MySQL Partitioning

Abstract

This is the MySQL Partitioning extract from the MySQL 8.2 Reference Manual.

For legal information, see the Legal Notices.

For help with using MySQL, please visit the MySQL Forums, where you can discuss your issues with other MySQL users.

Document generated on: 2024-01-25 (revision: 77710)

Table of Contents

Preface and Legal Notices

This is the MySQL Partitioning extract from the MySQL 8.2 Reference Manual.

Licensing information—MySQL 8.1. This product may include third-party software, used under license. If you are using a *Commercial* release of MySQL 8.1, see the MySQL 8.1 Commercial Release License Information User Manual for licensing information, including licensing information relating to third-party software that may be included in this Commercial release. If you are using a *Community* release of MySQL 8.1, see the MySQL 8.1 Community Release License Information User Manual for licensing information, including licensing information relating to third-party software that may be included in this Community release.

Legal Notices

License Restrictions

Warranty Disclaimer

Restricted Rights Notice

Hazardous Applications Notice

measures to ensure its safe use. Oracle Corporation and its affiliates disclaim any liability for any damages caused by use of this software or hardware in dangerous applications.

Documentation Accessibility

For information about Oracle's commitment to accessibility, visit the Oracle Accessibility Program website at
http://www.oracle.com/pls/topic/lookup?ctx=acc&id=docacc.

Access to Oracle Support for Accessibility

Oracle customers that have purchased support have access to electronic support through My Oracle Support. For information, visit
http://www.oracle.com/pls/topic/lookup?ctx=acc&id=info or visit `http://www.oracle.com/pls/topic/lookup?ctx=acc&id=trs` if you are hearing impaired.

Chapter 1 Partitioning

This chapter discusses *user-defined partitioning*.

> **Note**
>
> Table partitioning differs from partitioning as used by window functions. For information about window functions, see Window Functions.

In MySQL 8.2, partitioning support is provided by the `InnoDB` and `NDB` storage engines.

MySQL 8.2 does not currently support partitioning of tables using any storage engine other than `InnoDB` or `NDB`, such as `MyISAM`. An attempt to create a partitioned tables using a storage engine that does not supply native partitioning support fails with `ER_CHECK_NOT_IMPLEMENTED`.

MySQL 8.2 Community binaries provided by Oracle include partitioning support provided by the `InnoDB` and `NDB` storage engines. For information about partitioning support offered in MySQL Enterprise Edition binaries, see MySQL Enterprise Edition.

If you are compiling MySQL 8.2 from source, configuring the build with `InnoDB` support is sufficient to produce binaries with partition support for `InnoDB` tables. For more information, see Installing MySQL from Source.

Nothing further needs to be done to enable partitioning support by `InnoDB` (for example, no special entries are required in the `my.cnf` file).

It is not possible to disable partitioning support by the `InnoDB` storage engine.

See Chapter 2, *Overview of Partitioning in MySQL*, for an introduction to partitioning and partitioning concepts.

Several types of partitioning are supported, as well as subpartitioning; see Chapter 3, *Partitioning Types*, and Section 3.6, “Subpartitioning”.

Chapter 4, *Partition Management*, covers methods of adding, removing, and altering partitions in existing partitioned tables.

Section 4.4, “Maintenance of Partitions”, discusses table maintenance commands for use with partitioned tables.

The `PARTITIONS` table in the `INFORMATION_SCHEMA` database provides information about partitions and partitioned tables. See The INFORMATION_SCHEMA PARTITIONS Table, for more information; for some examples of queries against this table, see Section 3.7, “How MySQL Partitioning Handles NULL”.

For known issues with partitioning in MySQL 8.2, see Chapter 6, *Restrictions and Limitations on Partitioning*.

You may also find the following resources to be useful when working with partitioned tables.

Additional Resources. Other sources of information about user-defined partitioning in MySQL include the following:

- MySQL Partitioning Forum

  This is the official discussion forum for those interested in or experimenting with MySQL Partitioning technology. It features announcements and updates from MySQL developers and others. It is monitored by members of the Partitioning Development and Documentation Teams.

- PlanetMySQL

  A MySQL news site featuring MySQL-related blogs, which should be of interest to anyone using my MySQL. We encourage you to check here for links to blogs kept by those working with MySQL Partitioning, or to have your own blog added to those covered.

Chapter 2 Overview of Partitioning in MySQL

This section provides a conceptual overview of partitioning in MySQL 8.2.

For information on partitioning restrictions and feature limitations, see Chapter 6, *Restrictions and Limitations on Partitioning*.

The SQL standard does not provide much in the way of guidance regarding the physical aspects of data storage. The SQL language itself is intended to work independently of any data structures or media underlying the schemas, tables, rows, or columns with which it works. Nonetheless, most advanced database management systems have evolved some means of determining the physical location to be used for storing specific pieces of data in terms of the file system, hardware or even both. In MySQL, the `InnoDB` storage engine has long supported the notion of a tablespace (see Tablespaces), and the MySQL Server, even prior to the introduction of partitioning, could be configured to employ different physical directories for storing different databases (see Using Symbolic Links, for an explanation of how this is done).

Partitioning takes this notion a step further, by enabling you to distribute portions of individual tables across a file system according to rules which you can set largely as needed. In effect, different portions of a table are stored as separate tables in different locations. The user-selected rule by which the division of data is accomplished is known as a *partitioning function*, which in MySQL can be the modulus, simple matching against a set of ranges or value lists, an internal hashing function, or a linear hashing function. The function is selected according to the partitioning type specified by the user, and takes as its parameter the value of a user-supplied expression. This expression can be a column value, a function acting on one or more column values, or a set of one or more column values, depending on the type of partitioning that is used.

In the case of `RANGE`, `LIST`, and [`LINEAR`] `HASH` partitioning, the value of the partitioning column is passed to the partitioning function, which returns an integer value representing the number of the partition in which that particular record should be stored. This function must be nonconstant and nonrandom. It may not contain any queries, but may use an SQL expression that is valid in MySQL, as long as that expression returns either `NULL` or an integer *`intval`* such that

```
-MAXVALUE <= intval <= MAXVALUE
```

(`MAXVALUE` is used to represent the least upper bound for the type of integer in question. `-MAXVALUE` represents the greatest lower bound.)

For [`LINEAR`] `KEY`, `RANGE COLUMNS`, and `LIST COLUMNS` partitioning, the partitioning expression consists of a list of one or more columns.

For [`LINEAR`] `KEY` partitioning, the partitioning function is supplied by MySQL.

For more information about permitted partitioning column types and partitioning functions, see Chapter 3, *Partitioning Types*, as well as CREATE TABLE Statement, which provides partitioning syntax descriptions and additional examples. For information about restrictions on partitioning functions, see Section 6.3, “Partitioning Limitations Relating to Functions”.

This is known as *horizontal partitioning*—that is, different rows of a table may be assigned to different physical partitions. MySQL 8.2 does not support *vertical partitioning*, in which different columns of a table are assigned to different physical partitions. There are no plans at this time to introduce vertical partitioning into MySQL.

For creating partitioned tables, you must use a storage engine that supports them. In MySQL 8.2, all partitions of the same partitioned table must use the same storage engine. However, there is nothing preventing you from using different storage engines for different partitioned tables on the same MySQL server or even in the same database.

In MySQL 8.2, the only storage engines that support partitioning are `InnoDB` and `NDB`. Partitioning cannot be used with storage engines that do not support it; these include the `MyISAM`, `MERGE`, `CSV`, and `FEDERATED` storage engines.

Partitioning by `KEY` or `LINEAR KEY` is possible with `NDB`, but other types of user-defined partitioning are not supported for tables using this storage engine. In addition, an `NDB` table that employs user-defined partitioning must have an explicit primary key, and any columns referenced in the table's partitioning expression must be part of the primary key. However, if no columns are listed in the `PARTITION BY KEY` or `PARTITION BY LINEAR KEY` clause of the `CREATE TABLE` or `ALTER TABLE` statement used to create or modify a user-partitioned `NDB` table, then the table is not required to have an explicit primary key. For more information, see Noncompliance with SQL Syntax in NDB Cluster.

When creating a partitioned table, the default storage engine is used just as when creating any other table; to override this behavior, it is necessary only to use the `[STORAGE] ENGINE` option just as you would for a table that is not partitioned. The target storage engine must provide native partitioning support, or the statement fails. You should keep in mind that `[STORAGE] ENGINE` (and other table options) need to be listed *before* any partitioning options are used in a `CREATE TABLE` statement. This example shows how to create a table that is partitioned by hash into 6 partitions and which uses the `InnoDB` storage engine (regardless of the value of `default_storage_engine`):

```
CREATE TABLE ti (id INT, amount DECIMAL(7,2), tr_date DATE)
    ENGINE=INNODB
    PARTITION BY HASH( MONTH(tr_date) )
    PARTITIONS 6;
```

Each `PARTITION` clause can include a `[STORAGE] ENGINE` option, but in MySQL 8.2 this has no effect.

Unless otherwise specified, the remaining examples in this discussion assume that `default_storage_engine` is `InnoDB`.

> **Important**
>
> Partitioning applies to all data and indexes of a table; you cannot partition only the data and not the indexes, or vice versa, nor can you partition only a portion of the table.

Data and indexes for each partition can be assigned to a specific directory using the `DATA DIRECTORY` and `INDEX DIRECTORY` options for the `PARTITION` clause of the `CREATE TABLE` statement used to create the partitioned table.

Only the `DATA DIRECTORY` option is supported for individual partitions and subpartitions of `InnoDB` tables. The directory specified in a `DATA DIRECTORY` clause must be known to `InnoDB`. For more information, see Using the DATA DIRECTORY Clause.

All columns used in the table's partitioning expression must be part of every unique key that the table may have, including any primary key. This means that a table such as this one, created by the following SQL statement, cannot be partitioned:

```
CREATE TABLE tnp (
    id INT NOT NULL AUTO_INCREMENT,
    ref BIGINT NOT NULL,
    name VARCHAR(255),
    PRIMARY KEY pk (id),
    UNIQUE KEY uk (name)
);
```

Because the keys `pk` and `uk` have no columns in common, there are no columns available for use in a partitioning expression. Possible workarounds in this situation include adding the `name` column to the

table's primary key, adding the `id` column to `uk`, or simply removing the unique key altogether. See Section 6.1, “Partitioning Keys, Primary Keys, and Unique Keys”, for more information.

In addition, `MAX_ROWS` and `MIN_ROWS` can be used to determine the maximum and minimum numbers of rows, respectively, that can be stored in each partition. See Chapter 4, *Partition Management*, for more information on these options.

The `MAX_ROWS` option can also be useful for creating NDB Cluster tables with extra partitions, thus allowing for greater storage of hash indexes. See the documentation for the `DataMemory` data node configuration parameter, as well as NDB Cluster Nodes, Node Groups, Fragment Replicas, and Partitions, for more information.

Some advantages of partitioning are listed here:

- Partitioning makes it possible to store more data in one table than can be held on a single disk or file system partition.
- Data that loses its usefulness can often be easily removed from a partitioned table by dropping the partition (or partitions) containing only that data. Conversely, the process of adding new data can in some cases be greatly facilitated by adding one or more new partitions for storing specifically that data.
- Some queries can be greatly optimized in virtue of the fact that data satisfying a given `WHERE` clause can be stored only on one or more partitions, which automatically excludes any remaining partitions from the search. Because partitions can be altered after a partitioned table has been created, you can reorganize your data to enhance frequent queries that may not have been often used when the partitioning scheme was first set up. This ability to exclude non-matching partitions (and thus any rows they contain) is often referred to as *partition pruning*. For more information, see Chapter 5, *Partition Pruning*.

  In addition, MySQL supports explicit partition selection for queries. For example, `SELECT * FROM t PARTITION (p0,p1) WHERE c < 5` selects only those rows in partitions `p0` and `p1` that match the `WHERE` condition. In this case, MySQL does not check any other partitions of table `t`; this can greatly speed up queries when you already know which partition or partitions you wish to examine. Partition selection is also supported for the data modification statements `DELETE`, `INSERT`, `REPLACE`, `UPDATE`, and `LOAD DATA`, `LOAD XML`. See the descriptions of these statements for more information and examples.

Chapter 3 Partitioning Types

Table of Contents

This section discusses the types of partitioning which are available in MySQL 8.2. These include the types listed here:

- **RANGE partitioning.** This type of partitioning assigns rows to partitions based on column values falling within a given range. See Section 3.1, “RANGE Partitioning”. For information about an extension to this type, `RANGE COLUMNS`, see Section 3.3.1, “RANGE COLUMNS partitioning”.

- **LIST partitioning.** Similar to partitioning by `RANGE`, except that the partition is selected based on columns matching one of a set of discrete values. See Section 3.2, “LIST Partitioning”. For information about an extension to this type, `LIST COLUMNS`, see Section 3.3.2, “LIST COLUMNS partitioning”.

- **HASH partitioning.** With this type of partitioning, a partition is selected based on the value returned by a user-defined expression that operates on column values in rows to be inserted into the table. The function may consist of any expression valid in MySQL that yields an integer value. See Section 3.4, “HASH Partitioning”.

  An extension to this type, `LINEAR HASH`, is also available, see Section 3.4.1, “LINEAR HASH Partitioning”.

- **KEY partitioning.** This type of partitioning is similar to partitioning by `HASH`, except that only one or more columns to be evaluated are supplied, and the MySQL server provides its own hashing function. These columns can contain other than integer values, since the hashing function supplied by MySQL guarantees an integer result regardless of the column data type. An extension to this type, `LINEAR KEY`, is also available. See Section 3.5, “KEY Partitioning”.

A very common use of database partitioning is to segregate data by date. Some database systems support explicit date partitioning, which MySQL does not implement in 8.2. However, it is not difficult in MySQL to create partitioning schemes based on `DATE`, `TIME`, or `DATETIME` columns, or based on expressions making use of such columns.

When partitioning by `KEY` or `LINEAR KEY`, you can use a `DATE`, `TIME`, or `DATETIME` column as the partitioning column without performing any modification of the column value. For example, this table creation statement is perfectly valid in MySQL:

```
CREATE TABLE members (
    firstname VARCHAR(25) NOT NULL,
    lastname VARCHAR(25) NOT NULL,
    username VARCHAR(16) NOT NULL,
```

```
    email VARCHAR(35),
    joined DATE NOT NULL
)
PARTITION BY KEY(joined)
PARTITIONS 6;
```

In MySQL 8.2, it is also possible to use a `DATE` or `DATETIME` column as the partitioning column using `RANGE COLUMNS` and `LIST COLUMNS` partitioning.

Other partitioning types require a partitioning expression that yields an integer value or `NULL`. If you wish to use date-based partitioning by `RANGE`, `LIST`, `HASH`, or `LINEAR HASH`, you can simply employ a function that operates on a `DATE`, `TIME`, or `DATETIME` column and returns such a value, as shown here:

```
CREATE TABLE members (
    firstname VARCHAR(25) NOT NULL,
    lastname VARCHAR(25) NOT NULL,
    username VARCHAR(16) NOT NULL,
    email VARCHAR(35),
    joined DATE NOT NULL
)
PARTITION BY RANGE( YEAR(joined) ) (
    PARTITION p0 VALUES LESS THAN (1960),
    PARTITION p1 VALUES LESS THAN (1970),
    PARTITION p2 VALUES LESS THAN (1980),
    PARTITION p3 VALUES LESS THAN (1990),
    PARTITION p4 VALUES LESS THAN MAXVALUE
);
```

Additional examples of partitioning using dates may be found in the following sections of this chapter:

- Section 3.1, “RANGE Partitioning”
- Section 3.4, “HASH Partitioning”
- Section 3.4.1, “LINEAR HASH Partitioning”

For more complex examples of date-based partitioning, see the following sections:

- Chapter 5, *Partition Pruning*
- Section 3.6, “Subpartitioning”

MySQL partitioning is optimized for use with the `TO_DAYS()`, `YEAR()`, and `TO_SECONDS()` functions. However, you can use other date and time functions that return an integer or `NULL`, such as `WEEKDAY()`, `DAYOFYEAR()`, or `MONTH()`. See Date and Time Functions, for more information about such functions.

It is important to remember—regardless of the type of partitioning that you use—that partitions are always numbered automatically and in sequence when created, starting with `0`. When a new row is inserted into a partitioned table, it is these partition numbers that are used in identifying the correct partition. For example, if your table uses 4 partitions, these partitions are numbered `0`, `1`, `2`, and `3`. For the `RANGE` and `LIST` partitioning types, it is necessary to ensure that there is a partition defined for each partition number. For `HASH` partitioning, the user-supplied expression must evaluate to an integer value. For `KEY` partitioning, this issue is taken care of automatically by the hashing function which the MySQL server employs internally.

Names of partitions generally follow the rules governing other MySQL identifiers, such as those for tables and databases. However, you should note that partition names are not case-sensitive. For example, the following `CREATE TABLE` statement fails as shown:

```
mysql> CREATE TABLE t2 (val INT)
    -> PARTITION BY LIST(val)(
    ->     PARTITION mypart VALUES IN (1,3,5),
    ->     PARTITION MyPart VALUES IN (2,4,6)
```

```
    -> );
ERROR 1488 (HY000): Duplicate partition name mypart
```

Failure occurs because MySQL sees no difference between the partition names `mypart` and `MyPart`.

When you specify the number of partitions for the table, this must be expressed as a positive, nonzero integer literal with no leading zeros, and may not be an expression such as `0.8E+01` or `6-2`, even if it evaluates to an integer value. Decimal fractions are not permitted.

In the sections that follow, we do not necessarily provide all possible forms for the syntax that can be used for creating each partition type; for this information, see CREATE TABLE Statement.

3.1 RANGE Partitioning

A table that is partitioned by range is partitioned in such a way that each partition contains rows for which the partitioning expression value lies within a given range. Ranges should be contiguous but not overlapping, and are defined using the `VALUES LESS THAN` operator. For the next few examples, suppose that you are creating a table such as the following to hold personnel records for a chain of 20 video stores, numbered 1 through 20:

```
CREATE TABLE employees (
    id INT NOT NULL,
    fname VARCHAR(30),
    lname VARCHAR(30),
    hired DATE NOT NULL DEFAULT '1970-01-01',
    separated DATE NOT NULL DEFAULT '9999-12-31',
    job_code INT NOT NULL,
    store_id INT NOT NULL
);
```

> **Note**
>
> The `employees` table used here has no primary or unique keys. While the examples work as shown for purposes of the present discussion, you should keep in mind that tables are extremely likely in practice to have primary keys, unique keys, or both, and that allowable choices for partitioning columns depend on the columns used for these keys, if any are present. For a discussion of these issues, see Section 6.1, “Partitioning Keys, Primary Keys, and Unique Keys”.

This table can be partitioned by range in a number of ways, depending on your needs. One way would be to use the `store_id` column. For instance, you might decide to partition the table 4 ways by adding a `PARTITION BY RANGE` clause as shown here:

```
CREATE TABLE employees (
    id INT NOT NULL,
    fname VARCHAR(30),
    lname VARCHAR(30),
    hired DATE NOT NULL DEFAULT '1970-01-01',
    separated DATE NOT NULL DEFAULT '9999-12-31',
    job_code INT NOT NULL,
    store_id INT NOT NULL
)
PARTITION BY RANGE (store_id) (
    PARTITION p0 VALUES LESS THAN (6),
    PARTITION p1 VALUES LESS THAN (11),
    PARTITION p2 VALUES LESS THAN (16),
    PARTITION p3 VALUES LESS THAN (21)
);
```

In this partitioning scheme, all rows corresponding to employees working at stores 1 through 5 are stored in partition `p0`, to those employed at stores 6 through 10 are stored in partition `p1`, and so on. Each

partition is defined in order, from lowest to highest. This is a requirement of the `PARTITION BY RANGE` syntax; you can think of it as being analogous to a series of `if ... elseif ...` statements in C or Java in this regard.

It is easy to determine that a new row containing the data `(72, 'Mitchell', 'Wilson', '1998-06-25', DEFAULT, 7, 13)` is inserted into partition `p2`, but what happens when your chain adds a 21st store? Under this scheme, there is no rule that covers a row whose `store_id` is greater than 20, so an error results because the server does not know where to place it. You can keep this from occurring by using a "catchall" `VALUES LESS THAN` clause in the `CREATE TABLE` statement that provides for all values greater than the highest value explicitly named:

```
CREATE TABLE employees (
    id INT NOT NULL,
    fname VARCHAR(30),
    lname VARCHAR(30),
    hired DATE NOT NULL DEFAULT '1970-01-01',
    separated DATE NOT NULL DEFAULT '9999-12-31',
    job_code INT NOT NULL,
    store_id INT NOT NULL
)
PARTITION BY RANGE (store_id) (
    PARTITION p0 VALUES LESS THAN (6),
    PARTITION p1 VALUES LESS THAN (11),
    PARTITION p2 VALUES LESS THAN (16),
    PARTITION p3 VALUES LESS THAN MAXVALUE
);
```

(As with the other examples in this chapter, we assume that the default storage engine is `InnoDB`.)

Another way to avoid an error when no matching value is found is to use the `IGNORE` keyword as part of the `INSERT` statement. For an example, see Section 3.2, "LIST Partitioning".

`MAXVALUE` represents an integer value that is always greater than the largest possible integer value (in mathematical language, it serves as a *least upper bound*). Now, any rows whose `store_id` column value is greater than or equal to 16 (the highest value defined) are stored in partition `p3`. At some point in the future—when the number of stores has increased to 25, 30, or more—you can use an `ALTER TABLE` statement to add new partitions for stores 21-25, 26-30, and so on (see Chapter 4, *Partition Management*, for details of how to do this).

In much the same fashion, you could partition the table based on employee job codes—that is, based on ranges of `job_code` column values. For example—assuming that two-digit job codes are used for regular (in-store) workers, three-digit codes are used for office and support personnel, and four-digit codes are used for management positions—you could create the partitioned table using the following statement:

```
CREATE TABLE employees (
    id INT NOT NULL,
    fname VARCHAR(30),
    lname VARCHAR(30),
    hired DATE NOT NULL DEFAULT '1970-01-01',
    separated DATE NOT NULL DEFAULT '9999-12-31',
    job_code INT NOT NULL,
    store_id INT NOT NULL
)
PARTITION BY RANGE (job_code) (
    PARTITION p0 VALUES LESS THAN (100),
    PARTITION p1 VALUES LESS THAN (1000),
    PARTITION p2 VALUES LESS THAN (10000)
);
```

In this instance, all rows relating to in-store workers would be stored in partition `p0`, those relating to office and support staff in `p1`, and those relating to managers in partition `p2`.

