# InnoDB存储引擎

## 15.1 Introduction to InnoDB

[15.1.1 Benefits of Using InnoDB Tables](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-benefits)

[15.1.2 Best Practices for InnoDB Tables](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-best-practices)

[15.1.3 Verifying that InnoDB is the Default Storage Engine](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-check-availability)

[15.1.4 Testing and Benchmarking with InnoDB](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-benchmarking)

**InnoDB** is a general-purpose storage engine that balances high reliability and high performance. In MySQL 8.0, **InnoDB** is the default MySQL storage engine. Unless you have configured a different default storage engine, issuing a [**CREATE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-table) statement without an **ENGINE** clause creates an **InnoDB** table.

### Key Advantages of InnoDB

Its DML operations follow the ACID model, with transactions featuring commit, rollback, and crash-recovery capabilities to protect user data. See [Section 15.2, “InnoDB and the ACID Model”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#mysql-acid).

Row-level locking and Oracle-style consistent reads increase multi-user concurrency and performance. See [Section 15.7, “InnoDB Locking and Transaction Model”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-locking-transaction-model).

**InnoDB** tables arrange your data on disk to optimize queries based on primary keys. Each **InnoDB** table has a primary key index called the clustered index that organizes the data to minimize I/O for primary key lookups. See [Section 15.6.2.1, “Clustered and Secondary Indexes”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-index-types).

To maintain data integrity, **InnoDB** supports **FOREIGN KEY** constraints. With foreign keys, inserts, updates, and deletes are checked to ensure they do not result in inconsistencies across related tables. See [Section 13.1.20.5, “FOREIGN KEY Constraints”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-table-foreign-keys).

**Table 15.1 InnoDB Storage Engine Features**

| **Feature** | **Support** |
| --- | --- |
| ***B-tree indexes*** | Yes |
| ***Backup/point-in-time recovery*** (Implemented in the server, rather than in the storage engine.) | Yes |
| ***Cluster database support*** | No |
| ***Clustered indexes*** | Yes |
| ***Compressed data*** | Yes |
| ***Data caches*** | Yes |
| ***Encrypted data*** | Yes (Implemented in the server via encryption functions; In MySQL 5.7 and later, data-at-rest encryption is supported.) |
| ***Foreign key support*** | Yes |
| ***Full-text search indexes*** | Yes (Support for FULLTEXT indexes is available in MySQL 5.6 and later.) |
| ***Geospatial data type support*** | Yes |
| ***Geospatial indexing support*** | Yes (Support for geospatial indexing is available in MySQL 5.7 and later.) |
| ***Hash indexes*** | No (InnoDB utilizes hash indexes internally for its Adaptive Hash Index feature.) |
| ***Index caches*** | Yes |
| ***Locking granularity*** | Row |
| ***MVCC*** | Yes |
| ***Replication support*** (Implemented in the server, rather than in the storage engine.) | Yes |
| ***Storage limits*** | 64TB |
| ***T-tree indexes*** | No |
| ***Transactions*** | Yes |
| ***Update statistics for data dictionary*** | Yes |

To compare the features of **InnoDB** with other storage engines provided with MySQL, see the Storage Engine Features table in [Chapter 16, *Alternative Storage Engines*](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\storage-engines.html).

### InnoDB Enhancements and New Features

For information about **InnoDB** enhancements and new features, refer to:

The **InnoDB** enhancements list in [Section 1.3, “What Is New in MySQL 8.0”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\introduction.html#mysql-nutshell).

The [Release Notes](https://dev.mysql.com/doc/relnotes/mysql/8.0/en/).

### Additional InnoDB Information and Resources

For **InnoDB**-related terms and definitions, see the [MySQL Glossary](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html).

For a forum dedicated to the **InnoDB** storage engine, see [MySQL Forums::InnoDB](http://forums.mysql.com/list.php?22).

**InnoDB** is published under the same GNU GPL License Version 2 (of June 1991) as MySQL. For more information on MySQL licensing, see <http://www.mysql.com/company/legal/licensing/>.

### 15.1.1 Benefits of Using InnoDB Tables

**InnoDB** tables have the following benefits:

If the server unexpectedly exits because of a hardware or software issue, regardless of what was happening in the database at the time, you don't need to do anything special after restarting the database. **InnoDB** crash recovery automatically finalizes changes that were committed before the time of the crash, and undoes changes that were in process but not committed, permitting you to restart and continue from where you left off. See [Section 15.18.2, “InnoDB Recovery”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-recovery).

The **InnoDB** storage engine maintains its own buffer pool that caches table and index data in main memory as data is accessed. Frequently used data is processed directly from memory. This cache applies to many types of information and speeds up processing. On dedicated database servers, up to 80% of physical memory is often assigned to the buffer pool. See [Section 15.5.1, “Buffer Pool”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-buffer-pool).

If you split up related data into different tables, you can set up foreign keys that enforce referential integrity. See [Section 13.1.20.5, “FOREIGN KEY Constraints”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-table-foreign-keys).

If data becomes corrupted on disk or in memory, a checksum mechanism alerts you to the bogus data before you use it. The [**innodb\_checksum\_algorithm**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_checksum_algorithm) variable defines the checksum algorithm used by **InnoDB**.

When you design a database with appropriate primary key columns for each table, operations involving those columns are automatically optimized. It is very fast to reference the primary key columns in [**WHERE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#select) clauses, [**ORDER BY**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#select) clauses, [**GROUP BY**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#select) clauses, and join operations. See [Section 15.6.2.1, “Clustered and Secondary Indexes”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-index-types).

Inserts, updates, and deletes are optimized by an automatic mechanism called change buffering. **InnoDB** not only allows concurrent read and write access to the same table, it caches changed data to streamline disk I/O. See [Section 15.5.2, “Change Buffer”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-change-buffer).

Performance benefits are not limited to large tables with long-running queries. When the same rows are accessed over and over from a table, the Adaptive Hash Index takes over to make these lookups even faster, as if they came out of a hash table. See [Section 15.5.3, “Adaptive Hash Index”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-adaptive-hash).

You can compress tables and associated indexes. See [Section 15.9, “InnoDB Table and Page Compression”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-compression).

You can encrypt your data. See [Section 15.13, “InnoDB Data-at-Rest Encryption”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-data-encryption).

You can create and drop indexes and perform other DDL operations with much less impact on performance and availability. See [Section 15.12.1, “Online DDL Operations”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-online-ddl-operations).

Truncating a file-per-table tablespace is very fast and can free up disk space for the operating system to reuse rather than only **InnoDB**. See [Section 15.6.3.2, “File-Per-Table Tablespaces”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-file-per-table-tablespaces).

The storage layout for table data is more efficient for [**BLOB**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-types.html#blob) and long text fields, with the **DYNAMIC** row format. See [Section 15.10, “InnoDB Row Formats”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-row-format).

You can monitor the internal workings of the storage engine by querying **INFORMATION\_SCHEMA** tables. See [Section 15.15, “InnoDB INFORMATION\_SCHEMA Tables”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-information-schema).

You can monitor the performance details of the storage engine by querying Performance Schema tables. See [Section 15.16, “InnoDB Integration with MySQL Performance Schema”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-performance-schema).

You can mix **InnoDB** tables with tables from other MySQL storage engines, even within the same statement. For example, you can use a join operation to combine data from **InnoDB** and [**MEMORY**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\storage-engines.html#memory-storage-engine) tables in a single query.

**InnoDB** has been designed for CPU efficiency and maximum performance when processing large data volumes.

**InnoDB** tables can handle large quantities of data, even on operating systems where file size is limited to 2GB.

For **InnoDB**-specific tuning techniques you can apply to your MySQL server and application code, see [Section 8.5, “Optimizing for InnoDB Tables”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizing-innodb).

### 15.1.2 Best Practices for InnoDB Tables

This section describes best practices when using **InnoDB** tables.

Specify a primary key for every table using the most frequently queried column or columns, or an auto-increment value if there is no obvious primary key.

Use joins wherever data is pulled from multiple tables based on identical ID values from those tables. For fast join performance, define foreign keys on the join columns, and declare those columns with the same data type in each table. Adding foreign keys ensures that referenced columns are indexed, which can improve performance. Foreign keys also propagate deletes and updates to all affected tables, and prevent insertion of data in a child table if the corresponding IDs are not present in the parent table.

Turn off autocommit. Committing hundreds of times a second puts a cap on performance (limited by the write speed of your storage device).

Group sets of related DML operations into transactions by bracketing them with **START TRANSACTION** and **COMMIT** statements. While you don't want to commit too often, you also don't want to issue huge batches of [**INSERT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#insert), [**UPDATE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#update), or [**DELETE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#delete) statements that run for hours without committing.

Do not use [**LOCK TABLES**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#lock-tables) statements. **InnoDB** can handle multiple sessions all reading and writing to the same table at once without sacrificing reliability or high performance. To get exclusive write access to a set of rows, use the [**SELECT ... FOR UPDATE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-locking-reads) syntax to lock just the rows you intend to update.

Enable the [**innodb\_file\_per\_table**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_file_per_table) variable or use general tablespaces to put the data and indexes for tables into separate files instead of the system tablespace. The [**innodb\_file\_per\_table**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_file_per_table) variable is enabled by default.

Evaluate whether your data and access patterns benefit from the **InnoDB** table or page compression features. You can compress **InnoDB** tables without sacrificing read/write capability.

Run the server with the [**--sql\_mode=NO\_ENGINE\_SUBSTITUTION**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_sql_mode) option to prevent tables from being created with storage engines that you do not want to use.

### 15.1.3 Verifying that InnoDB is the Default Storage Engine

Issue the [**SHOW ENGINES**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#show-engines) statement to view the available MySQL storage engines. Look for **DEFAULT** in the **SUPPORT** column.

mysql> SHOW ENGINES;

Alternatively, query the [**INFORMATION\_SCHEMA.ENGINES**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-engines-table) table.

mysql> SELECT \* FROM INFORMATION\_SCHEMA.ENGINES;

### 15.1.4 Testing and Benchmarking with InnoDB

If **InnoDB** is not the default storage engine, you can determine if your database server and applications work correctly with **InnoDB** by restarting the server with [**--default-storage-engine=InnoDB**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_default_storage_engine) defined on the command line or with [**default-storage-engine=innodb**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_default_storage_engine) defined in the **[mysqld]** section of the MySQL server option file.

Since changing the default storage engine only affects newly created tables, run your application installation and setup steps to confirm that everything installs properly, then exercise the application features to make sure the data loading, editing, and querying features work. If a table relies on a feature that is specific to another storage engine, you receive an error. In this case, add the **ENGINE=*other\_engine\_name*** clause to the [**CREATE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-table) statement to avoid the error.

If you did not make a deliberate decision about the storage engine, and you want to preview how certain tables work when created using **InnoDB**, issue the command [**ALTER TABLE table\_name ENGINE=InnoDB;**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) for each table. Alternatively, to run test queries and other statements without disturbing the original table, make a copy:

CREATE TABLE ... ENGINE=InnoDB AS SELECT \* FROM ***other\_engine\_table***;

To assess performance with a full application under a realistic workload, install the latest MySQL server and run benchmarks.

Test the full application lifecycle, from installation, through heavy usage, and server restart. Kill the server process while the database is busy to simulate a power failure, and verify that the data is recovered successfully when you restart the server.

Test any replication configurations, especially if you use different MySQL versions and options on the source server and replicas.

## 15.2 InnoDB and the ACID Model

The [ACID](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_acid) model is a set of database design principles that emphasize aspects of reliability that are important for business data and mission-critical applications. MySQL includes components such as the **InnoDB** storage engine that adhere closely to the ACID model so that data is not corrupted and results are not distorted by exceptional conditions such as software crashes and hardware malfunctions. When you rely on ACID-compliant features, you do not need to reinvent the wheel of consistency checking and crash recovery mechanisms. In cases where you have additional software safeguards, ultra-reliable hardware, or an application that can tolerate a small amount of data loss or inconsistency, you can adjust MySQL settings to trade some of the ACID reliability for greater performance or throughput.

The following sections discuss how MySQL features, in particular the **InnoDB** storage engine, interact with the categories of the ACID model:

***A***: atomicity.

***C***: consistency.

***I:***: isolation.

***D***: durability.

### Atomicity

The ***atomicity*** aspect of the ACID model mainly involves **InnoDB** [transactions](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_transaction). Related MySQL features include:

The [**autocommit**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_autocommit) setting.

The [**COMMIT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#commit) statement.

The [**ROLLBACK**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#commit) statement.

### Consistency

The ***consistency*** aspect of the ACID model mainly involves internal **InnoDB** processing to protect data from crashes. Related MySQL features include:

The **InnoDB** doublewrite buffer. See [Section 15.6.4, “Doublewrite Buffer”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-doublewrite-buffer).

**InnoDB** crash recovery. See [InnoDB Crash Recovery](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-crash-recovery).

### Isolation

The ***isolation*** aspect of the ACID model mainly involves **InnoDB** [transactions](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_transaction), in particular the [isolation level](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_isolation_level) that applies to each transaction. Related MySQL features include:

The [**autocommit**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_autocommit) setting.

Transaction isolation levels and the [**SET TRANSACTION**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#set-transaction) statement. See [Section 15.7.2.1, “Transaction Isolation Levels”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-transaction-isolation-levels).

The low-level details of **InnoDB** [locking](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_locking). Details can be viewed in the **INFORMATION\_SCHEMA** tables (see [Section 15.15.2, “InnoDB INFORMATION\_SCHEMA Transaction and Locking Information”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-information-schema-transactions)) and Performance Schema [**data\_locks**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html#performance-schema-data-locks-table) and [**data\_lock\_waits**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html#performance-schema-data-lock-waits-table) tables.

### Durability

The ***durability*** aspect of the ACID model involves MySQL software features interacting with your particular hardware configuration. Because of the many possibilities depending on the capabilities of your CPU, network, and storage devices, this aspect is the most complicated to provide concrete guidelines for. (And those guidelines might take the form of “buy new hardware”.) Related MySQL features include:

The **InnoDB** doublewrite buffer. See [Section 15.6.4, “Doublewrite Buffer”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-doublewrite-buffer).

The [**innodb\_flush\_log\_at\_trx\_commit**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_flush_log_at_trx_commit) variable.

The [**sync\_binlog**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\replication.html#sysvar_sync_binlog) variable.

The [**innodb\_file\_per\_table**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_file_per_table) variable.

The write buffer in a storage device, such as a disk drive, SSD, or RAID array.

A battery-backed cache in a storage device.

The operating system used to run MySQL, in particular its support for the **fsync()** system call.

An uninterruptible power supply (UPS) protecting the electrical power to all computer servers and storage devices that run MySQL servers and store MySQL data.

Your backup strategy, such as frequency and types of backups, and backup retention periods.

For distributed or hosted data applications, the particular characteristics of the data centers where the hardware for the MySQL servers is located, and network connections between the data centers.

## 15.3 InnoDB Multi-Versioning

**InnoDB** is a multi-version storage engine. It keeps information about old versions of changed rows to support transactional features such as concurrency and rollback. This information is stored in undo tablespaces in a data structure called a rollback segment. See [Section 15.6.3.4, “Undo Tablespaces”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-undo-tablespaces). **InnoDB** uses the information in the rollback segment to perform the undo operations needed in a transaction rollback. It also uses the information to build earlier versions of a row for a consistent read. See [Section 15.7.2.3, “Consistent Nonlocking Reads”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-consistent-read).

Internally, **InnoDB** adds three fields to each row stored in the database:

A 6-byte **DB\_TRX\_ID** field indicates the transaction identifier for the last transaction that inserted or updated the row. Also, a deletion is treated internally as an update where a special bit in the row is set to mark it as deleted.

A 7-byte **DB\_ROLL\_PTR** field called the roll pointer. The roll pointer points to an undo log record written to the rollback segment. If the row was updated, the undo log record contains the information necessary to rebuild the content of the row before it was updated.

A 6-byte **DB\_ROW\_ID** field contains a row ID that increases monotonically as new rows are inserted. If **InnoDB** generates a clustered index automatically, the index contains row ID values. Otherwise, the **DB\_ROW\_ID** column does not appear in any index.

Undo logs in the rollback segment are divided into insert and update undo logs. Insert undo logs are needed only in transaction rollback and can be discarded as soon as the transaction commits. Update undo logs are used also in consistent reads, but they can be discarded only after there is no transaction present for which **InnoDB** has assigned a snapshot that in a consistent read could require the information in the update undo log to build an earlier version of a database row. For additional information about undo logs, see [Section 15.6.6, “Undo Logs”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-undo-logs).

It is recommend that you commit transactions regularly, including transactions that issue only consistent reads. Otherwise, **InnoDB** cannot discard data from the update undo logs, and the rollback segment may grow too big, filling up the undo tablespace in which it resides. For information about managing undo tablespaces, see [Section 15.6.3.4, “Undo Tablespaces”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-undo-tablespaces).

The physical size of an undo log record in the rollback segment is typically smaller than the corresponding inserted or updated row. You can use this information to calculate the space needed for your rollback segment.

In the **InnoDB** multi-versioning scheme, a row is not physically removed from the database immediately when you delete it with an SQL statement. **InnoDB** only physically removes the corresponding row and its index records when it discards the update undo log record written for the deletion. This removal operation is called a purge, and it is quite fast, usually taking the same order of time as the SQL statement that did the deletion.

If you insert and delete rows in smallish batches at about the same rate in the table, the purge thread can start to lag behind and the table can grow bigger and bigger because of all the “dead” rows, making everything disk-bound and very slow. In such cases, throttle new row operations, and allocate more resources to the purge thread by tuning the [**innodb\_max\_purge\_lag**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_max_purge_lag) system variable. For more information, see [Section 15.8.9, “Purge Configuration”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-purge-configuration).

### Multi-Versioning and Secondary Indexes

**InnoDB** multiversion concurrency control (MVCC) treats secondary indexes differently than clustered indexes. Records in a clustered index are updated in-place, and their hidden system columns point undo log entries from which earlier versions of records can be reconstructed. Unlike clustered index records, secondary index records do not contain hidden system columns nor are they updated in-place.

When a secondary index column is updated, old secondary index records are delete-marked, new records are inserted, and delete-marked records are eventually purged. When a secondary index record is delete-marked or the secondary index page is updated by a newer transaction, **InnoDB** looks up the database record in the clustered index. In the clustered index, the record's **DB\_TRX\_ID** is checked, and the correct version of the record is retrieved from the undo log if the record was modified after the reading transaction was initiated.

If a secondary index record is marked for deletion or the secondary index page is updated by a newer transaction, the [covering index](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_covering_index) technique is not used. Instead of returning values from the index structure, **InnoDB** looks up the record in the clustered index.

However, if the [index condition pushdown (ICP)](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#index-condition-pushdown-optimization) optimization is enabled, and parts of the **WHERE** condition can be evaluated using only fields from the index, the MySQL server still pushes this part of the **WHERE** condition down to the storage engine where it is evaluated using the index. If no matching records are found, the clustered index lookup is avoided. If matching records are found, even among delete-marked records, **InnoDB** looks up the record in the clustered index.

## 15.4 InnoDB Architecture

The following diagram shows in-memory and on-disk structures that comprise the **InnoDB** storage engine architecture. For information about each structure, see [Section 15.5, “InnoDB In-Memory Structures”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-in-memory-structures), and [Section 15.6, “InnoDB On-Disk Structures”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-on-disk-structures).

**Figure 15.1 InnoDB Architecture**

## 15.5 InnoDB In-Memory Structures

[15.5.1 Buffer Pool](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-buffer-pool)

[15.5.2 Change Buffer](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-change-buffer)

[15.5.3 Adaptive Hash Index](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-adaptive-hash)

[15.5.4 Log Buffer](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-redo-log-buffer)

This section describes **InnoDB** in-memory structures and related topics.

### 15.5.1 Buffer Pool

The buffer pool is an area in main memory where **InnoDB** caches table and index data as it is accessed. The buffer pool permits frequently used data to be accessed directly from memory, which speeds up processing. On dedicated servers, up to 80% of physical memory is often assigned to the buffer pool.

For efficiency of high-volume read operations, the buffer pool is divided into pages that can potentially hold multiple rows. For efficiency of cache management, the buffer pool is implemented as a linked list of pages; data that is rarely used is aged out of the cache using a variation of the least recently used (LRU) algorithm.

Knowing how to take advantage of the buffer pool to keep frequently accessed data in memory is an important aspect of MySQL tuning.

#### Buffer Pool LRU Algorithm

The buffer pool is managed as a list using a variation of the LRU algorithm. When room is needed to add a new page to the buffer pool, the least recently used page is evicted and a new page is added to the middle of the list. This midpoint insertion strategy treats the list as two sublists:

At the head, a sublist of new (“young”) pages that were accessed recently

At the tail, a sublist of old pages that were accessed less recently

**Figure 15.2 Buffer Pool List**

The algorithm keeps frequently used pages in the new sublist. The old sublist contains less frequently used pages; these pages are candidates for [eviction](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_eviction).

By default, the algorithm operates as follows:

3/8 of the buffer pool is devoted to the old sublist.

The midpoint of the list is the boundary where the tail of the new sublist meets the head of the old sublist.

When **InnoDB** reads a page into the buffer pool, it initially inserts it at the midpoint (the head of the old sublist). A page can be read because it is required for a user-initiated operation such as an SQL query, or as part of a [read-ahead](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_read_ahead) operation performed automatically by **InnoDB**.

Accessing a page in the old sublist makes it “young”, moving it to the head of the new sublist. If the page was read because it was required by a user-initiated operation, the first access occurs immediately and the page is made young. If the page was read due to a read-ahead operation, the first access does not occur immediately and might not occur at all before the page is evicted.

As the database operates, pages in the buffer pool that are not accessed “age” by moving toward the tail of the list. Pages in both the new and old sublists age as other pages are made new. Pages in the old sublist also age as pages are inserted at the midpoint. Eventually, a page that remains unused reaches the tail of the old sublist and is evicted.

By default, pages read by queries are immediately moved into the new sublist, meaning they stay in the buffer pool longer. A table scan, performed for a [**mysqldump**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\programs.html#mysqldump) operation or a **SELECT** statement with no **WHERE** clause, for example, can bring a large amount of data into the buffer pool and evict an equivalent amount of older data, even if the new data is never used again. Similarly, pages that are loaded by the read-ahead background thread and accessed only once are moved to the head of the new list. These situations can push frequently used pages to the old sublist where they become subject to eviction. For information about optimizing this behavior, see [Section 15.8.3.3, “Making the Buffer Pool Scan Resistant”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-performance-midpoint_insertion), and [Section 15.8.3.4, “Configuring InnoDB Buffer Pool Prefetching (Read-Ahead)”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-performance-read_ahead).

**InnoDB** Standard Monitor output contains several fields in the **BUFFER POOL AND MEMORY** section regarding operation of the buffer pool LRU algorithm. For details, see [Monitoring the Buffer Pool Using the InnoDB Standard Monitor](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-buffer-pool-monitoring).

#### Buffer Pool Configuration

You can configure the various aspects of the buffer pool to improve performance.

Ideally, you set the size of the buffer pool to as large a value as practical, leaving enough memory for other processes on the server to run without excessive paging. The larger the buffer pool, the more **InnoDB** acts like an in-memory database, reading data from disk once and then accessing the data from memory during subsequent reads. See [Section 15.8.3.1, “Configuring InnoDB Buffer Pool Size”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-buffer-pool-resize).

On 64-bit systems with sufficient memory, you can split the buffer pool into multiple parts to minimize contention for memory structures among concurrent operations. For details, see [Section 15.8.3.2, “Configuring Multiple Buffer Pool Instances”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-multiple-buffer-pools).

You can keep frequently accessed data in memory regardless of sudden spikes of activity from operations that would bring large amounts of infrequently accessed data into the buffer pool. For details, see [Section 15.8.3.3, “Making the Buffer Pool Scan Resistant”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-performance-midpoint_insertion).

You can control how and when to perform read-ahead requests to prefetch pages into the buffer pool asynchronously in anticipation of impending need for them. For details, see [Section 15.8.3.4, “Configuring InnoDB Buffer Pool Prefetching (Read-Ahead)”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-performance-read_ahead).

You can control when background flushing occurs and whether or not the rate of flushing is dynamically adjusted based on workload. For details, see [Section 15.8.3.5, “Configuring Buffer Pool Flushing”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-buffer-pool-flushing).

You can configure how **InnoDB** preserves the current buffer pool state to avoid a lengthy warmup period after a server restart. For details, see [Section 15.8.3.6, “Saving and Restoring the Buffer Pool State”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-preload-buffer-pool).

#### Monitoring the Buffer Pool Using the InnoDB Standard Monitor

**InnoDB** Standard Monitor output, which can be accessed using [**SHOW ENGINE INNODB STATUS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-standard-monitor), provides metrics regarding operation of the buffer pool. Buffer pool metrics are located in the **BUFFER POOL AND MEMORY** section of **InnoDB** Standard Monitor output:

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BUFFER POOL AND MEMORY

----------------------

Total large memory allocated 2198863872

Dictionary memory allocated 776332

Buffer pool size 131072

Free buffers 124908

Database pages 5720

Old database pages 2071

Modified db pages 910

Pending reads 0

Pending writes: LRU 0, flush list 0, single page 0

Pages made young 4, not young 0

0.10 youngs/s, 0.00 non-youngs/s

Pages read 197, created 5523, written 5060

0.00 reads/s, 190.89 creates/s, 244.94 writes/s

Buffer pool hit rate 1000 / 1000, young-making rate 0 / 1000 not

0 / 1000

Pages read ahead 0.00/s, evicted without access 0.00/s, Random read

ahead 0.00/s

LRU len: 5720, unzip\_LRU len: 0

I/O sum[0]:cur[0], unzip sum[0]:cur[0]

The following table describes buffer pool metrics reported by the **InnoDB** Standard Monitor.

Per second averages provided in **InnoDB** Standard Monitor output are based on the elapsed time since **InnoDB** Standard Monitor output was last printed.

**Table 15.2 InnoDB Buffer Pool Metrics**

| **Name** | **Description** |
| --- | --- |
| Total memory allocated | The total memory allocated for the buffer pool in bytes. |
| Dictionary memory allocated | The total memory allocated for the **InnoDB** data dictionary in bytes. |
| Buffer pool size | The total size in pages allocated to the buffer pool. |
| Free buffers | The total size in pages of the buffer pool free list. |
| Database pages | The total size in pages of the buffer pool LRU list. |
| Old database pages | The total size in pages of the buffer pool old LRU sublist. |
| Modified db pages | The current number of pages modified in the buffer pool. |
| Pending reads | The number of buffer pool pages waiting to be read into the buffer pool. |
| Pending writes LRU | The number of old dirty pages within the buffer pool to be written from the bottom of the LRU list. |
| Pending writes flush list | The number of buffer pool pages to be flushed during checkpointing. |
| Pending writes single page | The number of pending independent page writes within the buffer pool. |
| Pages made young | The total number of pages made young in the buffer pool LRU list (moved to the head of sublist of “new” pages). |
| Pages made not young | The total number of pages not made young in the buffer pool LRU list (pages that have remained in the “old” sublist without being made young). |
| youngs/s | The per second average of accesses to old pages in the buffer pool LRU list that have resulted in making pages young. See the notes that follow this table for more information. |
| non-youngs/s | The per second average of accesses to old pages in the buffer pool LRU list that have resulted in not making pages young. See the notes that follow this table for more information. |
| Pages read | The total number of pages read from the buffer pool. |
| Pages created | The total number of pages created within the buffer pool. |
| Pages written | The total number of pages written from the buffer pool. |
| reads/s | The per second average number of buffer pool page reads per second. |
| creates/s | The average number of buffer pool pages created per second. |
| writes/s | The average number of buffer pool page writes per second. |
| Buffer pool hit rate | The buffer pool page hit rate for pages read from the buffer pool vs from disk storage. |
| young-making rate | The average hit rate at which page accesses have resulted in making pages young. See the notes that follow this table for more information. |
| not (young-making rate) | The average hit rate at which page accesses have not resulted in making pages young. See the notes that follow this table for more information. |
| Pages read ahead | The per second average of read ahead operations. |
| Pages evicted without access | The per second average of the pages evicted without being accessed from the buffer pool. |
| Random read ahead | The per second average of random read ahead operations. |
| LRU len | The total size in pages of the buffer pool LRU list. |
| unzip\_LRU len | The length (in pages) of the buffer pool unzip\_LRU list. |
| I/O sum | The total number of buffer pool LRU list pages accessed. |
| I/O cur | The total number of buffer pool LRU list pages accessed in the current interval. |
| I/O unzip sum | The total number of buffer pool unzip\_LRU list pages decompressed. |
| I/O unzip cur | The total number of buffer pool unzip\_LRU list pages decompressed in the current interval. |

***Notes***:

The **youngs/s** metric is applicable only to old pages. It is based on the number of page accesses. There can be multiple accesses for a given page, all of which are counted. If you see very low **youngs/s** values when there are no large scans occurring, consider reducing the delay time or increasing the percentage of the buffer pool used for the old sublist. Increasing the percentage makes the old sublist larger so that it takes longer for pages in that sublist to move to the tail, which increases the likelihood that those pages are accessed again and made young. See [Section 15.8.3.3, “Making the Buffer Pool Scan Resistant”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-performance-midpoint_insertion).

The **non-youngs/s** metric is applicable only to old pages. It is based on the number of page accesses. There can be multiple accesses for a given page, all of which are counted. If you do not see a higher **non-youngs/s** value when performing large table scans (and a higher **youngs/s** value), increase the delay value. See [Section 15.8.3.3, “Making the Buffer Pool Scan Resistant”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-performance-midpoint_insertion).

The **young-making** rate accounts for all buffer pool page accesses, not just accesses for pages in the old sublist. The **young-making** rate and **not** rate do not normally add up to the overall buffer pool hit rate. Page hits in the old sublist cause pages to move to the new sublist, but page hits in the new sublist cause pages to move to the head of the list only if they are a certain distance from the head.

**not (young-making rate)** is the average hit rate at which page accesses have not resulted in making pages young due to the delay defined by [**innodb\_old\_blocks\_time**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_old_blocks_time) not being met, or due to page hits in the new sublist that did not result in pages being moved to the head. This rate accounts for all buffer pool page accesses, not just accesses for pages in the old sublist.

Buffer pool [server status variables](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#server-status-variables) and the [**INNODB\_BUFFER\_POOL\_STATS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-buffer-pool-stats-table) table provide many of the same buffer pool metrics found in **InnoDB** Standard Monitor output. For more information, see [Example 15.10, “Querying the INNODB\_BUFFER\_POOL\_STATS Table”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-information-schema-buffer-pool-stats-example).

### 15.5.2 Change Buffer

The change buffer is a special data structure that caches changes to [secondary index](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_secondary_index) pages when those pages are not in the [buffer pool](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_buffer_pool). The buffered changes, which may result from [**INSERT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#insert), [**UPDATE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#update), or [**DELETE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#delete) operations (DML), are merged later when the pages are loaded into the buffer pool by other read operations.

**Figure 15.3 Change Buffer**

Unlike [clustered indexes](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_clustered_index), secondary indexes are usually nonunique, and inserts into secondary indexes happen in a relatively random order. Similarly, deletes and updates may affect secondary index pages that are not adjacently located in an index tree. Merging cached changes at a later time, when affected pages are read into the buffer pool by other operations, avoids substantial random access I/O that would be required to read secondary index pages into the buffer pool from disk.

Periodically, the purge operation that runs when the system is mostly idle, or during a slow shutdown, writes the updated index pages to disk. The purge operation can write disk blocks for a series of index values more efficiently than if each value were written to disk immediately.

Change buffer merging may take several hours when there are many affected rows and numerous secondary indexes to update. During this time, disk I/O is increased, which can cause a significant slowdown for disk-bound queries. Change buffer merging may also continue to occur after a transaction is committed, and even after a server shutdown and restart (see [Section 15.21.2, “Forcing InnoDB Recovery”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#forcing-innodb-recovery) for more information).

In memory, the change buffer occupies part of the buffer pool. On disk, the change buffer is part of the system tablespace, where index changes are buffered when the database server is shut down.

The type of data cached in the change buffer is governed by the [**innodb\_change\_buffering**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_change_buffering) variable. For more information, see [Configuring Change Buffering](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-change-buffer-configuration). You can also configure the maximum change buffer size. For more information, see [Configuring the Change Buffer Maximum Size](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-change-buffer-maximum-size).

Change buffering is not supported for a secondary index if the index contains a descending index column or if the primary key includes a descending index column.

For answers to frequently asked questions about the change buffer, see [Section A.16, “MySQL 8.0 FAQ: InnoDB Change Buffer”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\faqs.html#faqs-innodb-change-buffer).

#### Configuring Change Buffering

When [**INSERT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#insert), [**UPDATE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#update), and [**DELETE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#delete) operations are performed on a table, the values of indexed columns (particularly the values of secondary keys) are often in an unsorted order, requiring substantial I/O to bring secondary indexes up to date. The [change buffer](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_change_buffer) caches changes to secondary index entries when the relevant [page](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_page) is not in the [buffer pool](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_buffer_pool), thus avoiding expensive I/O operations by not immediately reading in the page from disk. The buffered changes are merged when the page is loaded into the buffer pool, and the updated page is later flushed to disk. The **InnoDB** main thread merges buffered changes when the server is nearly idle, and during a [slow shutdown](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_slow_shutdown).

Because it can result in fewer disk reads and writes, change buffering is most valuable for workloads that are I/O-bound; for example, applications with a high volume of DML operations such as bulk inserts benefit from change buffering.

However, the change buffer occupies a part of the buffer pool, reducing the memory available to cache data pages. If the working set almost fits in the buffer pool, or if your tables have relatively few secondary indexes, it may be useful to disable change buffering. If the working data set fits entirely within the buffer pool, change buffering does not impose extra overhead, because it only applies to pages that are not in the buffer pool.

The [**innodb\_change\_buffering**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_change_buffering) variable controls the extent to which **InnoDB** performs change buffering. You can enable or disable buffering for inserts, delete operations (when index records are initially marked for deletion) and purge operations (when index records are physically deleted). An update operation is a combination of an insert and a delete. The default [**innodb\_change\_buffering**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_change_buffering) value is **all**.

Permitted [**innodb\_change\_buffering**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_change_buffering) values include:

***all***

The default value: buffer inserts, delete-marking operations, and purges.

***none***

Do not buffer any operations.

***inserts***

Buffer insert operations.

***deletes***

Buffer delete-marking operations.

***changes***

Buffer both inserts and delete-marking operations.

***purges***

Buffer the physical deletion operations that happen in the background.

You can set the [**innodb\_change\_buffering**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_change_buffering) variable in the MySQL option file (**my.cnf** or **my.ini**) or change it dynamically with the [**SET GLOBAL**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#set-variable) statement, which requires privileges sufficient to set global system variables. See [Section 5.1.9.1, “System Variable Privileges”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#system-variable-privileges). Changing the setting affects the buffering of new operations; the merging of existing buffered entries is not affected.

#### Configuring the Change Buffer Maximum Size

The [**innodb\_change\_buffer\_max\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_change_buffer_max_size) variable permits configuring the maximum size of the change buffer as a percentage of the total size of the buffer pool. By default, [**innodb\_change\_buffer\_max\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_change_buffer_max_size) is set to 25. The maximum setting is 50.

Consider increasing [**innodb\_change\_buffer\_max\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_change_buffer_max_size) on a MySQL server with heavy insert, update, and delete activity, where change buffer merging does not keep pace with new change buffer entries, causing the change buffer to reach its maximum size limit.

Consider decreasing [**innodb\_change\_buffer\_max\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_change_buffer_max_size) on a MySQL server with static data used for reporting, or if the change buffer consumes too much of the memory space shared with the buffer pool, causing pages to age out of the buffer pool sooner than desired.

Test different settings with a representative workload to determine an optimal configuration. The [**innodb\_change\_buffer\_max\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_change_buffer_max_size) variable is dynamic, which permits modifying the setting without restarting the server.

#### Monitoring the Change Buffer

The following options are available for change buffer monitoring:

**InnoDB** Standard Monitor output includes change buffer status information. To view monitor data, issue the **SHOW ENGINE INNODB STATUS** statement.

mysql> **SHOW ENGINE INNODB STATUS\G**

Change buffer status information is located under the **INSERT BUFFER AND ADAPTIVE HASH INDEX** heading and appears similar to the following:

-------------------------------------

INSERT BUFFER AND ADAPTIVE HASH INDEX

-------------------------------------

Ibuf: size 1, free list len 0, seg size 2, 0 merges

merged operations:

insert 0, delete mark 0, delete 0

discarded operations:

insert 0, delete mark 0, delete 0

Hash table size 4425293, used cells 32, node heap has 1 buffer(s)

13577.57 hash searches/s, 202.47 non-hash searches/s

For more information, see [Section 15.17.3, “InnoDB Standard Monitor and Lock Monitor Output”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-standard-monitor).

The [**INFORMATION\_SCHEMA.INNODB\_METRICS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-metrics-table) table provides most of the data points found in **InnoDB** Standard Monitor output plus other data points. To view change buffer metrics and a description of each, issue the following query:

mysql> **SELECT NAME, COMMENT FROM INFORMATION\_SCHEMA.INNODB\_METRICS WHERE NAME LIKE '%ibuf%'\G**

For [**INNODB\_METRICS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-metrics-table) table usage information, see [Section 15.15.6, “InnoDB INFORMATION\_SCHEMA Metrics Table”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-information-schema-metrics-table).

The [**INFORMATION\_SCHEMA.INNODB\_BUFFER\_PAGE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-buffer-page-table) table provides metadata about each page in the buffer pool, including change buffer index and change buffer bitmap pages. Change buffer pages are identified by **PAGE\_TYPE**. **IBUF\_INDEX** is the page type for change buffer index pages, and **IBUF\_BITMAP** is the page type for change buffer bitmap pages.

**Warning**

Querying the [**INNODB\_BUFFER\_PAGE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-buffer-page-table) table can introduce significant performance overhead. To avoid impacting performance, reproduce the issue you want to investigate on a test instance and run your queries on the test instance.

For example, you can query the [**INNODB\_BUFFER\_PAGE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-buffer-page-table) table to determine the approximate number of **IBUF\_INDEX** and **IBUF\_BITMAP** pages as a percentage of total buffer pool pages.

mysql> **SELECT (SELECT COUNT(\*) FROM INFORMATION\_SCHEMA.INNODB\_BUFFER\_PAGE**

**WHERE PAGE\_TYPE LIKE 'IBUF%') AS change\_buffer\_pages,**

**(SELECT COUNT(\*) FROM INFORMATION\_SCHEMA.INNODB\_BUFFER\_PAGE) AS total\_pages,**

**(SELECT ((change\_buffer\_pages/total\_pages)\*100))**

**AS change\_buffer\_page\_percentage;**

+---------------------+-------------+-------------------------------+

| change\_buffer\_pages | total\_pages | change\_buffer\_page\_percentage |

+---------------------+-------------+-------------------------------+

| 25 | 8192 | 0.3052 |

+---------------------+-------------+-------------------------------+

For information about other data provided by the [**INNODB\_BUFFER\_PAGE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-buffer-page-table) table, see [Section 26.4.2, “The INFORMATION\_SCHEMA INNODB\_BUFFER\_PAGE Table”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-buffer-page-table). For related usage information, see [Section 15.15.5, “InnoDB INFORMATION\_SCHEMA Buffer Pool Tables”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-information-schema-buffer-pool-tables).

[Performance Schema](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html) provides change buffer mutex wait instrumentation for advanced performance monitoring. To view change buffer instrumentation, issue the following query:

mysql> **SELECT \* FROM performance\_schema.setup\_instruments**

**WHERE NAME LIKE '%wait/synch/mutex/innodb/ibuf%';**

+-------------------------------------------------------+---------+-------+

| NAME | ENABLED | TIMED |

+-------------------------------------------------------+---------+-------+

| wait/synch/mutex/innodb/ibuf\_bitmap\_mutex | YES | YES |

| wait/synch/mutex/innodb/ibuf\_mutex | YES | YES |

| wait/synch/mutex/innodb/ibuf\_pessimistic\_insert\_mutex | YES | YES |

+-------------------------------------------------------+---------+-------+

For information about monitoring **InnoDB** mutex waits, see [Section 15.16.2, “Monitoring InnoDB Mutex Waits Using Performance Schema”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#monitor-innodb-mutex-waits-performance-schema).

### 15.5.3 Adaptive Hash Index

The adaptive hash index enables **InnoDB** to perform more like an in-memory database on systems with appropriate combinations of workload and sufficient memory for the buffer pool without sacrificing transactional features or reliability. The adaptive hash index is enabled by the [**innodb\_adaptive\_hash\_index**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_adaptive_hash_index) variable, or turned off at server startup by **--skip-innodb-adaptive-hash-index**.

Based on the observed pattern of searches, a hash index is built using a prefix of the index key. The prefix can be any length, and it may be that only some values in the B-tree appear in the hash index. Hash indexes are built on demand for the pages of the index that are accessed often.

