_ulonglong mysql_affected_rows(MYSQL *mysql)
```

**Description**

Returns the number of rows affected (changed) by the last UPDATE, DELETE or INSERT query. May be called immediately after mysql_query() for UPDATE, DELETE or INSERT statements. For SELECT statements, mysql_affected_rows() works like mysql_num_rows(). mysql_affected_rows() is currently implemented as a macro.

**Return values**

An integer greater than zero indicates the number of rows affected or retrieved. Zero indicates that no records matched the WHERE clause in the query or that no query has yet
been executed. -1 indicates that the query returned an error or that, for a SELECT query, mysql_affected_rows() was called prior to calling mysql_store_result().

Errors
None.

Example

mysql_query(&mysql,"UPDATE products SET cost=cost*1.25 WHERE group=10");
printf("%d products updated",mysql_affected_rows(&mysql));

21.4.2 mysql_close()

void mysql_close(MYSQL *mysql)

Description
Closes a previously opened connection. mysql_close() also deallocates the connection handle pointed to by mysql if the handle was allocated automatically by mysql_init() or mysql_connect().

Return values
None.

Errors

CR_COMMANDS_OUT_OF_SYNC
Commands were executed in an improper order.

CR_SERVER_GONE_ERROR
The MySQL server has gone away.

CR_SERVER_LOST
The connection to the server was lost during the query.

CR_UNKNOWN_ERROR
An unknown error occurred.

21.4.3 mysql_connect()

MYSQL *mysql_connect(MYSQL *mysql, const char *host, const char *user, const char *passwd)
Description

This function is deprecated. It is preferable to use `mysql_real_connect()` instead. `mysql_connect()` attempts to establish a connection to a MySQL database engine running on host. `mysql_connect()` must complete successfully before you can execute any of the other API functions, with the exception of `mysql_get_client_info()`.

The meanings of the parameters are the same as for the corresponding parameters for `mysql_real_connect()` with the difference that the connection parameter may be `NULL`. In this case the C API allocates memory for the connection structure automatically and frees it when you call `mysql_close()`. The disadvantage of this approach is that you can’t retrieve an error message if the connection fails. (To get error information from `mysql_errno()` or `mysql_error()`, you must provide a valid `MYSQL` pointer.)

Return values

Same as for `mysql_real_connect()`.

Errors

Same as for `mysql_real_connect()`.

21.4.4 `mysql_change_user()`

my_bool mysql_change_user(MYSQL *mysql, const char *user, const char *password, const char *db)

Description

Changes the user and causes the database specified by `db` to become the default (current) database on the connection specified by `mysql`. In subsequent queries, this database is the default for table references that do not include an explicit database specifier.

This function was introduced in MySQL 3.23.3.

`mysql_change_user()` fails unless the connected user can be authenticated or if he doesn’t have permission to use the database. In this case the user and database are not changed. The `db` parameter may be set to `NULL` if you don’t want to have a default database.

Return values

Zero for success. Non-zero if an error occurred.

Errors

The same that you can get from `mysql_real_connect()`.

CR_COMMANDS_OUT_OF_SYNC

Commands were executed in an improper order.
CR_SERVER_GONE_ERROR
The MySQL server has gone away.

CR_SERVER_LOST
The connection to the server was lost during the query.

CR_UNKNOWN_ERROR
An unknown error occurred.

ER_UNKNOWN_COM_ERROR
The MySQL server doesn’t implement this command (probably an old server).

ER_ACCESS_DENIED_ERROR
The user or password was wrong.

ER_BAD_DB_ERROR
The database didn’t exist.

ER_DBACCESS_DENIED_ERROR
The user did not have access rights to the database.

ER_WRONG_DB_NAME
The database name was too long.

Example

```c
if (mysql_change_user(&mysql, "user", "password", "new_database"))
{
    fprintf(stderr, "Failed to change user. Error: %s\n",
            mysql_error(&mysql));
}
```

21.4.5 mysql_create_db()

```c
int mysql_create_db(MYSQL *mysql, const char *db)
```

Description

Creates the database named by the db parameter.

This function is deprecated. It is preferable to use mysql_query() to issue a SQL CREATE DATABASE statement instead.

Return values

Zero if the database was created successfully. Non-zero if an error occurred.
Errors

CR_COMMANDS_OUT_OF_SYNC
Commands were executed in an improper order.

CR_SERVER_GONE_ERROR
The MySQL server has gone away.

CR_SERVER_LOST
The connection to the server was lost during the query.

CR_UNKNOWN_ERROR
An unknown error occurred.

Example

```c
if(mysql_create_db(&mysql, "my_database"))
{
    fprintf(stderr, "Failed to create new database. Error: %s\n",
            mysql_error(&mysql));
}
```

21.4.6 mysql_data_seek()

```c
void mysql_data_seek(MYSQL_RES *result, unsigned long long offset)
```

Description

Seeks to an arbitrary row in a query result set. This requires that the result set structure contains the entire result of the query, so `mysql_data_seek()` may be used in conjunction only with `mysql_store_result()`, not with `mysql_use_result()`.

The offset should be a value in the range from 0 to `mysql_num_rows(result) - 1`.

Return values

None.

Errors

None.

21.4.7 mysql_debug()

```c
void mysql_debug(char *debug)
```
Description

Does a DEBUG_PUSH with the given string. mysql_debug() uses the Fred Fish debug library. To use this function, you must compile the client library to support debugging. See Section G.1 [Debugging server], page 506. See Section G.2 [Debugging client], page 508.

Return values

None.

Errors

None.

Example

The call shown below causes the client library to generate a trace file in ‘/tmp/client.trace’ on the client machine:

    mysql_debug("d:t:0,/tmp/client.trace");

21.4.8 mysql_drop_db()

int mysql_drop_db(MYSQL *mysql, const char *db)

Description

Drops the database named by the db parameter. This function is deprecated. It is preferable to use mysql_query() to issue a SQL DROP DATABASE statement instead.

Return values

Zero if the database was dropped successfully. Non-zero if an error occurred.

Errors

CR_COMMANDS_OUT_OF_SYNC

Commands were executed in an improper order.

CR_SERVER_GONE_ERROR

The MySQL server has gone away.

CR_SERVER_LOST

The connection to the server was lost during the query.

CR_UNKNOWN_ERROR

An unknown error occurred.
Example

```c
if(mysql_drop_db(&mysql, "my_database"))
    fprintf(stderr, "Failed to drop the database: Error: %s\n", mysql_error(&mysql));
```

21.4.9 mysql_dump_debug_info()

```c
int mysql_dump_debug_info(MYSQL *mysql)
```

**Description**

Instructs the server to write some debug information to the log. The connected user must have the *process* privilege for this to work.

**Return values**

Zero if the command was successful. Non-zero if an error occurred.

**Errors**

- **CR_COMMANDS_OUT_OF_SYNC**
  Commands were executed in an improper order.
- **CR_SERVER_GONE_ERROR**
  The MySQL server has gone away.
- **CR_SERVER_LOST**
  The connection to the server was lost during the query.
- **CR_UNKNOWN_ERROR**
  An unknown error occurred.

21.4.10 mysql_eof()

```c
my_bool mysql_eof(MYSQL_RES *result)
```

**Description**

This function is deprecated. `mysql_errno()` or `mysql_error()` may be used instead. `mysql_eof()` determines whether or not the last row of a result set has been read. If you acquire a result set from a successful call to `mysql_store_result()`, the client receives the entire set in one operation. In this case, a NULL return from `mysql_fetch_row()` always means the end of the result set has been reached and it is unnecessary to call `mysql_eof()`.
On the other hand, if you use `mysql_use_result()` to initiate a result set retrieval, the rows of the set are obtained from the server one by one as you call `mysql_fetch_row()` repeatedly. Because an error may occur on the connection during this process, a NULL return value from `mysql_fetch_row()` does not necessarily mean the end of the result set was reached normally. In this case, you can use `mysql_eof()` to determine what happened. `mysql_eof()` returns a non-zero value if the end of the result set was reached and zero if an error occurred.

Historically, `mysql_eof()` predates the standard MySQL error functions `mysql_errno()` and `mysql_error()`. Since those error functions provide the same information, their use is preferred over `mysql_eof()`, which is now deprecated. (In fact, they provide more information, since `mysql_eof()` returns only a boolean value whereas the error functions indicate a reason for the error when one occurs.)

**Return values**

Zero if an error occurred. Non-zero if the end of the result set has been reached.

**Errors**

None.

**Example**

The following example shows how you might use `mysql_eof()`:

```c
mysql_query(&mysql,"SELECT * FROM some_table");
result = mysql_use_result(&mysql);
while((row = mysql_fetch_row(result)))
{
    // do something with data
}
if(!mysql_eof(result)) // mysql_fetch_row() failed due to an error
{
    fprintf(stderr, "Error: %s\n", mysql_error(&mysql));
}
```

However, you can achieve the same effect with the standard MySQL error functions:

```c
mysql_query(&mysql,"SELECT * FROM some_table");
result = mysql_use_result(&mysql);
while((row = mysql_fetch_row(result)))
{
    // do something with data
}
if(mysql_errno(&mysql)) // mysql_fetch_row() failed due to an error
{
    fprintf(stderr, "Error: %s\n", mysql_error(&mysql));
}
```

Version: 3.23.11-alpha Printed: 25 February 2000
21.4.11 mysql_errno()

unsigned int mysql_errno(MYSQL *mysql)

Description
For the connection specified by mysql, mysql_errno() returns the error code for the most recently invoked API function that can succeed or fail. A return value of zero means that no error occurred. Client error message numbers are listed in the MySQL 'errmsg.h' header file. Server error message numbers are listed in 'mysqld_error.h'

Return values:
An error code value. Zero if no error occurred.

Errors
None.

21.4.12 mysql_error()

cchar *mysql_error(MYSQL *mysql)

Description
For the connection specified by mysql, mysql_error() returns the error message for the most recently invoked API function that can succeed or fail. An empty string ("") is returned if no error occurred. This means the following two tests are equivalent:

```
if(mysql_errno(&mysql))
{
    // an error occurred
}
if(mysql_error(&mysql)[0] != '\0')
{
    // an error occurred
}
```

The language of the client error messages may be changed by recompiling the MySQL client library. Currently you can choose error messages in several different languages. See Section 10.1 [Languages], page 271.

Return values
A character string that describes the error. An empty string if no error occurred.
Errors

None.

21.4.13 mysql_escape_string()

unsigned int mysql_escape_string(char *to, const char *from, unsigned int length)

Description

Encodes the string in from to an escaped SQL string that can be sent to the server in a SQL statement, places the result in to, and adds a terminating null byte. Characters encoded are \NUL (ASCII 0), ‘\n’, ‘\r’, ‘\’, ‘\’’, ‘\’ and Control-Z (see Section 7.1 [Literals], page 130). The string pointed to by from must be length bytes long. You must allocate the to buffer to be at least length*2+1 bytes long. (In the worse case, each character may need to be encoded as using two bytes, and you need room for the terminating null byte.) When mysql_escape_string() returns, the contents of to will be a null-terminated string. The return value is the length of the encoded string, not including the terminating null character.

Example

```c
char query[1000],*end;

end = strmov(query,"INSERT INTO test_table values(");
*end++ = '\'';
end += mysql_escape_string(end,"What's this",11);
  *end++ = '\'';
  *end++ = '\',';
  *end++ = '\'';
end += mysql_escape_string(end,"binary data: \0\r\n",16);
  *end++ = '\'';
  *end++ = '\'';
if (mysql_real_query(&mysql,query,(unsigned int) (end - query)))
  {
    fprintf(stderr, "Failed to insert row, Error: %s\n",
                mysql_error(&mysql));
  }
```

The strmov() function used in the example is included in the mysqlclient library and works like strcpy() but returns a pointer to the terminating null of the first parameter.

Return values

The length of the value placed into to, not including the terminating null character.

Errors

None.
21.4.14 mysql_fetch_field()

MYSQL_FIELD *mysql_fetch_field(MYSQL_RES *result)

Description

Returns the definition of one column of a result set as a MYSQL_FIELD structure. Call this function repeatedly to retrieve information about all columns in the result set. mysql_fetch_field() returns NULL when no more fields are left. mysql_fetch_field() is reset to return information about the first field each time you execute a new SELECT query. The field returned by mysql_fetch_field() is also affected by calls to mysql_field_seek().

If you’ve called mysql_query() to perform a SELECT on a table but have not called mysql_store_result(). MySQL returns the default blob length (8K bytes) if you call mysql_fetch_field() to ask for the length of a BLOB field. (The 8K size is chosen because MySQL doesn’t know the maximum length for the BLOB. This should be made configurable sometime.) Once you’ve retrieved the result set, field->max_length contains the length of the largest value for this column in the specific query.

Return values

The MYSQL_FIELD structure for the current column. NULL if no columns are left.

Errors

None.

Example

MYSQL_FIELD *field;

while((field = mysql_fetch_field(result)))
{
    printf("field name %s\n", field->name);
}

21.4.15 mysql_fetch_fields()

MYSQL_FIELD *mysql_fetch_fields(MYSQL_RES *result)

Description

Returns an array of all MYSQL_FIELD structures for a result set. Each structure provides the field definition for one column of the result set.
Return values

An array of MYSQL_FIELD structures for all columns of a result set.

Errors

None.

Example

```c
unsigned int num_fields;
unsigned int i;
MYSQL_FIELD *fields;

num_fields = mysql_num_fields(result);
fields = mysql_fetch_fields(result);
for(i = 0; i < num_fields; i++)
{
    printf("Field %u is %s\n", i, fields[i].name);
}
```

21.4.16 mysql_fetch_field_direct()

MYSQL_FIELD *mysql_fetch_field_direct(MYSQL_RES *result, unsigned int fieldnr)

Description

Given a field number fieldnr for a column within a result set, returns that column’s field definition as a MYSQL_FIELD structure. You may use this function to retrieve the definition for an arbitrary column. The value of fieldnr should be in the range from 0 to mysql_num_fields(result) - 1.

Return values

The MYSQL_FIELD structure for the specified column.

Errors

None.

Example

```c
unsigned int num_fields;
unsigned int i;
MYSQL_FIELD *field;

num_fields = mysql_num_fields(result);
```
for(i = 0; i < num_fields; i++)
{
    field = mysql_fetch_field_direct(result, i);
    printf("Field %u is %s\n", i, field->name);
}

21.4.17 mysql_fetch_lengths()

unsigned long *mysql_fetch_lengths(MYSQL_RES *result)

Description

Returns the lengths of the columns of the current row within a result set. If you plan to copy field values, this length information is also useful for optimization, because you can avoid calling strlen(). In addition, if the result set contains binary data, you must use this function to determine the size of the data, because strlen() returns incorrect results for any field containing null characters.

The length for empty columns and for columns containing NULL values is zero. To see how to distinguish these two cases, see the description for mysql_fetch_row().

Return values

An array of unsigned long integers representing the size of each column (not including any terminating null characters). NULL if an error occurred.

Errors

mysql_fetch_lengths() is valid only for the current row of the result set. It returns NULL if you call it before calling mysql_fetch_row() or after retrieving all rows in the result.

Example

MYSQL_ROW row;
unsigned long *lengths;
unsigned int num_fields;
unsigned int i;

row = mysql_fetch_row(result);
if (row)
{
    num_fields = mysql_num_fields(result);
    lengths = mysql_fetch_lengths(result);
    for(i = 0; i < num_fields; i++)
    {
        printf("Column %u is %lu bytes in length.\n", i, lengths[i]);
    }
}
21.4.18 mysql_fetch_row()

MYSQL_ROW mysql_fetch_row(MYSQL_RES *result)

Description

Retrieves the next row of a result set. When used after mysql_store_result(), mysql_fetch_row() returns NULL when there are no more rows to retrieve. When used after mysql_use_result(), mysql_fetch_row() returns NULL when there are no more rows to retrieve or if an error occurred.

The number of values in the row is given by mysql_num_fields(result). If row holds the return value from a call to mysql_fetch_row(), pointers to the values are accessed as row[0] to row[mysql_num_fields(result)-1]. NULL values in the row are indicated by NULL pointers.

The lengths of the field values in the row may be obtained by calling mysql_fetch_lengths(). Empty fields and fields containing NULL both have length 0; you can distinguish these by checking the pointer for the field value. If the pointer is NULL, the field is NULL; otherwise the field is empty.

Return values

A MYSQL_ROW structure for the next row. NULL if there are no more rows to retrieve or if an error occurred.

Errors

CR_SERVER_LOST
The connection to the server was lost during the query.

CR_UNKNOWN_ERROR
An unknown error occurred.

Example

MYSQL_ROW row;
unsigned int num_fields;
unsigned int i;

num_fields = mysql_num_fields(result);
while ((row = mysql_fetch_row(result)))
{
    unsigned long *lengths;
    lengths = mysql_fetch_lengths(result);
    for(i = 0; i < num_fields; i++)
    {
        printf("[%.*s ]", (int) lengths[i], row[i] ? row[i] : "NULL");
    }
}
21.4.19  mysql_field_count()

unsigned int mysql_field_count(MYSQL *mysql)
If you are using a version of MySQL earlier than 3.22.24, you should use unsigned int
mysql_num_fields(MYSQL *mysql) instead.

Description
Returns the number of columns for the most recent query on the connection.
The normal use of this function is when mysql_store_result() returned NULL (and thus
you have no result set pointer). In this case, you can call mysql_field_count() to de-
termine whether or not mysql_store_result() should have produced a non-empty result.
This allows the client program to take proper action without knowing whether or not the
query was a SELECT (or SELECT-like) statement. The example shown below illustrates how
this may be done.
See Section 21.4.51 [NULL mysql_store_result()], page 414.

Return values
An unsigned integer representing the number of fields in a result set.

Errors
None.

Example

MYSQL_RES *result;
unsigned int num_fields;
unsigned int num_rows;

if (mysql_query(&mysql,query_string))
{
    // error
}
else // query succeeded, process any data returned by it
{
    result = mysql_store_result(&mysql);
    if (result) // there are rows
    {
        num_fields = mysql_num_fields(result);
        // retrieve rows, then call mysql_free_result(result)
}
else // mysql_store_result() returned nothing; should it have?
{
   if(mysql_field_count(&mysql) == 0)
   {
      // query does not return data
      // (it was not a SELECT)
      num_rows = mysql_affected_rows(&mysql);
   }
   else // mysql_store_result() should have returned data
   {
      fprintf(stderr, "Error: %s\n", mysql_error(&mysql));
   }
}

An alternative is to replace the mysql_field_count(&mysql) call with mysql_errno(&mysql). In this case, you are checking directly for an error from mysql_store_result() rather than inferring from the value of mysql_field_count() whether or not the statement was a SELECT.

21.4.20 mysql_field_seek()

MYSQL_FIELD_OFFSET mysql_field_seek(MYSQL_RES *result, MYSQL_FIELD_OFFSET offset)

Description
Sets the field cursor to the given offset. The next call to mysql_fetch_field() will retrieve the field definition of the column associated with that offset.
To seek to the beginning of a row, pass an offset value of zero.

Return values
The previous value of the field cursor.

Errors
None.

21.4.21 mysql_field.tell()

MYSQL_FIELD_OFFSET mysql_field_tell(MYSQL_RES *result)

Description
Returns the position of the field cursor used for the last mysql_fetch_field(). This value can be used as an argument to mysql_field_seek().

Version: 3.23.11-alpha Printed: 25 February 2000
Return values
The current offset of the field cursor.

Errors
None.

21.4.22 mysql_free_result()

void mysql_free_result(MYSQL_RES *result)

Description
Frees the memory allocated for a result set by mysql_store_result(), mysql_use_result(), mysql_list_dbs(), etc. When you are done with a result set, you must free the memory it uses by calling mysql_free_result().

Return values
None.

Errors
None.

21.4.23 mysql_get_client_info()

char *mysql_get_client_info(void)

Description
Returns a string that represents the client library version.

Return values
A character string that represents the MySQL client library version.

Errors
None.

21.4.24 mysql_get_host_info()

char *mysql_get_host_info(MYSQL *mysql)
Description

Returns a string describing the type of connection in use, including the server host name.

Return values

A character string representing the server host name and the connection type.

Errors

None.

21.4.25  mysql_get_proto_info()

unsigned int mysql_get_proto_info(MYSQL *mysql)

Description

Returns the protocol version used by current connection.

Return values

An unsigned integer representing the protocol version used by the current connection.

Errors

None.

21.4.26  mysql_get_server_info()

char *mysql_get_server_info(MYSQL *mysql)

Description

Returns a string that represents the server version number.

Return values

A character string that represents the server version number.

Errors

None.
21.4.27 mysql_info()

char *mysql_info(MYSQL *mysql)

**Description**

Retrieves a string providing information about the most recently executed query, but only for the statements listed below. For other statements, `mysql_info()` returns NULL. The format of the string varies depending on the type of query, as described below. The numbers are illustrative only; the string will contain values appropriate for the query.

**INSERT INTO ... SELECT ...**
String format: Records: 100 Duplicates: 0 Warnings: 0

**INSERT INTO ... VALUES (...),(...),(...),...**
String format: Records: 3 Duplicates: 0 Warnings: 0

**LOAD DATA INFILE ...**
String format: Records: 1 Deleted: 0 Skipped: 0 Warnings: 0

**ALTER TABLE**
String format: Records: 3 Duplicates: 0 Warnings: 0

**UPDATE**
String format: Rows matched: 40 Changed: 40 Warnings: 0

Note that `mysql_info()` returns a non-NULL value for the `INSERT ... VALUES` statement only if multiple value lists are specified in the statement.

**Return values**

A character string representing additional information about the most recently executed query. NULL if no information is available for the query.

**Errors**

None.

21.4.28 mysql_init()

MYSQL *mysql_init(MYSQL *mysql)

**Description**

Allocates or initializes a MYSQL object suitable for `mysql_real_connect()`. If `mysql` is a NULL pointer, the function allocates, initializes and returns a new object. Otherwise the object is initialized and the address of the object is returned. If `mysql_init()` allocates a new object, it will be freed when `mysql_close()` is called to close the connection.
Return values
An initialized MYSQL* handle. NULL if there was insufficient memory to allocate a new object.

Errors
In case of insufficient memory, NULL is returned.

21.4.29 mysql_insert_id()

my_ulonglong mysql_insert_id(MYSQL *mysql)

Description
Returns the ID generated for an AUTO_INCREMENT column by the previous query. Use this function after you have performed an INSERT query into a table that contains an AUTO_INCREMENT field.

Note that mysql_insert_id() returns 0 if the previous query does not generate an AUTO_INCREMENT value. If you need to save the value for later, be sure to call mysql_insert_id() immediately after the query that generates the value.

Also note that the value of the SQL LAST_INSERT_ID() function always contains the most recently generated AUTO_INCREMENT value, and is not reset between queries since the value of that function is maintained in the server.

Return values
The value of the AUTO_INCREMENT field that was updated by the previous query. Returns zero if there was no previous query on the connection or if the query did not update an AUTO_INCREMENT value.

Errors
None.

21.4.30 mysql_kill()

int mysql_kill(MYSQL *mysql, unsigned long pid)

Description
Asks the server to kill the thread specified by pid.

Return values
Zero for success. Non-zero if an error occurred.
Errors

CR_COMMANDS_OUT_OF_SYNC
Commands were executed in an improper order.

CR_SERVER_GONE_ERROR
The MySQL server has gone away.

CR_SERVER_LOST
The connection to the server was lost during the query.

CR_UNKNOWN_ERROR
An unknown error occurred.

21.4.31 mysql_list_dbs()

MYSQL_RES *mysql_list_dbs(MYSQL *mysql, const char *wild)

Description

Returns a result set consisting of database names on the server that match the simple regular expression specified by the wild parameter. wild may contain the wildcard characters ‘%’ or ‘_’, or may be a NULL pointer to match all databases. Calling mysql_list_dbs() is similar to executing the query SHOW databases [LIKE wild].

You must free the result set with mysql_free_result().

Return values

A MYSQL_RES result set for success. NULL if an error occurred.

Errors

CR_COMMANDS_OUT_OF_SYNC
Commands were executed in an improper order.

CR_OUT_OF_MEMORY
Out of memory.

CR_SERVER_GONE_ERROR
The MySQL server has gone away.

CR_SERVER_LOST
The connection to the server was lost during the query.

CR_UNKNOWN_ERROR
An unknown error occurred.
21.4.32 mysql_list_fields()

MYSQL_RES *mysql_list_fields(MYSQL *mysql, const char *table, const char *wild)

Description

Returns a result set consisting of field names in the given table that match the simple regular
expression specified by the wild parameter. wild may contain the wildcard characters ‘%’
or ‘_', or may be a NULL pointer to match all fields. Calling mysql_list_fields() is similar
to executing the query SHOW COLUMNS FROM tbl_name [LIKE wild].

Note that it’s recommended that you use SHOW COLUMNS FROM tbl_name instead of mysql_
list_fields().

You must free the result set with mysql_free_result().

Return values

A MYSQL_RES result set for success. NULL if an error occurred.

Errors

CR_COMMANDS_OUT_OF_SYNC
Commands were executed in an improper order.

CR_SERVER_GONE_ERROR
The MySQL server has gone away.

CR_SERVER_LOST
The connection to the server was lost during the query.

CR_UNKNOWN_ERROR
An unknown error occurred.

21.4.33 mysql_list_processes()

MYSQL_RES *mysql_list_processes(MYSQL *mysql)

Description

Returns a result set describing the current server threads. This is the same kind of inform-
ation as that reported by mysqladmin processlist or a SHOW PROCESSLIST query.

You must free the result set with mysql_free_result().

Return values

A MYSQL_RES result set for success. NULL if an error occurred.
Errors

CR_COMMANDS_OUT_OF_SYNC
   Commands were executed in an improper order.

CR_SERVER_GONE_ERROR
   The MySQL server has gone away.

CR_SERVER_LOST
   The connection to the server was lost during the query.

CR_UNKNOWN_ERROR
   An unknown error occurred.

21.4.34 mysql_list_tables()

MYSQL_RES *mysql_list_tables(MYSQL *mysql, const char *wild)

Description

Returns a result set consisting of table names in the current database that match the simple regular expression specified by the wild parameter. wild may contain the wildcard characters ‘%’ or ‘_’, or may be a NULL pointer to match all tables. Calling mysql_list_tables() is similar to executing the query SHOW tables [LIKE wild].

You must free the result set with mysql_free_result().

Return values

A MYSQL_RES result set for success. NULL if an error occurred.

Errors

CR_COMMANDS_OUT_OF_SYNC
   Commands were executed in an improper order.

CR_SERVER_GONE_ERROR
   The MySQL server has gone away.

CR_SERVER_LOST
   The connection to the server was lost during the query.

CR_UNKNOWN_ERROR
   An unknown error occurred.
21.4.35 mysql_num_fields()

unsigned int mysql_num_fields(MYSQL_RES *result)

or

unsigned int mysql_num_fields(MYSQL *mysql)

The second form doesn’t work on MySQL 3.22.24 or newer. To pass a MYSQL* argument, you must use unsigned int mysql_field_count(MYSQL *mysql) instead.

Description

Returns the number of columns in a result set.

Note that you can get the number of columns either from a pointer to a result set or to a connection handle. You would use the connection handle if mysql_store_result() or mysql_user_result() returned NULL (and thus you have no result set pointer). In this case, you can call mysql_field_count() to determine whether or not mysql_store_result() should have produced a non-empty result. This allows the client program to take proper action without knowing whether or not the query was a SELECT (or SELECT-like) statement. The example shown below illustrates how this may be done.

See Section 21.4.51 [NULL mysql_store_result()], page 414.

Return values

An unsigned integer representing the number of fields in a result set.

Errors

None.

Example

MYSQL_RES *result;
unsigned int num_fields;
unsigned int num_rows;

if (mysql_query(&mysql,query_string))
{
    // error
}
else // query succeeded, process any data returned by it
{
    result = mysql_store_result(&mysql);
    if (result) // there are rows
    {
        num_fields = mysql_num_fields(result);
        // retrieve rows, then call mysql_free_result(result)
}
}  // mysql_store_result() returned nothing; should it have?
{
    if (mysql_errno(&mysql))
    {
        fprintf(stderr, "Error: %s\n", mysql_error(&mysql));
    }
    else if (mysql_field_count(&mysql) == 0)
    {
        // query does not return data
        // (it was not a SELECT)
        num_rows = mysql_affected_rows(&mysql);
    }
}

An alternative (if you KNOW that your query should have returned a result set) is to
replace the mysql_errno(&mysql) call with a check if mysql_field_count(&mysql) is = 0. This will only happen if something went wrong.

21.4.36 mysql_num_rows()

my_ulonglong mysql_num_rows(MYSQL_RES *result)

Description

Returns the number of rows in the result set.

The use of mysql_num_rows() depends on whether you use mysql_store_result() or
mysql_use_result() to return the result set. If you use mysql_store_result(), mysql_num_rows() may be called immediately. If you use mysql_use_result(), mysql_num_rows() will not return the correct value until all the rows in the result set have been retrieved.

Return values

The number of rows in the result set.

Errors

None.

21.4.37 mysql_options()

int mysql_options(MYSQL *mysql, enum mysql_option option, const char *arg)
Description

Can be used to set extra connect options and affect behavior for a connection. This function may be called multiple times to set several options.

`mysql_options()` should be called after `mysql_init()` and before `mysql_connect()` or `mysql_real_connect()`.

The `option` argument is the option that you want to set; the `arg` argument is the value for the option. If the option is an integer, then `arg` should point to the value of the integer.

Possible options values:

<table>
<thead>
<tr>
<th>Option</th>
<th>Argument type</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>MYSQL_OPT_CONNECT_TIMEOUT</td>
<td>unsigned int *</td>
<td>Connect timeout in seconds.</td>
</tr>
<tr>
<td>MYSQL_OPT_COMPRESS</td>
<td>Not used</td>
<td>Use the compressed client/server protocol.</td>
</tr>
<tr>
<td>MYSQL_OPT_NAMED_PIPE</td>
<td>Not used</td>
<td>Use named pipes to connect to a MySQL server on NT.</td>
</tr>
<tr>
<td>MYSQL_INIT_COMMAND</td>
<td>char *</td>
<td>Command to execute when connecting to the MySQL server. Will automatically be re-executed when reconnecting.</td>
</tr>
<tr>
<td>MYSQL_READ_DEFAULT_FILE</td>
<td>char *</td>
<td>Read options from the named option file instead of from ‘my.cnf’.</td>
</tr>
<tr>
<td>MYSQL_READ_DEFAULT_GROUP</td>
<td>char *</td>
<td>Read options from the named group from ‘my.cnf’ or the file specified with <code>MYSQL_READ_DEFAULT_FILE</code>.</td>
</tr>
</tbody>
</table>

Note that the group `client` is always read if you use `MYSQL_READ_DEFAULT_FILE` or `MYSQL_READ_DEFAULT_GROUP`.

The specified group in the option file may contain the following options:

- `compress`: Use the compressed client/server protocol.
- `database`: Connect to this database if there no database was specified in the connect command.
- `debug`: Debug options.
- `host`: Default host name.
- `init-command`: Command to execute when connecting to MySQL server. Will automatically be re-executed when reconnecting.
- `password`: Default password.
- `pipe`: Use named pipes to connect to a MySQL server on NT.
- `port`: Default port number.
- `return-found-rows`: Tell `mysql_info()` to return found rows instead of updated rows when using `UPDATE`.
- `socket`: Default socket number.
- `timeout`: Connect timeout in seconds.
- `user`: Default user.

For more information about option files, see Section 4.15.4 [Option files], page 89.
Return values

Zero for success. Non-zero if you used an unknown option.

Example