It is also possible to use an expression in `VALUES LESS THAN` clauses. However, MySQL must be able to evaluate the expression's return value as part of a `LESS THAN` (`<`) comparison.

Rather than splitting up the table data according to store number, you can use an expression based on one of the two `DATE` columns instead. For example, let us suppose that you wish to partition based on the year that each employee left the company; that is, the value of `YEAR(separated)`. An example of a `CREATE TABLE` statement that implements such a partitioning scheme is shown here:

```
CREATE TABLE employees (
    id INT NOT NULL,
    fname VARCHAR(30),
    lname VARCHAR(30),
    hired DATE NOT NULL DEFAULT '1970-01-01',
    separated DATE NOT NULL DEFAULT '9999-12-31',
    job_code INT,
    store_id INT
)
PARTITION BY RANGE ( YEAR(separated) ) (
    PARTITION p0 VALUES LESS THAN (1991),
    PARTITION p1 VALUES LESS THAN (1996),
    PARTITION p2 VALUES LESS THAN (2001),
    PARTITION p3 VALUES LESS THAN MAXVALUE
);
```

In this scheme, for all employees who left before 1991, the rows are stored in partition `p0`; for those who left in the years 1991 through 1995, in `p1`; for those who left in the years 1996 through 2000, in `p2`; and for any workers who left after the year 2000, in `p3`.

It is also possible to partition a table by `RANGE`, based on the value of a `TIMESTAMP` column, using the `UNIX_TIMESTAMP()` function, as shown in this example:

```
CREATE TABLE quarterly_report_status (
    report_id INT NOT NULL,
    report_status VARCHAR(20) NOT NULL,
    report_updated TIMESTAMP NOT NULL DEFAULT CURRENT_TIMESTAMP ON UPDATE CURRENT_TIMESTAMP
)
PARTITION BY RANGE ( UNIX_TIMESTAMP(report_updated) ) (
    PARTITION p0 VALUES LESS THAN ( UNIX_TIMESTAMP('2008-01-01 00:00:00') ),
    PARTITION p1 VALUES LESS THAN ( UNIX_TIMESTAMP('2008-04-01 00:00:00') ),
    PARTITION p2 VALUES LESS THAN ( UNIX_TIMESTAMP('2008-07-01 00:00:00') ),
    PARTITION p3 VALUES LESS THAN ( UNIX_TIMESTAMP('2008-10-01 00:00:00') ),
    PARTITION p4 VALUES LESS THAN ( UNIX_TIMESTAMP('2009-01-01 00:00:00') ),
    PARTITION p5 VALUES LESS THAN ( UNIX_TIMESTAMP('2009-04-01 00:00:00') ),
    PARTITION p6 VALUES LESS THAN ( UNIX_TIMESTAMP('2009-07-01 00:00:00') ),
    PARTITION p7 VALUES LESS THAN ( UNIX_TIMESTAMP('2009-10-01 00:00:00') ),
    PARTITION p8 VALUES LESS THAN ( UNIX_TIMESTAMP('2010-01-01 00:00:00') ),
    PARTITION p9 VALUES LESS THAN (MAXVALUE)
);
```

Any other expressions involving `TIMESTAMP` values are not permitted. (See Bug #42849.)

Range partitioning is particularly useful when one or more of the following conditions is true:

- You want or need to delete “old” data. If you are using the partitioning scheme shown previously for the `employees` table, you can simply use `ALTER TABLE employees DROP PARTITION p0;` to delete all rows relating to employees who stopped working for the firm prior to 1991. (See ALTER TABLE Statement, and Chapter 4, *Partition Management*, for more information.) For a table with a great many rows, this can be much more efficient than running a `DELETE` query such as `DELETE FROM employees WHERE YEAR(separated) <= 1990;`.
- You want to use a column containing date or time values, or containing values arising from some other series.

- You frequently run queries that depend directly on the column used for partitioning the table. For example, when executing a query such as `EXPLAIN SELECT COUNT(*) FROM employees WHERE separated BETWEEN '2000-01-01' AND '2000-12-31' GROUP BY store_id;`, MySQL can quickly determine that only partition `p2` needs to be scanned because the remaining partitions cannot contain any records satisfying the `WHERE` clause. See Chapter 5, *Partition Pruning*, for more information about how this is accomplished.

A variant on this type of partitioning is `RANGE COLUMNS` partitioning. Partitioning by `RANGE COLUMNS` makes it possible to employ multiple columns for defining partitioning ranges that apply both to placement of rows in partitions and for determining the inclusion or exclusion of specific partitions when performing partition pruning. See Section 3.3.1, “RANGE COLUMNS partitioning”, for more information.

Partitioning schemes based on time intervals. If you wish to implement a partitioning scheme based on ranges or intervals of time in MySQL 8.2, you have two options:

1. Partition the table by `RANGE`, and for the partitioning expression, employ a function operating on a `DATE`, `TIME`, or `DATETIME` column and returning an integer value, as shown here:

```
CREATE TABLE members (
    firstname VARCHAR(25) NOT NULL,
    lastname VARCHAR(25) NOT NULL,
    username VARCHAR(16) NOT NULL,
    email VARCHAR(35),
    joined DATE NOT NULL
)
PARTITION BY RANGE( YEAR(joined) ) (
    PARTITION p0 VALUES LESS THAN (1960),
    PARTITION p1 VALUES LESS THAN (1970),
    PARTITION p2 VALUES LESS THAN (1980),
    PARTITION p3 VALUES LESS THAN (1990),
    PARTITION p4 VALUES LESS THAN MAXVALUE
);
```

   In MySQL 8.2, it is also possible to partition a table by `RANGE` based on the value of a `TIMESTAMP` column, using the `UNIX_TIMESTAMP()` function, as shown in this example:

```
CREATE TABLE quarterly_report_status (
    report_id INT NOT NULL,
    report_status VARCHAR(20) NOT NULL,
    report_updated TIMESTAMP NOT NULL DEFAULT CURRENT_TIMESTAMP ON UPDATE CURRENT_TIMESTAMP
)
PARTITION BY RANGE ( UNIX_TIMESTAMP(report_updated) ) (
    PARTITION p0 VALUES LESS THAN ( UNIX_TIMESTAMP('2008-01-01 00:00:00') ),
    PARTITION p1 VALUES LESS THAN ( UNIX_TIMESTAMP('2008-04-01 00:00:00') ),
    PARTITION p2 VALUES LESS THAN ( UNIX_TIMESTAMP('2008-07-01 00:00:00') ),
    PARTITION p3 VALUES LESS THAN ( UNIX_TIMESTAMP('2008-10-01 00:00:00') ),
    PARTITION p4 VALUES LESS THAN ( UNIX_TIMESTAMP('2009-01-01 00:00:00') ),
    PARTITION p5 VALUES LESS THAN ( UNIX_TIMESTAMP('2009-04-01 00:00:00') ),
    PARTITION p6 VALUES LESS THAN ( UNIX_TIMESTAMP('2009-07-01 00:00:00') ),
    PARTITION p7 VALUES LESS THAN ( UNIX_TIMESTAMP('2009-10-01 00:00:00') ),
    PARTITION p8 VALUES LESS THAN ( UNIX_TIMESTAMP('2010-01-01 00:00:00') ),
    PARTITION p9 VALUES LESS THAN (MAXVALUE)
);
```

   In MySQL 8.2, any other expressions involving `TIMESTAMP` values are not permitted. (See Bug #42849.)

   > **Note**
   >
   > It is also possible in MySQL 8.2 to use `UNIX_TIMESTAMP(timestamp_column)` as a partitioning expression for tables that are partitioned by `LIST`. However, it is usually not practical to do so.

2. Partition the table by `RANGE COLUMNS`, using a `DATE` or `DATETIME` column as the partitioning column. For example, the `members` table could be defined using the `joined` column directly, as shown here:

```
CREATE TABLE members (
    firstname VARCHAR(25) NOT NULL,
    lastname VARCHAR(25) NOT NULL,
    username VARCHAR(16) NOT NULL,
    email VARCHAR(35),
    joined DATE NOT NULL
)
PARTITION BY RANGE COLUMNS(joined) (
    PARTITION p0 VALUES LESS THAN ('1960-01-01'),
    PARTITION p1 VALUES LESS THAN ('1970-01-01'),
    PARTITION p2 VALUES LESS THAN ('1980-01-01'),
    PARTITION p3 VALUES LESS THAN ('1990-01-01'),
    PARTITION p4 VALUES LESS THAN MAXVALUE
);
```

> **Note**
>
> The use of partitioning columns employing date or time types other than `DATE` or `DATETIME` is not supported with `RANGE COLUMNS`.

3.2 LIST Partitioning

List partitioning in MySQL is similar to range partitioning in many ways. As in partitioning by `RANGE`, each partition must be explicitly defined. The chief difference between the two types of partitioning is that, in list partitioning, each partition is defined and selected based on the membership of a column value in one of a set of value lists, rather than in one of a set of contiguous ranges of values. This is done by using `PARTITION BY LIST(`*`expr`*`)` where *`expr`* is a column value or an expression based on a column value and returning an integer value, and then defining each partition by means of a `VALUES IN (`*`value_list`*`)`, where *`value_list`* is a comma-separated list of integers.

> **Note**
>
> In MySQL 8.2, it is possible to match against only a list of integers (and possibly `NULL`—see Section 3.7, “How MySQL Partitioning Handles NULL”) when partitioning by `LIST`.
>
> However, other column types may be used in value lists when employing `LIST COLUMN` partitioning, which is described later in this section.

Unlike the case with partitions defined by range, list partitions do not need to be declared in any particular order. For more detailed syntactical information, see CREATE TABLE Statement.

For the examples that follow, we assume that the basic definition of the table to be partitioned is provided by the `CREATE TABLE` statement shown here:

```
CREATE TABLE employees (
    id INT NOT NULL,
    fname VARCHAR(30),
    lname VARCHAR(30),
    hired DATE NOT NULL DEFAULT '1970-01-01',
    separated DATE NOT NULL DEFAULT '9999-12-31',
    job_code INT,
    store_id INT
);
```

(This is the same table used as a basis for the examples in Section 3.1, “RANGE Partitioning”. As with the other partitioning examples, we assume that the `default_storage_engine` is `InnoDB`.)

Suppose that there are 20 video stores distributed among 4 franchises as shown in the following table.

Region	Store ID Numbers
North	3, 5, 6, 9, 17
East	1, 2, 10, 11, 19, 20
West	4, 12, 13, 14, 18
Central	7, 8, 15, 16

To partition this table in such a way that rows for stores belonging to the same region are stored in the same partition, you could use the `CREATE TABLE` statement shown here:

```
CREATE TABLE employees (
    id INT NOT NULL,
    fname VARCHAR(30),
    lname VARCHAR(30),
    hired DATE NOT NULL DEFAULT '1970-01-01',
    separated DATE NOT NULL DEFAULT '9999-12-31',
    job_code INT,
    store_id INT
)
PARTITION BY LIST(store_id) (
    PARTITION pNorth VALUES IN (3,5,6,9,17),
    PARTITION pEast VALUES IN (1,2,10,11,19,20),
    PARTITION pWest VALUES IN (4,12,13,14,18),
    PARTITION pCentral VALUES IN (7,8,15,16)
);
```

This makes it easy to add or drop employee records relating to specific regions to or from the table. For instance, suppose that all stores in the West region are sold to another company. In MySQL 8.2, all rows relating to employees working at stores in that region can be deleted with the query `ALTER TABLE employees TRUNCATE PARTITION pWest`, which can be executed much more efficiently than the equivalent `DELETE` statement `DELETE FROM employees WHERE store_id IN (4,12,13,14,18);`. (Using `ALTER TABLE employees DROP PARTITION pWest` would also delete all of these rows, but would also remove the partition `pWest` from the definition of the table; you would need to use an `ALTER TABLE ... ADD PARTITION` statement to restore the table's original partitioning scheme.)

As with `RANGE` partitioning, it is possible to combine `LIST` partitioning with partitioning by hash or key to produce a composite partitioning (subpartitioning). See Section 3.6, “Subpartitioning”.

Unlike the case with `RANGE` partitioning, there is no “catch-all” such as `MAXVALUE`; all expected values for the partitioning expression should be covered in `PARTITION ... VALUES IN (...)` clauses. An `INSERT` statement containing an unmatched partitioning column value fails with an error, as shown in this example:

```
mysql> CREATE TABLE h2 (
    ->   c1 INT,
    ->   c2 INT
    -> )
    -> PARTITION BY LIST(c1) (
    ->   PARTITION p0 VALUES IN (1, 4, 7),
    ->   PARTITION p1 VALUES IN (2, 5, 8)
    -> );
Query OK, 0 rows affected (0.11 sec)
mysql> INSERT INTO h2 VALUES (3, 5);
ERROR 1525 (HY000): Table has no partition for value 3
```

When inserting multiple rows using a single `INSERT` statement into a single `InnoDB` table, `InnoDB` considers the statement a single transaction, so that the presence of any unmatched values causes the statement to fail completely, and so no rows are inserted.

You can cause this type of error to be ignored by using the `IGNORE` keyword, although a warning is issued for each row containing unmatched partitioning column values, as shown here.

```
mysql> TRUNCATE h2;
Query OK, 1 row affected (0.00 sec)
mysql> TABLE h2;
Empty set (0.00 sec)
mysql> INSERT IGNORE INTO h2 VALUES (2, 5), (6, 10), (7, 5), (3, 1), (1, 9);
Query OK, 3 rows affected, 2 warnings (0.01 sec)
Records: 5  Duplicates: 2  Warnings: 2
mysql> SHOW WARNINGS;
+---------+------+-------------------------------------+
| Level   | Code | Message                             |
+---------+------+-------------------------------------+
| Warning | 1526 | Table has no partition for value 6 |
| Warning | 1526 | Table has no partition for value 3 |
+---------+------+-------------------------------------+
2 rows in set (0.00 sec)
```

You can see in the output of the following `TABLE` statement that rows containing unmatched partitioning column values were silently rejected, while rows containing no unmatched values were inserted into the table:

```
mysql> TABLE h2;
+------+------+
| c1   | c2   |
+------+------+
|    7 |    5 |
|    1 |    9 |
|    2 |    5 |
+------+------+
3 rows in set (0.00 sec)
```

MySQL also provides support for `LIST COLUMNS` partitioning, a variant of `LIST` partitioning that enables you to use columns of types other than integer for partitioning columns, and to use multiple columns as partitioning keys. For more information, see Section 3.3.2, “LIST COLUMNS partitioning”.

3.3 COLUMNS Partitioning

The next two sections discuss *`COLUMNS` partitioning*, which are variants on `RANGE` and `LIST` partitioning. `COLUMNS` partitioning enables the use of multiple columns in partitioning keys. All of these columns are taken into account both for the purpose of placing rows in partitions and for the determination of which partitions are to be checked for matching rows in partition pruning.

In addition, both `RANGE COLUMNS` partitioning and `LIST COLUMNS` partitioning support the use of non-integer columns for defining value ranges or list members. The permitted data types are shown in the following list:

- All integer types: `TINYINT`, `SMALLINT`, `MEDIUMINT`, `INT` (`INTEGER`), and `BIGINT`. (This is the same as with partitioning by `RANGE` and `LIST`.)

  Other numeric data types (such as `DECIMAL` or `FLOAT`) are not supported as partitioning columns.

- `DATE` and `DATETIME`.

  Columns using other data types relating to dates or times are not supported as partitioning columns.

- The following string types: `CHAR`, `VARCHAR`, `BINARY`, and `VARBINARY`.

  `TEXT` and `BLOB` columns are not supported as partitioning columns.

The discussions of `RANGE COLUMNS` and `LIST COLUMNS` partitioning in the next two sections assume that you are already familiar with partitioning based on ranges and lists as supported in MySQL 5.1 and later; for more information about these, see Section 3.1, “RANGE Partitioning”, and Section 3.2, “LIST Partitioning”, respectively.

3.3.1 RANGE COLUMNS partitioning

Range columns partitioning is similar to range partitioning, but enables you to define partitions using ranges based on multiple column values. In addition, you can define the ranges using columns of types other than integer types.

`RANGE COLUMNS` partitioning differs significantly from `RANGE` partitioning in the following ways:

- `RANGE COLUMNS` does not accept expressions, only names of columns.
- `RANGE COLUMNS` accepts a list of one or more columns.

  `RANGE COLUMNS` partitions are based on comparisons between *tuples* (lists of column values) rather than comparisons between scalar values. Placement of rows in `RANGE COLUMNS` partitions is also based on comparisons between tuples; this is discussed further later in this section.
- `RANGE COLUMNS` partitioning columns are not restricted to integer columns; string, `DATE` and `DATETIME` columns can also be used as partitioning columns. (See Section 3.3, “COLUMNS Partitioning”, for details.)

The basic syntax for creating a table partitioned by `RANGE COLUMNS` is shown here:

```
CREATE TABLE table_name
PARTITION BY RANGE COLUMNS(column_list) (
    PARTITION partition_name VALUES LESS THAN (value_list)[,
    PARTITION partition_name VALUES LESS THAN (value_list)][,
    ...]
)
column_list:
    column_name[, column_name][, ...]
value_list:
    value[, value][, ...]
```

> **Note**
>
> Not all `CREATE TABLE` options that can be used when creating partitioned tables are shown here. For complete information, see CREATE TABLE Statement.

In the syntax just shown, *`column_list`* is a list of one or more columns (sometimes called a *partitioning column list*), and *`value_list`* is a list of values (that is, it is a *partition definition value list*). A *`value_list`* must be supplied for each partition definition, and each *`value_list`* must have the same number of values as the *`column_list`* has columns. Generally speaking, if you use *`N`* columns in the `COLUMNS` clause, then each `VALUES LESS THAN` clause must also be supplied with a list of *`N`* values.

The elements in the partitioning column list and in the value list defining each partition must occur in the same order. In addition, each element in the value list must be of the same data type as the corresponding element in the column list. However, the order of the column names in the partitioning column list and the value lists does not have to be the same as the order of the table column definitions in the main part of the `CREATE TABLE` statement. As with table partitioned by `RANGE`, you can use `MAXVALUE` to represent a value such that any legal value inserted into a given column is always less than this value. Here is an example of a `CREATE TABLE` statement that helps to illustrate all of these points:

```
mysql> CREATE TABLE rcx (
    ->     a INT,
```

```
    ->     b INT,
    ->     c CHAR(3),
    ->     d INT
    -> )
    -> PARTITION BY RANGE COLUMNS(a,d,c) (
    ->     PARTITION p0 VALUES LESS THAN (5,10,'ggg'),
    ->     PARTITION p1 VALUES LESS THAN (10,20,'mmm'),
    ->     PARTITION p2 VALUES LESS THAN (15,30,'sss'),
    ->     PARTITION p3 VALUES LESS THAN (MAXVALUE,MAXVALUE,MAXVALUE)
    -> );
Query OK, 0 rows affected (0.15 sec)
```

Table `rcx` contains the columns `a`, `b`, `c`, `d`. The partitioning column list supplied to the `COLUMNS` clause uses 3 of these columns, in the order `a`, `d`, `c`. Each value list used to define a partition contains 3 values in the same order; that is, each value list tuple has the form (`INT`, `INT`, `CHAR(3)`), which corresponds to the data types used by columns `a`, `d`, and `c` (in that order).

Placement of rows into partitions is determined by comparing the tuple from a row to be inserted that matches the column list in the `COLUMNS` clause with the tuples used in the `VALUES LESS THAN` clauses to define partitions of the table. Because we are comparing tuples (that is, lists or sets of values) rather than scalar values, the semantics of `VALUES LESS THAN` as used with `RANGE COLUMNS` partitions differs somewhat from the case with simple `RANGE` partitions. In `RANGE` partitioning, a row generating an expression value that is equal to a limiting value in a `VALUES LESS THAN` is never placed in the corresponding partition; however, when using `RANGE COLUMNS` partitioning, it is sometimes possible for a row whose partitioning column list's first element is equal in value to the that of the first element in a `VALUES LESS THAN` value list to be placed in the corresponding partition.

Consider the `RANGE` partitioned table created by this statement:

```
CREATE TABLE r1 (
    a INT,
    b INT
)
PARTITION BY RANGE (a)  (
    PARTITION p0 VALUES LESS THAN (5),
    PARTITION p1 VALUES LESS THAN (MAXVALUE)
);
```

If we insert 3 rows into this table such that the column value for `a` is `5` for each row, all 3 rows are stored in partition `p1` because the `a` column value is in each case not less than 5, as we can see by executing the proper query against the Information Schema `PARTITIONS` table:

```
mysql> INSERT INTO r1 VALUES (5,10), (5,11), (5,12);
Query OK, 3 rows affected (0.00 sec)
Records: 3  Duplicates: 0  Warnings: 0
mysql> SELECT PARTITION_NAME, TABLE_ROWS
    ->     FROM INFORMATION_SCHEMA.PARTITIONS
    ->     WHERE TABLE_NAME = 'r1';
+----------------+------------+
| PARTITION_NAME | TABLE_ROWS |
+----------------+------------+
| p0             |          0 |
| p1             |          3 |
+----------------+------------+
2 rows in set (0.00 sec)
```

Now consider a similar table `rc1` that uses `RANGE COLUMNS` partitioning with both columns `a` and `b` referenced in the `COLUMNS` clause, created as shown here:

```
CREATE TABLE rc1 (
    a INT,
    b INT
)
```

```
PARTITION BY RANGE COLUMNS(a, b) (
    PARTITION p0 VALUES LESS THAN (5, 12),
    PARTITION p3 VALUES LESS THAN (MAXVALUE, MAXVALUE)
);
```

If we insert exactly the same rows into `rc1` as we just inserted into `r1`, the distribution of the rows is quite different:

```
mysql> INSERT INTO rc1 VALUES (5,10), (5,11), (5,12);
Query OK, 3 rows affected (0.00 sec)
Records: 3  Duplicates: 0  Warnings: 0
mysql> SELECT PARTITION_NAME, TABLE_ROWS
    ->     FROM INFORMATION_SCHEMA.PARTITIONS
    ->     WHERE TABLE_NAME = 'rc1';
+----------------+------------+
| PARTITION_NAME | TABLE_ROWS |
+----------------+------------+
| p0             |          2 |
| p3             |          1 |
+----------------+------------+
2 rows in set (0.00 sec)
```

This is because we are comparing rows rather than scalar values. We can compare the row values inserted with the limiting row value from the `VALUES THAN LESS THAN` clause used to define partition `p0` in table `rc1`, like this:

```
mysql> SELECT (5,10) < (5,12), (5,11) < (5,12), (5,12) < (5,12);
+-----------------+-----------------+-----------------+
| (5,10) < (5,12) | (5,11) < (5,12) | (5,12) < (5,12) |
+-----------------+-----------------+-----------------+
|               1 |               1 |               0 |
+-----------------+-----------------+-----------------+
1 row in set (0.00 sec)
```

The 2 tuples `(5,10)` and `(5,11)` evaluate as less than `(5,12)`, so they are stored in partition `p0`. Since 5 is not less than 5 and 12 is not less than 12, `(5,12)` is considered not less than `(5,12)`, and is stored in partition `p1`.