If a table fits almost entirely in main memory, a hash index speeds up queries by enabling direct lookup of any element, turning the index value into a sort of pointer. **InnoDB** has a mechanism that monitors index searches. If **InnoDB** notices that queries could benefit from building a hash index, it does so automatically.

With some workloads, the speedup from hash index lookups greatly outweighs the extra work to monitor index lookups and maintain the hash index structure. Access to the adaptive hash index can sometimes become a source of contention under heavy workloads, such as multiple concurrent joins. Queries with **LIKE** operators and **%** wildcards also tend not to benefit. For workloads that do not benefit from the adaptive hash index, turning it off reduces unnecessary performance overhead. Because it is difficult to predict in advance whether the adaptive hash index is appropriate for a particular system and workload, consider running benchmarks with it enabled and disabled.

The adaptive hash index feature is partitioned. Each index is bound to a specific partition, and each partition is protected by a separate latch. Partitioning is controlled by the [**innodb\_adaptive\_hash\_index\_parts**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_adaptive_hash_index_parts) variable. The [**innodb\_adaptive\_hash\_index\_parts**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_adaptive_hash_index_parts) variable is set to 8 by default. The maximum setting is 512.

You can monitor adaptive hash index use and contention in the **SEMAPHORES** section of [**SHOW ENGINE INNODB STATUS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#show-engine) output. If there are numerous threads waiting on rw-latches created in btr0sea.c, consider increasing the number of adaptive hash index partitions or disabling the adaptive hash index.

For information about the performance characteristics of hash indexes, see [Section 8.3.9, “Comparison of B-Tree and Hash Indexes”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#index-btree-hash).

### 15.5.4 Log Buffer

The log buffer is the memory area that holds data to be written to the log files on disk. Log buffer size is defined by the [**innodb\_log\_buffer\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_log_buffer_size) variable. The default size is 16MB. The contents of the log buffer are periodically flushed to disk. A large log buffer enables large transactions to run without the need to write redo log data to disk before the transactions commit. Thus, if you have transactions that update, insert, or delete many rows, increasing the size of the log buffer saves disk I/O.

The [**innodb\_flush\_log\_at\_trx\_commit**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_flush_log_at_trx_commit) variable controls how the contents of the log buffer are written and flushed to disk. The [**innodb\_flush\_log\_at\_timeout**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_flush_log_at_timeout) variable controls log flushing frequency.

For related information, see [Memory Configuration](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-startup-memory-configuration), and [Section 8.5.4, “Optimizing InnoDB Redo Logging”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizing-innodb-logging).

## 15.6 InnoDB On-Disk Structures

[15.6.1 Tables](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-tables)

[15.6.2 Indexes](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-indexes)

[15.6.3 Tablespaces](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-tablespace)

[15.6.4 Doublewrite Buffer](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-doublewrite-buffer)

[15.6.5 Redo Log](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-redo-log)

[15.6.6 Undo Logs](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-undo-logs)

This section describes **InnoDB** on-disk structures and related topics.

### 15.6.1 Tables

[15.6.1.1 Creating InnoDB Tables](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#using-innodb-tables)

[15.6.1.2 Creating Tables Externally](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-create-table-external)

[15.6.1.3 Importing InnoDB Tables](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-table-import)

[15.6.1.4 Moving or Copying InnoDB Tables](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-migration)

[15.6.1.5 Converting Tables from MyISAM to InnoDB](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#converting-tables-to-innodb)

[15.6.1.6 AUTO\_INCREMENT Handling in InnoDB](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-auto-increment-handling)

This section covers topics related to **InnoDB** tables.

#### 15.6.1.1 Creating InnoDB Tables

**InnoDB** tables are created using the [**CREATE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-table) statement; for example:

CREATE TABLE t1 (a INT, b CHAR (20), PRIMARY KEY (a)) ENGINE=InnoDB;

The **ENGINE=InnoDB** clause is not required when **InnoDB** is defined as the default storage engine, which it is by default. However, the **ENGINE** clause is useful if the [**CREATE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-table) statement is to be replayed on a different MySQL Server instance where the default storage engine is not **InnoDB** or is unknown. You can determine the default storage engine on a MySQL Server instance by issuing the following statement:

mysql> **SELECT @@default\_storage\_engine;**

+--------------------------+

| @@default\_storage\_engine |

+--------------------------+

| InnoDB |

+--------------------------+

**InnoDB** tables are created in file-per-table tablespaces by default. To create an **InnoDB** table in the **InnoDB** system tablespace, disable the [**innodb\_file\_per\_table**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_file_per_table) variable before creating the table. To create an **InnoDB** table in a general tablespace, use [**CREATE TABLE ... TABLESPACE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-table) syntax. For more information, see [Section 15.6.3, “Tablespaces”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-tablespace).

##### Row Formats

The row format of an **InnoDB** table determines how its rows are physically stored on disk. **InnoDB** supports four row formats, each with different storage characteristics. Supported row formats include **REDUNDANT**, **COMPACT**, **DYNAMIC**, and **COMPRESSED**. The **DYNAMIC** row format is the default. For information about row format characteristics, see [Section 15.10, “InnoDB Row Formats”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-row-format).

The [**innodb\_default\_row\_format**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_default_row_format) variable defines the default row format. The row format of a table can also be defined explicitly using the **ROW\_FORMAT** table option in a **CREATE TABLE** or **ALTER TABLE** statement. See [Defining the Row Format of a Table](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-row-format-defining).

##### Primary Keys

It is recommended that you define a primary key for each table that you create. When selecting primary key columns, choose columns with the following characteristics:

Columns that are referenced by the most important queries.

Columns that are never left blank.

Columns that never have duplicate values.

Columns that rarely if ever change value once inserted.

For example, in a table containing information about people, you would not create a primary key on **(firstname, lastname)** because more than one person can have the same name, a name column may be left blank, and sometimes people change their names. With so many constraints, often there is not an obvious set of columns to use as a primary key, so you create a new column with a numeric ID to serve as all or part of the primary key. You can declare an [auto-increment](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_auto_increment) column so that ascending values are filled in automatically as rows are inserted:

# The value of ID can act like a pointer between related items in different tables.

CREATE TABLE t5 (id INT AUTO\_INCREMENT, b CHAR (20), PRIMARY KEY (id));

# The primary key can consist of more than one column. Any autoinc column must come first.

CREATE TABLE t6 (id INT AUTO\_INCREMENT, a INT, b CHAR (20), PRIMARY KEY (id,a));

For more information about auto-increment columns, see [Section 15.6.1.6, “AUTO\_INCREMENT Handling in InnoDB”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-auto-increment-handling).

Although a table works correctly without defining a primary key, the primary key is involved with many aspects of performance and is a crucial design aspect for any large or frequently used table. It is recommended that you always specify a primary key in the [**CREATE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-table) statement. If you create the table, load data, and then run [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) to add a primary key later, that operation is much slower than defining the primary key when creating the table. For more information about primary keys, see [Section 15.6.2.1, “Clustered and Secondary Indexes”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-index-types).

##### Viewing InnoDB Table Properties

To view the properties of an **InnoDB** table, issue a [**SHOW TABLE STATUS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#show-table-status) statement:

mysql> **SHOW TABLE STATUS FROM test LIKE 't%' \G;**

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\* 1. row \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

Name: t1

Engine: InnoDB

Version: 10

Row\_format: Dynamic

Rows: 0

Avg\_row\_length: 0

Data\_length: 16384

Max\_data\_length: 0

Index\_length: 0

Data\_free: 0

Auto\_increment: NULL

Create\_time: 2021-02-18 12:18:28

Update\_time: NULL

Check\_time: NULL

Collation: utf8mb4\_0900\_ai\_ci

Checksum: NULL

Create\_options:

Comment:

For information about [**SHOW TABLE STATUS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#show-table-status) output, see [Section 13.7.7.38, “SHOW TABLE STATUS Statement”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#show-table-status).

You can also access **InnoDB** table properties by querying the **InnoDB** Information Schema system tables:

mysql> **SELECT \* FROM INFORMATION\_SCHEMA.INNODB\_TABLES WHERE NAME='test/t1' \G**

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\* 1. row \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

TABLE\_ID: 1144

NAME: test/t1

FLAG: 33

N\_COLS: 5

SPACE: 30

ROW\_FORMAT: Dynamic

ZIP\_PAGE\_SIZE: 0

SPACE\_TYPE: Single

INSTANT\_COLS: 0

For more information, see [Section 15.15.3, “InnoDB INFORMATION\_SCHEMA Schema Object Tables”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-information-schema-system-tables).

#### 15.6.1.2 Creating Tables Externally

There are different reasons for creating **InnoDB** tables externally; that is, creating tables outside of the data directory. Those reasons might include space management, I/O optimization, or placing tables on a storage device with particular performance or capacity characteristics, for example.

**InnoDB** supports the following methods for creating tables externally:

[Using the DATA DIRECTORY Clause](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-create-table-external-data-directory)

[Using CREATE TABLE ... TABLESPACE Syntax](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-create-table-external-tablespace-syntax)

[Creating a Table in an External General Tablespace](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-create-table-external-tablespace)

##### Using the DATA DIRECTORY Clause

You can create an **InnoDB** table in an external directory by specifying a **DATA DIRECTORY** clause in the **CREATE TABLE** statement.

CREATE TABLE t1 (c1 INT PRIMARY KEY) DATA DIRECTORY = '***/external/directory***';

The **DATA DIRECTORY** clause is supported for tables created in file-per-table tablespaces. Tables are implicitly created in file-per-table tablespaces when the [**innodb\_file\_per\_table**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_file_per_table) variable is enabled, which it is by default.

mysql> **SELECT @@innodb\_file\_per\_table;**

+-------------------------+

| @@innodb\_file\_per\_table |

+-------------------------+

| 1 |

+-------------------------+

For more information about file-per-table tablespaces, see [Section 15.6.3.2, “File-Per-Table Tablespaces”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-file-per-table-tablespaces).

When you specify a **DATA DIRECTORY** clause in a **CREATE TABLE** statement, the table's data file (***table\_name***.ibd) is created in a schema directory under the specified directory.

As of MySQL 8.0.21, tables and table partitions created outside of the data directory using the **DATA DIRECTORY** clause are restricted to directories known to **InnoDB**. This requirement permits database administrators to control where tablespace data files are created and ensures that data files can be found during recovery (see [Tablespace Discovery During Crash Recovery](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-recovery-tablespace-discovery)). Known directories are those defined by the [**datadir**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_datadir), [**innodb\_data\_home\_dir**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_data_home_dir), and [**innodb\_directories**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_directories) variables. You can use the following statement to check those settings:

mysql> SELECT @@datadir,@@innodb\_data\_home\_dir,@@innodb\_directories;

If the directory you want to use is unknown, add it to the [**innodb\_directories**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_directories) setting before you create the table. The [**innodb\_directories**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_directories) variable is read-only. Configuring it requires restarting the server. For general information about setting system variables, see [Section 5.1.9, “Using System Variables”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#using-system-variables).

The following example demonstrates creating a table in an external directory using the **DATA DIRECTORY** clause. It is assumed that the [**innodb\_file\_per\_table**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_file_per_table) variable is enabled and that the directory is known to **InnoDB**.

mysql> **USE test;**

Database changed

mysql> **CREATE TABLE t1 (c1 INT PRIMARY KEY) DATA DIRECTORY = '*/external/directory*';**

# MySQL creates the table's data file in a schema directory

# under the external directory

shell> **cd /external/directory/test**

shell> **ls**

t1.ibd

###### Usage Notes:

MySQL initially holds the tablespace data file open, preventing you from dismounting the device, but might eventually close the file if the server is busy. Be careful not to accidentally dismount an external device while MySQL is running, or start MySQL while the device is disconnected. Attempting to access a table when the associated data file is missing causes a serious error that requires a server restart.

A server restart might fail if the data file is not found at the expected path. In this case, you can restore the tablespace data file from a backup or drop the table to remove the information about it from the [data dictionary](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_data_dictionary).

Before placing a table on an NFS-mounted volume, review potential issues outlined in [Using NFS with MySQL](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#disk-issues-nfs).

If using an LVM snapshot, file copy, or other file-based mechanism to back up the table's data file, always use the [**FLUSH TABLES ... FOR EXPORT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#flush-tables-for-export-with-list) statement first to ensure that all changes buffered in memory are [flushed](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_flush) to disk before the backup occurs.

Using the **DATA DIRECTORY** clause to create a table in an external directory is an alternative to using [symbolic links](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#symbolic-links), which **InnoDB** does not support.

The **DATA DIRECTORY** clause is not supported in a replication environment where the source and replica reside on the same host. The **DATA DIRECTORY** clause requires a full directory path. Replicating the path in this case would cause the source and replica to create the table in same location.

As of MySQL 8.0.21, tables created in file-per-table tablespaces can no longer be created in the undo tablespace directory ([**innodb\_undo\_directory**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_undo_directory)) unless that directly is known to **InnoDB**. Known directories are those defined by the [**datadir**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_datadir), [**innodb\_data\_home\_dir**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_data_home_dir), and [**innodb\_directories**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_directories) variables.

##### Using CREATE TABLE ... TABLESPACE Syntax

[**CREATE TABLE ... TABLESPACE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-table) syntax can be used in combination with the **DATA DIRECTORY** clause to create a table in an external directory. To do so, specify **innodb\_file\_per\_table** as the tablespace name.

mysql> **CREATE TABLE t2 (c1 INT PRIMARY KEY) TABLESPACE = innodb\_file\_per\_table**

**DATA DIRECTORY = '/external/directory';**

This method is supported only for tables created in file-per-table tablespaces, but does not require the [**innodb\_file\_per\_table**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_file_per_table) variable to be enabled. In all other respects, this method is equivalent to the **CREATE TABLE ... DATA DIRECTORY** method described above. The same usage notes apply.

##### Creating a Table in an External General Tablespace

You can create a table in a general tablespace that resides in an external directory.

For information about creating a general tablespace in an external directory, see [Creating a General Tablespace](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#general-tablespaces-creating).

For information about creating a table in a general tablespace, see [Adding Tables to a General Tablespace](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#general-tablespaces-adding-tables).

#### 15.6.1.3 Importing InnoDB Tables

This section describes how to import tables using the Transportable Tablespaces feature, which permits importing tables, partitioned tables, or individual table partitions that reside in file-per-table tablespaces. There are many reasons why you might want to import tables:

To run reports on a non-production MySQL server instance to avoid placing extra load on a production server.

To copy data to a new replica server.

To restore a table from a backed-up tablespace file.

As a faster way of moving data than importing a dump file, which requires reinserting data and rebuilding indexes.

To move a data to a server with storage media that is better suited to your storage requirements. For example, you might move busy tables to an SSD device, or move large tables to a high-capacity HDD device.

The Transportable Tablespaces feature is described under the following topics in this section:

[Prerequisites](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-table-import-prerequsites)

[Importing Tables](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-table-import-example)

[Importing Partitioned Tables](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-table-import-partitioned-table)

[Importing Table Partitions](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-table-import-partitions)

[Limitations](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-table-import-limitations)

[Usage Notes](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-table-import-usage-notes)

[Internals](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-table-import-internals)

##### Prerequisites

The [**innodb\_file\_per\_table**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_file_per_table) variable must be enabled, which it is by default.

The page size of the tablespace must match the page size of the destination MySQL server instance. **InnoDB** page size is defined by the [**innodb\_page\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_page_size) variable, which is configured when initializing a MySQL server instance.

If the table has a foreign key relationship, [**foreign\_key\_checks**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_foreign_key_checks) must be disabled before executing **DISCARD TABLESPACE**. Also, you should export all foreign key related tables at the same logical point in time, as [**ALTER TABLE ... IMPORT TABLESPACE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) does not enforce foreign key constraints on imported data. To do so, stop updating the related tables, commit all transactions, acquire shared locks on the tables, and perform the export operations.

When importing a table from another MySQL server instance, both MySQL server instances must have General Availability (GA) status and must be the same version. Otherwise, the table must be created on the same MySQL server instance into which it is being imported.

If the table was created in an external directory by specifying the **DATA DIRECTORY** clause in the [**CREATE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-table) statement, the table that you replace on the destination instance must be defined with the same **DATA DIRECTORY** clause. A schema mismatch error is reported if the clauses do not match. To determine if the source table was defined with a **DATA DIRECTORY** clause, use [**SHOW CREATE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#show-create-table) to view the table definition. For information about using the **DATA DIRECTORY** clause, see [Section 15.6.1.2, “Creating Tables Externally”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-create-table-external).

If a **ROW\_FORMAT** option is not defined explicitly in the table definition or **ROW\_FORMAT=DEFAULT** is used, the [**innodb\_default\_row\_format**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_default_row_format) setting must be the same on the source and destination instances. Otherwise, a schema mismatch error is reported when you attempt the import operation. Use [**SHOW CREATE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#show-create-table) to check the table definition. Use [**SHOW VARIABLES**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#show-variables) to check the [**innodb\_default\_row\_format**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_default_row_format) setting. For related information, see [Defining the Row Format of a Table](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-row-format-defining).

##### Importing Tables

This example demonstrates how to import a regular non-partitioned table that resides in a file-per-table tablespace.

On the destination instance, create a table with the same definition as the table you intend to import. (You can obtain the table definition using [**SHOW CREATE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#show-create-table) syntax.) If the table definition does not match, a schema mismatch error is reported when you attempt the import operation.

mysql> USE test;

mysql> CREATE TABLE t1 (c1 INT) ENGINE=INNODB;

On the destination instance, discard the tablespace of the table that you just created. (Before importing, you must discard the tablespace of the receiving table.)

mysql> ALTER TABLE t1 DISCARD TABLESPACE;

On the source instance, run [**FLUSH TABLES ... FOR EXPORT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#flush-tables-for-export-with-list) to quiesce the table you intend to import. When a table is quiesced, only read-only transactions are permitted on the table.

mysql> USE test;

mysql> FLUSH TABLES t1 FOR EXPORT;

[**FLUSH TABLES ... FOR EXPORT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#flush-tables-for-export-with-list) ensures that changes to the named table are flushed to disk so that a binary table copy can be made while the server is running. When [**FLUSH TABLES ... FOR EXPORT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#flush-tables-for-export-with-list) is run, **InnoDB** generates a .cfg metadata file in the schema directory of the table. The .cfg file contains metadata that is used for schema verification during the import operation.

Copy the .ibd file and .cfg metadata file from the source instance to the destination instance. For example:

shell> scp ***/path/to/datadir***/test/t1.{ibd,cfg} destination-server:***/path/to/datadir***/test

The .ibd file and .cfg file must be copied before releasing the shared locks, as described in the next step.

**Note**

If you are importing a table from an encrypted tablespace, **InnoDB** generates a .cfp file in addition to a .cfg metadata file. The .cfp file must be copied to the destination instance together with the .cfg file. The .cfp file contains a transfer key and an encrypted tablespace key. On import, **InnoDB** uses the transfer key to decrypt the tablespace key. For related information, see [Section 15.13, “InnoDB Data-at-Rest Encryption”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-data-encryption).

On the source instance, use [**UNLOCK TABLES**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#lock-tables) to release the locks acquired by the [**FLUSH TABLES ... FOR EXPORT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#flush-tables-for-export-with-list) statement:

mysql> USE test;

mysql> UNLOCK TABLES;

On the destination instance, import the tablespace:

mysql> USE test;

mysql> ALTER TABLE t1 IMPORT TABLESPACE;

##### Importing Partitioned Tables

This example demonstrates how to import a partitioned table, where each table partition resides in a file-per-table tablespace.

On the destination instance, create a partitioned table with the same definition as the partitioned table that you want to import. (You can obtain the table definition using [**SHOW CREATE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#show-create-table) syntax.) If the table definition does not match, a schema mismatch error is reported when you attempt the import operation.

mysql> **USE test;**

mysql> **CREATE TABLE t1 (i int) ENGINE = InnoDB PARTITION BY KEY (i) PARTITIONS 3;**

In the **/*datadir*/test** directory, there is a tablespace .ibd file for each of the three partitions.

mysql> **\! ls */path/to/datadir*/test/**

t1#p#p0.ibd t1#p#p1.ibd t1#p#p2.ibd

On the destination instance, discard the tablespace for the partitioned table. (Before the import operation, you must discard the tablespace of the receiving table.)

mysql> **ALTER TABLE t1 DISCARD TABLESPACE;**

The three tablespace .ibd files of the partitioned table are discarded from the **/*datadir*/test** directory.

On the source instance, run [**FLUSH TABLES ... FOR EXPORT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#flush-tables-for-export-with-list) to quiesce the partitioned table that you intend to import. When a table is quiesced, only read-only transactions are permitted on the table.

mysql> **USE test;**

mysql> **FLUSH TABLES t1 FOR EXPORT;**

[**FLUSH TABLES ... FOR EXPORT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#flush-tables-for-export-with-list) ensures that changes to the named table are flushed to disk so that binary table copy can be made while the server is running. When [**FLUSH TABLES ... FOR EXPORT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#flush-tables-for-export-with-list) is run, **InnoDB** generates .cfg metadata files in the schema directory of the table for each of the table's tablespace files.

mysql> **\! ls */path/to/datadir*/test/**

t1#p#p0.ibd t1#p#p1.ibd t1#p#p2.ibd

t1#p#p0.cfg t1#p#p1.cfg t1#p#p2.cfg

The .cfg files contain metadata that is used for schema verification when importing the tablespace. [**FLUSH TABLES ... FOR EXPORT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#flush-tables-for-export-with-list) can only be run on the table, not on individual table partitions.

Copy the .ibd and .cfg files from the source instance schema directory to the destination instance schema directory. For example:

shell>scp ***/path/to/datadir*/test/t1\*.{ibd,cfg} destination-server:*/path/to/datadir*/test**

The .ibd and .cfg files must be copied before releasing the shared locks, as described in the next step.

**Note**

If you are importing a table from an encrypted tablespace, **InnoDB** generates a .cfp files in addition to a .cfg metadata files. The .cfp files must be copied to the destination instance together with the .cfg files. The .cfp files contain a transfer key and an encrypted tablespace key. On import, **InnoDB** uses the transfer key to decrypt the tablespace key. For related information, see [Section 15.13, “InnoDB Data-at-Rest Encryption”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-data-encryption).

On the source instance, use [**UNLOCK TABLES**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#lock-tables) to release the locks acquired by [**FLUSH TABLES ... FOR EXPORT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#flush-tables-for-export-with-list):

mysql> **USE test;**

mysql> **UNLOCK TABLES;**

On the destination instance, import the tablespace of the partitioned table:

mysql> **USE test;**

mysql> **ALTER TABLE t1 IMPORT TABLESPACE;**

##### Importing Table Partitions

This example demonstrates how to import individual table partitions, where each partition resides in a file-per-table tablespace file.

In the following example, two partitions (**p2** and **p3**) of a four-partition table are imported.

On the destination instance, create a partitioned table with the same definition as the partitioned table that you want to import partitions from. (You can obtain the table definition using [**SHOW CREATE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#show-create-table) syntax.) If the table definition does not match, a schema mismatch error is reported when you attempt the import operation.

mysql> **USE test;**

mysql> **CREATE TABLE t1 (i int) ENGINE = InnoDB PARTITION BY KEY (i) PARTITIONS 4;**

In the **/*datadir*/test** directory, there is a tablespace .ibd file for each of the four partitions.

mysql> **\! ls */path/to/datadir*/test/**

t1#p#p0.ibd t1#p#p1.ibd t1#p#p2.ibd t1#p#p3.ibd

On the destination instance, discard the partitions that you intend to import from the source instance. (Before importing partitions, you must discard the corresponding partitions from the receiving partitioned table.)

mysql> **ALTER TABLE t1 DISCARD PARTITION p2, p3 TABLESPACE;**

The tablespace **.ibd** files for the two discarded partitions are removed from the **/*datadir*/test** directory on the destination instance, leaving the following files:

mysql> **\! ls */path/to/datadir*/test/**

t1#p#p0.ibd t1#p#p1.ibd

**Note**

When [**ALTER TABLE ... DISCARD PARTITION ... TABLESPACE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) is run on subpartitioned tables, both partition and subpartition table names are permitted. When a partition name is specified, subpartitions of that partition are included in the operation.

On the source instance, run [**FLUSH TABLES ... FOR EXPORT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#flush-tables-for-export-with-list) to quiesce the partitioned table. When a table is quiesced, only read-only transactions are permitted on the table.

mysql> **USE test;**

mysql> **FLUSH TABLES t1 FOR EXPORT;**

[**FLUSH TABLES ... FOR EXPORT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#flush-tables-for-export-with-list) ensures that changes to the named table are flushed to disk so that binary table copy can be made while the instance is running. When [**FLUSH TABLES ... FOR EXPORT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#flush-tables-for-export-with-list) is run, **InnoDB** generates a .cfg metadata file for each of the table's tablespace files in the schema directory of the table.

mysql> **\! ls */path/to/datadir*/test/**

t1#p#p0.ibd t1#p#p1.ibd t1#p#p2.ibd t1#p#p3.ibd

t1#p#p0.cfg t1#p#p1.cfg t1#p#p2.cfg t1#p#p3.cfg

The .cfg files contain metadata that used for schema verification during the import operation. [**FLUSH TABLES ... FOR EXPORT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#flush-tables-for-export-with-list) can only be run on the table, not on individual table partitions.

Copy the .ibd and .cfg files for partition **p2** and partition **p3** from the source instance schema directory to the destination instance schema directory.

shell> **scp t1#p#p2.ibd t1#p#p2.cfg t1#p#p3.ibd t1#p#p3.cfg destination-server:*/path/to/datadir*/test**

The .ibd and .cfg files must be copied before releasing the shared locks, as described in the next step.

**Note**

If you are importing partitions from an encrypted tablespace, **InnoDB** generates a .cfp files in addition to a .cfg metadata files. The .cfp files must be copied to the destination instance together with the .cfg files. The .cfp files contain a transfer key and an encrypted tablespace key. On import, **InnoDB** uses the transfer key to decrypt the tablespace key. For related information, see [Section 15.13, “InnoDB Data-at-Rest Encryption”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-data-encryption).

On the source instance, use [**UNLOCK TABLES**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#lock-tables) to release the locks acquired by [**FLUSH TABLES ... FOR EXPORT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#flush-tables-for-export-with-list):

mysql> **USE test;**

mysql> **UNLOCK TABLES;**

On the destination instance, import table partitions **p2** and **p3**:

mysql> **USE test;**

mysql> **ALTER TABLE t1 IMPORT PARTITION p2, p3 TABLESPACE;**

**Note**

When [**ALTER TABLE ... IMPORT PARTITION ... TABLESPACE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) is run on subpartitioned tables, both partition and subpartition table names are permitted. When a partition name is specified, subpartitions of that partition are included in the operation.

##### Limitations

The Transportable Tablespaces feature is only supported for tables that reside in file-per-table tablespaces. It is not supported for the tables that reside in the system tablespace or general tablespaces. Tables in shared tablespaces cannot be quiesced.

[**FLUSH TABLES ... FOR EXPORT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#flush-tables-for-export-with-list) is not supported on tables with a **FULLTEXT** index, as full-text search auxiliary tables cannot be flushed. After importing a table with a **FULLTEXT** index, run [**OPTIMIZE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#optimize-table) to rebuild the **FULLTEXT** indexes. Alternatively, drop **FULLTEXT** indexes before the export operation and recreate the indexes after importing the table on the destination instance.

Due to a **.cfg** metadata file limitation, schema mismatches are not reported for partition type or partition definition differences when importing a partitioned table. Column differences are reported.

Prior to MySQL 8.0.19, index key part sort order information is not stored to the **.cfg** metadata file used during a tablespace import operation. The index key part sort order is therefore assumed to be ascending, which is the default. As a result, records could be sorted in an unintended order if one table involved in the import operation is defined with a DESC index key part sort order and the other table is not. The workaround is to drop and recreate affected indexes. For information about index key part sort order, see [Section 13.1.15, “CREATE INDEX Statement”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-index).

The **.cfg** file format was updated in MySQL 8.0.19 to include index key part sort order information. The issue described above does not affect import operations between MySQL 8.0.19 server instances or higher.

##### Usage Notes

[**ALTER TABLE ... IMPORT TABLESPACE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) does not require a .cfg metadata file to import a table. However, metadata checks are not performed when importing without a .cfg file, and a warning similar to the following is issued:

Message: InnoDB: IO Read error: (2, No such file or directory) Error opening '.\

test\t.cfg', will attempt to import without schema verification

1 row in set (0.00 sec)

Importing a table without a .cfg metadata file should only be considered if no schema mismatches are expected. The ability to import without a .cfg file could be useful in crash recovery scenarios where metadata is not accessible.

On Windows, **InnoDB** stores database, tablespace, and table names internally in lowercase. To avoid import problems on case-sensitive operating systems such as Linux and Unix, create all databases, tablespaces, and tables using lowercase names. A convenient way to ensure that names are created in lowercase is to set [**lower\_case\_table\_names**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_lower_case_table_names) to 1 before initializing the server. (It is prohibited to start the server with a [**lower\_case\_table\_names**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_lower_case_table_names) setting that is different from the setting used when the server was initialized.)

[mysqld]

lower\_case\_table\_names=1

When running [**ALTER TABLE ... DISCARD PARTITION ... TABLESPACE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) and [**ALTER TABLE ... IMPORT PARTITION ... TABLESPACE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) on subpartitioned tables, both partition and subpartition table names are permitted. When a partition name is specified, subpartitions of that partition are included in the operation.

##### Internals

The following information describes internals and messages written to the error log during a table import procedure.

When [**ALTER TABLE ... DISCARD TABLESPACE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) is run on the destination instance:

The table is locked in X mode.

The tablespace is detached from the table.

When [**FLUSH TABLES ... FOR EXPORT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#flush-tables-for-export-with-list) is run on the source instance:

The table being flushed for export is locked in shared mode.

The purge coordinator thread is stopped.

Dirty pages are synchronized to disk.

Table metadata is written to the binary .cfg file.

Expected error log messages for this operation:

[Note] InnoDB: Sync to disk of '"test"."t1"' started.

[Note] InnoDB: Stopping purge

[Note] InnoDB: Writing table metadata to './test/t1.cfg'

[Note] InnoDB: Table '"test"."t1"' flushed to disk

When [**UNLOCK TABLES**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#lock-tables) is run on the source instance:

The binary **.cfg** file is deleted.

The shared lock on the table or tables being imported is released and the purge coordinator thread is restarted.

Expected error log messages for this operation:

[Note] InnoDB: Deleting the meta-data file './test/t1.cfg'

[Note] InnoDB: Resuming purge

When [**ALTER TABLE ... IMPORT TABLESPACE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) is run on the destination instance, the import algorithm performs the following operations for each tablespace being imported:

Each tablespace page is checked for corruption.

The space ID and log sequence numbers (LSNs) on each page are updated.

Flags are validated and LSN updated for the header page.

Btree pages are updated.

The page state is set to dirty so that it is written to disk.

Expected error log messages for this operation:

[Note] InnoDB: Importing tablespace for table 'test/t1' that was exported

from host '***host\_name***'

[Note] InnoDB: Phase I - Update all pages

[Note] InnoDB: Sync to disk

[Note] InnoDB: Sync to disk - done!

[Note] InnoDB: Phase III - Flush changes to disk

[Note] InnoDB: Phase IV - Flush complete

**Note**

You may also receive a warning that a tablespace is discarded (if you discarded the tablespace for the destination table) and a message stating that statistics could not be calculated due to a missing .ibd file:

[Warning] InnoDB: Table "test"."t1" tablespace is set as discarded.

7f34d9a37700 InnoDB: cannot calculate statistics for table

"test"."t1" because the .ibd file is missing. For help, please refer to

http://dev.mysql.com/doc/refman/8.0/en/innodb-troubleshooting.html

#### 15.6.1.4 Moving or Copying InnoDB Tables

This section describes techniques for moving or copying some or all **InnoDB** tables to a different server or instance. For example, you might move an entire MySQL instance to a larger, faster server; you might clone an entire MySQL instance to a new replica server; you might copy individual tables to another instance to develop and test an application, or to a data warehouse server to produce reports.

On Windows, **InnoDB** always stores database and table names internally in lowercase. To move databases in a binary format from Unix to Windows or from Windows to Unix, create all databases and tables using lowercase names. A convenient way to accomplish this is to add the following line to the **[mysqld]** section of your my.cnf or my.ini file before creating any databases or tables:

[mysqld]

lower\_case\_table\_names=1

**Note**

It is prohibited to start the server with a [**lower\_case\_table\_names**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_lower_case_table_names) setting that is different from the setting used when the server was initialized.

Techniques for moving or copying **InnoDB** tables include:

[Importing Tables](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#copy-tables-import)

[MySQL Enterprise Backup](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#copy-tables-meb)

[Copying Data Files (Cold Backup Method)](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#copy-tables-cold-backup)

[Restoring from a Logical Backup](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#copy-tables-logical-backup)

##### Importing Tables

A table that resides in a file-per-table tablespace can be imported from another MySQL server instance or from a backup using the Transportable Tablespace feature. See [Section 15.6.1.3, “Importing InnoDB Tables”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-table-import).

##### MySQL Enterprise Backup

The MySQL Enterprise Backup product lets you back up a running MySQL database with minimal disruption to operations while producing a consistent snapshot of the database. When MySQL Enterprise Backup is copying tables, reads and writes can continue. In addition, MySQL Enterprise Backup can create compressed backup files, and back up subsets of tables. In conjunction with the MySQL binary log, you can perform point-in-time recovery. MySQL Enterprise Backup is included as part of the MySQL Enterprise subscription.

For more details about MySQL Enterprise Backup, see [Section 30.2, “MySQL Enterprise Backup Overview”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\mysql-enterprise.html#mysql-enterprise-backup).

##### Copying Data Files (Cold Backup Method)

You can move an **InnoDB** database simply by copying all the relevant files listed under "Cold Backups" in [Section 15.18.1, “InnoDB Backup”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-backup).

**InnoDB** data and log files are binary-compatible on all platforms having the same floating-point number format. If the floating-point formats differ but you have not used [**FLOAT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-types.html#floating-point-types) or [**DOUBLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-types.html#floating-point-types) data types in your tables, then the procedure is the same: simply copy the relevant files.

When you move or copy file-per-table .ibd files, the database directory name must be the same on the source and destination systems. The table definition stored in the **InnoDB** shared tablespace includes the database name. The transaction IDs and log sequence numbers stored in the tablespace files also differ between databases.

To move an .ibd file and the associated table from one database to another, use a [**RENAME TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#rename-table) statement:

RENAME TABLE ***db1.tbl\_name*** TO ***db2.tbl\_name***;

If you have a “clean” backup of an .ibd file, you can restore it to the MySQL installation from which it originated as follows:

The table must not have been dropped or truncated since you copied the .ibd file, because doing so changes the table ID stored inside the tablespace.

Issue this [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) statement to delete the current .ibd file:

ALTER TABLE ***tbl\_name*** DISCARD TABLESPACE;

Copy the backup .ibd file to the proper database directory.

Issue this [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) statement to tell **InnoDB** to use the new .ibd file for the table:

ALTER TABLE ***tbl\_name*** IMPORT TABLESPACE;

**Note**

The [**ALTER TABLE ... IMPORT TABLESPACE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) feature does not enforce foreign key constraints on imported data.

In this context, a “clean” .ibd file backup is one for which the following requirements are satisfied:

There are no uncommitted modifications by transactions in the .ibd file.

There are no unmerged insert buffer entries in the .ibd file.

Purge has removed all delete-marked index records from the .ibd file.

[**mysqld**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\programs.html#mysqld) has flushed all modified pages of the .ibd file from the buffer pool to the file.

You can make a clean backup .ibd file using the following method:

Stop all activity from the [**mysqld**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\programs.html#mysqld) server and commit all transactions.

Wait until [**SHOW ENGINE INNODB STATUS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#show-engine) shows that there are no active transactions in the database, and the main thread status of **InnoDB** is **Waiting for server activity**. Then you can make a copy of the .ibd file.

Another method for making a clean copy of an .ibd file is to use the MySQL Enterprise Backup product:

Use MySQL Enterprise Backup to back up the **InnoDB** installation.

Start a second [**mysqld**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\programs.html#mysqld) server on the backup and let it clean up the .ibd files in the backup.

##### Restoring from a Logical Backup

You can use a utility such as [**mysqldump**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\programs.html#mysqldump) to perform a logical backup, which produces a set of SQL statements that can be executed to reproduce the original database object definitions and table data for transfer to another SQL server. Using this method, it does not matter whether the formats differ or if your tables contain floating-point data.

To improve the performance of this method, disable [**autocommit**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_autocommit) when importing data. Perform a commit only after importing an entire table or segment of a table.

#### 15.6.1.5 Converting Tables from MyISAM to InnoDB

If you have [**MyISAM**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\storage-engines.html#myisam-storage-engine) tables that you want to convert to [**InnoDB**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html) for better reliability and scalability, review the following guidelines and tips before converting.

**Note**

Partitioned **MyISAM** tables created in previous versions of MySQL are not compatible with MySQL 8.0. Such tables must be prepared prior to upgrade, either by removing the partitioning, or by converting them to **InnoDB**. See [Section 24.6.2, “Partitioning Limitations Relating to Storage Engines”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\partitioning.html#partitioning-limitations-storage-engines), for more information.

[Adjusting Memory Usage for MyISAM and InnoDB](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-convert-memory-usage)

[Handling Too-Long Or Too-Short Transactions](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-convert-transactions)

[Handling Deadlocks](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-convert-deadlock)

[Storage Layout](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-convert-plan-storage)

[Converting an Existing Table](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-convert-convert)

[Cloning the Structure of a Table](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-convert-clone)

[Transferring Data](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-convert-transfer)

[Storage Requirements](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-convert-storage-requirements)

[Defining Primary Keys](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-convert-primary-key)

[Application Performance Considerations](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-convert-application-performance)

[Understanding Files Associated with InnoDB Tables](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-convert-understand-files)

##### Adjusting Memory Usage for MyISAM and InnoDB

As you transition away from **MyISAM** tables, lower the value of the [**key\_buffer\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_key_buffer_size) configuration option to free memory no longer needed for caching results. Increase the value of the [**innodb\_buffer\_pool\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_size) configuration option, which performs a similar role of allocating cache memory for **InnoDB** tables. The **InnoDB** [buffer pool](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_buffer_pool) caches both table data and index data, speeding up lookups for queries and keeping query results in memory for reuse. For guidance regarding buffer pool size configuration, see [Section 8.12.3.1, “How MySQL Uses Memory”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#memory-use).

##### Handling Too-Long Or Too-Short Transactions

Because **MyISAM** tables do not support [transactions](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_transaction), you might not have paid much attention to the [**autocommit**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_autocommit) configuration option and the [**COMMIT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#commit) and [**ROLLBACK**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#commit) statements. These keywords are important to allow multiple sessions to read and write **InnoDB** tables concurrently, providing substantial scalability benefits in write-heavy workloads.

While a transaction is open, the system keeps a snapshot of the data as seen at the beginning of the transaction, which can cause substantial overhead if the system inserts, updates, and deletes millions of rows while a stray transaction keeps running. Thus, take care to avoid transactions that run for too long:

If you are using a [**mysql**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\programs.html#mysql) session for interactive experiments, always [**COMMIT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#commit) (to finalize the changes) or [**ROLLBACK**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#commit) (to undo the changes) when finished. Close down interactive sessions rather than leave them open for long periods, to avoid keeping transactions open for long periods by accident.

Make sure that any error handlers in your application also [**ROLLBACK**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#commit) incomplete changes or [**COMMIT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#commit) completed changes.

[**ROLLBACK**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#commit) is a relatively expensive operation, because [**INSERT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#insert), [**UPDATE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#update), and [**DELETE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#delete) operations are written to **InnoDB** tables prior to the [**COMMIT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#commit), with the expectation that most changes are committed successfully and rollbacks are rare. When experimenting with large volumes of data, avoid making changes to large numbers of rows and then rolling back those changes.

When loading large volumes of data with a sequence of [**INSERT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#insert) statements, periodically [**COMMIT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#commit) the results to avoid having transactions that last for hours. In typical load operations for data warehousing, if something goes wrong, you truncate the table (using [**TRUNCATE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#truncate-table)) and start over from the beginning rather than doing a [**ROLLBACK**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#commit).

The preceding tips save memory and disk space that can be wasted during too-long transactions. When transactions are shorter than they should be, the problem is excessive I/O. With each [**COMMIT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#commit), MySQL makes sure each change is safely recorded to disk, which involves some I/O.

For most operations on **InnoDB** tables, you should use the setting [**autocommit=0**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_autocommit). From an efficiency perspective, this avoids unnecessary I/O when you issue large numbers of consecutive [**INSERT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#insert), [**UPDATE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#update), or [**DELETE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#delete) statements. From a safety perspective, this allows you to issue a [**ROLLBACK**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#commit) statement to recover lost or garbled data if you make a mistake on the [**mysql**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\programs.html#mysql) command line, or in an exception handler in your application.