```c
MYSQL mysql;
mysql_init(&mysql);
mysql_options(&mysql, MYSQL_OPT_COMPRESS, 0);
mysql_options(&mysql, MYSQL_READ_DEFAULT_GROUP, "odbc");
if (!mysql_real_connect(&mysql, "host", "user", "passwd", "database", 0, NULL, 0)) {
    fprintf(stderr, "Failed to connect to database: Error: %s\n",
            mysql_error(&mysql));
}
```

The above requests the client to use the compressed client/server protocol and read the additional options from the odbc section in the my.cnf file.

21.4.38 mysql_ping()

```c
int mysql_ping(MYSQL *mysql)
```

Description

Checks whether or not the connection to the server is working. If it has gone down, an automatic reconnection is attempted.

This function can be used by clients that remain idle for a long while, to check whether or not the server has closed the connection and reconnect if necessary.

Return values

Zero if the server is alive. Non-zero if an error occurred.

Errors

- **CR_COMMANDS_OUT_OF_SYNC**
  
  Commands were executed in an improper order.

- **CR_SERVER_GONE_ERROR**
  
  The MySQL server has gone away.

- **CR_UNKNOWN_ERROR**
  
  An unknown error occurred.
21.4.39 mysql_query()

```c
int mysql_query(MYSQL *mysql, const char *query)
```

**Description**

Executes the SQL query pointed to by the null-terminated string `query`. The query must consist of a single SQL statement. You should not add a terminating semicolon (`;`) or `\g` to the statement.

`mysql_query()` cannot be used for queries that contain binary data; you should use `mysql_real_query()` instead. (Binary data may contain the `\0` character, which `mysql_query()` interprets as the end of the query string.)

**Return values**

Zero if the query was successful. Non-zero if an error occurred.

**Errors**

- **CR_COMMANDS_OUT_OF_SYNC**
  
  Commands were executed in an improper order.

- **CR_SERVER_GONE_ERROR**

  The MySQL server has gone away.

- **CR_SERVER_LOST**

  The connection to the server was lost during the query.

- **CR_UNKNOWN_ERROR**

  An unknown error occurred.

21.4.40 mysql_real_connect()

```c
MYSQL *mysql_real_connect(MYSQL *mysql, const char *host, const char *user, const char *passwd, const char *db, unsigned int port, const char *unix_socket, unsigned int client_flag)
```

**Description**

`mysql_real_connect()` attempts to establish a connection to a MySQL database engine running on `host`. `mysql_real_connect()` must complete successfully before you can execute any of the other API functions, with the exception of `mysql_get_client_info()`.

The parameters are specified as follows:

- The first parameter should be the address of an existing `MYSQL` structure. Before calling `mysql_real_connect()` you must call `mysql_init()` to initialize the `MYSQL` structure. See the example below.
• The value of host may be either a hostname or an IP address. If host is NULL or the string "localhost", a connection to the local host is assumed. If the OS supports sockets (Unix) or named pipes (Win32), they are used instead of TCP/IP to connect to the server.

• The user parameter contains the user’s MySQL login ID. If user is NULL, the current user is assumed. Under Unix, this is the current login name. Under Windows ODBC, the current user name must be specified explicitly. See Section 17.2 [ODBC administrator], page 346.

• The passwd parameter contains the password for user. If passwd is NULL, only entries in the user table for the user that have a blank password field will be checked for a match. This allows the database administrator to set up the MySQL privilege system in such a way that users get different privileges depending on whether or not they have specified a password.

Note: Do not attempt to encrypt the password before calling mysql_real_connect(); password encryption is handled automatically by the client API.

• db is the database name. If db is not NULL, the connection will set the default database to this value.

• If port is not 0, the value will be used as the port number for the TCP/IP connection. Note that the host parameter determines the type of the connection.

• If unix_socket is not NULL, the string specifies the socket or named pipe that should be used. Note that the host parameter determines the type of the connection.

• The value of client_flag is usually 0, but can be set to a combination of the following flags in very special circumstances:

<table>
<thead>
<tr>
<th>Flag name</th>
<th>Flag meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>CLIENT_FOUND_ROWS</td>
<td>Return the number of found (matched) rows, not the number of affected rows</td>
</tr>
<tr>
<td>CLIENT_NO_SCHEMA</td>
<td>Don’t allow the db_name.tbl_name.col_name syntax. This is for ODBC; It causes the parser to generate an error if you use that syntax, which is useful for trapping bugs in some ODBC programs.</td>
</tr>
<tr>
<td>CLIENT_COMPRESS</td>
<td>Use compression protocol</td>
</tr>
<tr>
<td>CLIENT_ODBC</td>
<td>The client is an ODBC client. This changes mysqld to be more ODBC-friendly.</td>
</tr>
</tbody>
</table>

Return values

A MYSQL* connection handle if the connection was successful. NULL if the connection was unsuccessful. For a successful connection, the return value is the same as the value of the first parameter, unless you pass NULL for that parameter.

Errors

CR_CONN_HOST_ERROR

Failed to connect to the MySQL server.
CR_CONNECTION_ERROR
Failed to connect to the local MySQL server.

CR_IPSOCK_ERROR
Failed to create an IP socket.

CR_OUT_OF_MEMORY
Out of memory.

CR_SOCKET_CREATE_ERROR
Failed to create a Unix socket.

CR_UNKNOWN_HOST
Failed to find the IP address for the hostname.

CR_VERSION_ERROR
A protocol mismatch resulted from attempting to connect to a server with a client library that uses a different protocol version. This can happen if you use a very old client library to connect to a new server that wasn’t started with the --old-protocol option.

CR_NAMEDPIPEOPEN_ERROR;
Failed to create a named pipe on Win32.

CR_NAMEDPIPEWAIT_ERROR;
Failed to wait for a named pipe on Win32.

CR_NAMEDPIPESETSTATE_ERROR;
Failed to get a pipe handler on Win32.

Example

MYSQL mysql;

mysql_init(&mysql);
if (!mysql_real_connect(&mysql, "host", "user", "passwd", "database", 0, NULL, 0))
{
    fprintf(stderr, "Failed to connect to database: Error: %s\n",
            mysql_error(&mysql));
}

21.4.41 mysql_real_query()

int mysql_real_query(MYSQL *mysql, const char *query, unsigned int length)

Description

Executes the SQL query pointed to by query, which should be a string length bytes long. The query must consist of a single SQL statement. You should not add a terminating semicolon (‘;’) or \g to the statement.
You must use \texttt{mysql\_real\_query()} rather than \texttt{mysql\_query()} for queries that contain binary data, since binary data may contain the '\0' character. In addition, \texttt{mysql\_real\_query()} is faster than \texttt{mysql\_query()} since it does not call \texttt{strlen()} on the query string.

\textbf{Return values}

Zero if the query was successful. Non-zero if an error occurred.

\textbf{Errors}

\texttt{CR\_COMMANDS\_OUT\_OF\_SYNC}

Commands were executed in an improper order.

\texttt{CR\_SERVER\_GONE\_ERROR}

The \texttt{MySQL} server has gone away.

\texttt{CR\_SERVER\_LOST}

The connection to the server was lost during the query.

\texttt{CR\_UNKNOWN\_ERROR}

An unknown error occurred.

\textbf{21.4.42 mysql\_reload()}

\begin{verbatim}
int mysql_reload(MYSQL *mysql)
\end{verbatim}

\textbf{Description}

Asks the \texttt{MySQL} server to reload the grant tables. The connected user must have the \texttt{reload} privilege.

This function is deprecated. It is preferable to use \texttt{mysql\_query()} to issue a SQL \texttt{FLUSH PRIVILEGES} statement instead.

\textbf{Return values}

Zero for success. Non-zero if an error occurred.

\textbf{Errors}

\texttt{CR\_COMMANDS\_OUT\_OF\_SYNC}

Commands were executed in an improper order.

\texttt{CR\_SERVER\_GONE\_ERROR}

The \texttt{MySQL} server has gone away.

\texttt{CR\_SERVER\_LOST}

The connection to the server was lost during the query.

\texttt{CR\_UNKNOWN\_ERROR}

An unknown error occurred.
21.4.43 mysql_row_seek()

MYSQL_ROW_OFFSET mysql_row_seek(MYSQL_RES *result, MYSQL_ROW_OFFSET offset)

Description

Sets the row cursor to an arbitrary row in a query result set. This requires that the result set structure contains the entire result of the query, so `mysql_row_seek()` may be used in conjunction only with `mysql_store_result()`, not with `mysql_use_result()`.

The offset should be a value returned from a call to `mysql_row_tell()` or to `mysql_row_seek()`. This value is not simply a row number; if you want to seek to a row within a result set using a row number, use `mysql_data_seek()` instead.

Return values

The previous value of the row cursor. This value may be passed to a subsequent call to `mysql_row_seek()`.

Errors

None.

21.4.44 mysql_row_tell()

MYSQL_ROW_OFFSET mysql_row_tell(MYSQL_RES *result)

Description

Returns the current position of the row cursor for the last `mysql_fetch_row()`. This value can be used as an argument to `mysql_row_seek()`.

You should use `mysql_row_tell()` only after `mysql_store_result()`, not after `mysql_use_result()`.

Return values

The current offset of the row cursor.

Errors

None.

21.4.45 mysql_select_db()

int mysql_select_db(MYSQL *mysql, const char *db)
Description

Causes the database specified by \texttt{db} to become the default (current) database on the connection specified by \texttt{mysql}. In subsequent queries, this database is the default for table references that do not include an explicit database specifier. \texttt{mysql_select_db()} fails unless the connected user can be authenticated as having permission to use the database.

Return values

Zero for success. Non-zero if an error occurred.

Errors

\texttt{CR\_COMMANDS\_OUT\_OF\_SYNC}

Commands were executed in an improper order.

\texttt{CR\_SERVER\_GONE\_ERROR}

The MySQL server has gone away.

\texttt{CR\_SERVER\_LOST}

The connection to the server was lost during the query.

\texttt{CR\_UNKNOWN\_ERROR}

An unknown error occurred.

21.4.46 \texttt{mysql\_shutdown()}

\begin{verbatim}
int mysql_shutdown(MYSQL *mysql)
\end{verbatim}

Description

Asks the database server to shutdown. The connected user must have \texttt{shutdown} privileges.

Return values

Zero for success. Non-zero if an error occurred.

Errors

\texttt{CR\_COMMANDS\_OUT\_OF\_SYNC}

Commands were executed in an improper order.

\texttt{CR\_SERVER\_GONE\_ERROR}

The MySQL server has gone away.

\texttt{CR\_SERVER\_LOST}

The connection to the server was lost during the query.

\texttt{CR\_UNKNOWN\_ERROR}

An unknown error occurred.
**21.4.47 mysql_stat()**

```c
char *mysql_stat(MYSQL *mysql)
```

**Description**

Returns a character string containing information similar to that provided by the `mysqladmin status` command. This includes uptime in seconds and the number of running threads, questions, reloads and open tables.

**Return values**

A character string describing the server status. NULL if an error occurred.

**Errors**

- **CR_COMMANDS_OUT_OF_SYNC**
  Commands were executed in an improper order.
- **CR_SERVER_GONE_ERROR**
  The MySQL server has gone away.
- **CR_SERVER_LOST**
  The connection to the server was lost during the query.
- **CR_UNKNOWN_ERROR**
  An unknown error occurred.

**21.4.48 mysql_store_result()**

```c
MYSQL_RES *mysql_store_result(MYSQL *mysql)
```

**Description**

You must call `mysql_store_result()` or `mysql_use_result()` for every query which successfully retrieves data (`SELECT`, `SHOW`, `DESCRIBE`, `EXPLAIN`).

`mysql_store_result()` reads the entire result of a query to the client, allocates a `MYSQL_RES` structure, and places the result into this structure.

An empty result set is returned if there are no rows returned. (An empty result set differs from a NULL return value.)

Once you have called `mysql_store_result()`, you may call `mysql_num_rows()` to find out how many rows are in the result set.

You can call `mysql_fetch_row()` to fetch rows from the result set, or `mysql_row_seek()` and `mysql_row_tell()` to obtain or set the current row position within the result set.

You must call `mysql_free_result()` once you are done with the result set.

See Section 21.4.51 [NULL mysql_store_result()], page 414.
Return values

A MYSQL_RES result structure with the results. NULL if an error occurred.

Errors

CR_COMMANDS_OUT_OF_SYNC
Commands were executed in an improper order.

CR_OUT_OF_MEMORY
Out of memory.

CR_SERVER_GONE_ERROR
The MySQL server has gone away.

CR_SERVER_LOST
The connection to the server was lost during the query.

CR_UNKNOWN_ERROR
An unknown error occurred.

21.4.49 mysql_thread_id()

unsigned long mysql_thread_id(MYSQL *mysql)

Description

Returns the thread ID of the current connection. This value can be used as an argument to mysql_kill() to kill the thread.

If the connection is lost and you reconnect with mysql_ping(), the thread ID will change. This means you should not get the thread ID and store it for later, you should get it when you need it.

Return values

The thread ID of the current connection.

Errors

None.

21.4.50 mysql_use_result()

MYSQL_RES *mysql_use_result(MYSQL *mysql)
Description

You must call `mysql_store_result()` or `mysql_use_result()` for every query which successfully retrieves data (SELECT, SHOW, DESCRIBE, EXPLAIN).

`mysql_use_result()` initiates a result set retrieval but does not actually read the result set into the client like `mysql_store_result()` does. Instead, each row must be retrieved individually by making calls to `mysql_fetch_row()`. This reads the result of a query directly from the server without storing it in a temporary table or local buffer, which is somewhat faster and uses much less memory than `mysql_store_result()`. The client will only allocate memory for the current row and a communication buffer that may grow up to `max_allowed_packet` bytes.

On the other hand, you shouldn’t use `mysql_use_result()` if you are doing a lot of processing for each row on the client side, or if the output is sent to a screen on which the user may type a ^S (stop scroll). This will tie up the server and prevent other threads from updating any tables from which the data are fetched.

When using `mysql_use_result()`, you must execute `mysql_fetch_row()` until a NULL value is returned, otherwise the unfetched rows will be returned as part of the result set for your next query. The C API will give the error `Commands out of sync; You can’t run this command now` if you forget to do this!

You may not use `mysql_data_seek()`, `mysql_row_seek()`, `mysql_row_tell()`, `mysql_num_rows()` or `mysql_affected_rows()` with a result returned from `mysql_use_result()`, nor may you issue other queries until the `mysql_use_result()` has finished. (However, after you have fetched all the rows, `mysql_num_rows()` will accurately return the number of rows fetched.)

You must call `mysql_free_result()` once you are done with the result set.

Return values

A `MYSQL_RES` result structure. NULL if an error occurred.

Errors

`CR_COMMANDS_OUT_OF_SYNC`
Commands were executed in an improper order.

`CR_OUT_OF_MEMORY`
Out of memory.

`CR_SERVER_GONE_ERROR`
The MySQL server has gone away.

`CR_SERVER_LOST`
The connection to the server was lost during the query.

`CR_UNKNOWN_ERROR`
An unknown error occurred.
21.4.51 Why is it that after mysql_query() returns success, mysql_store_result() sometimes returns NULL?

It is possible for mysql_store_result() to return NULL following a successful call to mysql_query(). When this happens, it means one of the following conditions occurred:

- There was a malloc() failure (for example, if the result set was too large).
- The data couldn’t be read (an error occurred on the connection).
- The query returned no data (e.g., it was an INSERT, UPDATE or DELETE).

You can always check whether or not the statement should have produced a non-empty result by calling mysql_field_count(). If mysql_field_count() returns zero, the result is empty and the last query was a statement that does not return values (for example, an INSERT or a DELETE). If mysql_field_count() returns a non-zero value, the statement should have produced a non-empty result. See the description of the mysql_field_count() function for an example.

You can test for an error by calling mysql_error() or mysql_errno().

21.4.52 What results can I get from a query?

In addition to the result set returned by a query, you can also get the following information:

- mysql_affected_rows() returns the number of rows affected by the last query when doing an INSERT, UPDATE or DELETE. An exception is that if DELETE is used without a WHERE clause, the table is truncated, which is much faster! In this case, mysql_affected_rows() returns zero for the number of records affected.
- mysql_num_rows() returns the number of rows in a result set. With mysql_store_result(), mysql_num_rows() may be called as soon as mysql_store_result() returns. With mysql_use_result(), mysql_num_rows() may be called only after you have fetched all the rows with mysql_fetch_row().
- mysql_insert_id() returns the ID generated by the last query that inserted a row into a table with an AUTO_INCREMENT index. See Section 21.4.29 [mysql_insert_id()], page 397.
- Some queries (LOAD DATA INFILE ..., INSERT INTO ... SELECT ..., UPDATE) return additional info. The result is returned by mysql_info(). See the description for mysql_info() for the format of the string that it returns. mysql_info() returns a NULL pointer if there is no additional information.

21.4.53 How can I get the unique ID for the last inserted row?

If you insert a record in a table containing a column that has the AUTO_INCREMENT attribute, you can get the most recently generated ID by calling the mysql_insert_id() function.

You can also retrieve the ID by using the LAST_INSERT_ID() function in a query string that you pass to mysql_query().
You can check if an AUTO_INCREMENT index is used by executing the following code. This also checks if the query was an INSERT with an AUTO_INCREMENT index:

```c
if (mysql_error(&mysql)[0] == 0 &&
    mysql_num_fields(result) == 0 &&
    mysql_insert_id(&mysql) != 0)
{
    used_id = mysql_insert_id(&mysql);
}
```

The most recently generated ID is maintained in the server on a per-connection basis. It will not be changed by another client. It will not even be changed if you update another AUTO_INCREMENT column with a non-magic value (that is, a value that is not NULL and not 0).

If you want to use the ID that was generated for one table and insert it into a second table, you can use SQL statements like this:

```sql
INSERT INTO foo (auto,text)
VALUES(NULL,'text'); # generate ID by inserting NULL

INSERT INTO foo2 (id,text)
VALUES(LAST_INSERT_ID(),'text'); # use ID in second table
```

### 21.4.54 Problems linking with the C API

When linking with the C API, the following errors may occur on some systems:

```
gcc -g -o client test.o -L/usr/local/lib/mysql -lmysqlclient -lsocket -lnsl

Undefined first referenced
symbol in file
floor /usr/local/lib/mysql/libmysqlclient.a(password.o)
ld: fatal: Symbol referencing errors. No output written to client
```

If this happens on your system, you must include the math library by adding `-lm` to the end of the compile/link line.

### 21.4.55 How to make a thread-safe client

The client is “almost” thread-safe. The biggest problem is that the subroutines in ‘net.c’ that read from sockets are not interrupt-safe. This was done with the thought that you might want to have your own alarm that can break a long read to a server.

The standard client libraries are not compiled with the thread options.

To get a thread-safe client, use the `-lmysys`, `-lstring` and `-ldbug` libraries and `net_serv.o` that the server uses.

When using a threaded client, you can make great use of the routines in the ‘thr_alarm.c’ file. If you are using routines from the `mysys` library, the only thing you must remember is to call `my_init()` first!
All functions except `mysql_real_connect()` are currently thread-safe. The following notes describe how to compile a thread-safe client library and use it in a thread-safe manner. (The notes below for `mysql_real_connect()` actually apply to `mysql_connect()` as well, but since `mysql_connect()` is deprecated, you should be using `mysql_real_connect()` anyway.)

To make `mysql_real_connect()` thread-safe, you must recompile the client library with this command:

```
shell> CPPFLAGS=-DTHREAD_SAFE_CLIENT ./configure ...
```

You may get some errors because of undefined symbols when linking the standard client, because the pthread libraries are not included by default.

The resulting `libmysqlclient.a` library is now thread-safe. What this means is that client code is thread-safe as long as two threads don’t query the same connection handle returned by `mysql_real_connect()` at the same time; the client/server protocol allows only one request at a time on a given connection. If you want to use multiple threads on the same connection, you must have a mutex lock around your `mysql_query()` and `mysql_store_result()` call combination. Once `mysql_store_result()` is ready, the lock can be released and other threads may query the same connection. (In other words, different threads can use different `MYSQL_RES` pointers that were created with `mysql_store_result()`, as long as they use the proper locking protocol.) If you program with POSIX threads, you can use `pthread_mutex_lock()` and `pthread_mutex_unlock()` to establish and release a mutex lock.

If you used `mysql_use_result()` rather than `mysql_store_result()`, the lock would need to surround `mysql_use_result()` and the calls to `mysql_fetch_row()`. However, it really is best for threaded clients not to use `mysql_use_result()`.

### 21.5 MySQL Perl API

This section documents the Perl DBI interface. The former interface was called `mysqlperl`. Since DBI/DBD now is the recommended Perl interface, `mysqlperl` is obsolete and is not documented here.

#### 21.5.1 DBI with `DBD::mysql`

DBI is a generic interface for many databases. That means that you can write a script that works with many different database engines without change. You need a DataBase Driver (DBD) defined for each database type. For MySQL, this driver is called `DBD::mysql`.

For more information on the Perl5 DBI, please visit the DBI web page and read the documentation:

```
```

For more information on Object Oriented Programming (OOP) as defined in Perl5, see the Perl OOP page:
Installation instructions for MySQL Perl support are given in Section 4.10 [Perl support], page 53.

21.5.2 The DBI interface

Portable DBI methods

- `connect`: Establishes a connection to a database server.
- `disconnect`: Disconnects from the database server.
- `prepare`: Prepares a SQL statement for execution.
- `execute`: Executes prepared statements.
- `do`: Prepares and executes a SQL statement.
- `quote`: Quotes string or BLOB values to be inserted.
- `fetchrow_array`: Fetches the next row as an array of fields.
- `fetchrow_arrayref`: Fetches next row as a reference array of fields.
- `fetchrow_hashref`: Fetches next row as a reference to a hashtable.
- `fetchall_arrayref`: Fetches all data as an array of arrays.
- `finish`: Finishes a statement and let the system free resources.
- `rows`: Returns the number of rows affected.
- `data_sources`: Returns an array of databases available on localhost.
- `ChopBlanks`: Controls whether `fetchrow_*` methods trim spaces.
- `NUM_OF_PARAMS`: The number of placeholders in the prepared statement.
- `NULLABLE`: Which columns can be NULL.
- `trace`: Perform tracing for debugging.

MySQL-specific methods

- `insertid`: The latest AUTO_INCREMENT value.
- `is_blob`: Which column are BLOB values.
- `is_key`: Which columns are keys.
- `is_num`: Which columns are numeric.
- `is_pri_key`: Which columns are primary keys.
- `is_not_null`: Which columns CANNOT be NULL. See `NULLABLE`.
- `length`: Maximum possible column sizes.
- `max_length`: Maximum column sizes actually present in result.
- `NAME`: Column names.
- `NUM_OF_FIELDS`: Number of fields returned.
- `table`: Table names in returned set.
- `type`: All column types.

The Perl methods are described in more detail in the following sections. Variables used for method return values have these meanings:

- `$dbh`: Database handle.
- `$sth`: Statement handle.
- `$rc`: Return code (often a status).
$rv Return value (often a row count)

Portable DBI methods

connect($data_source, $username, $password)

Use the connect method to make a database connection to the data source. The $data_source value should begin with DBI:driver_name:. Example uses of connect with the DBD::mysql driver:

$dbh = DBI->connect("DBI:mysql:$database", $user, $password);
$dbh = DBI->connect("DBI:mysql:$database:$hostname", $user, $password);
$dbh = DBI->connect("DBI:mysql:$database:$hostname:$port", $user, $password);

If the user name and/or password are undefined, DBI uses the values of the DBI_USER and DBI_PASS environment variables, respectively. If you don't specify a hostname, it defaults to 'localhost'. If you don't specify a port number, it defaults to the default MySQL port (3306).

As of Msql-Mysql-modules version 1.2009, the $data_source value allows certain modifiers:

mysql_read_default_file=file_name

Read 'filename' as an option file. For information on option files, see Section 4.15.4 [Option files], page 89.

mysql_read_default_group=group_name

The default group when reading an option file is normally the [client] group. By specifying the mysql_read_default_group option, the default group becomes the [group_name] group.

mysql_compression=1

Use compressed communication between the client and server (MySQL 3.22.3 or later).

mysql_socket=/path/to/socket

Specify the pathname of the Unix socket that is used to connect to the server (MySQL 3.21.15 or later).

Multiple modifiers may be given; each must be preceded by a semicolon.

For example, if you want to avoid hardcoding the user name and password into a DBI script, you can take them from the user's '~/my.cnf' option file instead by writing your connect call like this:

$dbh = DBI->connect("DBI:mysql:$database" . ";mysql_read_default_file=$ENV{HOME}/.my.cnf", $user, $password);

This call will read options defined for the [client] group in the option file. If you wanted to do the same thing, but use options specified for the [perl] group as well, you could use this:
$dbh = DBI->connect("DBI:mysql:$database"
    . ";mysql_read_default_file=$ENV{HOME}/.my.cnf"
    . ";mysql_read_default_group=perl",
    $user, $password);

disconnect

The disconnect method disconnects the database handle from the database. This is typically called right before you exit from the program. Example:

$rc = $dbh->disconnect;

prepare($statement)

Prepares a SQL statement for execution by the database engine and returns a statement handle ($sth) which you can use to invoke the execute method. Typically you handle SELECT statements (and SELECT-like statements such as SHOW, DESCRIBE and EXPLAIN) by means of prepare and execute. Example:

$sth = $dbh->prepare($statement)
    or die "Can't prepare $statement: $dbh->errstr\n";

execute

The execute method executes a prepared statement. For non-SELECT statements, execute returns the number of rows affected. If no rows are affected, execute returns "0E0", which Perl treats as zero but regards as true. For SELECT statements, execute only starts the SQL query in the database; you need to use one of the fetch_* methods described below to retrieve the data. Example:

$rv = $sth->execute
    or die "can't execute the query: $sth->errstr;"

do($statement)

The do method prepares and executes a SQL statement and returns the number of rows affected. If no rows are affected, do returns "0E0", which Perl treats as zero but regards as true. This method is generally used for non-SELECT statements which cannot be prepared in advance (due to driver limitations) or which do not need to executed more than once (inserts, deletes, etc.). Example:

$rv = $dbh->do($statement)
    or die "Can't execute $statement: $dbh->errstr\n";

quote($string)

The quote method is used to "escape" any special characters contained in the string and to add the required outer quotation marks. Example:

$sql = $dbh->quote($string)

fetchrow_array

This method fetches the next row of data and returns it as an array of field values. Example:

while(@row = $sth->fetchrow_array) {
    print qw($row[0]\t$row[1]\t$row[2]\n);  
}
fetchrow_arrayref
This method fetches the next row of data and returns it as a reference to an array of field values. Example:
```perl
while($row_ref = $sth->fetchrow_arrayref) {
    print qw($row_ref->[0]\t$row_ref->[1]\t$row_ref->[2]\n);
}
```

fetchrow_hashref
This method fetches a row of data and returns a reference to a hash table containing field name/value pairs. This method is not nearly as efficient as using array references as demonstrated above. Example:
```perl
while($hash_ref = $sth->fetchrow_hashref) {
    print qw($hash_ref->{firstname}\t$hash_ref->{lastname}\t
             $hash_ref->{title}\n);
}
```

fetchall_arrayref
This method is used to get all the data (rows) to be returned from the SQL statement. It returns a reference to an array of references to arrays for each row. You access or print the data by using a nested loop. Example:
```perl
my $table = $sth->fetchall_arrayref
    or die "$sth->errstr\n";
my($i, $j);
for $i ( 0 .. $#{$table} ) {
    for $j ( 0 .. $#{$table->[i]} ) {
        print "$table->[i][$j]\t";
    }
    print "\n";
}
```

finish
Indicates that no more data will be fetched from this statement handle. You call this method to free up the statement handle and any system resources associated with it. Example:
```perl
$rc = $sth->finish;
```

rows
Returns the number of rows changed (updated, deleted, etc.) by the last command. This is usually used after a non-SELECT execute statement. Example:
```perl
$rv = $sth->rows;
```

NULLABLE
Returns a reference to an array of boolean values; for each element of the array, a value of TRUE indicates that this column may contain NULL values. Example:
```perl
$null_possible = $sth->{NULLABLE};
```

NUM_OF_FIELDS
This attribute indicates the number of fields returned by a SELECT or SHOW FIELDS statement. You may use this for checking whether a statement returned a result: A zero value indicates a non-SELECT statement like INSERT, DELETE or UPDATE. Example:
```perl
$nr_of_fields = $sth->{NUM_OF_FIELDS};
```
data_sources($driver_name)

This method returns an array containing names of databases available to the MySQL server on the host 'localhost'. Example:

```perl
@dbs = DBI->data_sources("mysql");
```

ChopBlanks

This attribute determines whether the `fetchrow_*` methods will chop leading and trailing blanks from the returned values. Example:

```perl
$sth->{'ChopBlanks'} = 1;
```

trace($trace_level)

trace($trace_level, $trace_filename)

The `trace` method enables or disables tracing. When invoked as a `DBI` class method, it affects tracing for all handles. When invoked as a database or statement handle method, it affects tracing for the given handle (and any future children of the handle). Setting `$trace_level` to 2 provides detailed trace information. Setting `$trace_level` to 0 disables tracing. Trace output goes to the standard error output by default. If `$trace_filename` is specified, the file is opened in append mode and output for all traced handles is written to that file. Example:

```perl
DBI->trace(2); # trace everything
DBI->trace(2,"/tmp/dbi.out"); # trace everything to /tmp/dbi.out
$dth->trace(2); # trace this database handle
$sth->trace(2); # trace this statement handle
```

You can also enable `DBI` tracing by setting the `DBI_TRACE` environment variable. Setting it to a numeric value is equivalent to calling `DBI->($value)`. Setting it to a pathname is equivalent to calling `DBI->(2,$value)`. MySQL-specific methods

The methods shown below are MySQL-specific and not part of the DBI standard. Several of them are now deprecated: `is_blob`, `is_key`, `is_num`, `is_pri_key`, `is_not_null`, `length`, `max_length`, and `table`. Where DBI-standard alternatives exist, they are noted below.

insertid

If you use the `AUTO_INCREMENT` feature of MySQL, the new auto-incremented values will be stored here. Example:

```perl
$new_id = $sth->{insertid};
```

As an alternative, you can use `$dbh->{'mysql_insertid'}`.

is_blob

Returns a reference to an array of boolean values; for each element of the array, a value of TRUE indicates that the respective column is a BLOB. Example:

```perl
$keys = $sth->{is_blob};
```

is_key

Returns a reference to an array of boolean values; for each element of the array, a value of TRUE indicates that the respective column is a key. Example:

```perl
$keys = $sth->{is_key};
```

is_num

Returns a reference to an array of boolean values; for each element of the array, a value of TRUE indicates that the respective column contains numeric values. Example:
$nums = $sth->{is_num};

is_pri_key
Returns a reference to an array of boolean values; for each element of the array, a value of TRUE indicates that the respective column is a primary key. Example:

$pri_keys = $sth->{is_pri_key};

is_not_null
Returns a reference to an array of boolean values; for each element of the array, a value of FALSE indicates that this column may contain NULL values. Example:

$not_nulls = $sth->{is_not_null};

is_not_null is deprecated; it is preferable to use the NULLABLE attribute (described above), since that is a DBI standard.

length
max_length
Each of these methods returns a reference to an array of column sizes. The length array indicates the maximum possible sizes that each column may be (as declared in the table description). The max_length array indicates the maximum sizes actually present in the result table. Example:

$lengths = $sth->{length};
$max_lengths = $sth->{max_length};

NAME
Returns a reference to an array of column names. Example:

$names = $sth->{NAME};

table
Returns a reference to an array of table names. Example:

$tables = $sth->{table};

type
Returns a reference to an array of column types. Example:

$types = $sth->{type};

21.5.3 More DBI/DBD information

You can use the perldoc command to get more information about DBI.

perldoc DBI
perldoc DBI::FAQ
perldoc DBD::mysql

You can also use the pod2man, pod2html, etc., tools to translate to other formats. And of course you can find the latest DBI information at the DBI web page:


21.6 MySQL Eiffel wrapper

The MySQL Contrib directory (http://www.mysql.com/Contrib/) contains an Eiffel wrapper written by Michael Ravits.

You can also find this at:  http://www.netpedia.net/hosting/newplayer/
21.7 MySQL Java connectivity (JDBC)

There are 2 supported JDBC drivers for MySQL (the twz and mm driver). You can find a copy of these at http://www.mysql.com/Contrib. For documentation consult any JDBC documentation and the drivers own documentation for MySQL specific features.

21.8 MySQL PHP API

PHP is a server-side, HTML embedded scripting language that may be used to create dynamic web pages. It contains support for accessing several databases, including MySQL. PHP may be run as a separate program, or compiled as a module for use with the Apache web server.

The distribution and documentation are available at the PHP website (http://www.php.net/).

21.8.1 Common problems with MySQL and PHP

bullet Error: "Maximum Execution Time Exceeded" This is a PHP limit; Go into the 'php3.ini' file and set the maximum execution time up from 30 seconds to something higher, as needed. It is also not a bad idea to double the ram allowed per script to 16 instead of 8 MB.

bullet Error: "Fatal error: Call to unsupported or undefined function mysql_connect() in .." This means that your PHP version isn’t compiled with MySQL support. You can either compile a dynamic MySQL module and load it into PHP or recompile PHP with built-in MySQL support. This is described in detail in the PHP manual.

21.9 MySQL C++ APIs

Two API's are available in the MySQL Contrib directory (http://www.mysql.com/Contrib/).

21.10 MySQL Python APIs

The MySQL Contrib directory (http://www.mysql.com/Contrib/) contains a Python interface written by Joseph Skinner.

You can also use the Python interface to iODBC to access a MySQL server. mxODBC (http://starship.skyport.net/~lemburg/)
21.11 MySQL TCL APIs

22 How MySQL compares to other databases

22.1 How MySQL compares to mSQL

This section has been written by the MySQL developers, so it should be read with that in mind. But there are NO factual errors that we know of.

For a list of all supported limits, functions and types, see the crash-me web page (http://www.mysql.com/crash-me-choose.htm).

Performance

For a true comparison of speed, consult the growing MySQL benchmark suite. See Section 11.7 [Benchmarks], page 300.

Because there is no thread creation overhead, a small parser, few features and simple security, mSQL should be quicker at:

- Tests that perform repeated connects and disconnects, running a very simple query during each connection.
- INSERT operations into very simple tables with few columns and keys.
- CREATE TABLE and DROP TABLE.
- SELECT on something that isn’t an index. (A table scan is very easy.)

Since these operations are so simple, it is hard to be better at them when you have a higher startup overhead. After the connection is established, MySQL should perform much better.

On the other hand, MySQL is much faster than mSQL (and most other SQL implementations) on the following:

- Complex SELECT operations.
- Retrieving large results (MySQL has a better, faster and safer protocol).
- Tables with variable-length strings, since MySQL has more efficient handling and can have indexes on VARCHAR columns.
- Handling tables with many columns.
- Handling tables with large record lengths.
- SELECT with many expressions.
- SELECT on large tables.
- Handling many connections at the same time. MySQL is fully multi-threaded. Each connection has its own thread, which means that no thread has to wait for another (unless a thread is modifying a table another thread wants to access.) In mSQL, once one connection is established, all others must wait until the first has finished, regardless of whether the connection is running a query that is short or long. When the first connection terminates, the next can be served, while all the others wait again, etc.
Joins. mSQL can become pathologically slow if you change the order of tables in a `SELECT`. In the benchmark suite, a time more than 15000 times slower than MySQL was seen. This is due to mSQL’s lack of a join optimizer to order tables in the optimal order. However, if you put the tables in exactly the right order in mSQL2 and the `WHERE` is simple and uses index columns, the join will be relatively fast! See Section 11.7 [Benchmarks], page 300.

- ORDER BY and GROUP BY.
- DISTINCT.
- Using TEXT or BLOB columns.

**SQL Features**

- **GROUP BY and HAVING.** mSQL does not support GROUP BY at all. MySQL supports a full GROUP BY with both HAVING and the following functions: `COUNT()`, `AVG()`, `MIN()`, `MAX()`, `SUM()` and `STD()`. `COUNT(*)` is optimized to return very quickly if the `SELECT` retrieves from one table, no other columns are retrieved and there is no `WHERE` clause. `MIN()` and `MAX()` may take string arguments.
- **INSERT and UPDATE with calculations.** MySQL can do calculations in an INSERT or UPDATE. For example:
  ```sql
  mysql> UPDATE SET x=x*10+y WHERE x<20;
  ```
- **Aliasing.** MySQL has column aliasing.
- **Qualifying column names.** In MySQL, if a column name is unique among the tables used in a query, you do not have to use the full qualifier.
- **SELECT with functions.** MySQL has many functions (too many to list here; see Section 7.4 [Functions], page 153).

**Disk space efficiency**

That is, how small can you make your tables?

MySQL has very precise types, so you can create tables that take very little space. An example of a useful MySQL datatype is the MEDIUMINT that is 3 bytes long. If you have 100,000,000 records, saving even one byte per record is very important.

mSQL2 has a more limited set of column types, so it is more difficult to get small tables.

**Stability**

This is harder to judge objectively. For a discussion of MySQL stability, see Section 1.6 [Stability], page 7.

We have no experience with mSQL stability, so we cannot say anything about that.

**Price**

Another important issue is the license. MySQL has a more flexible license than mSQL, and is also less expensive than mSQL. Whichever product you choose to use, remember to at least consider paying for a license or email support. (You are required to get a license if you include MySQL with a product that you sell, of course.)
Perl interfaces

MySQL has basically the same interfaces to Perl as mSQL with some added features.

JDBC (Java)

MySQL currently has 4 JDBC drivers:

- The gwe driver: A Java interface by GWE technologies (not supported anymore).
- The jms driver: An improved gwe driver by Xiaokun Kelvin Zhu X.Zhu@brad.ac.uk.
- The twz driver: A type 4 JDBC driver by Terrence W. Zellers zellert@voicenet.com. This is commercial but is free for private and educational use.
- The mm driver: A type 4 JDBC driver by Mark Matthews mmatthew@ecn.purdue.edu. This is released under the GPL.

The recommended drivers are the twz or mm driver. Both are reported to work excellently.

We know that mSQL has a JDBC driver, but we have too little experience with it to compare.

Rate of development

MySQL has a very small team of developers, but we are quite used to coding C and C++ very rapidly. Since threads, functions, GROUP BY and so on are still not implemented in mSQL, it has a lot of catching up to do. To get some perspective on this, you can view the mSQL ‘HISTORY’ file for the last year and compare it with the News section of the MySQL Reference Manual (see Appendix D [News], page 452). It should be pretty obvious which one has developed most rapidly.

Utility programs

Both mSQL and MySQL have many interesting third-party tools. Since it is very easy to port upward (from mSQL to MySQL), almost all the interesting applications that are available for mSQL are also available for MySQL.

MySQL comes with a simple msql2mysql program that fixes differences in spelling between mSQL and MySQL for the most-used C API functions. For example, it changes instances of msqlConnect() to mysql_connect(). Converting a client program from mSQL to MySQL usually takes a couple of minutes.

22.1.1 How to convert mSQL tools for MySQL

According to our experience, it would just take a few hours to convert tools such as msql-tcl and msqljava that use the mSQL C API so that they work with the MySQL C API.

The conversion procedure is:

1. Run the shell script msql2mysql on the source. This requires the replace program, which is distributed with MySQL.
Differences between the mSQL C API and the MySQL C API are:

- **MySQL** uses a MYSQL structure as a connection type (mSQL uses an int).
- `mysql_connect()` takes a pointer to a MYSQL structure as a parameter. It is easy to define one globally or to use `malloc()` to get one. `mysql_connect()` also takes 2 parameters for specifying the user and password. You may set these to NULL, NULL for default use.
- `mysql_error()` takes the MYSQL structure as a parameter. Just add the parameter to your old msql_error() code if you are porting old code.
- **MySQL** returns an error number and a text error message for all errors. mSQL returns only a text error message.
- Some incompatibilities exist as a result of MySQL supporting multiple connections to the server from the same process.

### 22.1.2 How mSQL and MySQL client/server communications protocols differ

There are enough differences that it is impossible (or at least not easy) to support both. The most significant ways in which the MySQL protocol differs from the mSQL protocol are listed below:

- A message buffer may contain many result rows.
- The message buffers are dynamically enlarged if the query or the result is bigger than the current buffer, up to a configurable server and client limit.
- All packets are numbered to catch duplicated or missing packets.
- All column values are sent in ASCII. The lengths of columns and rows are sent in packed binary coding (1, 2 or 3 bytes).
- **MySQL** can read in the result unbuffered (without having to store the full set in the client).
- If a single write/read takes more than 30 seconds, the server closes the connection.
- If a connection is idle for 8 hours, the server closes the connection.

### 22.1.3 How mSQL 2.0 SQL syntax differs from MySQL

**Column types**

MySQL has the following additional types (among others; see see Section 7.7 [CREATE TABLE], page 187):

- ENUM type for one of a set of strings.
- SET type for many of a set of strings.
• BIGINT type for 64-bit integers.

MySQL also supports the following additional type attributes:
• UNSIGNED option for integer columns.
• ZEROFILL option for integer columns.
• AUTO_INCREMENT option for integer columns that are a PRIMARY KEY. See Section 21.4.29 [mysql_insert_id()], page 397.
• DEFAULT value for all columns.

mSQL column types correspond to the MySQL types shown below:

<table>
<thead>
<tr>
<th>mSQL type</th>
<th>Corresponding MySQL type</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHAR(len)</td>
<td>CHAR(len)</td>
</tr>
<tr>
<td>TEXT(len)</td>
<td>TEXT(len). len is the maximal length. And LIKE works.</td>
</tr>
<tr>
<td>INT</td>
<td>INT. With many more options!</td>
</tr>
<tr>
<td>REAL</td>
<td>REAL. Or FLOAT. Both 4- and 8-byte versions are available.</td>
</tr>
<tr>
<td>UINT</td>
<td>INT UNSIGNED</td>
</tr>
<tr>
<td>DATE</td>
<td>DATE. Uses ANSI SQL format rather than mSQL’s own.</td>
</tr>
<tr>
<td>TIME</td>
<td>TIME</td>
</tr>
<tr>
<td>MONEY</td>
<td>DECIMAL(12,2). A fixed-point value with two decimals.</td>
</tr>
</tbody>
</table>

Index creation

MySQL Indexes may be specified at table creation time with the CREATE TABLE statement.

mSQL Indexes must be created after the table has been created, with separate CREATE INDEX statements.

To insert a unique identifier into a table

MySQL Use AUTO_INCREMENT as a column type specifier. See Section 21.4.29 [mysql_insert_id()], page 397.

mSQL Create a SEQUENCE on a table and select the _seq column.

To obtain a unique identifier for a row

MySQL Add a PRIMARY KEY or UNIQUE key to the table and use this. New in 3.23.11: If the PRIMARY or UNIQUE key consists of only one column and this is of type integer, one can also refer to it as _rowid.

mSQL Use the _rowid column. Observe that _rowid may change over time depending on many factors.

To get the time a column was last modified

MySQL Add a TIMESTAMP column to the table. This column is automatically set to the current date and time for INSERT or UPDATE statements if you don’t give the column a value or if you give it a NULL value.

mSQL Use the _timestamp column.

NULL value comparisons
MySQL follows ANSI SQL and a comparison with NULL is always NULL.

mSQL In mSQL, NULL = NULL is TRUE. You must change =NULL to IS NULL and <>NULL to IS NOT NULL when porting old code from mSQL to MySQL.

String comparisons

MySQL Normally, string comparisons are performed in case-independent fashion with the sort order determined by the current character set (ISO-8859-1 Latin1 by default). If you don’t like this, declare your columns with the BINARY attribute, which causes comparisons to be done according to the ASCII order used on the MySQL server host.

mSQL All string comparisons are performed in case-sensitive fashion with sorting in ASCII order.

Case-insensitive searching

MySQL LIKE is a case-insensitive or case-sensitive operator, depending on the columns involved. If possible, MySQL uses indexes if the LIKE argument doesn’t start with a wildcard character.

mSQL Use CLIKE.

Handling of trailing spaces

MySQL Strips all spaces at the end of CHAR and VARCHAR columns. Use a TEXT column if this behavior is not desired.

mSQL Retains trailing space.

WHERE clauses

MySQL MySQL correctly prioritizes everything (AND is evaluated before OR). To get mSQL behavior in MySQL, use parentheses (as shown below).

mSQL Evaluates everything from left to right. This means that some logical calculations with more than three arguments cannot be expressed in any way. It also means you must change some queries when you upgrade to MySQL. You do this easily by adding parentheses. Suppose you have the following mSQL query:

```
mysql> SELECT * FROM table WHERE a=1 AND b=2 OR a=3 AND b=4;
```

To make MySQL evaluate this the way that mSQL would, you must add parentheses:

```
mysql> SELECT * FROM table WHERE (a=1 AND (b=2 OR (a=3 AND (b=4))));
```

Access control

MySQL Has tables to store grant (permission) options per user, host and database. See Section 6.8 [Privileges], page 113.

mSQL Has a file ‘mSQL.acl’ in which you can grant read/write privileges for users.
22.2 How MySQL compares to PostgreSQL

`PostgreSQL` has some more advanced features like user-defined types, triggers, rules and some transaction support. However, `PostgreSQL` lacks many of the standard types and functions from ANSI SQL and ODBC. See the crash-me web page ([http://www.mysql.com/crash-me-choose.](http://www.mysql.com/crash-me-choose.)) for a complete list of limits and which types and functions are supported or unsupported. Normally, `PostgreSQL` is a magnitude slower than `MySQL`. See Section 11.7 [Benchmarks], page 300. This is due largely to their transactions system. If you really need transactions or the rich type system `PostgreSQL` offers and you can afford the speed penalty, you should take a look at `PostgreSQL`. 
23 MySQL internals

This chapter describes a lot of things that you need to know when working on the MySQL code.

23.1 MySQL threads

The MySQL server creates the following threads:

- The TCP/IP connection thread handles all connect requests and creates a new dedicated thread to handle the authentication and SQL query processing for the connection.
- On NT there is a named pipe handler thread that does the same work as the TCP/IP connection thread on named pipe connect requests.
- The signal thread handles all signals. This thread also normally handles alarms and calls process_alarm() to force timeouts on connections that have been idle too long.
- If compiled with -DUSE_ALARM_THREAD, a dedicated thread that handles alarms is created. This is only used on some systems where there are some problems with sigwait() or if one wants to use the thr_alarm() code in one's application without a dedicated signal handling thread.
- If one uses the --flush-time option, a dedicated thread is created to flush all tables at the given interval.
- Every connection has its own thread.
- Every different table on which one uses INSERT DELAYED gets its own thread.

mysqladmin processlist only shows the connection and INSERT DELAYED threads.
Appendix A Some MySQL users

A.1 General news sites

- A pro-Linux/tech news and comment/discussion site (http://www.slashdot.org)
- All about Linux (http://www.linux.com)
- 32Bits Online: because there's more than one way to compute (http://www.32bitsonline.com)
- New about new versions of computer related stuff (http://www.freshmeat.net)

A.2 Some Web search engines

- What's New (http://www.whatsnu.com/)
- Aladin (http://www.aladin.de/)
- Columbus Finder (http://www.columbus-finder.de/)
- Spider (http://www.spider.de/)
- Blitzsuche (http://www.blitzsuche.de/)
- Indoseek Indonesia (http://www.indoseek.co.id)
- Yaboo - Yet Another BOOkmarker (http://www.yaboo.dk/)
- Yahoosuck (http://www.yahoosuck.com)
- Splat! Search (http://www.splatsearch.com/)

A.3 Some Information search engines concentrated on some area

- Jobvertise: Post and search for jobs (http://www.jobvertise.com)
- The Music Database (http://www.musicdatabase.com)
- Fotball (Soccer) search page (http://www.soccersearch.com)
- TAKEDOWN - wrestling (http://www.headrush.net/takedown)
- The International Lyrics Network (http://www.lyrics.net)
- Musicians looking for other musicians (Free Service) (http://TheMatrix.com/~matrix/band_search.phtml)
- AddALL books searching and price comparison (http://www.addall.com/AddBooks/Stores.html)
- Harvard’s Gray Herbarium Index of Plant Names (http://www.herbaria.harvard.edu/Data/Gray/gx)
- The Game Development Search Engine (http://www.game-developer.com/)
- My-Recipe.com; Cookbook at i-run.com (http://www.i-run.com/html/cookbook.html)
- The Innkeeper Vacation Guides (www.theinnkeeper.com)

Version: 3.23.11-alpha Printed: 25 February 2000
The Mac Game Database uses PHP and MySQL (http://www.macgamedatabase.com/)
Research Publications at Monash University in Australia (http://www.csse.monash.edu.au/publications/)
Occupational Health & Safety website database (a project for the ECC) (http://www.iipielle.emr.it/)
Bioinformatics databases at the Montreal Children’s Hospital using MySQL (http://data.mch.mcgill.ca/)

A.4 Online magazines

- Spoiler Webzine (http://www spoiler.com). An online magazine featuring music, literature, arts, and design content.
- Daily news about Linux in German language (http://www.linux-magazin.de/newsflash/)
- Betazine - The Ultimate Online Beta Tester’s Magazine (http://www.betazine.com)
- Computer Currents Magazine (http://www.currents.net/ccinfo/aboutcc.html)

A.5 Web sites that use MySQL as a backed

- Qt Widget and Object Repository (http://lindev.jmc.tju.edu/qwor)
- Brazilian samba site (in Portuguese) (http://www.samba-choro.com.br)
- Polish General Social Survey (http://pgss.iss.uw.edu.pl/en_index.ISS)
- Expo2000 (http://www.expo2000.com) World-wide distribution of tickets for this event is implemented using MySQL and tcl/tk. More than 5000 travel-agencies all over the world have access to it.
- FreeVote.com is a free voting service with millions of users. (http://www.freevote.com/)
- Forza Motorsport (http://f1.tauzero.se)

A.6 Some Domain/Internet/Web and related services

- Registry of Web providers that support MySQL (http://www.wix.com/mysql-hosting)
- Dynamic DNS Services (http://www.yi.org/)
- Dynamic domain name service (http://www.dynodns.net/)
- Open DNS Project; free dynamic DNS service (http://www.ods.org/)
- Free 3rd level domains (http://www.fdns.net/)
- Online Database (http://worldcommunity.com/)
- BigBiz Internet Services (http://www.bigbiz.com)
- The Virt Gazette (http://virt.circle.net)
- Global InfoNet Inc (http://www.california.com)
- Internet information server (http://online.dn.ru)
- A technology news site (http://www.stopbit.com)
- WorldNet Communications - An Internet Services Provider (http://www.worldnetla.net)

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• Search site for training courses in the UK (http://www.trainingpages.co.uk)
• Gannon Chat (GPL). Written in Perl and Javascript (http://chat.nitco.com)
• A general links directory (http://www.addurls.com/)
• A web-based bookmark management service (http://www.bookmarktracker.com)
• Walnut Creek CDROM (http://www.cdrom.com)
• WWWThreads: Interactive discussion Forums (http://www.wwwthreads.org/)
• In Italian; Storage data from meteo station (http://pvmon.portici.enea.it/Meteo)
• Online "Person To Person" Auction (http://www.buysell.net/)
• Tips on web development (http://tips.pair.com)
• Mailfriends.com is a FREE service for everybody who wants to find friends over the internet. (http://www.mailfriends.com)
• Web Page Telnet BBS List (http://www.uninova.com/cgi-bin/wctelnets?list)
• UniNova Digital Postcards (http://www.uninova.com/cnc.html)
• DSL providers search with reviews (http://www.dslreports.com) Made with MySQL and Modperl, all pages are generated dynamically out of the MySQL database

A.7 Web sites that use PHP and MySQL

• Jgaa’s Internet - Official Support Site (http://war.jgaa.com:8080/support/index.php3)
• Ionline - online publication (http://io.incluso.com) MySQL, PHP, Java, Web programming, DB development
• BaBoo(Browse and bookmark). Free web-based bookmark manager and Calendar (http://www.baboo.com)
• Course Schedule System at Pensacola Junior College (http://www.courses.pjc.cc.fl.us/Schedule/)
• Florida Community College at Jacksonville (http://www.fccj.org)
• 32bit.com; An extensive shareware / freeware archive (http://www.32bit.com/)
• Jokes 2000 (http://www.jokes2000.com/)
• Burken.NU (http://www.burken.nu/) Burken is a webhotel that provides scripts, among other things, for remote users, like counters, guestbooks etc.
• tips.pair.com (http://tips.pair.com) Contains tips on html, javascript, 2d/3d graphics and PHP3/MySQL. All pages are generated from a database.

A.8 Some MySQL consultants

• Ayni AG (http://www.ayni.com)
• Online Database (http://worldcommunity.com/)
• DataGuard (Uses MySQL and PHP) (http://www2.dataguard.no/)
• WWITS (Uses MySQL and PHP) (http://wwits.net/programs/mysql.phtml)
• WCN - The World Community Network (http://www.worldcommunity.com/)
• Chip Castle Dot Com Inc (http://www.chipcastle.com)
Appendix A: Some MySQL users

- Cybersource Pty. Ltd (http://www.cyber.com.au/)
- Spring infotainment gmbh & co. kg (http://www.spring.de)
- Develops websites using MySQL (http://www.wamdesign.com/)

A.9 Programming

- The Perl CPAN Testers results page (http://www.perl.org/cpan-testers)

A.10 Uncategorized pages

- AZC.COM's Feature Showcase (http://www.feature-showcase.com/htmls/demo_mysql.sql)
- Course Search (http://www.teach.org.uk/subjects/trainingcourse/g.html)
- Northerbys Online Auctions (http://www.northerbys.com)
- Amsterdam Airport Schiphol (http://www.schiphol.nl/planes/home.htm)
- CD database (http://TheMatrix.com/seventhsin/query.phtml)
- Used Audio Gear Database (http://TheMatrix.com/~flmm/GEAR.html)
- Musical note-sheets (http://www.kiss.de/musik-mueller)
- Bagism - A John Lennon fan page (http://www.bagism.com)
- US Folk art broker (http://www.selftaught.com/)
- Mail reading on the web (http://organizer.net/)
- Free home pages on www.somecoolname.mypage.org (http://www.mypage.org/)
- Der Server für Schulen im Web (In German) (http://www.schulweb.de/)
- Auldhaefen Online Services (http://www.ald.net/)
- CaryNET Information Center (http://www.cary.net/)
- Dataden Computer Systems (http://www.dataden.com/)
- Andrémuseet (In Swedish) (http://andree.grm.se/)
- HOMESITE Internet Marketing (http://www.him.net/)
- Jade-V Network Services (http://www.jade-v.com/techinfo.html)
- Weather World 2010 Technical Credits (http://ww2010.atmos.uiuc.edu/(Gl)/abt/aknw/tech.rxml)

- About The Gimp plugin registry (http://gimp.foebud.org/registry/doc/)
- Java tool Archiver technical detail (Slightly optimistic about MySQL ANSI-92 compliance) (http://www.fast-inc.com/Products/Archiver/database.html)
- Games Domain Cheats Database (http://www.gamesdomain.com/cheats/usrcheat.phtml)
- The "Powered By" Page (Kcilink) (http://www.kcilink.com/poweredby/)
- Netcasting (http://www.netcasting.net/index.whtml)
- CGI shop (http://www.cgishop.com/)

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• Whirlycott: Website Design (http://www.whirlycott.com/)
• Museum Tusculanum Press (http://www.mtp.dk)
• Centro Siciliano di Documentazione (http://csdgi.historie.ku.dk/biblio)
• Quake statistics database (http://caribou.dyn.ml.org:8000)
• Astroforum: Astrologie and related things (in German) (http://www.astroforum.ch)
• OpenDebate - Interactive Polls & Open Discussion (http://www.opendebate.com)
• Online chemical dissertation server (http://vermeer.organik.uni-erlangen.de/dissertationen/)
• FreSch! The Free Scholarship Search Service (http://www.freschinfo.com)
• Stockholm Pinball Locator (http://www.nada.kth.se/~staffanu/pinball)
• HEK A construction company (http://www.hek.com)
• Elsevier A business information (http://www.nbi.nl)
• Medical Links (Using ColdFusion and MySQL) (http://vaccination.medicallink.se/)
• Search for jobs & people at JobLink-USA (http://www.joblink-usa.com)
• Competition Formation Skydiving (http://www.skydive.net/competfs)
• E-commerce and internal accounting (http://www.galaxy-net.net/Galaxy-NETTelecommunications)
• Denmark’s leading business daily newspaper Børsen (http://www.borsen.dk/)
• The Internet NES Database (http://tmmm.simplenet.com/indb/)
• Travel agency in Prague in 3 languages (http://www.russia.cz)
• Linkstation (http://www.linkstation.de)
• Searchable online database at Peoplestaff (http://www.peoplestaff.com)
• A searchable database system for horse classified ads (http://www.dreamhorse.com)
• The Poot site (http://pootpoot.com/)
• "Playin’ in the LAN": a network monitoring suite (http://grateful.net/hw_html/)
• U.S. Army Publishing Agency (http://www.usapa.army.mil)
• Realestate handling in Yugoslavia (http://www.nekretnine.co.yu/)
• PIMS; a Patient Information Management System (http://demo.cpsoft.com/pims/devFAQ.html)
• Pilkington Software Inc (http://cpsoft.com)
• A Vietnam Veteran’s Memorial (The Wall) database. (http://www.no-quarter.org/)
• Gamer’s Union specializes in auctions of used & out of print gaming material (http://www.gamers-union.com/)
• A daily bulletin at Monterey High school (http://www.montereyhigh.com/office/dbul.php3)
• Community-owned site serving Lake Washington’s Eastside residents and businesses (http://www.myEastside.com)
• French bowling site (http://bowling-france.net/).

Send any additions to this list to webmaster@mysql.com.
Appendix B Contributed programs

Many users of MySQL have contributed very useful support tools and addons.
A list of what is available at http://www.mysql.com/Contrib (or any mirror) is shown below. If you want to build MySQL support for the Perl DBI/DBD interface, you should fetch the Data-Dumper, DBI, and Msql-Mysql-modules files and install them. See Section 4.10 [Perl support], page 53.

00-README (http://www.mysql.com/Contrib/00-README) This listing.

B.1 API's

- Perl modules
  - KAMXbase1.0.tar.gz (http://www.mysql.com/Contrib/KAMXbase1.0.tar.gz) Convert between '.dbf' files and MySQL tables. Perl module written by Pratap Pereira pereira@ee.eng.ohio-state.edu, extened by Kevin A. McGrail kmcgrail@digital1.peregrinehw.com. This converter can handle MEMO fields.
  - Msql-Mysql-modules-1.2209.tar.gz (http://www.mysql.com/Contrib/Msql-Mysql-modules-1.2209.tar.gz) Perl DBD module to access mSQL and MySQL databases.
  - Data-ShowTable-3.3.tar.gz (http://www.mysql.com/Contrib/Data-ShowTable-3.3.tar.gz) Perl Data-ShowTable module. Useful with DBI/DBD support.

- JDBC
  - mm.mysql.jdbc-1.2b.tar.gz (http://www.mysql.com/Contrib/mm.mysql.jdbc-1.2b.tar.gz) The mm JDBC driver for MySQL. This is a production release and is actively developed. By Mark Matthews (mmatthew@ecn.purdue.edu). This driver has a LGPL license. Please check http://www.worldserver.com/mm.mysql/ for the latest drivers (and other JDBC information) since this driver is not updated as frequently.
  - twzjdbcForMysql-1.0.4-GA.tar.gz (http://www.mysql.com/Contrib/twzjdbcForMysql-1.0.4-GA.tar.gz) The twz driver: A type 4 JDBC driver by Terrence W. Zellers zellert@voicenet.com. This is commercial but is free for private and educational use.
  - mysql-c++-0.02.tar.gz (http://www.mysql.com/Contrib/mysql-c++-0.02.tar.gz) MySQL C++ wrapper library. By Roland Haenel, rh@ginster.net.
  - MyDAO (http://www.mysql.com/Contrib/MyDAO.tar.gz) MySQL C++ API. By Satish spitfire@pn3.vsnl.net.in. Inspired by Roland Haenel's C++ API and Ed Carp's MyC library.
  - mysql++ (http://www.mysql.com/download_mysql++.html) MySQL C++ API (More than just a wrapper library). Originally by kevina@clark.net. Nowadays maintained by Sinisa at TCX.
• mysql-ruby-2.1.6.tar.gz (http://www.mysql.com/Contrib/mysql-ruby-2.1.6.tar.gz)  
MySQL Ruby module. By TOMITA Masahiro tommy@tmtm.org Ruby (http://www.netlab.co.jp/ruby/) is Object-Oriented Interpreter Language.

• delphi-interface.gz (http://www.mysql.com/Contrib/delphi-interface.gz) Delphi interface to libmysql.dll, by Blestan Tabakov, root@tdg.bis.bg.

• DelphiMySQL2.zip (http://www.mysql.com/Contrib/DelphiMySQL2.zip) Delphi interface to libmysql.dll, by bsilva@umesd.k12.or.us.

• JdmMysqlDriver-0.1.0.tar.gz (http://www.mysql.com/Contrib/JdmMysqlDriver-0.1.0.tar.gz)  
A VisualWorks 3.0 Smalltalk driver for MySQL. By joshmiller@earthlink.net.

• Db.py (http://www.mysql.com/Contrib/Db.py) Python module with caching. By gandalf@rosmail.com.

• MySQLmodule-1.4.tar.gz (http://www.mysql.com/Contrib/MySQLmodule-1.4.tar.gz)  
Python interface for the MySQL. By Joseph Skinner joe@earthlight.co.nz; Modified by Joerg Senekowitsch senekow@ibm.net.

• mysql_mex_1.1.tar.gz (http://www.mysql.com/Contrib/mysql_mex_1.1.tar.gz)  
An interface program for the Matlab program by MathWorks. The interface is done by Kimmo Uutela and John Fisher (not by Mathworks). Check mysqlmex.html (http://boojum.hut.fi/~kuutela/mysqlmex.html) for more information.

• mysqltcl-1.53.tar.gz (http://www.mysql.com/Contrib/mysqltcl-1.53.tar.gz)  
Tcl interface for MySQL. Based on ‘msqltcl-1.50.tar.gz’. Updated by Tobias Ritzau, tobri@ida.liu.se.

• MyC-0.1.tar.gz (http://www.mysql.com/Contrib/MyC-0.1.tar.gz)  
A Visual Basic-like API, by Ed Carp.

• sqlescreens-1.0.1.tar.gz (http://www.mysql.com/Contrib/sqlescreens-1.0.1.tar.gz)  
TCL/TK code to generate database screens. By Jean-Francois Dockes.

• Vdb-dflts-2.1.tar.gz (http://www.mysql.com/Contrib/Vdb-dflts-2.1.tar.gz)  
This is a new version of a set of library utilities intended to provide a generic interface to SQL database engines such that your application becomes a 3-tiered application. The advantage is that you can easily switch between and move to other database engines by implementing one file for the new backend without needing to make any changes to your applications. By damian@cablenet.net.

• DbFramework-1.10.tar.gz (http://www.mysql.com/Contrib/DbFramework-1.10.tar.gz)  
DbFramework is a collection of classes for manipulating MySQL databases. The classes are loosely based on the CDIF Data Model Subject Area. By Paul Sharpe paul@miraclefish.com.

• pike-mysql-1.4.tar.gz (http://www.mysql.com/Contrib/pike-mysql-1.4.tar.gz)  
MySQL module for pike. For use with the Roxen web server.

• squile.tar.gz (http://www.mysql.com/Contrib/squile.tar.gz)  
Module for guile that allows guile to interact with SQL databases. By Hal Roberts.

• stk-mysql.tar.gz (http://www.mysql.com/Contrib/stk-mysql.tar.gz)  
Interface for Stk. Stk is the Tk widgets with Scheme underneath instead of Tcl. By Terry Jones.

• eiffel-wrapper-1.0.tar.gz (http://www.mysql.com/Contrib/eiffel-wrapper-1.0.tar.gz).  
Eiffel wrapper by Michael Ravits.

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B.2 Clients

- Graphical clients
  - kmysqladmin-0.4.1.tar.gz (http://www.mysql.com/Contrib/kmysqladmin-0.4.1.tar.gz)
  - kmysqladmin-0.4.1-1.src.rpm (http://www.mysql.com/Contrib/kmysqladmin-0.4.1-1.src.rpm)
  - kmysqladmin-0.4.1-1.i386.rpm (http://www.mysql.com/Contrib/kmysqladmin-0.4.1-1.i386.rpm)
    An administration tool for the MySQL server using QT / KDE. Tested only on Linux.
  - Java client using Swing (http://www.mysql.com/Contrib/mysql-admin-using-java+swing.tar.gz)
    By Fredy Fischer, se-afs@dial.eunet.ch. You can always find the latest version here (http://www.trash.net/~ffischer/admin/index.html).
  - mysqlwinadmn.zip (http://www.mysql.com/Contrib/mysqlwinadmn.zip) Win32 GUI (binary only) to administrate a database, by David B. Mansel, david@zhadum.org.
    You can write queries and show tables, indexes, table syntax and administrate user,host and database and so on. The is still beta and have still some bugs. you can test the program with all features. Please send bugs and hints to Marco Suess ms@it-netservice.de. Original URL http://www.it-netservice.de/pages/software/index.html.
  - xmysqladmin-1.0.tar.gz (http://www.mysql.com/Contrib/xmysqladmin-1.0.tar.gz)
    A front end to the MySQL database engine. It allows reloads, status check, process control, myisamchk, grant/revoke privileges, creating databases, dropping databases, create, alter, browse and drop tables. Originally by Gilbert Therrien, gilbert@ican.net but now in public domain and supported by TcX.
  - xmysql-1.9.tar.gz (http://www.mysql.com/Contrib/xmysql-1.9.tar.gz)
  - xmysql home page (http://web.wt.net/~dblhack) A front end to the MySQL database engine. It allows for simple queries and table maintenance, as well as batch queries. By Rick Mehalick, dblhack@wt.net. Requires xforms 0.88 (http://bragg.phys.uwm.edu/xforms) to work.
  - dbMetrix (http://www.tamos.net/sw/dbMetrix) An open source client for exploring databases and executing SQL. Supports MySQL, Oracle, PostgreSQL and mSQL.
  - GtkSQL (http://www.multimania.com/bbrox/GtkSQL) A query tool for MySQL and PostgreSQL.
- Web clients
Appendix B: Contributed programs

- mysqladmin-atif-1.0.tar.gz (http://www.mysql.com/Contrib/mysqladmin-atif-1.0.tar.gz) WWW MySQL administrator for the user, db and host tables. By Tim Sailer, modified by Atif Ghaffar aghaffar@artemedia.ch.

- mysql-webadmin-1.0.tar.gz (http://www.mysql.com/Contrib/mysql-webadmin-1.0.tar.gz) A tool written in PHP-FI to administrate MySQL databases remotely over the web within a Web-Browser. By Peter Kuppelwieser, peter.kuppelwieser@kantea.it. Updated by Wim Bonis, bonis@kiss.de. Not maintained anymore!


- billowmysql.zip (http://www.mysql.com/Contrib/billowmysql.zip) Updated version of ‘mysqladm.tar.gz’, by Ying Gao. You can get the newest version from the home site (http://civeng.com/sql demo/).

- myadmin-0.4.tar.gz (http://www.mysql.com/Contrib/myadmin-0.4.tar.gz)

- MyAdmin home page (http://myadmin.cheapnet.net/) A web based mysql administrator by Mike Machado.

- phpMyAdmin_2.0.1.tar.gz (http://www.mysql.com/Contrib/phpMyAdmin_2.0.1.tar.gz) A set of PHP3-scripts to administrate MySQL over the WWW.

- phpMyAdmin home page (http://www.htmlwizard.net/phpMyAdmin/) A PHP3 tool in the spirit of mysql-webadmin, by Tobias Ratschiller, tobias@dnet.it

- useradm.tar.gz (http://www.mysql.com/Contrib/useradm.tar.gz) MySQL administrator in PHP. By Ofni Thomas othomas@vaidsystems.com.

- mysql-editor.tar.gz (http://www.mysql.com/Contrib/mysql-editor.tar.gz) This cgi scripts in Perl enables you to edit content of Mysql database. By Tomas Zeman.

B.3 Web tools

- mod_mysql_include_1.0.tar.gz (http://www.mysql.com/Contrib/mod_mysql_include_1.0.tar.gz) Banner handling on non-PHP pages. By Sasha Pachev.

- http://www.odbsoft.com/cook/sources.htm This package has various functions for generating html code from an SQL table structure and for generating SQL statements (Select, Insert, Update, Delete) from an html form. You can build a complete forms interface to an SQL database (query, add, update, delete) without any programming! By Marc Beneteau, marc@odbsoft.com.

- sqlhtml.tar.gz (http://www.mysql.com/Contrib/sqlhtml.tar.gz) SQL/HTML is an HTML database manager for MySQL using DBI 1.06.


- wmtcl.doc (http://www.mysql.com/Contrib/wmtcl.doc)

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• wmtcl.lex ([http://www.mysql.com/Contrib/wmtcl.lex](http://www.mysql.com/Contrib/wmtcl.lex)) With this you can write HTML files with inclusions of TCL code. By vvs@scil.npi.msu.su.

• www-sql-0.5.7.lsm ([http://www.mysql.com/Contrib/www-sql-0.5.7.lsm](http://www.mysql.com/Contrib/www-sql-0.5.7.lsm))

• www-sql-0.5.7.tar.gz ([http://www.mysql.com/Contrib/www-sql-0.5.7.tar.gz](http://www.mysql.com/Contrib/www-sql-0.5.7.tar.gz)) A CGI program that parses an HTML file containing special tags, parses them and inserts data from a MySQL database.


• cgi++-0.2.tar.gz ([http://www.mysql.com/Contrib/cgi++-0.2.tar.gz](http://www.mysql.com/Contrib/cgi++-0.2.tar.gz)) A CGI wrapper by Sasha Pachev.

• WebBoard 1.0 ([http://www.mysql.com/Contrib/webboard-1.0.zip](http://www.mysql.com/Contrib/webboard-1.0.zip)) EU-Industries Internet-Message-Board.

• DBIx-TextIndex-0.02.tar.gz ([http://www.mysql.com/Contrib/DBIx-TextIndex-0.02.tar.gz](http://www.mysql.com/Contrib/DBIx-TextIndex-0.02.tar.gz)) Full-text searching with Perl on BLOB/TEXT columns by Daniel Koch.

### B.4 Authentication tools

• ascend-radius-mysql-0.6.4.patch.gz ([http://www.mysql.com/Contrib/ascend-radius-mysql-0.6.4.patch.gz](http://www.mysql.com/Contrib/ascend-radius-mysql-0.6.4.patch.gz)) This is authentication and logging patch using MySQL for Ascend-Radius. By takeshi@SoftAgency.co.jp.

• icradius 0.10 ([http://www.mysql.com/Contrib/icradius-0.10.tar.gz](http://www.mysql.com/Contrib/icradius-0.10.tar.gz)) icradius readme file ([http://www.mysql.com/Contrib/icradius.README](http://www.mysql.com/Contrib/icradius.README))

• checkpassword-0.81-mysql-0.6.1.patch.gz ([http://www.mysql.com/Contrib/checkpassword-0.81-mysql-0.6.1.patch.gz](http://www.mysql.com/Contrib/checkpassword-0.81-mysql-0.6.1.patch.gz)) MySQL authentication patch for QMAIL and checkpassword. These are useful for management user(mail,pop account) by MySQL. By takeshi@SoftAgency.co.jp

• jradius-diff.gz ([http://www.mysql.com/Contrib/jradius-diff.gz](http://www.mysql.com/Contrib/jradius-diff.gz)) MySQL support for Livingston’s Radius 2.01. Authentication and Accounting. By Jose de Leon, jdl@thevision.net

• mod_auth_mysql-2.20.tar.gz ([http://www.mysql.com/Contrib/mod_auth_mysql-2.20.tar.gz](http://www.mysql.com/Contrib/mod_auth_mysql-2.20.tar.gz)) Apache authentication module for MySQL. By Zeev Suraski, bourbon@netvision.net.il.

Please register this module at: [http://bourbon.netvision.net.il/mysql/mod_auth_mysql/register.html](http://bourbon.netvision.net.il/mysql/mod_auth_mysql/register.html). The registering information is only used for statistical purposes and will encourage further development of this module!

• mod_log_mysql-1.05.tar.gz ([http://www.mysql.com/Contrib/mod_log_mysql-1.05.tar.gz](http://www.mysql.com/Contrib/mod_log_mysql-1.05.tar.gz)) MySQL logging module for Apache. By Zeev Suraski, bourbon@netvision.net.il.

• mypasswd-2.0.tar.gz ([http://www.mysql.com/Contrib/mypassword-2.0.tar.gz](http://www.mysql.com/Contrib/mypassword-2.0.tar.gz)) Extra for mod_auth_mysql. This is a little tool that allows you to add/change user records storing group and/or password entries in MySQL tables. By Harry Brueckner, brueckner@respublica.de.

• mysql-pwswd.README ([http://www.mysql.com/Contrib/mysql-pwswd.README](http://www.mysql.com/Contrib/mysql-pwswd.README))

• mysql-pwswd-1.2.tar.gz ([http://www.mysql.com/Contrib/mysql-pwswd-1.2.tar.gz](http://www.mysql.com/Contrib/mysql-pwswd-1.2.tar.gz)) Extra for mod_auth_mysql. This is a two-part system for use with mod_auth_mysql.
Appendix B: Contributed programs

- **pam_mysql.tar.gz** ([http://www.mysql.com/Contrib/pam_mysql.tar.gz](http://www.mysql.com/Contrib/pam_mysql.tar.gz)) This module authenticates users via pam, using MySQL.
- **qmail-1.03-mysql-0.6.2.patch.gz** ([http://www.mysql.com/Contrib/qmail-1.03-mysql-0.6.2.patch.gz](http://www.mysql.com/Contrib/qmail-1.03-mysql-0.6.2.patch.gz)) Patch for qmail to authenticate users from a MySQL table.
- **pwcheck_mysql-0.1.tar.gz** ([http://www.mysql.com/Contrib/pwcheck_mysql-0.1.tar.gz](http://www.mysql.com/Contrib/pwcheck_mysql-0.1.tar.gz)) An authentication module for the Cyrus IMAP server. By Aaron Newsome.

B.5 Converters

- **dbf2mysql-1.13.tgz** ([http://www.mysql.com/Contrib/dbf2mysql-1.13.tgz](http://www.mysql.com/Contrib/dbf2mysql-1.13.tgz)) Convert between `.dbf` files and MySQL tables. By Maarten Boekhold, boekhold@cindy.et.tudelft.nl, and Michael Widenius. This converter can’t handle MEMO fields.
- **dbf2mysql.zip** ([http://www.mysql.com/Contrib/dbf2mysql.zip](http://www.mysql.com/Contrib/dbf2mysql.zip)) Convert between FoxPro `.dbf` files and MySQL tables on Win32. By Alexander Eltsyn, ae@nica.ru or ae@usa.net.
- **dump2h-1.20.gz** ([http://www.mysql.com/Contrib/dump2h-1.20.gz](http://www.mysql.com/Contrib/dump2h-1.20.gz)) Convert from mysqldump output to a C header file. By Harry Brueckner, brueckner@mail.respublica.de.
- **exportsql.txt** ([http://www.mysql.com/Contrib/exportsql.txt](http://www.mysql.com/Contrib/exportsql.txt)) A script that is similar to access_to_mysql.txt, except that this one is fully configurable, has better type conversion (including detection of TIMESTAMP fields), provides warnings and suggestions while converting, quotes all special characters in text and binary data, and so on. It will also convert to mSQL v1 and v2, and is free of charge for anyone. See [http://www.cynergi.net/prod/exportsql/](http://www.cynergi.net/prod/exportsql/) for latest version. By Pedro Freire, support@cynergi.net. Note: Doesn’t work with Access2!
- **access_to_mysql.txt** ([http://www.mysql.com/Contrib/access_to_mysql.txt](http://www.mysql.com/Contrib/access_to_mysql.txt)) Paste this function into an Access module of a database which has the tables you want to export. See also exportsql. By Brian Andrews. Note: Doesn’t work with Access2!
- **importsql.txt** ([http://www.mysql.com/Contrib/importsql.txt](http://www.mysql.com/Contrib/importsql.txt)) A script that does the exact reverse of exportsql.txt. That is, it imports data from MySQL into an Access database via ODBC. This is very handy when combined with exportSQL, since it lets you use Access for all DB design and administration, and synchronize with your actual MySQL server either way. Free of charge. See [http://www.netdive.com/freebies/importsql/](http://www.netdive.com/freebies/importsql/) for any updates. Created by Laurent Bossavit of NetDIVE. Note: Doesn’t work with Access2!
- **/msql2mysqlWrapper 1.0** ([http://www.mysql.com/Contrib/msql2mysqlWrapper-1.0.tgz](http://www.mysql.com/Contrib/msql2mysqlWrapper-1.0.tgz)) A C wrapper from mSQL to MySQL. By alfred@sb.net
- **sqlconv.pl** ([http://www.mysql.com/Contrib/sqlconv.pl](http://www.mysql.com/Contrib/sqlconv.pl)) A simple script that can be used to copy fields from one MySQL table to another in bulk. Basically, you can run mysqldump and pipe it to the sqlconv.pl script and the script will parse through the mysqldump output and will rearrange the fields so they can be inserted into a new table. An example is when you want to create a new table for a different site you are
working on, but the table is just a bit different (ie - fields in different order, etc.). By Steve Shreeve.

B.6 Using MySQL with other products

- radius-0.3.tar.gz (http://www.mysql.com/Contrib/radius-0.3.tar.gz) Patches for radiusd to make it support MySQL. By Wim Bonis, bonis@kiss.de.

B.7 Useful tools

- mysqltop.tar.gz (http://www.mysql.com/Contrib/mysqltop.tar.gz) Sends a query in a fixed time interval to the server and shows the resulting table. By Thomas Wana.
- mysqlsync-1.0-alpha.tar.gz (http://www.mysql.com/Contrib/mysqlsync). A perl script to keep remote copies of a MySQL database in sync with a central master copy. By Mark Jeftovic. markjr@easydns.com
- mysql_replicate.pl (http://www.mysql.com/Contrib/mysql_replicate.pl) Perl program that handles replication. By elbie@icculus.nsg.nwu.edu
- DBIx-TextIndex-0.02.tar.gz (http://www.mysql.com/Contrib/DBIx-TextIndex-0.02.tar.gz) Perl program that uses reverse indexing to handle text searching. By Daniel Koch.

B.8 RPMs for common tools (Most are for RedHat 6.1)

- perl-Data-ShowTable-3.3-2.i386.rpm (http://www.mysql.com/Contrib/perl-Data-ShowTable-3.3-2.i386.rpm)
• php-pg-3.0.13-1.i386.rpm (http://www.mysql.com/Contrib/php-pg-3.0.13-1.i386.rpm)
• php-pg-manual-3.0.13-1.i386.rpm (http://www.mysql.com/Contrib/php-pg-manual-3.0.13-1.i386.rpm)
• php-pg-mysql-3.0.13-1.i386.rpm (http://www.mysql.com/Contrib/php-pg-mysql-3.0.13-1.i386.rpm)
• phpMyAdmin-2.0.5-1.noarch.rpm (http://www.mysql.com/Contrib/phpMyAdmin-2.0.5-1.noarch.rpm)

B.9 Useful functions

• mysnprintf.c (http://www.mysql.com/Contrib/mysnprintf.c) sprintf() function for SQL queries that can escape blobs. By Chunhua Liu.

B.10 Uncategorized

• mysql-bench-0.0.1.tar.gz (http://www.mysql.com/Contrib/mysql-bench-0.0.1.tar.gz) Some tools to benchmark MySQL. By Sasha Pachev.
• handicap.tar.gz (http://www.mysql.com/Contrib/handicap.tar.gz) Performance handicapping system for yachts. Uses PHP. By rhill@stobyn.ml.org.
• hylalog-1.0.tar.gz (http://www.mysql.com/Contrib/hylalog-1.0.tar.gz) Store hylafax outgoing faxes in a MySQL database. By Sinisa Milivojevic, sinisa@coresinc.com.
• mrtg-mysql-1.0.tar.gz (http://www.mysql.com/Contrib/mrtg-mysql-1.0.tar.gz) MySQL status plotting with MRTG, by Luuk de Boer, luuk@wxs.nl.
• wuftpd-2.4.2.18-mysql_support.2.tar.gz (http://www.mysql.com/Contrib/wuftpd-2.4.2.18-mysql_support.2.tar.gz) Patches to add logging to MySQL for WU-ftpd. By Zeev Suraski, bourbon@netvision.net.il.
• wu-ftpd-2.6.0-mysql_support.2.tar.gz (http://www.mysql.com/Contrib/wu-ftpd-2.6.0-mysql_support.2.tar.gz) Patches to add logging to MySQL for WU-ftpd 2.6.0. By, takeshi@SoftAgency.co.jp, based on Zeev Suraski wuftpdp patches.
• Old-Versions (http://www.mysql.com/Contrib/Old-Versions) Previous versions of things found here that you probably won’t be interested in.
Appendix C  Contributors to MySQL

Contributors to the MySQL distribution are listed below, in somewhat random order:

Michael (Monty) Widenius

Has written the following parts of MySQL:

- All the main code in mysqld.
- New functions for the string library.
- Most of the msys library.
- The ISAM and MyISAM libraries (B-tree index file handlers with index compression and different record formats).
- The replace program (look into it, it’s COOL!).
- MyODBC, the ODBC driver for Windows95.
- Fixing bugs in MIT-pthreads to get it to work for MySQL. And also Unireg, a curses-based application tool with many utilities.
- Porting of mSQL tools like msqlperl, DBD/DBI and DB2mysql.
- Most parts of crash-me and the MySQL benchmarks.

David Axmark

- Coordinator and main writer for the Reference Manual, including enhancements to texi2html. Also automatic website updating from this manual.
- Autoconf, Automake and libtool support.
- The licensing stuff.
- Parts of all the text files. (Nowadays only the ‘README’ is left. The rest ended up in the manual.)
- Our Mail master.
- Lots of testing of new features.
- Our in-house “free” software lawyer.
- Mailing list maintainer (who never has the time to do it right...)
- Our original portability code (more than 10 years old now). Nowadays only some parts of msys are left.
- Someone for Monty to call in the middle of the night when he just got that new feature to work. :-)

Paul DuBois

Help with making the Reference Manual correct and understandable. That includes rewriting Monty’s and David’s attempts at English into English as other people know it.

Gianmassimo Vigazzola qwerg@mbox.vol.it or qwerg@tin.it

The initial port to Win32/NT.
Kim Aldale
Helped to rewrite Monty’s and David’s early attempts at English into English.

Allan Larsson (The BOSS at TcX)
For all the time he has allowed Monty to spend on this “maybe useful” tool (MySQL). Dedicated user (and bug finder) of Unireg & MySQL.

Per Eric Olsson
For more or less constructive criticism and real testing of the dynamic record format.

Irena Pancirov irena@mail.yacc.it
Win32 port with Borland compiler. mysqlshutdown.exe and mysqlwatch.exe

David J. Hughes
For the effort to make a shareware SQL database. We at TcX started with mSQL, but found that it couldn’t satisfy our purposes so instead we wrote a SQL interface to our application builder Unireg. mysqladmin and mysql are programs that were largely influenced by their mSQL counterparts. We have put a lot of effort into making the MySQL syntax a superset of mSQL. Many of the APIs ideas are borrowed from mSQL to make it easy to port free mSQL programs to MySQL. MySQL doesn’t contain any code from mSQL. Two files in the distribution (‘client/insert_test.c’ and ‘client/select_test.c’) are based on the corresponding (non-copyrighted) files in the mSQL distribution, but are modified as examples showing the changes necessary to convert code from mSQL to MySQL. (mSQL is copyrighted David J. Hughes.)

Fred Fish
For his excellent C debugging and trace library. Monty has made a number of smaller improvements to the library (speed and additional options).

Richard A. O’Keefe
For his public domain string library.

Henry Spencer
For his regex library, used in WHERE column REGEXP regexp.

Free Software Foundation
From whom we got an excellent compiler (gcc), the libc library (from which we have borrowed ‘strto.c’ to get some code working in Linux) and the readline library (for the mysql client).

Free Software Foundation & The XEmacs development team
For a really great editor/environment used by almost everybody at TcX/detron.

Patrick Lynch
For helping us acquire www.mysql.com.

Fred Lindberg
For setting up qmail to handle MySQL mailing list and for the incredible help we got in managing the MySQL mailing lists.

Igor Romanenko igor@frog.kiev.ua
mysqldump (previously msqldump, but ported and enhanced by Monty).
Tim Bunce, Alligator Descartes
For the DBD (Perl) interface.

Andreas Koenig a.koenig@mind.de
For the Perl interface to MySQL.

Eugene Chan eugene@acenet.com.sg
For porting PHP to MySQL.

Michael J. Miller Jr. mke@terrapin.turbolift.com
For the first MySQL manual. And a lot of spelling/language fixes for the FAQ (that turned into the MySQL manual a long time ago).

Giovanni Maruzzelli maruzz@matrice.it
For porting iODBC (Unix ODBC).

Chris Provenzano
Portable user level pthreads. From the copyright: This product includes software developed by Chris Provenzano, the University of California, Berkeley, and contributors. We are currently using version 1.60_beta6 patched by Monty (see 'mit-pthreads/Changes-mysql').

Xavier Leroy Xavier.Leroy@inria.fr
The author of LinuxThreads (used by MySQL on Linux).

Zarko Mocnik zarko.mocnik@dem.si
Sorting for Slovenian language and the ‘cset.tar.gz’ module that makes it easier to add other character sets.

"TAMITO" tommy@valley.ne.jp
The _MB character set macros and the ujis and sjis character sets.

Yves Carlier Yves.Carlier@rug.ac.be
mysqlaccess, a program to show the access rights for a user.

Rhys Jones rhys@wales.com (And GWE Technologies Limited)
For the JDBC, a module to extract data from MySQL with a Java client.

Dr Xiaokun Kelvin Zhu X.Zhu@brad.ac.uk
Further development of the JDBC driver and other MySQL-related Java tools.

James Cooper pixel@organic.com
For setting up a searchable mailing list archive at his site.

Rick Mehalick Rick_Mehalick@i-o.com
For xmysql, a graphical X client for MySQL.

Doug Sisk sisk@wix.com
For providing RPM packages of MySQL for RedHat Linux.

Diemand Alexander V. axeld@vial.ethz.ch
For providing RPM packages of MySQL for RedHat Linux/Alpha.

Antoni Pamies Olive toni@readysoft.es
For providing RPM versions of a lot of MySQL clients for Intel and SPARC.
Jay Bloodworth jay@pathways.sde.state.sc.us
For providing RPM versions for MySQL 3.21 versions.

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For maintaining the Perl DBD::mysql module.

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French error messages.

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Russian error messages.

brenno@dewinter.com && Filippo Grassilli phil@hyppo.com
Italian error messages.

Dirk Munzinger dirk@trinity.saar.de
German error messages.

Billik Stefan billik@sun.uniag.sk
Slovak error messages.

David Sacerdote davids@secnet.com
Ideas for secure checking of DNS hostnames.

Wei-Jou Chen jou@nematic.ieo.nctu.edu.tw
Some support for Chinese(BIG5) characters.

Wei He hewei@mail.ied.ac.cn
A lot of functionality for the Chinese(GBK) character set.

Zeev Suraski bourbon@netvision.net.il
FROM_UNIXTIME() time formatting, ENCRYPT() functions, and bison adviser.
Active mailing list member.

Luuk de Boer luuk@wxs.nl
Ported (and extended) the benchmark suite to DBI/DBD. Have been of great help with crash-me and running benchmarks. Some new date functions. The mysql_setpermissions script.

Jay Flaherty fty@utk.edu
Big parts of the Perl DBI/DBD section in the manual.

Paul Southworth pauls@etext.org, Ray Loyzaga yar@cs.su.oz.au

Version: 3.23.11-alpha Printed: 25 February 2000
Alexis Mikhailov root@medinf.chuvashia.su
User definable functions (UDFs); CREATE FUNCTION and DROP FUNCTION.

Andreas F. Bobak bobak@relog.ch
The AGGREGATE extension to UDF functions.

Ross Wakelin R.Wakelin@march.co.uk
Help to set up InstallShield for MySQL-Win32.

Jethro Wright III jetman@li.net
The ‘libmysql.dll’ library.

James Pereria jpereria@iafrica.com
Mysqlmanager, a Win32 GUI tool for administrating MySQL.

Curt Sampson cjs@portal.ca
Porting of MIT-pthreads to NetBSD/Alpha and NetBSD 1.3/i386.

Sinisa Milivojevic sinisa@coresinc.com
Compression (with zlib) to the client/server protocol. Perfect hashing for the lexical analyzer phase.

Antony T. Curtis antony.curtis@olcs.net
Porting of MySQL to OS/2.

Martin Ramsch m.ramsch@computer.org
Examples in the MySQL Tutorial.

Tim Bunce
Author of mysqlhotcopy.

Steve Harvey
For making mysqlaccess more secure.

Other contributors, bugfinders and testers: James H. Thompson, Maurizio Menghini, Wojciech Tryc, Luca Berra, Zarko Mocnik, Wim Bonis, Elmar Haneke, jehamby@lightside, psmith@BayNetworks.COM, duane@connect.com.au, Ted Deppner ted@psyber.com, Mike Simons, Jaakko Hyvätti.

And lots of bug report/patches from the folks on the mailing list.

And a big tribute to those that help us answer questions on the mysql@lists.mysql.com mailing list:

Daniel Koch dkoch@amcity.com
Irix setup.

Luuk de Boer luuk@wxs.nl
Benchmark questions.

Tim Sailer tps@users.buoy.com
DBD-mysql questions.

Boyd Lynn Gerber gerberb@zenez.com
SCO related questions.
Richard Mehalick RM186061@shellus.com
  xmysql-related questions and basic installation questions.

Zeev Suraski bourbon@netvision.net.il
  Apache module configuration questions (log & auth), PHP-related questions,
  SQL syntax related questions and other general questions.

Francesc Guasch frankie@citel.upc.es
  General questions.

Jonathan J Smith jsmith@wtp.net
  Questions pertaining to OS-specifics with Linux, SQL syntax, and other things
  that might be needing some work.

David Sklar sklar@student.net
  Using MySQL from PHP and Perl.

Alistair MacDonald A.MacDonald@uel.ac.uk
  Not yet specified, but is flexible and can handle Linux and maybe HP-UX. Will
  try to get user to use mysqlbug.

John Lyon jlyon@imag.net
  Questions about installing MySQL on Linux systems, using either ‘.rpm’ files,
  or compiling from source.

Lorvid Ltd. lorvid@WOLFENET.com
  Simple billing/license/support/copyright issues.

Patrick Sherrill patrick@coconet.com
  ODBC and VisualC++ interface questions.

Randy Harmon rjharmon@uptimecomputers.com
  DBD, Linux, some SQL syntax questions.
Appendix D MySQL change history

Note that we tend to update the manual at the same time we implement new things to MySQL. If you find a version listed below that you can’t find on the MySQL download page (http://www.mysql.com/download.html), this means that the version has not yet been released!

D.1 Changes in release 3.23.x (Released as alpha)

The major difference between release 3.23 and releases 3.22 and 3.21 is that 3.23 contains a new ISAM library (MyISAM), which is more tuned for SQL than the old ISAM was.

The 3.23 release is under development, and things will be added at a fast pace to it. For the moment we recommend this version only for users that desperately need a new feature that is found only in this release (like big file support and machine-independent tables). (Note that all new functionality in MySQL 3.23 is extensively tested, but as this release involves much new code, it’s difficult to test everything).

We are not adding any more new features that are likely to break any old code in MySQL 3.23 so this version should stabilise pretty soon and will soon be declared beta, gamma and release.

D.1.1 Changes in release 3.23.12

- Added options --all-databases and --databases to mysqldump to allow dumping of many databases at the same time.
- Fixed bug in compressed DECIMAL() index in MyISAM tables.
- Fixed bug when storing 0 into a timestamp.
- When doing mysqladmin shutdown on a local connection, mysqladmin now waits until the pidfile is gone before doing an shutdown.
- Fixed core dump with some COUNT(DISTINCT ...) queries.
- Fixed that myisamchk works properly with RAID:ed tables.
- Fixed problem with LEFT JOIN and key_field IS NULL.
- Fixed bug in net_clear() which could give the error Aborted connection in the MySQL clients.
- Added options USE KEYS (key_list) and IGNORE KEYS (key_list) as join parameters in SELECT.
- DELETE and RENAME should now work on RAID tables.

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D.1.2 Changes in release 3.23.11

- Allow the ALTER TABLE table_name ADD (field_list) syntax.
- Fixed problem with optimizer that could sometimes use wrong keys.
- Fixed that GRANT/REVOKE ALL PRIVILEGES doesn’t affect GRANT OPTION.
- Removed extra ) from the output of SHOW GRANTS.
- Fixed problem when storing numbers in timestamps.
- Fix problem with timezones that have half hour offsets.
- Allow the syntax UNIQUE INDEX in CREATE statements.
- mysqlhotcopy - fast on-line hot-backup utility for local MySQL databases. By Tim Bunce.
- New more secure mysqlacess. Thanks to Steve Harvey for this.
- Added options --i-am-a-dummy and --safe-updates to mysql.
- Added variables select_limit and max_join_size to mysql.
- Added sql variables: SQL_MAX_JOIN_SIZE and SQL_SAFE_UPDATES.
- Added READ LOCAL lock that doesn’t lock the table for concurrent inserts. (This is used by mysqldump).
- Changed that LOCK TABLES .. READ doesn’t anymore allow concurrent inserts.
- Added option --skip-delay-key-write to mysqld.
- Fixed security problem in the protocol regarding password checking.
- _rowid can now be used as an alias for an integer type unique indexed column.
- Added back blocking of SIGPIPE when compiling with --thread-safe-clients to make things safe for old clients.

D.1.3 Changes in release 3.23.10

- Fixed bug in 3.23.9 where memory wasn’t properly freed when doing LOCK TABLES.

D.1.4 Changes in release 3.23.9

- Fixed problem that affected queries that did arithmetic on group functions.
- Fixed problem with timestamps and INSERT DELAYED.
- Fixed that date_column BETWEEN const_date AND const_date works.
- Fixed problem when only changing a 0 to NULL in a table with BLOB/TEXT columns.
- Fixed bug in range optimizer when using many key parts and or on the middle key parts: WHERE K1=1 and K3=2 and (K2=2 and K4=4 or K2=3 and K4=5)
- Added command source to mysql to allow reading of batch files inside the mysql client. Original patch by Matthew Vanecek.
• Fixed critical problem with the WITH GRANT OPTION option.
• Don’t give an unnecessary GRANT error when using tables from many databases in the same query.
• Added VIO wrapper (needed for SSL support; By Andrei Errapart and Tnu Samuel).
• Fixed optimizer problem on SELECT when using many overlapping indexes. MySQL should now be able to choose keys even better when there is many keys to choose from.
• Changed optimizer to prefer a range key instead of a ref key when the range key can uses more columns than the ref key (which only can use columns with =). For example, the following type of queries should now be faster: SELECT * from key_part_1=const and key_part_2 > const2
• Fixed bug that a change of all VARCHAR columns to CHAR columns didn’t change row type from dynamic to fixed.
• Disabled floating point exceptions for FreeBSD to fix core dump when doing SELECT floor(pow(2,63)).
• Changed mysqld startup option --delay-key-write to --delay-key-write-for-all-tables
• Added read-next-on-key to HEAP tables. This should fix all problems with HEAP tables when using not UNIQUE keys.
• Added print of default arguments options to all clients.
• Added --log-slow-queries to mysqld to log all queries that take a long time to a separate log file with a time of how long the query took.
• Fixed core dump when doing WHERE key_column=RAND(...)
• Fixed optimization bug in SELECT .. LEFT JOIN ... key_column IS NULL, when key_column could contain NULL values.
• Fixed problem with 8-bit characters as separators in LOAD DATA INFILE.

D.1.5 Changes in release 3.23.8

• Fixed problem when handling indexfiles larger than 8G.
• Added latest patches to mit-pthreads for NetBSD.
• Fixed problem with timezones that are < GMT -11.
• Fixed a bug when deleting packed keys in NISAM.
• Fixed problem with ISAM when doing some ORDER BY ... DESC queries.
• Fixed bug when doing a join on a text key which didn’t cover the whole key.
• Option --delay-key-write didn’t enable delayed key writing.
• Fixed update of TEXT column which only involved case changes.
• Fixed that INSERT DELAYED doesn’t update timestamps that are given.
• Added function YEARWEEK() and options x, X, v and V to DATE_FORMAT().
• Fixed problem with MAX(indexed_column) and HEAP tables.

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• Fixed problem with BLOB NULL keys and LIKE "prefix%".
• Fixed problem with MyISAM and fixed length rows < 5 bytes.
• Fixed problem that could cause MySQL to touch freed memory when doing very complicated GROUP BY queries.
• Fixed core dump if you got a crashed table where an ENUM field value was too big.

D.1.6 Changes in release 3.23.7

• Fixed workaround under Linux to avoid problems with pthread_mutex_timedwait, which is used with INSERT DELAYED. See Section 4.11.5 [Linux], page 59.
• Fixed that one will get a 'disk full' error message if one gets disk full when doing sorting (instead of waiting until we got more disk space).
• Fixed a bug in MyISAM with keys > 250 characters.
• In MyISAM one can now do an INSERT at the same time as other threads are reading from the table.
• Added variable max_write_lock_count to mysqld to force a READ lock after a certain number of WRITE locks.
• Inverted flag delayed_key_write on show variables.
• Renamed variable concurrency to thread_concurrency.
• The following functions are now multi-byte-safe: LOCATE(substr,str), POSITION(substr IN str), LOCATE(substr,str,pos), INSTR(str,substr), LEFT(str,len), RIGHT(str,len), SUBSTRING(str,pos,len), SUBSTRING(str FROM pos FOR len), MID(str,pos,len), SUBSTRING(str,pos), SUBSTRING_INDEX(str,delim,count), RTRIM(str), TRIM([TRAILING | BOTH] [remstr] FROM str), REPLACE(str,from_str,to_str), REVERSE(str), INSERT(str,pos,len,newstr), LCASE(str), LOWER(str), UCASE(str) and UPPER(str); Patch by Wei He.
• Fix core dump when releasing a lock from a non existing table.
• Remove locks on tables before starting to remove duplicates.
• Added option FULL to SHOW PROCESSLIST.
• Added option --verbose to mysqladmin.
• Fixed problem when automatically converting HEAP to MyISAM.
• Fixed bug in HEAP tables when doing insert + delete + insert + scan the table.
• Fixed bugs on Alpha with REPLACE() and LOAD DATA INFILE.
• Added mysqld variable interactive_timeout.
• Changed the argument to mysql_data_seek() from ulong to ulonglong.

D.1.7 Changes in release 3.23.6

• Added mysqld option --lower_case_table_names={0|1} to allow users to force table names to lower case.
Appendix D: MySQL change history

- Added `SELECT ... INTO DUMPFILE`.
- Added `mysqld` option `--ansi` to make some functions ANSI SQL compatible.
- Temporary tables now starts with `#sql`.
- Added quoting of identifiers with `('` in `--ansi` mode).
- Changed to use `snprintf()` when printing floats to avoid some buffer overflows on FreeBSD.
- Made `floor()` overflow safe on FreeBSD.
- Added `mysqldump` option `--quote-names` to make some functions ANSI SQL compatible.
- Temporary tables now starts with `#sql`.
- Added quoting of identifiers with `'` in `--ansi` mode).
- Changed to use `snprintf()` when printing floats to avoid some buffer overflows on FreeBSD.
- Made `floor()` overflow safe on FreeBSD.
- Added function `ORD(string)`.

D.1.8 Changes in release 3.23.5

- Fixed some Y2K problems in the new date handling in 3.23.
- Fixed problem with `SELECT DISTINCT ... ORDER BY RAND()`.
- Added patches by Sergei A. Golubchik for text searching on the MyISAM level.
- Fixed cache overflow problem when using full joins without keys.
- Fixed some configure issues.
- Some small changes to make parsing faster.
- `ALTER TABLE` + adding a column after the last field didn’t work.
- Fixed problem when using an auto_increment column in two keys
- One can now with MyISAM have the auto_increment part as a sub part: `CREATE TABLE foo (a int not null auto_increment, b char(5), primary key (b,a))`
- Fixed bug in MyISAM with packed char keys that could be NULL.

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AS on fieldname with CREATE TABLE table_name SELECT ... didn’t work.

- Allow use of NATIONAL and NCHAR when defining character columns. This is the same as not using BINARY.

- Don’t allow NULL columns in a PRIMARY KEY (only in UNIQUE keys).

- Clear LAST_INSERT_ID if in uses this in ODBC: WHERE auto_increment_column IS NULL. This seems to fix some problems with Access.

- SET SQL_AUTO_IS_NULL=0|1 now turns off/on the handling of searching after the last inserted row with WHERE auto_increment_column IS NULL.

- Added new mysql variable concurrency for Solaris.

- Added option --relative to mysqladmin to make extended-status more useful to monitor changes.

- Fixed bug when using COUNT(DISTINCT...) on an empty table.

- Added support for the Chinese character set GBK.

- Fixed problem with LOAD DATA INFILE and BLOB columns.

- Added bit operator ~ (negation).

- Fixed problem with UDF functions.

**D.1.9 Changes in release 3.23.4**

- Inserting a DATETIME into a TIME column will not anymore try to store 'days' in it.

- Fixed problem with storage of float/double on low endian machines. (This affected SUM().)

- Added connect timeout on TCP/IP connections.

- Fixed problem with LIKE "%" on a index that may have NULL values.

- REVOKE ALL PRIVILEGES didn’t revoke all privileges.

- Allow creation of temporary tables with same name as the original table.

- When granting a user a grant option for a database, he couldn’t grant privileges to other users.

- New command: SHOW GRANTS FOR user (by Sinisa).

- New date_add syntax: date/datetime + INTERVAL # interval_type. By Joshua Chamas.

- Fixed privilege check for LOAD DATA REPLACE.

- Automatic fixing of broken include files on Solaris 2.7

- Some configure issues to fix problems with big file system detection.

- REGEXP is now case insensitive if you use not binary strings.

**D.1.10 Changes in release 3.23.3**

Added patches for MIT-pthreads on NetBSD.

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• Fixed range bug in MyISAM.
• ASC is now the default again for ORDER BY.
• Added LIMIT to UPDATE.
• New client function: mysql_change_user().
• Added character set to SHOW VARIABLES.
• Added support of -- [whitespace] comments.
• Allow INSERT into tbl_name VALUES (), that is, you may now specify an empty value list to insert a row in which each column is set to its default value.
• Changed SUBSTRING(text FROM pos) to conform to ANSI SQL. (Before this construct returned the rightmost 'pos' characters).
• SUM(...) with GROUP BY returned 0 on some systems.
• Changed output for SHOW TABLE STATUS.
• Added DELAY_KEY_WRITE option to CREATE TABLE.
• Allow AUTO_INCREMENT on any key part.
• Fixed problem with YEAR(NOW()) and YEAR(CURDATE()).
• Added CASE construct.
• New function COALESCE().

D.1.11 Changes in release 3.23.2

• Fixed range optimizer bug: SELECT * FROM table_name WHERE key_part1 >= const AND (key_part2 = const OR key_part2 = const). The bug was that some rows could be duplicated in the result.
• Running myisamchk without -a updated the index distribution wrong.
• SET SQL_LOW_PRIORITY_UPDATES=1 gave parse error before.
• You can now update indexes columns that are used in the WHERE clause. UPDATE tbl_name SET KEY=KEY+1 WHERE KEY > 100
• Date handling should now be a bit faster.
• Added handling of fuzzy dates (dates where day or month is 0): (Like: 1999-01-00)
• Fixed optimization of SELECT ... WHERE key_part1=const1 AND key_part_2=const2 AND key_part1=const4 AND key_part2=const4 ; Indextype should be range instead of ref.
• Fixed egcs 1.1.2 optimizer bug (when using BLOBs) on Linux Alpha.
• Fixed problem with LOCK TABLES combined with DELETE FROM table.
• MyISAM tables now allow keys on NULL and BLOB/TEXT columns.
• The following join is now much faster: SELECT ... FROM t1 LEFT JOIN t2 ON ... WHERE t2.not_null_column IS NULL.
• ORDER BY and GROUP BY can be done on functions.
• Changed handling of 'const_item' to allow handling of ORDER BY RAND().

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• Indexes are now used for WHERE key_column = function.
• Indexes are now used for WHERE key_column = column_name even if the columns are not identically packed.
• Indexes are now used for WHERE column_name IS NULL.
• Changed heap tables to be stored in low_byte_first order (to make it easy to convert to MyISAM tables)
• Automatic change of HEAP temporary tables to MyISAM tables in case of 'table is full' errors.
• Added option --init-file=file_name to mysqld.
• COUNT(DISTINCT value,[value,...])
• CREATE TEMPORARY TABLE now creates a temporary table, in its own namespace, that is automatically deleted if connection is dropped.
• New reserved words (required for CASE): CASE, THEN, WHEN, ELSE and END.
• New functions EXPORT_SET() and MD5().
• Support for the GB2312 Chinese character set.

D.1.12 Changes in release 3.23.1

• Fixed some compilation problems.

D.1.13 Changes in release 3.23.0

A new table handler library (MyISAM) with a lot of new features. See Section 8.1 [MyISAM], page 232.
• You can create in-memory HEAP tables which are extremely fast for lookups.
• Support for big files (63 bit) on OSes that support big files.
• New function LOAD_FILE(filename) to get the contents of a file as a string value.
• New operator <=> which will act as = but will return TRUE if both arguments are NULL. This is useful for comparing changes between tables.
• Added the ODBC 3.0 EXTRACT(interval FROM datetime) function.
• Columns defined as FLOAT(X) is not rounded on storage and may be in scientific notation (1.0 E+10) when retrieved.
• REPLACE is now faster than before.
• Changed LIKE character comparison to behave as =; This means that 'é' LIKE 'é' is now true.
• SHOW TABLE STATUS returns a lot of information about the tables.
• Added LIKE to the SHOW STATUS command.
• Added privilege column to SHOW COLUMNS.
• Added columns packed and comment to SHOW INDEX.

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• Added comments to tables (with `CREATE TABLE ... COMMENT "xxx"`).
• Added UNIQUE, as in `CREATE TABLE table_name (col int not null UNIQUE)`.
• New create syntax: `CREATE TABLE table_name SELECT ...`
• New create syntax: `CREATE TABLE IF NOT EXISTS ...`
• Allow creation of `CHAR(0)` columns.
• `DATE_FORMAT()` now requires `'%`' before any format character.
• `DELAYED` is now a reserved word (sorry about that :( ).
• An example procedure is added: `analyse`, file: `sql_analyse.c`. This will describe the data in your query. Try the following:

```
SELECT ... FROM ... WHERE ... PROCEDURE ANALYSE([max elements,[max memory]])
```

This procedure is extremely useful when you want to check the data in your table!
• `BINARY` cast to force a string to be compared case sensitively.
• Added option `--skip-show-database` to `mysqld`.
• Check if a row has changed in an `UPDATE` now also works with `BLOB/TEXT` columns.
• Added the `INNER` join syntax. **NOTE:** This made `INNER` an reserved word!
• Added support for netmasks to the hostname in the MySQL tables. You can specify a netmask using the `IP/NETMASK` syntax.
• If you compare a NOT NULL `DATE/DATETIME` column with `IS NULL`, this is changed to a compare against `0` to satisfy some ODBC applications. (By shreeve@uci.edu).
• `NULL IN (...)` now returns `NULL` instead of `0`. This will ensure that `null_column NOT IN (...)` doesn’t match `NULL` values.
• Fix storage of floating point values in `TIME` columns.
• Changed parsing of `TIME` strings to be more strict. Now the fractional second part is detected (and currently skipped). The following formats are supported:

```
[[[DAYS] [H]:[M]:]SS[.fraction]]
[[[[H]:][M]:][S][.fraction]]
```
• Detect (and ignore) second fraction part from `DATETIME`.
• Added the `LOW_PRIORITY` attribute to `LOAD DATA INFILE`.
• The default index name now uses the same case as the used column name.
• Changed default number of connections to 100.
• Use bigger buffers when using `LOAD DATA INFILE`.
• `DECIMAL(x,y)` now works according to ANSI SQL.
• Added aggregate UDF functions. Thanks to Andreas F. Bobak bobak@relog.ch for this!
• `LAST_INSERT_ID()` is now updated for `INSERT INTO ... SELECT`.
• Some small changes to the join table optimizer to make some joins faster.
• `SELECT DISTINCT` is much faster; It uses the new `UNIQUE` functionality in `MyISAM`. One difference compared to MySQL 3.22 is that the output of `DISTINCT` is not sorted anymore.
- All C client API macros are now functions to make shared libraries more reliable. Because of this, you can no longer call `mysql_num_fields()` on a MYSQL object, you must use `mysql_field_count()` instead.
- Added use of LIBEWRAP; Patch by Henning P. Schmiedehausen.
- Don’t allow AUTO_INCREMENT for other than numerical columns.
- Using AUTO_INCREMENT will now automatically make the column NOT NULL.
- Show NULL as the default value for AUTO_INCREMENT columns.
- Added SQL_BIG_RESULT; SQL_SMALL_RESULT is now default.
- Added a shared library RPM. This enhancement was contributed by David Fox (ds-fox@cogsci.ucsd.edu).
- Added a `--enable-large-files/--disable-large-files` switch to `configure`. See ‘configure.in’ for some systems where this is automatically turned off because of broken implementations.
- Upgraded readline to 4.0.
- New CREATE TABLE options: PACK_KEYS and CHECKSUM.
- Added `mysqld` option `--default-table-type`.

### D.2 Changes in release 3.22.x

The 3.22 version has faster and safer connect code and a lot of new nice enhancements. The reason for not including these changes in the 3.21 version is mainly that we are trying to avoid big changes to 3.21 to keep it as stable as possible. As there aren’t really any MAJOR changes, upgrading to 3.22 should be very easy and painless. See Section 4.16.2 [Upgrading-from-3.21], page 93.

3.22 should also be used with the new DBD-mysql (1.20xx) driver that can use the new connect protocol!

### D.2.1 Changes in release 3.22.32

- Fixed problem when storing numbers in timestamps.
- Fix problem with timezones that have half hour offsets.
- `mysqlhotcopy` - fast on-line hot-backup utility for local MySQL databases. By Tim Bunce.
- New more secure `mysqlaccess`. Thanks to Steve Harvey for this.
- Fixed security problem in the protocol regarding password checking.
- Fixed problem that affected queries that did arithmetic on GROUP functions.
- Fixed a bug in the ISAM code when deleting rows on tables with packed indexes.
D.2.2 Changes in release 3.22.31

- A few small fixes for the Win32 version.

D.2.3 Changes in release 3.22.30

- Fixed optimizer problem on SELECT when using many overlapping indexes.
- Disabled floating point exceptions for FreeBSD to fix core dump when doing SELECT floor(pow(2,63)).
- Added print of default arguments options to all clients.
- Fixed critical problem with the WITH GRANT OPTION option.
- Fixed non-critical Y2K problem when writing short date to log files.

D.2.4 Changes in release 3.22.29

- Upgraded the configure and include files to match the latest 3.23 version. This should increase portability and make it easier to build shared libraries.
- Added latest patches to mit-pthreads for NetBSD.
- Fixed problem with timezones that are < GMT -11.
- Fixed a bug when deleting packed keys in NISAM.
- Fixed problem that could cause MySQL to touch freed memory when doing very complicated GROUP BY queries.
- Fixed core dump if you got a crashed table where an ENUM field value was too big.
- Added mysqlshutdown.exe and mysqlwatch.exe to the Windows distribution.
- Fixed problem when doing ORDER BY on a reference key.
- Fixed that INSERT DELAYED doesn’t update timestamps that are given.

D.2.5 Changes in release 3.22.28

- Fixed problem with LEFT JOIN and COUNT() on a column which was declared NULL + and it had a DEFAULT value.
- Fixed core dump problem when using CONCAT() in a WHERE clause.
- Fixed problem with AVG() and STD() with NULL values.

D.2.6 Changes in release 3.22.27

- Fixed prototype in 'my_ctype.h' when using other character sets.
• Some configure issues to fix problems with big file system detection.
• Fixed problem when sorting on big blob columns.
• ROUND() will now work on Win32.

D.2.7 Changes in release 3.22.26

• Fixed core dump with empty BLOB/TEXT column to REVERSE().
• Extended /*! */ with version numbers.
• Changed SUBSTRING(text FROM pos) to conform to ANSI SQL. (Before this construct returned the rightmost ‘pos’ characters).
• Fixed problem with LOCK TABLES combined with DELETE FROM table
• Fixed problem that INSERT ... SELECT didn’t use SQL_BIG_TABLES.
• SET SQL_LOW_PRIORITY_UPDATES= did’t work.
• Password wasn’t updated correctly if privileges didn’t change on: GRANT ... IDENTIFIED BY
• Fixed range optimizer bug in SELECT * FROM table_name WHERE key_part1 >= const AND (key_part2 = const OR key_part2 = const)
• Fixed bug in compression key handling in ISAM.

D.2.8 Changes in release 3.22.25

• Fixed some small problems with the installation.

D.2.9 Changes in release 3.22.24

• DATA is not a reserved word anymore.
• Fixed optimizer bug with tables with only one row.
• Fixed bug when using LOCK TABLES table_name READ; FLUSH TABLES;
• Applied some patches for HP-UX.
• isamchk should now work on Win32.
• Changed ‘configure’ to not use big file handling on Linux as this crashes some RedHat 6.0 systems

D.2.10 Changes in release 3.22.23

• Upgraded to use Autoconf 2.13, Automake 1.4 and libtool 1.3.2.
• Better support for SCO in configure.
Appendix D: MySQL change history

- Added option `--defaults-file=###` to option file handling to force use of only one specific option file.
- Extended `CREATE` syntax to ignore MySQL 3.23 keywords.
- Fixed deadlock problem when using `INSERT DELAYED` on a table locked with `LOCK TABLES`.
- Fixed deadlock problem when using `DROP TABLE` on a table that was locked by another thread.
- Add logging of `GRANT/REVOKE` commands in the update log.
- Fixed `isamchk` to detect a new error condition.
- Fixed `NATURAL LEFT JOIN`.

D.2.11 Changes in release 3.22.22

- Fixed problem in the C API when you called `mysql_close()` directly after `mysql_init()`.
- Better client error message when you can’t open socket.
- Fixed `delayed_insert_thread` counting when you couldn’t create a new delayed_insert thread.
- Fixed bug in `CONCAT()` with many arguments.
- Added patches for DEC 3.2 and SCO.
- Fixed path-bug when installing MySQL as a service on NT.
- The MySQL-Win32 version is now compiled with VC++ 6.0 instead of with VC++ 5.0.
- New installation setup for MySQL-Win32.

D.2.12 Changes in release 3.22.21

- Fixed problem with `DELETE FROM TABLE` when table was locked by another thread.
- Fixed bug in `LEFT JOIN` involving empty tables.
- Changed the `mysql.db` column from `char(32)` to `char(60)`.
- `MODIFY` and `DELAYED` are not reserved words anymore.
- Fixed a bug when storing days in a `TIME` column.
- Fixed a problem with `Host '..' is not allowed to connect to this MySQL server` after one had inserted a new MySQL user with a `GRANT` command.
- Changed to use `TCP_NODELAY` also on Linux (Should give faster TCP/IP connections).

D.2.13 Changes in release 3.22.20

- Fixed `STD()` for big tables when result should be 0.
- The update log didn’t have newlines on some operating systems.
- `INSERT DELAYED` had some garbage at end in the update log.
D.2.14 Changes in release 3.22.19

- Fixed bug in mysql_install_db (from 3.22.17).
- Changed default key cache size to 8M.
- Fixed problem with queries that needed temporary tables with BLOB columns.

D.2.15 Changes in release 3.22.18

- Fixes a fatal problem in 3.22.17 on Linux: After shutdown all threads didn’t die properly.
- Added option -O flush-time=# to mysqld. This is mostly useful on Win32 and tells how often MySQL should close all unused tables and flush all updated tables to disk.
- Fixed problem that a VARCHAR column compared with CHAR column didn’t use keys efficiently.

D.2.16 Changes in release 3.22.17

- Fixed a core dump problem when using --log-update and connecting without a default database.
- Fixed some configure and portability problems.
- Using LEFT JOIN on tables that had circular dependencies caused mysqld to hang forever.

D.2.17 Changes in release 3.22.16

- mysqladmin processlist could kill the server if a new user logged in.
- DELETE FROM tbl_name WHERE key_column=col_name didn’t find any matching rows. Fixed.
- DATE_ADD(column,...) didn’t work.
- INSERT DELAYED could deadlock with status 'upgrading lock'
- Extended ENCRYPT() to take longer salt strings than 2 characters.
- longlong2str is now much faster than before. For Intel x86 platforms, this function is written in optimized assembler.
- Added the MODIFY keyword to ALTER TABLE.

D.2.18 Changes in release 3.22.15

- GRANT used with IDENTIFIED BY didn’t take effect until privileges were flushed.
• Name change of some variables in `SHOW STATUS`.
• Fixed problem with `ORDER BY` with ‘only index’ optimzation when there were multiple key definitions for a used column.
• `DATE` and `DATETIME` columns are now up to 5 times faster than before.
• `INSERT DELAYED` can be used to let the client do other things while the server inserts rows into a table.
• `LEFT JOIN USING (col1,col2)` didn’t work if one used it with tables from 2 different databases.
• `LOAD DATA LOCAL INFILE` didn’t work in the Unix version because of a missing file.
• Fixed problems with `VARCHAR/BLOB` on very short rows (< 4 bytes); error 127 could occur when deleting rows.
• Updating `BLOB/TEXT` through formulas didn’t work for short (< 256 char) strings.
• When you did a `GRANT` on a new host, `mysqld` could die on the first connect from this host.
• Fixed bug when one used `ORDER BY` on column name that was the same name as an alias.
• Added `BENCHMARK(loop_count,expression)` function to time expressions.

D.2.19 Changes in release 3.22.14

• Allow empty arguments to `mysqld` to make it easier to start from shell scripts.
• Setting a `TIMESTAMP` column to `NULL` didn’t record the timestamp value in the update log.
• Fixed lock handler bug when one did `INSERT INTO TABLE ... SELECT ... GROUP BY`.
• Added a patch for `localtime_r()` on Win32 so that it will not crash anymore if your date is > 2039, but instead will return a time of all zero.
• Names for user-defined functions are no longer case sensitive.
• Added escape of `^Z` (ASCII 26) to \Z as `^Z` doesn’t work with pipes on Win32.
• `mysql_fix_privileges` adds a new column to the `mysql.func` to support aggregate UDF functions in future MySQL releases.

D.2.20 Changes in release 3.22.13

• Saving `NOW()`, `CURDATE()` or `CURTIME()` directly in a column didn’t work.
• `SELECT COUNT(*) ... LEFT JOIN ...` didn’t work with no `WHERE` part.
• Updated ‘config.guess’ to allow MySQL to configure on UnixWare 7.0.x.
• Changed the implementation of `pthread_cond()` on the Win32 version. `get_lock()` now correctly times out on Win32!
D.2.21 Changes in release 3.22.12

- Fixed problem when using DATE_ADD() and DATE_SUB() in a WHERE clause.
- You can now set the password for a user with the GRANT ... TO user IDENTIFIED BY 'password' syntax.
- Fixed bug in GRANT checking with SELECT on many tables.
- Added missing file mysql_fix_privilege_tables to the RPM distribution. This is not run by default since it relies on the client package.
- Added option SQL_SMALL_RESULT to SELECT to force use of fast temporary tables when you know that the result set will be small.
- Allow use of negative real numbers without a decimal point.
- Day number is now adjusted to maximum days in month if the resulting month after DATE_ADD/DATE_SUB() doesn’t have enough days.
- Fix that GRANT compares columns in case-insensitive fashion.
- Fixed a bug in ’sql_list.h’ that made ALTER TABLE dump core in some contexts.
- The hostname in user@hostname can now include ‘.’ and ‘-’ without quotes in the context of the GRANT, REVOKE and SET PASSWORD FOR ... statements.
- Fix for isamchk for tables which need big temporary files.

D.2.22 Changes in release 3.22.11

- **IMPORTANT**: You must run the mysql_fix_privilege_tables script when you upgrade to this version! This is needed because of the new GRANT system. If you don’t do this, you will get Access denied when you try to use ALTER TABLE, CREATE INDEX or DROP INDEX.
- GRANT to allow/deny users table and column access.
- Changed USER() to return user@host.
- Changed the syntax for how to set PASSWORD for another user.
- New command FLUSH STATUS that sets most status variables to zero.
- New status variables: aborted_threads, aborted_connects.
- New option variable: connection_timeout.
- Added support for Thai sorting (by Pruet Boonma pruet@ds90.intanon.nectec.or.th).
- Slovak and japanese error messages.
- Configuration and portability fixes.
- Added option SET SQL_WARNINGS=1 to get a warning count also for simple inserts.
- MySQL now uses SIGTERM instead of SIGQUIT with shutdown to work better on FreeBSD.
- Added option \G (print vertically) to mysql.
- SELECT HIGH_PRIORITY ... killed mysqld.
Appendix D: MySQL change history

- IS NULL on a AUTO_INCREMENT column in a LEFT JOIN didn’t work as expected.
- New function MAKE_SET().

D.2.23 Changes in release 3.22.10

- mysql_install_db no longer starts the MySQL server! You should start mysqld with safe_mysqld after installing it! The MySQL RPM will however start the server as before.
- Added --bootstrap option to mysqld and recoded mysql_install_db to use it. This will make it easier to install MySQL with RPMs.
- Changed +, - (sign and minus), *, /, %, ABS() and MOD() to be BIGINT aware (64-bit safe).
- Fixed a bug in ALTER TABLE that caused mysqld to crash.
- MySQL now always reports the conflicting key values when a duplicate key entry occurs. (Before this was only reported for INSERT).
- New syntax: INSERT INTO tbl_name SET col_name=value, col_name=value, ...
- Most errors in the '.err' log are now prefixed with a time stamp.
- Added option MYSQL_INIT_COMMAND to mysql_options() to make a query on connect or reconnect.
- Added option MYSQL_READ_DEFAULT_FILE and MYSQL_READ_DEFAULT_GROUP to mysql_options() to read the following parameters from the MySQL option files: port, socket, compress, password, pipe, timeout, user, init-command, host and database.
- Added maybe_null to the UDF structure.
- Added option IGNORE to INSERT statements with many rows.
- Fixed some problems with sorting of the koi8 character sets; Users of koi8 MUST run isamchk -rq on each table that has an index on a CHAR or VARCHAR column.
- New script mysql_setpermission, by Luuk de Boer, allows one to easily create new users with permissions for specific databases.
- Allow use of hexadecimal strings (0x...) when specifying a constant string (like in the column separators with LOAD DATA INFILE).
- Ported to OS/2 (thanks to Antony T. Curtis antony.curtis@olcs.net).
- Added more variables to SHOW STATUS and changed format of output to be like SHOW VARIABLES.
- Added extended-status command to mysqladmin which will show the new status variables.

D.2.24 Changes in release 3.22.9

- SET SQL_LOG_UPDATE=0 caused a lockup of the server.
- New SQL command: FLUSH [ TABLES | HOSTS | LOGS | PRIVILEGES ] [ , ... ]
Appendix D: MySQL change history

- New SQL command: `KILL thread_id`.
- Added casts and changed include files to make MySQL easier to compile on AIX and DEC OSF1 4.x.
- Fixed conversion problem when using `ALTER TABLE` from an INT to a short CHAR() column.
- Added `SELECT HIGH_PRIORITY`. This will get a lock for the `SELECT` even if there is a thread waiting for another `SELECT` to get a WRITE LOCK.
- Moved `wild_compare` to string class to be able to use `LIKE` on BLOB/TEXT columns with \0.
- Added `ESCAPE` option to `LIKE`.
- Added a lot more output to `mysqladmin debug`.
- You can now start `mysqld` on Win32 with the `--flush` option. This will flush all tables to disk after each update. This makes things much safer on NT/Win98 but also MUCH slower.

D.2.25 Changes in release 3.22.8

- Czech character sets should now work much better. You must also install ftp://www.mysql.com/pub/mysql/Downloads/Patches/czech-3.22.8-patch. This patch should also be installed if you are using a character set with uses my_strcoll(). The patch should always be safe to install (for any system), but as this patch changes ISAM internals it’s not yet in the default distribution.
- `DATE_ADD()` and `DATE_SUB()` didn’t work with group functions.
- `mysql` will now also try to reconnect on `USE DATABASE` commands.
- Fix problem with `ORDER BY` and `LEFT JOIN` and `const` tables.
- Fixed problem with `ORDER BY` if the first `ORDER BY` column was a key and the rest of the `ORDER BY` columns wasn’t part of the key.
- Fixed a big problem with `OPTIMIZE TABLE`.
- MySQL clients on NT will now by default first try to connect with named pipes and after this with TCP/IP.
- Fixed a problem with `DROP TABLE` and `mysqladmin shutdown` on Win32 (a fatal bug from 3.22.6).
- Fixed problems with `TIME` columns and negative strings.
- Added an extra thread signal loop on shutdown to avoid some error messages from the client.
- MySQL now uses the next available number as extension for the update log file.
- Added patches for UNIXWARE 7.

D.2.26 Changes in release 3.22.7

- Added `LIMIT` clause for the `DELETE` statement.
• You can now use the /*! ... */ syntax to hide MySQL-specific keywords when you write portable code. MySQL will parse the code inside the comments as if the surrounding /*! */ and */ comment characters didn’t exist.

• OPTIMIZE TABLE tbl_name can now be used to reclaim disk space after many deletes. Currently, this uses ALTER TABLE to re-generate the table, but in the future it will use an integrated isamchk for more speed.

• Upgraded libtool to get the configure more portable.

• Fixed slow UPDATE and DELETE operations when using DATETIME or DATE keys.

• Changed optimizer to make it better at deciding when to do a full join and when using keys.

• You can now use mysqladmin proc to display information about your own threads. Only users with the Process_priv privilege can get information about all threads.

• Added handling of formats YYMMDD, YYYYMMDD, YYMMDDHHMMSS for numbers when using DATETIME and TIMESTAMP types. (Formerly these formats only worked with strings.)

• Added connect option CLIENT_IGNORE_SPACE to allow use of spaces after function names and before ‘(’ (Powerbuilder requires this). This will make all function names reserved words.

• Added the --log-long-format option to mysqld to enable timestamps and INSERT_ID’s in the update log.

• Added --where option to mysqldump (patch by Jim Faucette).

• The lexical analyzer now uses “perfect hashing” for faster parsing of SQL statements.

D.2.27 Changes in release 3.22.6

• Faster mysqldump.

• For the LOAD DATA INFILE statement, you can now use the new LOCAL keyword to read the file from the client. mysqlimport will automatically use LOCAL when importing with the TCP/IP protocol.

• Fixed small optimize problem when updating keys.

• Changed makefiles to support shared libraries.

• MySQL-NT can now use named pipes, which means that you can now use MySQL-NT without having to install TCP/IP.

D.2.28 Changes in release 3.22.5

• All table lock handling is changed to avoid some very subtle deadlocks when using DROP TABLE, ALTER TABLE, DELETE FROM TABLE and mysqladmin flush-tables under heavy usage. Changed locking code to get better handling of locks of different types.

• Updated DBI to 1.00 and DBD to 1.2.0.
• Added a check that the error message file contains error messages suitable for the current version of mysqld. (To avoid errors if you accidentally try to use an old error message file.)

• All count structures in the client (affected_rows(), insert_id(),...) are now of type BIGINT to allow 64-bit values to be used. This required a minor change in the MySQL protocol which should affect only old clients when using tables with AUTO_INCREMENT values > 24M.

• The return type of mysql_fetch_lengths() has changed from uint * to ulong *. This may give a warning for old clients but should work on most machines.

• Change msys and dbug libraries to allocate all thread variables in one struct. This makes it easier to make a threaded ‘libmysql.dll’ library.

• Use the result from gethostname() (instead of uname()) when constructing ‘.pid’ file names.

• New better compressed server/client protocol.

• COUNT(), STD() and AVG() are extended to handle more than 4G rows.

• You can now store values in the range -838:59:59 <= x <= 838:59:59 in a TIME column.

• WARNING: INCOMPATIBLE CHANGE!! If you set a TIME column to too short a value, MySQL now assumes the value is given as: [[D][H]:[M]:]SS instead of HH[:MM[:SS]].

• TIME_TO_SEC() and SEC_TO_TIME() can now handle negative times and hours up to 32767.

• Added new option SET OPTION SQL_LOG_UPDATE={0|1} to allow users with the process privilege to bypass the update log. (Modified patch from Sergey A Mukhin violet@rosnet.net.)

• Fixed fatal bug in LPAD().

• Initialize line buffer in ‘mysql.cc’ to make BLOB reading from pipes safer.

• Added --low-priority-updates option to mysqld, to give table-modifying operations (INSERT, REPLACE, UPDATE, DELETE) lower priority than retrievals. You can now use {INSERT | REPLACE | UPDATE | DELETE} LOW_PRIORITY ... You can also use SET OPTION SQL_LOW_PRIORITY_UPDATES={0|1} to change the priority for one thread. One side effect is that LOW_PRIORITY is now a reserved word.:(

• Add support for INSERT INTO table ... VALUES(...),(...),(...) , to allow inserting multiple rows with a single statement.

• INSERT INTO tbl_name is now also cached when used with LOCK TABLES. (Previously only INSERT ... SELECT and LOAD DATA INFILE were cached.)

• Allow GROUP BY functions with HAVING:

```sql
mysql> SELECT col FROM table GROUP BY col HAVING COUNT(*)>0;
```

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• `mysqld` will now ignore trailing ‘;’ characters in queries. This is to make it easier to migrate from some other SQL servers that require the trailing ‘;’.
• Fix for corrupted fixed-format output generated by `SELECT INTO OUTFILE`.
• **WARNING: INCOMPATIBLE CHANGE!!** Added Oracle `GREATEST()` and `LEAST()` functions. You must now use these instead of the `MAX()` and `MIN()` functions to get the largest/smallest value from a list of values. These can now handle `REAL`, `BIGINT` and string (CHAR or VARCHAR) values.
• **WARNING: INCOMPATIBLE CHANGE!!** `DAYOFWEEK()` had offset 0 for Sunday. Changed the offset to 1.
• Give an error for queries that mix `GROUP BY` columns and fields when there is no `GROUP BY` specification.
• Added `--vertical` option to `mysql`, for printing results in vertical mode.
• Index-only optimization; some queries are now resolved using only indexes. Until MySQL 4.0, this works only for numeric columns. See Section 11.4 [MySQL indexes], page 289.
• Lots of new benchmarks.
• A new C API chapter and lots of other improvements in the manual.

### D.2.29 Changes in release 3.22.4

• Added `--tmpdir` option to `mysqld`, for specifying the location of the temporary file directory.
• **MySQL** now automatically changes a query from an ODBC client:
  
  \[
  \text{SELECT ... FROM table WHERE auto_increment_column IS NULL}
  \]

  to:

  \[
  \text{SELECT ... FROM table WHERE auto_increment_column == LAST_INSERT_ID()}
  \]

  This allows some ODBC programs (Delphi, Access) to retrieve the newly inserted row by fetching the `AUTO_INCREMENT` id.
• `DROP TABLE` now waits for all users to free a table before deleting it.
• Fixed small memory leak in the new connect protocol.
• New functions `BIN()`, `OCT()`, `HEX()` and `CONV()` for converting between different number bases.
• Added function `SUBSTRING()` with 2 arguments.
• If you created a table with a record length smaller than 5, you couldn’t delete rows from the table.
• Added optimization to remove const reference tables from `ORDER BY` and `GROUP BY`.
• `mysqld` now automatically disables system locking on Linux and Win32, and for systems that use MIT-pthreads. You can force the use of locking with the `--enable-locking` option.
• Added `--console` option to `mysqld`, to force a console window (for error messages) when using Win32.
• Fixed table locks for Win32.
• Allow ‘$’ in identifiers.
• Changed name of user-specific configuration file from ‘my.cnf’ to ‘.my.cnf’ (Unix only).
• Added DATE_ADD() and DATE_SUB() functions.

D.2.30 Changes in release 3.22.3

• Fixed a lock problem (bug in MySQL 3.22.1) when closing temporary tables.
• Added missing mysql_ping() to the client library.
• Added --compress option to all MySQL clients.
• Changed byte to char in ‘mysql.h’ and ‘mysql_com.h’.

D.2.31 Changes in release 3.22.2

• Searching on multiple constant keys that matched more than 30% of the rows didn’t always use the best possible key.
• New functions <<, >>, RPAD() and LPAD().
• You can now save default options (like passwords) in a configuration file (‘my.cnf’).
• Lots of small changes to get ORDER BY to work when no records are found when using fields that are not in GROUP BY (MySQL extension).
• Added --chroot option to mysqld, to start mysqld in a chroot environment (by Nikki
Chumakov nikkic@cityline.ru).
• Trailing spaces are now ignored when comparing case-sensitive strings; this should fix some problems with ODBC and flag 512!
• Fixed a core-dump bug in the range optimizer.
• Added --one-thread option to mysqld, for debugging with LinuxThreads (or glibc).
  (This replaces the -T32 flag)
• Added DROP TABLE IF EXISTS to prevent an error from occurring if the table doesn’t exist.
• IF and EXISTS are now reserved words (they would have to be sooner or later).
• Added lots of new options to mysqldump.
• Server error messages are now in ‘mysqld_error.h’.
• The server/client protocol now supports compression.
• All bug fixes from MySQL 3.21.32.

D.2.32 Changes in release 3.22.1

• Added new C API function mysql_ping().
• Added new API functions `mysql_init()` and `mysql_options()`. You now MUST call `mysql_init()` before you call `mysql_real_connect()`. You don’t have to call `mysql_init()` if you only use `mysql_connect()`.

• Added `mysql_options(..., MYSQL_OPT_CONNECT_TIMEOUT, ...)` so you can set a timeout for connecting to a server.

• Added `--timeout` option to `mysqladmin`, as a test of `mysql_options()`.

• Added `AFTER` column and `FIRST` options to `ALTER TABLE ... ADD columns`. This makes it possible to add a new column at some specific location within a row in an existing table.

• `WEEK()` now takes an optional argument to allow handling of weeks when the week starts on Monday (some European countries). By default, `WEEK()` assumes the week starts on Sunday.

• `TIME` columns weren’t stored properly (bug in MySQL 3.22.0).

• `UPDATE` now returns information about how many rows were matched and updated, and how many “warnings” occurred when doing the update.

• Fixed incorrect result from `FORMAT(-100,2)`.

• `ENUM` and `SET` columns were compared in binary (case-sensitive) fashion; changed to be case insensitive.

D.2.33 Changes in release 3.22.0

• New (backward compatible) connect protocol that allows you to specify the database to use when connecting, to get much faster connections to a specific database.

  The `mysql_real_connect()` call is changed to:

  ```c
  mysql_real_connect(MYSQL *mysql, const char *host, const char *user, 
  const char *passwd, const char *db, uint port, 
  const char *unix_socket, uint client_flag)
  ```

• Each connection is handled by its own thread, rather than by the master `accept()` thread. This fixes permanently the telnet bug that was a topic on the mail list some time ago.

• All TCP/IP connections are now checked with backward resolution of the hostname to get better security. `mysqld` now has a local hostname resolver cache so connections should actually be faster than before, even with this feature.

• A site automatically will be blocked from future connections if someone repeatedly connects with an “improper header” (like when one uses telnet).

• You can now refer to tables in different databases with references of the form `tbl_name@db_name` or `db_name.tbl_name`. This makes it possible to give a user read access to some tables and write access to others simply by keeping them in different databases!

• Added `--user` option to `mysqld`, to allow it to run as another Unix user (if it is started as the Unix `root` user).

• Added caching of users and access rights (for faster access rights checking)

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• Normal users (not anonymous ones) can change their password with `mysqladmin password 'new_password'`. This uses encrypted passwords that are not logged in the normal MySQL log!
• All important string functions are now coded in assembler for x86 Linux machines. This gives a speedup of 10% in many cases.
• For tables that have many columns, the column names are now hashed for much faster column name lookup (this will speed up some benchmark tests a lot!)
• Some benchmarks are changed to get better individual timing. (Some loops were so short that a specific test took < 2 seconds. The loops have been changed to take about 20 seconds to make it easier to compare different databases. A test that took 1-2 seconds before now takes 11-24 seconds, which is much better)
• Re-arranged `SELECT` code to handle some very specific queries involving group functions (like `COUNT(*)`) without a `GROUP BY` but with `HAVING`. The following now works:

```
mysql> SELECT count(*) as C FROM table HAVING C > 1;
```
• Changed the protocol for field functions to be faster and avoid some calls to `malloc()`.
• Added `-T32` option to `mysqld`, for running all queries under the main thread. This makes it possible to debug `mysqld` under Linux with `gdb`!
• Added optimization of `not_null_column IS NULL` (needed for some Access queries).
• Allow `STRAIGHT_JOIN` to be used between two tables to force the optimizer to join them in a specific order.
• String functions now return `VARCHAR` rather than `CHAR` and the column type is now `VARCHAR` for fields saved as `VARCHAR`. This should make the `MyODBC` driver better, but may break some old MySQL clients that don’t handle `FIELD_TYPE_VARCHAR` the same way as `FIELD_TYPE_CHAR`.
• `CREATE INDEX` and `DROP INDEX` are now implemented through `ALTER TABLE`. `CREATE TABLE` is still the recommended (fast) way to create indexes.
• Added `--set-variable` option `wait_timeout` to `mysqld`.
• Added time column to `mysqladmin processlist` to show how long a query has taken or how long a thread has slept.
• Added lots of new variables to `show variables` and some new to `show status`.
• Added new type `YEAR`. `YEAR` is stored in 1 byte with allowable values of 0, and 1901 to 2155.
• Added new `DATE` type that is stored in 3 bytes rather than 4 bytes. All new tables are created with the new date type if you don’t use the `--old-protocol` option to `mysqld`.
• Fixed bug in record caches; for some queries, you could get `Error from table handler: #` on some operating systems.
• Added `--enable-assembler` option to `configure`, for x86 machines (tested on Linux + gcc). This will enable assembler functions for the most important string functions for more speed!

D.3 Changes in release 3.21.x
D.3.1 Changes in release 3.21.33

- Fixed problem when sending SIGHUP to mysqld; mysqld core dumped when starting from boot on some systems.
- Fixed problem with losing a little memory for some connections.
- DELETE FROM tbl_name without a WHERE condition is now done the long way when you use LOCK TABLES or if the table is in use, to avoid race conditions.
- INSERT INTO TABLE (timestamp_column) VALUES (NULL); didn’t set timestamp.

D.3.2 Changes in release 3.21.32

- Fixed some possible race conditions when doing many reopen/close on the same tables under heavy load! This can happen if you execute mysqladmin refresh often. This could in some very rare cases corrupt the header of the index file and cause error 126 or 138.
- Fixed fatal bug in refresh() when running with the --skip-locking option. There was a “very small” time gap after a mysqladmin refresh when a table could be corrupted if one thread updated a table while another thread did mysqladmin refresh and another thread started a new update out the same table before the first thread had finished. A refresh (or --flush-tables) will now not return until all used tables are closed!
- SELECT DISTINCT with a WHERE clause that didn’t match any rows returned a row in some contexts (bug only in 3.21.31).
- GROUP BY + ORDER BY returned one empty row when no rows were found.
- Fixed a bug in the range optimizer that wrote Use_count: Wrong count for ... in the error log file.

D.3.3 Changes in release 3.21.31

- Fixed a sign extension problem for the TINYINT type on Irix.
- Fixed problem with LEFT("constant_string",function).
- Fixed problem with FIND_IN_SET().
- LEFT JOIN core dumped if the second table is used with a constant WHERE/ON expression that uniquely identifies one record.
- Fixed problems with DATE_FORMAT() and incorrect dates. DATE_FORMAT() now ignores 'Y' to make it possible to extend it more easily in the future.

D.3.4 Changes in release 3.21.30
• `mysql` now returns an exit code > 0 if the query returned an error.
• Saving of command line history to file in `mysql` client. By Tommy Larsen `tommy@mix.hive.no`.
• Fixed problem with empty lines that were ignored in `mysql.cc`.
• Save the pid of the signal handler thread in the pid file instead of the pid of the main thread.
• Added patch by `tommy@valley.ne.jp` to support Japanese characters SJIS and UJIS.
• Changed `safe_mysqld` to redirect startup messages to `hostname`.err instead of `hostname`.log to reclaim file space on `mysqladmin refresh`.
• `ENUM` always had the first entry as default value.
• `ALTER TABLE` wrote two entries to the update log.
• `sql_acc()` now closes the `mysql` grant tables after a reload to save table space and memory.
• Changed `LOAD DATA` to use less memory with tables and `BLOB` columns.
• Sorting on a function which made a division / 0 produced a wrong set in some cases.
• Fixed `SELECT` problem with `LEFT()` when using the czech character set.
• Fixed problem in `isamchk`; it couldn’t repair a packed table in a very unusual case.
• `SELECT` statements with `&` or `|` (bit functions) failed on columns with `NULL` values.
• When comparing a field = field, where one of the fields was a part key, only the length of the part key was compared.

D.3.5 Changes in release 3.21.29

• `LOCK TABLES` + `DELETE` from `tbl_name` never removed locks properly.
• Fixed problem when grouping on an `OR` function.
• Fixed permission problem with `umask()` and creating new databases.
• Fixed permission problem on result file with `SELECT ... INTO OUTFILE ...`
• Fixed problem in range optimizer (core dump) for a very complex query.
• Fixed problem when using `MIN(integer)` or `MAX(integer)` in `GROUP BY`.
• Fixed bug on Alpha when using integer keys. (Other keys worked on Alpha).
• Fixed bug in `WEEK("XXXX-xx-01")`.

D.3.6 Changes in release 3.21.28

• Fixed socket permission (clients couldn’t connect to Unix socket on Linux).
• Fixed bug in record caches; for some queries, you could get `Error from table handler: #` on some operating systems.

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D.3.7 Changes in release 3.21.27

- Added user level lock functions `GET_LOCK(string,timeout)`, `RELEASE_LOCK(string)`.  
- Added `opened_tables` to show status.  
- Changed connect timeout to 3 seconds to make it somewhat harder for crackers to kill `mysqld` through `telnet + TCP/IP`.  
- Fixed bug in range optimizer when using `WHERE key_part_1 >= something AND key_part_2 <= something_else`.  
- Changed `configure` for detection of FreeBSD 3.0 9803xx and above  
- `WHERE` with `string_column_key = constant_string` didn’t always find all rows if the column had many values differing only with characters of the same sort value (like e and è).  
- Strings keys looked up with `ref` were not compared in case-sensitive fashion.  
- Added `umask()` to make log files non-readable for normal users.  
- Ignore users with old (8-byte) password on startup if not using `--old-protocol` option to `mysqld`.  
- `SELECT` which matched all key fields returned the values in the case of the matched values, not of the found values. (Minor problem.)

D.3.8 Changes in release 3.21.26

- `FROM_DAYS(0)` now returns "0000-00-00".  
- In `DATE_FORMAT()`, PM and AM were swapped for hours 00 and 12.  
- Extended the default maximum key size to 256.  
- Fixed bug when using `BLOB/TEXT` in `GROUP BY` with many tables.  
- An `ENUM` field that is not declared `NOT NULL` has NULL as the default value. (Previously, the default value was the first enumeration value.)  
- Fixed bug in the join optimizer code when using many part keys on the same key: `INDEX (Organization,Surname(35),Initials(35))`.  
- Added some tests to the table order optimizer to get some cases with `SELECT ... FROM many_tables` much faster.  
- Added a retry loop around `accept()` to possibly fix some problems on some Linux machines.

D.3.9 Changes in release 3.21.25

- Changed `typedef 'string'` to `typedef 'my_string'` for better portability.  
- You can now kill threads that are waiting on a disk full condition.  
- Fixed some problems with UDF functions.

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• Added long options to `isamchk`. Try `isamchk --help`.
• Fixed a bug when using 8 bytes long (alpha): `filesort()` didn’t work. Affects `DISTINCT`, `ORDER BY` and `GROUP BY` on 64-bit processors.

**D.3.10 Changes in release 3.21.24**

• Dynamic loadable functions. Based on source from Alexis Mikhailov.
• You couldn’t delete from a table if no one had done a `SELECT` on the table.
• Fixed problem with range optimizer with many `OR` operators on key parts inside each other.
• Recoded `MIN()` and `MAX()` to work properly with strings and `HAVING`.
• Changed default umask value for new files from `0664` to `0660`.
• Fixed problem with `LEFT JOIN` and constant expressions in the `ON` part.
• Added Italian error messages from `brenno@dewinter.com`.
• `configure` now works better on OSF1 (tested on 4.0D).
• Added hooks to allow `LIKE` optimization with international character support.
• Upgraded DBI to 0.93.

**D.3.11 Changes in release 3.21.23**

• The following symbols are now reserved words: `TIME`, `DATE`, `TIMESTAMP`, `TEXT`, `BIT`, `ENUM`, `NO`, `ACTION`, `CHECK`, `YEAR`, `MONTH`, `DAY`, `HOUR`, `MINUTE`, `SECOND`, `STATUS`, `VARIABLES`.
• Setting a `TIMESTAMP` to `NULL` in `LOAD DATA INFILE ...` didn’t set the current time for the `TIMESTAMP`.
• Fix `BETWEEN` to recognize binary strings. Now `BETWEEN` is case sensitive.
• Added `--skip-thread-priority` option to `mysql`, for systems where `mysqld`’s thread scheduling doesn’t work properly (BSDI 3.1).
• Added ODBC functions `DAYNAME()` and `MONTHNAME()`.
• Added function `TIME_FORMAT()`. This works like `DATE_FORMAT()`, but takes a time string (`'HH:MM:DD'`) as argument.
• Fixed unlikely(?) key optimizer bug when using `ORs` of key parts inside `ANDs`.
• Added command `variables` to `mysqladmin`.
• A lot of small changes to the binary releases.
• Fixed a bug in the new protocol from MySQL 3.21.20.
• Changed `ALTER TABLE` to work with Win32 (Win32 can’t rename open files). Also fixed a couple of small bugs in the Win32 version.
• All standard MySQL clients are now ported to MySQL-Win32.
• MySQL can now be started as a service on NT.

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D.3.12 Changes in release 3.21.22

- Starting with this version, all MySQL distributions will be configured, compiled and tested with crash-me and the benchmarks on the following platforms: SunOS 5.6 sun4u, SunOS 5.5.1 sun4u, SunOS 4.14 sun4c, SunOS 5.6 i86pc, Irix 6.3 mips5k, HP-UX 10.20 hppa, AIX 4.2.1 ppc, OSF1 V4.0 alpha, FreeBSD 2.2.2 i86pc and BSDI 3.1 i386.
- Fix COUNT(*) problems when the WHERE clause didn’t match any records. (Bug from 3.21.17.)
- Removed that NULL = NULL is true. Now you must use IS NULL or IS NOT NULL to test whether or not a value is NULL. (This is according to ANSI SQL but may break old applications that are ported from mSQL.) You can get the old behavior by compiling with -DmSQL_COMPLIANT.
- Fixed bug that core dumped when using many LEFT OUTER JOIN clauses.
- Fixed bug in ORDER BY on string formula with possible NULL values.
- Fixed problem in range optimizer when using <= on sub index.
- Added functions DAYOFYEAR(), DAYOFMONTH(), MONTH(), YEAR(), WEEK(), QUARTER(), HOUR(), MINUTE(), SECOND() and FIND_IN_SET().
- Added command SHOW VARIABLES.
- Added support of “long constant strings” from ANSI SQL:

  mysql> SELECT 'first ' 'second';     -> 'first second'

- Upgraded mSQL-Mysql-modules to 1.1825.
- Upgraded mysqlaccess to 2.02.
- Fixed problem with Russian character set and LIKE.
- Ported to OpenBSD 2.1.
- New Dutch error messages.

D.3.13 Changes in release 3.21.21a

- Configure changes for some operating systems.

D.3.14 Changes in release 3.21.21

- Fixed optimizer bug when using WHERE data_field = date_field2 AND date_field2 = constant.
- Added command SHOW STATUS.
- Removed ‘manual.ps’ from the source distribution to make it smaller.
### D.3.15 Changes in release 3.21.20

- Changed the maximum table name and column name lengths from 32 to 64.
- Aliases can now be of “any” length.
- Fixed `mysqladmin stat` to return the right number of queries.
- Changed protocol (downward compatible) to mark if a column has the `AUTO_INCREMENT` attribute or is a `TIMESTAMP`. This is needed for the new Java driver.
- Added Hebrew sorting order by Zeev Suraski.
- Solaris 2.6: Fixed `configure` bugs and increased maximum table size from 2G to 4G.

### D.3.16 Changes in release 3.21.19

- Upgraded `DBD` to 1823. This version implements `mysql_use_result` in `DBD-Mysql`.
- Benchmarks updated for empress (by Luuk).
- Fixed a case of slow range searching.
- Configure fixes (‘Docs’ directory).
- Added function `REVERSE()` (by Zeev Suraski).

### D.3.17 Changes in release 3.21.18

- Issue error message if client C functions are called in wrong order.
- Added automatic reconnect to the ‘libmysql.c’ library. If a write command fails, an automatic reconnect is done.
- Small sort sets no longer use temporary files.
- Upgraded `DBI` to 0.91.
- Fixed a couple of problems with `LEFT OUTER JOIN`.
- Added `CROSS JOIN` syntax. `CROSS` is now a reserved word.
- Recoded `yacc/bison` stack allocation to be even safer and to allow `MySQL` to handle even bigger expressions.
- Fixed a couple of problems with the update log.
- `ORDER BY` was slow when used with key ranges.

### D.3.18 Changes in release 3.21.17

- Changed documentation string of `--with-unix-socket-path` to avoid confusion.
- Added ODBC and ANSI SQL style `LEFT OUTER JOIN`.
- The following are new reserved words: `LEFT`, `NATURAL`, `USING`. 
The client library now uses the value of the environment variable `MYSQL_HOST` as the default host if it's defined.

- `SELECT col_name, SUM(expr)` now returns `NULL` for `col_name` when there are matching rows.
- Fixed problem with comparing binary strings and `BLOBs` with ASCII characters over 127.
- Fixed lock problem: when freeing a read lock on a table with multiple read locks, a thread waiting for a write lock would have been given the lock. This shouldn't affect data integrity, but could possibly make `mysqld` restart if one thread was reading data that another thread modified.
- `LIMIT offset,count` didn't work in `INSERT ... SELECT`.
- Optimized key block caching. This will be quicker than the old algorithm when using bigger key caches.

D.3.19 Changes in release 3.21.16

- Added ODBC 2.0 & 3.0 functions `POWER()`, `SPACE()`, `COT()`, `DEGREES()`, `RADIANS()`, `ROUND(2 arg)` and `TRUNCATE()`
- **WARNING: INCOMPATIBLE CHANGE!!** `LOCATE()` parameters were swapped according to ODBC standard. Fixed.
- Added function `TIME_TO_SEC()`.
- In some cases, default values were not used for `NOT NULL` fields.
- Timestamp wasn’t always updated properly in `UPDATE SET ...` statements.
- Allow empty strings as default values for `BLOB` and `TEXT`, to be compatible with `mysqldump`.

D.3.20 Changes in release 3.21.15

- **WARNING: INCOMPATIBLE CHANGE!!** `mysqlperl` is now from `Msql-Mysql-modules`. This means that `connect()` now takes `host, database, user, password` arguments! The old version took `host, database, password, user`.
- Allow `DATE '1997-01-01', TIME '12:10:10'` and `TIMESTAMP '1997-01-01 12:10:10'` formats required by ANSI SQL. **WARNING: INCOMPATIBLE CHANGE!!** This has the unfortunate side-effect that you no longer can have columns named `DATE`, `TIME` or `TIMESTAMP`. :( Old columns can still be accessed through `tablename.columnname`!
- Changed Makefiles to hopefully work better with BSD systems. Also, `‘manual.dvi’` is now included in the distribution to avoid having stupid `make` programs trying to rebuild it.
- `readline` library upgraded to version 2.1.
- A new sortorder `german-1`. That is a normal ISO-Latin1 with a german sort order.
Appendix D: MySQL change history

- Perl DBI/DBD is now included in the distribution. DBI is now the recommended way to connect to MySQL from Perl.
- New portable benchmark suite with DBD, with test results from mSQL 2.0.3, MySQL, PostgreSQL 6.2.1 and Solid server 2.2.
- crash-me is now included with the benchmarks; This is a Perl program designed to find as many limits as possible in a SQL server. Tested with mSQL, PostgreSQL, Solid and MySQL.
- Fixed bug in range-optimizer that crashed MySQL on some queries.
- Table and column name completion for mysql command line tool, by Zeev Suraski and Andi Gutmans.
- Added new command REPLACE that works like INSERT but replaces conflicting records with the new record. REPLACE INTO TABLE ... SELECT ... works also.
- Added new commands CREATE DATABASE db_name and DROP DATABASE db_name.
- Added RENAME option to ALTER TABLE: ALTER TABLE name RENAME AS new_name.
- make_binary_distribution now includes ‘libgcc.a’ in ‘libmysqlclient.a’. This should make linking work for people who don’t have gcc.
- Changed net_write() to my_net_write() because of a name conflict with Sybase.
- New function DAYOFWEEK() compatible with ODBC.
- Stack checking and bison memory overrun checking to make MySQL safer with weird queries.

D.3.21 Changes in release 3.21.14b

- Fixed a couple of small configure problems on some platforms.

D.3.22 Changes in release 3.21.14a

- Ported to SCO Openserver 5.0.4 with FSU Pthreads.
- HP-UX 10.20 should work.
- Added new function DATE_FORMAT().
- Added NOT IN.
- Added automatic removal of ‘ODBC function conversions’: {fn now() }
- Handle ODBC 2.50.3 option flags.
- Fixed comparison of DATE and TIME values with NULL.
- Changed language name from germany to german to be consistent with the other language names.
- Fixed sorting problem on functions returning a FLOAT. Previously, the values were converted to INTs before sorting.
- Fixed slow sorting when sorting on key field when using key_column=constant.
• Sorting on calculated DOUBLE values sorted on integer results instead.
• mysql no longer needs a database argument.
• Changed the place where HAVING should be. According to ANSI, it should be after GROUP BY but before ORDER BY. MySQL 3.20 incorrectly had it last.
• Added Sybase command USE DATABASE to start using another database.
• Added automatic adjusting of number of connections and table cache size if the maximum number of files that can be opened is less than needed. This should fix that mysqld doesn’t crash even if you haven’t done a ulimit -n 256 before starting mysqld.
• Added lots of limit checks to make it safer when running with too little memory or when doing weird queries.

D.3.23 Changes in release 3.21.13

• Added retry of interrupted reads and clearing of errno. This makes Linux systems much safer!
• Fixed locking bug when using many aliases on the same table in the same SELECT.
• Fixed bug with LIKE on number key.
• New error message so you can check whether the connection was lost while the command was running or whether the connection was down from the start.
• Added --table option to mysql to print in table format. Moved time and row information after query result. Added automatic reconnect of lost connections.
• Added != as a synonym for <>.
• Added function VERSION() to make easier logs.
• New multi-user test ‘tests/fork_test.pl’ to put some strain on the thread library.


• Fixed ftruncate() call in MIT-pthreads. This made isamchk destroy the ‘.ISM’ files on (Free)BSD 2.x systems.
• Fixed broken __P_ patch in MIT-pthreads.
• Many memory overrun checks. All string functions now return NULL if the returned string should be longer than max_allowed_packet bytes.
• Changed the name of the INTERVAL type to ENUM, because INTERVAL is used in ANSI SQL.
• In some cases, doing a JOIN + GROUP + INTO OUTFILE, the result wasn’t grouped.
• LIKE with ‘_’ as last character didn’t work. Fixed.
• Added extended ANSI SQL TRIM() function.
• Added CURTIME().
• Added ENCRYPT() function by Zeev Suraski.
Appendix D: MySQL change history

• Fixed better FOREIGN KEY syntax skipping. New reserved words: MATCH, FULL, PARTIAL.
• mysqld now allows IP number and hostname to the --bind-address option.
• Added SET OPTION CHARACTER SET cp1251_koi8 to enable conversions of data to/from cp1251_koi8.
• Lots of changes for Win95 port. In theory, this version should now be easily portable to Win95.
• Changed the CREATE COLUMN syntax of NOT NULL columns to be after the DEFAULT value, as specified in the ANSI SQL standard. This will make mysqldump with NOT NULL and default values incompatible with MySQL 3.20.
• Added many function name aliases so the functions can be used with ODBC or ANSI SQL92 syntax.
• Fixed syntax of ALTER TABLE tbl_name ALTER COLUMN col_name SET DEFAULT NULL.
• Added CHAR and BIT as synonyms for CHAR(1).
• Fixed core dump when updating as a user who has only select privilege.
• INSERT ... SELECT ... GROUP BY didn’t work in some cases. An Invalid use of group function error occurred.
• When using LIMIT, SELECT now always uses keys instead of record scan. This will give better performance on SELECT and a WHERE that matches many rows.
• Added Russian error messages.

D.3.25 Changes in release 3.21.11

• Configure changes.
• MySQL now works with the new thread library on BSD/OS 3.0.
• Added new group functions BIT_OR() and BIT_AND().
• Added compatibility functions CHECK and REFERENCES. CHECK is now a reserved word.
• Added ALL option to GRANT for better compatibility. (GRANT is still a dummy function.)
• Added partly-translated dutch messages.
• Fixed bug in ORDER BY and GROUP BY with NULL columns.
• Added function last_insert_id() to retrieve last AUTO_INCREMENT value. This is intended for clients to ODBC that can’t use the mysql_insert_id() API function, but can be used by any client.
• Added --flush-logs option to mysqladmin.
• Added command STATUS to mysql.
• Fixed problem with ORDER BY/GROUP BY because of bug in gcc.
• Fixed problem with INSERT ... SELECT ... GROUP BY.

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D.3.26 Changes in release 3.21.10

- New mysqlaccess.
- `CREATE` now supports all ODBC types and the mSQL TEXT type. All ODBC 2.5 functions are also supported (added REPEAT). This provides better portability.
- Added text types TINYTEXT, TEXT, MEDIUMTEXT and LONGTEXT. These are actually BLOB types, but all searching is done in case-insensitive fashion.
- All old BLOB fields are now TEXT fields. This only changes that all searching on strings is done in case-sensitive fashion. You must do an `ALTER TABLE` and change the field type to BLOB if you want to have tests done in case-sensitive fashion.
- Fixed some configure issues.
- Made the locking code a bit safer. Fixed very unlikely deadlock situation.
- Fixed a couple of bugs in the range optimizer. Now the new range benchmark `test-select` works.

D.3.27 Changes in release 3.21.9

- Added `--enable-unix-socket=pathname` option to `configure`.
- Fixed a couple of portability problems with include files.
- Fixed bug in range calculation that could return empty set when searching on multiple key with only one entry (very rare).
- Most things ported to FSU Pthreads, which should allow MySQL to run on SCO. See Section 4.11.13 [SCO], page 68.

D.3.28 Changes in release 3.21.8

- Works now in Solaris 2.6.
- Added handling of calculation of SUM() functions. For example, you can now use `SUM(column)/COUNT(column)`.
- Added handling of trigometric functions: PI(), ACOS(), ASIN(), ATAN(), COS(), SIN() and TAN().
- New languages: norwegian, norwegian-ny and portuguese.
- Fixed parameter bug in `net_print()` in 'procedure.cc'.
- Fixed a couple of memory leaks.
- Now allow also the old SELECT ... INTO OUTFILE syntax.
- Fixed bug with GROUP BY and SELECT on key with many values.
- `mysql_fetch_lengths()` sometimes returned incorrect lengths when you used `mysql_use_result()`. This affected at least some cases of `mysqldump --quick`.
- Fixed bug in optimization of WHERE const op field.
Appendix D: MySQL change history

- Fixed problem when sorting on NULL fields.
- Fixed a couple of 64-bit (Alpha) problems.
- Added --pid-file=# option to mysqld.
- Added date formatting to FROM_UNIXTIME(), originally by Zeev Suraski.
- Fixed bug in BETWEEN in range optimizer (Did only test = of the first argument).
- Added machine-dependent files for MIT-pthreads i386-SCO. There is probably more to do to get this to work on SCO 3.5.

D.3.29 Changes in release 3.21.7

- Changed ‘Makefile.am’ to take advantage of Automake 1.2.
- Added the beginnings of a benchmark suite.
- Added more secure password handling.
- Added new client function mysql_errno(), to get the error number of the error message. This makes error checking in the client much easier. This makes the new server incompatible with the 3.20.x server when running without --old-protocol. The client code is backward compatible. More information can be found in the ‘README’ file!
- Fixed some problems when using very long, illegal names.

D.3.30 Changes in release 3.21.6

- Fixed more portability issues (incorrect sigwait and sigset defines).
- configure should now be able to detect the last argument to accept().

D.3.31 Changes in release 3.21.5

- Should now work with FreeBSD 3.0 if used with ‘FreeBSD-3.0-libc_r-1.0.diff’, which can be found at http://www.mysql.com/Download/Patches.
- Added new option -O tmp_table_size=# to mysqld.
- New function FROM_UNIXTIME(timestamp) which returns a date string in 'YYYY-MM-DD HH:MM:SS' format.
- New function SEC_TO_TIME(seconds) which returns a string in 'HH:MM:SS' format.
- New function SUBSTRING_INDEX(), originally by Zeev Suraski.

D.3.32 Changes in release 3.21.4

- Should now configure and compile on OSF1 4.0 with the DEC compiler.
- Configuration and compilation on BSD/OS 3.0 works, but due to some bugs in BSD/OS 3.0, mysqld doesn’t work on it yet.

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Configuration and compilation on FreeBSD 3.0 works, but I couldn’t get `pthread_create` to work.

### D.3.33 Changes in release 3.21.3

- Added reverse check lookup of hostnames to get better security.
- Fixed some possible buffer overflows if filenames that are too long are used.
- `mysqld` doesn’t accept hostnames that start with digits followed by a ’.’, because the hostname may look like an IP number.
- Added `--skip-networking` option to `mysqld`, to only allow socket connections. (This will not work with MIT-pthreads!)
- Added check of too long table names for alias.
- Added check if database name is okay.
- Added check if too long table names.
- Removed incorrect `free()` that killed the server on `CREATE DATABASE` or `DROP DATABASE`.
- Changed some `mysqld -O` options to better names.
- Added `-O join_cache_size=#` option to `mysqld`.
- Added `-O max_join_size=#` option to `mysqld`, to be able to set a limit how big queries (in this case big = slow) one should be able to handle without specifying `SET OPTION SQL_BIG_SELECTS=1`. A # = is about 10 examined records. The default is “unlimited”.
- When comparing a `TIME`, `DATE`, `DATETIME` or `TIMESTAMP` column to a constant, the constant is converted to a time value before performing the comparison. This will make it easier to get ODBC (particularly Access97) to work with the above types. It should also make dates easier to use and the comparisons should be quicker than before.
- Applied patch from Jochen Wiedmann that allows `query()` in `mysqlperl` to take a query with `\0` in it.
- Storing a timestamp with a 2-digit year (YYMMDD) didn’t work.
- Fix that timestamp wasn’t automatically updated if set in an `UPDATE` clause.
- Now the automatic timestamp field is the FIRST timestamp field.
- `SELECT * INTO OUTFILE`, which didn’t correctly if the outfile already existed.
- `mysql` now shows the thread ID when starting or doing a reconnect.
- Changed the default sort buffer size from 2M to 1M.

### D.3.34 Changes in release 3.21.2

- The range optimizer is coded, but only 85% tested. It can be enabled with `--new`, but it crashes core a lot yet...
- More portable. Should compile on AIX and alpha-digital. At least the `isam` library should be relatively 64-bit clean.
New `isamchk` which can detect and fix more problems.
New options for `isamlog`.
Using new version of Automake.
Many small portability changes (from the AIX and alpha-digital port) Better checking of pthreads library.
czech error messages by snajdr@pvt.net.
Decreased size of some buffers to get fewer problems on systems with little memory. Also added more checks to handle “out of memory” problems.
`mysqladmin`: you can now do `mysqladmin kill 5,6,7,8` to kill multiple threads.
When the maximum connection limit is reached, one extra connection by a user with the `PROCESS_ACL` privilege is granted.
Added `-0 backl=##` option to `mysqld`.
Increased maximum packet size from 512K to 1024K for client.
Almost all of the function code is now tested in the internal test suite.
`ALTER TABLE` now returns warnings from field conversions.
Port changed to 3306 (got it reserved from ISI).
Added a fix for Visual FoxBase so that any schema name from a table specification is automatically removed.
New function `ASCII()`.
Removed function `BETWEEN(a,b,c)`. Use the standard ANSI syntax instead: `expr BETWEEN expr AND expr`.
MySQL no longer has to use an extra temporary table when sorting on functions or `SUM()` functions.
Fixed bug that you couldn’t use `tbl_name.field_name` in `UPDATE`.
Fixed `SELECT DISTINCT` when using 'hidden group'. For example:
```
mysql> SELECT DISTINCT MOD(some_field,10) FROM test
GROUP BY some_field;
```
Note: `some_field` is normally in the `SELECT` part. ANSI SQL should require it.

### Changes in release 3.21.0

- New reserved words used: `INTERVAL`, `EXPLAIN`, `READ`, `WRITE`, `BINARY`.
- Added ODBC function `CHAR(num,...)`.
- New operator `IN`. This uses a binary search to find a match.
- New command `LOCK TABLES tbl_name [AS alias] {READ|WRITE} ...`
- Added `--log-update` option to `mysqld`, to get a log suitable for incremental updates.
- New command `EXPLAIN SELECT` ... to get information about how the optimizer will do the join.
• For easier client code, the client should no longer use `FIELD_TYPE_TINY_BLOB`, `FIELD_TYPE_MEDIUM_BLOB`, `FIELD_TYPE_LONG_BLOB` or `FIELD_TYPE_VAR_STRING` (as previously returned by `mysql_list_fields`). You should instead only use `FIELD_TYPE_BLOB` or `FIELD_TYPE_STRING`. If you want exact types, you should use the command `SHOW FIELDS`.

• Added varbinary syntax: `0x####` which can be used as a string (default) or a number.

• `FIELD_TYPE_CHAR` is renamed to `FIELD_TYPE_TINY`.

• Changed all fields to C++ classes.

• Removed `FORM` struct.

• Fields with `DEFAULT` values no longer need to be `NOT NULL`.

• New field types:
  - `ENUM`: A string which can take only a couple of defined values. The value is stored as a 1-3 byte number that is mapped automatically to a string. This is sorted according to string positions!
  - `SET`: A string which may have one or many string values separated with `','`. The string is stored as a 1-, 2-, 3-, 4- or 8-byte number where each bit stands for a specific set member. This is sorted according to the unsigned value of the stored packed number.

• Now all function calculation is done with `double` or `long long`. This will provide the full 64-bit range with bit functions and fix some conversions that previously could result in precision losses. One should avoid using `unsigned long long` columns with full 64-bit range (numbers bigger than 9223372036854775807) because calculations are done with `signed long long`.

• `ORDER BY` will now put `NULL` field values first. `GROUP BY` will also work with `NULL` values.

• Full `WHERE` with expressions.

• New range optimizer that can resolve ranges when some keypart prefix is constant. Example:

```sql
mysql> SELECT * FROM tbl_name
    > WHERE key_part_1="customer"
    > AND key_part_2>=10 AND key_part_2<=10;
```

D.4 Changes in release 3.20.x

Changes from 3.20.18 to 3.20.32b are not documented here since the 3.21 release branched here. And the relevant changes are also documented as changes to the 3.21 version.

D.4.1 Changes in release 3.20.18

• Added `-p#` (remove # directories from path) to `isamlog`. All files are written with a relative path from the database directory. Now `mysqld` shouldn’t crash on shutdown when using the `--log-isam` option.
• New mysqlperl version. It is now compatible with mysqlperl-0.63.
• Added group function STD() (standard deviation).
• The mysqld server is now compiled by default without debugging information. This will make the daemon smaller and faster.
• Now one usually only has to specify the --basedir option to mysqld. All other paths are relative in a normal installation.
• BLOB columns sometimes contained garbage when used with a SELECT on more than one table and ORDER BY.
• Fixed that calculations that are not in GROUP BY work as expected (ANSI SQL extension). Example:

  mysql> SELECT id,id+1 FROM table GROUP BY id;
• The test of using MYSQL_PWD was reversed. Now MYSQL_PWD is enabled as default in the default release.
• Fixed conversion bug which caused mysqld to core dump with Arithmetic error on Sparc-386.
• Added --unbuffered option to mysql, for new mysqlaccess.
• When using overlapping (unnecessary) keys and join over many tables, the optimizer could get confused and return 0 records.

D.4.2 Changes in release 3.20.17

• You can now use BLOB columns and the functions IS NULL and IS NOT NULL in the WHERE clause.
• All communication packets and row buffers are now allocated dynamically on demand. The default value of max_allowed_packet is now 64K for the server and 512K for the client. This is mainly used to catch incorrect packets that could trash all memory. The server limit may be changed when it is started.
• Changed stack usage to use less memory.
• Changed safe_mysqld to check for running daemon.
• The ELT() function is renamed to FIELD(). The new ELT() function returns a value based on an index: FIELD() is the inverse of ELT() Example: ELT(2,"A","B","C") returns "B". FIELD("B","A","B","C") returns 2.
• COUNT(field), where field could have a NULL value, now works.
• A couple of bugs fixed in SELECT ... GROUP BY.
• Fixed memory over run bug in WHERE with many unoptimizable brace levels.
• Fixed some small bugs in the grant code.
• If hostname isn’t found by get_hostname, only the IP is checked. Previously, you got Access denied.
• Inserts of timestamps with values didn’t always work.
• INSERT INTO ... SELECT ... WHERE could give the error Duplicated field.
• Added some tests to safe_mysqld to make it “safer”.
• LIKE was case sensitive in some places and case insensitive in others. Now LIKE is always case insensitive.
• ‘mysql.cc’: Allow '#' anywhere on the line.
• New command SET OPTION SQL_SELECT_LIMIT=#. See the FAQ for more details.
• New version of the mysqlaccess script.
• Change FROM_DAYS() and WEEKDAY() to also take a full TIMESTAMP or DATETIME as argument. Before they only took a number of type YYYYMMDD or YYMMDD.
• Added new function UNIX_TIMESTAMP(timestamp_column).

D.4.3 Changes in release 3.20.16

• More changes in MIT-pthreads to get them safer. Fixed also some link bugs at least in SunOS.
• Changed mysqld to work around a bug in MIT-pthreads. This makes multiple small SELECT operations 20 times faster. Now lock_test.pl should work.
• Added mysql_fetchHash(handle) to mysqlperl.
• The mysqlbug script is now distributed built to allow for reporting bugs that appear during the build with it.
• Changed ‘libmysql.c’ to prefer getpwuid() instead of cuserid().
• Fixed bug in SELECT optimizer when using many tables with the same column used as key to different tables.
• Added new latin2 and Russian KOI8 character tables.
• Added support for a dummy GRANT command to satisfy Powerbuilder.

D.4.4 Changes in release 3.20.15

• Fixed fatal bug packets out of order when using MIT-pthreads.
• Removed possible loop when a thread waits for command from client and fcntl() fails. Thanks to Mike Bretz for finding this bug.
• Changed alarm loop in ‘mysqld.cc’ because shutdown didn’t always succeed in Linux.
• Removed use of termbits from ‘mysqld.cc’. This conflicted with glibc 2.0.
• Fixed some syntax errors for at least BSD and Linux.
• Fixed bug when doing a SELECT as superuser without a database.
• Fixed bug when doing SELECT with group calculation to outfile.

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D.4.5 Changes in release 3.20.14

- If one gives -p or --password option to mysql without an argument, the user is solicited for the password from the tty.
- Added default password from MYSQL_PWD (by Elmar Haneke).
- Added command kill to mysqladmin to kill a specific MySQL thread.
- Sometimes when doing a reconnect on a down connection this succeeded first on second try.
- Fixed adding an AUTO_INCREMENT key with ALTER_TABLE.
- AVG() gave too small value on some SELECTs with GROUP BY and ORDER BY.
- Added new DATETIME type (by Giovanni Maruzzelli maruzz@matrice.it).
- Fixed that define DONT_USE_DEFAULT_FIELDS works.
- Changed to use a thread to handle alarms instead of signals on Solaris to avoid race conditions.
- Fixed default length of signed numbers. (George Harvey georgeh@pinacl.co.uk.)
- Allow anything for CREATE INDEX.
- Added support for Slovenian characters. The ‘Contrib’ directory contains source and instructions for adding other character sets.
- Fixed bug with LIMIT and ORDER BY.
- Allow ORDER BY and GROUP BY on items that aren’t in the SELECT list. (Thanks to Wim Bonis bonis@kiss.de, for pointing this out.)
- Allow setting of timestamp values in INSERT.
- Fixed a bug in OR of multiple tables (gave empty set).
- Added many patches to MIT-pthreads. This fixes at least one lookup bug.

D.4.6 Changes in release 3.20.13

- Added ANSI SQL94 DATE and TIME types.
- Fixed bug in SELECT with AND-OR levels.
- Added support for Slovenian characters. The ‘Contrib’ directory contains source and instructions for adding other character sets.
- Fixed bug with LIMIT and ORDER BY.
- Allow ORDER BY and GROUP BY on items that aren’t in the SELECT list. (Thanks to Wim Bonis bonis@kiss.de, for pointing this out.)
- Allow setting of timestamp values in INSERT.
- Fixed bug with SELECT ... WHERE ... = NULL.
- Added changes for glibc 2.0. To get glibc to work, you should add the ‘glibc-2.0-sigwait-patch’ before compiling glibc.
- Fixed bug in ALTER_TABLE when changing a NOT NULL field to allow NULL values.
- Added some ANSI92 synonyms as field types to CREATE_TABLE. CREATE_TABLE now allows FLOAT(4) and FLOAT(8) to mean FLOAT and DOUBLE.
- New utility program mysqlaccess by Yves.Carlier@rug.ac.be. This program shows the access rights for a specific user and the grant rows that determine this grant.
- Added WHERE const op field (by bonis@kiss.de).
D.4.7 Changes in release 3.20.11

- When using `SELECT ... INTO OUTFILE`, all temporary tables are ISAM instead of HEAP to allow big dumps.
- Changed date functions to be string functions. This fixed some “funny” side effects when sorting on dates.
- Extended `ALTER TABLE` according to SQL92.
- Some minor compatibility changes.
- Added `--port` and `--socket` options to all utility programs and `mysqld`.
- Fixed MIT-pthreads `readdir_r()`. Now `mysqladmin create database` and `mysqladmin drop database` should work.
- Changed MIT-pthreads to use our `tempnam()`. This should fix the “sort aborted” bug.
- Added sync of records count in `sql_update`. This fixed slow updates on first connection.
  (Thanks to Vaclav Bittner for the test.)

D.4.8 Changes in release 3.20.10

- New insert type: `INSERT INTO ... SELECT ...`
- `MEDIUMBLOB` fixed.
- Fixed bug in `ALTER TABLE` and `BLOBs`.
- `SELECT ... INTO OUTFILE` now creates the file in the current database directory.
- `DROP TABLE` now can take a list of tables.
- Oracle synonym `DESCRIBE` (`DESC`).
- Changes to `make_binary_distribution`.
- Added some comments to installation instructions about `configure`’s C++ link test.
- Added `--without-perl` option to `configure`.
- Lots of small portability changes.

D.4.9 Changes in release 3.20.9

- `ALTER TABLE` didn’t copy null bit. As a result, fields that were allowed to have `NULL` values were always `NULL`.
- `CREATE` didn’t take numbers as `DEFAULT`.
- Some compatibility changes for SunOS.
- Removed ‘`config.cache`’ from old distribution.

D.4.10 Changes in release 3.20.8

- Fixed bug with `ALTER TABLE` and multi-part keys.
D.4.11 Changes in release 3.20.7

- New commands: ALTER TABLE, SELECT ... INTO OUTFILE and LOAD DATA INFILE.
- New function: NOW().
- Added new field file_priv to mysql/user table.
- New script add_file_priv which adds the new field file_priv to the user table. This script must be executed if you want to use the new SELECT ... INTO and LOAD DATA INFILE ... commands with a version of MySQL earlier than 3.20.7.
- Fixed bug in locking code, which made lock_test.pl test fail.
- New files 'NEW' and 'BUGS'.
- Changed 'select_test.c' and 'insert_test.c' to include 'config.h'.
- Added command status to mysqladmin for short logging.
- Increased maximum number of keys to 16 and maximum number of key parts to 15.
- Use of sub keys. A key may now be a prefix of a string field.
- Added -k option to mysqlshow, to get key information for a table.
- Added long options to mysqldump.

D.4.12 Changes in release 3.20.6

- Portable to more systems because of MIT-pthreads, which will be used automatically if configure cannot find a -lpthreads library.
- Added GNU-style long options to almost all programs. Test with program --help.
- Some shared library support for Linux.
- The FAQ is now in '.texi' format and is available in '.html', '.txt' and '.ps' formats.
- Added new SQL function RAND([init]).
- Changed sql_lex to handle \0 unquoted, but the client can’t send the query through the C API, because it takes a str pointer. You must use mysql_real_query() to send the query.
- Added API function mysql_get_client_info().
- mysqld now uses the N_MAX_KEY_LENGTH from 'nisam.h' as the maximum allowed key length.
- The following now works:
  mysql> SELECT filter_nr,filter_nr FROM filter ORDER BY filter_nr;
Previously, this resulted in the error: Column: 'filter_nr' in order clause is ambiguous.
- mysql now outputs \0, \t, \n and \" when encountering ASCII 0, tab, newline or \ while writing tab-separated output. This is to allow printing of binary data in a portable format. To get the old behavior, use -r (or --raw).
- Added german error messages (60 of 80 error messages translated).
• Added new API function `mysql_fetch_lengths(MYSQL_RES *)`, which returns an array of column lengths (of type `uint`).
• Fixed bug with `IS NULL` in `WHERE` clause.
• Changed the optimizer a little to get better results when searching on a key part.
• Added `SELECT` option `STRAIGHT_JOIN` to tell the optimizer that it should join tables in the given order.
• Added support for comments starting with `--` in `mysql.cc` (Postgres syntax).
• You can have `SELECT` expressions and table columns in a `SELECT` which are not used in the group part. This makes it efficient to implement lookups. The column that is used should be a constant for each group because the value is calculated only once for the first row that is found for a group.
  ```sql
  mysql> SELECT id,lookup.text,sum(*) FROM test,lookup
             WHERE test.id=lookup.id GROUP BY id;
  ```
• Fixed bug in `SUM(function)` (could cause a core dump).
• Changed `AUTO_INCREMENT` placement in the SQL query:
  ```sql
  INSERT into table (auto_field) values (0);
  ```
  inserted 0, but it should insert an `AUTO_INCREMENT` value.
• `mysqlshow.c`: Added number of records in table. Had to change the client code a little to fix this.
• `mysql` now allows doubled `'` or `"` within strings for embedded `'` or `"`
• New math functions: `EXP()`, `LOG()`, `SQRT()`, `ROUND()`, `CEILING()`.

D.4.13 Changes in release 3.20.3

• The `configure` source now compiles a thread-free client library `-lmysqlclient`. This is the only library that needs to be linked with client applications. When using the binary releases, you must link with `-lmysql -lmysys -ldbug -lstrings` as before.
• New `readline` library from `bash-2.0`.
• LOTS of small changes to `configure` and makefiles (and related source).
• It should now be possible to compile in another directory using `VPATH`. Tested with GNU Make 3.75.
• `safe_mysqld` and `mysql.server` changed to be more compatible between the source and the binary releases.
• `LIMIT` now takes one or two numeric arguments. If one argument is given, it indicates the maximum number of rows in a result. If two arguments are given, the first argument indicates the offset of the first row to return, the second is the maximum number of rows. With this it’s easy to do a poor man’s next page/previous page WWW application.
• Changed name of SQL function `FIELDS()` to `ELT()`. Changed SQL function `INTERVALL()` to `INTERVAL()`.
• Made `SHOW COLUMNS` a synonym for `SHOW FIELDS`. Added compatibility syntax `FRIEND KEY` to `CREATE TABLE`. In `MySQL`, this creates a non-unique key on the given columns.
• Added CREATE INDEX and DROP INDEX as compatibility functions. In MySQL, CREATE INDEX only checks if the index exists and issues an error if it doesn’t exist. DROP INDEX always succeeds.

• ‘mysqladmin.c’: added client version to version information.

• Fixed core dump bug in sql_acl (core on new connection).

• Removed host, user and db tables from database test in the distribution.

• FIELD_TYPE_CHAR can now be signed (-128 - 127) or unsigned (0 - 255) Previously, it was always unsigned.

• Bug fixes in CONCAT() and WEEKDAY().

• Changed a lot of source to get mysqld to be compiled with SunPro compiler.

• SQL functions must now have a ‘(’ immediately after the function name (no intervening space). For example, ‘user(‘ is regarded as beginning a function call, and ‘user (‘ is regarded as an identifier user followed by a ‘(’, not as a function call.

D.4.14 Changes in release 3.20.0

• The source distribution is done with configure and Automake. It will make porting much easier. The readline library is included in the distribution.

• Separate client compilation: the client code should be very easy to compile on systems which don’t have threads.

• The old Perl interface code is automatically compiled and installed. Automatic compiling of DBD will follow when the new DBD code is ported.

• Dynamic language support: mysqld can now be started with Swedish or English (default) error messages.

• New functions: INSERT(), RTRIM(), LTRIM() and FORMAT().

• mysqldump now works correctly for all field types (even AUTO_INCREMENT). The format for SHOW FIELDS FROM tbl_name is changed so the Type column contains information suitable for CREATE TABLE. In previous releases, some CREATE TABLE information had to be patched when recreating tables.

• Some parser bugs from 3.19.5 (BLOB and TIMESTAMP) are corrected. TIMESTAMP now returns different date information depending on its create length.

• Changed parser to allow a database, table or field name to start with a number or ‘_’.

• All old C code from Unireg changed to C++ and cleaned up. This makes the daemon a little smaller and easier to understand.

• A lot of small bug fixes done.

• New ‘INSTALL’ files (not final version) and some info regarding porting.

D.5 Changes in release 3.19.x
D.5.1 Changes in release 3.19.5

- Some new functions, some more optimization on joins.
- Should now compile clean on Linux (2.0.x).
- Added functions `DATABASE()`, `USER()`, `POW()`, `LOG10()` (needed for ODBC).
- In a `WHERE` with an `ORDER BY` on fields from only one table, the table is now preferred as first table in a multi-join.
- `HAVING` and `IS NULL` or `IS NOT NULL` now works.
- A group on one column and a sort on a group function (`SUM()`, `AVG()...`) didn’t work together. Fixed.
- `mysqldump`: Didn’t send password to server.

D.5.2 Changes in release 3.19.4

- Fixed horrible locking bug when inserting in one thread and reading in another thread.
- Fixed one-off decimal bug. 1.00 was output as 1.0.
- Added attribute ‘Locked’ to process list as info if a query is locked by another query.
- Fixed full magic timestamp. Timestamp length may now be 14, 12, 10, 8, 6, 4 or 2 bytes.
- Sort on some numeric timestamp. Timestamp length may now be 14, 12, 10, 8, 6, 4 or 2 bytes.
- Sort on some numeric functions could sort incorrectly on last number.
- `IF(arg,syntax_error,syntax_error)` crashed.
- Added functions `CEILING()`, `ROUND()`, `EXP()`, `LOG()` and `SQRT()`.
- Enhanced `BETWEEN` to handle strings.

D.5.3 Changes in release 3.19.3

- Fixed `SELECT` with grouping on `BLOB` columns not to return incorrect `BLOB` info. Grouping, sorting and distinct on `BLOB` columns will not yet work as expected (probably it will group/sort by the first 7 characters in the `BLOB`). Grouping on formulas with a fixed string size (use `MID()` on a `BLOB`) should work.
- When doing a full join (no direct keys) on multiple tables with `BLOB` fields, the `BLOB` was garbage on output.
- Fixed `DISTINCT` with calculated columns.
Appendix E: Known errors and design deficiencies in MySQL

• You cannot build in another directory when using MIT-pthreads. Since this requires changes to MIT-pthreads, we are not likely to fix this.

• BLOB values can’t “reliably” be used in GROUP BY or ORDER BY or DISTINCT. Only the first max_sort_length bytes (default 1024) are used when comparing BLOBs in these cases. This can be changed with the -0 max_sort_length option to mysqld. A workaround for most cases is to use a substring: SELECT DISTINCT LEFT(blob,2048) FROM tbl_name.

• Calculation is done with BIGINT or DOUBLE (both are normally 64 bits long). It depends on the function which precision one gets. The general rule is that bit functions are done with BIGINT precision, IF, and ELT() with BIGINT or DOUBLE precision and the rest with DOUBLE precision. One should try to avoid using bigger unsigned long long values than 63 bits (9223372036854775807) for anything else than bit fields!

• All string columns, except BLOB and TEXT columns, automatically have all trailing spaces removed when retrieved. For CHAR types this is okay, and may be regarded as a feature according to ANSI SQL92. The bug is that in MySQL, VARCHAR columns are treated the same way.

• You can only have up to 255 ENUM and SET columns in one table.

• safe_mysqld re-directs all messages from mysqld to the mysqld log. One problem with this is that if you execute mysqldadmin refresh to close and reopen the log, stdout and stderr are still redirected to the old log. If you use --log extensively, you should edit safe_mysqld to log to ‘hostname’.err instead of ‘hostname’.log so you can easily reclaim the space for the old log by deleting the old one and executing mysqldadmin refresh.

• In the UPDATE statement, columns are updated from left to right. If you refer to a updated column, you will get the updated value instead of the original value. For example:

```
mysql> UPDATE tbl_name SET KEY=KEY+1,KEY=KEY+1
```

will update KEY with 2 instead of with 1.

• You can’t use temporary tables more than once in the same query.