The `SELECT` statement in the preceding example could also have been written using explicit row constructors, like this:

```
SELECT ROW(5,10) < ROW(5,12), ROW(5,11) < ROW(5,12), ROW(5,12) < ROW(5,12);
```

For more information about the use of row constructors in MySQL, see Row Subqueries.

For a table partitioned by `RANGE COLUMNS` using only a single partitioning column, the storing of rows in partitions is the same as that of an equivalent table that is partitioned by `RANGE`. The following `CREATE TABLE` statement creates a table partitioned by `RANGE COLUMNS` using 1 partitioning column:

```
CREATE TABLE rx (
    a INT,
    b INT
)
PARTITION BY RANGE COLUMNS (a)  (
    PARTITION p0 VALUES LESS THAN (5),
    PARTITION p1 VALUES LESS THAN (MAXVALUE)
);
```

If we insert the rows `(5,10)`, `(5,11)`, and `(5,12)` into this table, we can see that their placement is the same as it is for the table `r` we created and populated earlier:

```
mysql> INSERT INTO rx VALUES (5,10), (5,11), (5,12);
Query OK, 3 rows affected (0.00 sec)
Records: 3  Duplicates: 0  Warnings: 0
```

```
mysql> SELECT PARTITION_NAME,TABLE_ROWS
    ->     FROM INFORMATION_SCHEMA.PARTITIONS
    ->     WHERE TABLE_NAME = 'rx';
+----------------+------------+
| PARTITION_NAME | TABLE_ROWS |
+----------------+------------+
| p0             |          0 |
| p1             |          3 |
+----------------+------------+
2 rows in set (0.00 sec)
```

It is also possible to create tables partitioned by `RANGE COLUMNS` where limiting values for one or more columns are repeated in successive partition definitions. You can do this as long as the tuples of column values used to define the partitions are strictly increasing. For example, each of the following `CREATE TABLE` statements is valid:

```
CREATE TABLE rc2 (
    a INT,
    b INT
)
PARTITION BY RANGE COLUMNS(a,b) (
    PARTITION p0 VALUES LESS THAN (0,10),
    PARTITION p1 VALUES LESS THAN (10,20),
    PARTITION p2 VALUES LESS THAN (10,30),
    PARTITION p3 VALUES LESS THAN (MAXVALUE,MAXVALUE)
 );
CREATE TABLE rc3 (
    a INT,
    b INT
)
PARTITION BY RANGE COLUMNS(a,b) (
    PARTITION p0 VALUES LESS THAN (0,10),
    PARTITION p1 VALUES LESS THAN (10,20),
    PARTITION p2 VALUES LESS THAN (10,30),
    PARTITION p3 VALUES LESS THAN (10,35),
    PARTITION p4 VALUES LESS THAN (20,40),
    PARTITION p5 VALUES LESS THAN (MAXVALUE,MAXVALUE)
 );
```

The following statement also succeeds, even though it might appear at first glance that it would not, since the limiting value of column `b` is 25 for partition `p0` and 20 for partition `p1`, and the limiting value of column `c` is 100 for partition `p1` and 50 for partition `p2`:

```
CREATE TABLE rc4 (
    a INT,
    b INT,
    c INT
)
PARTITION BY RANGE COLUMNS(a,b,c) (
    PARTITION p0 VALUES LESS THAN (0,25,50),
    PARTITION p1 VALUES LESS THAN (10,20,100),
    PARTITION p2 VALUES LESS THAN (10,30,50),
    PARTITION p3 VALUES LESS THAN (MAXVALUE,MAXVALUE,MAXVALUE)
 );
```

When designing tables partitioned by `RANGE COLUMNS`, you can always test successive partition definitions by comparing the desired tuples using the `mysql` client, like this:

```
mysql> SELECT (0,25,50) < (10,20,100), (10,20,100) < (10,30,50);
+-------------------------+-------------------------+
| (0,25,50) < (10,20,100) | (10,20,100) < (10,30,50) |
+-------------------------+-------------------------+
|                       1 |                       1 |
+-------------------------+-------------------------+
1 row in set (0.00 sec)
```

If a `CREATE TABLE` statement contains partition definitions that are not in strictly increasing order, it fails with an error, as shown in this example:

```
mysql> CREATE TABLE rcf (
    ->     a INT,
    ->     b INT,
    ->     c INT
    -> )
    -> PARTITION BY RANGE COLUMNS(a,b,c) (
    ->     PARTITION p0 VALUES LESS THAN (0,25,50),
    ->     PARTITION p1 VALUES LESS THAN (20,20,100),
    ->     PARTITION p2 VALUES LESS THAN (10,30,50),
    ->     PARTITION p3 VALUES LESS THAN (MAXVALUE,MAXVALUE,MAXVALUE)
    ->  );
ERROR 1493 (HY000): VALUES LESS THAN value must be strictly increasing for each partition
```

When you get such an error, you can deduce which partition definitions are invalid by making “less than” comparisons between their column lists. In this case, the problem is with the definition of partition `p2` because the tuple used to define it is not less than the tuple used to define partition `p3`, as shown here:

```
mysql> SELECT (0,25,50) < (20,20,100), (20,20,100) < (10,30,50);
+------------------------+------------------------+
| (0,25,50) < (20,20,100) | (20,20,100) < (10,30,50) |
+------------------------+------------------------+
|                      1 |                      0 |
+------------------------+------------------------+
1 row in set (0.00 sec)
```

It is also possible for `MAXVALUE` to appear for the same column in more than one `VALUES LESS THAN` clause when using `RANGE COLUMNS`. However, the limiting values for individual columns in successive partition definitions should otherwise be increasing, there should be no more than one partition defined where `MAXVALUE` is used as the upper limit for all column values, and this partition definition should appear last in the list of `PARTITION ... VALUES LESS THAN` clauses. In addition, you cannot use `MAXVALUE` as the limiting value for the first column in more than one partition definition.

As stated previously, it is also possible with `RANGE COLUMNS` partitioning to use non-integer columns as partitioning columns. (See Section 3.3, “COLUMNS Partitioning”, for a complete listing of these.) Consider a table named `employees` (which is not partitioned), created using the following statement:

```
CREATE TABLE employees (
    id INT NOT NULL,
    fname VARCHAR(30),
    lname VARCHAR(30),
    hired DATE NOT NULL DEFAULT '1970-01-01',
    separated DATE NOT NULL DEFAULT '9999-12-31',
    job_code INT NOT NULL,
    store_id INT NOT NULL
);
```

Using `RANGE COLUMNS` partitioning, you can create a version of this table that stores each row in one of four partitions based on the employee's last name, like this:

```
CREATE TABLE employees_by_lname (
    id INT NOT NULL,
    fname VARCHAR(30),
    lname VARCHAR(30),
    hired DATE NOT NULL DEFAULT '1970-01-01',
    separated DATE NOT NULL DEFAULT '9999-12-31',
    job_code INT NOT NULL,
    store_id INT NOT NULL
)
PARTITION BY RANGE COLUMNS (lname)  (
    PARTITION p0 VALUES LESS THAN ('g'),
    PARTITION p1 VALUES LESS THAN ('m'),
```

```
    PARTITION p2 VALUES LESS THAN ('t'),
    PARTITION p3 VALUES LESS THAN (MAXVALUE)
);
```

Alternatively, you could cause the `employees` table as created previously to be partitioned using this scheme by executing the following `ALTER TABLE` statement:

```
ALTER TABLE employees PARTITION BY RANGE COLUMNS (lname)  (
    PARTITION p0 VALUES LESS THAN ('g'),
    PARTITION p1 VALUES LESS THAN ('m'),
    PARTITION p2 VALUES LESS THAN ('t'),
    PARTITION p3 VALUES LESS THAN (MAXVALUE)
);
```

> **Note**
>
> Because different character sets and collations have different sort orders, the character sets and collations in use may effect which partition of a table partitioned by `RANGE COLUMNS` a given row is stored in when using string columns as partitioning columns. In addition, changing the character set or collation for a given database, table, or column after such a table is created may cause changes in how rows are distributed. For example, when using a case-sensitive collation, `'and'` sorts before `'Andersen'`, but when using a collation that is case-insensitive, the reverse is true.
>
> For information about how MySQL handles character sets and collations, see Character Sets, Collations, Unicode.

Similarly, you can cause the `employees` table to be partitioned in such a way that each row is stored in one of several partitions based on the decade in which the corresponding employee was hired using the `ALTER TABLE` statement shown here:

```
ALTER TABLE employees PARTITION BY RANGE COLUMNS (hired)  (
    PARTITION p0 VALUES LESS THAN ('1970-01-01'),
    PARTITION p1 VALUES LESS THAN ('1980-01-01'),
    PARTITION p2 VALUES LESS THAN ('1990-01-01'),
    PARTITION p3 VALUES LESS THAN ('2000-01-01'),
    PARTITION p4 VALUES LESS THAN ('2010-01-01'),
    PARTITION p5 VALUES LESS THAN (MAXVALUE)
);
```

See CREATE TABLE Statement, for additional information about `PARTITION BY RANGE COLUMNS` syntax.

3.3.2 LIST COLUMNS partitioning

MySQL 8.2 provides support for `LIST COLUMNS` partitioning. This is a variant of `LIST` partitioning that enables the use of multiple columns as partition keys, and for columns of data types other than integer types to be used as partitioning columns; you can use string types, `DATE`, and `DATETIME` columns. (For more information about permitted data types for `COLUMNS` partitioning columns, see Section 3.3, “COLUMNS Partitioning”.)

Suppose that you have a business that has customers in 12 cities which, for sales and marketing purposes, you organize into 4 regions of 3 cities each as shown in the following table:

Region	Cities
1	Oskarshamn, Högsby, Mönsterås
2	Vimmerby, Hultsfred, Västervik

Region	Cities
3	Nässjö, Eksjö, Vetlanda
4	Uppvidinge, Alvesta, Växjo

With `LIST COLUMNS` partitioning, you can create a table for customer data that assigns a row to any of 4 partitions corresponding to these regions based on the name of the city where a customer resides, as shown here:

```
CREATE TABLE customers_1 (
    first_name VARCHAR(25),
    last_name VARCHAR(25),
    street_1 VARCHAR(30),
    street_2 VARCHAR(30),
    city VARCHAR(15),
    renewal DATE
)
PARTITION BY LIST COLUMNS(city) (
    PARTITION pRegion_1 VALUES IN('Oskarshamn', 'Högsby', 'Mönsterås'),
    PARTITION pRegion_2 VALUES IN('Vimmerby', 'Hultsfred', 'Västervik'),
    PARTITION pRegion_3 VALUES IN('Nässjö', 'Eksjö', 'Vetlanda'),
    PARTITION pRegion_4 VALUES IN('Uppvidinge', 'Alvesta', 'Växjo')
);
```

As with partitioning by `RANGE COLUMNS`, you do not need to use expressions in the `COLUMNS()` clause to convert column values into integers. (In fact, the use of expressions other than column names is not permitted with `COLUMNS()`.)

It is also possible to use `DATE` and `DATETIME` columns, as shown in the following example that uses the same name and columns as the `customers_1` table shown previously, but employs `LIST COLUMNS` partitioning based on the `renewal` column to store rows in one of 4 partitions depending on the week in February 2010 the customer's account is scheduled to renew:

```
CREATE TABLE customers_2 (
    first_name VARCHAR(25),
    last_name VARCHAR(25),
    street_1 VARCHAR(30),
    street_2 VARCHAR(30),
    city VARCHAR(15),
    renewal DATE
)
PARTITION BY LIST COLUMNS(renewal) (
    PARTITION pWeek_1 VALUES IN('2010-02-01', '2010-02-02', '2010-02-03',
        '2010-02-04', '2010-02-05', '2010-02-06', '2010-02-07'),
    PARTITION pWeek_2 VALUES IN('2010-02-08', '2010-02-09', '2010-02-10',
        '2010-02-11', '2010-02-12', '2010-02-13', '2010-02-14'),
    PARTITION pWeek_3 VALUES IN('2010-02-15', '2010-02-16', '2010-02-17',
        '2010-02-18', '2010-02-19', '2010-02-20', '2010-02-21'),
    PARTITION pWeek_4 VALUES IN('2010-02-22', '2010-02-23', '2010-02-24',
        '2010-02-25', '2010-02-26', '2010-02-27', '2010-02-28')
);
```

This works, but becomes cumbersome to define and maintain if the number of dates involved grows very large; in such cases, it is usually more practical to employ `RANGE` or `RANGE COLUMNS` partitioning instead. In this case, since the column we wish to use as the partitioning key is a `DATE` column, we use `RANGE COLUMNS` partitioning, as shown here:

```
CREATE TABLE customers_3 (
    first_name VARCHAR(25),
    last_name VARCHAR(25),
    street_1 VARCHAR(30),
    street_2 VARCHAR(30),
    city VARCHAR(15),
```

```
    renewal DATE
)
PARTITION BY RANGE COLUMNS(renewal) (
    PARTITION pWeek_1 VALUES LESS THAN('2010-02-09'),
    PARTITION pWeek_2 VALUES LESS THAN('2010-02-15'),
    PARTITION pWeek_3 VALUES LESS THAN('2010-02-22'),
    PARTITION pWeek_4 VALUES LESS THAN('2010-03-01')
);
```

See Section 3.3.1, “RANGE COLUMNS partitioning”, for more information.

In addition (as with `RANGE COLUMNS` partitioning), you can use multiple columns in the `COLUMNS()` clause.

See CREATE TABLE Statement, for additional information about `PARTITION BY LIST COLUMNS()` syntax.

3.4 HASH Partitioning

Partitioning by `HASH` is used primarily to ensure an even distribution of data among a predetermined number of partitions. With range or list partitioning, you must specify explicitly which partition a given column value or set of column values should be stored in; with hash partitioning, this decision is taken care of for you, and you need only specify a column value or expression based on a column value to be hashed and the number of partitions into which the partitioned table is to be divided.

To partition a table using `HASH` partitioning, it is necessary to append to the `CREATE TABLE` statement a `PARTITION BY HASH (expr)` clause, where *`expr`* is an expression that returns an integer. This can simply be the name of a column whose type is one of MySQL's integer types. In addition, you most likely want to follow this with `PARTITIONS num`, where *`num`* is a positive integer representing the number of partitions into which the table is to be divided.

> **Note**
>
> For simplicity, the tables in the examples that follow do not use any keys. You should be aware that, if a table has any unique keys, every column used in the partitioning expression for this table must be part of every unique key, including the primary key. See Section 6.1, “Partitioning Keys, Primary Keys, and Unique Keys”, for more information.

The following statement creates a table that uses hashing on the `store_id` column and is divided into 4 partitions:

```
CREATE TABLE employees (
    id INT NOT NULL,
    fname VARCHAR(30),
    lname VARCHAR(30),
    hired DATE NOT NULL DEFAULT '1970-01-01',
    separated DATE NOT NULL DEFAULT '9999-12-31',
    job_code INT,
    store_id INT
)
PARTITION BY HASH(store_id)
PARTITIONS 4;
```

If you do not include a `PARTITIONS` clause, the number of partitions defaults to `1`; using the `PARTITIONS` keyword without a number following it results in a syntax error.

You can also use an SQL expression that returns an integer for *`expr`*. For instance, you might want to partition based on the year in which an employee was hired. This can be done as shown here:

```
CREATE TABLE employees (
    id INT NOT NULL,
    fname VARCHAR(30),
    lname VARCHAR(30),
    hired DATE NOT NULL DEFAULT '1970-01-01',
    separated DATE NOT NULL DEFAULT '9999-12-31',
    job_code INT,
    store_id INT
)
PARTITION BY HASH( YEAR(hired) )
PARTITIONS 4;
```

expr must return a nonconstant, nonrandom integer value (in other words, it should be varying but deterministic), and must not contain any prohibited constructs as described in Chapter 6, *Restrictions and Limitations on Partitioning*. You should also keep in mind that this expression is evaluated each time a row is inserted or updated (or possibly deleted); this means that very complex expressions may give rise to performance issues, particularly when performing operations (such as batch inserts) that affect a great many rows at one time.

The most efficient hashing function is one which operates upon a single table column and whose value increases or decreases consistently with the column value, as this allows for “pruning” on ranges of partitions. That is, the more closely that the expression varies with the value of the column on which it is based, the more efficiently MySQL can use the expression for hash partitioning.

For example, where `date_col` is a column of type `DATE`, then the expression `TO_DAYS(date_col)` is said to vary directly with the value of `date_col`, because for every change in the value of `date_col`, the value of the expression changes in a consistent manner. The variance of the expression `YEAR(date_col)` with respect to `date_col` is not quite as direct as that of `TO_DAYS(date_col)`, because not every possible change in `date_col` produces an equivalent change in `YEAR(date_col)`. Even so, `YEAR(date_col)` is a good candidate for a hashing function, because it varies directly with a portion of `date_col` and there is no possible change in `date_col` that produces a disproportionate change in `YEAR(date_col)`.

By way of contrast, suppose that you have a column named `int_col` whose type is `INT`. Now consider the expression `POW(5-int_col,3) + 6`. This would be a poor choice for a hashing function because a change in the value of `int_col` is not guaranteed to produce a proportional change in the value of the expression. Changing the value of `int_col` by a given amount can produce widely differing changes in the value of the expression. For example, changing `int_col` from `5` to `6` produces a change of `-1` in the value of the expression, but changing the value of `int_col` from `6` to `7` produces a change of `-7` in the expression value.

In other words, the more closely the graph of the column value versus the value of the expression follows a straight line as traced by the equation `y=cx` where *c* is some nonzero constant, the better the expression is suited to hashing. This has to do with the fact that the more nonlinear an expression is, the more uneven the distribution of data among the partitions it tends to produce.

In theory, pruning is also possible for expressions involving more than one column value, but determining which of such expressions are suitable can be quite difficult and time-consuming. For this reason, the use of hashing expressions involving multiple columns is not particularly recommended.

When `PARTITION BY HASH` is used, the storage engine determines which partition of *num* partitions to use based on the modulus of the result of the expression. In other words, for a given expression *expr*, the partition in which the record is stored is partition number *N*, where *N = MOD(expr, num)*. Suppose that table `t1` is defined as follows, so that it has 4 partitions:

```
CREATE TABLE t1 (col1 INT, col2 CHAR(5), col3 DATE)
    PARTITION BY HASH( YEAR(col3) )
```

```
    PARTITIONS 4;
```

If you insert a record into `t1` whose `col3` value is `'2005-09-15'`, then the partition in which it is stored is determined as follows:

```
MOD(YEAR('2005-09-01'),4)
=  MOD(2005,4)
=  1
```

MySQL 8.2 also supports a variant of `HASH` partitioning known as *linear hashing* which employs a more complex algorithm for determining the placement of new rows inserted into the partitioned table. See Section 3.4.1, “LINEAR HASH Partitioning”, for a description of this algorithm.

The user-supplied expression is evaluated each time a record is inserted or updated. It may also—depending on the circumstances—be evaluated when records are deleted.

3.4.1 LINEAR HASH Partitioning

MySQL also supports linear hashing, which differs from regular hashing in that linear hashing utilizes a linear powers-of-two algorithm whereas regular hashing employs the modulus of the hashing function's value.

Syntactically, the only difference between linear-hash partitioning and regular hashing is the addition of the `LINEAR` keyword in the `PARTITION BY` clause, as shown here:

```
CREATE TABLE employees (
    id INT NOT NULL,
    fname VARCHAR(30),
    lname VARCHAR(30),
    hired DATE NOT NULL DEFAULT '1970-01-01',
    separated DATE NOT NULL DEFAULT '9999-12-31',
    job_code INT,
    store_id INT
)
PARTITION BY LINEAR HASH( YEAR(hired) )
PARTITIONS 4;
```

Given an expression *`expr`*, the partition in which the record is stored when linear hashing is used is partition number *`N`* from among *`num`* partitions, where *`N`* is derived according to the following algorithm:

1. Find the next power of 2 greater than *`num`*. We call this value *`V`*; it can be calculated as:

   ```
   V = POWER(2, CEILING(LOG(2, num)))
   ```

   (Suppose that *`num`* is 13. Then `LOG(2,13)` is 3.7004397181411. `CEILING(3.7004397181411)` is 4, and *`V`* = `POWER(2,4)`, which is 16.)

2. Set *`N`* = *`F`*(*`column_list`*) & (*`V`* - 1).

3. While *`N`* >= *`num`*:

   - Set *`V`* = *`V`* / 2
   - Set *`N`* = *`N`* & (*`V`* - 1)

Suppose that the table `t1`, using linear hash partitioning and having 6 partitions, is created using this statement:

```
CREATE TABLE t1 (col1 INT, col2 CHAR(5), col3 DATE)
    PARTITION BY LINEAR HASH( YEAR(col3) )
    PARTITIONS 6;
```

Now assume that you want to insert two records into `t1` having the `col3` column values `'2003-04-14'` and `'1998-10-19'`. The partition number for the first of these is determined as follows:

```
V = POWER(2, CEILING( LOG(2,6) )) = 8
N = YEAR('2003-04-14') & (8 - 1)
   = 2003 & 7
   = 3
(3 >= 6 is FALSE: record stored in partition #3)
```

The number of the partition where the second record is stored is calculated as shown here:

```
V = 8
N = YEAR('1998-10-19') & (8 - 1)
  = 1998 & 7
  = 6
(6 >= 6 is TRUE: additional step required)
N = 6 & ((8 / 2) - 1)
  = 6 & 3
  = 2
(2 >= 6 is FALSE: record stored in partition #2)
```

The advantage in partitioning by linear hash is that the adding, dropping, merging, and splitting of partitions is made much faster, which can be beneficial when dealing with tables containing extremely large amounts (terabytes) of data. The disadvantage is that data is less likely to be evenly distributed between partitions as compared with the distribution obtained using regular hash partitioning.

3.5 KEY Partitioning

Partitioning by key is similar to partitioning by hash, except that where hash partitioning employs a user-defined expression, the hashing function for key partitioning is supplied by the MySQL server. NDB Cluster uses `MD5()` for this purpose; for tables using other storage engines, the server employs its own internal hashing function.