[**autocommit=1**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_autocommit) is suitable for **InnoDB** tables when running a sequence of queries for generating reports or analyzing statistics. In this situation, there is no I/O penalty related to [**COMMIT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#commit) or [**ROLLBACK**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#commit), and **InnoDB** can [automatically optimize the read-only workload](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#innodb-performance-ro-txn).

If you make a series of related changes, finalize all the changes at once with a single [**COMMIT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#commit) at the end. For example, if you insert related pieces of information into several tables, do a single [**COMMIT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#commit) after making all the changes. Or if you run many consecutive [**INSERT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#insert) statements, do a single [**COMMIT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#commit) after all the data is loaded; if you are doing millions of [**INSERT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#insert) statements, perhaps split up the huge transaction by issuing a [**COMMIT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#commit) every ten thousand or hundred thousand records, so the transaction does not grow too large.

Remember that even a [**SELECT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#select) statement opens a transaction, so after running some report or debugging queries in an interactive [**mysql**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\programs.html#mysql) session, either issue a [**COMMIT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#commit) or close the [**mysql**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\programs.html#mysql) session.

For related information, see [Section 15.7.2.2, “autocommit, Commit, and Rollback”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-autocommit-commit-rollback).

##### Handling Deadlocks

You might see warning messages referring to “deadlocks” in the MySQL error log, or the output of [**SHOW ENGINE INNODB STATUS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#show-engine). A [deadlock](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_deadlock) is not a serious issue for **InnoDB** tables, and often does not require any corrective action. When two transactions start modifying multiple tables, accessing the tables in a different order, they can reach a state where each transaction is waiting for the other and neither can proceed. When [deadlock detection](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_deadlock_detection) is enabled (the default), MySQL immediately detects this condition and cancels ([rolls back](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_rollback)) the “smaller” transaction, allowing the other to proceed. If deadlock detection is disabled using the [**innodb\_deadlock\_detect**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_deadlock_detect) configuration option, **InnoDB** relies on the [**innodb\_lock\_wait\_timeout**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_lock_wait_timeout) setting to roll back transactions in case of a deadlock.

Either way, your applications need error-handling logic to restart a transaction that is forcibly cancelled due to a deadlock. When you re-issue the same SQL statements as before, the original timing issue no longer applies. Either the other transaction has already finished and yours can proceed, or the other transaction is still in progress and your transaction waits until it finishes.

If deadlock warnings occur constantly, you might review the application code to reorder the SQL operations in a consistent way, or to shorten the transactions. You can test with the [**innodb\_print\_all\_deadlocks**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_print_all_deadlocks) option enabled to see all deadlock warnings in the MySQL error log, rather than only the last warning in the [**SHOW ENGINE INNODB STATUS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#show-engine) output.

For more information, see [Section 15.7.5, “Deadlocks in InnoDB”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-deadlocks).

##### Storage Layout

To get the best performance from **InnoDB** tables, you can adjust a number of parameters related to storage layout.

When you convert **MyISAM** tables that are large, frequently accessed, and hold vital data, investigate and consider the [**innodb\_file\_per\_table**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_file_per_table) and [**innodb\_page\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_page_size) variables, and the [**ROW\_FORMAT** and **KEY\_BLOCK\_SIZE** clauses](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-row-format) of the [**CREATE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-table) statement.

During your initial experiments, the most important setting is [**innodb\_file\_per\_table**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_file_per_table). When this setting is enabled, which is the default, new **InnoDB** tables are implicitly created in [file-per-table](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_file_per_table) tablespaces. In contrast with the **InnoDB** system tablespace, file-per-table tablespaces allow disk space to be reclaimed by the operating system when a table is truncated or dropped. File-per-table tablespaces also support [DYNAMIC](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_dynamic_row_format) and [COMPRESSED](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_compressed_row_format) row formats and associated features such as table compression, efficient off-page storage for long variable-length columns, and large index prefixes. For more information, see [Section 15.6.3.2, “File-Per-Table Tablespaces”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-file-per-table-tablespaces).

You can also store **InnoDB** tables in a shared general tablespace, which support multiple tables and all row formats. For more information, see [Section 15.6.3.3, “General Tablespaces”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#general-tablespaces).

##### Converting an Existing Table

To convert a non-**InnoDB** table to use **InnoDB** use [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table):

ALTER TABLE ***table\_name*** ENGINE=InnoDB;

##### Cloning the Structure of a Table

You might make an **InnoDB** table that is a clone of a MyISAM table, rather than using [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) to perform conversion, to test the old and new table side-by-side before switching.

Create an empty **InnoDB** table with identical column and index definitions. Use **SHOW CREATE TABLE *table\_name*\G** to see the full [**CREATE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-table) statement to use. Change the **ENGINE** clause to **ENGINE=INNODB**.

##### Transferring Data

To transfer a large volume of data into an empty **InnoDB** table created as shown in the previous section, insert the rows with **INSERT INTO *innodb\_table* SELECT \* FROM *myisam\_table* ORDER BY *primary\_key\_columns***.

You can also create the indexes for the **InnoDB** table after inserting the data. Historically, creating new secondary indexes was a slow operation for **InnoDB**, but now you can create the indexes after the data is loaded with relatively little overhead from the index creation step.

If you have **UNIQUE** constraints on secondary keys, you can speed up a table import by turning off the uniqueness checks temporarily during the import operation:

SET unique\_checks=0;

***... import operation ...***

SET unique\_checks=1;

For big tables, this saves disk I/O because **InnoDB** can use its [change buffer](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_change_buffer) to write secondary index records as a batch. Be certain that the data contains no duplicate keys. [**unique\_checks**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_unique_checks) permits but does not require storage engines to ignore duplicate keys.

For better control over the insertion process, you can insert big tables in pieces:

INSERT INTO newtable SELECT \* FROM oldtable

WHERE yourkey > ***something*** AND yourkey <= ***somethingelse***;

After all records are inserted, you can rename the tables.

During the conversion of big tables, increase the size of the **InnoDB** buffer pool to reduce disk I/O. Typically, the recommended buffer pool size is 50 to 75 percent of system memory. You can also increase the size of **InnoDB** log files.

##### Storage Requirements

If you intend to make several temporary copies of your data in **InnoDB** tables during the conversion process, it is recommended that you create the tables in file-per-table tablespaces so that you can reclaim the disk space when you drop the tables. When the [**innodb\_file\_per\_table**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_file_per_table) configuration option is enabled (the default), newly created **InnoDB** tables are implicitly created in file-per-table tablespaces.

Whether you convert the **MyISAM** table directly or create a cloned **InnoDB** table, make sure that you have sufficient disk space to hold both the old and new tables during the process. ***InnoDB tables require more disk space than MyISAM tables.*** If an [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) operation runs out of space, it starts a rollback, and that can take hours if it is disk-bound. For inserts, **InnoDB** uses the insert buffer to merge secondary index records to indexes in batches. That saves a lot of disk I/O. For rollback, no such mechanism is used, and the rollback can take 30 times longer than the insertion.

In the case of a runaway rollback, if you do not have valuable data in your database, it may be advisable to kill the database process rather than wait for millions of disk I/O operations to complete. For the complete procedure, see [Section 15.21.2, “Forcing InnoDB Recovery”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#forcing-innodb-recovery).

##### Defining Primary Keys

The **PRIMARY KEY** clause is a critical factor affecting the performance of MySQL queries and the space usage for tables and indexes. The primary key uniquely identifies a row in a table. Every row in the table should have a primary key value, and no two rows can have the same primary key value.

These are guidelines for the primary key, followed by more detailed explanations.

Declare a **PRIMARY KEY** for each table. Typically, it is the most important column that you refer to in **WHERE** clauses when looking up a single row.

Declare the **PRIMARY KEY** clause in the original [**CREATE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-table) statement, rather than adding it later through an [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) statement.

Choose the column and its data type carefully. Prefer numeric columns over character or string ones.

Consider using an auto-increment column if there is not another stable, unique, non-null, numeric column to use.

An auto-increment column is also a good choice if there is any doubt whether the value of the primary key column could ever change. Changing the value of a primary key column is an expensive operation, possibly involving rearranging data within the table and within each secondary index.

Consider adding a [primary key](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_primary_key) to any table that does not already have one. Use the smallest practical numeric type based on the maximum projected size of the table. This can make each row slightly more compact, which can yield substantial space savings for large tables. The space savings are multiplied if the table has any [secondary indexes](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_secondary_index), because the primary key value is repeated in each secondary index entry. In addition to reducing data size on disk, a small primary key also lets more data fit into the [buffer pool](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_buffer_pool), speeding up all kinds of operations and improving concurrency.

If the table already has a primary key on some longer column, such as a **VARCHAR**, consider adding a new unsigned **AUTO\_INCREMENT** column and switching the primary key to that, even if that column is not referenced in queries. This design change can produce substantial space savings in the secondary indexes. You can designate the former primary key columns as **UNIQUE NOT NULL** to enforce the same constraints as the **PRIMARY KEY** clause, that is, to prevent duplicate or null values across all those columns.

If you spread related information across multiple tables, typically each table uses the same column for its primary key. For example, a personnel database might have several tables, each with a primary key of employee number. A sales database might have some tables with a primary key of customer number, and other tables with a primary key of order number. Because lookups using the primary key are very fast, you can construct efficient join queries for such tables.

If you leave the **PRIMARY KEY** clause out entirely, MySQL creates an invisible one for you. It is a 6-byte value that might be longer than you need, thus wasting space. Because it is hidden, you cannot refer to it in queries.

##### Application Performance Considerations

The reliability and scalability features of **InnoDB** require more disk storage than equivalent **MyISAM** tables. You might change the column and index definitions slightly, for better space utilization, reduced I/O and memory consumption when processing result sets, and better query optimization plans making efficient use of index lookups.

If you set up a numeric ID column for the primary key, use that value to cross-reference with related values in any other tables, particularly for [join](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_join) queries. For example, rather than accepting a country name as input and doing queries searching for the same name, do one lookup to determine the country ID, then do other queries (or a single join query) to look up relevant information across several tables. Rather than storing a customer or catalog item number as a string of digits, potentially using up several bytes, convert it to a numeric ID for storing and querying. A 4-byte unsigned [**INT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-types.html#integer-types) column can index over 4 billion items (with the US meaning of billion: 1000 million). For the ranges of the different integer types, see [Section 11.1.2, “Integer Types (Exact Value) - INTEGER, INT, SMALLINT, TINYINT, MEDIUMINT, BIGINT”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-types.html#integer-types).

##### Understanding Files Associated with InnoDB Tables

**InnoDB** files require more care and planning than **MyISAM** files do.

You must not delete the [ibdata files](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_ibdata_file) that represent the **InnoDB** [system tablespace](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_system_tablespace).

Methods of moving or copying **InnoDB** tables to a different server are described in [Section 15.6.1.4, “Moving or Copying InnoDB Tables”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-migration).

#### 15.6.1.6 AUTO\_INCREMENT Handling in InnoDB

**InnoDB** provides a configurable locking mechanism that can significantly improve scalability and performance of SQL statements that add rows to tables with **AUTO\_INCREMENT** columns. To use the **AUTO\_INCREMENT** mechanism with an **InnoDB** table, an **AUTO\_INCREMENT** column must be defined as part of an index such that it is possible to perform the equivalent of an indexed **SELECT MAX(*ai\_col*)** lookup on the table to obtain the maximum column value. Typically, this is achieved by making the **AUTO\_INCREMENT** column the first column of some table index.

This section describes the **AUTO\_INCREMENT** lock modes, usage implications of different **AUTO\_INCREMENT** lock mode settings, and how **InnoDB** initializes the **AUTO\_INCREMENT** counter.

[InnoDB AUTO\_INCREMENT Lock Modes](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-auto-increment-lock-modes)

[InnoDB AUTO\_INCREMENT Lock Mode Usage Implications](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-auto-increment-lock-mode-usage-implications)

[InnoDB AUTO\_INCREMENT Counter Initialization](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-auto-increment-initialization)

[Notes](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-auto-increment-notes)

##### InnoDB AUTO\_INCREMENT Lock Modes

This section describes the **AUTO\_INCREMENT** lock modes used to generate auto-increment values, and how each lock mode affects replication. The auto-increment lock mode is configured at startup using the [**innodb\_autoinc\_lock\_mode**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_autoinc_lock_mode) variable.

The following terms are used in describing [**innodb\_autoinc\_lock\_mode**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_autoinc_lock_mode) settings:

“[**INSERT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#insert)-like” statements

All statements that generate new rows in a table, including [**INSERT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#insert), [**INSERT ... SELECT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#insert-select), [**REPLACE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#replace), [**REPLACE ... SELECT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#replace), and [**LOAD DATA**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#load-data). Includes “simple-inserts”, “bulk-inserts”, and “mixed-mode” inserts.

“Simple inserts”

Statements for which the number of rows to be inserted can be determined in advance (when the statement is initially processed). This includes single-row and multiple-row [**INSERT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#insert) and [**REPLACE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#replace) statements that do not have a nested subquery, but not [**INSERT ... ON DUPLICATE KEY UPDATE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#insert-on-duplicate).

“Bulk inserts”

Statements for which the number of rows to be inserted (and the number of required auto-increment values) is not known in advance. This includes [**INSERT ... SELECT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#insert-select), [**REPLACE ... SELECT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#replace), and [**LOAD DATA**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#load-data) statements, but not plain **INSERT**. **InnoDB** assigns new values for the **AUTO\_INCREMENT** column one at a time as each row is processed.

“Mixed-mode inserts”

These are “simple insert” statements that specify the auto-increment value for some (but not all) of the new rows. An example follows, where **c1** is an **AUTO\_INCREMENT** column of table **t1**:

INSERT INTO t1 (c1,c2) VALUES (1,'a'), (NULL,'b'), (5,'c'), (NULL,'d');

Another type of “mixed-mode insert” is [**INSERT ... ON DUPLICATE KEY UPDATE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#insert-on-duplicate), which in the worst case is in effect an [**INSERT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#insert) followed by a [**UPDATE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#update), where the allocated value for the **AUTO\_INCREMENT** column may or may not be used during the update phase.

There are three possible settings for the [**innodb\_autoinc\_lock\_mode**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_autoinc_lock_mode) variable. The settings are 0, 1, or 2, for “traditional”, “consecutive”, or “interleaved” lock mode, respectively. As of MySQL 8.0, interleaved lock mode ([**innodb\_autoinc\_lock\_mode=2**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_autoinc_lock_mode)) is the default setting. Prior to MySQL 8.0, consecutive lock mode is the default ([**innodb\_autoinc\_lock\_mode=1**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_autoinc_lock_mode)).

The default setting of interleaved lock mode in MySQL 8.0 reflects the change from statement-based replication to row based replication as the default replication type. Statement-based replication requires the consecutive auto-increment lock mode to ensure that auto-increment values are assigned in a predictable and repeatable order for a given sequence of SQL statements, whereas row-based replication is not sensitive to the execution order of SQL statements.

**innodb\_autoinc\_lock\_mode = 0** (“traditional” lock mode)

The traditional lock mode provides the same behavior that existed before the [**innodb\_autoinc\_lock\_mode**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_autoinc_lock_mode) variable was introduced. The traditional lock mode option is provided for backward compatibility, performance testing, and working around issues with “mixed-mode inserts”, due to possible differences in semantics.

In this lock mode, all “INSERT-like” statements obtain a special table-level **AUTO-INC** lock for inserts into tables with **AUTO\_INCREMENT** columns. This lock is normally held to the end of the statement (not to the end of the transaction) to ensure that auto-increment values are assigned in a predictable and repeatable order for a given sequence of [**INSERT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#insert) statements, and to ensure that auto-increment values assigned by any given statement are consecutive.

In the case of statement-based replication, this means that when an SQL statement is replicated on a replica server, the same values are used for the auto-increment column as on the source server. The result of execution of multiple [**INSERT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#insert) statements is deterministic, and the replica reproduces the same data as on the source. If auto-increment values generated by multiple [**INSERT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#insert) statements were interleaved, the result of two concurrent [**INSERT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#insert) statements would be nondeterministic, and could not reliably be propagated to a replica server using statement-based replication.

To make this clear, consider an example that uses this table:

CREATE TABLE t1 (

c1 INT(11) NOT NULL AUTO\_INCREMENT,

c2 VARCHAR(10) DEFAULT NULL,

PRIMARY KEY (c1)

) ENGINE=InnoDB;

Suppose that there are two transactions running, each inserting rows into a table with an **AUTO\_INCREMENT** column. One transaction is using an [**INSERT ... SELECT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#insert-select) statement that inserts 1000 rows, and another is using a simple [**INSERT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#insert) statement that inserts one row:

Tx1: INSERT INTO t1 (c2) SELECT 1000 rows from another table ...

Tx2: INSERT INTO t1 (c2) VALUES ('xxx');

**InnoDB** cannot tell in advance how many rows are retrieved from the [**SELECT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#select) in the [**INSERT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#insert) statement in Tx1, and it assigns the auto-increment values one at a time as the statement proceeds. With a table-level lock, held to the end of the statement, only one [**INSERT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#insert) statement referring to table **t1** can execute at a time, and the generation of auto-increment numbers by different statements is not interleaved. The auto-increment values generated by the Tx1 [**INSERT ... SELECT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#insert-select) statement are consecutive, and the (single) auto-increment value used by the [**INSERT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#insert) statement in Tx2 is either smaller or larger than all those used for Tx1, depending on which statement executes first.

As long as the SQL statements execute in the same order when replayed from the binary log (when using statement-based replication, or in recovery scenarios), the results are the same as they were when Tx1 and Tx2 first ran. Thus, table-level locks held until the end of a statement make [**INSERT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#insert) statements using auto-increment safe for use with statement-based replication. However, those table-level locks limit concurrency and scalability when multiple transactions are executing insert statements at the same time.

In the preceding example, if there were no table-level lock, the value of the auto-increment column used for the [**INSERT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#insert) in Tx2 depends on precisely when the statement executes. If the [**INSERT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#insert) of Tx2 executes while the [**INSERT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#insert) of Tx1 is running (rather than before it starts or after it completes), the specific auto-increment values assigned by the two [**INSERT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#insert) statements are nondeterministic, and may vary from run to run.

Under the [consecutive](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-auto-increment-lock-mode-consecutive) lock mode, **InnoDB** can avoid using table-level **AUTO-INC** locks for “simple insert” statements where the number of rows is known in advance, and still preserve deterministic execution and safety for statement-based replication.

If you are not using the binary log to replay SQL statements as part of recovery or replication, the [interleaved](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-auto-increment-lock-mode-interleaved) lock mode can be used to eliminate all use of table-level **AUTO-INC** locks for even greater concurrency and performance, at the cost of permitting gaps in auto-increment numbers assigned by a statement and potentially having the numbers assigned by concurrently executing statements interleaved.

**innodb\_autoinc\_lock\_mode = 1** (“consecutive” lock mode)

In this mode, “bulk inserts” use the special **AUTO-INC** table-level lock and hold it until the end of the statement. This applies to all [**INSERT ... SELECT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#insert-select), [**REPLACE ... SELECT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#replace), and [**LOAD DATA**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#load-data) statements. Only one statement holding the **AUTO-INC** lock can execute at a time. If the source table of the bulk insert operation is different from the target table, the **AUTO-INC** lock on the target table is taken after a shared lock is taken on the first row selected from the source table. If the source and target of the bulk insert operation are the same table, the **AUTO-INC** lock is taken after shared locks are taken on all selected rows.

“Simple inserts” (for which the number of rows to be inserted is known in advance) avoid table-level **AUTO-INC** locks by obtaining the required number of auto-increment values under the control of a mutex (a light-weight lock) that is only held for the duration of the allocation process, not until the statement completes. No table-level **AUTO-INC** lock is used unless an **AUTO-INC** lock is held by another transaction. If another transaction holds an **AUTO-INC** lock, a “simple insert” waits for the **AUTO-INC** lock, as if it were a “bulk insert”.

This lock mode ensures that, in the presence of [**INSERT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#insert) statements where the number of rows is not known in advance (and where auto-increment numbers are assigned as the statement progresses), all auto-increment values assigned by any “[**INSERT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#insert)-like” statement are consecutive, and operations are safe for statement-based replication.

Simply put, this lock mode significantly improves scalability while being safe for use with statement-based replication. Further, as with “traditional” lock mode, auto-increment numbers assigned by any given statement are consecutive. There is no change in semantics compared to “traditional” mode for any statement that uses auto-increment, with one important exception.

The exception is for “mixed-mode inserts”, where the user provides explicit values for an **AUTO\_INCREMENT** column for some, but not all, rows in a multiple-row “simple insert”. For such inserts, **InnoDB** allocates more auto-increment values than the number of rows to be inserted. However, all values automatically assigned are consecutively generated (and thus higher than) the auto-increment value generated by the most recently executed previous statement. “Excess” numbers are lost.

**innodb\_autoinc\_lock\_mode = 2** (“interleaved” lock mode)

In this lock mode, no “[**INSERT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#insert)-like” statements use the table-level **AUTO-INC** lock, and multiple statements can execute at the same time. This is the fastest and most scalable lock mode, but it is not safe when using statement-based replication or recovery scenarios when SQL statements are replayed from the binary log.

In this lock mode, auto-increment values are guaranteed to be unique and monotonically increasing across all concurrently executing “[**INSERT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#insert)-like” statements. However, because multiple statements can be generating numbers at the same time (that is, allocation of numbers is interleaved across statements), the values generated for the rows inserted by any given statement may not be consecutive.

If the only statements executing are “simple inserts” where the number of rows to be inserted is known ahead of time, there are no gaps in the numbers generated for a single statement, except for “mixed-mode inserts”. However, when “bulk inserts” are executed, there may be gaps in the auto-increment values assigned by any given statement.

##### InnoDB AUTO\_INCREMENT Lock Mode Usage Implications

Using auto-increment with replication

If you are using statement-based replication, set [**innodb\_autoinc\_lock\_mode**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_autoinc_lock_mode) to 0 or 1 and use the same value on the source and its replicas. Auto-increment values are not ensured to be the same on the replicas as on the source if you use [**innodb\_autoinc\_lock\_mode**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_autoinc_lock_mode) = 2 (“interleaved”) or configurations where the source and replicas do not use the same lock mode.

If you are using row-based or mixed-format replication, all of the auto-increment lock modes are safe, since row-based replication is not sensitive to the order of execution of the SQL statements (and the mixed format uses row-based replication for any statements that are unsafe for statement-based replication).

“Lost” auto-increment values and sequence gaps

In all lock modes (0, 1, and 2), if a transaction that generated auto-increment values rolls back, those auto-increment values are “lost”. Once a value is generated for an auto-increment column, it cannot be rolled back, whether or not the “[**INSERT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#insert)-like” statement is completed, and whether or not the containing transaction is rolled back. Such lost values are not reused. Thus, there may be gaps in the values stored in an **AUTO\_INCREMENT** column of a table.

Specifying NULL or 0 for the **AUTO\_INCREMENT** column

In all lock modes (0, 1, and 2), if a user specifies NULL or 0 for the **AUTO\_INCREMENT** column in an [**INSERT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#insert), **InnoDB** treats the row as if the value was not specified and generates a new value for it.

Assigning a negative value to the **AUTO\_INCREMENT** column

In all lock modes (0, 1, and 2), the behavior of the auto-increment mechanism is undefined if you assign a negative value to the **AUTO\_INCREMENT** column.

If the **AUTO\_INCREMENT** value becomes larger than the maximum integer for the specified integer type

In all lock modes (0, 1, and 2), the behavior of the auto-increment mechanism is undefined if the value becomes larger than the maximum integer that can be stored in the specified integer type.

Gaps in auto-increment values for “bulk inserts”

With [**innodb\_autoinc\_lock\_mode**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_autoinc_lock_mode) set to 0 (“traditional”) or 1 (“consecutive”), the auto-increment values generated by any given statement are consecutive, without gaps, because the table-level **AUTO-INC** lock is held until the end of the statement, and only one such statement can execute at a time.

With [**innodb\_autoinc\_lock\_mode**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_autoinc_lock_mode) set to 2 (“interleaved”), there may be gaps in the auto-increment values generated by “bulk inserts,” but only if there are concurrently executing “[**INSERT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#insert)-like” statements.

For lock modes 1 or 2, gaps may occur between successive statements because for bulk inserts the exact number of auto-increment values required by each statement may not be known and overestimation is possible.

Auto-increment values assigned by “mixed-mode inserts”

Consider a “mixed-mode insert,” where a “simple insert” specifies the auto-increment value for some (but not all) resulting rows. Such a statement behaves differently in lock modes 0, 1, and 2. For example, assume **c1** is an **AUTO\_INCREMENT** column of table **t1**, and that the most recent automatically generated sequence number is 100.

mysql> **CREATE TABLE t1 (**

-> **c1 INT UNSIGNED NOT NULL AUTO\_INCREMENT PRIMARY KEY,**

-> **c2 CHAR(1)**

-> **) ENGINE = INNODB;**

Now, consider the following “mixed-mode insert” statement:

mysql> **INSERT INTO t1 (c1,c2) VALUES (1,'a'), (NULL,'b'), (5,'c'), (NULL,'d');**

With [**innodb\_autoinc\_lock\_mode**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_autoinc_lock_mode) set to 0 (“traditional”), the four new rows are:

mysql> **SELECT c1, c2 FROM t1 ORDER BY c2;**

+-----+------+

| c1 | c2 |

+-----+------+

| 1 | a |

| 101 | b |

| 5 | c |

| 102 | d |

+-----+------+

The next available auto-increment value is 103 because the auto-increment values are allocated one at a time, not all at once at the beginning of statement execution. This result is true whether or not there are concurrently executing “[**INSERT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#insert)-like” statements (of any type).

With [**innodb\_autoinc\_lock\_mode**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_autoinc_lock_mode) set to 1 (“consecutive”), the four new rows are also:

mysql> **SELECT c1, c2 FROM t1 ORDER BY c2;**

+-----+------+

| c1 | c2 |

+-----+------+

| 1 | a |

| 101 | b |

| 5 | c |

| 102 | d |

+-----+------+

However, in this case, the next available auto-increment value is 105, not 103 because four auto-increment values are allocated at the time the statement is processed, but only two are used. This result is true whether or not there are concurrently executing “[**INSERT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#insert)-like” statements (of any type).

With [**innodb\_autoinc\_lock\_mode**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_autoinc_lock_mode) set to 2 (“interleaved”), the four new rows are:

mysql> **SELECT c1, c2 FROM t1 ORDER BY c2;**

+-----+------+

| c1 | c2 |

+-----+------+

| 1 | a |

| ***x*** | b |

| 5 | c |

| ***y*** | d |

+-----+------+

The values of ***x*** and ***y*** are unique and larger than any previously generated rows. However, the specific values of ***x*** and ***y*** depend on the number of auto-increment values generated by concurrently executing statements.

Finally, consider the following statement, issued when the most-recently generated sequence number is 100:

mysql> **INSERT INTO t1 (c1,c2) VALUES (1,'a'), (NULL,'b'), (101,'c'), (NULL,'d');**

With any [**innodb\_autoinc\_lock\_mode**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_autoinc_lock_mode) setting, this statement generates a duplicate-key error 23000 (**Can't write; duplicate key in table**) because 101 is allocated for the row **(NULL, 'b')** and insertion of the row **(101, 'c')** fails.

Modifying **AUTO\_INCREMENT** column values in the middle of a sequence of [**INSERT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#insert) statements

In MySQL 5.7 and earlier, modifying an **AUTO\_INCREMENT** column value in the middle of a sequence of [**INSERT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#insert) statements could lead to “Duplicate entry” errors. For example, if you performed an [**UPDATE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#update) operation that changed an **AUTO\_INCREMENT** column value to a value larger than the current maximum auto-increment value, subsequent [**INSERT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#insert) operations that did not specify an unused auto-increment value could encounter “Duplicate entry” errors. In MySQL 8.0 and later, if you modify an **AUTO\_INCREMENT** column value to a value larger than the current maximum auto-increment value, the new value is persisted, and subsequent [**INSERT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#insert) operations allocate auto-increment values starting from the new, larger value. This behavior is demonstrated in the following example.

mysql> **CREATE TABLE t1 (**

-> **c1 INT NOT NULL AUTO\_INCREMENT,**

-> **PRIMARY KEY (c1)**

-> **) ENGINE = InnoDB;**

mysql> **INSERT INTO t1 VALUES(0), (0), (3);**

mysql> **SELECT c1 FROM t1;**

+----+

| c1 |

+----+

| 1 |

| 2 |

| 3 |

+----+

mysql> **UPDATE t1 SET c1 = 4 WHERE c1 = 1;**

mysql> **SELECT c1 FROM t1;**

+----+

| c1 |

+----+

| 2 |

| 3 |

| 4 |

+----+

mysql> **INSERT INTO t1 VALUES(0);**

mysql> **SELECT c1 FROM t1;**

+----+

| c1 |

+----+

| 2 |

| 3 |

| 4 |

| 5 |

+----+

##### InnoDB AUTO\_INCREMENT Counter Initialization

This section describes how **InnoDB** initializes **AUTO\_INCREMENT** counters.

If you specify an **AUTO\_INCREMENT** column for an **InnoDB** table, the in-memory table object contains a special counter called the auto-increment counter that is used when assigning new values for the column.

In MySQL 5.7 and earlier, the auto-increment counter is stored in main memory, not on disk. To initialize an auto-increment counter after a server restart, **InnoDB** would execute the equivalent of the following statement on the first insert into a table containing an **AUTO\_INCREMENT** column.

SELECT MAX(ai\_col) FROM ***table\_name*** FOR UPDATE;

In MySQL 8.0, this behavior is changed. The current maximum auto-increment counter value is written to the redo log each time it changes and saved to the data dictionary on each checkpoint. These changes make the current maximum auto-increment counter value persistent across server restarts.

On a server restart following a normal shutdown, **InnoDB** initializes the in-memory auto-increment counter using the current maximum auto-increment value stored in the data dictionary.

On a server restart during crash recovery, **InnoDB** initializes the in-memory auto-increment counter using the current maximum auto-increment value stored in the data dictionary and scans the redo log for auto-increment counter values written since the last checkpoint. If a redo-logged value is greater than the in-memory counter value, the redo-logged value is applied. However, in the case of an unexpected server exit, reuse of a previously allocated auto-increment value cannot be guaranteed. Each time the current maximum auto-increment value is changed due to an [**INSERT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#insert) or [**UPDATE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#update) operation, the new value is written to the redo log, but if the unexpected exit occurs before the redo log is flushed to disk, the previously allocated value could be reused when the auto-increment counter is initialized after the server is restarted.

The only circumstance in which **InnoDB** uses the equivalent of a **SELECT MAX(ai\_col) FROM *table\_name* FOR UPDATE** statement to initialize an auto-increment counter is when [importing a table](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-table-import) without a .cfg metadata file. Otherwise, the current maximum auto-increment counter value is read from the .cfg metadata file if present. Aside from counter value initialization, the equivalent of a **SELECT MAX(ai\_col) FROM *table\_name*** statement is used to determine the current maximum auto-increment counter value of the table when attempting to set the counter value to one that is smaller than or equal to the persisted counter value using an **ALTER TABLE ... AUTO\_INCREMENT = *N* FOR UPDATE** statement. For example, you might try to set the counter value to a lesser value after deleting some records. In this case, the table must be searched to ensure that the new counter value is not less than or equal to the actual current maximum counter value.

In MySQL 5.7 and earlier, a server restart cancels the effect of the **AUTO\_INCREMENT = N** table option, which may be used in a **CREATE TABLE** or **ALTER TABLE** statement to set an initial counter value or alter the existing counter value, respectively. In MySQL 8.0, a server restart does not cancel the effect of the **AUTO\_INCREMENT = N** table option. If you initialize the auto-increment counter to a specific value, or if you alter the auto-increment counter value to a larger value, the new value is persisted across server restarts.

**Note**

[**ALTER TABLE ... AUTO\_INCREMENT = N**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) can only change the auto-increment counter value to a value larger than the current maximum.

In MySQL 5.7 and earlier, a server restart immediately following a [**ROLLBACK**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#commit) operation could result in the reuse of auto-increment values that were previously allocated to the rolled-back transaction, effectively rolling back the current maximum auto-increment value. In MySQL 8.0, the current maximum auto-increment value is persisted, preventing the reuse of previously allocated values.

If a [**SHOW TABLE STATUS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#show-table-status) statement examines a table before the auto-increment counter is initialized, **InnoDB** opens the table and initializes the counter value using the current maximum auto-increment value that is stored in the data dictionary. The value is then stored in memory for use by later inserts or updates. Initialization of the counter value uses a normal exclusive-locking read on the table which lasts to the end of the transaction. **InnoDB** follows the same procedure when initializing the auto-increment counter for a newly created table that has a user-specified auto-increment value greater than 0.

After the auto-increment counter is initialized, if you do not explicitly specify an auto-increment value when inserting a row, **InnoDB** implicitly increments the counter and assigns the new value to the column. If you insert a row that explicitly specifies an auto-increment column value, and the value is greater than the current maximum counter value, the counter is set to the specified value.

**InnoDB** uses the in-memory auto-increment counter as long as the server runs. When the server is stopped and restarted, **InnoDB** reinitializes the auto-increment counter, as described earlier.

The [**auto\_increment\_offset**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\replication.html#sysvar_auto_increment_offset) variable determines the starting point for the **AUTO\_INCREMENT** column value. The default setting is 1.

The [**auto\_increment\_increment**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\replication.html#sysvar_auto_increment_increment) variable controls the interval between successive column values. The default setting is 1.

##### Notes

When an **AUTO\_INCREMENT** integer column runs out of values, a subsequent **INSERT** operation returns a duplicate-key error. This is general MySQL behavior.

### 15.6.2 Indexes

[15.6.2.1 Clustered and Secondary Indexes](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-index-types)

[15.6.2.2 The Physical Structure of an InnoDB Index](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-physical-structure)

[15.6.2.3 Sorted Index Builds](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sorted-index-builds)

[15.6.2.4 InnoDB Full-Text Indexes](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-fulltext-index)

This section covers topics related to **InnoDB** indexes.

#### 15.6.2.1 Clustered and Secondary Indexes

Each **InnoDB** table has a special index called the clustered index that stores row data. Typically, the clustered index is synonymous with the primary key. To get the best performance from queries, inserts, and other database operations, it is important to understand how **InnoDB** uses the clustered index to optimize the common lookup and DML operations.

When you define a **PRIMARY KEY** on a table, **InnoDB** uses it as the clustered index. A primary key should be defined for each table. If there is no logical unique and non-null column or set of columns to use a the primary key, add an auto-increment column. Auto-increment column values are unique and are added automatically as new rows are inserted.

If you do not define a **PRIMARY KEY** for a table, **InnoDB** uses the first **UNIQUE** index with all key columns defined as **NOT NULL** as the clustered index.

If a table has no **PRIMARY KEY** or suitable **UNIQUE** index, **InnoDB** generates a hidden clustered index named **GEN\_CLUST\_INDEX** on a synthetic column that contains row ID values. The rows are ordered by the row ID that **InnoDB** assigns. The row ID is a 6-byte field that increases monotonically as new rows are inserted. Thus, the rows ordered by the row ID are physically in order of insertion.

##### How the Clustered Index Speeds Up Queries

Accessing a row through the clustered index is fast because the index search leads directly to the page that contains the row data. If a table is large, the clustered index architecture often saves a disk I/O operation when compared to storage organizations that store row data using a different page from the index record.

##### How Secondary Indexes Relate to the Clustered Index

Indexes other than the clustered index are known as secondary indexes. In **InnoDB**, each record in a secondary index contains the primary key columns for the row, as well as the columns specified for the secondary index. **InnoDB** uses this primary key value to search for the row in the clustered index.

If the primary key is long, the secondary indexes use more space, so it is advantageous to have a short primary key.

For guidelines to take advantage of **InnoDB** clustered and secondary indexes, see [Section 8.3, “Optimization and Indexes”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimization-indexes).

#### 15.6.2.2 The Physical Structure of an InnoDB Index

With the exception of spatial indexes, **InnoDB** indexes are [B-tree](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_b_tree) data structures. Spatial indexes use [R-trees](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_r_tree), which are specialized data structures for indexing multi-dimensional data. Index records are stored in the leaf pages of their B-tree or R-tree data structure. The default size of an index page is 16KB. The page size is determined by the [**innodb\_page\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_page_size) setting when when the MySQL instance is initialized. See [Section 15.8.1, “InnoDB Startup Configuration”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-init-startup-configuration).

When new records are inserted into an **InnoDB** [clustered index](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_clustered_index), **InnoDB** tries to leave 1/16 of the page free for future insertions and updates of the index records. If index records are inserted in a sequential order (ascending or descending), the resulting index pages are about 15/16 full. If records are inserted in a random order, the pages are from 1/2 to 15/16 full.

**InnoDB** performs a bulk load when creating or rebuilding B-tree indexes. This method of index creation is known as a sorted index build. The [**innodb\_fill\_factor**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_fill_factor) variable defines the percentage of space on each B-tree page that is filled during a sorted index build, with the remaining space reserved for future index growth. Sorted index builds are not supported for spatial indexes. For more information, see [Section 15.6.2.3, “Sorted Index Builds”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sorted-index-builds). An [**innodb\_fill\_factor**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_fill_factor) setting of 100 leaves 1/16 of the space in clustered index pages free for future index growth.

If the fill factor of an **InnoDB** index page drops below the **MERGE\_THRESHOLD**, which is 50% by default if not specified, **InnoDB** tries to contract the index tree to free the page. The **MERGE\_THRESHOLD** setting applies to both B-tree and R-tree indexes. For more information, see [Section 15.8.11, “Configuring the Merge Threshold for Index Pages”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#index-page-merge-threshold).

#### 15.6.2.3 Sorted Index Builds

**InnoDB** performs a bulk load instead of inserting one index record at a time when creating or rebuilding indexes. This method of index creation is also known as a sorted index build. Sorted index builds are not supported for spatial indexes.

There are three phases to an index build. In the first phase, the [clustered index](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_clustered_index) is scanned, and index entries are generated and added to the sort buffer. When the [sort buffer](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_sort_buffer) becomes full, entries are sorted and written out to a temporary intermediate file. This process is also known as a “run”. In the second phase, with one or more runs written to the temporary intermediate file, a merge sort is performed on all entries in the file. In the third and final phase, the sorted entries are inserted into the [B-tree](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_b_tree).

Prior to the introduction of sorted index builds, index entries were inserted into the B-tree one record at a time using insert APIs. This method involved opening a B-tree [cursor](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_cursor) to find the insert position and then inserting entries into a B-tree page using an [optimistic](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_optimistic) insert. If an insert failed due to a page being full, a [pessimistic](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_pessimistic) insert would be performed, which involves opening a B-tree cursor and splitting and merging B-tree nodes as necessary to find space for the entry. The drawbacks of this “top-down” method of building an index are the cost of searching for an insert position and the constant splitting and merging of B-tree nodes.

Sorted index builds use a “bottom-up” approach to building an index. With this approach, a reference to the right-most leaf page is held at all levels of the B-tree. The right-most leaf page at the necessary B-tree depth is allocated and entries are inserted according to their sorted order. Once a leaf page is full, a node pointer is appended to the parent page and a sibling leaf page is allocated for the next insert. This process continues until all entries are inserted, which may result in inserts up to the root level. When a sibling page is allocated, the reference to the previously pinned leaf page is released, and the newly allocated leaf page becomes the right-most leaf page and new default insert location.

##### Reserving B-tree Page Space for Future Index Growth

To set aside space for future index growth, you can use the [**innodb\_fill\_factor**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_fill_factor) variable to reserve a percentage of B-tree page space. For example, setting [**innodb\_fill\_factor**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_fill_factor) to 80 reserves 20 percent of the space in B-tree pages during a sorted index build. This setting applies to both B-tree leaf and non-leaf pages. It does not apply to external pages used for [**TEXT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-types.html#blob) or [**BLOB**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-types.html#blob) entries. The amount of space that is reserved may not be exactly as configured, as the [**innodb\_fill\_factor**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_fill_factor) value is interpreted as a hint rather than a hard limit.

##### Sorted Index Builds and Full-Text Index Support

Sorted index builds are supported for [fulltext indexes](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_fulltext_index). Previously, SQL was used to insert entries into a fulltext index.

##### Sorted Index Builds and Compressed Tables

For [compressed tables](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_compression), the previous index creation method appended entries to both compressed and uncompressed pages. When the modification log (representing free space on the compressed page) became full, the compressed page would be recompressed. If compression failed due to a lack of space, the page would be split. With sorted index builds, entries are only appended to uncompressed pages. When an uncompressed page becomes full, it is compressed. Adaptive padding is used to ensure that compression succeeds in most cases, but if compression fails, the page is split and compression is attempted again. This process continues until compression is successful. For more information about compression of B-Tree pages, see [Section 15.9.1.5, “How Compression Works for InnoDB Tables”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-compression-internals).