```
select * from temporary_table, temporary_table as t2;
```

The following is known bugs in earlier versions of MySQL:

• Before MySQL 3.23.2 an UPDATE that updated a key with a WHERE on the same key may have failed because the key was used to search for records and the same row may have been found multiple times:

```
UPDATE tbl_name SET KEY=KEY+1 WHERE KEY > 100;
```

A workaround is to use:

```
mysql> UPDATE tbl_name SET KEY=KEY+1 WHERE KEY+0 > 100;
```

This will work because MySQL will not use index on expressions in the WHERE clause.
- Before MySQL 3.23, all numeric types were treated as fixed-point fields. That means you had to specify how many decimals a floating-point field shall have. All results were returned with the correct number of decimals.

For platform-specific bugs, see the sections about compiling and porting.
Appendix F List of things we want to add to MySQL in the future (The TODO)

Appendix F List of things we want to add to MySQL in the future (The TODO)

Everything in this list is in the order it will be done. If you want to affect the priority order, please register a license or support us and tell us what you want to have done more quickly. See Chapter 3 [Licensing and Support], page 24.

F.1 Things that must done in the real near future

- One way replication
- Transactions
- Subqueries. `select id from t where grp in (select grp from g where u > 100)`
- Allow `mysqld` to support many character sets at the same time.
- If you perform an ALTER TABLE on a table that is symlinked to another disk, create temporary tables on this disk.
- RENAME table as table, table as table [...]
- FreeBSD and MIT-pthreads; Do sleeping threads take CPU?
- Check if locked threads take any CPU.
- Allow join on key parts (optimization issue).
- Entry for DECRYPT().
- Remember FOREIGN key definitions in the ‘.frm’ file.
- Server side cursors.
- Allow users to change startup options.
- Check if `lockd` works with modern Linux kernels; If not, we have to fix `lockd`! To test this, start `mysqld` with `--enable-locking` and run the different fork* test suits. They shouldn’t give any errors if `lockd` works.
- Allow SQL variables in LIMIT, like in LIMIT @a, @b.
- Don’t add automatic DEFAULT values to columns. Give an error when using an INSERT that doesn’t contain a column that doesn’t have a DEFAULT.
- Caching of queries and results. This should be done as a separated module that examines each query and if this is query is in the cache the cached result should be returned. When one updates a table one should remove as few queries as possible from the cache. This should give a big speed bost on machines with much RAM where queries are often repeated (like WWW applications). One idea would be to only cache queries of type: SELECT CACHED ....
- Fix ‘libmysql.c’ to allow two `mysql_query()` commands in a row without reading results or give a nice error message when one does this.
- Optimize BIT type to take 1 bit (now BIT takes 1 char).
- Check why MIT-pthreads `ctime()` doesn’t work on some FreeBSD systems.

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Appendix F: List of things we want to add to MySQL in the future (The TODO)

- Add ORDER BY to update. This would be handy with functions like: `generate_id(start, step)`.
- Add an IMAGE option to LOAD DATA INFILE to not update TIMESTAMP and AUTO_INCREMENT fields.
- Make LOAD DATA INFILE understand a syntax like:
  ```sql
  LOAD DATA INFILE 'file_name.txt' INTO TABLE tbl_name
  TEXT_FIELDS (text_field1, text_field2, text_field3)
  SET table_field1=concatenate(text_field1, text_field2), table_field3=23
  IGNORE text_field3
  ```
- Add true VARCHAR support (There is already support for this in MyISAM).
- Automatic output from mysql to netscape.
- LOCK DATABASES. (with various options)
- NATURAL JOIN.
- Change sort to allocate memory in “hunks” to get better memory utilization.
- DECIMAL and NUMERIC types can’t read exponential numbers; `Field_decimal::store(const char *from, uint len)` must be recoded to fix this.
- Fix mysql.cc to do fewer malloc() calls when hashing field names.
- Functions: ADD_TO_SET(value, set) and REMOVE_FROM_SET(value, set)
- Add use of `t1 JOIN t2 ON ...` and `t1 JOIN t2 USING ...`. Currently, you can only use this syntax with LEFT JOIN.
- Add full support for unsigned long long type.
- Function CASE.
- Many more variables for show status. Counts for: INSERT/DELETE/UPDATE statements. Records reads and updated. Selects on 1 table and selects with joins. Mean number of tables in select. Key buffer read/write hits (logical and real). ORDER BY, GROUP BY, temporary tables created.
- If you abort mysql in the middle of a query, you should open another connection and kill the old running query. Alternatively, an attempt should be made to detect this in the server.
- Add a handler interface for table information so you can use it as a system table. This would be a bit slow if you requested information about all tables, but very flexible. SHOW INFO FROM tbl_name for basic table information should be implemented.
- Add support for UNICODE.
- NATURAL JOIN.
- Oracle like CONNECT BY PRIOR ... to search hierarchy structures.
- RENAME DATABASE
  ```sql
  mysqladmin copy database new-database
  ```
- Processlist should show number of queries/thread.
- IGNORE option to the UPDATE statement (this will delete all rows that gets a duplicate key error while updating).
- Change the format of DATETIME to store fractions of seconds.
Appendix F: List of things we want to add to MySQL in the future (The TODO)

- Add all missing ANSI92 and ODBC 3.0 types.
- Change table names from empty strings to NULL for calculated columns.
- Don’t use 'Item_copy_string' on numerical values to avoid number->string->number conversion in case of: SELECT COUNT(*)*(id+0) FROM table_name GROUP BY id
- Make it possible to use the new GNU regexp library instead of the current one (The GNU library should be much faster than the old one).
- Change that ALTER TABLE doesn’t abort clients that executes INSERT DELAYED.
- Allow select a from crash_me left join crash_me2 using (a); In this case a is assumed to come from the crash_me table.

F.2 Things that have to be done sometime

- Implement function: get_changed_tables(timeout,table1,table2,...)
- Implement function: LAST_UPDATED(tbl_name)
- Atomic updates; This includes a language that one can even use for a set of stored procedures.
- update items,month set items.price=month.price where items.id=month.id;
- Change reading through tables to use memmap when possible. Now only compressed tables use memmap.
- Add a new privilege 'Show_priv' for SHOW commands.
- Make the automatic timestamp code nicer. Add timestamps to the update log with SET TIMESTAMP=#;
- Use read/write mutex in some places to get more speed.
- Full foreign key support. One probably wants to implement a procedural language first.
- Simple views (first on one table, later on any expression).
- Automatically close some tables if a table, temporary table or temporary files gets error 23 (not enough open files).
- When one finds a field=#, change all occurrences of field to #. Now this is only done for some simple cases.
- Change all const expressions with calculated expressions if possible.
- Optimize key = expression. At the moment only key = field or key = constant are optimized.
- Join some of the copy functions for nicer code.
- Change ‘sql_yacc.yy’ to an inline parser to reduce its size and get better error messages (5 days).
- Change the parser to use only one rule per different number of arguments in function.
- Use of full calculation names in the order part. (For ACCESS97)
- UNION, MINUS, INTERSECT and FULL OUTER JOIN. (Currently only LEFT OUTER JOIN is supported)
Appendix F: List of things we want to add to MySQL in the future (The TODO)

- Allow UNIQUE on fields that can be NULL.
- SQL_OPTION MAX_SELECT_TIME=# to put a time limit on a query.
- Make the update log to a database.
- Negative LIMIT to retrieve data from the end.
- Alarm around client connect/read/write functions.
- Make a mysqld version which isn’t multithreaded (3-5 days).
- Please note the changes to safe_mysqld: according to FSSTND (which Debian tries to follow) PID files should go into ‘/var/run/<progname>.pid’ and log files into ‘/var/log’. It would be nice if you could put the "DATADIR" in the first declaration of "pidfile" and "log", so the placement of these files can be changed with a single statement.
- Better dynamic record layout to avoid fragmentation.
- UPDATE SET blob=read_blob_from_file('my_gif') where id=1;
- Allow a client to request logging.
- Add use of zlib() for gzip-ed files to LOAD DATA INFILE.
- Fix sorting and grouping of BLOB columns (partly solved now).
- Stored procedures. This is currently not regarded to be very important as stored procedures are not very standardized yet. Another problem is that true stored procedures make it much harder for the optimizer and in many cases the result is slower than before We will, on the other hand, add a simple (atomic) update language that can be used to write loops and such in the MySQL server.
- Change to use semaphores when counting threads. One should first implement a semaphore library to MIT-pthreads.
- Don’t assign a new AUTO_INCREMENT value when one sets a column to 0. Use NULL instead.
- Add full support for JOIN with parentheses.
- Reuse threads for systems with a lot of connections.
- As an alternative for one thread / connection manage a pool of threads to handle the queries.

Time is given according to amount of work, not real time. TcX’s main business is the use of MySQL not the development of it. But since TcX is a very flexible company, we have put a lot of resources into the development of MySQL.

F.3 Some things we don’t have any plans to do

- Nothing; In the long run we plan to be fully ANSI 92 / ANSI 99 compliant.
Appendix G Comments on porting to other systems

A working Posix thread library is needed for the server. On Solaris 2.5 we use SUN PThreads (the native thread support in 2.4 and earlier versions are not good enough) and on Linux we use LinuxThreads by Xavier Leroy, Xavier.Leroy@inria.fr.

The hard part of porting to a new Unix variant without good native thread support is probably to port MIT-pthreads. See ’mit-pthreads/README’ and Programming POSIX Threads (http://www.humanfactor.com/pthreads/).

The MySQL distribution includes a patched version of Provenzano’s Pthreads from MIT (see MIT Pthreads web page (http://www.mit.edu:8001/people/proven/pthreads.html)). This can be used for some operating systems that do not have POSIX threads.

It is also possible to use another user level thread package named FSU Pthreads (see FSU Pthreads home page (http://www.informatik.hu-berlin.de/~mueller/pthreads.html)). This implementation is being used for the SCO port.

See the ‘thr_lock.c’ and ‘thr_alarm.c’ programs in the ‘mysys’ directory for some tests/examples of these problems.

Both the server and the client need a working C++ compiler (we use gcc and have tried SparcWorks). Another compiler that is known to work is the Irix cc.

To compile only the client use .configure --without-server.

There is currently no support for only compiling the server. Nor is it likely to be added unless someone has a good reason for it.

If you want/need to change any ‘Makefile’ or the configure script you must get Automake and Autoconf. We have used the automake-1.2 and autoconf-2.12 distributions.

All steps needed to remake everything from the most basic files.

```
/bin/rm */.deps/*.P
/bin/rm -f config.cache
aclocal
autoheader
aclocal
automake
autoconf
./configure --with-debug --prefix='your installation directory'
```

# The makefiles generated above need GNU make 3.75 or newer.
# (called gmake below)
gmake clean all install init-db

If you run into problems with a new port, you may have to do some debugging of MySQL! See Section G.1 [Debugging server], page 506.

Note: Before you start debugging mysqld, first get the test programs mysys/thr_alarm and mysys/thr_lock to work. This will ensure that your thread installation has even a remote chance to work!
G.1 Debugging a MySQL server

If you are using some functionality that is very new in MySQL, you can try to run mysqld with the --skip-new (which will disable all new, potentially unsafe functionality) or with --safe-mode which disables a lot of optimization that may cause problems. See Section 19.1 [Crashing], page 352.

If mysqld doesn’t want to start, you should check that you don’t have any my.cnf file that interferes with your setup! You can check your my.cnf arguments with mysqld --print-defaults and avoid using them by starting with mysqld --no-defaults ....

If you have some very specific problem, you can always try to debug MySQL. To do this you must configure MySQL with the option --with-debug. You can check whether or not MySQL was compiled with debugging by doing: mysqld --help. If the --debug flag is listed with the options then you have debugging enabled. mysqladmin ver also lists the mysqld version as mysql ... -debug in this case.

If you are using gcc or egcs, the recommended configure line is:

```
CC=gcc CFLAGS="-O6" CXX=gcc CXXFLAGS="-O6 -felide-constructors -fno-exceptions -fno-rtti" ./configure --prefix=/usr/local/mysql --with-debug
```

This will avoid problems with the libstdc++ library and with C++ exceptions (many compilers have problems with C++ exceptions in threaded code).

If mysqld stops crashing when you compile it with --with-debug, you have probably found a compiler bug or a timing bug within MySQL. In this case you can try to add -g to the CFLAGS and CXXFLAGS variables above and not use --with-debug. If mysqld now dies, you can at least attach to it with gdb or use gdb on the core file to find out what happened.

If you can cause the mysqld server to crash quickly, you can try to create a trace file of this:

Start the mysqld server with a trace log in '/tmp/mysql.trace'. The log file will get very BIG.

```
mysqld --debug --log
```

or you can start it with

```
mysqld --debug=d,info,error,query,general,where:O,/tmp/mysql.trace
```

which only prints information with the most interesting tags.

When you configure MySQL for debugging you automatically enable a lot of extra safety check functions that monitor the health of mysqld. If they find something “unexpected,” an entry will be written to stderr, which safe_mysqld directs to the error log! This also means that if you are having some unexpected problems with MySQL and are using a source distribution, the first thing you should do is to configure MySQL for debugging! (The second thing, of course, is to send mail to mysql@lists.mysql.com and ask for help. Please use the mysqlbug script for all bug reports or questions regarding the MySQL version you are using!)

On most systems you can also start mysqld from gdb to get more information if mysqld crashes.

With some gdb versions on Linux you must use run --one-thread if you want to be able to debug mysqld threads. In this case you can only have one thread active at a time.
If you are using gdb 4.17.x on Linux, you should install a '.gdb' file, with the following information, in your current directory:

```
set print sevenbit off
handle SIGUSR1 nostop nopr
handle SIGUSR2 nostop nopr
handle SIGWAITING nostop nopr
handle SIGLWP nostop nopr
handle SIGPIPE nostop
handle SIGALRM nostop
handle SIGHUP nostop
handle SIGTERM nostop
handle SIGTERM nostop nopr
```

Here follows an example how to debug mysqld:

```
shell> gdb /usr/local/libexec/mysqld
gdb> run
...
back # Do this when mysqld crashes
info locals
up
info locals
up
...
(until you get some information about local variables)
quit
```

Include the above output in a mail generated with `mysqlbug` and mail this to `mysql@lists.mysql.com`.

If mysqld hangs you can try to use some system tools like `strace` or `/usr/proc/bin/pstack` to examine where mysqld has hanged.

If mysqld starts to eat up CPU or memory or if it “hangs”, you can use `mysqladmin processlist status` to find out if someone is executing some query that takes a long time. It may be a good idea to run `mysqladmin -i10 processlist status` in some window if you are experiencing performance problems or problems when new clients can’t connect.

If mysqld dies or hangs, you should start mysqld with `--log`. When mysqld dies again, you can check in the log file for the query that killed mysqld. Note that before starting mysqld with `--log` you should check all your tables with `myisamchk`. See Chapter 14 [Maintenance], page 323.

If you find the text `mysqld restarted` in the error log file (normally named `hostname.err`) you have probably found a query that causes mysqld to fail. If this happens you should check all your tables with `myisamchk` (see Chapter 14 [Maintenance], page 323), and test the queries in the MySQL log files if someone doesn’t work. If you find such a query, try first upgrading to the newest MySQL version. If this doesn’t help...
Appendix G: Comments on porting to other systems

and you can’t find anything in the mysql mail archive, you should report the bug to mysql@lists.mysql.com. Links to mail archives are available at the online MySQL documentation page (http://www.mysql.com/doc.html).

If you get corrupted tables or if mysqld always fails after some update commands, you can test if this bug is reproducible by doing the following:

- Stop the mysqld daemon (with mysqladmin shutdown)
- Check all tables with myisamchk -s database/*.MYI. Repair any wrong tables with myisamchk -r database/table.MYI.
- Start mysqld with --log-update
- When you have got a crashed table, stop the mysqld server.
- Restore the backup.
- Restart the mysqld server without --log-update
- Re-execute the commands with mysql < update-log. The update log is saved in the MySQL database directory with the name your-hostname.#.
- If the tables are now again corrupted, you have found reproducible bug in the ISAM code! FTP the tables and the update log to ftp://www.mysql.com/pub/mysql/secret and we will fix this as soon as possible!

The command mysqladmin debug will dump some information about locks in use, used memory and query usage to the mysql log file. This may help solve some problems. This command also provides some useful information even if you haven’t compiled MySQL for debugging!

If the problem is that some tables are getting slower and slower you should try to optimize the table with OPTIMIZE TABLE or myisamchk. See Chapter 14 [Maintenance], page 323. You should also check the slow queries with EXPLAIN.

You should also read the OS-specific section in this manual for problems that may be unique to your environment. See Section 4.11 [Source install system issues], page 56.

If you are using the Perl DBI interface, you can turn on debugging information by using the trace method or by setting the DBI_TRACE environment variable. See Section 21.5.2 [Perl DBI Class], page 417.

G.2 Debugging a MySQL client

To be able to debug a MySQL client with the integrated debug package, you should configure MySQL with --with-debug. See Section 4.7.3 [configure options], page 47.

Before running a client, you should set the MYSQL_DEBUG environment variable:

```
shell> MYSQL_DEBUG=d:t:O,/tmp/client.trace
shell> export MYSQL_DEBUG
```

This causes clients to generate a trace file in ‘/tmp/client.trace’.

If you have problems with your own client code, you should attempt to connect to the server and run your query using a client that is known to work. Do this by running mysql MySQL in debugging mode (assuming you have compiled MySQL with debugging on):

```
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```
shell> mysql --debug=d:t:0,/tmp/client.trace
This will provide useful information in case you mail a bug report. See Section 2.3 [Bug reports], page 19.
If your client crashes at some ‘legal’ looking code, you should check that your ‘mysql.h’ include file matches your mysql library file. A very common mistake is to use an old ‘mysql.h’ file from an old MySQL installation with new MySQL library.

G.3 Comments about RTS threads

I have tried to use the RTS thread packages with MySQL but stumbled on the following problems:
They use old version of a lot of POSIX calls and it is very tedious to make wrappers for all functions. I am inclined to think that it would be easier to change the thread libraries to the newest POSIX specification.
Some wrappers are already written. See ‘mysys/my_pthread.c’ for more info.
At least the following should be changed:

- pthread_get_specific should use one argument. sigwait should take two arguments.
- A lot of functions (at least pthread_cond_wait, pthread_cond_timedwait) should return the error code on error. Now they return -1 and set errno.

Another problem is that user-level threads use the ALRM signal and this aborts a lot of functions (read, write, open...). MySQL should do a retry on interrupt on all of these but it is not that easy to verify it.

The biggest unsolved problem is the following:
To get thread-level alarms I changed ‘mysys/thr_alarm.c’ to wait between alarms with pthread_cond_timedwait(), but this aborts with error EINTR. I tried to debug the thread library as to why this happens, but couldn’t find any easy solution.

If someone wants to try MySQL with RTS threads I suggest the following:

- Change functions MySQL uses from the thread library to POSIX. This shouldn’t take that long.
- Compile all libraries with the -DHAVE_rts_threads.
- Compile thr_alarm.
- If there are some small differences in the implementation, they may be fixed by changing ‘my_pthread.h’ and ‘my_pthread.c’.
- Run thr_alarm. If it runs without any “warning”, “error” or aborted messages, you are on the right track. Here follows a successful run on Solaris:

```
Main thread: 1
Thread 0 (5) started
Thread: 5 Waiting
process_alarm
Thread 1 (6) started
Thread: 6 Waiting
process_alarm
```

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process_alarm
thread_alarm
Thread: 6 Slept for 1 (1) sec
Thread: 6 Waiting
process_alarm
process_alarm
thread_alarm
Thread: 6 Slept for 2 (2) sec
Thread: 6 Simulation of no alarm needed
Thread: 6 Slept for 0 (3) sec
Thread: 6 Waiting
process_alarm
process_alarm
thread_alarm
Thread: 6 Slept for 4 (4) sec
Thread: 6 Waiting
process_alarm
thread_alarm
Thread: 6 Slept for 5 (5) sec
Thread: 6 Waiting
process_alarm
process_alarm
... 
thread_alarm
Thread: 5 Slept for 0 (1) sec
end

G.4 Differences between different thread packages

MySQL is very dependent on the thread package used. So when choosing a good platform for MySQL, the thread package is very important.

There are at least three types of thread packages:

- User threads in a single process. Thread switching is managed with alarms and the threads library manages all non-thread-safe functions with locks. Read, write and select operations are usually managed with a thread-specific select that switches to another thread if the running threads have to wait for data. If the user thread packages are integrated in the standard libs (FreeBSD and BSDI threads) the thread package requires less overhead than thread packages that have to map all unsafe calls (MIT-pthreads, FSU Pthreads and RTS threads). In some environments (for example, SCO), all system calls are thread-safe so the mapping can be done very easily (FSU Pthreads
Appendix G: Comments on porting to other systems

on SCO). Downside: All mapped calls take a little time and it’s quite tricky to be able to handle all situations. There are usually also some system calls that are not handled by the thread package (like MIT-pthreads and sockets). Thread scheduling isn’t always optimal.

- User threads in separate processes. Thread switching is done by the kernel and all data are shared between threads. The thread package manages the standard thread calls to allow sharing data between threads. LinuxThreads is using this method. Downside: Lots of processes. Thread creating is slow. If one thread dies the rest are usually left hanging and you must kill them all before restarting. Thread switching is somewhat expensive.

- Kernel threads. Thread switching is handled by the thread library or the kernel and is very fast. Everything is done in one process, but on some systems, `ps` may show the different threads. If one thread aborts the whole process aborts. Most system calls are thread-safe and should require very little overhead. Solaris, HP-UX, AIX and OSF1 have kernel threads.

In some systems kernel threads are managed by integrating user level threads in the system libraries. In such cases, the thread switching can only be done by the thread library and the kernel isn’t really “thread aware”.
Appendix H Description of MySQL regular expression syntax

A regular expression (regex) is a powerful way of specifying a complex search. MySQL uses regular Henry Spencer’s implementation of regular expressions. And that is aimed to conform to POSIX 1003.2. MySQL uses the extended version.

This is a simplistic reference that skips the details. To get more exact information, see Henry Spencer’s `regex(7)` manual page that is included in the source distribution. See Appendix C [Credits], page 446.

A regular expression describes a set of strings. The simplest regexp is one that has no special characters in it. For example, the regexp `hello` matches `hello` and nothing else.

Nontrivial regular expressions use certain special constructs so that they can match more than one string. For example, the regexp `hello|word` matches either the string `hello` or the string `word`.

As a more complex example, the regexp `B[an]*s` matches any of the strings `Bananas`, `Baaaaas`, `Bs` and any other string starting with a `B`, ending with an `s`, and containing any number of `a` or `n` characters in between.

A regular expression may use any of the following special characters/constructs:

- `^` Match the beginning of a string.

  ```
  mysql> select "fo\nfo" REGEXP "^fo$"; -> 0
  mysql> select "fofo" REGEXP "^fo"; -> 1
  ```

- `$` Match the end of a string.

  ```
  mysql> select "fo\no" REGEXP "^fo\no$"; -> 1
  mysql> select "fo\no" REGEXP "^fo$"; -> 0
  ```

- `.` Match any character (including newline).

  ```
  mysql> select "fofo" REGEXP "^f.*"; -> 1
  mysql> select "fo\nfo" REGEXP "^f.*"; -> 1
  ```

- `a*` Match any sequence of zero or more `a` characters.

  ```
  mysql> select "Ban" REGEXP "^Ba*n"; -> 1
  mysql> select "Baaan" REGEXP "^Ba*n"; -> 1
  mysql> select "Bn" REGEXP "^Ba*n"; -> 1
  ```

- `a+` Match any sequence of one or more `a` characters.

  ```
  mysql> select "Ban" REGEXP "^Ba+n"; -> 1
  mysql> select "Bn" REGEXP "^Ba+n"; -> 0
  ```

- `a?` Match either zero or one a character.

  ```
  mysql> select "Bn" REGEXP "^Ba?n"; -> 1
  mysql> select "Ban" REGEXP "^Ba?n"; -> 1
  mysql> select "Baan" REGEXP "^Ba?n"; -> 0
  ```

- `de|abc` Match either of the sequences `de` or `abc`. 
### Appendix H: Description of MySQL regular expression syntax

MySQL supports regular expressions for pattern matching. Here are some examples:

```sql
mysql> select "pi" REGEXP "pi|apa"; -> 1
mysql> select "axe" REGEXP "pi|apa"; -> 0
mysql> select "apa" REGEXP "pi|apa"; -> 1
mysql> select "apa" REGEXP "^(pi|apa)$"; -> 1
mysql> select "pi" REGEXP "^(pi|apa)$"; -> 1
mysql> select "pix" REGEXP "^(pi|apa)$"; -> 0
```

#### (abc)*

Match zero or more instances of the sequence abc.

```sql
mysql> select "pi" REGEXP "^(pi)*$"; -> 1
mysql> select "pip" REGEXP "^(pi)*$"; -> 0
mysql> select "pipi" REGEXP "^(pi)*$"; -> 1
```

#### {1}

The is a more general way of writing regexps that match many occurrences of the previous atom.

- a* Can be written as a{0,}.
- a+ Can be written as a{1,}.
- a? Can be written as a{0,1}.

To be more precise, an atom followed by a bound containing one integer i and no comma matches a sequence of exactly i matches of the atom. An atom followed by a bound containing one integer i and a comma matches a sequence of i or more matches of the atom. An atom followed by a bound containing two integers i and j matches a sequence of i through j (inclusive) matches of the atom.

Both arguments must 0 >= value <= RE_DUP_MAX (default 255). If there are two arguments, the second must be greater than or equal to the first.

#### [a-dX]

Matches any character which is (or is not, if ^ is used) either a, b, c, d or X. To include a literal ] character, it must immediately follow the opening bracket [. To include a literal - character, it must be written first or last. So [0-9] matches any decimal digit. Any character that does not have a defined meaning inside a [] pair has no special meaning and matches only itself.

```sql
mysql> select "aXbc" REGEXP ":[a-dXYZ]"; -> 1
mysql> select "aXbc" REGEXP "^[a-dXYZ]$"; -> 0
mysql> select "aXbc" REGEXP "^[a-dXYZ]+$"; -> 1
mysql> select "aXbc" REGEXP "^[a-dXYZ]+$"; -> 0
```

#### [[.characters.]]

The sequence of characters of that collating element. The sequence is a single element of the bracket expression's list. A bracket expression containing a multi-character collating element can thus match more than one character, e.g., if the collating sequence includes a ch collating element, then the regular expression [[.ch.]]*c matches the first five characters of chchccc.
Appendix H: Description of MySQL regular expression syntax

[=character_class=] An equivalence class, standing for the sequences of characters of all collating elements equivalent to that one, including itself.
For example, if o and (+) are the members of an equivalence class, then [=[o=]], [=[(+)=]], and [=[o(+)]=] are all synonymous. An equivalence class may not be an endpoint of a range.

[[:character_class:]] Within a bracket expression, the name of a character class enclosed in [: and :] stands for the list of all characters belonging to that class. Standard character class names are:
    alnum    digit    punct
    alpha    graph    space
    blank    lower    upper
    cntrl    print    xdigit
These stand for the character classes defined in the ctype(3) manual page. A locale may provide others. A character class may not be used as an endpoint of a range.

    mysql> select "justalnums" REGEXP "[[:alnum:]]+";     -> 1
    mysql> select "!!" REGEXP "[[:alnum:]]+";             -> 0

[[[:<:]]] [[[:>:]]] These match the null string at the beginning and end of a word respectively. A word is defined as a sequence of word characters which is neither preceded nor followed by word characters. A word character is an alnum character (as defined by ctype(3)) or an underscore (_).

    mysql> select "a word a" REGEXP "[[:<:]]word[[:>:]]";     -> 1
    mysql> select "a xword a" REGEXP "[[:<:]]word[[:>:]]";      -> 0
    mysql> select "weeknights" REGEXP "~(wee|week)(knights|nights)$"; -> 1

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Appendix I What is Unireg?

Unireg is our tty interface builder, but it uses a low level connection to our ISAM (which is used by MySQL) and because of this it is very quick. It has existed since 1979 (on Unix in C since ~1986).

Unireg has the following components:

- One table viewer with updates/browsing.
- Multi table viewer (with one scrolling region).
- Table creator. (With lots of column tags you can’t create with MySQL) This is WYSIWYG (for a tty). You design a screen and Unireg prompts for the column specification.
- Report generator.
- A lot of utilities (quick export/import of tables to/from text files, analysis of table contents...).
- Powerful multi-table updates (which we use a lot) with a BASIC-like language with LOTS of functions.
- Dynamic languages (at present in Swedish and Finnish). If somebody wants an English version there are a few files that would have to be translated.
- The ability to run updates interactively or in a batch.
- Emacs-like key definitions with keyboard macros.
- All this in a binary of 800K.
- The convform utility. Converts ‘.frm’ and text files between different character sets.
- The myisampack utility. Packs a ISAM table (makes it 50-80% smaller). The table can be read by MySQL like an ordinary table. Only one record has to be decompressed per access. Cannot handle BLOB or TEXT columns or updates (yet).

We update most of our production databases with the Unireg interface and serve web pages through MySQL (and in some extreme cases the Unireg report generator).

Unireg takes about 3M of disk space and works on at least the following platforms: SunOS 4.x, Solaris, Linux, HP-UX, ICL Unix, DNIX, SCO and MS-DOS.

Unireg is currently only available in Swedish and Finnish.

The price tag for Unireg is 10,000 Swedish kr (about $1500 US), but this includes support. Unireg is distributed as a binary. (But all the ISAM sources can be found in MySQL). Usually we compile the binary for the customer at their site.

All new development is concentrated to MySQL.
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