The syntax rules for `CREATE TABLE ... PARTITION BY KEY` are similar to those for creating a table that is partitioned by hash. The major differences are listed here:

- `KEY` is used rather than `HASH`.
- `KEY` takes only a list of zero or more column names. Any columns used as the partitioning key must comprise part or all of the table's primary key, if the table has one. Where no column name is specified as the partitioning key, the table's primary key is used, if there is one. For example, the following `CREATE TABLE` statement is valid in MySQL 8.2:

  ```
  CREATE TABLE k1 (
      id INT NOT NULL PRIMARY KEY,
      name VARCHAR(20)
  )
  PARTITION BY KEY()
  PARTITIONS 2;
  ```

  If there is no primary key but there is a unique key, then the unique key is used for the partitioning key:

  ```
  CREATE TABLE k1 (
      id INT NOT NULL,
      name VARCHAR(20),
      UNIQUE KEY (id)
  )
  PARTITION BY KEY()
  PARTITIONS 2;
  ```

  However, if the unique key column were not defined as `NOT NULL`, then the previous statement would fail.

In both of these cases, the partitioning key is the `id` column, even though it is not shown in the output of `SHOW CREATE TABLE` or in the `PARTITION_EXPRESSION` column of the Information Schema `PARTITIONS` table.

Unlike the case with other partitioning types, columns used for partitioning by `KEY` are not restricted to integer or `NULL` values. For example, the following `CREATE TABLE` statement is valid:

```
CREATE TABLE tm1 (
    s1 CHAR(32) PRIMARY KEY
)
PARTITION BY KEY(s1)
PARTITIONS 10;
```

The preceding statement would *not* be valid, were a different partitioning type to be specified. (In this case, simply using `PARTITION BY KEY()` would also be valid and have the same effect as `PARTITION BY KEY(s1)`, since `s1` is the table's primary key.)

For additional information about this issue, see Chapter 6, *Restrictions and Limitations on Partitioning*.

Columns with index prefixes are not supported in partitioning keys. This means that `CHAR`, `VARCHAR`, `BINARY`, and `VARBINARY` columns can be used in a partitioning key, as long as they do not employ prefixes; because a prefix must be specified for `BLOB` and `TEXT` columns in index definitions, it is not possible to use columns of these two types in partitioning keys. In older versions of MySQL, columns using prefixes were permitted when creating, altering, or upgrading a partitioned table, even though they were not included in the table's partitioning key; in MySQL 8.2, this permissive behavior is deprecated, and the server displays appropriate warnings or errors when one or more such columns are used. See Column index prefixes not supported for key partitioning, for more information and examples.

> **Note**
>
> Tables using the `NDB` storage engine are implicitly partitioned by `KEY`, using the table's primary key as the partitioning key (as with other MySQL storage engines). In the event that the NDB Cluster table has no explicit primary key, the “hidden” primary key generated by the `NDB` storage engine for each NDB Cluster table is used as the partitioning key.
>
> If you define an explicit partitioning scheme for an `NDB` table, the table must have an explicit primary key, and any columns used in the partitioning expression must be part of this key. However, if the table uses an “empty” partitioning expression —that is, `PARTITION BY KEY()` with no column references—then no explicit primary key is required.
>
> You can observe this partitioning using the `ndb_desc` utility (with the `-p` option).

> **Important**
>
> For a key-partitioned table, you cannot execute an `ALTER TABLE DROP PRIMARY KEY`, as doing so generates the error `ERROR 1466 (HY000): Field in list of fields for partition function not found in table`. This is not an issue for NDB Cluster tables which are partitioned by `KEY`; in such cases, the table is reorganized using the “hidden” primary key as the table's new partitioning key. See MySQL NDB Cluster 8.2.

It is also possible to partition a table by linear key. Here is a simple example:

```
CREATE TABLE tk (
```

```
    col1 INT NOT NULL,
    col2 CHAR(5),
    col3 DATE
)
PARTITION BY LINEAR KEY (col1)
PARTITIONS 3;
```

The `LINEAR` keyword has the same effect on `KEY` partitioning as it does on `HASH` partitioning, with the partition number being derived using a powers-of-two algorithm rather than modulo arithmetic. See Section 3.4.1, “LINEAR HASH Partitioning”, for a description of this algorithm and its implications.

3.6 Subpartitioning

Subpartitioning—also known as *composite partitioning*—is the further division of each partition in a partitioned table. Consider the following `CREATE TABLE` statement:

```
CREATE TABLE ts (id INT, purchased DATE)
    PARTITION BY RANGE( YEAR(purchased) )
    SUBPARTITION BY HASH( TO_DAYS(purchased) )
    SUBPARTITIONS 2 (
        PARTITION p0 VALUES LESS THAN (1990),
        PARTITION p1 VALUES LESS THAN (2000),
        PARTITION p2 VALUES LESS THAN MAXVALUE
    );
```

Table `ts` has 3 `RANGE` partitions. Each of these partitions—`p0`, `p1`, and `p2`—is further divided into 2 subpartitions. In effect, the entire table is divided into `3 * 2 = 6` partitions. However, due to the action of the `PARTITION BY RANGE` clause, the first 2 of these store only those records with a value less than 1990 in the `purchased` column.

It is possible to subpartition tables that are partitioned by `RANGE` or `LIST`. Subpartitions may use either `HASH` or `KEY` partitioning. This is also known as *composite partitioning*.

> **Note**
>
> `SUBPARTITION BY HASH` and `SUBPARTITION BY KEY` generally follow the same syntax rules as `PARTITION BY HASH` and `PARTITION BY KEY`, respectively. An exception to this is that `SUBPARTITION BY KEY` (unlike `PARTITION BY KEY`) does not currently support a default column, so the column used for this purpose must be specified, even if the table has an explicit primary key. This is a known issue which we are working to address; see Issues with subpartitions, for more information and an example.

It is also possible to define subpartitions explicitly using `SUBPARTITION` clauses to specify options for individual subpartitions. For example, a more verbose fashion of creating the same table `ts` as shown in the previous example would be:

```
CREATE TABLE ts (id INT, purchased DATE)
    PARTITION BY RANGE( YEAR(purchased) )
    SUBPARTITION BY HASH( TO_DAYS(purchased) ) (
        PARTITION p0 VALUES LESS THAN (1990) (
            SUBPARTITION s0,
            SUBPARTITION s1
        ),
        PARTITION p1 VALUES LESS THAN (2000) (
            SUBPARTITION s2,
            SUBPARTITION s3
        ),
        PARTITION p2 VALUES LESS THAN MAXVALUE (
            SUBPARTITION s4,
```

```
            SUBPARTITION s5
        )
    );
```

Some syntactical items of note are listed here:

- Each partition must have the same number of subpartitions.
- If you explicitly define any subpartitions using `SUBPARTITION` on any partition of a partitioned table, you must define them all. In other words, the following statement fails:

```
CREATE TABLE ts (id INT, purchased DATE)
    PARTITION BY RANGE( YEAR(purchased) )
    SUBPARTITION BY HASH( TO_DAYS(purchased) ) (
        PARTITION p0 VALUES LESS THAN (1990) (
            SUBPARTITION s0,
            SUBPARTITION s1
        ),
        PARTITION p1 VALUES LESS THAN (2000),
        PARTITION p2 VALUES LESS THAN MAXVALUE (
            SUBPARTITION s2,
            SUBPARTITION s3
        )
    );
```

  This statement would still fail even if it used `SUBPARTITIONS 2`.

- Each `SUBPARTITION` clause must include (at a minimum) a name for the subpartition. Otherwise, you may set any desired option for the subpartition or allow it to assume its default setting for that option.
- Subpartition names must be unique across the entire table. For example, the following `CREATE TABLE` statement is valid:

```
CREATE TABLE ts (id INT, purchased DATE)
    PARTITION BY RANGE( YEAR(purchased) )
    SUBPARTITION BY HASH( TO_DAYS(purchased) ) (
        PARTITION p0 VALUES LESS THAN (1990) (
            SUBPARTITION s0,
            SUBPARTITION s1
        ),
        PARTITION p1 VALUES LESS THAN (2000) (
            SUBPARTITION s2,
            SUBPARTITION s3
        ),
        PARTITION p2 VALUES LESS THAN MAXVALUE (
            SUBPARTITION s4,
            SUBPARTITION s5
        )
    );
```

3.7 How MySQL Partitioning Handles NULL

Partitioning in MySQL does nothing to disallow `NULL` as the value of a partitioning expression, whether it is a column value or the value of a user-supplied expression. Even though it is permitted to use `NULL` as the value of an expression that must otherwise yield an integer, it is important to keep in mind that `NULL` is not a number. MySQL's partitioning implementation treats `NULL` as being less than any non-`NULL` value, just as `ORDER BY` does.

This means that treatment of `NULL` varies between partitioning of different types, and may produce behavior which you do not expect if you are not prepared for it. This being the case, we discuss in this section how each MySQL partitioning type handles `NULL` values when determining the partition in which a row should be stored, and provide examples for each.

Handling of NULL with RANGE partitioning. If you insert a row into a table partitioned by RANGE such that the column value used to determine the partition is NULL, the row is inserted into the lowest partition. Consider these two tables in a database named p, created as follows:

```
mysql> CREATE TABLE t1 (
    ->     c1 INT,
    ->     c2 VARCHAR(20)
    -> )
    -> PARTITION BY RANGE(c1) (
    ->     PARTITION p0 VALUES LESS THAN (0),
    ->     PARTITION p1 VALUES LESS THAN (10),
    ->     PARTITION p2 VALUES LESS THAN MAXVALUE
    -> );
Query OK, 0 rows affected (0.09 sec)
mysql> CREATE TABLE t2 (
    ->     c1 INT,
    ->     c2 VARCHAR(20)
    -> )
    -> PARTITION BY RANGE(c1) (
    ->     PARTITION p0 VALUES LESS THAN (-5),
    ->     PARTITION p1 VALUES LESS THAN (0),
    ->     PARTITION p2 VALUES LESS THAN (10),
    ->     PARTITION p3 VALUES LESS THAN MAXVALUE
    -> );
Query OK, 0 rows affected (0.09 sec)
```

You can see the partitions created by these two CREATE TABLE statements using the following query against the PARTITIONS table in the INFORMATION_SCHEMA database:

```
mysql> SELECT TABLE_NAME, PARTITION_NAME, TABLE_ROWS, AVG_ROW_LENGTH, DATA_LENGTH
     >   FROM INFORMATION_SCHEMA.PARTITIONS
     >   WHERE TABLE_SCHEMA = 'p' AND TABLE_NAME LIKE 't_';
+------------+----------------+------------+----------------+-------------+
| TABLE_NAME | PARTITION_NAME | TABLE_ROWS | AVG_ROW_LENGTH | DATA_LENGTH |
+------------+----------------+------------+----------------+-------------+
| t1         | p0             |          0 |              0 |           0 |
| t1         | p1             |          0 |              0 |           0 |
| t1         | p2             |          0 |              0 |           0 |
| t2         | p0             |          0 |              0 |           0 |
| t2         | p1             |          0 |              0 |           0 |
| t2         | p2             |          0 |              0 |           0 |
| t2         | p3             |          0 |              0 |           0 |
+------------+----------------+------------+----------------+-------------+
7 rows in set (0.00 sec)
```

(For more information about this table, see The INFORMATION_SCHEMA PARTITIONS Table.) Now let us populate each of these tables with a single row containing a NULL in the column used as the partitioning key, and verify that the rows were inserted using a pair of SELECT statements:

```
mysql> INSERT INTO t1 VALUES (NULL, 'mothra');
Query OK, 1 row affected (0.00 sec)
mysql> INSERT INTO t2 VALUES (NULL, 'mothra');
Query OK, 1 row affected (0.00 sec)
mysql> SELECT * FROM t1;
+------+--------+
| id   | name   |
+------+--------+
| NULL | mothra |
+------+--------+
1 row in set (0.00 sec)
mysql> SELECT * FROM t2;
+------+--------+
| id   | name   |
+------+--------+
| NULL | mothra |
```

```
+------+--------+
1 row in set (0.00 sec)
```

You can see which partitions are used to store the inserted rows by rerunning the previous query against `INFORMATION_SCHEMA.PARTITIONS` and inspecting the output:

```
mysql> SELECT TABLE_NAME, PARTITION_NAME, TABLE_ROWS, AVG_ROW_LENGTH, DATA_LENGTH
    >   FROM INFORMATION_SCHEMA.PARTITIONS
    >   WHERE TABLE_SCHEMA = 'p' AND TABLE_NAME LIKE 't_';
+------------+----------------+------------+----------------+-------------+
| TABLE_NAME | PARTITION_NAME | TABLE_ROWS | AVG_ROW_LENGTH | DATA_LENGTH |
+------------+----------------+------------+----------------+-------------+
| t1         | p0             |          1 |             20 |          20 |
| t1         | p1             |          0 |              0 |           0 |
| t1         | p2             |          0 |              0 |           0 |
| t2         | p0             |          1 |             20 |          20 |
| t2         | p1             |          0 |              0 |           0 |
| t2         | p2             |          0 |              0 |           0 |
| t2         | p3             |          0 |              0 |           0 |
+------------+----------------+------------+----------------+-------------+
7 rows in set (0.01 sec)
```

You can also demonstrate that these rows were stored in the lowest-numbered partition of each table by dropping these partitions, and then re-running the `SELECT` statements:

```
mysql> ALTER TABLE t1 DROP PARTITION p0;
Query OK, 0 rows affected (0.16 sec)
mysql> ALTER TABLE t2 DROP PARTITION p0;
Query OK, 0 rows affected (0.16 sec)
mysql> SELECT * FROM t1;
Empty set (0.00 sec)
mysql> SELECT * FROM t2;
Empty set (0.00 sec)
```

(For more information on `ALTER TABLE ... DROP PARTITION`, see ALTER TABLE Statement.)

`NULL` is also treated in this way for partitioning expressions that use SQL functions. Suppose that we define a table using a `CREATE TABLE` statement such as this one:

```
CREATE TABLE tndate (
    id INT,
    dt DATE
)
PARTITION BY RANGE( YEAR(dt) ) (
    PARTITION p0 VALUES LESS THAN (1990),
    PARTITION p1 VALUES LESS THAN (2000),
    PARTITION p2 VALUES LESS THAN MAXVALUE
);
```

As with other MySQL functions, `YEAR(NULL)` returns `NULL`. A row with a `dt` column value of `NULL` is treated as though the partitioning expression evaluated to a value less than any other value, and so is inserted into partition `p0`.

Handling of NULL with LIST partitioning. A table that is partitioned by `LIST` admits `NULL` values if and only if one of its partitions is defined using that value-list that contains `NULL`. The converse of this is that a table partitioned by `LIST` which does not explicitly use `NULL` in a value list rejects rows resulting in a `NULL` value for the partitioning expression, as shown in this example:

```
mysql> CREATE TABLE ts1 (
    ->     c1 INT,
    ->     c2 VARCHAR(20)
    -> )
    -> PARTITION BY LIST(c1) (
```

```
    ->     PARTITION p0 VALUES IN (0, 3, 6),
    ->     PARTITION p1 VALUES IN (1, 4, 7),
    ->     PARTITION p2 VALUES IN (2, 5, 8)
    -> );
Query OK, 0 rows affected (0.01 sec)
mysql> INSERT INTO ts1 VALUES (9, 'mothra');
ERROR 1504 (HY000): Table has no partition for value 9
mysql> INSERT INTO ts1 VALUES (NULL, 'mothra');
ERROR 1504 (HY000): Table has no partition for value NULL
```

Only rows having a `c1` value between `0` and `8` inclusive can be inserted into `ts1`. `NULL` falls outside this range, just like the number `9`. We can create tables `ts2` and `ts3` having value lists containing `NULL`, as shown here:

```
mysql> CREATE TABLE ts2 (
    ->     c1 INT,
    ->     c2 VARCHAR(20)
    -> )
    -> PARTITION BY LIST(c1) (
    ->     PARTITION p0 VALUES IN (0, 3, 6),
    ->     PARTITION p1 VALUES IN (1, 4, 7),
    ->     PARTITION p2 VALUES IN (2, 5, 8),
    ->     PARTITION p3 VALUES IN (NULL)
    -> );
Query OK, 0 rows affected (0.01 sec)
mysql> CREATE TABLE ts3 (
    ->     c1 INT,
    ->     c2 VARCHAR(20)
    -> )
    -> PARTITION BY LIST(c1) (
    ->     PARTITION p0 VALUES IN (0, 3, 6),
    ->     PARTITION p1 VALUES IN (1, 4, 7, NULL),
    ->     PARTITION p2 VALUES IN (2, 5, 8)
    -> );
Query OK, 0 rows affected (0.01 sec)
```

When defining value lists for partitioning, you can (and should) treat `NULL` just as you would any other value. For example, both `VALUES IN (NULL)` and `VALUES IN (1, 4, 7, NULL)` are valid, as are `VALUES IN (1, NULL, 4, 7)`, `VALUES IN (NULL, 1, 4, 7)`, and so on. You can insert a row having `NULL` for column `c1` into each of the tables `ts2` and `ts3`:

```
mysql> INSERT INTO ts2 VALUES (NULL, 'mothra');
Query OK, 1 row affected (0.00 sec)
mysql> INSERT INTO ts3 VALUES (NULL, 'mothra');
Query OK, 1 row affected (0.00 sec)
```

By issuing the appropriate query against `INFORMATION_SCHEMA.PARTITIONS`, you can determine which partitions were used to store the rows just inserted (we assume, as in the previous examples, that the partitioned tables were created in the `p` database):

```
mysql> SELECT TABLE_NAME, PARTITION_NAME, TABLE_ROWS, AVG_ROW_LENGTH, DATA_LENGTH
     >   FROM INFORMATION_SCHEMA.PARTITIONS
     >   WHERE TABLE_SCHEMA = 'p' AND TABLE_NAME LIKE 'ts_';
+------------+----------------+------------+----------------+-------------+
| TABLE_NAME | PARTITION_NAME | TABLE_ROWS | AVG_ROW_LENGTH | DATA_LENGTH |
+------------+----------------+------------+----------------+-------------+
| ts2        | p0             |          0 |              0 |           0 |
| ts2        | p1             |          0 |              0 |           0 |
| ts2        | p2             |          0 |              0 |           0 |
| ts2        | p3             |          1 |             20 |          20 |
| ts3        | p0             |          0 |              0 |           0 |
| ts3        | p1             |          1 |             20 |          20 |
| ts3        | p2             |          0 |              0 |           0 |
+------------+----------------+------------+----------------+-------------+
7 rows in set (0.01 sec)
```

As shown earlier in this section, you can also verify which partitions were used for storing the rows by deleting these partitions and then performing a SELECT.

Handling of NULL with HASH and KEY partitioning. NULL is handled somewhat differently for tables partitioned by HASH or KEY. In these cases, any partition expression that yields a NULL value is treated as though its return value were zero. We can verify this behavior by examining the effects on the file system of creating a table partitioned by HASH and populating it with a record containing appropriate values. Suppose that you have a table th (also in the p database) created using the following statement:

```
mysql> CREATE TABLE th (
    ->     c1 INT,
    ->     c2 VARCHAR(20)
    -> )
    -> PARTITION BY HASH(c1)
    -> PARTITIONS 2;
Query OK, 0 rows affected (0.00 sec)
```

The partitions belonging to this table can be viewed using the query shown here:

```
mysql> SELECT TABLE_NAME,PARTITION_NAME,TABLE_ROWS,AVG_ROW_LENGTH,DATA_LENGTH
     >   FROM INFORMATION_SCHEMA.PARTITIONS
     >   WHERE TABLE_SCHEMA = 'p' AND TABLE_NAME ='th';
+------------+----------------+------------+----------------+-------------+
| TABLE_NAME | PARTITION_NAME | TABLE_ROWS | AVG_ROW_LENGTH | DATA_LENGTH |
+------------+----------------+------------+----------------+-------------+
| th         | p0             |          0 |              0 |           0 |
| th         | p1             |          0 |              0 |           0 |
+------------+----------------+------------+----------------+-------------+
2 rows in set (0.00 sec)
```

TABLE_ROWS for each partition is 0. Now insert two rows into th whose c1 column values are NULL and 0, and verify that these rows were inserted, as shown here:

```
mysql> INSERT INTO th VALUES (NULL, 'mothra'), (0, 'gigan');
Query OK, 1 row affected (0.00 sec)
mysql> SELECT * FROM th;
+------+---------+
| c1   | c2      |
+------+---------+
| NULL | mothra  |
+------+---------+
|    0 | gigan   |
+------+---------+
2 rows in set (0.01 sec)
```

Recall that for any integer *N*, the value of NULL MOD *N* is always NULL. For tables that are partitioned by HASH or KEY, this result is treated for determining the correct partition as 0. Checking the Information Schema PARTITIONS table once again, we can see that both rows were inserted into partition p0:

```
mysql> SELECT TABLE_NAME, PARTITION_NAME, TABLE_ROWS, AVG_ROW_LENGTH, DATA_LENGTH
     >   FROM INFORMATION_SCHEMA.PARTITIONS
     >   WHERE TABLE_SCHEMA = 'p' AND TABLE_NAME ='th';
+------------+----------------+------------+----------------+-------------+
| TABLE_NAME | PARTITION_NAME | TABLE_ROWS | AVG_ROW_LENGTH | DATA_LENGTH |
+------------+----------------+------------+----------------+-------------+
| th         | p0             |          2 |             20 |          20 |
| th         | p1             |          0 |              0 |           0 |
+------------+----------------+------------+----------------+-------------+
2 rows in set (0.00 sec)
```

By repeating the last example using PARTITION BY KEY in place of PARTITION BY HASH in the definition of the table, you can verify that NULL is also treated like 0 for this type of partitioning.

Chapter 4 Partition Management

Table of Contents

There are a number of ways using SQL statements to modify partitioned tables; it is possible to add, drop, redefine, merge, or split existing partitions using the partitioning extensions to the `ALTER TABLE` statement. There are also ways to obtain information about partitioned tables and partitions. We discuss these topics in the sections that follow.

- For information about partition management in tables partitioned by `RANGE` or `LIST`, see Section 4.1, “Management of RANGE and LIST Partitions”.
- For a discussion of managing `HASH` and `KEY` partitions, see Section 4.2, “Management of HASH and KEY Partitions”.
- See Section 4.5, “Obtaining Information About Partitions”, for a discussion of mechanisms provided in MySQL 8.2 for obtaining information about partitioned tables and partitions.
- For a discussion of performing maintenance operations on partitions, see Section 4.4, “Maintenance of Partitions”.

> **Note**
>
> All partitions of a partitioned table must have the same number of subpartitions; it is not possible to change the subpartitioning once the table has been created.