##### Sorted Index Builds and Redo Logging

[Redo logging](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_redo_log) is disabled during a sorted index build. Instead, there is a [checkpoint](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_checkpoint) to ensure that the index build can withstand an unexpected exit or failure. The checkpoint forces a write of all dirty pages to disk. During a sorted index build, the [page cleaner](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_page_cleaner) thread is signaled periodically to flush [dirty pages](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_dirty_page) to ensure that the checkpoint operation can be processed quickly. Normally, the page cleaner thread flushes dirty pages when the number of clean pages falls below a set threshold. For sorted index builds, dirty pages are flushed promptly to reduce checkpoint overhead and to parallelize I/O and CPU activity.

##### Sorted Index Builds and Optimizer Statistics

Sorted index builds may result in [optimizer](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_optimizer) statistics that differ from those generated by the previous method of index creation. The difference in statistics, which is not expected to affect workload performance, is due to the different algorithm used to populate the index.

#### 15.6.2.4 InnoDB Full-Text Indexes

Full-text indexes are created on text-based columns ([**CHAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-types.html#char), [**VARCHAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-types.html#char), or [**TEXT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-types.html#blob) columns) to speed up queries and DML operations on data contained within those columns.

A full-text index is defined as part of a [**CREATE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-table) statement or added to an existing table using [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) or [**CREATE INDEX**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-index).

Full-text search is performed using [**MATCH() ... AGAINST**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\functions.html#function_match) syntax. For usage information, see [Section 12.10, “Full-Text Search Functions”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\functions.html#fulltext-search).

**InnoDB** full-text indexes are described under the following topics in this section:

[InnoDB Full-Text Index Design](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-fulltext-index-design)

[InnoDB Full-Text Index Tables](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-fulltext-index-tables)

[InnoDB Full-Text Index Cache](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-fulltext-index-cache)

[InnoDB Full-Text Index DOC\_ID and FTS\_DOC\_ID Column](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-fulltext-index-docid)

[InnoDB Full-Text Index Deletion Handling](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-fulltext-index-deletion)

[InnoDB Full-Text Index Transaction Handling](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-fulltext-index-transaction)

[Monitoring InnoDB Full-Text Indexes](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-fulltext-index-monitoring)

##### InnoDB Full-Text Index Design

**InnoDB** full-text indexes have an inverted index design. Inverted indexes store a list of words, and for each word, a list of documents that the word appears in. To support proximity search, position information for each word is also stored, as a byte offset.

##### InnoDB Full-Text Index Tables

When an **InnoDB** full-text index is created, a set of index tables is created, as shown in the following example:

mysql> **CREATE TABLE opening\_lines (**

**id INT UNSIGNED AUTO\_INCREMENT NOT NULL PRIMARY KEY,**

**opening\_line TEXT(500),**

**author VARCHAR(200),**

**title VARCHAR(200),**

**FULLTEXT idx (opening\_line)**

**) ENGINE=InnoDB;**

mysql> **SELECT table\_id, name, space from INFORMATION\_SCHEMA.INNODB\_TABLES**

**WHERE name LIKE 'test/%';**

+----------+----------------------------------------------------+-------+

| table\_id | name | space |

+----------+----------------------------------------------------+-------+

| 333 | test/fts\_0000000000000147\_00000000000001c9\_index\_1 | 289 |

| 334 | test/fts\_0000000000000147\_00000000000001c9\_index\_2 | 290 |

| 335 | test/fts\_0000000000000147\_00000000000001c9\_index\_3 | 291 |

| 336 | test/fts\_0000000000000147\_00000000000001c9\_index\_4 | 292 |

| 337 | test/fts\_0000000000000147\_00000000000001c9\_index\_5 | 293 |

| 338 | test/fts\_0000000000000147\_00000000000001c9\_index\_6 | 294 |

| 330 | test/fts\_0000000000000147\_being\_deleted | 286 |

| 331 | test/fts\_0000000000000147\_being\_deleted\_cache | 287 |

| 332 | test/fts\_0000000000000147\_config | 288 |

| 328 | test/fts\_0000000000000147\_deleted | 284 |

| 329 | test/fts\_0000000000000147\_deleted\_cache | 285 |

| 327 | test/opening\_lines | 283 |

+----------+----------------------------------------------------+-------+

The first six index tables comprise the inverted index and are referred to as auxiliary index tables. When incoming documents are tokenized, the individual words (also referred to as “tokens”) are inserted into the index tables along with position information and an associated **DOC\_ID**. The words are fully sorted and partitioned among the six index tables based on the character set sort weight of the word's first character.

The inverted index is partitioned into six auxiliary index tables to support parallel index creation. By default, two threads tokenize, sort, and insert words and associated data into the index tables. The number of threads that perform this work is configurable using the [**innodb\_ft\_sort\_pll\_degree**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_ft_sort_pll_degree) variable. Consider increasing the number of threads when creating full-text indexes on large tables.

Auxiliary index table names are prefixed with **fts\_** and postfixed with **index\_*#***. Each auxiliary index table is associated with the indexed table by a hex value in the auxiliary index table name that matches the **table\_id** of the indexed table. For example, the **table\_id** of the **test/opening\_lines** table is **327**, for which the hex value is 0x147. As shown in the preceding example, the “147” hex value appears in the names of auxiliary index tables that are associated with the **test/opening\_lines** table.

A hex value representing the **index\_id** of the full-text index also appears in auxiliary index table names. For example, in the auxiliary table name **test/fts\_0000000000000147\_00000000000001c9\_index\_1**, the hex value **1c9** has a decimal value of 457. The index defined on the **opening\_lines** table (**idx**) can be identified by querying the [**INFORMATION\_SCHEMA.INNODB\_INDEXES**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-indexes-table) table for this value (457).

mysql> **SELECT index\_id, name, table\_id, space from INFORMATION\_SCHEMA.INNODB\_INDEXES**

**WHERE index\_id=457;**

+----------+------+----------+-------+

| index\_id | name | table\_id | space |

+----------+------+----------+-------+

| 457 | idx | 327 | 283 |

+----------+------+----------+-------+

Index tables are stored in their own tablespace if the primary table is created in a [file-per-table](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_file_per_table) tablespace. Otherwise, index tables are stored in the tablespace where the indexed table resides.

The other index tables shown in the preceding example are referred to as common index tables and are used for deletion handling and storing the internal state of full-text indexes. Unlike the inverted index tables, which are created for each full-text index, this set of tables is common to all full-text indexes created on a particular table.

Common index tables are retained even if full-text indexes are dropped. When a full-text index is dropped, the **FTS\_DOC\_ID** column that was created for the index is retained, as removing the **FTS\_DOC\_ID** column would require rebuilding the previously indexed table. Common index tables are required to manage the **FTS\_DOC\_ID** column.

**fts\_\*\_deleted** and **fts\_\*\_deleted\_cache**

Contain the document IDs (DOC\_ID) for documents that are deleted but whose data is not yet removed from the full-text index. The **fts\_\*\_deleted\_cache** is the in-memory version of the **fts\_\*\_deleted** table.

**fts\_\*\_being\_deleted** and **fts\_\*\_being\_deleted\_cache**

Contain the document IDs (DOC\_ID) for documents that are deleted and whose data is currently in the process of being removed from the full-text index. The **fts\_\*\_being\_deleted\_cache** table is the in-memory version of the **fts\_\*\_being\_deleted** table.

**fts\_\*\_config**

Stores information about the internal state of the full-text index. Most importantly, it stores the **FTS\_SYNCED\_DOC\_ID**, which identifies documents that have been parsed and flushed to disk. In case of crash recovery, **FTS\_SYNCED\_DOC\_ID** values are used to identify documents that have not been flushed to disk so that the documents can be re-parsed and added back to the full-text index cache. To view the data in this table, query the [**INFORMATION\_SCHEMA.INNODB\_FT\_CONFIG**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-ft-config-table) table.

##### InnoDB Full-Text Index Cache

When a document is inserted, it is tokenized, and the individual words and associated data are inserted into the full-text index. This process, even for small documents, can result in numerous small insertions into the auxiliary index tables, making concurrent access to these tables a point of contention. To avoid this problem, **InnoDB** uses a full-text index cache to temporarily cache index table insertions for recently inserted rows. This in-memory cache structure holds insertions until the cache is full and then batch flushes them to disk (to the auxiliary index tables). You can query the [**INFORMATION\_SCHEMA.INNODB\_FT\_INDEX\_CACHE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-ft-index-cache-table) table to view tokenized data for recently inserted rows.

The caching and batch flushing behavior avoids frequent updates to auxiliary index tables, which could result in concurrent access issues during busy insert and update times. The batching technique also avoids multiple insertions for the same word, and minimizes duplicate entries. Instead of flushing each word individually, insertions for the same word are merged and flushed to disk as a single entry, improving insertion efficiency while keeping auxiliary index tables as small as possible.

The [**innodb\_ft\_cache\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_ft_cache_size) variable is used to configure the full-text index cache size (on a per-table basis), which affects how often the full-text index cache is flushed. You can also define a global full-text index cache size limit for all tables in a given instance using the [**innodb\_ft\_total\_cache\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_ft_total_cache_size) variable.

The full-text index cache stores the same information as auxiliary index tables. However, the full-text index cache only caches tokenized data for recently inserted rows. The data that is already flushed to disk (to the auxiliary index tables) is not brought back into the full-text index cache when queried. The data in auxiliary index tables is queried directly, and results from the auxiliary index tables are merged with results from the full-text index cache before being returned.

##### InnoDB Full-Text Index DOC\_ID and FTS\_DOC\_ID Column

**InnoDB** uses a unique document identifier referred to as the **DOC\_ID** to map words in the full-text index to document records where the word appears. The mapping requires an **FTS\_DOC\_ID** column on the indexed table. If an **FTS\_DOC\_ID** column is not defined, **InnoDB** automatically adds a hidden **FTS\_DOC\_ID** column when the full-text index is created. The following example demonstrates this behavior.

The following table definition does not include an **FTS\_DOC\_ID** column:

mysql> **CREATE TABLE opening\_lines (**

**id INT UNSIGNED AUTO\_INCREMENT NOT NULL PRIMARY KEY,**

**opening\_line TEXT(500),**

**author VARCHAR(200),**

**title VARCHAR(200)**

**) ENGINE=InnoDB;**

When you create a full-text index on the table using **CREATE FULLTEXT INDEX** syntax, a warning is returned which reports that **InnoDB** is rebuilding the table to add the **FTS\_DOC\_ID** column.

mysql> **CREATE FULLTEXT INDEX idx ON opening\_lines(opening\_line);**

Query OK, 0 rows affected, 1 warning (0.19 sec)

Records: 0 Duplicates: 0 Warnings: 1

mysql> **SHOW WARNINGS;**

+---------+------+--------------------------------------------------+

| Level | Code | Message |

+---------+------+--------------------------------------------------+

| Warning | 124 | InnoDB rebuilding table to add column FTS\_DOC\_ID |

+---------+------+--------------------------------------------------+

The same warning is returned when using [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) to add a full-text index to a table that does not have an **FTS\_DOC\_ID** column. If you create a full-text index at [**CREATE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-table) time and do not specify an **FTS\_DOC\_ID** column, **InnoDB** adds a hidden **FTS\_DOC\_ID** column, without warning.

Defining an **FTS\_DOC\_ID** column at [**CREATE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-table) time is less expensive than creating a full-text index on a table that is already loaded with data. If an **FTS\_DOC\_ID** column is defined on a table prior to loading data, the table and its indexes do not have to be rebuilt to add the new column. If you are not concerned with **CREATE FULLTEXT INDEX** performance, leave out the **FTS\_DOC\_ID** column to have **InnoDB** create it for you. **InnoDB** creates a hidden **FTS\_DOC\_ID** column along with a unique index (**FTS\_DOC\_ID\_INDEX**) on the **FTS\_DOC\_ID** column. If you want to create your own **FTS\_DOC\_ID** column, the column must be defined as **BIGINT UNSIGNED NOT NULL** and named **FTS\_DOC\_ID** (all uppercase), as in the following example:

**Note**

The **FTS\_DOC\_ID** column does not need to be defined as an **AUTO\_INCREMENT** column, but doing so could make loading data easier.

mysql> **CREATE TABLE opening\_lines (**

**FTS\_DOC\_ID BIGINT UNSIGNED AUTO\_INCREMENT NOT NULL PRIMARY KEY,**

**opening\_line TEXT(500),**

**author VARCHAR(200),**

**title VARCHAR(200)**

**) ENGINE=InnoDB;**

If you choose to define the **FTS\_DOC\_ID** column yourself, you are responsible for managing the column to avoid empty or duplicate values. **FTS\_DOC\_ID** values cannot be reused, which means **FTS\_DOC\_ID** values must be ever increasing.

Optionally, you can create the required unique **FTS\_DOC\_ID\_INDEX** (all uppercase) on the **FTS\_DOC\_ID** column.

mysql> **CREATE UNIQUE INDEX FTS\_DOC\_ID\_INDEX on opening\_lines(FTS\_DOC\_ID);**

If you do not create the **FTS\_DOC\_ID\_INDEX**, **InnoDB** creates it automatically.

**Note**

**FTS\_DOC\_ID\_INDEX** cannot be defined as a descending index because the **InnoDB** SQL parser does not use descending indexes.

The permitted gap between the largest used **FTS\_DOC\_ID** value and new **FTS\_DOC\_ID** value is 65535.

To avoid rebuilding the table, the **FTS\_DOC\_ID** column is retained when dropping a full-text index.

##### InnoDB Full-Text Index Deletion Handling

Deleting a record that has a full-text index column could result in numerous small deletions in the auxiliary index tables, making concurrent access to these tables a point of contention. To avoid this problem, the **DOC\_ID** of a deleted document is logged in a special **FTS\_\*\_DELETED** table whenever a record is deleted from an indexed table, and the indexed record remains in the full-text index. Before returning query results, information in the **FTS\_\*\_DELETED** table is used to filter out deleted **DOC\_ID**s. The benefit of this design is that deletions are fast and inexpensive. The drawback is that the size of the index is not immediately reduced after deleting records. To remove full-text index entries for deleted records, run **OPTIMIZE TABLE** on the indexed table with [**innodb\_optimize\_fulltext\_only=ON**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_optimize_fulltext_only) to rebuild the full-text index. For more information, see [Optimizing InnoDB Full-Text Indexes](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\functions.html#fulltext-optimize).

##### InnoDB Full-Text Index Transaction Handling

**InnoDB** full-text indexes have special transaction handling characteristics due its caching and batch processing behavior. Specifically, updates and insertions on a full-text index are processed at transaction commit time, which means that a full-text search can only see committed data. The following example demonstrates this behavior. The full-text search only returns a result after the inserted lines are committed.

mysql> **CREATE TABLE opening\_lines (**

**id INT UNSIGNED AUTO\_INCREMENT NOT NULL PRIMARY KEY,**

**opening\_line TEXT(500),**

**author VARCHAR(200),**

**title VARCHAR(200),**

**FULLTEXT idx (opening\_line)**

**) ENGINE=InnoDB;**

mysql> **BEGIN;**

mysql> **INSERT INTO opening\_lines(opening\_line,author,title) VALUES**

**('Call me Ishmael.','Herman Melville','Moby-Dick'),**

**('A screaming comes across the sky.','Thomas Pynchon','Gravity\'s Rainbow'),**

**('I am an invisible man.','Ralph Ellison','Invisible Man'),**

**('Where now? Who now? When now?','Samuel Beckett','The Unnamable'),**

**('It was love at first sight.','Joseph Heller','Catch-22'),**

**('All this happened, more or less.','Kurt Vonnegut','Slaughterhouse-Five'),**

**('Mrs. Dalloway said she would buy the flowers herself.','Virginia Woolf','Mrs. Dalloway'),**

**('It was a pleasure to burn.','Ray Bradbury','Fahrenheit 451');**

mysql> **SELECT COUNT(\*) FROM opening\_lines WHERE MATCH(opening\_line) AGAINST('Ishmael');**

+----------+

| COUNT(\*) |

+----------+

| 0 |

+----------+

mysql> **COMMIT;**

mysql> **SELECT COUNT(\*) FROM opening\_lines WHERE MATCH(opening\_line) AGAINST('Ishmael');**

+----------+

| COUNT(\*) |

+----------+

| 1 |

+----------+

##### Monitoring InnoDB Full-Text Indexes

You can monitor and examine the special text-processing aspects of **InnoDB** full-text indexes by querying the following **INFORMATION\_SCHEMA** tables:

[**INNODB\_FT\_CONFIG**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-ft-config-table)

[**INNODB\_FT\_INDEX\_TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-ft-index-table-table)

[**INNODB\_FT\_INDEX\_CACHE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-ft-index-cache-table)

[**INNODB\_FT\_DEFAULT\_STOPWORD**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-ft-default-stopword-table)

[**INNODB\_FT\_DELETED**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-ft-deleted-table)

[**INNODB\_FT\_BEING\_DELETED**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-ft-being-deleted-table)

You can also view basic information for full-text indexes and tables by querying [**INNODB\_INDEXES**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-indexes-table) and [**INNODB\_TABLES**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-tables-table).

For more information, see [Section 15.15.4, “InnoDB INFORMATION\_SCHEMA FULLTEXT Index Tables”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-information-schema-fulltext_index-tables).

### 15.6.3 Tablespaces

[15.6.3.1 The System Tablespace](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-system-tablespace)

[15.6.3.2 File-Per-Table Tablespaces](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-file-per-table-tablespaces)

[15.6.3.3 General Tablespaces](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#general-tablespaces)

[15.6.3.4 Undo Tablespaces](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-undo-tablespaces)

[15.6.3.5 Temporary Tablespaces](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-temporary-tablespace)

[15.6.3.6 Moving Tablespace Files While the Server is Offline](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-moving-data-files-offline)

[15.6.3.7 Disabling Tablespace Path Validation](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-disabling-tablespace-path-validation)

[15.6.3.8 Optimizing Tablespace Space Allocation on Linux](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-optimize-tablespace-page-allocation)

[15.6.3.9 Tablespace AUTOEXTEND\_SIZE Configuration](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-tablespace-autoextend-size)

This section covers topics related to **InnoDB** tablespaces.

#### 15.6.3.1 The System Tablespace

The system tablespace is the storage area for the change buffer. It may also contain table and index data if tables are created in the system tablespace rather than file-per-table or general tablespaces. In previous MySQL versions, the system tablespace contained the **InnoDB** data dictionary. In MySQL 8.0, **InnoDB** stores metadata in the MySQL data dictionary. See [Chapter 14, *MySQL Data Dictionary*](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-dictionary.html). In previous MySQL releases, the system tablespace also contained the doublewrite buffer storage area. This storage area resides in separate doublewrite files as of MySQL 8.0.20. See [Section 15.6.4, “Doublewrite Buffer”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-doublewrite-buffer).

The system tablespace can have one or more data files. By default, a single system tablespace data file, named ibdata1, is created in the data directory. The size and number of system tablespace data files is defined by the [**innodb\_data\_file\_path**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_data_file_path) startup option. For configuration information, see [System Tablespace Data File Configuration](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-startup-data-file-configuration).

Additional information about the system tablespace is provided under the following topics in the section:

[Resizing the System Tablespace](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-resize-system-tablespace)

[Using Raw Disk Partitions for the System Tablespace](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-raw-devices)

##### Resizing the System Tablespace

This section describes how to increase or decrease the size of the system tablespace.

###### Increasing the Size of the System Tablespace

The easiest way to increase the size of the system tablespace is to configure it to be auto-extending. To do so, specify the **autoextend** attribute for the last data file in the [**innodb\_data\_file\_path**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_data_file_path) setting, and restart the server. For example:

innodb\_data\_file\_path=ibdata1:10M:autoextend

When the **autoextend** attribute is specified, the data file automatically increases in size by 8MB increments as space is required. The [**innodb\_autoextend\_increment**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_autoextend_increment) variable controls the increment size.

You can also increase system tablespace size by adding another data file. To do so:

Stop the MySQL server.

If the last data file in the [**innodb\_data\_file\_path**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_data_file_path) setting is defined with the **autoextend** attribute, remove it, and modify the size attribute to reflect the current data file size. To determine the appropriate data file size to specify, check your file system for the file size, and round that value down to the closest MB value, where a MB is equal to 1024 x 1024 bytes.

Append a new data file to the [**innodb\_data\_file\_path**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_data_file_path) setting, optionally specifying the **autoextend** attribute. The **autoextend** attribute can be specified only for the last data file in the [**innodb\_data\_file\_path**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_data_file_path) setting.

Start the MySQL server.

For example, this tablespace has one auto-extending data file:

innodb\_data\_home\_dir =

innodb\_data\_file\_path = /ibdata/ibdata1:10M:autoextend

Suppose that the data file has grown to 988MB over time. This is the [**innodb\_data\_file\_path**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_data_file_path) setting after modifying the size attribute to reflect the current data file size, and after specifying a new 50MB auto-extending data file:

innodb\_data\_home\_dir =

innodb\_data\_file\_path = /ibdata/ibdata1:988M;/disk2/ibdata2:50M:autoextend

When adding a new data file, do not specify an existing file name. **InnoDB** creates and initializes the new data file when you start the server.

**Note**

You cannot increase the size of an existing system tablespace data file by changing its size attribute. For example, changing the [**innodb\_data\_file\_path**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_data_file_path) setting from **ibdata1:10M:autoextend** to **ibdata1:12M:autoextend** produces the following error when starting the server:

[ERROR] [MY-012263] [InnoDB] The Auto-extending innodb\_system

data file './ibdata1' is of a different size 640 pages (rounded down to MB) than

specified in the .cnf file: initial 768 pages, max 0 (relevant if non-zero) pages!

The error indicates that the existing data file size (expressed in **InnoDB** pages) is different from the data file size specified in the configuration file. If you encounter this error, restore the previous [**innodb\_data\_file\_path**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_data_file_path) setting, and refer to the system tablespace resizing instructions.

###### Decreasing the Size of the InnoDB System Tablespace

Decreasing the size of an existing system tablespace is not supported. The only option to achieve a smaller system tablespace is to restore your data from a backup to a new MySQL instance created with the desired system tablespace size configuration.

For information about creating backups, see [Section 15.18.1, “InnoDB Backup”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-backup).

For information about configuring data files for a new system tablespace. See [System Tablespace Data File Configuration](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-startup-data-file-configuration).

To avoid a large system tablespace, consider using file-per-table tablespaces or general tablespaces for your data. File-per-table tablespaces are the default tablespace type and are used implicitly when creating an **InnoDB** table. Unlike the system tablespace, file-per-table tablespaces return disk space to the operating system when they are truncated or dropped. For more information, see [Section 15.6.3.2, “File-Per-Table Tablespaces”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-file-per-table-tablespaces). General tablespaces are multi-table tablespaces that can also be used as an alternative to the system tablespace. See [Section 15.6.3.3, “General Tablespaces”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#general-tablespaces).

##### Using Raw Disk Partitions for the System Tablespace

Raw disk partitions can be used as system tablespace data files. This technique enables nonbuffered I/O on Windows and some Linux and Unix systems without file system overhead. Perform tests with and without raw partitions to verify whether they improve performance on your system.

When using a raw disk partition, ensure that the user ID that runs the MySQL server has read and write privileges for that partition. For example, if running the server as the **mysql** user, the partition must be readable and writeable by **mysql**. If running the server with the [--memlock](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#option_mysqld_memlock) option, the server must be run as **root**, so the partition must be readable and writeable by **root**.

The procedures described below involve option file modification. For additional information, see [Section 4.2.2.2, “Using Option Files”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\programs.html#option-files).

###### Allocating a Raw Disk Partition on Linux and Unix Systems

When creating a new data file, specify the keyword **newraw** immediately after the data file size for the [**innodb\_data\_file\_path**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_data_file_path) option. The partition must be at least as large as the size that you specify. Note that 1MB in **InnoDB** is 1024 × 1024 bytes, whereas 1MB in disk specifications usually means 1,000,000 bytes.

[mysqld]

innodb\_data\_home\_dir=

innodb\_data\_file\_path=/dev/hdd1:3Gnewraw;/dev/hdd2:2Gnewraw

Restart the server. **InnoDB** notices the **newraw** keyword and initializes the new partition. However, do not create or change any **InnoDB** tables yet. Otherwise, when you next restart the server, **InnoDB** reinitializes the partition and your changes are lost. (As a safety measure **InnoDB** prevents users from modifying data when any partition with **newraw** is specified.)

After **InnoDB** has initialized the new partition, stop the server, change **newraw** in the data file specification to **raw**:

[mysqld]

innodb\_data\_home\_dir=

innodb\_data\_file\_path=/dev/hdd1:3Graw;/dev/hdd2:2Graw

Restart the server. **InnoDB** now permits changes to be made.

###### Allocating a Raw Disk Partition on Windows

On Windows systems, the same steps and accompanying guidelines described for Linux and Unix systems apply except that the [**innodb\_data\_file\_path**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_data_file_path) setting differs slightly on Windows.

When creating a new data file, specify the keyword **newraw** immediately after the data file size for the [**innodb\_data\_file\_path**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_data_file_path) option:

[mysqld]

innodb\_data\_home\_dir=

innodb\_data\_file\_path=//./D::10Gnewraw

The //./ corresponds to the Windows syntax of \\.\ for accessing physical drives. In the example above, **D:** is the drive letter of the partition.

Restart the server. **InnoDB** notices the **newraw** keyword and initializes the new partition.

After **InnoDB** has initialized the new partition, stop the server, change **newraw** in the data file specification to **raw**:

[mysqld]

innodb\_data\_home\_dir=

innodb\_data\_file\_path=//./D::10Graw

Restart the server. **InnoDB** now permits changes to be made.

#### 15.6.3.2 File-Per-Table Tablespaces

A file-per-table tablespace contains data and indexes for a single **InnoDB** table, and is stored on the file system in a single data file.

File-per-table tablespace characteristics are described under the following topics in this section:

[File-Per-Table Tablespace Configuration](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-file-per-table-configuration)

[File-Per-Table Tablespace Data Files](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-file-per-table-data-files)

[File-Per-Table Tablespace Advantages](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-file-per-table-advantages)

[File-Per-Table Tablespace Disadvantages](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-file-per-table-disadvantages)

##### File-Per-Table Tablespace Configuration

**InnoDB** creates tables in file-per-table tablespaces by default. This behavior is controlled by the [**innodb\_file\_per\_table**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_file_per_table) variable. Disabling [**innodb\_file\_per\_table**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_file_per_table) causes **InnoDB** to create tables in the system tablespace.

An [**innodb\_file\_per\_table**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_file_per_table) setting can be specified in an option file or configured at runtime using a [**SET GLOBAL**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#set-variable) statement. Changing the setting at runtime requires privileges sufficient to set global system variables. See [Section 5.1.9.1, “System Variable Privileges”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#system-variable-privileges).

Option file:

[mysqld]

innodb\_file\_per\_table=ON

Using [**SET GLOBAL**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#set-variable) at runtime:

mysql> SET GLOBAL innodb\_file\_per\_table=ON;

##### File-Per-Table Tablespace Data Files

A file-per-table tablespace is created in an .idb data file in a schema directory under the MySQL data directory. The .ibd file is named for the table (***table\_name***.ibd). For example, the data file for table **test.t1** is created in the test directory under the MySQL data directory:

mysql> USE test;

mysql> CREATE TABLE t1 (

id INT PRIMARY KEY AUTO\_INCREMENT,

name VARCHAR(100)

) ENGINE = InnoDB;

shell> cd /***path***/***to***/***mysql***/data/test

shell> ls

t1.ibd

You can use the **DATA DIRECTORY** clause of the [**CREATE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-table) statement to implicitly create a file-per-table tablespace data file outside of the data directory. For more information, see [Section 15.6.1.2, “Creating Tables Externally”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-create-table-external).

##### File-Per-Table Tablespace Advantages

File-per-table tablespaces have the following advantages over shared tablespaces such as the system tablespace or general tablespaces.

Disk space is returned to the operating system after truncating or dropping a table created in a file-per-table tablespace. Truncating or dropping a table stored in a shared tablespace creates free space within the shared tablespace data file, which can only be used for **InnoDB** data. In other words, a shared tablespace data file does not shrink in size after a table is truncated or dropped.

A table-copying [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) operation on a table that resides in a shared tablespace can increase the amount of disk space occupied by the tablespace. Such operations may require as much additional space as the data in the table plus indexes. This space is not released back to the operating system as it is for file-per-table tablespaces.

[**TRUNCATE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#truncate-table) performance is better when executed on tables that reside in file-per-table tablespaces.

File-per-table tablespace data files can be created on separate storage devices for I/O optimization, space management, or backup purposes. See [Section 15.6.1.2, “Creating Tables Externally”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-create-table-external).

You can import a table that resides in file-per-table tablespace from another MySQL instance. See [Section 15.6.1.3, “Importing InnoDB Tables”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-table-import).

Tables created in file-per-table tablespaces support features associated with **DYNAMIC** and **COMPRESSED** row formats, which are not supported by the system tablespace. See [Section 15.10, “InnoDB Row Formats”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-row-format).

Tables stored in individual tablespace data files can save time and improve chances for a successful recovery when data corruption occurs, when backups or binary logs are unavailable, or when the MySQL server instance cannot be restarted.

Tables created in file-per-table tablespaces cab be backed up or restored quickly using MySQL Enterprise Backup, without interrupting the use of other **InnoDB** tables. This is beneficial for tables on varying backup schedules or that require backup less frequently. See [Making a Partial Backup](https://dev.mysql.com/doc/mysql-enterprise-backup/8.0/en/partial.html) for details.

File-per-table tablespaces permit monitoring table size on the file system by monitoring the size of the tablespace data file.

Common Linux file systems do not permit concurrent writes to a single file such as a shared tablespace data file when [**innodb\_flush\_method**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_flush_method) is set to **O\_DIRECT**. As a result, there are possible performance improvements when using file-per-table tablespaces in conjunction with this setting.

Tables in a shared tablespace are limited in size by the 64TB tablespace size limit. By comparison, each file-per-table tablespace has a 64TB size limit, which provides plenty of room for individual tables to grow in size.

##### File-Per-Table Tablespace Disadvantages

File-per-table tablespaces have the following disadvantages compared to shared tablespaces such as the system tablespace or general tablespaces.

With file-per-table tablespaces, each table may have unused space that can only be utilized by rows of the same table, which can lead to wasted space if not properly managed.

**fsync** operations are performed on multiple file-per-table data files instead of a single shared tablespace data file. Because **fsync** operations are per file, write operations for multiple tables cannot be combined, which can result in a higher total number of **fsync** operations.

[**mysqld**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\programs.html#mysqld) must keep an open file handle for each file-per-table tablespace, which may impact performance if you have numerous tables in file-per-table tablespaces.

More file descriptors are required when each table has its own data file.

There is potential for more fragmentation, which can impede [**DROP TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#drop-table) and table scan performance. However, if fragmentation is managed, file-per-table tablespaces can improve performance for these operations.

The buffer pool is scanned when dropping a table that resides in a file-per-table tablespace, which can take several seconds for large buffer pools. The scan is performed with a broad internal lock, which may delay other operations.

The [**innodb\_autoextend\_increment**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_autoextend_increment) variable, which defines the increment size for extending the size of an auto-extending shared tablespace file when it becomes full, does not apply to file-per-table tablespace files, which are auto-extending regardless of the [**innodb\_autoextend\_increment**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_autoextend_increment) setting. Initial file-per-table tablespace extensions are by small amounts, after which extensions occur in increments of 4MB.

#### 15.6.3.3 General Tablespaces

A general tablespace is a shared **InnoDB** tablespace that is created using [**CREATE TABLESPACE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-tablespace) syntax. General tablespace capabilities and features are described under the following topics in this section:

[General Tablespace Capabilities](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#general-tablespaces-capabilities)

[Creating a General Tablespace](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#general-tablespaces-creating)

[Adding Tables to a General Tablespace](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#general-tablespaces-adding-tables)

[General Tablespace Row Format Support](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#general-tablespaces-row-format-support)

[Moving Tables Between Tablespaces Using ALTER TABLE](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#general-tablespaces-moving-non-partitioned-tables)

[Renaming a General Tablespace](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#general-tablespaces-renaming)

[Dropping a General Tablespace](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#general-tablespaces-dropping)

[General Tablespace Limitations](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#general-tablespaces-limitations)

##### General Tablespace Capabilities

General tablespaces provide the following capabilities:

Similar to the system tablespace, general tablespaces are shared tablespaces capable of storing data for multiple tables.

General tablespaces have a potential memory advantage over [file-per-table tablespaces](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-file-per-table-tablespaces). The server keeps tablespace metadata in memory for the lifetime of a tablespace. Multiple tables in fewer general tablespaces consume less memory for tablespace metadata than the same number of tables in separate file-per-table tablespaces.

General tablespace data files can be placed in a directory relative to or independent of the MySQL data directory, which provides you with many of the data file and storage management capabilities of [file-per-table tablespaces](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-file-per-table-tablespaces). As with file-per-table tablespaces, the ability to place data files outside of the MySQL data directory allows you to manage performance of critical tables separately, setup RAID or DRBD for specific tables, or bind tables to particular disks, for example.

General tablespaces support all table row formats and associated features.

The **TABLESPACE** option can be used with [**CREATE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-table) to create tables in a general tablespaces, file-per-table tablespace, or in the system tablespace.

The **TABLESPACE** option can be used with [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) to move tables between general tablespaces, file-per-table tablespaces, and the system tablespace.

##### Creating a General Tablespace

General tablespaces are created using [**CREATE TABLESPACE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-tablespace) syntax.

CREATE TABLESPACE ***tablespace\_name***

[ADD DATAFILE '***file\_name***']

[FILE\_BLOCK\_SIZE = ***value***]

[ENGINE [=] ***engine\_name***]

A general tablespace can be created in the data directory or outside of it. To avoid conflicts with implicitly created file-per-table tablespaces, creating a general tablespace in a subdirectory under the data directory is not supported. When creating a general tablespace outside of the data directory, the directory must exist and must be known to **InnoDB** prior to creating the tablespace. To make an unknown directory known to **InnoDB**, add the directory to the [**innodb\_directories**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_directories) argument value. [**innodb\_directories**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_directories) is a read-only startup option. Configuring it requires restarting the server.

Examples:

Creating a general tablespace in the data directory:

mysql> **CREATE TABLESPACE `ts1` ADD DATAFILE 'ts1.ibd' Engine=InnoDB;**

or

mysql> **CREATE TABLESPACE `ts1` Engine=InnoDB;**

The **ADD DATAFILE** clause is optional as of MySQL 8.0.14 and required before that. If the **ADD DATAFILE** clause is not specified when creating a tablespace, a tablespace data file with a unique file name is created implicitly. The unique file name is a 128 bit UUID formatted into five groups of hexadecimal numbers separated by dashes (***aaaaaaaa-bbbb-cccc-dddd-eeeeeeeeeeee***). General tablespace data files include an .ibd file extension. In a replication environment, the data file name created on the source is not the same as the data file name created on the replica.

Creating a general tablespace in a directory outside of the data directory:

mysql> **CREATE TABLESPACE `ts1` ADD DATAFILE '/my/tablespace/directory/ts1.ibd' Engine=InnoDB;**

You can specify a path that is relative to the data directory as long as the tablespace directory is not under the data directory. In this example, the my\_tablespace directory is at the same level as the data directory:

mysql> **CREATE TABLESPACE `ts1` ADD DATAFILE '../my\_tablespace/ts1.ibd' Engine=InnoDB;**

**Note**

The **ENGINE = InnoDB** clause must be defined as part of the [**CREATE TABLESPACE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-tablespace) statement, or **InnoDB** must be defined as the default storage engine ([**default\_storage\_engine=InnoDB**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_default_storage_engine)).

##### Adding Tables to a General Tablespace

After creating a general tablespace, [**CREATE TABLE *tbl\_name* ... TABLESPACE [=] *tablespace\_name***](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-table) or [**ALTER TABLE *tbl\_name* TABLESPACE [=] *tablespace\_name***](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) statements can be used to add tables to the tablespace, as shown in the following examples:

[**CREATE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-table):

mysql> **CREATE TABLE t1 (c1 INT PRIMARY KEY) TABLESPACE ts1;**

[**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table):

mysql> **ALTER TABLE t2 TABLESPACE ts1;**

**Note**

Support for adding table partitions to shared tablespaces was deprecated in MySQL 5.7.24 and removed in MySQL 8.0.13. Shared tablespaces include the **InnoDB** system tablespace and general tablespaces.

For detailed syntax information, see [**CREATE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-table) and [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table).

##### General Tablespace Row Format Support

General tablespaces support all table row formats (**REDUNDANT**, **COMPACT**, **DYNAMIC**, **COMPRESSED**) with the caveat that compressed and uncompressed tables cannot coexist in the same general tablespace due to different physical page sizes.

For a general tablespace to contain compressed tables (**ROW\_FORMAT=COMPRESSED**), the **FILE\_BLOCK\_SIZE** option must be specified, and the **FILE\_BLOCK\_SIZE** value must be a valid compressed page size in relation to the [**innodb\_page\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_page_size) value. Also, the physical page size of the compressed table (**KEY\_BLOCK\_SIZE**) must be equal to **FILE\_BLOCK\_SIZE/1024**. For example, if [**innodb\_page\_size=16KB**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_page_size) and **FILE\_BLOCK\_SIZE=8K**, the **KEY\_BLOCK\_SIZE** of the table must be 8.

The following table shows permitted [**innodb\_page\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_page_size), **FILE\_BLOCK\_SIZE**, and **KEY\_BLOCK\_SIZE** combinations. **FILE\_BLOCK\_SIZE** values may also be specified in bytes. To determine a valid **KEY\_BLOCK\_SIZE** value for a given **FILE\_BLOCK\_SIZE**, divide the **FILE\_BLOCK\_SIZE** value by 1024. Table compression is not support for 32K and 64K **InnoDB** page sizes. For more information about **KEY\_BLOCK\_SIZE**, see [**CREATE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-table), and [Section 15.9.1.2, “Creating Compressed Tables”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-compression-usage).

**Table 15.3 Permitted Page Size, FILE\_BLOCK\_SIZE, and KEY\_BLOCK\_SIZE Combinations for Compressed Tables**

| **InnoDB Page Size (innodb\_page\_size)** | **Permitted FILE\_BLOCK\_SIZE Value** | **Permitted KEY\_BLOCK\_SIZE Value** |
| --- | --- | --- |
| **64KB** | 64K (65536) | Compression is not supported |
| **32KB** | 32K (32768) | Compression is not supported |
| **16KB** | 16K (16384) | None. If [**innodb\_page\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_page_size) is equal to **FILE\_BLOCK\_SIZE**, the tablespace cannot contain a compressed table. |
| **16KB** | 8K (8192) | 8 |
| **16KB** | 4K (4096) | 4 |
| **16KB** | 2K (2048) | 2 |
| **16KB** | 1K (1024) | 1 |
| **8KB** | 8K (8192) | None. If [**innodb\_page\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_page_size) is equal to **FILE\_BLOCK\_SIZE**, the tablespace cannot contain a compressed table. |
| **8KB** | 4K (4096) | 4 |
| **8KB** | 2K (2048) | 2 |
| **8KB** | 1K (1024) | 1 |
| **4KB** | 4K (4096) | None. If [**innodb\_page\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_page_size) is equal to **FILE\_BLOCK\_SIZE**, the tablespace cannot contain a compressed table. |
| **4KB** | 2K (2048) | 2 |
| **4KB** | 1K (1024) | 1 |

This example demonstrates creating a general tablespace and adding a compressed table. The example assumes a default [**innodb\_page\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_page_size) of 16KB. The **FILE\_BLOCK\_SIZE** of 8192 requires that the compressed table have a **KEY\_BLOCK\_SIZE** of 8.

mysql> **CREATE TABLESPACE `ts2` ADD DATAFILE 'ts2.ibd' FILE\_BLOCK\_SIZE = 8192 Engine=InnoDB;**

mysql> **CREATE TABLE t4 (c1 INT PRIMARY KEY) TABLESPACE ts2 ROW\_FORMAT=COMPRESSED KEY\_BLOCK\_SIZE=8;**

If you do not specify **FILE\_BLOCK\_SIZE** when creating a general tablespace, **FILE\_BLOCK\_SIZE** defaults to [**innodb\_page\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_page_size). When **FILE\_BLOCK\_SIZE** is equal to [**innodb\_page\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_page_size), the tablespace may only contain tables with an uncompressed row format (**COMPACT**, **REDUNDANT**, and **DYNAMIC** row formats).

##### Moving Tables Between Tablespaces Using ALTER TABLE

[**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) with the **TABLESPACE** option can be used to move a table to an existing general tablespace, to a new file-per-table tablespace, or to the system tablespace.