To change a table's partitioning scheme, it is necessary only to use the `ALTER TABLE` statement with a *`partition_options`* option, which has the same syntax as that as used with `CREATE TABLE` for creating a partitioned table; this option (also) always begins with the keywords `PARTITION BY`. Suppose that the following `CREATE TABLE` statement was used to create a table that is partitioned by range:

```
CREATE TABLE trb3 (id INT, name VARCHAR(50), purchased DATE)
    PARTITION BY RANGE( YEAR(purchased) ) (
        PARTITION p0 VALUES LESS THAN (1990),
        PARTITION p1 VALUES LESS THAN (1995),
        PARTITION p2 VALUES LESS THAN (2000),
        PARTITION p3 VALUES LESS THAN (2005)
    );
```

To repartition this table so that it is partitioned by key into two partitions using the `id` column value as the basis for the key, you can use this statement:

```
ALTER TABLE trb3 PARTITION BY KEY(id) PARTITIONS 2;
```

This has the same effect on the structure of the table as dropping the table and re-creating it using `CREATE TABLE trb3 PARTITION BY KEY(id) PARTITIONS 2;`.

`ALTER TABLE ... ENGINE = ...` changes only the storage engine used by the table, and leaves the table's partitioning scheme intact. The statement succeeds only if the target storage engine provides

partitioning support. You can use `ALTER TABLE ... REMOVE PARTITIONING` to remove a table's partitioning; see ALTER TABLE Statement.

> **Important**
>
> Only a single `PARTITION BY`, `ADD PARTITION`, `DROP PARTITION`, `REORGANIZE PARTITION`, or `COALESCE PARTITION` clause can be used in a given `ALTER TABLE` statement. If you (for example) wish to drop a partition and reorganize a table's remaining partitions, you must do so in two separate `ALTER TABLE` statements (one using `DROP PARTITION` and then a second one using `REORGANIZE PARTITION`).

You can delete all rows from one or more selected partitions using `ALTER TABLE ... TRUNCATE PARTITION`.

4.1 Management of RANGE and LIST Partitions

Adding and dropping of range and list partitions are handled in a similar fashion, so we discuss the management of both sorts of partitioning in this section. For information about working with tables that are partitioned by hash or key, see Section 4.2, “Management of HASH and KEY Partitions”.

Dropping a partition from a table that is partitioned by either `RANGE` or by `LIST` can be accomplished using the `ALTER TABLE` statement with the `DROP PARTITION` option. Suppose that you have created a table that is partitioned by range and then populated with 10 records using the following `CREATE TABLE` and `INSERT` statements:

```
mysql> CREATE TABLE tr (id INT, name VARCHAR(50), purchased DATE)
    ->     PARTITION BY RANGE( YEAR(purchased) ) (
    ->         PARTITION p0 VALUES LESS THAN (1990),
    ->         PARTITION p1 VALUES LESS THAN (1995),
    ->         PARTITION p2 VALUES LESS THAN (2000),
    ->         PARTITION p3 VALUES LESS THAN (2005),
    ->         PARTITION p4 VALUES LESS THAN (2010),
    ->         PARTITION p5 VALUES LESS THAN (2015)
    ->     );
Query OK, 0 rows affected (0.28 sec)
mysql> INSERT INTO tr VALUES
    ->     (1, 'desk organiser', '2003-10-15'),
    ->     (2, 'alarm clock', '1997-11-05'),
    ->     (3, 'chair', '2009-03-10'),
    ->     (4, 'bookcase', '1989-01-10'),
    ->     (5, 'exercise bike', '2014-05-09'),
    ->     (6, 'sofa', '1987-06-05'),
    ->     (7, 'espresso maker', '2011-11-22'),
    ->     (8, 'aquarium', '1992-08-04'),
    ->     (9, 'study desk', '2006-09-16'),
    ->     (10, 'lava lamp', '1998-12-25');
Query OK, 10 rows affected (0.05 sec)
Records: 10  Duplicates: 0  Warnings: 0
```

You can see which items should have been inserted into partition `p2` as shown here:

```
mysql> SELECT * FROM tr
    ->     WHERE purchased BETWEEN '1995-01-01' AND '1999-12-31';
+------+-------------+------------+
| id   | name        | purchased  |
+------+-------------+------------+
|    2 | alarm clock | 1997-11-05 |
|   10 | lava lamp   | 1998-12-25 |
+------+-------------+------------+
2 rows in set (0.00 sec)
```

You can also get this information using partition selection, as shown here:

```
mysql> SELECT * FROM tr PARTITION (p2);
+------+-------------+------------+
| id   | name        | purchased  |
+------+-------------+------------+
|    2 | alarm clock | 1997-11-05 |
|   10 | lava lamp   | 1998-12-25 |
+------+-------------+------------+
2 rows in set (0.00 sec)
```

See Partition Selection, for more information.

To drop the partition named `p2`, execute the following command:

```
mysql> ALTER TABLE tr DROP PARTITION p2;
Query OK, 0 rows affected (0.03 sec)
```

> **Note**
>
> The `NDBCLUSTER` storage engine does not support `ALTER TABLE ... DROP PARTITION`. It does, however, support the other partitioning-related extensions to `ALTER TABLE` that are described in this chapter.

It is very important to remember that, *when you drop a partition, you also delete all the data that was stored in that partition*. You can see that this is the case by re-running the previous `SELECT` query:

```
mysql> SELECT * FROM tr WHERE purchased
    -> BETWEEN '1995-01-01' AND '1999-12-31';
Empty set (0.00 sec)
```

> **Note**
>
> `DROP PARTITION` is supported by native partitioning in-place APIs and may be used with `ALGORITHM={COPY|INPLACE}`. `DROP PARTITION` with `ALGORITHM=INPLACE` deletes data stored in the partition and drops the partition. However, `DROP PARTITION` with `ALGORITHM=COPY` or `old_alter_table=ON` rebuilds the partitioned table and attempts to move data from the dropped partition to another partition with a compatible `PARTITION ... VALUES` definition. Data that cannot be moved to another partition is deleted.

Because of this, you must have the `DROP` privilege for a table before you can execute `ALTER TABLE ... DROP PARTITION` on that table.

If you wish to drop all data from all partitions while preserving the table definition and its partitioning scheme, use the `TRUNCATE TABLE` statement. (See TRUNCATE TABLE Statement.)

If you intend to change the partitioning of a table *without* losing data, use `ALTER TABLE ... REORGANIZE PARTITION` instead. See below or in ALTER TABLE Statement, for information about `REORGANIZE PARTITION`.

If you now execute a `SHOW CREATE TABLE` statement, you can see how the partitioning makeup of the table has been changed:

```
mysql> SHOW CREATE TABLE tr\G
*************************** 1. row ***************************
       Table: tr
Create Table: CREATE TABLE `tr` (
  `id` int(11) DEFAULT NULL,
  `name` varchar(50) DEFAULT NULL,
```

```
  `purchased` date DEFAULT NULL
) ENGINE=InnoDB DEFAULT CHARSET=latin1
/*!50100 PARTITION BY RANGE ( YEAR(purchased))
(PARTITION p0 VALUES LESS THAN (1990) ENGINE = InnoDB,
 PARTITION p1 VALUES LESS THAN (1995) ENGINE = InnoDB,
 PARTITION p3 VALUES LESS THAN (2005) ENGINE = InnoDB,
 PARTITION p4 VALUES LESS THAN (2010) ENGINE = InnoDB,
 PARTITION p5 VALUES LESS THAN (2015) ENGINE = InnoDB) */
1 row in set (0.00 sec)
```

When you insert new rows into the changed table with `purchased` column values between `'1995-01-01'` and `'2004-12-31'` inclusive, those rows are stored in partition `p3`. You can verify this as follows:

```
mysql> INSERT INTO tr VALUES (11, 'pencil holder', '1995-07-12');
Query OK, 1 row affected (0.00 sec)
mysql> SELECT * FROM tr WHERE purchased
    -> BETWEEN '1995-01-01' AND '2004-12-31';
+------+---------------+------------+
| id   | name          | purchased  |
+------+---------------+------------+
|    1 | desk organiser | 2003-10-15 |
|   11 | pencil holder  | 1995-07-12 |
+------+---------------+------------+
2 rows in set (0.00 sec)
mysql> ALTER TABLE tr DROP PARTITION p3;
Query OK, 0 rows affected (0.03 sec)
mysql> SELECT * FROM tr WHERE purchased
    -> BETWEEN '1995-01-01' AND '2004-12-31';
Empty set (0.00 sec)
```

The number of rows dropped from the table as a result of `ALTER TABLE ... DROP PARTITION` is not reported by the server as it would be by the equivalent `DELETE` query.

Dropping `LIST` partitions uses exactly the same `ALTER TABLE ... DROP PARTITION` syntax as used for dropping `RANGE` partitions. However, there is one important difference in the effect this has on your use of the table afterward: You can no longer insert into the table any rows having any of the values that were included in the value list defining the deleted partition. (See Section 3.2, “LIST Partitioning”, for an example.)

To add a new range or list partition to a previously partitioned table, use the `ALTER TABLE ... ADD PARTITION` statement. For tables which are partitioned by `RANGE`, this can be used to add a new range to the end of the list of existing partitions. Suppose that you have a partitioned table containing membership data for your organization, which is defined as follows:

```
CREATE TABLE members (
    id INT,
    fname VARCHAR(25),
    lname VARCHAR(25),
    dob DATE
)
PARTITION BY RANGE( YEAR(dob) ) (
    PARTITION p0 VALUES LESS THAN (1980),
    PARTITION p1 VALUES LESS THAN (1990),
    PARTITION p2 VALUES LESS THAN (2000)
);
```

Suppose further that the minimum age for members is 16. As the calendar approaches the end of 2015, you realize that you must soon be prepared to admit members who were born in 2000 (and later). You can modify the `members` table to accommodate new members born in the years 2000 to 2010 as shown here:

```
ALTER TABLE members ADD PARTITION (PARTITION p3 VALUES LESS THAN (2010));
```

With tables that are partitioned by range, you can use `ADD PARTITION` to add new partitions to the high end of the partitions list only. Trying to add a new partition in this manner between or before existing partitions results in an error as shown here:

```
mysql> ALTER TABLE members
    >     ADD PARTITION (
    >     PARTITION n VALUES LESS THAN (1970));
ERROR 1463 (HY000): VALUES LESS THAN value must be strictly »
   increasing for each partition
```

You can work around this problem by reorganizing the first partition into two new ones that split the range between them, like this:

```
ALTER TABLE members
    REORGANIZE PARTITION p0 INTO (
        PARTITION n0 VALUES LESS THAN (1970),
        PARTITION n1 VALUES LESS THAN (1980)
);
```

Using `SHOW CREATE TABLE` you can see that the `ALTER TABLE` statement has had the desired effect:

```
mysql> SHOW CREATE TABLE members\G
*************************** 1. row ***************************
       Table: members
Create Table: CREATE TABLE `members` (
  `id` int(11) DEFAULT NULL,
  `fname` varchar(25) DEFAULT NULL,
  `lname` varchar(25) DEFAULT NULL,
  `dob` date DEFAULT NULL
) ENGINE=InnoDB DEFAULT CHARSET=latin1
/*!50100 PARTITION BY RANGE ( YEAR(dob))
(PARTITION n0 VALUES LESS THAN (1970) ENGINE = InnoDB,
 PARTITION n1 VALUES LESS THAN (1980) ENGINE = InnoDB,
 PARTITION p1 VALUES LESS THAN (1990) ENGINE = InnoDB,
 PARTITION p2 VALUES LESS THAN (2000) ENGINE = InnoDB,
 PARTITION p3 VALUES LESS THAN (2010) ENGINE = InnoDB) */
1 row in set (0.00 sec)
```

See also ALTER TABLE Partition Operations.

You can also use `ALTER TABLE ... ADD PARTITION` to add new partitions to a table that is partitioned by `LIST`. Suppose a table `tt` is defined using the following `CREATE TABLE` statement:

```
CREATE TABLE tt (
    id INT,
    data INT
)
PARTITION BY LIST(data) (
    PARTITION p0 VALUES IN (5, 10, 15),
    PARTITION p1 VALUES IN (6, 12, 18)
);
```

You can add a new partition in which to store rows having the `data` column values `7`, `14`, and `21` as shown:

```
ALTER TABLE tt ADD PARTITION (PARTITION p2 VALUES IN (7, 14, 21));
```

Keep in mind that you *cannot* add a new `LIST` partition encompassing any values that are already included in the value list of an existing partition. If you attempt to do so, an error results:

```
mysql> ALTER TABLE tt ADD PARTITION
    >     (PARTITION np VALUES IN (4, 8, 12));
ERROR 1465 (HY000): Multiple definition of same constant »
```

```
                    in list partitioning
```

Because any rows with the `data` column value `12` have already been assigned to partition `p1`, you cannot create a new partition on table `tt` that includes `12` in its value list. To accomplish this, you could drop `p1`, and add `np` and then a new `p1` with a modified definition. However, as discussed earlier, this would result in the loss of all data stored in `p1`—and it is often the case that this is not what you really want to do. Another solution might appear to be to make a copy of the table with the new partitioning and to copy the data into it using `CREATE TABLE ... SELECT ...`, then drop the old table and rename the new one, but this could be very time-consuming when dealing with a large amounts of data. This also might not be feasible in situations where high availability is a requirement.

You can add multiple partitions in a single `ALTER TABLE ... ADD PARTITION` statement as shown here:

```
CREATE TABLE employees (
  id INT NOT NULL,
  fname VARCHAR(50) NOT NULL,
  lname VARCHAR(50) NOT NULL,
  hired DATE NOT NULL
)
PARTITION BY RANGE( YEAR(hired) ) (
  PARTITION p1 VALUES LESS THAN (1991),
  PARTITION p2 VALUES LESS THAN (1996),
  PARTITION p3 VALUES LESS THAN (2001),
  PARTITION p4 VALUES LESS THAN (2005)
);
ALTER TABLE employees ADD PARTITION (
    PARTITION p5 VALUES LESS THAN (2010),
    PARTITION p6 VALUES LESS THAN MAXVALUE
);
```

Fortunately, MySQL's partitioning implementation provides ways to redefine partitions without losing data. Let us look first at a couple of simple examples involving `RANGE` partitioning. Recall the `members` table which is now defined as shown here:

```
mysql> SHOW CREATE TABLE members\G
*************************** 1. row ***************************
       Table: members
Create Table: CREATE TABLE `members` (
  `id` int(11) DEFAULT NULL,
  `fname` varchar(25) DEFAULT NULL,
  `lname` varchar(25) DEFAULT NULL,
  `dob` date DEFAULT NULL
) ENGINE=InnoDB DEFAULT CHARSET=latin1
/*!50100 PARTITION BY RANGE ( YEAR(dob))
(PARTITION n0 VALUES LESS THAN (1970) ENGINE = InnoDB,
 PARTITION n1 VALUES LESS THAN (1980) ENGINE = InnoDB,
 PARTITION p1 VALUES LESS THAN (1990) ENGINE = InnoDB,
 PARTITION p2 VALUES LESS THAN (2000) ENGINE = InnoDB,
 PARTITION p3 VALUES LESS THAN (2010) ENGINE = InnoDB) */
1 row in set (0.00 sec)
```

Suppose that you would like to move all rows representing members born before 1960 into a separate partition. As we have already seen, this cannot be done using `ALTER TABLE ... ADD PARTITION`. However, you can use another partition-related extension to `ALTER TABLE` to accomplish this:

```
ALTER TABLE members REORGANIZE PARTITION n0 INTO (
    PARTITION s0 VALUES LESS THAN (1960),
    PARTITION s1 VALUES LESS THAN (1970)
);
```

In effect, this command splits partition `p0` into two new partitions `s0` and `s1`. It also moves the data that was stored in `p0` into the new partitions according to the rules embodied in the two `PARTITION ...`

`VALUES ...` clauses, so that `s0` contains only those records for which `YEAR(dob)` is less than 1960 and `s1` contains those rows in which `YEAR(dob)` is greater than or equal to 1960 but less than 1970.

A `REORGANIZE PARTITION` clause may also be used for merging adjacent partitions. You can reverse the effect of the previous statement on the `members` table as shown here:

```
ALTER TABLE members REORGANIZE PARTITION s0,s1 INTO (
    PARTITION p0 VALUES LESS THAN (1970)
);
```

No data is lost in splitting or merging partitions using `REORGANIZE PARTITION`. In executing the above statement, MySQL moves all of the records that were stored in partitions `s0` and `s1` into partition `p0`.

The general syntax for `REORGANIZE PARTITION` is shown here:

```
ALTER TABLE tbl_name
    REORGANIZE PARTITION partition_list
    INTO (partition_definitions);
```

Here, *`tbl_name`* is the name of the partitioned table, and *`partition_list`* is a comma-separated list of names of one or more existing partitions to be changed. *`partition_definitions`* is a comma-separated list of new partition definitions, which follow the same rules as for the *`partition_definitions`* list used in `CREATE TABLE`. You are not limited to merging several partitions into one, or to splitting one partition into many, when using `REORGANIZE PARTITION`. For example, you can reorganize all four partitions of the `members` table into two, like this:

```
ALTER TABLE members REORGANIZE PARTITION p0,p1,p2,p3 INTO (
    PARTITION m0 VALUES LESS THAN (1980),
    PARTITION m1 VALUES LESS THAN (2000)
);
```

You can also use `REORGANIZE PARTITION` with tables that are partitioned by `LIST`. Let us return to the problem of adding a new partition to the list-partitioned `tt` table and failing because the new partition had a value that was already present in the value-list of one of the existing partitions. We can handle this by adding a partition that contains only nonconflicting values, and then reorganizing the new partition and the existing one so that the value which was stored in the existing one is now moved to the new one:

```
ALTER TABLE tt ADD PARTITION (PARTITION np VALUES IN (4, 8));
ALTER TABLE tt REORGANIZE PARTITION p1,np INTO (
    PARTITION p1 VALUES IN (6, 18),
    PARTITION np VALUES in (4, 8, 12)
);
```

Here are some key points to keep in mind when using `ALTER TABLE ... REORGANIZE PARTITION` to repartition tables that are partitioned by `RANGE` or `LIST`:

- The `PARTITION` options used to determine the new partitioning scheme are subject to the same rules as those used with a `CREATE TABLE` statement.

  A new `RANGE` partitioning scheme cannot have any overlapping ranges; a new `LIST` partitioning scheme cannot have any overlapping sets of values.

- The combination of partitions in the *`partition_definitions`* list should account for the same range or set of values overall as the combined partitions named in the *`partition_list`*.

  For example, partitions `p1` and `p2` together cover the years 1980 through 1999 in the `members` table used as an example in this section. Any reorganization of these two partitions should cover the same range of years overall.

- For tables partitioned by RANGE, you can reorganize only adjacent partitions; you cannot skip range partitions.

  For instance, you could not reorganize the example members table using a statement beginning with ALTER TABLE members REORGANIZE PARTITION p0,p2 INTO ... because p0 covers the years prior to 1970 and p2 the years from 1990 through 1999 inclusive, so these are not adjacent partitions. (You cannot skip partition p1 in this case.)

- You cannot use REORGANIZE PARTITION to change the type of partitioning used by the table (for example, you cannot change RANGE partitions to HASH partitions or the reverse). You also cannot use this statement to change the partitioning expression or column. To accomplish either of these tasks without dropping and re-creating the table, you can use ALTER TABLE ... PARTITION BY ..., as shown here:

```
ALTER TABLE members
    PARTITION BY HASH( YEAR(dob) )
    PARTITIONS 8;
```

4.2 Management of HASH and KEY Partitions

Tables which are partitioned by hash or by key are very similar to one another with regard to making changes in a partitioning setup, and both differ in a number of ways from tables which have been partitioned by range or list. For that reason, this section addresses the modification of tables partitioned by hash or by key only. For a discussion of adding and dropping of partitions of tables that are partitioned by range or list, see Section 4.1, “Management of RANGE and LIST Partitions”.

You cannot drop partitions from tables that are partitioned by HASH or KEY in the same way that you can from tables that are partitioned by RANGE or LIST. However, you can merge HASH or KEY partitions using ALTER TABLE ... COALESCE PARTITION. Suppose that a clients table containing data about clients is divided into 12 partitions, created as shown here:

```
CREATE TABLE clients (
    id INT,
    fname VARCHAR(30),
    lname VARCHAR(30),
    signed DATE
)
PARTITION BY HASH( MONTH(signed) )
PARTITIONS 12;
```

To reduce the number of partitions from 12 to 8, execute the following ALTER TABLE statement:

```
mysql> ALTER TABLE clients COALESCE PARTITION 4;
Query OK, 0 rows affected (0.02 sec)
```

COALESCE works equally well with tables that are partitioned by HASH, KEY, LINEAR HASH, or LINEAR KEY. Here is an example similar to the previous one, differing only in that the table is partitioned by LINEAR KEY:

```
mysql> CREATE TABLE clients_lk (
    ->     id INT,
    ->     fname VARCHAR(30),
    ->     lname VARCHAR(30),
    ->     signed DATE
    -> )
    -> PARTITION BY LINEAR KEY(signed)
    -> PARTITIONS 12;
Query OK, 0 rows affected (0.03 sec)
mysql> ALTER TABLE clients_lk COALESCE PARTITION 4;
Query OK, 0 rows affected (0.06 sec)
```

```
Records: 0  Duplicates: 0  Warnings: 0
```

The number following `COALESCE PARTITION` is the number of partitions to merge into the remainder—in other words, it is the number of partitions to remove from the table.

Attempting to remove more partitions than are in the table results in an error like this one:

```
mysql> ALTER TABLE clients COALESCE PARTITION 18;
ERROR 1478 (HY000): Cannot remove all partitions, use DROP TABLE instead
```

To increase the number of partitions for the `clients` table from 12 to 18, use `ALTER TABLE ... ADD PARTITION` as shown here:

```
ALTER TABLE clients ADD PARTITION PARTITIONS 6;
```

4.3 Exchanging Partitions and Subpartitions with Tables

In MySQL 8.2, it is possible to exchange a table partition or subpartition with a table using `ALTER TABLE pt EXCHANGE PARTITION p WITH TABLE nt`, where *`pt`* is the partitioned table and *`p`* is the partition or subpartition of *`pt`* to be exchanged with unpartitioned table *`nt`*, provided that the following statements are true:

1. Table *`nt`* is not itself partitioned.
2. Table *`nt`* is not a temporary table.
3. The structures of tables *`pt`* and *`nt`* are otherwise identical.
4. Table `nt` contains no foreign key references, and no other table has any foreign keys that refer to `nt`.
5. There are no rows in *`nt`* that lie outside the boundaries of the partition definition for *`p`*. This condition does not apply if `WITHOUT VALIDATION` is used.
6. Both tables must use the same character set and collation.
7. For `InnoDB` tables, both tables must use the same row format. To determine the row format of an `InnoDB` table, query `INFORMATION_SCHEMA.INNODB_TABLES`.
8. Any partition-level `MAX_ROWS` setting for `p` must be the same as the table-level `MAX_ROWS` value set for `nt`. The setting for any partition-level `MIN_ROWS` setting for `p` must also be the same any table-level `MIN_ROWS` value set for `nt`.