**Note**

Support for placing table partitions in shared tablespaces was deprecated in MySQL 5.7.24 and removed MySQL 8.0.13. Shared tablespaces include the **InnoDB** system tablespace and general tablespaces.

To move a table from a file-per-table tablespace or from the system tablespace to a general tablespace, specify the name of the general tablespace. The general tablespace must exist. See [**ALTER TABLESPACE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-tablespace) for more information.

ALTER TABLE tbl\_name TABLESPACE [=] ***tablespace\_name***;

To move a table from a general tablespace or file-per-table tablespace to the system tablespace, specify **innodb\_system** as the tablespace name.

ALTER TABLE tbl\_name TABLESPACE [=] innodb\_system;

To move a table from the system tablespace or a general tablespace to a file-per-table tablespace, specify **innodb\_file\_per\_table** as the tablespace name.

ALTER TABLE tbl\_name TABLESPACE [=] innodb\_file\_per\_table;

**ALTER TABLE ... TABLESPACE** operations cause a full table rebuild, even if the **TABLESPACE** attribute has not changed from its previous value.

**ALTER TABLE ... TABLESPACE** syntax does not support moving a table from a temporary tablespace to a persistent tablespace.

The **DATA DIRECTORY** clause is permitted with **CREATE TABLE ... TABLESPACE=innodb\_file\_per\_table** but is otherwise not supported for use in combination with the **TABLESPACE** option. As of MySQL 8.0.21, the directory specified in a **DATA DIRECTORY** clause must be known to **InnoDB**. For more information, see [Using the DATA DIRECTORY Clause](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-create-table-external-data-directory).

Restrictions apply when moving tables from encrypted tablespaces. See [Encryption Limitations](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-data-encryption-limitations).

##### Renaming a General Tablespace

Renaming a general tablespace is supported using [**ALTER TABLESPACE ... RENAME TO**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-tablespace) syntax.

ALTER TABLESPACE s1 RENAME TO s2;

The [**CREATE TABLESPACE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\security.html#priv_create-tablespace) privilege is required to rename a general tablespace.

**RENAME TO** operations are implicitly performed in [**autocommit**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_autocommit) mode regardless of the [**autocommit**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_autocommit) setting.

A **RENAME TO** operation cannot be performed while [**LOCK TABLES**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#lock-tables) or [**FLUSH TABLES WITH READ LOCK**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#flush) is in effect for tables that reside in the tablespace.

Exclusive [metadata locks](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_metadata_lock) are taken on tables within a general tablespace while the tablespace is renamed, which prevents concurrent DDL. Concurrent DML is supported.

##### Dropping a General Tablespace

The [**DROP TABLESPACE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#drop-tablespace) statement is used to drop an **InnoDB** general tablespace.

All tables must be dropped from the tablespace prior to a [**DROP TABLESPACE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#drop-tablespace) operation. If the tablespace is not empty, [**DROP TABLESPACE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#drop-tablespace) returns an error.

Use a query similar to the following to identify tables in a general tablespace.

mysql> **SELECT a.NAME AS space\_name, b.NAME AS table\_name FROM INFORMATION\_SCHEMA.INNODB\_TABLESPACES a,**

**INFORMATION\_SCHEMA.INNODB\_TABLES b WHERE a.SPACE=b.SPACE AND a.NAME LIKE 'ts1';**

+------------+------------+

| space\_name | table\_name |

+------------+------------+

| ts1 | test/t1 |

| ts1 | test/t2 |

| ts1 | test/t3 |

+------------+------------+

A general **InnoDB** tablespace is not deleted automatically when the last table in the tablespace is dropped. The tablespace must be dropped explicitly using [**DROP TABLESPACE *tablespace\_name***](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#drop-tablespace).

A general tablespace does not belong to any particular database. A [**DROP DATABASE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#drop-database) operation can drop tables that belong to a general tablespace but it cannot drop the tablespace, even if the [**DROP DATABASE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#drop-database) operation drops all tables that belong to the tablespace.

Similar to the system tablespace, truncating or dropping tables stored in a general tablespace creates free space internally in the general tablespace [.ibd data file](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_ibd_file) which can only be used for new **InnoDB** data. Space is not released back to the operating system as it is when a file-per-table tablespace is deleted during a [**DROP TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#drop-table) operation.

This example demonstrates how to drop an **InnoDB** general tablespace. The general tablespace **ts1** is created with a single table. The table must be dropped before dropping the tablespace.

mysql> **CREATE TABLESPACE `ts1` ADD DATAFILE 'ts1.ibd' Engine=InnoDB;**

mysql> **CREATE TABLE t1 (c1 INT PRIMARY KEY) TABLESPACE ts1 Engine=InnoDB;**

mysql> **DROP TABLE t1;**

mysql> **DROP TABLESPACE ts1;**

**Note**

***tablespace\_name*** is a case-sensitive identifier in MySQL.

##### General Tablespace Limitations

A generated or existing tablespace cannot be changed to a general tablespace.

Creation of temporary general tablespaces is not supported.

General tablespaces do not support temporary tables.

Similar to the system tablespace, truncating or dropping tables stored in a general tablespace creates free space internally in the general tablespace [.ibd data file](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_ibd_file) which can only be used for new **InnoDB** data. Space is not released back to the operating system as it is for [file-per-table](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_file_per_table) tablespaces.

Additionally, a table-copying [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) operation on table that resides in a shared tablespace (a general tablespace or the system tablespace) can increase the amount of space used by the tablespace. Such operations require as much additional space as the data in the table plus indexes. The additional space required for the table-copying [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) operation is not released back to the operating system as it is for file-per-table tablespaces.

[**ALTER TABLE ... DISCARD TABLESPACE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) and [**ALTER TABLE ...IMPORT TABLESPACE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) are not supported for tables that belong to a general tablespace.

Support for placing table partitions in general tablespaces was deprecated in MySQL 5.7.24 and removed in MySQL 8.0.13.

The **ADD DATAFILE** clause is not supported in a replication environment where the source and replica reside on the same host, as it would cause the source and replica to create a tablespace of the same name in the same location, which is not supported. However, if the **ADD DATAFILE** clause is omitted, the tablespace is created in the data directory with a generated file name that is unique, which is permitted.

As of MySQL 8.0.21, general tablespaces cannot be created in the undo tablespace directory ([**innodb\_undo\_directory**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_undo_directory)) unless that directly is known to **InnoDB**. Known directories are those defined by the [**datadir**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_datadir), [**innodb\_data\_home\_dir**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_data_home_dir), and [**innodb\_directories**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_directories) variables.

#### 15.6.3.4 Undo Tablespaces

Undo tablespaces contain undo logs, which are collections of records containing information about how to undo the latest change by a transaction to a clustered index record.

Undo tablespaces are described under the following topics in this section:

[Default Undo Tablespaces](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-default-undo-tablespaces)

[Undo Tablespace Size](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb--undo-tablespace-size)

[Adding Undo Tablespaces](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-add-undo-tablespaces)

[Dropping Undo Tablespaces](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-drop-undo-tablespaces)

[Moving Undo Tablespaces](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-move-undo-tablespaces)

[Configuring the Number of Rollback Segments](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-undo-tablespace-rollback-segments)

[Truncating Undo Tablespaces](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#truncate-undo-tablespace)

[Undo Tablespace Status Variables](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-undo-tablespace-status-variables)

##### Default Undo Tablespaces

Two default undo tablespaces are created when the MySQL instance is initialized. Default undo tablespaces are created at initialization time to provide a location for rollback segments that must exist before SQL statements can be accepted. A minimum of two undo tablespaces is required to support automated truncation of undo tablespaces. See [Truncating Undo Tablespaces](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#truncate-undo-tablespace).

Default undo tablespaces are created in the location defined by the [**innodb\_undo\_directory**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_undo_directory) variable. If the [**innodb\_undo\_directory**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_undo_directory) variable is undefined, default undo tablespaces are created in the data directory. Default undo tablespace data files are named undo\_001 and undo\_002. The corresponding undo tablespace names defined in the data dictionary are **innodb\_undo\_001** and **innodb\_undo\_002**.

As of MySQL 8.0.14, additional undo tablespaces can be created at runtime using SQL. See [Adding Undo Tablespaces](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-add-undo-tablespaces).

##### Undo Tablespace Size

Prior to MySQL 8.0.23, the initial size of an undo tablespace depends on the [**innodb\_page\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_page_size) value. For the default 16KB page size, the initial undo tablespace file size is 10MiB. For 4KB, 8KB, 32KB, and 64KB page sizes, the initial undo tablespace files sizes are 7MiB, 8MiB, 20MiB, and 40MiB, respectively. As of MySQL 8.0.23, the initial undo tablespace size is normally 16MiB. The initial size may differ when a new undo tablespace is created by a truncate operation. In this case, if the file extension size is larger than 16MB, and the previous file extension occurred within the last second, the new undo tablespace is created at a quarter of the size defined by the [**innodb\_max\_undo\_log\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_max_undo_log_size) variable.

Prior to MySQL 8.0.23, an undo tablespace is extended four extents at a time. From MySQL 8.0.23, an undo tablespace is extended by a minimum of 16MB. To handle aggressive growth, the file extension size is doubled if the previous file extension happened less than 0.1 seconds earlier. Doubling of the extension size can occur multiple times to a maximum of 256MB. If the previous file extension occurred more than 0.1 seconds earlier, the extension size is reduced by half, which can also occur multiple times, to a minimum of 16MB. If the **AUTOEXTEND\_SIZE** option is defined for an undo tablespace, it is extended by the greater of the **AUTOEXTEND\_SIZE** setting and the extension size determined by the logic described above. For information about the **AUTOEXTEND\_SIZE** option, see [Section 15.6.3.9, “Tablespace AUTOEXTEND\_SIZE Configuration”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-tablespace-autoextend-size).

##### Adding Undo Tablespaces

Because undo logs can become large during long-running transactions, creating additional undo tablespaces can help prevent individual undo tablespaces from becoming too large. As of MySQL 8.0.14, additional undo tablespaces can be created at runtime using [**CREATE UNDO TABLESPACE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-tablespace) syntax.

CREATE UNDO TABLESPACE ***tablespace\_name*** ADD DATAFILE '***file\_name***.ibu';

The undo tablespace file name must have an .ibu extension. It is not permitted to specify a relative path when defining the undo tablespace file name. A fully qualified path is permitted, but the path must be known to **InnoDB**. Known paths are those defined by the [**innodb\_directories**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_directories) variable. Unique undo tablespace file names are recommended to avoid potential file name conflicts when moving or cloning data.

**Note**

In a replication environment, the source and each replica must have its own undo tablespace file directory. Replicating the creation of an undo tablespace file to a common directory would cause a file name conflict.

At startup, directories defined by the [**innodb\_directories**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_directories) variable are scanned for undo tablespace files. (The scan also traverses subdirectories.) Directories defined by the [**innodb\_data\_home\_dir**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_data_home_dir), [**innodb\_undo\_directory**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_undo_directory), and [**datadir**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_datadir) variables are automatically appended to the [**innodb\_directories**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_directories) value regardless of whether the [**innodb\_directories**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_directories) variable is defined explicitly. An undo tablespace can therefore reside in paths defined by any of those variables.

If the undo tablespace file name does not include a path, the undo tablespace is created in the directory defined by the [**innodb\_undo\_directory**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_undo_directory) variable. If that variable is undefined, the undo tablespace is created in the data directory.

**Note**

The **InnoDB** recovery process requires that undo tablespace files reside in known directories. Undo tablespace files must be discovered and opened before redo recovery and before other data files are opened to permit uncommitted transactions and data dictionary changes to be rolled back. An undo tablespace not found before recovery cannot be used, which can lead to database inconsistencies. An error message is reported at startup if an undo tablespace known to the data dictionary is not found. The known directory requirement also supports undo tablespace portability. See [Moving Undo Tablespaces](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-move-undo-tablespaces).

To create undo tablespaces in a path relative to the data directory, set the [**innodb\_undo\_directory**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_undo_directory) variable to the relative path, and specify the file name only when creating an undo tablespace.

To view undo tablespace names and paths, query [**INFORMATION\_SCHEMA.FILES**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-files-table):

SELECT TABLESPACE\_NAME, FILE\_NAME FROM INFORMATION\_SCHEMA.FILES

WHERE FILE\_TYPE LIKE 'UNDO LOG';

A MySQL instance supports up to 127 undo tablespaces including the two default undo tablespaces created when the MySQL instance is initialized.

**Note**

Prior to MySQL 8.0.14, additional undo tablespaces are created by configuring the [**innodb\_undo\_tablespaces**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_undo_tablespaces) startup variable. This variable is deprecated and no longer configurable as of MySQL 8.0.14.

Prior to MySQL 8.0.14, increasing the [**innodb\_undo\_tablespaces**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_undo_tablespaces) setting creates the specified number of undo tablespaces and adds them to the list of active undo tablespaces. Decreasing the [**innodb\_undo\_tablespaces**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_undo_tablespaces) setting removes undo tablespaces from the list of active undo tablespaces. Undo tablespaces that are removed from the active list remain active until they are no longer used by existing transactions. The [**innodb\_undo\_tablespaces**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_undo_tablespaces) variable can be configured at runtime using a [**SET**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#set-statement) statement or defined in a configuration file.

Prior to MySQL 8.0.14, deactivated undo tablespaces cannot be removed. Manual removal of undo tablespace files is possible after a slow shutdown but is not recommended, as deactivated undo tablespaces may contain active undo logs for some time after the server is restarted if open transactions were present when shutting down the server. As of MySQL 8.0.14, undo tablespaces can be dropped using [**DROP UNDO TABALESPACE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-tablespace) syntax. See [Dropping Undo Tablespaces](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-drop-undo-tablespaces).

##### Dropping Undo Tablespaces

As of MySQL 8.0.14, undo tablespaces created using [**CREATE UNDO TABLESPACE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-tablespace) syntax can be dropped at runtime using [**DROP UNDO TABALESPACE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-tablespace) syntax.

An undo tablespace must be empty before it can be dropped. To empty an undo tablespace, the undo tablespace must first be marked as inactive using [**ALTER UNDO TABLESPACE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-tablespace) syntax so that the tablespace is no longer used for assigning rollback segments to new transactions.

ALTER UNDO TABLESPACE ***tablespace\_name*** SET INACTIVE;

After an undo tablespace is marked as inactive, transactions currently using rollback segments in the undo tablespace are permitted to finish, as are any transactions started before those transactions are completed. After transactions are completed, the purge system frees the rollback segments in the undo tablespace, and the undo tablespace is truncated to its initial size. (The same process is used when truncating undo tablespaces. See [Truncating Undo Tablespaces](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#truncate-undo-tablespace).) Once the undo tablespace is empty, it can be dropped.

DROP UNDO TABLESPACE ***tablespace\_name***;

**Note**

Alternatively, the undo tablespace can be left in an empty state and reactivated later, if needed, by issuing an [**ALTER UNDO TABLESPACE *tablespace\_name* SET ACTIVE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-tablespace) statement.

The state of an undo tablespace can be monitored by querying the [**INFORMATION\_SCHEMA.INNODB\_TABLESPACES**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-tablespaces-table) table.

SELECT NAME, STATE FROM INFORMATION\_SCHEMA.INNODB\_TABLESPACES

WHERE NAME LIKE '***tablespace\_name***';

An **inactive** state indicates that rollback segments in an undo tablespace are no longer used by new transactions. An **empty** state indicates that an undo tablespace is empty and ready to be dropped, or ready to be made active again using an [**ALTER UNDO TABLESPACE *tablespace\_name* SET ACTIVE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-tablespace) statement. Attempting to drop an undo tablespace that is not empty returns an error.

The default undo tablespaces (**innodb\_undo\_001** and **innodb\_undo\_002**) created when the MySQL instance is initialized cannot be dropped. They can, however, be made inactive using an [**ALTER UNDO TABLESPACE *tablespace\_name* SET INACTIVE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-tablespace) statement. Before a default undo tablespace can be made inactive, there must be an undo tablespace to take its place. A minimum of two active undo tablespaces are required at all times to support automated truncation of undo tablespaces.

##### Moving Undo Tablespaces

Undo tablespaces created with [**CREATE UNDO TABLESPACE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-tablespace) syntax can be moved while the server is offline to any known directory. Known directories are those defined by the [**innodb\_directories**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_directories) variable. Directories defined by [**innodb\_data\_home\_dir**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_data_home_dir), [**innodb\_undo\_directory**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_undo_directory), and [**datadir**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_datadir) are automatically appended to the [**innodb\_directories**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_directories) value regardless of whether the [**innodb\_directories**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_directories) variable is defined explicitly. Those directories and their subdirectories are scanned at startup for undo tablespaces files. An undo tablespace file moved to any of those directories is discovered at startup and assumed to be the undo tablespace that was moved.

The default undo tablespaces (**innodb\_undo\_001** and **innodb\_undo\_002**) created when the MySQL instance is initialized must reside in the directory defined by the [**innodb\_undo\_directory**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_undo_directory) variable. If the [**innodb\_undo\_directory**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_undo_directory) variable is undefined, default undo tablespaces reside in the data directory. If default undo tablespaces are moved while the server is offline, the server must be started with the [**innodb\_undo\_directory**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_undo_directory) variable configured to the new directory.

The I/O patterns for undo logs make undo tablespaces good candidates for [SSD](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_ssd) storage.

##### Configuring the Number of Rollback Segments

The [**innodb\_rollback\_segments**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_rollback_segments) variable defines the number of [rollback segments](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_rollback_segment) allocated to each undo tablespace and to the global temporary tablespace. The [**innodb\_rollback\_segments**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_rollback_segments) variable can be configured at startup or while the server is running.

The default setting for [**innodb\_rollback\_segments**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_rollback_segments) is 128, which is also the maximum value. For information about the number of transactions that a rollback segment supports, see [Section 15.6.6, “Undo Logs”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-undo-logs).

##### Truncating Undo Tablespaces

There are two methods of truncating undo tablespaces, which can be used individually or in combination to manage undo tablespace size. One method is automated, enabled using configuration variables. The other method is manual, performed using SQL statements.

The automated method does not require monitoring undo tablespace size and, once enabled, it performs deactivation, truncation, and reactivation of undo tablespaces without manual intervention. The manual truncation method may be preferable if you want to control when undo tablespaces are taken offline for truncation. For example, you may want to avoid truncating undo tablespaces during peak workload times.

###### Automated Truncation

Automated truncation of undo tablespaces requires a minimum of two active undo tablespaces, which ensures that one undo tablespace remains active while the other is taken offline to be truncated. By default, two undo tablespaces are created when the MySQL instance is initialized.

To have undo tablespaces automatically truncated, enable the [**innodb\_undo\_log\_truncate**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_undo_log_truncate) variable. For example:

mysql> **SET GLOBAL innodb\_undo\_log\_truncate=ON;**

When the [**innodb\_undo\_log\_truncate**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_undo_log_truncate) variable is enabled, undo tablespaces that exceed the size limit defined by the [**innodb\_max\_undo\_log\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_max_undo_log_size) variable are subject to truncation. The [**innodb\_max\_undo\_log\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_max_undo_log_size) variable is dynamic and has a default value of 1073741824 bytes (1024 MiB).

mysql> **SELECT @@innodb\_max\_undo\_log\_size;**

+----------------------------+

| @@innodb\_max\_undo\_log\_size |

+----------------------------+

| 1073741824 |

+----------------------------+

When the [**innodb\_undo\_log\_truncate**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_undo_log_truncate) variable is enabled:

Default and user-defined undo tablespaces that exceed the [**innodb\_max\_undo\_log\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_max_undo_log_size) setting are marked for truncation. Selection of an undo tablespace for truncation is performed in a circular fashion to avoid truncating the same undo tablespace each time.

Rollback segments residing in the selected undo tablespace are made inactive so that they are not assigned to new transactions. Existing transactions that are currently using rollback segments are permitted to finish.

The [purge](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_purge) system empties rollback segments by freeing undo logs that are no longer in use.

After all rollback segments in the undo tablespace are freed, the truncate operation runs and truncates the undo tablespace to its initial size.

The size of an undo tablespace after a truncate operation may be larger than the initial size due to immediate use following the completion of the operation.

The [**innodb\_undo\_directory**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_undo_directory) variable defines the location of default undo tablespace files. If the [**innodb\_undo\_directory**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_undo_directory) variable is undefined, default undo tablespaces reside in the data directory. The location of all undo tablespace files including user-defined undo tablespaces created using [**CREATE UNDO TABLESPACE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-tablespace) syntax can be determined by querying the [**INFORMATION\_SCHEMA.FILES**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-files-table) table:

SELECT TABLESPACE\_NAME, FILE\_NAME FROM INFORMATION\_SCHEMA.FILES WHERE FILE\_TYPE LIKE 'UNDO LOG';

Rollback segments are reactivated so that they can be assigned to new transactions.

###### Manual Truncation

Manual truncation of undo tablespaces requires a minimum of three active undo tablespaces. Two active undo tablespaces are required at all times to support the possibility that automated truncation is enabled. A minimum of three undo tablespaces satisfies this requirement while permitting an undo tablespace to be taken offline manually.

To manually initiate truncation of an undo tablespace, deactivate the undo tablespace by issuing the following statement:

ALTER UNDO TABLESPACE ***tablespace\_name*** SET INACTIVE;

After the undo tablespace is marked as inactive, transactions currently using rollback segments in the undo tablespace are permitted to finish, as are any transactions started before those transactions are completed. After transactions are completed, the purge system frees the rollback segments in the undo tablespace, the undo tablespace is truncated to its initial size, and the undo tablespace state changes from **inactive** to **empty**.

**Note**

When an **ALTER UNDO TABLESPACE *tablespace\_name* SET INACTIVE** statement deactivates an undo tablespace, the purge thread looks for that undo tablespace at the next opportunity. Once the undo tablespace is found and marked for truncation, the purge thread returns with increased frequency to quickly empty and truncate the undo tablespace.

To check the state of an undo tablespace, query the [**INFORMATION\_SCHEMA.INNODB\_TABLESPACES**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-tablespaces-table) table.

SELECT NAME, STATE FROM INFORMATION\_SCHEMA.INNODB\_TABLESPACES

WHERE NAME LIKE '***tablespace\_name***';

Once the undo tablespace is in an **empty** state, it can be reactivated by issuing the following statement:

ALTER UNDO TABLESPACE ***tablespace\_name*** SET ACTIVE;

An undo tablespace in an **empty** state can also be dropped. See [Dropping Undo Tablespaces](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-drop-undo-tablespaces).

###### Expediting Automated Truncation of Undo Tablespaces

The purge thread is responsible for emptying and truncating undo tablespaces. By default, the purge thread looks for undo tablespaces to truncate once every 128 times that purge is invoked. The frequency with which the purge thread looks for undo tablespaces to truncate is controlled by the [**innodb\_purge\_rseg\_truncate\_frequency**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_purge_rseg_truncate_frequency) variable, which has a default setting of 128.

mysql> **SELECT @@innodb\_purge\_rseg\_truncate\_frequency;**

+----------------------------------------+

| @@innodb\_purge\_rseg\_truncate\_frequency |

+----------------------------------------+

| 128 |

+----------------------------------------+

To increase the frequency, decrease the [**innodb\_purge\_rseg\_truncate\_frequency**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_purge_rseg_truncate_frequency) setting. For example, to have the purge thread look for undo tabespaces once every 32 times that purge is invoked, set [**innodb\_purge\_rseg\_truncate\_frequency**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_purge_rseg_truncate_frequency) to 32.

mysql> **SET GLOBAL innodb\_purge\_rseg\_truncate\_frequency=32;**

###### Performance Impact of Truncating Undo Tablespace Files

When an undo tablespace is truncated, the rollback segments in the undo tablespace are deactivated. The active rollback segments in other undo tablespaces assume responsibility for the entire system load, which may result in a slight performance degradation. The extent to which performance is affected depends on a number of factors:

Number of undo tablespaces

Number of undo logs

Undo tablespace size

Speed of the I/O susbsystem

Existing long running transactions

System load

The easiest way to avoid the potential performance impact is to increase the number of undo tablespaces.

###### Monitoring Undo Tablespace Truncation

As of MySQL 8.0.16, **undo** and **purge** susbsystem counters are provided for monitoring background activities associated with undo log truncation. For counter names and descriptions, query the [**INFORMATION\_SCHEMA.INNODB\_METRICS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-metrics-table) table.

SELECT NAME, SUBSYSTEM, COMMENT FROM INFORMATION\_SCHEMA.INNODB\_METRICS WHERE NAME LIKE '%truncate%';

For information about enabling counters and querying counter data, see [Section 15.15.6, “InnoDB INFORMATION\_SCHEMA Metrics Table”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-information-schema-metrics-table).

###### Undo Tablespace Truncation Limit

As of MySQL 8.0.21, the number of truncate operations on the same undo tablespace between checkpoints is limited to 64. The limit prevents potential issues caused by an excessive number of undo tablespace truncate operations, which can occur if [**innodb\_max\_undo\_log\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_max_undo_log_size) is set too low on a busy system, for example. If the limit is exceeded, an undo tablespace can still be made inactive, but it is not truncated until after the next checkpoint. The the limit was raised from 64 to 50,000 in MySQL 8.0.22.

###### Undo Tablespace Truncation Recovery

An undo tablespace truncate operation creates a temporary undo\_***space\_number***\_trunc.log file in the server log directory. That log directory is defined by [**innodb\_log\_group\_home\_dir**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_log_group_home_dir). If a system failure occurs during the truncate operation, the temporary log file permits the startup process to identify undo tablespaces that were being truncated and to continue the operation.

##### Undo Tablespace Status Variables

The following status variables permit tracking the total number of undo tablespaces, implicit (**InnoDB**-created) undo tablespaces, explicit (user-created) undo tablespaces, and the number of active undo tablespaces:

mysql> **SHOW STATUS LIKE 'Innodb\_undo\_tablespaces%';**

+----------------------------------+-------+

| Variable\_name | Value |

+----------------------------------+-------+

| Innodb\_undo\_tablespaces\_total | 2 |

| Innodb\_undo\_tablespaces\_implicit | 2 |

| Innodb\_undo\_tablespaces\_explicit | 0 |

| Innodb\_undo\_tablespaces\_active | 2 |

+----------------------------------+-------+

For status variable descriptions, see [Section 5.1.10, “Server Status Variables”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#server-status-variables).

#### 15.6.3.5 Temporary Tablespaces

**InnoDB** uses session temporary tablespaces and a global temporary tablespace.

##### Session Temporary Tablespaces

Session temporary tablespaces store user-created temporary tables and internal temporary tables created by the optimizer when **InnoDB** is configured as the storage engine for on-disk internal temporary tables. Beginning with MySQL 8.0.16, the storage engine used for on-disk internal temporary tables is always **InnoDB**. (Previously, the storage engine was determined by the value of [**internal\_tmp\_disk\_storage\_engine**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_internal_tmp_disk_storage_engine).)

Session temporary tablespaces are allocated to a session from a pool of temporary tablespaces on the first request to create an on-disk temporary table. A maximum of two tablespaces is allocated to a session, one for user-created temporary tables and the other for internal temporary tables created by the optimizer. The temporary tablespaces allocated to a session are used for all on-disk temporary tables created by the session. When a session disconnects, its temporary tablespaces are truncated and released back to the pool. A pool of 10 temporary tablespaces is created when the server is started. The size of the pool never shrinks and tablespaces are added to the pool automatically as necessary. The pool of temporary tablespaces is removed on normal shutdown or on an aborted initialization. Session temporary tablespace files are five pages in size when created and have an .ibt file name extension.

A range of 400 thousand space IDs is reserved for session temporary tablespaces. Because the pool of session temporary tablespaces is recreated each time the server is started, space IDs for session temporary tablespaces are not persisted when the server is shut down and may be reused.

The [**innodb\_temp\_tablespaces\_dir**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_temp_tablespaces_dir) variable defines the location where session temporary tablespaces are created. The default location is the #innodb\_temp directory in the data directory. Startup is refused if the pool of temporary tablespaces cannot be created.

shell> cd ***BASEDIR***/data/#innodb\_temp

shell> ls

temp\_10.ibt temp\_2.ibt temp\_4.ibt temp\_6.ibt temp\_8.ibt

temp\_1.ibt temp\_3.ibt temp\_5.ibt temp\_7.ibt temp\_9.ibt

In statement based replication (SBR) mode, temporary tables created on a replica reside in a single session temporary tablespace that is truncated only when the MySQL server is shut down.

The [**INNODB\_SESSION\_TEMP\_TABLESPACES**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-session-temp-tablespaces-table) table provides metadata about session temporary tablespaces.

The [**INFORMATION\_SCHEMA.INNODB\_TEMP\_TABLE\_INFO**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-temp-table-info-table) table provides metadata about user-created temporary tables that are active in an **InnoDB** instance.

##### Global Temporary Tablespace

The global temporary tablespace (ibtmp1) stores rollback segments for changes made to user-created temporary tables.

The [**innodb\_temp\_data\_file\_path**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_temp_data_file_path) variable defines the relative path, name, size, and attributes for global temporary tablespace data files. If no value is specified for [**innodb\_temp\_data\_file\_path**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_temp_data_file_path), the default behavior is to create a single auto-extending data file named ibtmp1 in the [**innodb\_data\_home\_dir**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_data_home_dir) directory. The initial file size is slightly larger than 12MB.

The global temporary tablespace is removed on normal shutdown or on an aborted initialization, and recreated each time the server is started. The global temporary tablespace receives a dynamically generated space ID when it is created. Startup is refused if the global temporary tablespace cannot be created. The global temporary tablespace is not removed if the server halts unexpectedly. In this case, a database administrator can remove the global temporary tablespace manually or restart the MySQL server. Restarting the MySQL server removes and recreates the global temporary tablespace automatically.

The global temporary tablespace cannot reside on a raw device.

[**INFORMATION\_SCHEMA.FILES**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-files-table) provides metadata about the global temporary tablespace. Issue a query similar to this one to view global temporary tablespace metadata:

mysql> **SELECT \* FROM INFORMATION\_SCHEMA.FILES WHERE TABLESPACE\_NAME='innodb\_temporary'\G**

By default, the global temporary tablespace data file is autoextending and increases in size as necessary.

To determine if a global temporary tablespace data file is autoextending, check the [**innodb\_temp\_data\_file\_path**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_temp_data_file_path) setting:

mysql> **SELECT @@innodb\_temp\_data\_file\_path;**

+------------------------------+

| @@innodb\_temp\_data\_file\_path |

+------------------------------+

| ibtmp1:12M:autoextend |

+------------------------------+

To check the size of global temporary tablespace data files, query the [**INFORMATION\_SCHEMA.FILES**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-files-table) table using a query similar to this one:

mysql> **SELECT FILE\_NAME, TABLESPACE\_NAME, ENGINE, INITIAL\_SIZE, TOTAL\_EXTENTS\*EXTENT\_SIZE**

**AS TotalSizeBytes, DATA\_FREE, MAXIMUM\_SIZE FROM INFORMATION\_SCHEMA.FILES**

**WHERE TABLESPACE\_NAME = 'innodb\_temporary'\G**

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\* 1. row \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

FILE\_NAME: ./ibtmp1

TABLESPACE\_NAME: innodb\_temporary

ENGINE: InnoDB

INITIAL\_SIZE: 12582912

TotalSizeBytes: 12582912

DATA\_FREE: 6291456

MAXIMUM\_SIZE: NULL

**TotalSizeBytes** shows the current size of the global temporary tablespace data file. For information about other field values, see [Section 26.3.15, “The INFORMATION\_SCHEMA FILES Table”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-files-table).

Alternatively, check the global temporary tablespace data file size on your operating system. The global temporary tablespace data file is located in the directory defined by the [**innodb\_temp\_data\_file\_path**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_temp_data_file_path) variable.

To reclaim disk space occupied by a global temporary tablespace data file, restart the MySQL server. Restarting the server removes and recreates the global temporary tablespace data file according to the attributes defined by [**innodb\_temp\_data\_file\_path**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_temp_data_file_path).

To limit the size of the global temporary tablespace data file, configure [**innodb\_temp\_data\_file\_path**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_temp_data_file_path) to specify a maximum file size. For example:

[mysqld]

innodb\_temp\_data\_file\_path=ibtmp1:12M:autoextend:max:500M

Configuring [**innodb\_temp\_data\_file\_path**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_temp_data_file_path) requires restarting the server.

#### 15.6.3.6 Moving Tablespace Files While the Server is Offline

The [**innodb\_directories**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_directories) option, which defines directories to scan at startup for tablespace files, supports moving or restoring tablespace files to a new location while the server is offline. During startup, discovered tablespace files are used instead those referenced in the data dictionary, and the data dictionary is updated to reference the relocated files. If duplicate tablespace files are discovered by the scan, startup fails with an error indicating that multiple files were found for the same tablespace ID.

The directories defined by the [**innodb\_data\_home\_dir**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_data_home_dir), [**innodb\_undo\_directory**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_undo_directory), and [**datadir**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_datadir) configuration options are automatically appended to the [**innodb\_directories**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_directories) argument value. These directories are scanned at startup regardless of whether the [**innodb\_directories**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_directories) option is specified explicitly. The implicit addition of these directories permits moving system tablespace files, the data directory, or undo tablespace files without configuring the [**innodb\_directories**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_directories) setting. However, settings must be updated when directories change. For example, after relocating the data directory, you must update the [**--datadir**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_datadir) setting before restarting the server.

The [**innodb\_directories**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_directories) option may be specified in a startup command or MySQL option file. Quotes are used around the argument value because otherwise a semicolon (;) is interpreted as a special character by some command interpreters. (Unix shells treat it as a command terminator, for example.)

Startup command:

mysqld --innodb-directories="***directory\_path\_1***;***directory\_path\_2***"

MySQL option file:

[mysqld]

innodb\_directories="***directory\_path\_1***;***directory\_path\_2***"

The following procedure is applicable to moving individual [file-per-table](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_file_per_table) and [general tablespace](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_general_tablespace) files, [system tablespace](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_system_tablespace) files, [undo tablespace](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_undo_tablespace) files, or the data directory. Before moving files or directories, review the usage notes that follow.

Stop the server.

Move the tablespace files or directories.

Make the new directory known to **InnoDB**.

If moving individual [file-per-table](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_file_per_table) or [general tablespace](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_general_tablespace) files, add unknown directories to the [**innodb\_directories**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_directories) value.

The directories defined by the [**innodb\_data\_home\_dir**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_data_home_dir), [**innodb\_undo\_directory**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_undo_directory), and [**datadir**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_datadir) configuration options are automatically appended to the [**innodb\_directories**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_directories) argument value, so you need not specify these.

A file-per-table tablespace file can only be moved to a directory with same name as the schema. For example, if the **actor** table belongs to the **sakila** schema, then the actor.ibd data file can only be moved to a directory named sakila.

General tablespace files cannot be moved to the data directory or a subdirectory of the data directory.

If moving system tablespace files, undo tablespaces, or the data directory, update the [**innodb\_data\_home\_dir**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_data_home_dir), [**innodb\_undo\_directory**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_undo_directory), and [**datadir**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_datadir) settings, as necessary.

Restart the server.

##### Usage Notes

Wildcard expressions cannot be used in the [**innodb\_directories**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_directories) argument value.

The [**innodb\_directories**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_directories) scan also traverses subdirectories of specified directories. Duplicate directories and subdirectories are discarded from the list of directories to be scanned.

The [**innodb\_directories**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_directories) option only supports moving **InnoDB** tablespace files. Moving files that belong to a storage engine other than **InnoDB** is not supported. This restriction also applies when moving the entire data directory.

The [**innodb\_directories**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_directories) option supports renaming of tablespace files when moving files to a scanned directory. It also supports moving tablespaces files to other supported operating systems.

When moving tablespace files to a different operating system, ensure that tablespace file names do not include prohibited characters or characters with a special meaning on the destination system.

When moving a data directory from a Windows operating system to a Linux operating system, modify the binary log file paths in the binary log index file to use backward slashes instead of forward slashes. By default, the binary log index file has the same base name as the binary log file, with the extension '.index'. The location of the binary log index file is defined by [--log-bin](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\replication.html#option_mysqld_log-bin). The default location is the data directory.

If moving tablespace files to a different operating system introduces cross-platform replication, it is the database administrator's responsibility to ensure proper replication of DDL statements that contain platform-specific directories. Statements that permit specifying directories include [**CREATE TABLE ... DATA DIRECTORY**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-table) and [**CREATE TABLESPACE ... ADD DATAFILE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-tablespace).

Add the directories of file-per-table and general tablespaces created with an absolute path or in a location outside of the data directory to the [**innodb\_directories**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_directories) setting. Otherwise, **InnoDB** is not able to locate the files during recovery. For related information, see [Tablespace Discovery During Crash Recovery](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-recovery-tablespace-discovery).

To view tablespace file locations, query the [**INFORMATION\_SCHEMA.FILES**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-files-table) table:

mysql> **SELECT TABLESPACE\_NAME, FILE\_NAME FROM INFORMATION\_SCHEMA.FILES \G**

#### 15.6.3.7 Disabling Tablespace Path Validation

At startup, **InnoDB** scans directories defined by the [**innodb\_directories**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_directories) variable for tablespace files. The paths of discovered tablespace files are validated against the paths recorded in the data dictionary. If the paths do not match, the paths in the data dictionary are updated.

The [**innodb\_validate\_tablespace\_paths**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_validate_tablespace_paths) variable, introduced in MySQL 8.0.21, permits disabling tablespace path validation. This feature is intended for environments where tablespaces files are not moved. Disabling path validation improves startup time on systems with a large number of tablespace files. If [**log\_error\_verbosity**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_log_error_verbosity) is set to 3, the following message is printed at startup when tablespace path validation is disabled:

[InnoDB] Skipping InnoDB tablespace path validation.

Manually moved tablespace files will not be detected!

**Warning**

Starting the server with tablespace path validation disabled after moving tablespace files can lead to undefined behavior.

#### 15.6.3.8 Optimizing Tablespace Space Allocation on Linux

As of MySQL 8.0.22, you can optimize how **InnoDB** allocates space to file-per-table and general tablespaces on Linux. By default, when additional space is required, **InnoDB** allocates pages to the tablespace and physically writes NULLs to those pages. This behavior can affect performance if new pages are allocated frequently. As of MySQL 8.0.22, you can disable [**innodb\_extend\_and\_initialize**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_extend_and_initialize) on Linux systems to avoid physically writing NULLs to newly allocated tablespace pages. When [**innodb\_extend\_and\_initialize**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_extend_and_initialize) is disabled, space is allocated to tablespace files using **posix\_fallocate()** calls, which reserve space without physically writing NULLs.

When pages are allocated using **posix\_fallocate()** calls, the extension size is small by default and pages are often allocated only a few at a time, which can cause fragmentation and increased random I/O. To avoid this potential issue, consider increasing the tablespace extension size when enabling **posix\_fallocate()** calls. Tablespace extension size can be increased up to 4GB using the **AUTOEXTEND\_SIZE** option. For more information, see [Section 15.6.3.9, “Tablespace AUTOEXTEND\_SIZE Configuration”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-tablespace-autoextend-size).

**InnoDB** writes a redo log record before allocating a new tablespace page. If a page allocation operation is interrupted, the operation is replayed from the redo log record during recovery. (A page allocation operation replayed from a redo log record physically writes NULLs to the newly allocated page.) A redo log record is written before allocating a page regardless of the [**innodb\_extend\_and\_initialize**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_extend_and_initialize) setting.

On non-Linux systems and Windows, **InnoDB** allocates new pages to the tablespace and physically writes NULLs to those pages, which is the default behavior. Attempting to disable [**innodb\_extend\_and\_initialize**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_extend_and_initialize) on those systems returns the following error:

Changing innodb\_extend\_and\_initialize not supported on this platform. Falling back to the default.

#### 15.6.3.9 Tablespace AUTOEXTEND\_SIZE Configuration

By default, when a file-per-table or general tablespace requires additional space, the tablespace is extended incrementally according to the following rules:

If the tablespace is less than an extent in size, it is extended one page at a time.

If the tablespace is greater than 1 extent but smaller than 32 extents in size, it is extended one extent at a time.

If the tablespace is more than 32 extents in size, it is extended four extents at a time.

For information about extent size, see [Section 15.11.2, “File Space Management”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-file-space).

From MySQL 8.0.23, the amount by which a file-per-table or general tablespace is extended is configurable by specifying the **AUTOEXTEND\_SIZE** option. Configuring a larger extension size can help avoid fragmentation and facilitate ingestion of large amounts of data.

To configure the extension size for a file-per-table tablespace, specify the **AUTOEXTEND\_SIZE** size in a [**CREATE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-table) or [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) statement:

CREATE TABLE t1 (c1 INT) AUTOEXTEND\_SIZE = 4M;

ALTER TABLE t1 AUTOEXTEND\_SIZE = 8M;

To configure the extension size for a general tablespace, specify the **AUTOEXTEND\_SIZE** size in a [**CREATE TABLESPACE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-tablespace) or [**ALTER TABLESPACE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-tablespace) statement:

CREATE TABLESPACE ts1 AUTOEXTEND\_SIZE = 4M;

ALTER TABLESPACE ts1 AUTOEXTEND\_SIZE = 8M;

**Note**

The **AUTOEXTEND\_SIZE** option can also be used when creating an undo tablespace, but the extension behavior for undo tablespaces differs. For more information, see [Section 15.6.3.4, “Undo Tablespaces”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-undo-tablespaces).