   This is true in either case whether not `pt` has an explicit table-level `MAX_ROWS` or `MIN_ROWS` option in effect.
9. The `AVG_ROW_LENGTH` cannot differ between the two tables `pt` and `nt`.
10. `INDEX DIRECTORY` cannot differ between the table and the partition to be exchanged with it.
11. No table or partition `TABLESPACE` options can be used in either of the tables.

In addition to the `ALTER`, `INSERT`, and `CREATE` privileges usually required for `ALTER TABLE` statements, you must have the `DROP` privilege to perform `ALTER TABLE ... EXCHANGE PARTITION`.

You should also be aware of the following effects of `ALTER TABLE ... EXCHANGE PARTITION`:

- Executing `ALTER TABLE ... EXCHANGE PARTITION` does not invoke any triggers on either the partitioned table or the table to be exchanged.

- Any AUTO_INCREMENT columns in the exchanged table are reset.
- The IGNORE keyword has no effect when used with ALTER TABLE ... EXCHANGE PARTITION.

The syntax for ALTER TABLE ... EXCHANGE PARTITION is shown here, where *pt* is the partitioned table, *p* is the partition (or subpartition) to be exchanged, and *nt* is the nonpartitioned table to be exchanged with *p*:

```
ALTER TABLE pt
    EXCHANGE PARTITION p
    WITH TABLE nt;
```

Optionally, you can append WITH VALIDATION or WITHOUT VALIDATION. When WITHOUT VALIDATION is specified, the ALTER TABLE ... EXCHANGE PARTITION operation does not perform any row-by-row validation when exchanging a partition a nonpartitioned table, allowing database administrators to assume responsibility for ensuring that rows are within the boundaries of the partition definition. WITH VALIDATION is the default.

One and only one partition or subpartition may be exchanged with one and only one nonpartitioned table in a single ALTER TABLE EXCHANGE PARTITION statement. To exchange multiple partitions or subpartitions, use multiple ALTER TABLE EXCHANGE PARTITION statements. EXCHANGE PARTITION may not be combined with other ALTER TABLE options. The partitioning and (if applicable) subpartitioning used by the partitioned table may be of any type or types supported in MySQL 8.2.

Exchanging a Partition with a Nonpartitioned Table

Suppose that a partitioned table e has been created and populated using the following SQL statements:

```
CREATE TABLE e (
    id INT NOT NULL,
    fname VARCHAR(30),
    lname VARCHAR(30)
)
    PARTITION BY RANGE (id) (
        PARTITION p0 VALUES LESS THAN (50),
        PARTITION p1 VALUES LESS THAN (100),
        PARTITION p2 VALUES LESS THAN (150),
        PARTITION p3 VALUES LESS THAN (MAXVALUE)
);
INSERT INTO e VALUES
    (1669, "Jim", "Smith"),
    (337, "Mary", "Jones"),
    (16, "Frank", "White"),
    (2005, "Linda", "Black");
```

Now we create a nonpartitioned copy of e named e2. This can be done using the mysql client as shown here:

```
mysql> CREATE TABLE e2 LIKE e;
Query OK, 0 rows affected (0.04 sec)
mysql> ALTER TABLE e2 REMOVE PARTITIONING;
Query OK, 0 rows affected (0.07 sec)
Records: 0  Duplicates: 0  Warnings: 0
```

You can see which partitions in table e contain rows by querying the Information Schema PARTITIONS table, like this:

```
mysql> SELECT PARTITION_NAME, TABLE_ROWS
           FROM INFORMATION_SCHEMA.PARTITIONS
           WHERE TABLE_NAME = 'e';
+----------------+------------+
```

```
| PARTITION_NAME | TABLE_ROWS |
+----------------+------------+
| p0             |          1 |
| p1             |          0 |
| p2             |          0 |
| p3             |          3 |
+----------------+------------+
2 rows in set (0.00 sec)
```

> **Note**
>
> For partitioned `InnoDB` tables, the row count given in the `TABLE_ROWS` column of the Information Schema `PARTITIONS` table is only an estimated value used in SQL optimization, and is not always exact.

To exchange partition `p0` in table `e` with table `e2`, you can use `ALTER TABLE`, as shown here:

```
mysql> ALTER TABLE e EXCHANGE PARTITION p0 WITH TABLE e2;
Query OK, 0 rows affected (0.04 sec)
```

More precisely, the statement just issued causes any rows found in the partition to be swapped with those found in the table. You can observe how this has happened by querying the Information Schema `PARTITIONS` table, as before. The table row that was previously found in partition `p0` is no longer present:

```
mysql> SELECT PARTITION_NAME, TABLE_ROWS
           FROM INFORMATION_SCHEMA.PARTITIONS
           WHERE TABLE_NAME = 'e';
+----------------+------------+
| PARTITION_NAME | TABLE_ROWS |
+----------------+------------+
| p0             |          0 |
| p1             |          0 |
| p2             |          0 |
| p3             |          3 |
+----------------+------------+
4 rows in set (0.00 sec)
```

If you query table `e2`, you can see that the “missing” row can now be found there:

```
mysql> SELECT * FROM e2;
+----+-------+-------+
| id | fname | lname |
+----+-------+-------+
| 16 | Frank | White |
+----+-------+-------+
1 row in set (0.00 sec)
```

The table to be exchanged with the partition does not necessarily have to be empty. To demonstrate this, we first insert a new row into table `e`, making sure that this row is stored in partition `p0` by choosing an `id` column value that is less than 50, and verifying this afterward by querying the `PARTITIONS` table:

```
mysql> INSERT INTO e VALUES (41, "Michael", "Green");
Query OK, 1 row affected (0.05 sec)
mysql> SELECT PARTITION_NAME, TABLE_ROWS
           FROM INFORMATION_SCHEMA.PARTITIONS
           WHERE TABLE_NAME = 'e';
+----------------+------------+
| PARTITION_NAME | TABLE_ROWS |
+----------------+------------+
| p0             |          1 |
| p1             |          0 |
| p2             |          0 |
| p3             |          3 |
+----------------+------------+
```

```
4 rows in set (0.00 sec)
```

Now we once again exchange partition `p0` with table `e2` using the same `ALTER TABLE` statement as previously:

```
mysql> ALTER TABLE e EXCHANGE PARTITION p0 WITH TABLE e2;
Query OK, 0 rows affected (0.28 sec)
```

The output of the following queries shows that the table row that was stored in partition `p0` and the table row that was stored in table `e2`, prior to issuing the `ALTER TABLE` statement, have now switched places:

```
mysql> SELECT * FROM e;
+------+-------+-------+
| id   | fname | lname |
+------+-------+-------+
|   16 | Frank | White |
| 1669 | Jim   | Smith |
|  337 | Mary  | Jones |
| 2005 | Linda | Black |
+------+-------+-------+
4 rows in set (0.00 sec)
mysql> SELECT PARTITION_NAME, TABLE_ROWS
           FROM INFORMATION_SCHEMA.PARTITIONS
           WHERE TABLE_NAME = 'e';
+----------------+------------+
| PARTITION_NAME | TABLE_ROWS |
+----------------+------------+
| p0             |          1 |
| p1             |          0 |
| p2             |          0 |
| p3             |          3 |
+----------------+------------+
4 rows in set (0.00 sec)
mysql> SELECT * FROM e2;
+----+---------+-------+
| id | fname   | lname |
+----+---------+-------+
| 41 | Michael | Green |
+----+---------+-------+
1 row in set (0.00 sec)
```

Nonmatching Rows

You should keep in mind that any rows found in the nonpartitioned table prior to issuing the `ALTER TABLE ... EXCHANGE PARTITION` statement must meet the conditions required for them to be stored in the target partition; otherwise, the statement fails. To see how this occurs, first insert a row into `e2` that is outside the boundaries of the partition definition for partition `p0` of table `e`. For example, insert a row with an `id` column value that is too large; then, try to exchange the table with the partition again:

```
mysql> INSERT INTO e2 VALUES (51, "Ellen", "McDonald");
Query OK, 1 row affected (0.08 sec)
mysql> ALTER TABLE e EXCHANGE PARTITION p0 WITH TABLE e2;
ERROR 1707 (HY000): Found row that does not match the partition
```

Only the `WITHOUT VALIDATION` option would permit this operation to succeed:

```
mysql> ALTER TABLE e EXCHANGE PARTITION p0 WITH TABLE e2 WITHOUT VALIDATION;
Query OK, 0 rows affected (0.02 sec)
```

When a partition is exchanged with a table that contains rows that do not match the partition definition, it is the responsibility of the database administrator to fix the non-matching rows, which can be performed using `REPAIR TABLE` or `ALTER TABLE ... REPAIR PARTITION`.

Exchanging Partitions Without Row-By-Row Validation

To avoid time consuming validation when exchanging a partition with a table that has many rows, it is possible to skip the row-by-row validation step by appending `WITHOUT VALIDATION` to the `ALTER TABLE ... EXCHANGE PARTITION` statement.

The following example compares the difference between execution times when exchanging a partition with a nonpartitioned table, with and without validation. The partitioned table (table `e`) contains two partitions of 1 million rows each. The rows in p0 of table e are removed and p0 is exchanged with a nonpartitioned table of 1 million rows. The `WITH VALIDATION` operation takes 0.74 seconds. By comparison, the `WITHOUT VALIDATION` operation takes 0.01 seconds.

```
# Create a partitioned table with 1 million rows in each partition
CREATE TABLE e (
    id INT NOT NULL,
    fname VARCHAR(30),
    lname VARCHAR(30)
)
    PARTITION BY RANGE (id) (
        PARTITION p0 VALUES LESS THAN (1000001),
        PARTITION p1 VALUES LESS THAN (2000001),
);
mysql> SELECT COUNT(*) FROM e;
| COUNT(*) |
+----------+
|  2000000 |
+----------+
1 row in set (0.27 sec)
# View the rows in each partition
SELECT PARTITION_NAME, TABLE_ROWS FROM INFORMATION_SCHEMA.PARTITIONS WHERE TABLE_NAME = 'e';
+----------------+-------------+
| PARTITION_NAME | TABLE_ROWS  |
+----------------+-------------+
| p0             |     1000000 |
| p1             |     1000000 |
+----------------+-------------+
2 rows in set (0.00 sec)
# Create a nonpartitioned table of the same structure and populate it with 1 million rows
CREATE TABLE e2 (
    id INT NOT NULL,
    fname VARCHAR(30),
    lname VARCHAR(30)
);
mysql> SELECT COUNT(*) FROM e2;
+----------+
| COUNT(*) |
+----------+
|  1000000 |
+----------+
1 row in set (0.24 sec)
# Create another nonpartitioned table of the same structure and populate it with 1 million rows
CREATE TABLE e3 (
    id INT NOT NULL,
    fname VARCHAR(30),
    lname VARCHAR(30)
);
mysql> SELECT COUNT(*) FROM e3;
+----------+
| COUNT(*) |
+----------+
|  1000000 |
+----------+
1 row in set (0.25 sec)
# Drop the rows from p0 of table e
mysql> DELETE FROM e WHERE id < 1000001;
```

```
Query OK, 1000000 rows affected (5.55 sec)
# Confirm that there are no rows in partition p0
mysql> SELECT PARTITION_NAME, TABLE_ROWS FROM INFORMATION_SCHEMA.PARTITIONS WHERE TABLE_NAME = 'e';
+----------------+------------+
| PARTITION_NAME | TABLE_ROWS |
+----------------+------------+
| p0             |          0 |
| p1             |    1000000 |
+----------------+------------+
2 rows in set (0.00 sec)
# Exchange partition p0 of table e with the table e2 'WITH VALIDATION'
mysql> ALTER TABLE e EXCHANGE PARTITION p0 WITH TABLE e2 WITH VALIDATION;
Query OK, 0 rows affected (0.74 sec)
# Confirm that the partition was exchanged with table e2
mysql> SELECT PARTITION_NAME, TABLE_ROWS FROM INFORMATION_SCHEMA.PARTITIONS WHERE TABLE_NAME = 'e';
+----------------+------------+
| PARTITION_NAME | TABLE_ROWS |
+----------------+------------+
| p0             |    1000000 |
| p1             |    1000000 |
+----------------+------------+
2 rows in set (0.00 sec)
# Once again, drop the rows from p0 of table e
mysql> DELETE FROM e WHERE id < 1000001;
Query OK, 1000000 rows affected (5.55 sec)
# Confirm that there are no rows in partition p0
mysql> SELECT PARTITION_NAME, TABLE_ROWS FROM INFORMATION_SCHEMA.PARTITIONS WHERE TABLE_NAME = 'e';
+----------------+------------+
| PARTITION_NAME | TABLE_ROWS |
+----------------+------------+
| p0             |          0 |
| p1             |    1000000 |
+----------------+------------+
2 rows in set (0.00 sec)
# Exchange partition p0 of table e with the table e3 'WITHOUT VALIDATION'
mysql> ALTER TABLE e EXCHANGE PARTITION p0 WITH TABLE e3 WITHOUT VALIDATION;
Query OK, 0 rows affected (0.01 sec)
# Confirm that the partition was exchanged with table e3
mysql> SELECT PARTITION_NAME, TABLE_ROWS FROM INFORMATION_SCHEMA.PARTITIONS WHERE TABLE_NAME = 'e';
+----------------+------------+
| PARTITION_NAME | TABLE_ROWS |
+----------------+------------+
| p0             |    1000000 |
| p1             |    1000000 |
+----------------+------------+
2 rows in set (0.00 sec)
```

If a partition is exchanged with a table that contains rows that do not match the partition definition, it is the responsibility of the database administrator to fix the non-matching rows, which can be performed using `REPAIR TABLE` or `ALTER TABLE ... REPAIR PARTITION`.

Exchanging a Subpartition with a Nonpartitioned Table

You can also exchange a subpartition of a subpartitioned table (see Section 3.6, “Subpartitioning”) with a nonpartitioned table using an `ALTER TABLE ... EXCHANGE PARTITION` statement. In the following example, we first create a table `es` that is partitioned by `RANGE` and subpartitioned by `KEY`, populate this table as we did table `e`, and then create an empty, nonpartitioned copy `es2` of the table, as shown here:

```
mysql> CREATE TABLE es (
    ->     id INT NOT NULL,
    ->     fname VARCHAR(30),
    ->     lname VARCHAR(30)
    -> )
    ->     PARTITION BY RANGE (id)
```

```
    ->     SUBPARTITION BY KEY (lname)
    ->     SUBPARTITIONS 2 (
    ->         PARTITION p0 VALUES LESS THAN (50),
    ->         PARTITION p1 VALUES LESS THAN (100),
    ->         PARTITION p2 VALUES LESS THAN (150),
    ->         PARTITION p3 VALUES LESS THAN (MAXVALUE)
    ->     );
Query OK, 0 rows affected (2.76 sec)
mysql> INSERT INTO es VALUES
    ->     (1669, "Jim", "Smith"),
    ->     (337, "Mary", "Jones"),
    ->     (16, "Frank", "White"),
    ->     (2005, "Linda", "Black");
Query OK, 4 rows affected (0.04 sec)
Records: 4  Duplicates: 0  Warnings: 0
mysql> CREATE TABLE es2 LIKE es;
Query OK, 0 rows affected (1.27 sec)
mysql> ALTER TABLE es2 REMOVE PARTITIONING;
Query OK, 0 rows affected (0.70 sec)
Records: 0  Duplicates: 0  Warnings: 0
```

Although we did not explicitly name any of the subpartitions when creating table `es`, we can obtain generated names for these by including the `SUBPARTITION_NAME` column of the `PARTITIONS` table from `INFORMATION_SCHEMA` when selecting from that table, as shown here:

```
mysql> SELECT PARTITION_NAME, SUBPARTITION_NAME, TABLE_ROWS
    ->     FROM INFORMATION_SCHEMA.PARTITIONS
    ->     WHERE TABLE_NAME = 'es';
+----------------+-------------------+------------+
| PARTITION_NAME | SUBPARTITION_NAME | TABLE_ROWS |
+----------------+-------------------+------------+
| p0             | p0sp0             |          1 |
| p0             | p0sp1             |          0 |
| p1             | p1sp0             |          0 |
| p1             | p1sp1             |          0 |
| p2             | p2sp0             |          0 |
| p2             | p2sp1             |          0 |
| p3             | p3sp0             |          3 |
| p3             | p3sp1             |          0 |
+----------------+-------------------+------------+
8 rows in set (0.00 sec)
```

The following `ALTER TABLE` statement exchanges subpartition `p3sp0` in table `es` with the nonpartitioned table `es2`:

```
mysql> ALTER TABLE es EXCHANGE PARTITION p3sp0 WITH TABLE es2;
Query OK, 0 rows affected (0.29 sec)
```

You can verify that the rows were exchanged by issuing the following queries:

```
mysql> SELECT PARTITION_NAME, SUBPARTITION_NAME, TABLE_ROWS
    ->     FROM INFORMATION_SCHEMA.PARTITIONS
    ->     WHERE TABLE_NAME = 'es';
+----------------+-------------------+------------+
| PARTITION_NAME | SUBPARTITION_NAME | TABLE_ROWS |
+----------------+-------------------+------------+
| p0             | p0sp0             |          1 |
| p0             | p0sp1             |          0 |
| p1             | p1sp0             |          0 |
| p1             | p1sp1             |          0 |
| p2             | p2sp0             |          0 |
| p2             | p2sp1             |          0 |
| p3             | p3sp0             |          0 |
| p3             | p3sp1             |          0 |
+----------------+-------------------+------------+
8 rows in set (0.00 sec)
```

```
mysql> SELECT * FROM es2;
+------+-------+-------+
| id   | fname | lname |
+------+-------+-------+
| 1669 | Jim   | Smith |
|  337 | Mary  | Jones |
| 2005 | Linda | Black |
+------+-------+-------+
3 rows in set (0.00 sec)
```

If a table is subpartitioned, you can exchange only a subpartition of the table—not an entire partition—with an unpartitioned table, as shown here:

```
mysql> ALTER TABLE es EXCHANGE PARTITION p3 WITH TABLE es2;
ERROR 1704 (HY000): Subpartitioned table, use subpartition instead of partition
```

Table structures are compared in a strict fashion; the number, order, names, and types of columns and indexes of the partitioned table and the nonpartitioned table must match exactly. In addition, both tables must use the same storage engine:

```
mysql> CREATE TABLE es3 LIKE e;
Query OK, 0 rows affected (1.31 sec)
mysql> ALTER TABLE es3 REMOVE PARTITIONING;
Query OK, 0 rows affected (0.53 sec)
Records: 0  Duplicates: 0  Warnings: 0
mysql> SHOW CREATE TABLE es3\G
*************************** 1. row ***************************
       Table: es3
Create Table: CREATE TABLE `es3` (
  `id` int(11) NOT NULL,
  `fname` varchar(30) DEFAULT NULL,
  `lname` varchar(30) DEFAULT NULL
) ENGINE=InnoDB DEFAULT CHARSET=utf8mb4
1 row in set (0.00 sec)
mysql> ALTER TABLE es3 ENGINE = MyISAM;
Query OK, 0 rows affected (0.15 sec)
Records: 0  Duplicates: 0  Warnings: 0
mysql> ALTER TABLE es EXCHANGE PARTITION p3sp0 WITH TABLE es3;
ERROR 1497 (HY000): The mix of handlers in the partitions is not allowed in this version of MySQL
```

4.4 Maintenance of Partitions

A number of table and partition maintenance tasks can be carried out on partitioned tables using SQL statements intended for such purposes.

Table maintenance of partitioned tables can be accomplished using the statements `CHECK TABLE`, `OPTIMIZE TABLE`, `ANALYZE TABLE`, and `REPAIR TABLE`, which are supported for partitioned tables.

You can use a number of extensions to `ALTER TABLE` for performing operations of this type on one or more partitions directly, as described in the following list:

- **Rebuilding partitions.** Rebuilds the partition; this has the same effect as dropping all records stored in the partition, then reinserting them. This can be useful for purposes of defragmentation.

  Example:

  ```
  ALTER TABLE t1 REBUILD PARTITION p0, p1;
  ```

- **Optimizing partitions.** If you have deleted a large number of rows from a partition or if you have made many changes to a partitioned table with variable-length rows (that is, having `VARCHAR`, `BLOB`, or `TEXT` columns), you can use `ALTER TABLE ... OPTIMIZE PARTITION` to reclaim any unused space and to defragment the partition data file.

Example:

```
ALTER TABLE t1 OPTIMIZE PARTITION p0, p1;
```

Using `OPTIMIZE PARTITION` on a given partition is equivalent to running `CHECK PARTITION`, `ANALYZE PARTITION`, and `REPAIR PARTITION` on that partition.

Some MySQL storage engines, including `InnoDB`, do not support per-partition optimization; in these cases, `ALTER TABLE ... OPTIMIZE PARTITION` analyzes and rebuilds the entire table, and causes an appropriate warning to be issued. (Bug #11751825, Bug #42822) Use `ALTER TABLE ... REBUILD PARTITION` and `ALTER TABLE ... ANALYZE PARTITION` instead, to avoid this issue.

- **Analyzing partitions.** This reads and stores the key distributions for partitions.

  Example:

  ```
  ALTER TABLE t1 ANALYZE PARTITION p3;
  ```

- **Repairing partitions.** This repairs corrupted partitions.

  Example:

  ```
  ALTER TABLE t1 REPAIR PARTITION p0,p1;
  ```

  Normally, `REPAIR PARTITION` fails when the partition contains duplicate key errors. You can use `ALTER IGNORE TABLE` with this option, in which case all rows that cannot be moved due to the presence of duplicate keys are removed from the partition (Bug #16900947).

- **Checking partitions.** You can check partitions for errors in much the same way that you can use `CHECK TABLE` with nonpartitioned tables.

  Example:

  ```
  ALTER TABLE trb3 CHECK PARTITION p1;
  ```

  This statement tells you whether the data or indexes in partition `p1` of table `t1` are corrupted. If this is the case, use `ALTER TABLE ... REPAIR PARTITION` to repair the partition.

  Normally, `CHECK PARTITION` fails when the partition contains duplicate key errors. You can use `ALTER IGNORE TABLE` with this option, in which case the statement returns the contents of each row in the partition where a duplicate key violation is found. Only the values for the columns in the partitioning expression for the table are reported. (Bug #16900947)

Each of the statements in the list just shown also supports the keyword `ALL` in place of the list of partition names. Using `ALL` causes the statement to act on all partitions in the table.

You can also truncate partitions using `ALTER TABLE ... TRUNCATE PARTITION`. This statement can be used to delete all rows from one or more partitions in much the same way that `TRUNCATE TABLE` deletes all rows from a table.

`ALTER TABLE ... TRUNCATE PARTITION ALL` truncates all partitions in the table.

4.5 Obtaining Information About Partitions

This section discusses obtaining information about existing partitions, which can be done in a number of ways. Methods of obtaining such information include the following:

- Using the `SHOW CREATE TABLE` statement to view the partitioning clauses used in creating a partitioned table.
- Using the `SHOW TABLE STATUS` statement to determine whether a table is partitioned.
- Querying the Information Schema `PARTITIONS` table.
- Using the statement `EXPLAIN SELECT` to see which partitions are used by a given `SELECT`.

When insertions, deletions, or updates are made to partitioned tables, the binary log records information about the partition and (if any) the subpartition in which the row event took place. A new row event is created for a modification that takes place in a different partition or subpartition, even if the table involved is the same. So if a transaction involves three partitions or subpartitions, three row events are generated. For an update event, the partition information is recorded for both the “before” image and the “after” image. The partition information is displayed if you specify the `-v` or `--verbose` option when viewing the binary log using `mysqlbinlog`. Partition information is only recorded when row-based logging is in use (`binlog_format=ROW`).

As discussed elsewhere in this chapter, `SHOW CREATE TABLE` includes in its output the `PARTITION BY` clause used to create a partitioned table. For example:

```
mysql> SHOW CREATE TABLE trb3\G
*************************** 1. row ***************************
       Table: trb3
Create Table: CREATE TABLE `trb3` (
  `id` int(11) DEFAULT NULL,
  `name` varchar(50) DEFAULT NULL,
  `purchased` date DEFAULT NULL
) ENGINE=InnoDB DEFAULT CHARSET=utf8mb4
/*!50100 PARTITION BY RANGE (YEAR(purchased))
(PARTITION p0 VALUES LESS THAN (1990) ENGINE = InnoDB,
 PARTITION p1 VALUES LESS THAN (1995) ENGINE = InnoDB,
 PARTITION p2 VALUES LESS THAN (2000) ENGINE = InnoDB,
 PARTITION p3 VALUES LESS THAN (2005) ENGINE = InnoDB) */
0 row in set (0.00 sec)
```

The output from `SHOW TABLE STATUS` for partitioned tables is the same as that for nonpartitioned tables, except that the `Create_options` column contains the string `partitioned`. The `Engine` column contains the name of the storage engine used by all partitions of the table. (See SHOW TABLE STATUS Statement, for more information about this statement.)

You can also obtain information about partitions from `INFORMATION_SCHEMA`, which contains a `PARTITIONS` table. See The INFORMATION_SCHEMA PARTITIONS Table.

It is possible to determine which partitions of a partitioned table are involved in a given `SELECT` query using `EXPLAIN`. The `partitions` column in the `EXPLAIN` output lists the partitions from which records would be matched by the query.

Suppose that a table `trb1` is created and populated as follows:

```
CREATE TABLE trb1 (id INT, name VARCHAR(50), purchased DATE)
    PARTITION BY RANGE(id)
    (
        PARTITION p0 VALUES LESS THAN (3),
        PARTITION p1 VALUES LESS THAN (7),
        PARTITION p2 VALUES LESS THAN (9),
        PARTITION p3 VALUES LESS THAN (11)
    );
INSERT INTO trb1 VALUES
    (1, 'desk organiser', '2003-10-15'),
    (2, 'CD player', '1993-11-05'),
    (3, 'TV set', '1996-03-10'),
```

```
    (4, 'bookcase', '1982-01-10'),
    (5, 'exercise bike', '2004-05-09'),
    (6, 'sofa', '1987-06-05'),
    (7, 'popcorn maker', '2001-11-22'),
    (8, 'aquarium', '1992-08-04'),
    (9, 'study desk', '1984-09-16'),
    (10, 'lava lamp', '1998-12-25');
```

You can see which partitions are used in a query such as `SELECT * FROM trb1;`, as shown here:

```
mysql> EXPLAIN SELECT * FROM trb1\G
*************************** 1. row ***************************
           id: 1
  select_type: SIMPLE
        table: trb1
   partitions: p0,p1,p2,p3
         type: ALL
possible_keys: NULL
          key: NULL
      key_len: NULL
          ref: NULL
         rows: 10
        Extra: Using filesort
```

In this case, all four partitions are searched. However, when a limiting condition making use of the partitioning key is added to the query, you can see that only those partitions containing matching values are scanned, as shown here:

```
mysql> EXPLAIN SELECT * FROM trb1 WHERE id < 5\G
*************************** 1. row ***************************
           id: 1
  select_type: SIMPLE
        table: trb1
   partitions: p0,p1
         type: ALL
possible_keys: NULL
          key: NULL
      key_len: NULL
          ref: NULL
         rows: 10
        Extra: Using where
```

`EXPLAIN` also provides information about keys used and possible keys:

```
mysql> ALTER TABLE trb1 ADD PRIMARY KEY (id);
Query OK, 10 rows affected (0.03 sec)
Records: 10  Duplicates: 0  Warnings: 0
mysql> EXPLAIN SELECT * FROM trb1 WHERE id < 5\G
*************************** 1. row ***************************
           id: 1
  select_type: SIMPLE
        table: trb1
   partitions: p0,p1
         type: range
possible_keys: PRIMARY
          key: PRIMARY
      key_len: 4
          ref: NULL
         rows: 7
        Extra: Using where
```

If `EXPLAIN` is used to examine a query against a nonpartitioned table, no error is produced, but the value of the `partitions` column is always `NULL`.

The `rows` column of `EXPLAIN` output displays the total number of rows in the table.

See also EXPLAIN Statement.

Chapter 5 Partition Pruning

The optimization known as *partition pruning* is based on a relatively simple concept which can be described as “Do not scan partitions where there can be no matching values”. Suppose a partitioned table `t1` is created by this statement:

```
CREATE TABLE t1 (
    fname VARCHAR(50) NOT NULL,
    lname VARCHAR(50) NOT NULL,
    region_code TINYINT UNSIGNED NOT NULL,
    dob DATE NOT NULL
)
PARTITION BY RANGE( region_code ) (
    PARTITION p0 VALUES LESS THAN (64),
    PARTITION p1 VALUES LESS THAN (128),
    PARTITION p2 VALUES LESS THAN (192),
    PARTITION p3 VALUES LESS THAN MAXVALUE
);
```

Suppose that you wish to obtain results from a `SELECT` statement such as this one:

```
SELECT fname, lname, region_code, dob
    FROM t1
    WHERE region_code > 125 AND region_code < 130;
```

It is easy to see that none of the rows which ought to be returned are in either of the partitions `p0` or `p3`; that is, we need search only in partitions `p1` and `p2` to find matching rows. By limiting the search, it is possible to expend much less time and effort in finding matching rows than by scanning all partitions in the table. This “cutting away” of unneeded partitions is known as *pruning*. When the optimizer can make use of partition pruning in performing this query, execution of the query can be an order of magnitude faster than the same query against a nonpartitioned table containing the same column definitions and data.

The optimizer can perform pruning whenever a `WHERE` condition can be reduced to either one of the following two cases:

- *`partition_column = constant`*
- *`partition_column`* `IN (`*`constant1, constant2, ..., constantN`*`)`

In the first case, the optimizer simply evaluates the partitioning expression for the value given, determines which partition contains that value, and scans only this partition. In many cases, the equal sign can be replaced with another arithmetic comparison, including `<`, `>`, `<=`, `>=`, and `<>`. Some queries using `BETWEEN` in the `WHERE` clause can also take advantage of partition pruning. See the examples later in this section.

In the second case, the optimizer evaluates the partitioning expression for each value in the list, creates a list of matching partitions, and then scans only the partitions in this partition list.

`SELECT`, `DELETE`, and `UPDATE` statements support partition pruning. An `INSERT` statement also accesses only one partition per inserted row; this is true even for a table that is partitioned by `HASH` or `KEY` although this is not currently shown in the output of `EXPLAIN`.

Pruning can also be applied to short ranges, which the optimizer can convert into equivalent lists of values. For instance, in the previous example, the `WHERE` clause can be converted to `WHERE region_code IN (126, 127, 128, 129)`. Then the optimizer can determine that the first two values in the list are found in partition `p1`, the remaining two values in partition `p2`, and that the other partitions contain no relevant values and so do not need to be searched for matching rows.

The optimizer can also perform pruning for `WHERE` conditions that involve comparisons of the preceding types on multiple columns for tables that use `RANGE COLUMNS` or `LIST COLUMNS` partitioning.

This type of optimization can be applied whenever the partitioning expression consists of an equality or a range which can be reduced to a set of equalities, or when the partitioning expression represents an increasing or decreasing relationship. Pruning can also be applied for tables partitioned on a `DATE` or `DATETIME` column when the partitioning expression uses the `YEAR()` or `TO_DAYS()` function. Pruning can also be applied for such tables when the partitioning expression uses the `TO_SECONDS()` function.

Suppose that table `t2`, partitioned on a `DATE` column, is created using the statement shown here:

```
CREATE TABLE t2 (
    fname VARCHAR(50) NOT NULL,
    lname VARCHAR(50) NOT NULL,
    region_code TINYINT UNSIGNED NOT NULL,
    dob DATE NOT NULL
)
PARTITION BY RANGE( YEAR(dob) ) (
    PARTITION d0 VALUES LESS THAN (1970),
    PARTITION d1 VALUES LESS THAN (1975),
    PARTITION d2 VALUES LESS THAN (1980),
    PARTITION d3 VALUES LESS THAN (1985),
    PARTITION d4 VALUES LESS THAN (1990),
    PARTITION d5 VALUES LESS THAN (2000),
    PARTITION d6 VALUES LESS THAN (2005),
    PARTITION d7 VALUES LESS THAN MAXVALUE
);
```

The following statements using `t2` can make of use partition pruning:

```
SELECT * FROM t2 WHERE dob = '1982-06-23';
UPDATE t2 SET region_code = 8 WHERE dob BETWEEN '1991-02-15' AND '1997-04-25';
DELETE FROM t2 WHERE dob >= '1984-06-21' AND dob <= '1999-06-21'
```

In the case of the last statement, the optimizer can also act as follows:

1. *Find the partition containing the low end of the range*.

   `YEAR('1984-06-21')` yields the value `1984`, which is found in partition `d3`.

2. *Find the partition containing the high end of the range*.

   `YEAR('1999-06-21')` evaluates to `1999`, which is found in partition `d5`.

3. *Scan only these two partitions and any partitions that may lie between them*.

   In this case, this means that only partitions `d3`, `d4`, and `d5` are scanned. The remaining partitions may be safely ignored (and are ignored).

   > **Important**
   >
   > Invalid `DATE` and `DATETIME` values referenced in the `WHERE` condition of a statement against a partitioned table are treated as `NULL`. This means that a query such as `SELECT * FROM partitioned_table WHERE date_column < '2008-12-00'` does not return any values (see Bug #40972).

So far, we have looked only at examples using `RANGE` partitioning, but pruning can be applied with other partitioning types as well.

Consider a table that is partitioned by `LIST`, where the partitioning expression is increasing or decreasing, such as the table `t3` shown here. (In this example, we assume for the sake of brevity that the `region_code` column is limited to values between 1 and 10 inclusive.)

```
CREATE TABLE t3 (
    fname VARCHAR(50) NOT NULL,
    lname VARCHAR(50) NOT NULL,
    region_code TINYINT UNSIGNED NOT NULL,
    dob DATE NOT NULL
)
PARTITION BY LIST(region_code) (
    PARTITION r0 VALUES IN (1, 3),
    PARTITION r1 VALUES IN (2, 5, 8),
    PARTITION r2 VALUES IN (4, 9),
    PARTITION r3 VALUES IN (6, 7, 10)
);
```

For a statement such as `SELECT * FROM t3 WHERE region_code BETWEEN 1 AND 3`, the optimizer determines in which partitions the values 1, 2, and 3 are found (`r0` and `r1`) and skips the remaining ones (`r2` and `r3`).

For tables that are partitioned by `HASH` or `[LINEAR] KEY`, partition pruning is also possible in cases in which the `WHERE` clause uses a simple `=` relation against a column used in the partitioning expression. Consider a table created like this:

```
CREATE TABLE t4 (
    fname VARCHAR(50) NOT NULL,
    lname VARCHAR(50) NOT NULL,
    region_code TINYINT UNSIGNED NOT NULL,
    dob DATE NOT NULL
)
PARTITION BY KEY(region_code)
PARTITIONS 8;
```

A statement that compares a column value with a constant can be pruned:

```
UPDATE t4 WHERE region_code = 7;
```

Pruning can also be employed for short ranges, because the optimizer can turn such conditions into `IN` relations. For example, using the same table `t4` as defined previously, queries such as these can be pruned:

```
SELECT * FROM t4 WHERE region_code > 2 AND region_code < 6;
SELECT * FROM t4 WHERE region_code BETWEEN 3 AND 5;
```

In both these cases, the `WHERE` clause is transformed by the optimizer into `WHERE region_code IN (3, 4, 5)`.

> **Important**
>
> This optimization is used only if the range size is smaller than the number of partitions. Consider this statement:
>
> ```
> DELETE FROM t4 WHERE region_code BETWEEN 4 AND 12;
> ```
>
> The range in the `WHERE` clause covers 9 values (4, 5, 6, 7, 8, 9, 10, 11, 12), but `t4` has only 8 partitions. This means that the `DELETE` cannot be pruned.

When a table is partitioned by `HASH` or `[LINEAR] KEY`, pruning can be used only on integer columns. For example, this statement cannot use pruning because `dob` is a `DATE` column:

```
SELECT * FROM t4 WHERE dob >= '2001-04-14' AND dob <= '2005-10-15';
```

However, if the table stores year values in an `INT` column, then a query having `WHERE year_col >= 2001 AND year_col <= 2005` can be pruned.

Tables using a storage engine that provides automatic partitioning, such as the NDB storage engine used by MySQL Cluster can be pruned if they are explicitly partitioned.

Chapter 6 Restrictions and Limitations on Partitioning

Table of Contents

This section discusses current restrictions and limitations on MySQL partitioning support.

Prohibited constructs. The following constructs are not permitted in partitioning expressions:

- Stored procedures, stored functions, loadable functions, or plugins.
- Declared variables or user variables.

For a list of SQL functions which are permitted in partitioning expressions, see Section 6.3, “Partitioning Limitations Relating to Functions”.

Arithmetic and logical operators. Use of the arithmetic operators `+`, `-`, and `*` is permitted in partitioning expressions. However, the result must be an integer value or `NULL` (except in the case of `[LINEAR] KEY` partitioning, as discussed elsewhere in this chapter; see Chapter 3, *Partitioning Types*, for more information).

The `DIV` operator is also supported; the `/` operator is not permitted.

The bit operators `|`, `&`, `^`, `<<`, `>>`, and `~` are not permitted in partitioning expressions.

Server SQL mode. Tables employing user-defined partitioning do not preserve the SQL mode in effect at the time that they were created. As discussed elsewhere in this Manual (see Server SQL Modes), the results of many MySQL functions and operators may change according to the server SQL mode. Therefore, a change in the SQL mode at any time after the creation of partitioned tables may lead to major changes in the behavior of such tables, and could easily lead to corruption or loss of data. For these reasons, *it is strongly recommended that you never change the server SQL mode after creating partitioned tables*.

For one such change in the server SQL mode making a partitioned tables unusable, consider the following `CREATE TABLE` statement, which can be executed successfully only if the `NO_UNSIGNED_SUBTRACTION` mode is in effect:

```
mysql> SELECT @@sql_mode;
+------------+
| @@sql_mode |
+------------+
|            |
+------------+
1 row in set (0.00 sec)
mysql> CREATE TABLE tu (c1 BIGINT UNSIGNED)
    ->   PARTITION BY RANGE(c1 - 10) (
    ->     PARTITION p0 VALUES LESS THAN (-5),
    ->     PARTITION p1 VALUES LESS THAN (0),
    ->     PARTITION p2 VALUES LESS THAN (5),
    ->     PARTITION p3 VALUES LESS THAN (10),
    ->     PARTITION p4 VALUES LESS THAN (MAXVALUE)
    -> );
ERROR 1563 (HY000): Partition constant is out of partition function domain
```

```
mysql> SET sql_mode='NO_UNSIGNED_SUBTRACTION';
Query OK, 0 rows affected (0.00 sec)
mysql> SELECT @@sql_mode;
+------------------------+
| @@sql_mode             |
+------------------------+
| NO_UNSIGNED_SUBTRACTION |
+------------------------+
1 row in set (0.00 sec)
mysql> CREATE TABLE tu (c1 BIGINT UNSIGNED)
    ->   PARTITION BY RANGE(c1 - 10) (
    ->     PARTITION p0 VALUES LESS THAN (-5),
    ->     PARTITION p1 VALUES LESS THAN (0),
    ->     PARTITION p2 VALUES LESS THAN (5),
    ->     PARTITION p3 VALUES LESS THAN (10),
    ->     PARTITION p4 VALUES LESS THAN (MAXVALUE)
    -> );
Query OK, 0 rows affected (0.05 sec)
```

If you remove the `NO_UNSIGNED_SUBTRACTION` server SQL mode after creating `tu`, you may no longer be able to access this table:

```
mysql> SET sql_mode='';
Query OK, 0 rows affected (0.00 sec)
mysql> SELECT * FROM tu;
ERROR 1563 (HY000): Partition constant is out of partition function domain
mysql> INSERT INTO tu VALUES (20);
ERROR 1563 (HY000): Partition constant is out of partition function domain
```

See also Server SQL Modes.

Server SQL modes also impact replication of partitioned tables. Disparate SQL modes on source and replica can lead to partitioning expressions being evaluated differently; this can cause the distribution of data among partitions to be different in the source's and replica's copies of a given table, and may even cause inserts into partitioned tables that succeed on the source to fail on the replica. For best results, you should always use the same server SQL mode on the source and on the replica.

Performance considerations. Some effects of partitioning operations on performance are given in the following list:

- **File system operations.** Partitioning and repartitioning operations (such as `ALTER TABLE` with `PARTITION BY ...`, `REORGANIZE PARTITION`, or `REMOVE PARTITIONING`) depend on file system operations for their implementation. This means that the speed of these operations is affected by such factors as file system type and characteristics, disk speed, swap space, file handling efficiency of the operating system, and MySQL server options and variables that relate to file handling. In particular, you should make sure that `large_files_support` is enabled and that `open_files_limit` is set properly. Partitioning and repartitioning operations involving `InnoDB` tables may be made more efficient by enabling `innodb_file_per_table`.

  See also Maximum number of partitions.

- **Table locks.** Generally, the process executing a partitioning operation on a table takes a write lock on the table. Reads from such tables are relatively unaffected; pending `INSERT` and `UPDATE` operations are performed as soon as the partitioning operation has completed. For `InnoDB`-specific exceptions to this limitation, see Partitioning Operations.

- **Indexes; partition pruning.** As with nonpartitioned tables, proper use of indexes can speed up queries on partitioned tables significantly. In addition, designing partitioned tables and queries on these tables to take advantage of *partition pruning* can improve performance dramatically. See Chapter 5, *Partition Pruning*, for more information.

Index condition pushdown is supported for partitioned tables. See Index Condition Pushdown Optimization.

- **Performance with LOAD DATA.** In MySQL 8.2, `LOAD DATA` uses buffering to improve performance. You should be aware that the buffer uses 130 KB memory per partition to achieve this.

Maximum number of partitions.
The maximum possible number of partitions for a given table not using the `NDB` storage engine is 8192. This number includes subpartitions.

The maximum possible number of user-defined partitions for a table using the `NDB` storage engine is determined according to the version of the NDB Cluster software being used, the number of data nodes, and other factors. See NDB and user-defined partitioning, for more information.

If, when creating tables with a large number of partitions (but less than the maximum), you encounter an error message such as `Got error ... from storage engine: Out of resources when opening file`, you may be able to address the issue by increasing the value of the `open_files_limit` system variable. However, this is dependent on the operating system, and may not be possible or advisable on all platforms; see File Not Found and Similar Errors, for more information. In some cases, using large numbers (hundreds) of partitions may also not be advisable due to other concerns, so using more partitions does not automatically lead to better results.

See also File system operations.

Foreign keys not supported for partitioned InnoDB tables.
Partitioned tables using the `InnoDB` storage engine do not support foreign keys. More specifically, this means that the following two statements are true:

1. No definition of an `InnoDB` table employing user-defined partitioning may contain foreign key references; no `InnoDB` table whose definition contains foreign key references may be partitioned.

2. No `InnoDB` table definition may contain a foreign key reference to a user-partitioned table; no `InnoDB` table with user-defined partitioning may contain columns referenced by foreign keys.

The scope of the restrictions just listed includes all tables that use the `InnoDB` storage engine. `CREATE TABLE` and `ALTER TABLE` statements that would result in tables violating these restrictions are not allowed.

ALTER TABLE ... ORDER BY. An `ALTER TABLE ... ORDER BY` *`column`* statement run against a partitioned table causes ordering of rows only within each partition.

ADD COLUMN ... ALGORITHM=INSTANT. Once you perform `ALTER TABLE ... ADD COLUMN ... ALGORITHM=INSTANT` on a partitioned table, it is no longer possible to exchange partitions with this table.

Effects on REPLACE statements by modification of primary keys. It can be desirable in some cases (see Section 6.1, “Partitioning Keys, Primary Keys, and Unique Keys”) to modify a table's primary key. Be aware that, if your application uses `REPLACE` statements and you do this, the results of these statements can be drastically altered. See REPLACE Statement, for more information and an example.

FULLTEXT indexes.
Partitioned tables do not support `FULLTEXT` indexes or searches.

Spatial columns. Columns with spatial data types such as `POINT` or `GEOMETRY` cannot be used in partitioned tables.

Temporary tables.
Temporary tables cannot be partitioned.

Log tables. It is not possible to partition the log tables; an `ALTER TABLE ... PARTITION BY ...` statement on such a table fails with an error.