The **AUTOEXTEND\_SIZE** setting must be a multiple of 4M. Specifying an **AUTOEXTEND\_SIZE** setting that is not a multiple of 4M returns an error.

The **AUTOEXTEND\_SIZE** default setting is 0, which causes the tablespace to be extended according to the default behavior described above.

The maximum **AUTOEXTEND\_SIZE** setting is 64M in MySQL 8.0.23. From MySQL 8.0.24, the maximum setting is 4GB.

The minimum **AUTOEXTEND\_SIZE** setting depends on the **InnoDB** page size, as shown in the following table:

| **InnoDB Page Size** | **Minimum AUTOEXTEND\_SIZE** |
| --- | --- |
| **4K** | **4M** |
| **8K** | **4M** |
| **16K** | **4M** |
| **32K** | **8M** |
| **64K** | **16M** |

The default **InnoDB** page size is 16K (16384 bytes). To determine the **InnoDB** page size for your MySQL instance, query the [**innodb\_page\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_page_size) setting:

mysql> **SELECT @@GLOBAL.innodb\_page\_size;**

+---------------------------+

| @@GLOBAL.innodb\_page\_size |

+---------------------------+

| 16384 |

+---------------------------+

When the **AUTOEXTEND\_SIZE** setting for a tablespace is altered, the first extension that occurs afterward increases the tablespace size to a multiple of the **AUTOEXTEND\_SIZE** setting. Subsequent extensions are of the configured size.

When a file-per-table or general tablespace is created with a non-zero **AUTOEXTEND\_SIZE** setting, the tablespace is initialized at the specified **AUTOEXTEND\_SIZE** size.

[**ALTER TABLESPACE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-tablespace) cannot be used to configure the **AUTOEXTEND\_SIZE** of a file-per-table tablespace. [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) must be used.

For tables created in file-per-table tablespaces, [**SHOW CREATE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#show-create-table) shows the **AUTOEXTEND\_SIZE** option only when it is configured to a non-zero value.

To determine the **AUTOEXTEND\_SIZE** for any **InnoDB** tablespace, query the [**INFORMATION\_SCHEMA.INNODB\_TABLESPACES**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-tablespaces-table) table. For example:

mysql> **SELECT NAME, AUTOEXTEND\_SIZE FROM INFORMATION\_SCHEMA.INNODB\_TABLESPACES**

**WHERE NAME LIKE 'test/t1';**

+---------+-----------------+

| NAME | AUTOEXTEND\_SIZE |

+---------+-----------------+

| test/t1 | 4194304 |

+---------+-----------------+

mysql> **SELECT NAME, AUTOEXTEND\_SIZE FROM INFORMATION\_SCHEMA.INNODB\_TABLESPACES**

**WHERE NAME LIKE 'ts1';**

+------+-----------------+

| NAME | AUTOEXTEND\_SIZE |

+------+-----------------+

| ts1 | 4194304 |

+------+-----------------+

**Note**

An **AUTOEXTEND\_SIZE** of 0, which is the default setting, means that the tablespace is extended according to the default tablespace extension behavior described above.

### 15.6.4 Doublewrite Buffer

The doublewrite buffer is a storage area where **InnoDB** writes pages flushed from the buffer pool before writing the pages to their proper positions in the **InnoDB** data files. If there is an operating system, storage subsystem, or unexpected [**mysqld**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\programs.html#mysqld) process exit in the middle of a page write, **InnoDB** can find a good copy of the page from the doublewrite buffer during crash recovery.

Although data is written twice, the doublewrite buffer does not require twice as much I/O overhead or twice as many I/O operations. Data is written to the doublewrite buffer in a large sequential chunk, with a single **fsync()** call to the operating system (except in the case that **innodb\_flush\_method** is set to **O\_DIRECT\_NO\_FSYNC**).

Prior to MySQL 8.0.20, the doublewrite buffer storage area is located in the **InnoDB** system tablespace. As of MySQL 8.0.20, the doublewrite buffer storage area is located in doublewrite files.

The following variables are provided for doublewrite buffer configuration:

[**innodb\_doublewrite**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_doublewrite)

The [**innodb\_doublewrite**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_doublewrite) variable controls whether the doublwrite buffer is enabled. It is enabled by default in most cases. To disable the doublewrite buffer, set [**innodb\_doublewrite**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_doublewrite) to 0 or start the server with **--skip-innodb-doublewrite**. You might consider disabling the doublewrite buffer if you are more concerned with performance than data integrity, as may be the case when performing benchmarks, for example.

If the doublewrite buffer is located on a Fusion-io device that supports atomic writes, the doublewrite buffer is automatically disabled and data file writes are performed using Fusion-io atomic writes instead. However, be aware that the [**innodb\_doublewrite**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_doublewrite) setting is global. When the doublewrite buffer is disabled, it is disabled for all data files including those that do not reside on Fusion-io hardware. This feature is only supported on Fusion-io hardware and is only enabled for Fusion-io NVMFS on Linux. To take full advantage of this feature, an [**innodb\_flush\_method**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_flush_method) setting of **O\_DIRECT** is recommended.

[**innodb\_doublewrite\_dir**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_doublewrite_dir)

The [**innodb\_doublewrite\_dir**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_doublewrite_dir) variable (introduced in MySQL 8.0.20) defines the directory where **InnoDB** creates doublewrite files. If no directory is specified, doublewrite files are created in the [**innodb\_data\_home\_dir**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_data_home_dir) directory, which defaults to the data directory if unspecified.

A hash symbol '#' is automatically prefixed to the specified directory name to avoid conflicts with schema names. However, if a '.', '#'. or '/' prefix is specified explicitly in the directory name, the hash symbol '#' is not prefixed to the directory name.

Ideally, the doublewrite directory should be placed on the fastest storage media available.

[**innodb\_doublewrite\_files**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_doublewrite_files)

The [**innodb\_doublewrite\_files**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_doublewrite_files) variable defines the number of doublewrite files. By default, two doublewrite files are created for each buffer pool instance: A flush list doublewrite file and an LRU list doublewrite file.

The flush list doublewrite file is for pages flushed from the buffer pool flush list. The default size of a flush list doublewrite file is the **InnoDB** page size \* doublewrite page bytes.

The LRU list doublewrite file is for pages flushed from the buffer pool LRU list. It also contains slots for single page flushes. The default size of an LRU list doublewrite file is the **InnoDB** page size \* (doublewrite pages + (512 / the number of buffer pool instances)) where 512 is the total number of slots reserved for single page flushes.

At a minimum, there are two doublewrite files. The maximum number of doublewrite files is two times the number of buffer pool instances. (The number of buffer pool instances is controlled by the [**innodb\_buffer\_pool\_instances**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_instances) variable.)

Doublewrite file names have the following format: #ib\_***page\_size***\_***file\_number***.dblwr. For example, the following doublewrite files are created for a MySQL instance with an **InnoDB** pages size of 16KB and a single buffer pool:

#ib\_16384\_0.dblwr

#ib\_16384\_1.dblwr

The [**innodb\_doublewrite\_files**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_doublewrite_files) variable is intended for advanced performance tuning. The default setting should be suitable for most users.

[**innodb\_doublewrite\_pages**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_doublewrite_pages)

The [**innodb\_doublewrite\_pages**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_doublewrite_pages) variable (introduced in MySQL 8.0.20) controls the maximum number of doublewrite pages per thread. If no value is specified, [**innodb\_doublewrite\_pages**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_doublewrite_pages) is set to the [**innodb\_write\_io\_threads**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_write_io_threads) value. This variable is intended for advanced performance tuning. The default value should be suitable for most users.

[**innodb\_doublewrite\_batch\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_doublewrite_batch_size)

The [**innodb\_doublewrite\_batch\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_doublewrite_batch_size) variable (introduced in MySQL 8.0.20) controls the number of doublewrite pages to write in a batch. This variable is intended for advanced performance tuning. The default value should be suitable for most users.

As of MySQL 8.0.23, **InnoDB** automatically encrypts doublewrite file pages that belong to encrypted tablespaces (see [Section 15.13, “InnoDB Data-at-Rest Encryption”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-data-encryption)). Likewise, doublewrite file pages belonging page-compressed tablespaces are compressed. As a result, doublewrite files can contain different page types including unencrypted and uncompressed pages, encrypted pages, compressed pages, and pages that are both encrypted and compressed.

### 15.6.5 Redo Log

The redo log is a disk-based data structure used during crash recovery to correct data written by incomplete transactions. During normal operations, the redo log encodes requests to change table data that result from SQL statements or low-level API calls. Modifications that did not finish updating the data files before an unexpected shutdown are replayed automatically during initialization, and before connections are accepted. For information about the role of the redo log in crash recovery, see [Section 15.18.2, “InnoDB Recovery”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-recovery).

By default, the redo log is physically represented on disk by two files named ib\_logfile0 and ib\_logfile1. MySQL writes to the redo log files in a circular fashion. Data in the redo log is encoded in terms of records affected; this data is collectively referred to as redo. The passage of data through the redo log is represented by an ever-increasing [LSN](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_lsn) value.

Information and procedures related to redo logs are described under the following topics in the section:

[Changing the Number or Size of Redo Log Files](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-redo-log-file-reconfigure)

[Group Commit for Redo Log Flushing](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-performance-group_commit)

[Redo Log Archiving](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-redo-log-archiving)

[Disabling Redo Logging](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-disable-redo-logging)

[Related Topics](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-redo-log-related-topics)

#### Changing the Number or Size of Redo Log Files

To change the number or the size of [redo log](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_redo_log) files, perform the following steps:

Stop the MySQL server and make sure that it shuts down without errors.

Edit my.cnf to change the log file configuration. To change the log file size, configure [**innodb\_log\_file\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_log_file_size). To increase the number of log files, configure [**innodb\_log\_files\_in\_group**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_log_files_in_group).

Start the MySQL server again.

If **InnoDB** detects that the [**innodb\_log\_file\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_log_file_size) differs from the redo log file size, it writes a log checkpoint, closes and removes the old log files, creates new log files at the requested size, and opens the new log files.

#### Group Commit for Redo Log Flushing

**InnoDB**, like any other [ACID](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_acid)-compliant database engine, flushes the [redo log](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_redo_log) of a transaction before it is committed. **InnoDB** uses [group commit](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_group_commit) functionality to group multiple flush requests together to avoid one flush for each commit. With group commit, **InnoDB** issues a single write to the log file to perform the commit action for multiple user transactions that commit at about the same time, significantly improving throughput.

#### Redo Log Archiving

Backup utilities that copy redo log records may sometimes fail to keep pace with redo log generation while a backup operation is in progress, resulting in lost redo log records due to those records being overwritten. This issue most often occurs when there is significant MySQL server activity during the backup operation, and the redo log file storage media operates at a faster speed than the backup storage media. The redo log archiving feature, introduced in MySQL 8.0.17, addresses this issue by sequentially writing redo log records to an archive file in addition to the redo log files. Backup utilities can copy redo log records from the archive file as necessary, thereby avoiding the potential loss of data.

If redo log archiving is configured on the server, [MySQL Enterprise Backup](https://dev.mysql.com/doc/mysql-enterprise-backup/8.0/en/), available with the [MySQL Enterprise Edition](https://www.mysql.com/products/enterprise/), uses the redo log archiving feature when backing up a MySQL server.

Enabling redo log archiving on the server requires setting a value for the [**innodb\_redo\_log\_archive\_dirs**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_redo_log_archive_dirs) system variable. The value is specified as a semicolon-separated list of labeled redo log archive directories. The ***label:directory*** pair is separated by a colon (**:**). For example:

mysql> SET GLOBAL innodb\_redo\_log\_archive\_dirs='***label1***:***directory\_path1***[;***label2***:***directory\_path2***;…]';

The ***label*** is an arbitrary identifier for the archive directory. It can be any string of characters, with the exception of colons (:), which are not permitted. An empty label is also permitted, but the colon (:) is still required in this case. A ***directory\_path*** must be specified. The directory selected for the redo log archive file must exist when redo log archiving is activated, or an error is returned. The path can contain colons (':'), but semicolons (;) are not permitted.

The [**innodb\_redo\_log\_archive\_dirs**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_redo_log_archive_dirs) variable must be configured before the redo log archiving can be activated. The default value is **NULL**, which does not permit activating redo log archiving.

**Notes**

The archive directories that you specify must satisfy the following requirements. (The requirements are enforced when redo log archiving is activated.):

Directories must exist. Directories are not created by the redo log archive process. Otherwise, the following error is returned:

ERROR 3844 (HY000): Redo log archive directory '***directory\_path1***' does not exist or is not a directory

Directories must not be world-accessible. This is to prevent the redo log data from being exposed to unauthorized users on the system. Otherwise, the following error is returned:

ERROR 3846 (HY000): Redo log archive directory '***directory\_path1***' is accessible to all OS users

Directories cannot be those defined by [**datadir**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_datadir), [**innodb\_data\_home\_dir**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_data_home_dir), [**innodb\_directories**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_directories), [**innodb\_log\_group\_home\_dir**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_log_group_home_dir), [**innodb\_temp\_tablespaces\_dir**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_temp_tablespaces_dir), [**innodb\_tmpdir**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_tmpdir) [**innodb\_undo\_directory**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_undo_directory), or [**secure\_file\_priv**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_secure_file_priv), nor can they be parent directories or subdirectories of those directories. Otherwise, an error similar to the following is returned:

ERROR 3845 (HY000): Redo log archive directory '***directory\_path1***' is in, under, or over server directory 'datadir' - '***/path/to/data\_directory***'

When a backup utility that supports redo log archiving initiates a backup, the backup utility activates redo log archiving by invoking the **innodb\_redo\_log\_archive\_start()** user-defined function.

If you are not using a backup utility that supports redo log archiving, redo log archiving can also be activated manually, as shown:

mysql> SELECT innodb\_redo\_log\_archive\_start('***label***', '***subdir***');

+------------------------------------------+

| innodb\_redo\_log\_archive\_start('***label***') |

+------------------------------------------+

| 0 |

+------------------------------------------+

Or:

mysql> **DO innodb\_redo\_log\_archive\_start('*label*', '*subdir*');**

Query OK, 0 rows affected (0.09 sec)

**Note**

The MySQL session that activates redo log archiving (using **innodb\_redo\_log\_archive\_start()**) must remain open for the duration of the archiving. The same session must deactivate redo log archiving (using **innodb\_redo\_log\_archive\_stop()**). If the session is terminated before the redo log archiving is explicitly deactivated, the server deactivates redo log archiving implicitly and removes the redo log archive file.

where ***label*** is a label defined by [**innodb\_redo\_log\_archive\_dirs**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_redo_log_archive_dirs); **subdir** is an optional argument for specifying a subdirectory of the directory identified by ***label*** for saving the archive file; it must be a simple directory name (no slash (/), backslash (\), or colon (:) is permitted). **subdir** can be empty, null, or it can be left out.

Only users with the [**INNODB\_REDO\_LOG\_ARCHIVE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\security.html#priv_innodb-redo-log-archive) privilege can activate redo log archiving by invoking **innodb\_redo\_log\_archive\_start()**, or deactivate it using **innodb\_redo\_log\_archive\_stop()**. The MySQL user running the backup utility or the MySQL user activating and deactivating redo log archiving manually must have this privilege.

The redo log archive file path is ***directory\_identified\_by\_label***/[***subdir***/]archive.***serverUUID***.000001.log, where ***directory\_identified\_by\_label*** is the archive directory identified by the ***label*** argument for **innodb\_redo\_log\_archive\_start()**. ***subdir*** is the optional argument used for **innodb\_redo\_log\_archive\_start()**.

For example, the full path and name for a redo log archive file appears similar to the following:

/***directory\_path***/***subdirectory***/archive.e71a47dc-61f8-11e9-a3cb-080027154b4d.000001.log

After the backup utility finishes copying **InnoDB** data files, it deactivates redo log archiving by calling the **innodb\_redo\_log\_archive\_stop()** user-defined function.

If you are not using a backup utility that supports redo log archiving, redo log archiving can also be deactivated manually, as shown:

mysql> **SELECT innodb\_redo\_log\_archive\_stop();**

+--------------------------------+

| innodb\_redo\_log\_archive\_stop() |

+--------------------------------+

| 0 |

+--------------------------------+

Or:

mysql> **DO innodb\_redo\_log\_archive\_stop();**

Query OK, 0 rows affected (0.01 sec)

After the stop function completes successfully, the backup utility looks for the relevant section of redo log data from the archive file and copies it into the backup.

After the backup utility finishes copying the redo log data and no longer needs the redo log archive file, it deletes the archive file.

Removal of the archive file is the responsibility of the backup utility in normal situations. However, if the redo log archiving operation quits unexpectedly before **innodb\_redo\_log\_archive\_stop()** is called, the MySQL server removes the file.

##### Performance Considerations

Activating redo log archiving typically has a minor performance cost due to the additional write activity.

On Unix and Unix-like operating systems, the performance impact is typically minor, assuming there is not a sustained high rate of updates. On Windows, the performance impact is typically a bit higher, assuming the same.

If there is a sustained high rate of updates and the redo log archive file is on the same storage media as the redo log files, the performance impact may be more significant due to compounded write activity.

If there is a sustained high rate of updates and the redo log archive file is on slower storage media than the redo log files, performance is impacted arbitrarily.

Writing to the redo log archive file does not impede normal transactional logging except in the case that the redo log archive file storage media operates at a much slower rate than the redo log file storage media, and there is a large backlog of persisted redo log blocks waiting to be written to the redo log archive file. In this case, the transactional logging rate is reduced to a level that can be managed by the slower storage media where the redo log archive file resides.

#### Disabling Redo Logging

As of MySQL 8.0.21, you can disable redo logging using the [**ALTER INSTANCE DISABLE INNODB REDO\_LOG**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-instance) statement. This functionality is intended for loading data into a new MySQL instance. Disabling redo logging speeds up data loading by avoiding redo log writes and doublewrite buffering.

**Warning**

This feature is intended only for loading data into a new MySQL instance. Do not disable redo logging on a production system. It is permitted to shutdown and restart the server while redo logging is disabled, but an unexpected server stoppage while redo logging is disabled can cause data loss and instance corruption.

Attempting to restart the server after an unexpected server stoppage while redo logging is disabled is refused with the following error:

[ERROR] [MY-013578] [InnoDB] Server was killed when Innodb Redo

logging was disabled. Data files could be corrupt. You can try

to restart the database with innodb\_force\_recovery=6

In this case, initialize a new MySQL instance and start the data loading procedure again.

The [**INNODB\_REDO\_LOG\_ENABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\security.html#priv_innodb-redo-log-enable) privilege is required to enable and disable redo logging.

The [**Innodb\_redo\_log\_enabled**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#statvar_Innodb_redo_log_enabled) status variable permits monitoring redo logging status.

Cloning operations and redo log archiving are not permitted while redo logging is disabled and vice versa.

An [**ALTER INSTANCE [ENABLE|DISABLE] INNODB REDO\_LOG**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-instance) operation requires an exclusive backup metadata lock, which prevents other [**ALTER INSTANCE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-instance) operations from executing concurrently. Other [**ALTER INSTANCE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-instance) operations must wait for the lock to be released before executing.

The following procedure demonstrates how to disable redo logging when loading data into a new MySQL instance.

On the new MySQL instance, grant the [**INNODB\_REDO\_LOG\_ENABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\security.html#priv_innodb-redo-log-enable) privilege to the user account responsible for disabling redo logging.

mysql> GRANT INNODB\_REDO\_LOG\_ENABLE ON \*.\* to 'data\_load\_admin';

As the **data\_load\_admin** user, disable redo logging:

mysql> ALTER INSTANCE DISABLE INNODB REDO\_LOG;

Check the [**Innodb\_redo\_log\_enabled**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#statvar_Innodb_redo_log_enabled) status variable to ensure that redo logging is disabled.

mysql> **SHOW GLOBAL STATUS LIKE 'Innodb\_redo\_log\_enabled';**

+-------------------------+-------+

| Variable\_name | Value |

+-------------------------+-------+

| Innodb\_redo\_log\_enabled | OFF |

+-------------------------+-------+

Run the data load operation.

As the **data\_load\_admin** user, enable redo logging after the data load operation finishes:

mysql> ALTER INSTANCE ENABLE INNODB REDO\_LOG;

Check the [**Innodb\_redo\_log\_enabled**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#statvar_Innodb_redo_log_enabled) status variable to ensure that redo logging is enabled.

mysql> **SHOW GLOBAL STATUS LIKE 'Innodb\_redo\_log\_enabled';**

+-------------------------+-------+

| Variable\_name | Value |

+-------------------------+-------+

| Innodb\_redo\_log\_enabled | ON |

+-------------------------+-------+

#### Related Topics

[Redo Log File Configuration](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-startup-log-file-configuration)

[Section 8.5.4, “Optimizing InnoDB Redo Logging”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizing-innodb-logging)

[Redo Log Encryption](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-data-encryption-redo-log)

### 15.6.6 Undo Logs

An undo log is a collection of undo log records associated with a single read-write transaction. An undo log record contains information about how to undo the latest change by a transaction to a [clustered index](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_clustered_index) record. If another transaction needs to see the original data as part of a consistent read operation, the unmodified data is retrieved from undo log records. Undo logs exist within [undo log segments](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_undo_log_segment), which are contained within [rollback segments](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_rollback_segment). Rollback segments reside in [undo tablespaces](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_undo_tablespace) and in the [global temporary tablespace](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_global_temporary_tablespace).

Undo logs that reside in the global temporary tablespace are used for transactions that modify data in user-defined temporary tables. These undo logs are not redo-logged, as they are not required for crash recovery. They are used only for rollback while the server is running. This type of undo log benefits performance by avoiding redo logging I/O.

For information about data-at-rest encryption for undo logs, see [Undo Log Encryption](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-data-encryption-undo-log).

Each undo tablespace and the global temporary tablespace individually support a maximum of 128 rollback segments. The [**innodb\_rollback\_segments**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_rollback_segments) variable defines the number of rollback segments.

The number of transactions that a rollback segment supports depends on the number of undo slots in the rollback segment and the number of undo logs required by each transaction. The number of undo slots in a rollback segment differs according to **InnoDB** page size.

| **InnoDB Page Size** | **Number of Undo Slots in a Rollback Segment (InnoDB Page Size / 16)** |
| --- | --- |
| **4096 (4KB)** | **256** |
| **8192 (8KB)** | **512** |
| **16384 (16KB)** | **1024** |
| **32768 (32KB)** | **2048** |
| **65536 (64KB)** | **4096** |

A transaction is assigned up to four undo logs, one for each of the following operation types:

[**INSERT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#insert) operations on user-defined tables

[**UPDATE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#update) and [**DELETE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#delete) operations on user-defined tables

[**INSERT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#insert) operations on user-defined temporary tables

[**UPDATE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#update) and [**DELETE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#delete) operations on user-defined temporary tables

Undo logs are assigned as needed. For example, a transaction that performs [**INSERT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#insert), [**UPDATE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#update), and [**DELETE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#delete) operations on regular and temporary tables requires a full assignment of four undo logs. A transaction that performs only [**INSERT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#insert) operations on regular tables requires a single undo log.

A transaction that performs operations on regular tables is assigned undo logs from an assigned undo tablespace rollback segment. A transaction that performs operations on temporary tables is assigned undo logs from an assigned global temporary tablespace rollback segment.

An undo log assigned to a transaction remains attached to the transaction for its duration. For example, an undo log assigned to a transaction for an [**INSERT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#insert) operation on a regular table is used for all [**INSERT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#insert) operations on regular tables performed by that transaction.

Given the factors described above, the following formulas can be used to estimate the number of concurrent read-write transactions that **InnoDB** is capable of supporting.

**Note**

It is possible to encounter a concurrent transaction limit error before reaching the number of concurrent read-write transactions that **InnoDB** is capable of supporting. This occurs when a rollback segment assigned to a transaction runs out of undo slots. In such cases, try rerunning the transaction.

When transactions perform operations on temporary tables, the number of concurrent read-write transactions that **InnoDB** is capable of supporting is constrained by the number of rollback segments allocated to the global temporary tablespace, which is 128 by default.

If each transaction performs either an [**INSERT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#insert) ***or*** an [**UPDATE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#update) or [**DELETE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#delete) operation, the number of concurrent read-write transactions that **InnoDB** is capable of supporting is:

(innodb\_page\_size / 16) \* innodb\_rollback\_segments \* number of undo tablespaces

If each transaction performs an [**INSERT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#insert) ***and*** an [**UPDATE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#update) or [**DELETE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#delete) operation, the number of concurrent read-write transactions that **InnoDB** is capable of supporting is:

(innodb\_page\_size / 16 / 2) \* innodb\_rollback\_segments \* number of undo tablespaces

If each transaction performs an [**INSERT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#insert) operation on a temporary table, the number of concurrent read-write transactions that **InnoDB** is capable of supporting is:

(innodb\_page\_size / 16) \* innodb\_rollback\_segments

If each transaction performs an [**INSERT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#insert) ***and*** an [**UPDATE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#update) or [**DELETE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#delete) operation on a temporary table, the number of concurrent read-write transactions that **InnoDB** is capable of supporting is:

(innodb\_page\_size / 16 / 2) \* innodb\_rollback\_segments

## 15.7 InnoDB Locking and Transaction Model

[15.7.1 InnoDB Locking](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-locking)

[15.7.2 InnoDB Transaction Model](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-transaction-model)

[15.7.3 Locks Set by Different SQL Statements in InnoDB](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-locks-set)

[15.7.4 Phantom Rows](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-next-key-locking)

[15.7.5 Deadlocks in InnoDB](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-deadlocks)

[15.7.6 Transaction Scheduling](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-transaction-scheduling)

To implement a large-scale, busy, or highly reliable database application, to port substantial code from a different database system, or to tune MySQL performance, it is important to understand **InnoDB** locking and the **InnoDB** transaction model.

This section discusses several topics related to **InnoDB** locking and the **InnoDB** transaction model with which you should be familiar.

[Section 15.7.1, “InnoDB Locking”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-locking) describes lock types used by **InnoDB**.

[Section 15.7.2, “InnoDB Transaction Model”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-transaction-model) describes transaction isolation levels and the locking strategies used by each. It also discusses the use of [**autocommit**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_autocommit), consistent non-locking reads, and locking reads.

[Section 15.7.3, “Locks Set by Different SQL Statements in InnoDB”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-locks-set) discusses specific types of locks set in **InnoDB** for various statements.

[Section 15.7.4, “Phantom Rows”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-next-key-locking) describes how **InnoDB** uses next-key locking to avoid phantom rows.

[Section 15.7.5, “Deadlocks in InnoDB”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-deadlocks) provides a deadlock example, discusses deadlock detection, and provides tips for minimizing and handling deadlocks in **InnoDB**.

### 15.7.1 InnoDB Locking

This section describes lock types used by **InnoDB**.

[Shared and Exclusive Locks](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-shared-exclusive-locks)

[Intention Locks](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-intention-locks)

[Record Locks](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-record-locks)

[Gap Locks](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-gap-locks)

[Next-Key Locks](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-next-key-locks)

[Insert Intention Locks](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-insert-intention-locks)

[AUTO-INC Locks](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-auto-inc-locks)

[Predicate Locks for Spatial Indexes](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-predicate-locks)

#### Shared and Exclusive Locks

**InnoDB** implements standard row-level locking where there are two types of locks, [shared (**S**) locks](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_shared_lock) and [exclusive (**X**) locks](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_exclusive_lock).

A [shared (**S**) lock](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_shared_lock) permits the transaction that holds the lock to read a row.

An [exclusive (**X**) lock](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_exclusive_lock) permits the transaction that holds the lock to update or delete a row.

If transaction **T1** holds a shared (**S**) lock on row **r**, then requests from some distinct transaction **T2** for a lock on row **r** are handled as follows:

A request by **T2** for an **S** lock can be granted immediately. As a result, both **T1** and **T2** hold an **S** lock on **r**.

A request by **T2** for an **X** lock cannot be granted immediately.

If a transaction **T1** holds an exclusive (**X**) lock on row **r**, a request from some distinct transaction **T2** for a lock of either type on **r** cannot be granted immediately. Instead, transaction **T2** has to wait for transaction **T1** to release its lock on row **r**.

#### Intention Locks

**InnoDB** supports multiple granularity locking which permits coexistence of row locks and table locks. For example, a statement such as [**LOCK TABLES ... WRITE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#lock-tables) takes an exclusive lock (an **X** lock) on the specified table. To make locking at multiple granularity levels practical, **InnoDB** uses [intention locks](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_intention_lock). Intention locks are table-level locks that indicate which type of lock (shared or exclusive) a transaction requires later for a row in a table. There are two types of intention locks:

An [intention shared lock](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_intention_shared_lock) (**IS**) indicates that a transaction intends to set a shared lock on individual rows in a table.

An [intention exclusive lock](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_intention_exclusive_lock) (**IX**) indicates that a transaction intends to set an exclusive lock on individual rows in a table.

For example, [**SELECT ... FOR SHARE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#select) sets an **IS** lock, and [**SELECT ... FOR UPDATE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#select) sets an **IX** lock.

The intention locking protocol is as follows:

Before a transaction can acquire a shared lock on a row in a table, it must first acquire an **IS** lock or stronger on the table.

Before a transaction can acquire an exclusive lock on a row in a table, it must first acquire an **IX** lock on the table.

Table-level lock type compatibility is summarized in the following matrix.

|  | **X** | **IX** | **S** | **IS** |
| --- | --- | --- | --- | --- |
| **X** | Conflict | Conflict | Conflict | Conflict |
| **IX** | Conflict | Compatible | Conflict | Compatible |
| **S** | Conflict | Conflict | Compatible | Compatible |
| **IS** | Conflict | Compatible | Compatible | Compatible |

A lock is granted to a requesting transaction if it is compatible with existing locks, but not if it conflicts with existing locks. A transaction waits until the conflicting existing lock is released. If a lock request conflicts with an existing lock and cannot be granted because it would cause [deadlock](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_deadlock), an error occurs.

Intention locks do not block anything except full table requests (for example, [**LOCK TABLES ... WRITE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#lock-tables)). The main purpose of intention locks is to show that someone is locking a row, or going to lock a row in the table.

Transaction data for an intention lock appears similar to the following in [**SHOW ENGINE INNODB STATUS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#show-engine) and [InnoDB monitor](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-standard-monitor) output:

TABLE LOCK table `test`.`t` trx id 10080 lock mode IX

#### Record Locks

A record lock is a lock on an index record. For example, **SELECT c1 FROM t WHERE c1 = 10 FOR UPDATE;** prevents any other transaction from inserting, updating, or deleting rows where the value of **t.c1** is **10**.

Record locks always lock index records, even if a table is defined with no indexes. For such cases, **InnoDB** creates a hidden clustered index and uses this index for record locking. See [Section 15.6.2.1, “Clustered and Secondary Indexes”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-index-types).

Transaction data for a record lock appears similar to the following in [**SHOW ENGINE INNODB STATUS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#show-engine) and [InnoDB monitor](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-standard-monitor) output:

RECORD LOCKS space id 58 page no 3 n bits 72 index `PRIMARY` of table `test`.`t`

trx id 10078 lock\_mode X locks rec but not gap

Record lock, heap no 2 PHYSICAL RECORD: n\_fields 3; compact format; info bits 0

0: len 4; hex 8000000a; asc ;;

1: len 6; hex 00000000274f; asc 'O;;

2: len 7; hex b60000019d0110; asc ;;

#### Gap Locks

A gap lock is a lock on a gap between index records, or a lock on the gap before the first or after the last index record. For example, **SELECT c1 FROM t WHERE c1 BETWEEN 10 and 20 FOR UPDATE;** prevents other transactions from inserting a value of **15** into column **t.c1**, whether or not there was already any such value in the column, because the gaps between all existing values in the range are locked.

A gap might span a single index value, multiple index values, or even be empty.

Gap locks are part of the tradeoff between performance and concurrency, and are used in some transaction isolation levels and not others.

Gap locking is not needed for statements that lock rows using a unique index to search for a unique row. (This does not include the case that the search condition includes only some columns of a multiple-column unique index; in that case, gap locking does occur.) For example, if the **id** column has a unique index, the following statement uses only an index-record lock for the row having **id** value 100 and it does not matter whether other sessions insert rows in the preceding gap:

SELECT \* FROM child WHERE id = 100;

If **id** is not indexed or has a nonunique index, the statement does lock the preceding gap.

It is also worth noting here that conflicting locks can be held on a gap by different transactions. For example, transaction A can hold a shared gap lock (gap S-lock) on a gap while transaction B holds an exclusive gap lock (gap X-lock) on the same gap. The reason conflicting gap locks are allowed is that if a record is purged from an index, the gap locks held on the record by different transactions must be merged.

Gap locks in **InnoDB** are “purely inhibitive”, which means that their only purpose is to prevent other transactions from inserting to the gap. Gap locks can co-exist. A gap lock taken by one transaction does not prevent another transaction from taking a gap lock on the same gap. There is no difference between shared and exclusive gap locks. They do not conflict with each other, and they perform the same function.

Gap locking can be disabled explicitly. This occurs if you change the transaction isolation level to [**READ COMMITTED**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#isolevel_read-committed). Under these circumstances, gap locking is disabled for searches and index scans and is used only for foreign-key constraint checking and duplicate-key checking.

There are also other effects of using the [**READ COMMITTED**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#isolevel_read-committed) isolation level. Record locks for nonmatching rows are released after MySQL has evaluated the **WHERE** condition. For **UPDATE** statements, **InnoDB** does a “semi-consistent” read, such that it returns the latest committed version to MySQL so that MySQL can determine whether the row matches the **WHERE** condition of the [**UPDATE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#update).

#### Next-Key Locks

A next-key lock is a combination of a record lock on the index record and a gap lock on the gap before the index record.

**InnoDB** performs row-level locking in such a way that when it searches or scans a table index, it sets shared or exclusive locks on the index records it encounters. Thus, the row-level locks are actually index-record locks. A next-key lock on an index record also affects the “gap” before that index record. That is, a next-key lock is an index-record lock plus a gap lock on the gap preceding the index record. If one session has a shared or exclusive lock on record **R** in an index, another session cannot insert a new index record in the gap immediately before **R** in the index order.

Suppose that an index contains the values 10, 11, 13, and 20. The possible next-key locks for this index cover the following intervals, where a round bracket denotes exclusion of the interval endpoint and a square bracket denotes inclusion of the endpoint:

(negative infinity, 10]

(10, 11]

(11, 13]

(13, 20]

(20, positive infinity)

For the last interval, the next-key lock locks the gap above the largest value in the index and the “supremum” pseudo-record having a value higher than any value actually in the index. The supremum is not a real index record, so, in effect, this next-key lock locks only the gap following the largest index value.

By default, **InnoDB** operates in [**REPEATABLE READ**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#isolevel_repeatable-read) transaction isolation level. In this case, **InnoDB** uses next-key locks for searches and index scans, which prevents phantom rows (see [Section 15.7.4, “Phantom Rows”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-next-key-locking)).

Transaction data for a next-key lock appears similar to the following in [**SHOW ENGINE INNODB STATUS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#show-engine) and [InnoDB monitor](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-standard-monitor) output:

RECORD LOCKS space id 58 page no 3 n bits 72 index `PRIMARY` of table `test`.`t`

trx id 10080 lock\_mode X

Record lock, heap no 1 PHYSICAL RECORD: n\_fields 1; compact format; info bits 0

0: len 8; hex 73757072656d756d; asc supremum;;

Record lock, heap no 2 PHYSICAL RECORD: n\_fields 3; compact format; info bits 0

0: len 4; hex 8000000a; asc ;;

1: len 6; hex 00000000274f; asc 'O;;

2: len 7; hex b60000019d0110; asc ;;

#### Insert Intention Locks

An insert intention lock is a type of gap lock set by [**INSERT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#insert) operations prior to row insertion. This lock signals the intent to insert in such a way that multiple transactions inserting into the same index gap need not wait for each other if they are not inserting at the same position within the gap. Suppose that there are index records with values of 4 and 7. Separate transactions that attempt to insert values of 5 and 6, respectively, each lock the gap between 4 and 7 with insert intention locks prior to obtaining the exclusive lock on the inserted row, but do not block each other because the rows are nonconflicting.

The following example demonstrates a transaction taking an insert intention lock prior to obtaining an exclusive lock on the inserted record. The example involves two clients, A and B.

Client A creates a table containing two index records (90 and 102) and then starts a transaction that places an exclusive lock on index records with an ID greater than 100. The exclusive lock includes a gap lock before record 102:

mysql> **CREATE TABLE child (id int(11) NOT NULL, PRIMARY KEY(id)) ENGINE=InnoDB;**

mysql> **INSERT INTO child (id) values (90),(102);**

mysql> **START TRANSACTION;**

mysql> **SELECT \* FROM child WHERE id > 100 FOR UPDATE;**

+-----+

| id |

+-----+

| 102 |

+-----+

Client B begins a transaction to insert a record into the gap. The transaction takes an insert intention lock while it waits to obtain an exclusive lock.

mysql> **START TRANSACTION;**

mysql> **INSERT INTO child (id) VALUES (101);**

Transaction data for an insert intention lock appears similar to the following in [**SHOW ENGINE INNODB STATUS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#show-engine) and [InnoDB monitor](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-standard-monitor) output:

RECORD LOCKS space id 31 page no 3 n bits 72 index `PRIMARY` of table `test`.`child`

trx id 8731 lock\_mode X locks gap before rec ***insert intention*** waiting

Record lock, heap no 3 PHYSICAL RECORD: n\_fields 3; compact format; info bits 0

0: len 4; hex 80000066; asc f;;

1: len 6; hex 000000002215; asc " ;;

2: len 7; hex 9000000172011c; asc r ;;...

#### AUTO-INC Locks

An **AUTO-INC** lock is a special table-level lock taken by transactions inserting into tables with **AUTO\_INCREMENT** columns. In the simplest case, if one transaction is inserting values into the table, any other transactions must wait to do their own inserts into that table, so that rows inserted by the first transaction receive consecutive primary key values.

The [**innodb\_autoinc\_lock\_mode**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_autoinc_lock_mode) configuration option controls the algorithm used for auto-increment locking. It allows you to choose how to trade off between predictable sequences of auto-increment values and maximum concurrency for insert operations.

For more information, see [Section 15.6.1.6, “AUTO\_INCREMENT Handling in InnoDB”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-auto-increment-handling).

#### Predicate Locks for Spatial Indexes

**InnoDB** supports **SPATIAL** indexing of columns containing spatial columns (see [Section 11.4.9, “Optimizing Spatial Analysis”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-types.html#optimizing-spatial-analysis)).

To handle locking for operations involving **SPATIAL** indexes, next-key locking does not work well to support [**REPEATABLE READ**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#isolevel_repeatable-read) or [**SERIALIZABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#isolevel_serializable) transaction isolation levels. There is no absolute ordering concept in multidimensional data, so it is not clear which is the “next” key.

To enable support of isolation levels for tables with **SPATIAL** indexes, **InnoDB** uses predicate locks. A **SPATIAL** index contains minimum bounding rectangle (MBR) values, so **InnoDB** enforces consistent read on the index by setting a predicate lock on the MBR value used for a query. Other transactions cannot insert or modify a row that would match the query condition.

### 15.7.2 InnoDB Transaction Model

[15.7.2.1 Transaction Isolation Levels](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-transaction-isolation-levels)

[15.7.2.2 autocommit, Commit, and Rollback](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-autocommit-commit-rollback)

[15.7.2.3 Consistent Nonlocking Reads](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-consistent-read)

[15.7.2.4 Locking Reads](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-locking-reads)

In the **InnoDB** transaction model, the goal is to combine the best properties of a [multi-versioning](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_mvcc) database with traditional two-phase locking. **InnoDB** performs locking at the row level and runs queries as nonlocking [consistent reads](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_consistent_read) by default, in the style of Oracle. The lock information in **InnoDB** is stored space-efficiently so that lock escalation is not needed. Typically, several users are permitted to lock every row in **InnoDB** tables, or any random subset of the rows, without causing **InnoDB** memory exhaustion.

#### 15.7.2.1 Transaction Isolation Levels

Transaction isolation is one of the foundations of database processing. Isolation is the I in the acronym [ACID](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_acid); the isolation level is the setting that fine-tunes the balance between performance and reliability, consistency, and reproducibility of results when multiple transactions are making changes and performing queries at the same time.

**InnoDB** offers all four transaction isolation levels described by the SQL:1992 standard: [**READ UNCOMMITTED**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#isolevel_read-uncommitted), [**READ COMMITTED**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#isolevel_read-committed), [**REPEATABLE READ**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#isolevel_repeatable-read), and [**SERIALIZABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#isolevel_serializable). The default isolation level for **InnoDB** is [**REPEATABLE READ**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#isolevel_repeatable-read).

A user can change the isolation level for a single session or for all subsequent connections with the [**SET TRANSACTION**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#set-transaction) statement. To set the server's default isolation level for all connections, use the [--transaction-isolation](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#option_mysqld_transaction-isolation) option on the command line or in an option file. For detailed information about isolation levels and level-setting syntax, see [Section 13.3.7, “SET TRANSACTION Statement”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#set-transaction).

**InnoDB** supports each of the transaction isolation levels described here using different [locking](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_locking) strategies. You can enforce a high degree of consistency with the default [**REPEATABLE READ**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#isolevel_repeatable-read) level, for operations on crucial data where [ACID](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_acid) compliance is important. Or you can relax the consistency rules with [**READ COMMITTED**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#isolevel_read-committed) or even [**READ UNCOMMITTED**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#isolevel_read-uncommitted), in situations such as bulk reporting where precise consistency and repeatable results are less important than minimizing the amount of overhead for locking. [**SERIALIZABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#isolevel_serializable) enforces even stricter rules than [**REPEATABLE READ**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#isolevel_repeatable-read), and is used mainly in specialized situations, such as with [XA](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_xa) transactions and for troubleshooting issues with concurrency and [deadlocks](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_deadlock).

The following list describes how MySQL supports the different transaction levels. The list goes from the most commonly used level to the least used.

**REPEATABLE READ**

This is the default isolation level for **InnoDB**. [Consistent reads](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_consistent_read) within the same transaction read the [snapshot](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_snapshot) established by the first read. This means that if you issue several plain (nonlocking) [**SELECT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#select) statements within the same transaction, these [**SELECT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#select) statements are consistent also with respect to each other. See [Section 15.7.2.3, “Consistent Nonlocking Reads”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-consistent-read).

For [locking reads](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_locking_read) ([**SELECT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#select) with **FOR UPDATE** or **FOR SHARE**), [**UPDATE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#update), and [**DELETE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#delete) statements, locking depends on whether the statement uses a unique index with a unique search condition, or a range-type search condition.

For a unique index with a unique search condition, **InnoDB** locks only the index record found, not the [gap](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_gap) before it.

For other search conditions, **InnoDB** locks the index range scanned, using [gap locks](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_gap_lock) or [next-key locks](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_next_key_lock) to block insertions by other sessions into the gaps covered by the range. For information about gap locks and next-key locks, see [Section 15.7.1, “InnoDB Locking”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-locking).

**READ COMMITTED**

Each consistent read, even within the same transaction, sets and reads its own fresh snapshot. For information about consistent reads, see [Section 15.7.2.3, “Consistent Nonlocking Reads”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-consistent-read).

For locking reads ([**SELECT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#select) with **FOR UPDATE** or **FOR SHARE**), [**UPDATE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#update) statements, and [**DELETE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#delete) statements, **InnoDB** locks only index records, not the gaps before them, and thus permits the free insertion of new records next to locked records. Gap locking is only used for foreign-key constraint checking and duplicate-key checking.

Because gap locking is disabled, phantom problems may occur, as other sessions can insert new rows into the gaps. For information about phantoms, see [Section 15.7.4, “Phantom Rows”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-next-key-locking).

Only row-based binary logging is supported with the **READ COMMITTED** isolation level. If you use **READ COMMITTED** with [**binlog\_format=MIXED**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\replication.html#sysvar_binlog_format), the server automatically uses row-based logging.

Using **READ COMMITTED** has additional effects:

For [**UPDATE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#update) or [**DELETE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#delete) statements, **InnoDB** holds locks only for rows that it updates or deletes. Record locks for nonmatching rows are released after MySQL has evaluated the **WHERE** condition. This greatly reduces the probability of deadlocks, but they can still happen.

For [**UPDATE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#update) statements, if a row is already locked, **InnoDB** performs a “semi-consistent” read, returning the latest committed version to MySQL so that MySQL can determine whether the row matches the **WHERE** condition of the [**UPDATE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#update). If the row matches (must be updated), MySQL reads the row again and this time **InnoDB** either locks it or waits for a lock on it.

Consider the following example, beginning with this table:

CREATE TABLE t (a INT NOT NULL, b INT) ENGINE = InnoDB;

INSERT INTO t VALUES (1,2),(2,3),(3,2),(4,3),(5,2);

COMMIT;

In this case, the table has no indexes, so searches and index scans use the hidden clustered index for record locking (see [Section 15.6.2.1, “Clustered and Secondary Indexes”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-index-types)) rather than indexed columns.

Suppose that one session performs an [**UPDATE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#update) using these statements:

# Session A

START TRANSACTION;

UPDATE t SET b = 5 WHERE b = 3;

Suppose also that a second session performs an [**UPDATE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#update) by executing these statements following those of the first session:

# Session B

UPDATE t SET b = 4 WHERE b = 2;

As [**InnoDB**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html) executes each [**UPDATE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#update), it first acquires an exclusive lock for each row, and then determines whether to modify it. If [**InnoDB**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html) does not modify the row, it releases the lock. Otherwise, [**InnoDB**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html) retains the lock until the end of the transaction. This affects transaction processing as follows.

When using the default **REPEATABLE READ** isolation level, the first [**UPDATE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#update) acquires an x-lock on each row that it reads and does not release any of them:

x-lock(1,2); retain x-lock

x-lock(2,3); update(2,3) to (2,5); retain x-lock

x-lock(3,2); retain x-lock

x-lock(4,3); update(4,3) to (4,5); retain x-lock

x-lock(5,2); retain x-lock

The second [**UPDATE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#update) blocks as soon as it tries to acquire any locks (because first update has retained locks on all rows), and does not proceed until the first [**UPDATE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#update) commits or rolls back:

x-lock(1,2); block and wait for first UPDATE to commit or roll back

If **READ COMMITTED** is used instead, the first [**UPDATE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#update) acquires an x-lock on each row that it reads and releases those for rows that it does not modify:

x-lock(1,2); unlock(1,2)

x-lock(2,3); update(2,3) to (2,5); retain x-lock

x-lock(3,2); unlock(3,2)

x-lock(4,3); update(4,3) to (4,5); retain x-lock

x-lock(5,2); unlock(5,2)

For the second **UPDATE**, **InnoDB** does a “semi-consistent” read, returning the latest committed version of each row that it reads to MySQL so that MySQL can determine whether the row matches the **WHERE** condition of the [**UPDATE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#update):

x-lock(1,2); update(1,2) to (1,4); retain x-lock

x-lock(2,3); unlock(2,3)

x-lock(3,2); update(3,2) to (3,4); retain x-lock

x-lock(4,3); unlock(4,3)

x-lock(5,2); update(5,2) to (5,4); retain x-lock

However, if the **WHERE** condition includes an indexed column, and **InnoDB** uses the index, only the indexed column is considered when taking and retaining record locks. In the following example, the first [**UPDATE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#update) takes and retains an x-lock on each row where b = 2. The second [**UPDATE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#update) blocks when it tries to acquire x-locks on the same records, as it also uses the index defined on column b.

CREATE TABLE t (a INT NOT NULL, b INT, c INT, INDEX (b)) ENGINE = InnoDB;

INSERT INTO t VALUES (1,2,3),(2,2,4);

COMMIT;

# Session A

START TRANSACTION;

UPDATE t SET b = 3 WHERE b = 2 AND c = 3;

# Session B

UPDATE t SET b = 4 WHERE b = 2 AND c = 4;

The **READ COMMITTED** isolation level can be set at startup or changed at runtime. At runtime, it can be set globally for all sessions, or individually per session.

**READ UNCOMMITTED**

**[SELECT](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\sql-statements.html" \l "select" \o "13.2.10 SELECT Statement)** statements are performed in a nonlocking fashion, but a possible earlier version of a row might be used. Thus, using this isolation level, such reads are not consistent. This is also called a [dirty read](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_dirty_read). Otherwise, this isolation level works like [**READ COMMITTED**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#isolevel_read-committed).

**SERIALIZABLE**

This level is like [**REPEATABLE READ**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#isolevel_repeatable-read), but **InnoDB** implicitly converts all plain [**SELECT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#select) statements to [**SELECT ... FOR SHARE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#select) if [**autocommit**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_autocommit) is disabled. If [**autocommit**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_autocommit) is enabled, the [**SELECT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#select) is its own transaction. It therefore is known to be read only and can be serialized if performed as a consistent (nonlocking) read and need not block for other transactions. (To force a plain [**SELECT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#select) to block if other transactions have modified the selected rows, disable [**autocommit**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_autocommit).)

**Note**

As of MySQL 8.0.22, DML operations that read data from MySQL grant tables (through a join list or subquery) but do not modify them do not acquire read locks on the MySQL grant tables, regardless of the isolation level. For more information, see [Grant Table Concurrency](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\security.html#grant-tables-concurrency).

#### 15.7.2.2 autocommit, Commit, and Rollback

In **InnoDB**, all user activity occurs inside a transaction. If [**autocommit**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_autocommit) mode is enabled, each SQL statement forms a single transaction on its own. By default, MySQL starts the session for each new connection with [**autocommit**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_autocommit) enabled, so MySQL does a commit after each SQL statement if that statement did not return an error. If a statement returns an error, the commit or rollback behavior depends on the error. See [Section 15.21.4, “InnoDB Error Handling”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-error-handling).

A session that has [**autocommit**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_autocommit) enabled can perform a multiple-statement transaction by starting it with an explicit [**START TRANSACTION**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#commit) or [**BEGIN**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#commit) statement and ending it with a [**COMMIT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#commit) or [**ROLLBACK**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#commit) statement. See [Section 13.3.1, “START TRANSACTION, COMMIT, and ROLLBACK Statements”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#commit).

If [**autocommit**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_autocommit) mode is disabled within a session with **SET autocommit = 0**, the session always has a transaction open. A [**COMMIT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#commit) or [**ROLLBACK**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#commit) statement ends the current transaction and a new one starts.

If a session that has [**autocommit**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_autocommit) disabled ends without explicitly committing the final transaction, MySQL rolls back that transaction.

Some statements implicitly end a transaction, as if you had done a [**COMMIT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#commit) before executing the statement. For details, see [Section 13.3.3, “Statements That Cause an Implicit Commit”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#implicit-commit).

A [**COMMIT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#commit) means that the changes made in the current transaction are made permanent and become visible to other sessions. A [**ROLLBACK**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#commit) statement, on the other hand, cancels all modifications made by the current transaction. Both [**COMMIT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#commit) and [**ROLLBACK**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#commit) release all **InnoDB** locks that were set during the current transaction.

##### Grouping DML Operations with Transactions

By default, connection to the MySQL server begins with [autocommit](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_autocommit) mode enabled, which automatically commits every SQL statement as you execute it. This mode of operation might be unfamiliar if you have experience with other database systems, where it is standard practice to issue a sequence of [DML](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_dml) statements and commit them or roll them back all together.

To use multiple-statement [transactions](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_transaction), switch autocommit off with the SQL statement **SET autocommit = 0** and end each transaction with [**COMMIT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#commit) or [**ROLLBACK**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#commit) as appropriate. To leave autocommit on, begin each transaction with [**START TRANSACTION**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#commit) and end it with [**COMMIT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#commit) or [**ROLLBACK**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#commit). The following example shows two transactions. The first is committed; the second is rolled back.

shell> **mysql test**

mysql> **CREATE TABLE customer (a INT, b CHAR (20), INDEX (a));**

Query OK, 0 rows affected (0.00 sec)

mysql> **-- Do a transaction with autocommit turned on.**

mysql> **START TRANSACTION;**

Query OK, 0 rows affected (0.00 sec)

mysql> **INSERT INTO customer VALUES (10, 'Heikki');**

Query OK, 1 row affected (0.00 sec)

mysql> **COMMIT;**

Query OK, 0 rows affected (0.00 sec)

mysql> **-- Do another transaction with autocommit turned off.**

mysql> **SET autocommit=0;**

Query OK, 0 rows affected (0.00 sec)

mysql> **INSERT INTO customer VALUES (15, 'John');**

Query OK, 1 row affected (0.00 sec)

mysql> **INSERT INTO customer VALUES (20, 'Paul');**

Query OK, 1 row affected (0.00 sec)

mysql> **DELETE FROM customer WHERE b = 'Heikki';**

Query OK, 1 row affected (0.00 sec)

mysql> **-- Now we undo those last 2 inserts and the delete.**

mysql> **ROLLBACK;**

Query OK, 0 rows affected (0.00 sec)

mysql> **SELECT \* FROM customer;**

+------+--------+

| a | b |

+------+--------+

| 10 | Heikki |

+------+--------+

1 row in set (0.00 sec)

mysql>

###### Transactions in Client-Side Languages

In APIs such as PHP, Perl DBI, JDBC, ODBC, or the standard C call interface of MySQL, you can send transaction control statements such as [**COMMIT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#commit) to the MySQL server as strings just like any other SQL statements such as [**SELECT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#select) or [**INSERT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#insert). Some APIs also offer separate special transaction commit and rollback functions or methods.

#### 15.7.2.3 Consistent Nonlocking Reads

A [consistent read](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_consistent_read) means that **InnoDB** uses multi-versioning to present to a query a snapshot of the database at a point in time. The query sees the changes made by transactions that committed before that point of time, and no changes made by later or uncommitted transactions. The exception to this rule is that the query sees the changes made by earlier statements within the same transaction. This exception causes the following anomaly: If you update some rows in a table, a [**SELECT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#select) sees the latest version of the updated rows, but it might also see older versions of any rows. If other sessions simultaneously update the same table, the anomaly means that you might see the table in a state that never existed in the database.

If the transaction [isolation level](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_isolation_level) is [**REPEATABLE READ**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#isolevel_repeatable-read) (the default level), all consistent reads within the same transaction read the snapshot established by the first such read in that transaction. You can get a fresher snapshot for your queries by committing the current transaction and after that issuing new queries.

With [**READ COMMITTED**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#isolevel_read-committed) isolation level, each consistent read within a transaction sets and reads its own fresh snapshot.

Consistent read is the default mode in which **InnoDB** processes [**SELECT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#select) statements in [**READ COMMITTED**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#isolevel_read-committed) and [**REPEATABLE READ**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#isolevel_repeatable-read) isolation levels. A consistent read does not set any locks on the tables it accesses, and therefore other sessions are free to modify those tables at the same time a consistent read is being performed on the table.

Suppose that you are running in the default [**REPEATABLE READ**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#isolevel_repeatable-read) isolation level. When you issue a consistent read (that is, an ordinary [**SELECT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#select) statement), **InnoDB** gives your transaction a timepoint according to which your query sees the database. If another transaction deletes a row and commits after your timepoint was assigned, you do not see the row as having been deleted. Inserts and updates are treated similarly.

**Note**

The snapshot of the database state applies to [**SELECT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#select) statements within a transaction, not necessarily to [DML](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_dml) statements. If you insert or modify some rows and then commit that transaction, a [**DELETE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#delete) or [**UPDATE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#update) statement issued from another concurrent **REPEATABLE READ** transaction could affect those just-committed rows, even though the session could not query them. If a transaction does update or delete rows committed by a different transaction, those changes do become visible to the current transaction. For example, you might encounter a situation like the following:

SELECT COUNT(c1) FROM t1 WHERE c1 = 'xyz';

-- Returns 0: no rows match.

DELETE FROM t1 WHERE c1 = 'xyz';

-- Deletes several rows recently committed by other transaction.

SELECT COUNT(c2) FROM t1 WHERE c2 = 'abc';

-- Returns 0: no rows match.

UPDATE t1 SET c2 = 'cba' WHERE c2 = 'abc';

-- Affects 10 rows: another txn just committed 10 rows with 'abc' values.

SELECT COUNT(c2) FROM t1 WHERE c2 = 'cba';

-- Returns 10: this txn can now see the rows it just updated.

You can advance your timepoint by committing your transaction and then doing another [**SELECT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#select) or [**START TRANSACTION WITH CONSISTENT SNAPSHOT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#commit).

This is called multi-versioned concurrency control.

In the following example, session A sees the row inserted by B only when B has committed the insert and A has committed as well, so that the timepoint is advanced past the commit of B.

Session A Session B

SET autocommit=0; SET autocommit=0;

time

| SELECT \* FROM t;

| empty set

| INSERT INTO t VALUES (1, 2);

|

v SELECT \* FROM t;

empty set

COMMIT;

SELECT \* FROM t;

empty set

COMMIT;

SELECT \* FROM t;

---------------------

| 1 | 2 |

---------------------

If you want to see the “freshest” state of the database, use either the [**READ COMMITTED**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#isolevel_read-committed) isolation level or a [locking read](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_locking_read):

SELECT \* FROM t FOR SHARE;

With [**READ COMMITTED**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#isolevel_read-committed) isolation level, each consistent read within a transaction sets and reads its own fresh snapshot. With **FOR SHARE**, a locking read occurs instead: A **SELECT** blocks until the transaction containing the freshest rows ends (see [Section 15.7.2.4, “Locking Reads”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-locking-reads)).

Consistent read does not work over certain DDL statements:

Consistent read does not work over [**DROP TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#drop-table), because MySQL cannot use a table that has been dropped and **InnoDB** destroys the table.

Consistent read does not work over [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) operations that make a temporary copy of the original table and delete the original table when the temporary copy is built. When you reissue a consistent read within a transaction, rows in the new table are not visible because those rows did not exist when the transaction's snapshot was taken. In this case, the transaction returns an error: [**ER\_TABLE\_DEF\_CHANGED**](https://dev.mysql.com/doc/mysql-errors/8.0/en/server-error-reference.html#error_er_table_def_changed), “Table definition has changed, please retry transaction”.

The type of read varies for selects in clauses like [**INSERT INTO ... SELECT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#insert), [**UPDATE ... (SELECT)**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#update), and [**CREATE TABLE ... SELECT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-table) that do not specify **FOR UPDATE** or **FOR SHARE**:

By default, **InnoDB** uses stronger locks for those statements and the [**SELECT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#select) part acts like [**READ COMMITTED**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#isolevel_read-committed), where each consistent read, even within the same transaction, sets and reads its own fresh snapshot.

To perform a nonlocking read in such cases, set the isolation level of the transaction to [**READ UNCOMMITTED**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#isolevel_read-uncommitted) or [**READ COMMITTED**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#isolevel_read-committed) to avoid setting locks on rows read from the selected table.

#### 15.7.2.4 Locking Reads

If you query data and then insert or update related data within the same transaction, the regular **SELECT** statement does not give enough protection. Other transactions can update or delete the same rows you just queried. **InnoDB** supports two types of [locking reads](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_locking_read) that offer extra safety:

[**SELECT ... FOR SHARE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#select)

Sets a shared mode lock on any rows that are read. Other sessions can read the rows, but cannot modify them until your transaction commits. If any of these rows were changed by another transaction that has not yet committed, your query waits until that transaction ends and then uses the latest values.

**Note**

**SELECT ... FOR SHARE** is a replacement for **SELECT ... LOCK IN SHARE MODE**, but **LOCK IN SHARE MODE** remains available for backward compatibility. The statements are equivalent. However, **FOR SHARE** supports **OF *table\_name***, **NOWAIT**, and **SKIP LOCKED** options. See [Locking Read Concurrency with NOWAIT and SKIP LOCKED](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-locking-reads-nowait-skip-locked).

Prior to MySQL 8.0.22, **SELECT ... FOR SHARE** requires the [**SELECT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\security.html#priv_select) privilege and at least one of the [**DELETE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\security.html#priv_delete), [**LOCK TABLES**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\security.html#priv_lock-tables), or [**UPDATE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\security.html#priv_update) privileges. As of MySQL 8.0.22, only the [**SELECT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\security.html#priv_select) privilege is required.

As of MySQL 8.0.22, **SELECT ... FOR SHARE** statements do not acquire read locks on MySQL grant tables. For more information, see [Grant Table Concurrency](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\security.html#grant-tables-concurrency).

[**SELECT ... FOR UPDATE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#select)

For index records the search encounters, locks the rows and any associated index entries, the same as if you issued an **UPDATE** statement for those rows. Other transactions are blocked from updating those rows, from doing **SELECT ... FOR SHARE**, or from reading the data in certain transaction isolation levels. Consistent reads ignore any locks set on the records that exist in the read view. (Old versions of a record cannot be locked; they are reconstructed by applying [undo logs](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_undo_log) on an in-memory copy of the record.)

**SELECT ... FOR UPDATE** requires the [**SELECT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\security.html#priv_select) privilege and at least one of the [**DELETE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\security.html#priv_delete), [**LOCK TABLES**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\security.html#priv_lock-tables), or [**UPDATE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\security.html#priv_update) privileges.

These clauses are primarily useful when dealing with tree-structured or graph-structured data, either in a single table or split across multiple tables. You traverse edges or tree branches from one place to another, while reserving the right to come back and change any of these “pointer” values.

All locks set by **FOR SHARE** and **FOR UPDATE** queries are released when the transaction is committed or rolled back.

**Note**

Locking reads are only possible when autocommit is disabled (either by beginning transaction with [**START TRANSACTION**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#commit) or by setting [**autocommit**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_autocommit) to 0.

A locking read clause in an outer statement does not lock the rows of a table in a nested subquery unless a locking read clause is also specified in the subquery. For example, the following statement does not lock rows in table **t2**.

SELECT \* FROM t1 WHERE c1 = (SELECT c1 FROM t2) FOR UPDATE;

To lock rows in table **t2**, add a locking read clause to the subquery:

SELECT \* FROM t1 WHERE c1 = (SELECT c1 FROM t2 FOR UPDATE) FOR UPDATE;

##### Locking Read Examples

Suppose that you want to insert a new row into a table **child**, and make sure that the child row has a parent row in table **parent**. Your application code can ensure referential integrity throughout this sequence of operations.

First, use a consistent read to query the table **PARENT** and verify that the parent row exists. Can you safely insert the child row to table **CHILD**? No, because some other session could delete the parent row in the moment between your **SELECT** and your **INSERT**, without you being aware of it.

To avoid this potential issue, perform the [**SELECT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#select) using **FOR SHARE**:

SELECT \* FROM parent WHERE NAME = 'Jones' FOR SHARE;

After the **FOR SHARE** query returns the parent **'Jones'**, you can safely add the child record to the **CHILD** table and commit the transaction. Any transaction that tries to acquire an exclusive lock in the applicable row in the **PARENT** table waits until you are finished, that is, until the data in all tables is in a consistent state.

For another example, consider an integer counter field in a table **CHILD\_CODES**, used to assign a unique identifier to each child added to table **CHILD**. Do not use either consistent read or a shared mode read to read the present value of the counter, because two users of the database could see the same value for the counter, and a duplicate-key error occurs if two transactions attempt to add rows with the same identifier to the **CHILD** table.

Here, **FOR SHARE** is not a good solution because if two users read the counter at the same time, at least one of them ends up in deadlock when it attempts to update the counter.

To implement reading and incrementing the counter, first perform a locking read of the counter using **FOR UPDATE**, and then increment the counter. For example:

SELECT counter\_field FROM child\_codes FOR UPDATE;

UPDATE child\_codes SET counter\_field = counter\_field + 1;

A [**SELECT ... FOR UPDATE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#select) reads the latest available data, setting exclusive locks on each row it reads. Thus, it sets the same locks a searched SQL [**UPDATE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#update) would set on the rows.

The preceding description is merely an example of how [**SELECT ... FOR UPDATE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#select) works. In MySQL, the specific task of generating a unique identifier actually can be accomplished using only a single access to the table:

UPDATE child\_codes SET counter\_field = LAST\_INSERT\_ID(counter\_field + 1);

SELECT LAST\_INSERT\_ID();

The [**SELECT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#select) statement merely retrieves the identifier information (specific to the current connection). It does not access any table.

##### Locking Read Concurrency with NOWAIT and SKIP LOCKED

If a row is locked by a transaction, a **SELECT ... FOR UPDATE** or **SELECT ... FOR SHARE** transaction that requests the same locked row must wait until the blocking transaction releases the row lock. This behavior prevents transactions from updating or deleting rows that are queried for updates by other transactions. However, waiting for a row lock to be released is not necessary if you want the query to return immediately when a requested row is locked, or if excluding locked rows from the result set is acceptable.

To avoid waiting for other transactions to release row locks, **NOWAIT** and **SKIP LOCKED** options may be used with **SELECT ... FOR UPDATE** or **SELECT ... FOR SHARE** locking read statements.

**NOWAIT**

A locking read that uses **NOWAIT** never waits to acquire a row lock. The query executes immediately, failing with an error if a requested row is locked.

**SKIP LOCKED**

A locking read that uses **SKIP LOCKED** never waits to acquire a row lock. The query executes immediately, removing locked rows from the result set.

**Note**

Queries that skip locked rows return an inconsistent view of the data. **SKIP LOCKED** is therefore not suitable for general transactional work. However, it may be used to avoid lock contention when multiple sessions access the same queue-like table.

**NOWAIT** and **SKIP LOCKED** only apply to row-level locks.

Statements that use **NOWAIT** or **SKIP LOCKED** are unsafe for statement based replication.

The following example demonstrates **NOWAIT** and **SKIP LOCKED**. Session 1 starts a transaction that takes a row lock on a single record. Session 2 attempts a locking read on the same record using the **NOWAIT** option. Because the requested row is locked by Session 1, the locking read returns immediately with an error. In Session 3, the locking read with **SKIP LOCKED** returns the requested rows except for the row that is locked by Session 1.

# Session 1:

mysql> **CREATE TABLE t (i INT, PRIMARY KEY (i)) ENGINE = InnoDB;**

mysql> **INSERT INTO t (i) VALUES(1),(2),(3);**

mysql> **START TRANSACTION;**

mysql> **SELECT \* FROM t WHERE i = 2 FOR UPDATE;**

+---+

| i |

+---+

| 2 |

+---+

# Session 2:

mysql> **START TRANSACTION;**

mysql> **SELECT \* FROM t WHERE i = 2 FOR UPDATE NOWAIT;**

ERROR 3572 (HY000): Do not wait for lock.

# Session 3:

mysql> **START TRANSACTION;**

mysql> **SELECT \* FROM t FOR UPDATE SKIP LOCKED;**

+---+

| i |

+---+

| 1 |

| 3 |

+---+

### 15.7.3 Locks Set by Different SQL Statements in InnoDB

A [locking read](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_locking_read), an [**UPDATE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#update), or a [**DELETE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#delete) generally set record locks on every index record that is scanned in the processing of the SQL statement. It does not matter whether there are **WHERE** conditions in the statement that would exclude the row. **InnoDB** does not remember the exact **WHERE** condition, but only knows which index ranges were scanned. The locks are normally [next-key locks](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_next_key_lock) that also block inserts into the “gap” immediately before the record. However, [gap locking](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_gap_lock) can be disabled explicitly, which causes next-key locking not to be used. For more information, see [Section 15.7.1, “InnoDB Locking”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-locking). The transaction isolation level also can affect which locks are set; see [Section 15.7.2.1, “Transaction Isolation Levels”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-transaction-isolation-levels).

If a secondary index is used in a search and index record locks to be set are exclusive, **InnoDB** also retrieves the corresponding clustered index records and sets locks on them.

If you have no indexes suitable for your statement and MySQL must scan the entire table to process the statement, every row of the table becomes locked, which in turn blocks all inserts by other users to the table. It is important to create good indexes so that your queries do not unnecessarily scan many rows.

**InnoDB** sets specific types of locks as follows.

[**SELECT ... FROM**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#select) is a consistent read, reading a snapshot of the database and setting no locks unless the transaction isolation level is set to [**SERIALIZABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#isolevel_serializable). For [**SERIALIZABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#isolevel_serializable) level, the search sets shared next-key locks on the index records it encounters. However, only an index record lock is required for statements that lock rows using a unique index to search for a unique row.

[**SELECT ... FOR UPDATE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#select) and [**SELECT ... FOR SHARE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#select) statements that use a unique index acquire locks for scanned rows, and release the locks for rows that do not qualify for inclusion in the result set (for example, if they do not meet the criteria given in the **WHERE** clause). However, in some cases, rows might not be unlocked immediately because the relationship between a result row and its original source is lost during query execution. For example, in a [**UNION**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#union), scanned (and locked) rows from a table might be inserted into a temporary table before evaluation whether they qualify for the result set. In this circumstance, the relationship of the rows in the temporary table to the rows in the original table is lost and the latter rows are not unlocked until the end of query execution.

For [locking reads](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_locking_read) ([**SELECT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#select) with **FOR UPDATE** or **FOR SHARE**), [**UPDATE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#update), and [**DELETE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#delete) statements, the locks that are taken depend on whether the statement uses a unique index with a unique search condition, or a range-type search condition.

For a unique index with a unique search condition, **InnoDB** locks only the index record found, not the [gap](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_gap) before it.

For other search conditions, and for non-unique indexes, **InnoDB** locks the index range scanned, using [gap locks](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_gap_lock) or [next-key locks](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_next_key_lock) to block insertions by other sessions into the gaps covered by the range. For information about gap locks and next-key locks, see [Section 15.7.1, “InnoDB Locking”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-locking).

For index records the search encounters, [**SELECT ... FOR UPDATE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#select) blocks other sessions from doing [**SELECT ... FOR SHARE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#select) or from reading in certain transaction isolation levels. Consistent reads ignore any locks set on the records that exist in the read view.

[**UPDATE ... WHERE ...**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#update) sets an exclusive next-key lock on every record the search encounters. However, only an index record lock is required for statements that lock rows using a unique index to search for a unique row.

When [**UPDATE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#update) modifies a clustered index record, implicit locks are taken on affected secondary index records. The [**UPDATE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#update) operation also takes shared locks on affected secondary index records when performing duplicate check scans prior to inserting new secondary index records, and when inserting new secondary index records.

[**DELETE FROM ... WHERE ...**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#delete) sets an exclusive next-key lock on every record the search encounters. However, only an index record lock is required for statements that lock rows using a unique index to search for a unique row.

[**INSERT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#insert) sets an exclusive lock on the inserted row. This lock is an index-record lock, not a next-key lock (that is, there is no gap lock) and does not prevent other sessions from inserting into the gap before the inserted row.

Prior to inserting the row, a type of gap lock called an insert intention gap lock is set. This lock signals the intent to insert in such a way that multiple transactions inserting into the same index gap need not wait for each other if they are not inserting at the same position within the gap. Suppose that there are index records with values of 4 and 7. Separate transactions that attempt to insert values of 5 and 6 each lock the gap between 4 and 7 with insert intention locks prior to obtaining the exclusive lock on the inserted row, but do not block each other because the rows are nonconflicting.

If a duplicate-key error occurs, a shared lock on the duplicate index record is set. This use of a shared lock can result in deadlock should there be multiple sessions trying to insert the same row if another session already has an exclusive lock. This can occur if another session deletes the row. Suppose that an **InnoDB** table **t1** has the following structure:

CREATE TABLE t1 (i INT, PRIMARY KEY (i)) ENGINE = InnoDB;

Now suppose that three sessions perform the following operations in order:

Session 1:

START TRANSACTION;

INSERT INTO t1 VALUES(1);

Session 2:

START TRANSACTION;

INSERT INTO t1 VALUES(1);

Session 3:

START TRANSACTION;

INSERT INTO t1 VALUES(1);

Session 1:

ROLLBACK;

The first operation by session 1 acquires an exclusive lock for the row. The operations by sessions 2 and 3 both result in a duplicate-key error and they both request a shared lock for the row. When session 1 rolls back, it releases its exclusive lock on the row and the queued shared lock requests for sessions 2 and 3 are granted. At this point, sessions 2 and 3 deadlock: Neither can acquire an exclusive lock for the row because of the shared lock held by the other.

A similar situation occurs if the table already contains a row with key value 1 and three sessions perform the following operations in order:

Session 1:

START TRANSACTION;

DELETE FROM t1 WHERE i = 1;

Session 2:

START TRANSACTION;

INSERT INTO t1 VALUES(1);

Session 3:

START TRANSACTION;

INSERT INTO t1 VALUES(1);

Session 1:

COMMIT;

The first operation by session 1 acquires an exclusive lock for the row. The operations by sessions 2 and 3 both result in a duplicate-key error and they both request a shared lock for the row. When session 1 commits, it releases its exclusive lock on the row and the queued shared lock requests for sessions 2 and 3 are granted. At this point, sessions 2 and 3 deadlock: Neither can acquire an exclusive lock for the row because of the shared lock held by the other.

[**INSERT ... ON DUPLICATE KEY UPDATE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#insert-on-duplicate) differs from a simple [**INSERT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#insert) in that an exclusive lock rather than a shared lock is placed on the row to be updated when a duplicate-key error occurs. An exclusive index-record lock is taken for a duplicate primary key value. An exclusive next-key lock is taken for a duplicate unique key value.

[**REPLACE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#replace) is done like an [**INSERT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#insert) if there is no collision on a unique key. Otherwise, an exclusive next-key lock is placed on the row to be replaced.

**INSERT INTO T SELECT ... FROM S WHERE ...** sets an exclusive index record lock (without a gap lock) on each row inserted into **T**. If the transaction isolation level is [**READ COMMITTED**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#isolevel_read-committed), **InnoDB** does the search on **S** as a consistent read (no locks). Otherwise, **InnoDB** sets shared next-key locks on rows from **S**. **InnoDB** has to set locks in the latter case: During roll-forward recovery using a statement-based binary log, every SQL statement must be executed in exactly the same way it was done originally.

[**CREATE TABLE ... SELECT ...**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-table) performs the [**SELECT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#select) with shared next-key locks or as a consistent read, as for [**INSERT ... SELECT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#insert-select).

When a **SELECT** is used in the constructs **REPLACE INTO t SELECT ... FROM s WHERE ...** or **UPDATE t ... WHERE col IN (SELECT ... FROM s ...)**, **InnoDB** sets shared next-key locks on rows from table **s**.

**InnoDB** sets an exclusive lock on the end of the index associated with the **AUTO\_INCREMENT** column while initializing a previously specified **AUTO\_INCREMENT** column on a table.

With [**innodb\_autoinc\_lock\_mode=0**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_autoinc_lock_mode), **InnoDB** uses a special **AUTO-INC** table lock mode where the lock is obtained and held to the end of the current SQL statement (not to the end of the entire transaction) while accessing the auto-increment counter. Other clients cannot insert into the table while the **AUTO-INC** table lock is held. The same behavior occurs for “bulk inserts” with [**innodb\_autoinc\_lock\_mode=1**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_autoinc_lock_mode). Table-level **AUTO-INC** locks are not used with [**innodb\_autoinc\_lock\_mode=2**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_autoinc_lock_mode). For more information, See [Section 15.6.1.6, “AUTO\_INCREMENT Handling in InnoDB”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-auto-increment-handling).

**InnoDB** fetches the value of a previously initialized **AUTO\_INCREMENT** column without setting any locks.

If a **FOREIGN KEY** constraint is defined on a table, any insert, update, or delete that requires the constraint condition to be checked sets shared record-level locks on the records that it looks at to check the constraint. **InnoDB** also sets these locks in the case where the constraint fails.

[**LOCK TABLES**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#lock-tables) sets table locks, but it is the higher MySQL layer above the **InnoDB** layer that sets these locks. **InnoDB** is aware of table locks if **innodb\_table\_locks = 1** (the default) and [**autocommit = 0**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_autocommit), and the MySQL layer above **InnoDB** knows about row-level locks.

Otherwise, **InnoDB**'s automatic deadlock detection cannot detect deadlocks where such table locks are involved. Also, because in this case the higher MySQL layer does not know about row-level locks, it is possible to get a table lock on a table where another session currently has row-level locks. However, this does not endanger transaction integrity, as discussed in [Section 15.7.5.2, “Deadlock Detection”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-deadlock-detection).

[**LOCK TABLES**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#lock-tables) acquires two locks on each table if **innodb\_table\_locks=1** (the default). In addition to a table lock on the MySQL layer, it also acquires an **InnoDB** table lock. Versions of MySQL before 4.1.2 did not acquire **InnoDB** table locks; the old behavior can be selected by setting **innodb\_table\_locks=0**. If no **InnoDB** table lock is acquired, [**LOCK TABLES**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#lock-tables) completes even if some records of the tables are being locked by other transactions.

In MySQL 8.0, [**innodb\_table\_locks=0**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_table_locks) has no effect for tables locked explicitly with [**LOCK TABLES ... WRITE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#lock-tables). It does have an effect for tables locked for read or write by [**LOCK TABLES ... WRITE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#lock-tables) implicitly (for example, through triggers) or by [**LOCK TABLES ... READ**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#lock-tables).

All **InnoDB** locks held by a transaction are released when the transaction is committed or aborted. Thus, it does not make much sense to invoke [**LOCK TABLES**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#lock-tables) on **InnoDB** tables in [**autocommit=1**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_autocommit) mode because the acquired **InnoDB** table locks would be released immediately.

You cannot lock additional tables in the middle of a transaction because [**LOCK TABLES**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#lock-tables) performs an implicit [**COMMIT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#commit) and [**UNLOCK TABLES**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#lock-tables).

### 15.7.4 Phantom Rows

The so-called phantom problem occurs within a transaction when the same query produces different sets of rows at different times. For example, if a [**SELECT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#select) is executed twice, but returns a row the second time that was not returned the first time, the row is a “phantom” row.

Suppose that there is an index on the **id** column of the **child** table and that you want to read and lock all rows from the table having an identifier value larger than 100, with the intention of updating some column in the selected rows later:

SELECT \* FROM child WHERE id > 100 FOR UPDATE;

The query scans the index starting from the first record where **id** is bigger than 100. Let the table contain rows having **id** values of 90 and 102. If the locks set on the index records in the scanned range do not lock out inserts made in the gaps (in this case, the gap between 90 and 102), another session can insert a new row into the table with an **id** of 101. If you were to execute the same [**SELECT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#select) within the same transaction, you would see a new row with an **id** of 101 (a “phantom”) in the result set returned by the query. If we regard a set of rows as a data item, the new phantom child would violate the isolation principle of transactions that a transaction should be able to run so that the data it has read does not change during the transaction.

To prevent phantoms, **InnoDB** uses an algorithm called next-key locking that combines index-row locking with gap locking. **InnoDB** performs row-level locking in such a way that when it searches or scans a table index, it sets shared or exclusive locks on the index records it encounters. Thus, the row-level locks are actually index-record locks. In addition, a next-key lock on an index record also affects the “gap” before that index record. That is, a next-key lock is an index-record lock plus a gap lock on the gap preceding the index record. If one session has a shared or exclusive lock on record **R** in an index, another session cannot insert a new index record in the gap immediately before **R** in the index order.

When **InnoDB** scans an index, it can also lock the gap after the last record in the index. Just that happens in the preceding example: To prevent any insert into the table where **id** would be bigger than 100, the locks set by **InnoDB** include a lock on the gap following **id** value 102.

You can use next-key locking to implement a uniqueness check in your application: If you read your data in share mode and do not see a duplicate for a row you are going to insert, then you can safely insert your row and know that the next-key lock set on the successor of your row during the read prevents anyone meanwhile inserting a duplicate for your row. Thus, the next-key locking enables you to “lock” the nonexistence of something in your table.

Gap locking can be disabled as discussed in [Section 15.7.1, “InnoDB Locking”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-locking). This may cause phantom problems because other sessions can insert new rows into the gaps when gap locking is disabled.

### 15.7.5 Deadlocks in InnoDB

[15.7.5.1 An InnoDB Deadlock Example](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-deadlock-example)

[15.7.5.2 Deadlock Detection](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-deadlock-detection)

[15.7.5.3 How to Minimize and Handle Deadlocks](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-deadlocks-handling)

A deadlock is a situation where different transactions are unable to proceed because each holds a lock that the other needs. Because both transactions are waiting for a resource to become available, neither ever release the locks it holds.

A deadlock can occur when transactions lock rows in multiple tables (through statements such as [**UPDATE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#update) or [**SELECT ... FOR UPDATE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#select)), but in the opposite order. A deadlock can also occur when such statements lock ranges of index records and gaps, with each transaction acquiring some locks but not others due to a timing issue. For a deadlock example, see [Section 15.7.5.1, “An InnoDB Deadlock Example”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-deadlock-example).

To reduce the possibility of deadlocks, use transactions rather than [**LOCK TABLES**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#lock-tables) statements; keep transactions that insert or update data small enough that they do not stay open for long periods of time; when different transactions update multiple tables or large ranges of rows, use the same order of operations (such as [**SELECT ... FOR UPDATE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#select)) in each transaction; create indexes on the columns used in [**SELECT ... FOR UPDATE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#select) and [**UPDATE ... WHERE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#update) statements. The possibility of deadlocks is not affected by the isolation level, because the isolation level changes the behavior of read operations, while deadlocks occur because of write operations. For more information about avoiding and recovering from deadlock conditions, see [Section 15.7.5.3, “How to Minimize and Handle Deadlocks”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-deadlocks-handling).