Data type of partitioning key.
A partitioning key must be either an integer column or an expression that resolves to an integer. Expressions employing `ENUM` columns cannot be used. The column or expression value may also be `NULL`; see Section 3.7, "How MySQL Partitioning Handles NULL".

There are two exceptions to this restriction:

1. When partitioning by [`LINEAR`] `KEY`, it is possible to use columns of any valid MySQL data type other than `TEXT` or `BLOB` as partitioning keys, because the internal key-hashing functions produce the correct data type from these types. For example, the following two `CREATE TABLE` statements are valid:

```
CREATE TABLE tkc (c1 CHAR)
PARTITION BY KEY(c1)
PARTITIONS 4;
CREATE TABLE tke
    ( c1 ENUM('red', 'orange', 'yellow', 'green', 'blue', 'indigo', 'violet') )
PARTITION BY LINEAR KEY(c1)
PARTITIONS 6;
```

2. When partitioning by `RANGE COLUMNS` or `LIST COLUMNS`, it is possible to use string, `DATE`, and `DATETIME` columns. For example, each of the following `CREATE TABLE` statements is valid:

```
CREATE TABLE rc (c1 INT, c2 DATE)
PARTITION BY RANGE COLUMNS(c2) (
    PARTITION p0 VALUES LESS THAN('1990-01-01'),
    PARTITION p1 VALUES LESS THAN('1995-01-01'),
    PARTITION p2 VALUES LESS THAN('2000-01-01'),
    PARTITION p3 VALUES LESS THAN('2005-01-01'),
    PARTITION p4 VALUES LESS THAN(MAXVALUE)
);
CREATE TABLE lc (c1 INT, c2 CHAR(1))
PARTITION BY LIST COLUMNS(c2) (
    PARTITION p0 VALUES IN('a', 'd', 'g', 'j', 'm', 'p', 's', 'v', 'y'),
    PARTITION p1 VALUES IN('b', 'e', 'h', 'k', 'n', 'q', 't', 'w', 'z'),
    PARTITION p2 VALUES IN('c', 'f', 'i', 'l', 'o', 'r', 'u', 'x', NULL)
);
```

Neither of the preceding exceptions applies to `BLOB` or `TEXT` column types.

Subqueries.
A partitioning key may not be a subquery, even if that subquery resolves to an integer value or `NULL`.

Column index prefixes not supported for key partitioning. When creating a table that is partitioned by key, any columns in the partitioning key which use column prefixes are not used in the table's partitioning function. Consider the following `CREATE TABLE` statement, which has three `VARCHAR` columns, and whose primary key uses all three columns and specifies prefixes for two of them:

```
CREATE TABLE t1 (
    a VARCHAR(10000),
    b VARCHAR(25),
    c VARCHAR(10),
    PRIMARY KEY (a(10), b, c(2))
) PARTITION BY KEY() PARTITIONS 2;
```

This statement is accepted, but the resulting table is actually created as if you had issued the following statement, using only the primary key column which does not include a prefix (column `b`) for the partitioning key:

```
CREATE TABLE t1 (
    a VARCHAR(10000),
```

```
    b VARCHAR(25),
    c VARCHAR(10),
    PRIMARY KEY (a(10), b, c(2))
) PARTITION BY KEY(b) PARTITIONS 2;
```

This permissive behavior is deprecated (and is subject to removal in a future version of MySQL). Using one or more columns having a prefix in the partitioning key results in a warning for each such column, as shown here:

```
mysql> CREATE TABLE t1 (
    ->     a VARCHAR(10000),
    ->     b VARCHAR(25),
    ->     c VARCHAR(10),
    ->     PRIMARY KEY (a(10), b, c(2))
    -> ) PARTITION BY KEY() PARTITIONS 2;
Query OK, 0 rows affected, 2 warnings (1.25 sec)
mysql> SHOW WARNINGS\G
*************************** 1. row ***************************
  Level: Warning
   Code: 1681
Message: Column 'test.t1.a' having prefix key part 'a(10)' is ignored by the
partitioning function. Use of prefixed columns in the PARTITION BY KEY() clause
is deprecated and will be removed in a future release.
*************************** 2. row ***************************
  Level: Warning
   Code: 1681
Message: Column 'test.t1.c' having prefix key part 'c(2)' is ignored by the
partitioning function. Use of prefixed columns in the PARTITION BY KEY() clause
is deprecated and will be removed in a future release.
2 rows in set (0.00 sec)
```

This includes cases in which the columns used in the partitioning function are defined implicitly as those in the table's primary key by employing an empty `PARTITION BY KEY()` clause.

If all columns specified for the partitioning key employ prefixes, the `CREATE TABLE` statement used fails with an error message that identifies the issue correctly:

```
mysql> CREATE TABLE t1 (
    ->     a VARCHAR(10000),
    ->     b VARCHAR(25),
    ->     c VARCHAR(10),
    ->     PRIMARY KEY (a(10), b(5), c(2))
    -> ) PARTITION BY KEY() PARTITIONS 2;
ERROR 1503 (HY000): A PRIMARY KEY must include all columns in the table's
partitioning function (prefixed columns are not considered).
```

For general information about partitioning tables by key, see Section 3.5, “KEY Partitioning”.

Issues with subpartitions.
Subpartitions must use `HASH` or `KEY` partitioning. Only `RANGE` and `LIST` partitions may be subpartitioned; `HASH` and `KEY` partitions cannot be subpartitioned.

`SUBPARTITION BY KEY` requires that the subpartitioning column or columns be specified explicitly, unlike the case with `PARTITION BY KEY`, where it can be omitted (in which case the table's primary key column is used by default). Consider the table created by this statement:

```
CREATE TABLE ts (
    id INT NOT NULL AUTO_INCREMENT PRIMARY KEY,
    name VARCHAR(30)
);
```

You can create a table having the same columns, partitioned by `KEY`, using a statement such as this one:

```
CREATE TABLE ts (
```

```
    id INT NOT NULL AUTO_INCREMENT PRIMARY KEY,
    name VARCHAR(30)
)
PARTITION BY KEY()
PARTITIONS 4;
```

The previous statement is treated as though it had been written like this, with the table's primary key column used as the partitioning column:

```
CREATE TABLE ts (
    id INT NOT NULL AUTO_INCREMENT PRIMARY KEY,
    name VARCHAR(30)
)
PARTITION BY KEY(id)
PARTITIONS 4;
```

However, the following statement that attempts to create a subpartitioned table using the default column as the subpartitioning column fails, and the column must be specified for the statement to succeed, as shown here:

```
mysql> CREATE TABLE ts (
    ->     id INT NOT NULL AUTO_INCREMENT PRIMARY KEY,
    ->     name VARCHAR(30)
    -> )
    -> PARTITION BY RANGE(id)
    -> SUBPARTITION BY KEY()
    -> SUBPARTITIONS 4
    -> (
    ->     PARTITION p0 VALUES LESS THAN (100),
    ->     PARTITION p1 VALUES LESS THAN (MAXVALUE)
    -> );
ERROR 1064 (42000): You have an error in your SQL syntax; check the manual that
corresponds to your MySQL server version for the right syntax to use near ')
mysql> CREATE TABLE ts (
    ->     id INT NOT NULL AUTO_INCREMENT PRIMARY KEY,
    ->     name VARCHAR(30)
    -> )
    -> PARTITION BY RANGE(id)
    -> SUBPARTITION BY KEY(id)
    -> SUBPARTITIONS 4
    -> (
    ->     PARTITION p0 VALUES LESS THAN (100),
    ->     PARTITION p1 VALUES LESS THAN (MAXVALUE)
    -> );
Query OK, 0 rows affected (0.07 sec)
```

This is a known issue (see Bug #51470).

DATA DIRECTORY and INDEX DIRECTORY options. Table-level `DATA DIRECTORY` and `INDEX DIRECTORY` options are ignored (see Bug #32091). You can employ these options for individual partitions or subpartitions of `InnoDB` tables. The directory specified in a `DATA DIRECTORY` clause must be known to `InnoDB`. For more information, see Using the DATA DIRECTORY Clause.

Repairing and rebuilding partitioned tables. The statements `CHECK TABLE`, `OPTIMIZE TABLE`, `ANALYZE TABLE`, and `REPAIR TABLE` are supported for partitioned tables.

In addition, you can use `ALTER TABLE ... REBUILD PARTITION` to rebuild one or more partitions of a partitioned table; `ALTER TABLE ... REORGANIZE PARTITION` also causes partitions to be rebuilt. See ALTER TABLE Statement, for more information about these two statements.

`ANALYZE`, `CHECK`, `OPTIMIZE`, `REPAIR`, and `TRUNCATE` operations are supported with subpartitions. See ALTER TABLE Partition Operations.

File name delimiters for partitions and subpartitions. Table partition and subpartition file names include generated delimiters such as #P# and #SP#. The lettercase of such delimiters can vary and should not be depended upon.

6.1 Partitioning Keys, Primary Keys, and Unique Keys

This section discusses the relationship of partitioning keys with primary keys and unique keys. The rule governing this relationship can be expressed as follows: All columns used in the partitioning expression for a partitioned table must be part of every unique key that the table may have.

In other words, *every unique key on the table must use every column in the table's partitioning expression*. (This also includes the table's primary key, since it is by definition a unique key. This particular case is discussed later in this section.) For example, each of the following table creation statements is invalid:

```
CREATE TABLE t1 (
    col1 INT NOT NULL,
    col2 DATE NOT NULL,
    col3 INT NOT NULL,
    col4 INT NOT NULL,
    UNIQUE KEY (col1, col2)
)
PARTITION BY HASH(col3)
PARTITIONS 4;
CREATE TABLE t2 (
    col1 INT NOT NULL,
    col2 DATE NOT NULL,
    col3 INT NOT NULL,
    col4 INT NOT NULL,
    UNIQUE KEY (col1),
    UNIQUE KEY (col3)
)
PARTITION BY HASH(col1 + col3)
PARTITIONS 4;
```

In each case, the proposed table would have at least one unique key that does not include all columns used in the partitioning expression.

Each of the following statements is valid, and represents one way in which the corresponding invalid table creation statement could be made to work:

```
CREATE TABLE t1 (
    col1 INT NOT NULL,
    col2 DATE NOT NULL,
    col3 INT NOT NULL,
    col4 INT NOT NULL,
    UNIQUE KEY (col1, col2, col3)
)
PARTITION BY HASH(col3)
PARTITIONS 4;
CREATE TABLE t2 (
    col1 INT NOT NULL,
    col2 DATE NOT NULL,
    col3 INT NOT NULL,
    col4 INT NOT NULL,
    UNIQUE KEY (col1, col3)
)
PARTITION BY HASH(col1 + col3)
PARTITIONS 4;
```

This example shows the error produced in such cases:

```
mysql> CREATE TABLE t3 (
```

```
    ->     col1 INT NOT NULL,
    ->     col2 DATE NOT NULL,
    ->     col3 INT NOT NULL,
    ->     col4 INT NOT NULL,
    ->     UNIQUE KEY (col1, col2),
    ->     UNIQUE KEY (col3)
    -> )
    -> PARTITION BY HASH(col1 + col3)
    -> PARTITIONS 4;
ERROR 1491 (HY000): A PRIMARY KEY must include all columns in the table's partitioning function
```

The `CREATE TABLE` statement fails because both `col1` and `col3` are included in the proposed partitioning key, but neither of these columns is part of both of unique keys on the table. This shows one possible fix for the invalid table definition:

```
mysql> CREATE TABLE t3 (
    ->     col1 INT NOT NULL,
    ->     col2 DATE NOT NULL,
    ->     col3 INT NOT NULL,
    ->     col4 INT NOT NULL,
    ->     UNIQUE KEY (col1, col2, col3),
    ->     UNIQUE KEY (col3)
    -> )
    -> PARTITION BY HASH(col3)
    -> PARTITIONS 4;
Query OK, 0 rows affected (0.05 sec)
```

In this case, the proposed partitioning key `col3` is part of both unique keys, and the table creation statement succeeds.

The following table cannot be partitioned at all, because there is no way to include in a partitioning key any columns that belong to both unique keys:

```
CREATE TABLE t4 (
    col1 INT NOT NULL,
    col2 INT NOT NULL,
    col3 INT NOT NULL,
    col4 INT NOT NULL,
    UNIQUE KEY (col1, col3),
    UNIQUE KEY (col2, col4)
);
```

Since every primary key is by definition a unique key, this restriction also includes the table's primary key, if it has one. For example, the next two statements are invalid:

```
CREATE TABLE t5 (
    col1 INT NOT NULL,
    col2 DATE NOT NULL,
    col3 INT NOT NULL,
    col4 INT NOT NULL,
    PRIMARY KEY(col1, col2)
)
PARTITION BY HASH(col3)
PARTITIONS 4;
CREATE TABLE t6 (
    col1 INT NOT NULL,
    col2 DATE NOT NULL,
    col3 INT NOT NULL,
    col4 INT NOT NULL,
    PRIMARY KEY(col1, col3),
    UNIQUE KEY(col2)
)
PARTITION BY HASH( YEAR(col2) )
PARTITIONS 4;
```

In both cases, the primary key does not include all columns referenced in the partitioning expression. However, both of the next two statements are valid:

```
CREATE TABLE t7 (
    col1 INT NOT NULL,
    col2 DATE NOT NULL,
    col3 INT NOT NULL,
    col4 INT NOT NULL,
    PRIMARY KEY(col1, col2)
)
PARTITION BY HASH(col1 + YEAR(col2))
PARTITIONS 4;
CREATE TABLE t8 (
    col1 INT NOT NULL,
    col2 DATE NOT NULL,
    col3 INT NOT NULL,
    col4 INT NOT NULL,
    PRIMARY KEY(col1, col2, col4),
    UNIQUE KEY(col2, col1)
)
PARTITION BY HASH(col1 + YEAR(col2))
PARTITIONS 4;
```

If a table has no unique keys—this includes having no primary key—then this restriction does not apply, and you may use any column or columns in the partitioning expression as long as the column type is compatible with the partitioning type.

For the same reason, you cannot later add a unique key to a partitioned table unless the key includes all columns used by the table's partitioning expression. Consider the partitioned table created as shown here:

```
mysql> CREATE TABLE t_no_pk (c1 INT, c2 INT)
    ->     PARTITION BY RANGE(c1) (
    ->         PARTITION p0 VALUES LESS THAN (10),
    ->         PARTITION p1 VALUES LESS THAN (20),
    ->         PARTITION p2 VALUES LESS THAN (30),
    ->         PARTITION p3 VALUES LESS THAN (40)
    ->     );
Query OK, 0 rows affected (0.12 sec)
```

It is possible to add a primary key to `t_no_pk` using either of these `ALTER TABLE` statements:

```
#  possible PK
mysql> ALTER TABLE t_no_pk ADD PRIMARY KEY(c1);
Query OK, 0 rows affected (0.13 sec)
Records: 0  Duplicates: 0  Warnings: 0
# drop this PK
mysql> ALTER TABLE t_no_pk DROP PRIMARY KEY;
Query OK, 0 rows affected (0.10 sec)
Records: 0  Duplicates: 0  Warnings: 0
#  use another possible PK
mysql> ALTER TABLE t_no_pk ADD PRIMARY KEY(c1, c2);
Query OK, 0 rows affected (0.12 sec)
Records: 0  Duplicates: 0  Warnings: 0
# drop this PK
mysql> ALTER TABLE t_no_pk DROP PRIMARY KEY;
Query OK, 0 rows affected (0.09 sec)
Records: 0  Duplicates: 0  Warnings: 0
```

However, the next statement fails, because `c1` is part of the partitioning key, but is not part of the proposed primary key:

```
#  fails with error 1503
mysql> ALTER TABLE t_no_pk ADD PRIMARY KEY(c2);
ERROR 1503 (HY000): A PRIMARY KEY must include all columns in the table's partitioning function
```

Since `t_no_pk` has only `c1` in its partitioning expression, attempting to adding a unique key on `c2` alone fails. However, you can add a unique key that uses both `c1` and `c2`.

These rules also apply to existing nonpartitioned tables that you wish to partition using `ALTER TABLE ... PARTITION BY`. Consider a table `np_pk` created as shown here:

```
mysql> CREATE TABLE np_pk (
    ->     id INT NOT NULL AUTO_INCREMENT,
    ->     name VARCHAR(50),
    ->     added DATE,
    ->     PRIMARY KEY (id)
    -> );
Query OK, 0 rows affected (0.08 sec)
```

The following `ALTER TABLE` statement fails with an error, because the `added` column is not part of any unique key in the table:

```
mysql> ALTER TABLE np_pk
    ->     PARTITION BY HASH( TO_DAYS(added) )
    ->     PARTITIONS 4;
ERROR 1503 (HY000): A PRIMARY KEY must include all columns in the table's partitioning function
```

However, this statement using the `id` column for the partitioning column is valid, as shown here:

```
mysql> ALTER TABLE np_pk
    ->     PARTITION BY HASH(id)
    ->     PARTITIONS 4;
Query OK, 0 rows affected (0.11 sec)
Records: 0  Duplicates: 0  Warnings: 0
```

In the case of `np_pk`, the only column that may be used as part of a partitioning expression is `id`; if you wish to partition this table using any other column or columns in the partitioning expression, you must first modify the table, either by adding the desired column or columns to the primary key, or by dropping the primary key altogether.

6.2 Partitioning Limitations Relating to Storage Engines

In MySQL 8.2, partitioning support is not actually provided by the MySQL Server, but rather by a table storage engine's own or native partitioning handler. In MySQL 8.2, only the `InnoDB` and `NDB` storage engines provide native partitioning handlers. This means that partitioned tables cannot be created using any other storage engine than these. (You must be using MySQL NDB Cluster with the `NDB` storage engine to create `NDB` tables.)

InnoDB storage engine. `InnoDB` foreign keys and MySQL partitioning are not compatible. Partitioned `InnoDB` tables cannot have foreign key references, nor can they have columns referenced by foreign keys. `InnoDB` tables which have or which are referenced by foreign keys cannot be partitioned.

`ALTER TABLE ... OPTIMIZE PARTITION` does not work correctly with partitioned tables that use `InnoDB`. Use `ALTER TABLE ... REBUILD PARTITION` and `ALTER TABLE ... ANALYZE PARTITION`, instead, for such tables. For more information, see ALTER TABLE Partition Operations.

User-defined partitioning and the NDB storage engine (NDB Cluster). Partitioning by `KEY` (including `LINEAR KEY`) is the only type of partitioning supported for the `NDB` storage engine. It is not possible under normal circumstances in NDB Cluster to create an NDB Cluster table using any partitioning type other than [`LINEAR`] `KEY`, and attempting to do so fails with an error.

Exception (not for production): It is possible to override this restriction by setting the `new` system variable on NDB Cluster SQL nodes to `ON`. If you choose to do this, you should be aware that tables using partitioning types other than `[LINEAR] KEY` are not supported in production. *In such cases, you can*

create and use tables with partitioning types other than `KEY` or `LINEAR KEY`, but you do this entirely at your own risk. You should also be aware that this functionality is now deprecated and subject to removal without further notice in a future release of NDB Cluster.

The maximum number of partitions that can be defined for an `NDB` table depends on the number of data nodes and node groups in the cluster, the version of the NDB Cluster software in use, and other factors. See NDB and user-defined partitioning, for more information.

The maximum amount of fixed-size data that can be stored per partition in an `NDB` table is 128 TB. Previously, this was 16 GB.

`CREATE TABLE` and `ALTER TABLE` statements that would cause a user-partitioned `NDB` table not to meet either or both of the following two requirements are not permitted, and fail with an error:

1. The table must have an explicit primary key.
2. All columns listed in the table's partitioning expression must be part of the primary key.

Exception. If a user-partitioned `NDB` table is created using an empty column-list (that is, using `PARTITION BY KEY()` or `PARTITION BY LINEAR KEY()`), then no explicit primary key is required.

Partition selection. Partition selection is not supported for `NDB` tables. See Partition Selection, for more information.

Upgrading partitioned tables. When performing an upgrade, tables which are partitioned by `KEY` must be dumped and reloaded.

> **Note**
>
> Partitioned tables using storage engines other than `InnoDB` cannot be upgraded from MySQL 5.7 or earlier to MySQL 8.0 or later; you must either drop the partitioning from such tables with `ALTER TABLE ... REMOVE PARTITIONING` or convert them to `InnoDB` using `ALTER TABLE ... ENGINE=INNODB` prior to the upgrade.

For information about converting `MyISAM` tables to `InnoDB`, see Converting Tables from MyISAM to InnoDB.

6.3 Partitioning Limitations Relating to Functions

This section discusses limitations in MySQL Partitioning relating specifically to functions used in partitioning expressions.

Only the MySQL functions shown in the following list are allowed in partitioning expressions:

- `ABS()`
- `CEILING()` (see CEILING() and FLOOR())
- `DATEDIFF()`
- `DAY()`
- `DAYOFMONTH()`
- `DAYOFWEEK()`
- `DAYOFYEAR()`

- `EXTRACT()` (see EXTRACT() function with WEEK specifier)
- `FLOOR()` (see CEILING() and FLOOR())
- `HOUR()`
- `MICROSECOND()`
- `MINUTE()`
- `MOD()`
- `MONTH()`
- `QUARTER()`
- `SECOND()`
- `TIME_TO_SEC()`
- `TO_DAYS()`
- `TO_SECONDS()`
- `UNIX_TIMESTAMP()` (with `TIMESTAMP` columns)
- `WEEKDAY()`
- `YEAR()`
- `YEARWEEK()`

In MySQL 8.2, partition pruning is supported for the `TO_DAYS()`, `TO_SECONDS()`, `YEAR()`, and `UNIX_TIMESTAMP()` functions. See Chapter 5, *Partition Pruning*, for more information.

CEILING() and FLOOR(). Each of these functions returns an integer only if it is passed an argument of an exact numeric type, such as one of the `INT` types or `DECIMAL`. This means, for example, that the following `CREATE TABLE` statement fails with an error, as shown here:

```
mysql> CREATE TABLE t (c FLOAT) PARTITION BY LIST( FLOOR(c) )(
    ->     PARTITION p0 VALUES IN (1,3,5),
    ->     PARTITION p1 VALUES IN (2,4,6)
    -> );
ERROR 1490 (HY000): The PARTITION function returns the wrong type
```

EXTRACT() function with WEEK specifier. The value returned by the `EXTRACT()` function, when used as `EXTRACT(WEEK FROM col)`, depends on the value of the `default_week_format` system variable. For this reason, `EXTRACT()` is not permitted as a partitioning function when it specifies the unit as `WEEK`. (Bug #54483)

See Mathematical Functions, for more information about the return types of these functions, as well as Numeric Data Types.