When deadlock detection is enabled (the default) and a deadlock does occur, **InnoDB** detects the condition and rolls back one of the transactions (the victim). If deadlock detection is disabled using the [**innodb\_deadlock\_detect**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_deadlock_detect) configuration option, **InnoDB** relies on the [**innodb\_lock\_wait\_timeout**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_lock_wait_timeout) setting to roll back transactions in case of a deadlock. Thus, even if your application logic is correct, you must still handle the case where a transaction must be retried. To see the last deadlock in an **InnoDB** user transaction, use the [**SHOW ENGINE INNODB STATUS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#show-engine) command. If frequent deadlocks highlight a problem with transaction structure or application error handling, run with the [**innodb\_print\_all\_deadlocks**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_print_all_deadlocks) setting enabled to print information about all deadlocks to the [**mysqld**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\programs.html#mysqld) error log. For more information about how deadlocks are automatically detected and handled, see [Section 15.7.5.2, “Deadlock Detection”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-deadlock-detection).

#### 15.7.5.1 An InnoDB Deadlock Example

The following example illustrates how an error can occur when a lock request would cause a deadlock. The example involves two clients, A and B.

First, client A creates a table containing one row, and then begins a transaction. Within the transaction, A obtains an **S** lock on the row by selecting it in share mode:

mysql> **CREATE TABLE t (i INT) ENGINE = InnoDB;**

Query OK, 0 rows affected (1.07 sec)

mysql> **INSERT INTO t (i) VALUES(1);**

Query OK, 1 row affected (0.09 sec)

mysql> **START TRANSACTION;**

Query OK, 0 rows affected (0.00 sec)

mysql> **SELECT \* FROM t WHERE i = 1 FOR SHARE;**

+------+

| i |

+------+

| 1 |

+------+

Next, client B begins a transaction and attempts to delete the row from the table:

mysql> **START TRANSACTION;**

Query OK, 0 rows affected (0.00 sec)

mysql> **DELETE FROM t WHERE i = 1;**

The delete operation requires an **X** lock. The lock cannot be granted because it is incompatible with the **S** lock that client A holds, so the request goes on the queue of lock requests for the row and client B blocks.

Finally, client A also attempts to delete the row from the table:

mysql> **DELETE FROM t WHERE i = 1;**

ERROR 1213 (40001): Deadlock found when trying to get lock;

try restarting transaction

Deadlock occurs here because client A needs an **X** lock to delete the row. However, that lock request cannot be granted because client B already has a request for an **X** lock and is waiting for client A to release its **S** lock. Nor can the **S** lock held by A be upgraded to an **X** lock because of the prior request by B for an **X** lock. As a result, **InnoDB** generates an error for one of the clients and releases its locks. The client returns this error:

ERROR 1213 (40001): Deadlock found when trying to get lock;

try restarting transaction

At that point, the lock request for the other client can be granted and it deletes the row from the table.

#### 15.7.5.2 Deadlock Detection

When [deadlock detection](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_deadlock_detection) is enabled (the default), **InnoDB** automatically detects transaction [deadlocks](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_deadlock) and rolls back a transaction or transactions to break the deadlock. **InnoDB** tries to pick small transactions to roll back, where the size of a transaction is determined by the number of rows inserted, updated, or deleted.

**InnoDB** is aware of table locks if **innodb\_table\_locks = 1** (the default) and [**autocommit = 0**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_autocommit), and the MySQL layer above it knows about row-level locks. Otherwise, **InnoDB** cannot detect deadlocks where a table lock set by a MySQL [**LOCK TABLES**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#lock-tables) statement or a lock set by a storage engine other than **InnoDB** is involved. Resolve these situations by setting the value of the [**innodb\_lock\_wait\_timeout**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_lock_wait_timeout) system variable.

If the **LATEST DETECTED DEADLOCK** section of **InnoDB** Monitor output includes a message stating TOO DEEP OR LONG SEARCH IN THE LOCK TABLE WAITS-FOR GRAPH, WE WILL ROLL BACK FOLLOWING TRANSACTION, this indicates that the number of transactions on the wait-for list has reached a limit of 200. A wait-for list that exceeds 200 transactions is treated as a deadlock and the transaction attempting to check the wait-for list is rolled back. The same error may also occur if the locking thread must look at more than 1,000,000 locks owned by transactions on the wait-for list.

For techniques to organize database operations to avoid deadlocks, see [Section 15.7.5, “Deadlocks in InnoDB”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-deadlocks).

##### Disabling Deadlock Detection

On high concurrency systems, deadlock detection can cause a slowdown when numerous threads wait for the same lock. At times, it may be more efficient to disable deadlock detection and rely on the [**innodb\_lock\_wait\_timeout**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_lock_wait_timeout) setting for transaction rollback when a deadlock occurs. Deadlock detection can be disabled using the [**innodb\_deadlock\_detect**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_deadlock_detect) configuration option.

#### 15.7.5.3 How to Minimize and Handle Deadlocks

This section builds on the conceptual information about deadlocks in [Section 15.7.5.2, “Deadlock Detection”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-deadlock-detection). It explains how to organize database operations to minimize deadlocks and the subsequent error handling required in applications.

[Deadlocks](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_deadlock) are a classic problem in transactional databases, but they are not dangerous unless they are so frequent that you cannot run certain transactions at all. Normally, you must write your applications so that they are always prepared to re-issue a transaction if it gets rolled back because of a deadlock.

**InnoDB** uses automatic row-level locking. You can get deadlocks even in the case of transactions that just insert or delete a single row. That is because these operations are not really “atomic”; they automatically set locks on the (possibly several) index records of the row inserted or deleted.

You can cope with deadlocks and reduce the likelihood of their occurrence with the following techniques:

At any time, issue the [**SHOW ENGINE INNODB STATUS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#show-engine) command to determine the cause of the most recent deadlock. That can help you to tune your application to avoid deadlocks.

If frequent deadlock warnings cause concern, collect more extensive debugging information by enabling the [**innodb\_print\_all\_deadlocks**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_print_all_deadlocks) configuration option. Information about each deadlock, not just the latest one, is recorded in the MySQL [error log](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_error_log). Disable this option when you are finished debugging.

Always be prepared to re-issue a transaction if it fails due to deadlock. Deadlocks are not dangerous. Just try again.

Keep transactions small and short in duration to make them less prone to collision.

Commit transactions immediately after making a set of related changes to make them less prone to collision. In particular, do not leave an interactive [**mysql**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\programs.html#mysql) session open for a long time with an uncommitted transaction.

If you use [locking reads](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_locking_read) ([**SELECT ... FOR UPDATE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#select) or **SELECT ... FOR SHARE**), try using a lower isolation level such as [**READ COMMITTED**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#isolevel_read-committed).

When modifying multiple tables within a transaction, or different sets of rows in the same table, do those operations in a consistent order each time. Then transactions form well-defined queues and do not deadlock. For example, organize database operations into functions within your application, or call stored routines, rather than coding multiple similar sequences of **INSERT**, **UPDATE**, and **DELETE** statements in different places.

Add well-chosen indexes to your tables. Then your queries need to scan fewer index records and consequently set fewer locks. Use [**EXPLAIN SELECT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#explain) to determine which indexes the MySQL server regards as the most appropriate for your queries.

Use less locking. If you can afford to permit a [**SELECT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#select) to return data from an old snapshot, do not add the clause **FOR UPDATE** or **FOR SHARE** to it. Using the [**READ COMMITTED**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#isolevel_read-committed) isolation level is good here, because each consistent read within the same transaction reads from its own fresh snapshot.

If nothing else helps, serialize your transactions with table-level locks. The correct way to use [**LOCK TABLES**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#lock-tables) with transactional tables, such as **InnoDB** tables, is to begin a transaction with **SET autocommit = 0** (not [**START TRANSACTION**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#commit)) followed by [**LOCK TABLES**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#lock-tables), and to not call [**UNLOCK TABLES**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#lock-tables) until you commit the transaction explicitly. For example, if you need to write to table **t1** and read from table **t2**, you can do this:

SET autocommit=0;

LOCK TABLES t1 WRITE, t2 READ, ...;

***... do something with tables t1 and t2 here ...***

COMMIT;

UNLOCK TABLES;

Table-level locks prevent concurrent updates to the table, avoiding deadlocks at the expense of less responsiveness for a busy system.

Another way to serialize transactions is to create an auxiliary “semaphore” table that contains just a single row. Have each transaction update that row before accessing other tables. In that way, all transactions happen in a serial fashion. Note that the **InnoDB** instant deadlock detection algorithm also works in this case, because the serializing lock is a row-level lock. With MySQL table-level locks, the timeout method must be used to resolve deadlocks.

### 15.7.6 Transaction Scheduling

**InnoDB** uses the Contention-Aware Transaction Scheduling (CATS) algorithm to prioritize transactions that are waiting for locks. When multiple transactions are waiting for a lock on the same object, the CATS algorithm determines which transaction receives the lock first.

The CATS algorithm prioritizes waiting transactions by assigning a scheduling weight, which is computed based on the number of transactions that a transaction blocks. For example, if two transactions are waiting for a lock on the same object, the transaction that blocks the most transactions is assigned a greater scheduling weight. If weights are equal, priority is given to the longest waiting transaction.

**Note**

Prior to MySQL 8.0.20, **InnoDB** also uses a First In First Out (FIFO) algorithm to schedule transactions, and the CATS algorithm is used under heavy lock contention only. CATS algorithm enhancements in MySQL 8.0.20 rendered the FIFO algorithm redundant, permitting its removal. Transaction scheduling previously performed by the FIFO algorithm is performed by the CATS algorithm as of MySQL 8.0.20. In some cases, this change may affect the order in which transactions are granted locks.

You can view transaction scheduling weights by querying the **TRX\_SCHEDULE\_WEIGHT** column in the [**INFORMATION\_SCHEMA.INNODB\_TRX**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-trx-table) table. Weights are computed for waiting transactions only. Waiting transactions are those in a **LOCK WAIT** transaction execution state, as reported by the **TRX\_STATE** column. A transaction that is not waiting for a lock reports a NULL **TRX\_SCHEDULE\_WEIGHT** value.

[**INNODB\_METRICS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-metrics-table) counters are provided for monitoring of code-level transaction scheduling events. For information about using [**INNODB\_METRICS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-metrics-table) counters, see [Section 15.15.6, “InnoDB INFORMATION\_SCHEMA Metrics Table”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-information-schema-metrics-table).

**lock\_rec\_release\_attempts**

The number of attempts to release record locks. A single attempt may lead to zero or more record locks being released, as there may be zero or more record locks in a single structure.

**lock\_rec\_grant\_attempts**

The number of attempts to grant record locks. A single attempt may result in zero or more record locks being granted.

**lock\_schedule\_refreshes**

The number of times the wait-for graph was analyzed to update the scheduled transaction weights.

## 15.8 InnoDB Configuration

[15.8.1 InnoDB Startup Configuration](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-init-startup-configuration)

[15.8.2 Configuring InnoDB for Read-Only Operation](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-read-only-instance)

[15.8.3 InnoDB Buffer Pool Configuration](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-performance-buffer-pool)

[15.8.4 Configuring Thread Concurrency for InnoDB](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-performance-thread_concurrency)

[15.8.5 Configuring the Number of Background InnoDB I/O Threads](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-performance-multiple_io_threads)

[15.8.6 Using Asynchronous I/O on Linux](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-linux-native-aio)

[15.8.7 Configuring InnoDB I/O Capacity](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-configuring-io-capacity)

[15.8.8 Configuring Spin Lock Polling](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-performance-spin_lock_polling)

[15.8.9 Purge Configuration](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-purge-configuration)

[15.8.10 Configuring Optimizer Statistics for InnoDB](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-performance-optimizer-statistics)

[15.8.11 Configuring the Merge Threshold for Index Pages](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#index-page-merge-threshold)

[15.8.12 Enabling Automatic Configuration for a Dedicated MySQL Server](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-dedicated-server)

This section provides configuration information and procedures for **InnoDB** initialization, startup, and various components and features of the **InnoDB** storage engine. For information about optimizing database operations for **InnoDB** tables, see [Section 8.5, “Optimizing for InnoDB Tables”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizing-innodb).

### 15.8.1 InnoDB Startup Configuration

The first decisions to make about **InnoDB** configuration involve the configuration of data files, log files, page size, and memory buffers. It is recommended that you define data file, log file, and page size configuration before creating the **InnoDB** instance. Modifying data file or log file configuration after the **InnoDB** instance is created may involve a non-trivial procedure, and page size can only be defined when the **InnoDB** instance is first initialized.

In addition to these topics, this section provides information about specifying **InnoDB** options in a configuration file, viewing **InnoDB** initialization information, and important storage considerations.

[Specifying Options in a MySQL Configuration File](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-startup-mysql-configuration-file)

[Viewing InnoDB Initialization Information](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-startup-initialization-information)

[Important Storage Considerations](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-startup-storage-considerations)

[System Tablespace Data File Configuration](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-startup-data-file-configuration)

[InnoDB Doublewrite Buffer File Configuration](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-startup-doublewrite-file-config)

[Redo Log File Configuration](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-startup-log-file-configuration)

[Undo Tablespace Configuration](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-startup-undo-tablespace)

[Global Temporary Tablespace Configuration](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-startup-temporary-tablespace)

[Session Temporary Tablespace Configuration](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-startup-session-temporary-tablespaces)

[Page Size Configuration](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-startup-page-size)

[Memory Configuration](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-startup-memory-configuration)

#### Specifying Options in a MySQL Configuration File

Because MySQL uses data file, log file, and page size configuration settings to initialize the **InnoDB** instance, it is recommended that you define these settings in a configuration file that MySQL reads at startup, prior to initializing **InnoDB** for the first time. **InnoDB** is initialized when the MySQL server is started, and the first initialization of **InnoDB** normally occurs the first time you start the MySQL server.

You can place **InnoDB** options in the **[mysqld]** group of any option file that your server reads when it starts. The locations of MySQL option files are described in [Section 4.2.2.2, “Using Option Files”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\programs.html#option-files).

To make sure that [**mysqld**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\programs.html#mysqld) reads options only from a specific file (and mysqld-auto.cnf), use the [--defaults-file](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\programs.html#option_general_defaults-file) option as the first option on the command line when starting the server:

mysqld --defaults-file=***path\_to\_configuration\_file***

#### Viewing InnoDB Initialization Information

To view **InnoDB** initialization information during startup, start [**mysqld**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\programs.html#mysqld) from a command prompt. When [**mysqld**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\programs.html#mysqld) is started from a command prompt, initialization information is printed to the console.

For example, on Windows, if [**mysqld**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\programs.html#mysqld) is located in C:\Program Files\MySQL\MySQL Server 8.0\bin, start the MySQL server like this:

C:\> **"C:\Program Files\MySQL\MySQL Server 8.0\bin\mysqld" --console**

On Unix-like systems, [**mysqld**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\programs.html#mysqld) is located in the bin directory of your MySQL installation:

shell> **bin/mysqld --user=mysql &**

If you do not send server output to the console, check the error log after startup to see the initialization information **InnoDB** printed during the startup process.

For information about starting MySQL using other methods, see [Section 2.10.5, “Starting and Stopping MySQL Automatically”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\installing.html#automatic-start).

**Note**

**InnoDB** does not open all user tables and associated data files at startup. However, **InnoDB** does check for the existence of tablespace files (\*.ibd files) that are referenced in the data dictionary. If a tablespace file is not found, **InnoDB** logs an error and continues the startup sequence. Tablespace files that are referenced in the redo log may be opened during crash recovery for redo application.

#### Important Storage Considerations

Review the following storage-related considerations before proceeding with your startup configuration.

In some cases, database performance improves if the data is not all placed on the same physical disk. Putting log files on a different disk from data is very often beneficial for performance. For example, you can place system tablespace data files and log files on different disks. You can also use raw disk partitions (raw devices) for **InnoDB** data files, which may speed up I/O. See [Using Raw Disk Partitions for the System Tablespace](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-raw-devices).

**InnoDB** is a transaction-safe (ACID compliant) storage engine for MySQL that has commit, rollback, and crash-recovery capabilities to protect user data. ***However, it cannot do so*** if the underlying operating system or hardware does not work as advertised. Many operating systems or disk subsystems may delay or reorder write operations to improve performance. On some operating systems, the very **fsync()** system call that should wait until all unwritten data for a file has been flushed might actually return before the data has been flushed to stable storage. Because of this, an operating system crash or a power outage may destroy recently committed data, or in the worst case, even corrupt the database because of write operations having been reordered. If data integrity is important to you, perform some “pull-the-plug” tests before using anything in production. On macOS, **InnoDB** uses a special **fcntl()** file flush method. Under Linux, it is advisable to ***disable the write-back cache***.

On ATA/SATA disk drives, a command such **hdparm -W0 /dev/hda** may work to disable the write-back cache. ***Beware that some drives or disk controllers may be unable to disable the write-back cache.***

With regard to **InnoDB** recovery capabilities that protect user data, **InnoDB** uses a file flush technique involving a structure called the [doublewrite buffer](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_doublewrite_buffer), which is enabled by default ([**innodb\_doublewrite=ON**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_doublewrite)). The doublewrite buffer adds safety to recovery following an unexpected exit or power outage, and improves performance on most varieties of Unix by reducing the need for **fsync()** operations. It is recommended that the [**innodb\_doublewrite**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_doublewrite) option remains enabled if you are concerned with data integrity or possible failures. For additional information about the doublewrite buffer, see [Section 15.11.1, “InnoDB Disk I/O”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-disk-io).

Before using NFS with **InnoDB**, review potential issues outlined in [Using NFS with MySQL](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#disk-issues-nfs).

#### System Tablespace Data File Configuration

The [**innodb\_data\_file\_path**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_data_file_path) startup option defines the name, size, and attributes of **InnoDB** system tablespace data files. If you do not configure this option prior to initializing the MySQL server, the default behavior is to create a single auto-extending data file, slightly larger than 12MB, named ibdata1:

mysql> **SHOW VARIABLES LIKE 'innodb\_data\_file\_path';**

+-----------------------+------------------------+

| Variable\_name | Value |

+-----------------------+------------------------+

| innodb\_data\_file\_path | ibdata1:12M:autoextend |

+-----------------------+------------------------+

The full data file specification syntax includes the file name, file size, **autoextend** attribute, and **max** attribute:

***file\_name***:***file\_size***[:autoextend[:max:***max\_file\_size***]]

File sizes are specified in kilobytes, megabytes, or gigabytes by appending **K**, **M** or **G** to the size value. If specifying the data file size in kilobytes, do so in multiples of 1024. Otherwise, kilobyte values are rounded to nearest megabyte (MB) boundary. The sum of file sizes must be, at a minimum, slightly larger than 12MB.

You can specify more than one data file using a semicolon-separated list. For example:

[mysqld]

innodb\_data\_file\_path=ibdata1:50M;ibdata2:50M:autoextend

The **autoextend** and **max** attributes can be used only for the data file that is specified last.

When the **autoextend** attribute is specified, the data file automatically increases in size by 64MB increments as space is required. The [**innodb\_autoextend\_increment**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_autoextend_increment) variable controls the increment size.

To specify a maximum size for an auto-extending data file, use the **max** attribute following the **autoextend** attribute. Use the **max** attribute only in cases where constraining disk usage is of critical importance. The following configuration permits ibdata1 to grow to a limit of 500MB:

[mysqld]

innodb\_data\_file\_path=ibdata1:12M:autoextend:max:500M

A minimum file size is enforced for the first system tablespace data file to ensure that there is enough space for doublewrite buffer pages. The following table shows minimum file sizes for each **InnoDB** page size. The default **InnoDB** page size is 16384 (16KB).

| **Page Size (innodb\_page\_size)** | **Minimum File Size** |
| --- | --- |
| 16384 (16KB) or less | 3MB |
| 32768 (32KB) | 6MB |
| 65536 (64KB) | 12MB |

If your disk becomes full, you can add a data file on another disk. For instructions, see [Resizing the System Tablespace](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-resize-system-tablespace).

The size limit for individual files is determined by your operating system. You can set the file size to more than 4GB on operating systems that support large files. You can also use raw disk partitions as data files. See [Using Raw Disk Partitions for the System Tablespace](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-raw-devices).

**InnoDB** is not aware of the file system maximum file size, so be cautious on file systems where the maximum file size is a small value such as 2GB.

System tablespace files are created in the data directory by default ([**datadir**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_datadir)). To specify an alternate location, you can use the [**innodb\_data\_home\_dir**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_data_home_dir) option. For example, to create a system tablespace data file in a directory named myibdata, use this configuration:

[mysqld]

innodb\_data\_home\_dir = /myibdata/

innodb\_data\_file\_path=ibdata1:50M:autoextend

A trailing slash is required when specifying a value for [**innodb\_data\_home\_dir**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_data_home_dir). **InnoDB** does not create directories, so ensure that the specified directory exists before you start the server. Also, ensure sure that the MySQL server has the proper access rights to create files in the directory.

**InnoDB** forms the directory path for each data file by textually concatenating the value of [**innodb\_data\_home\_dir**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_data_home_dir) to the data file name. If [**innodb\_data\_home\_dir**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_data_home_dir) is not defined, the default value is “./”, which is the data directory. (The MySQL server changes its current working directory to the data directory when it begins executing.)

Alternatively, you can specify an absolute path for system tablespace data files. The following configuration is equivalent to the preceding one:

[mysqld]

innodb\_data\_file\_path=/myibdata/ibdata1:50M:autoextend

When you specify an absolute path for [**innodb\_data\_file\_path**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_data_file_path), the setting is not concatenated with the [**innodb\_data\_home\_dir**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_data_home_dir) setting. System tablespace files are created in the specified absolute path. The specified directory must exist before you start the server.

#### InnoDB Doublewrite Buffer File Configuration

As of MySQL 8.0.20, the doublewrite buffer storage area resides in doublewrite files, which provides flexibility with respect to the storage location of doublewrite pages. In previous releases, the doublwrite buffer storage area resided in the system tablespace. The [**innodb\_doublewrite\_dir**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_doublewrite_dir) variable defines the directory where **InnoDB** creates doublewrite files at startup. If no directory is specified, doublewrite files are created in the [**innodb\_data\_home\_dir**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_data_home_dir) directory, which defaults to the data directory if unspecified.

To have doublewrite files created in a location other than the [**innodb\_data\_home\_dir**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_data_home_dir) directory, configure [**innodb\_doublewrite\_dir**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_doublewrite_dir) variable. For example:

innodb\_doublewrite\_dir=***/path/to/doublewrite\_directory***

Other doublewrite buffer variables permit defining the number of doublewrite files, the number of pages per thread, and the doublewrite batch size. For more information about doublewrite buffer configuration, see [Section 15.6.4, “Doublewrite Buffer”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-doublewrite-buffer).

#### Redo Log File Configuration

By default, **InnoDB** creates two 5MB redo log files in the data directory named ib\_logfile0 and ib\_logfile1.

The following options can be used to modify the default configuration:

[**innodb\_log\_group\_home\_dir**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_log_group_home_dir) defines directory path to the **InnoDB** log files (the redo logs). If this option is not configured, **InnoDB** log files are created in the MySQL data directory ([**datadir**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_datadir)).

You might use this option to place **InnoDB** log files in a different physical storage location than **InnoDB** data files to avoid potential I/O resource conflicts. For example:

[mysqld]

innodb\_log\_group\_home\_dir = /dr3/iblogs

**Note**

**InnoDB** does not create directories, so make sure that the log directory exists before you start the server. Use the Unix or DOS **mkdir** command to create any necessary directories.

Make sure that the MySQL server has the proper access rights to create files in the log directory. More generally, the server must have access rights in any directory where it needs to create log files.

[**innodb\_log\_files\_in\_group**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_log_files_in_group) defines the number of log files in the log group. The default and recommended value is 2.

[**innodb\_log\_file\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_log_file_size) defines the size in bytes of each log file in the log group. The combined size of log files ([**innodb\_log\_file\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_log_file_size) \* [**innodb\_log\_files\_in\_group**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_log_files_in_group)) cannot exceed a maximum value that is slightly less than 512GB. A pair of 255 GB log files, for example, approaches the limit but does not exceed it. The default log file size is 48MB. Generally, the combined size of the log files should be large enough that the server can smooth out peaks and troughs in workload activity, which often means that there is enough redo log space to handle more than an hour of write activity. The larger the value, the less checkpoint flush activity is needed in the buffer pool, saving disk I/O. For additional information, see [Section 8.5.4, “Optimizing InnoDB Redo Logging”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizing-innodb-logging).

#### Undo Tablespace Configuration

By default, undo logs reside in two undo tablespaces that are created when the MySQL instance is initialized. The I/O patterns for undo logs make undo tablespaces good candidates for [SSD](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_ssd) storage.

The [**innodb\_undo\_directory**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_undo_directory) variable defines the path where **InnoDB** creates default undo tablespaces. If that variable is undefined, default undo tablespaces are created in the data directory. The [**innodb\_undo\_directory**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_undo_directory) variable is not dynamic. Configuring it requires restarting the server.

For information about configuring additional undo tablespaces, see [Section 15.6.3.4, “Undo Tablespaces”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-undo-tablespaces).

#### Global Temporary Tablespace Configuration

The global temporary tablespace stores rollback segments for changes made to user-created temporary tables.

By default, **InnoDB** creates a single auto-extending global temporary tablespace data file named ibtmp1 in the [**innodb\_data\_home\_dir**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_data_home_dir) directory. The initial file size is slightly larger than 12MB.

The [**innodb\_temp\_data\_file\_path**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_temp_data_file_path) variable specifies the path, file name, and file size for global temporary tablespace data files. File size is specified in KB, MB, or GB by appending K, M, or G to the size value. The sum of the sizes of the files must be slightly larger than 12MB.

To specify an alternate location for global temporary tablespace data files, configure the [**innodb\_temp\_data\_file\_path**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_temp_data_file_path) variable at startup.

#### Session Temporary Tablespace Configuration

In MySQL 8.0.15 and earlier, session temporary tablespaces store user-created temporary tables and internal temporary tables created by the optimizer when **InnoDB** is configured as the on-disk storage engine for internal temporary tables ([**internal\_tmp\_disk\_storage\_engine=InnoDB**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_internal_tmp_disk_storage_engine)). In MySQL 8.0.16 and later, the **InnoDB** storage engine is always used for internal temporary tables on disk.

The [**innodb\_temp\_tablespaces\_dir**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_temp_tablespaces_dir) variable defines the location where **InnoDB** creates session temporary tablespaces. The default location is the #innodb\_temp directory in the data directory.

To specify an alternate location for session temporary tablespaces, configure the [**innodb\_temp\_tablespaces\_dir**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_temp_tablespaces_dir) variable at startup. A fully qualified path or path relative to the data directory is permitted.

#### Page Size Configuration

The [**innodb\_page\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_page_size) option specifies the page size for all **InnoDB** tablespaces in a MySQL instance. This value is set when the instance is created and remains constant afterward. Valid values are 64KB, 32KB, 16KB (the default), 8KB, and 4KB. Alternatively, you can specify page size in bytes (65536, 32768, 16384, 8192, 4096).

The default page size of 16KB is appropriate for a wide range of workloads, particularly for queries involving table scans and DML operations involving bulk updates. Smaller page sizes might be more efficient for OLTP workloads involving many small writes, where contention can be an issue when a single page contains many rows. Smaller pages might also be efficient with SSD storage devices, which typically use small block sizes. Keeping the **InnoDB** page size close to the storage device block size minimizes the amount of unchanged data that is rewritten to disk.

#### Memory Configuration

MySQL allocates memory to various caches and buffers to improve performance of database operations. When allocating memory for **InnoDB**, always consider memory required by the operating system, memory allocated to other applications, and memory allocated for other MySQL buffers and caches. For example, if you use **MyISAM** tables, consider the amount of memory allocated for the key buffer ([**key\_buffer\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_key_buffer_size)). For an overview of MySQL buffers and caches, see [Section 8.12.3.1, “How MySQL Uses Memory”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#memory-use).

Buffers specific to **InnoDB** are configured using the following parameters:

[**innodb\_buffer\_pool\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_size) defines size of the buffer pool, which is the memory area that holds cached data for **InnoDB** tables, indexes, and other auxiliary buffers. The size of the buffer pool is important for system performance, and it is typically recommended that [**innodb\_buffer\_pool\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_size) is configured to 50 to 75 percent of system memory. The default buffer pool size is 128MB. For additional guidance, see [Section 8.12.3.1, “How MySQL Uses Memory”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#memory-use). For information about how to configure **InnoDB** buffer pool size, see [Section 15.8.3.1, “Configuring InnoDB Buffer Pool Size”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-buffer-pool-resize). Buffer pool size can be configured at startup or dynamically.

On systems with a large amount of memory, you can improve concurrency by dividing the buffer pool into multiple buffer pool instances. The number of buffer pool instances is controlled by the by [**innodb\_buffer\_pool\_instances**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_instances) option. By default, **InnoDB** creates one buffer pool instance. The number of buffer pool instances can be configured at startup. For more information, see [Section 15.8.3.2, “Configuring Multiple Buffer Pool Instances”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-multiple-buffer-pools).

[**innodb\_log\_buffer\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_log_buffer_size) defines the size in bytes of the buffer that **InnoDB** uses to write to the log files on disk. The default size is 16MB. A large log buffer enables large transactions to run without a need to write the log to disk before the transactions commit. If you have transactions that update, insert, or delete many rows, you might consider increasing the size of the log buffer to save disk I/O. [**innodb\_log\_buffer\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_log_buffer_size) can be configured at startup. For related information, see [Section 8.5.4, “Optimizing InnoDB Redo Logging”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizing-innodb-logging).

**Warning**

On 32-bit GNU/Linux x86, be careful not to set memory usage too high. **glibc** may permit the process heap to grow over thread stacks, which crashes your server. It is a risk if the memory allocated to the [**mysqld**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\programs.html#mysqld) process for global and per-thread buffers and caches is close to or exceeds 2GB.

A formula similar to the following that calculates global and per-thread memory allocation for MySQL can be used to estimate MySQL memory usage. You may need to modify the formula to account for buffers and caches in your MySQL version and configuration. For an overview of MySQL buffers and caches, see [Section 8.12.3.1, “How MySQL Uses Memory”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#memory-use).

innodb\_buffer\_pool\_size

+ key\_buffer\_size

+ max\_connections\*(sort\_buffer\_size+read\_buffer\_size+binlog\_cache\_size)

+ max\_connections\*2MB

Each thread uses a stack (often 2MB, but only 256KB in MySQL binaries provided by Oracle Corporation.) and in the worst case also uses **sort\_buffer\_size + read\_buffer\_size** additional memory.

On Linux, if the kernel is enabled for large page support, **InnoDB** can use large pages to allocate memory for its buffer pool. See [Section 8.12.3.2, “Enabling Large Page Support”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#large-page-support).

### 15.8.2 Configuring InnoDB for Read-Only Operation

You can query **InnoDB** tables where the MySQL data directory is on read-only media by enabling the [**--innodb-read-only**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_read_only) configuration option at server startup.

#### How to Enable

To prepare an instance for read-only operation, make sure all the necessary information is [flushed](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_flush) to the data files before storing it on the read-only medium. Run the server with change buffering disabled ([**innodb\_change\_buffering=0**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_change_buffering)) and do a [slow shutdown](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_slow_shutdown).

To enable read-only mode for an entire MySQL instance, specify the following configuration options at server startup:

[**--innodb-read-only=1**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_read_only)

If the instance is on read-only media such as a DVD or CD, or the /var directory is not writeable by all: [**--pid-file=*path\_on\_writeable\_media***](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_pid_file) and [**--event-scheduler=disabled**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_event_scheduler)

[**--innodb-temp-data-file-path**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_temp_data_file_path). This option specifies the path, file name, and file size for **InnoDB** temporary tablespace data files. The default setting is **ibtmp1:12M:autoextend**, which creates the ibtmp1 temporary tablespace data file in the data directory. To prepare an instance for read-only operation, set [**innodb\_temp\_data\_file\_path**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_temp_data_file_path) to a location outside of the data directory. The path must be relative to the data directory. For example:

--innodb-temp-data-file-path=../../../tmp/ibtmp1:12M:autoextend

As of MySQL 8.0, enabling [**innodb\_read\_only**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_read_only) prevents table creation and drop operations for all storage engines. These operations modify data dictionary tables in the **mysql** system database, but those tables use the **InnoDB** storage engine and cannot be modified when [**innodb\_read\_only**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_read_only) is enabled. The same restriction applies to any operation that modifies data dictionary tables, such as [**ANALYZE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#analyze-table) and [**ALTER TABLE *tbl\_name* ENGINE=*engine\_name***](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table).

In addition, other tables in the **mysql** system database use the **InnoDB** storage engine in MySQL 8.0. Making those tables read only results in restrictions on operations that modify them. For example, [**CREATE USER**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-user), [**GRANT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#grant), [**REVOKE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#revoke), and [**INSTALL PLUGIN**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#install-plugin) operations are not permitted in read-only mode.

#### Usage Scenarios

This mode of operation is appropriate in situations such as:

Distributing a MySQL application, or a set of MySQL data, on a read-only storage medium such as a DVD or CD.

Multiple MySQL instances querying the same data directory simultaneously, typically in a data warehousing configuration. You might use this technique to avoid [bottlenecks](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_bottleneck) that can occur with a heavily loaded MySQL instance, or you might use different configuration options for the various instances to tune each one for particular kinds of queries.

Querying data that has been put into a read-only state for security or data integrity reasons, such as archived backup data.

**Note**

This feature is mainly intended for flexibility in distribution and deployment, rather than raw performance based on the read-only aspect. See [Section 8.5.3, “Optimizing InnoDB Read-Only Transactions”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#innodb-performance-ro-txn) for ways to tune the performance of read-only queries, which do not require making the entire server read-only.

#### How It Works

When the server is run in read-only mode through the [**--innodb-read-only**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_read_only) option, certain **InnoDB** features and components are reduced or turned off entirely:

No [change buffering](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_change_buffering) is done, in particular no merges from the change buffer. To make sure the change buffer is empty when you prepare the instance for read-only operation, disable change buffering ([**innodb\_change\_buffering=0**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_change_buffering)) and do a [slow shutdown](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_slow_shutdown) first.

There is no [crash recovery](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_crash_recovery) phase at startup. The instance must have performed a [slow shutdown](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_slow_shutdown) before being put into the read-only state.

Because the [redo log](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_redo_log) is not used in read-only operation, you can set [**innodb\_log\_file\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_log_file_size) to the smallest size possible (1 MB) before making the instance read-only.

Most background threads are turned off. I/O read threads remain, as well as I/O write threads and a page flush coordinator thread for writes to temporary files, which are permitted in read-only mode. A buffer pool resize thread also remains active to enable online resizing of the buffer pool.

Information about deadlocks, monitor output, and so on is not written to temporary files. As a consequence, [**SHOW ENGINE INNODB STATUS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#show-engine) does not produce any output.

Changes to configuration option settings that would normally change the behavior of write operations, have no effect when the server is in read-only mode.

The [MVCC](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_mvcc) processing to enforce [isolation levels](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_isolation_level) is turned off. All queries read the latest version of a record, because update and deletes are not possible.

The [undo log](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_undo_log) is not used. Disable any settings for the [**innodb\_undo\_tablespaces**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_undo_tablespaces) and [**innodb\_undo\_directory**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_undo_directory) configuration options.

### 15.8.3 InnoDB Buffer Pool Configuration

[15.8.3.1 Configuring InnoDB Buffer Pool Size](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-buffer-pool-resize)

[15.8.3.2 Configuring Multiple Buffer Pool Instances](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-multiple-buffer-pools)

[15.8.3.3 Making the Buffer Pool Scan Resistant](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-performance-midpoint_insertion)

[15.8.3.4 Configuring InnoDB Buffer Pool Prefetching (Read-Ahead)](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-performance-read_ahead)

[15.8.3.5 Configuring Buffer Pool Flushing](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-buffer-pool-flushing)

[15.8.3.6 Saving and Restoring the Buffer Pool State](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-preload-buffer-pool)

[15.8.3.7 Excluding Buffer Pool Pages from Core Files](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-buffer-pool-in-core-file)

This section provides configuration and tuning information for the **InnoDB** buffer pool.

#### 15.8.3.1 Configuring InnoDB Buffer Pool Size

You can configure **InnoDB** buffer pool size offline or while the server is running. Behavior described in this section applies to both methods. For additional information about configuring buffer pool size online, see [Configuring InnoDB Buffer Pool Size Online](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-buffer-pool-online-resize).

When increasing or decreasing [**innodb\_buffer\_pool\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_size), the operation is performed in chunks. Chunk size is defined by the [**innodb\_buffer\_pool\_chunk\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_chunk_size) configuration option, which has a default of **128M**. For more information, see [Configuring InnoDB Buffer Pool Chunk Size](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-buffer-pool-chunk-size).

Buffer pool size must always be equal to or a multiple of [**innodb\_buffer\_pool\_chunk\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_chunk_size) \* [**innodb\_buffer\_pool\_instances**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_instances). If you configure [**innodb\_buffer\_pool\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_size) to a value that is not equal to or a multiple of [**innodb\_buffer\_pool\_chunk\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_chunk_size) \* [**innodb\_buffer\_pool\_instances**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_instances), buffer pool size is automatically adjusted to a value that is equal to or a multiple of [**innodb\_buffer\_pool\_chunk\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_chunk_size) \* [**innodb\_buffer\_pool\_instances**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_instances).

In the following example, [**innodb\_buffer\_pool\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_size) is set to **8G**, and [**innodb\_buffer\_pool\_instances**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_instances) is set to **16**. [**innodb\_buffer\_pool\_chunk\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_chunk_size) is **128M**, which is the default value.

**8G** is a valid [**innodb\_buffer\_pool\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_size) value because **8G** is a multiple of [**innodb\_buffer\_pool\_instances=16**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_instances) \* [**innodb\_buffer\_pool\_chunk\_size=128M**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_chunk_size), which is **2G**.

shell> **mysqld --innodb-buffer-pool-size=8G --innodb-buffer-pool-instances=16**

mysql> **SELECT @@innodb\_buffer\_pool\_size/1024/1024/1024;**

+------------------------------------------+

| @@innodb\_buffer\_pool\_size/1024/1024/1024 |

+------------------------------------------+

| 8.000000000000 |

+------------------------------------------+

In this example, [**innodb\_buffer\_pool\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_size) is set to **9G**, and [**innodb\_buffer\_pool\_instances**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_instances) is set to **16**. [**innodb\_buffer\_pool\_chunk\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_chunk_size) is **128M**, which is the default value. In this case, **9G** is not a multiple of [**innodb\_buffer\_pool\_instances=16**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_instances) \* [**innodb\_buffer\_pool\_chunk\_size=128M**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_chunk_size), so [**innodb\_buffer\_pool\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_size) is adjusted to **10G**, which is a multiple of [**innodb\_buffer\_pool\_chunk\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_chunk_size) \* [**innodb\_buffer\_pool\_instances**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_instances).

shell> **mysqld --innodb-buffer-pool-size=9G --innodb-buffer-pool-instances=16**

mysql> **SELECT @@innodb\_buffer\_pool\_size/1024/1024/1024;**

+------------------------------------------+

| @@innodb\_buffer\_pool\_size/1024/1024/1024 |

+------------------------------------------+

| 10.000000000000 |

+------------------------------------------+

##### Configuring InnoDB Buffer Pool Chunk Size

[**innodb\_buffer\_pool\_chunk\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_chunk_size) can be increased or decreased in 1MB (1048576 byte) units but can only be modified at startup, in a command line string or in a MySQL configuration file.

Command line:

shell> **mysqld --innodb-buffer-pool-chunk-size=134217728**

Configuration file:

[mysqld]

innodb\_buffer\_pool\_chunk\_size=134217728

The following conditions apply when altering [**innodb\_buffer\_pool\_chunk\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_chunk_size):

If the new [**innodb\_buffer\_pool\_chunk\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_chunk_size) value \* [**innodb\_buffer\_pool\_instances**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_instances) is larger than the current buffer pool size when the buffer pool is initialized, [**innodb\_buffer\_pool\_chunk\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_chunk_size) is truncated to [**innodb\_buffer\_pool\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_size) / [**innodb\_buffer\_pool\_instances**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_instances).

For example, if the buffer pool is initialized with a size of **2GB** (2147483648 bytes), **4** buffer pool instances, and a chunk size of **1GB** (1073741824 bytes), chunk size is truncated to a value equal to [**innodb\_buffer\_pool\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_size) / [**innodb\_buffer\_pool\_instances**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_instances), as shown below:

shell> **mysqld --innodb-buffer-pool-size=2147483648 --innodb-buffer-pool-instances=4**

**--innodb-buffer-pool-chunk-size=1073741824;**

mysql> **SELECT @@innodb\_buffer\_pool\_size;**

+---------------------------+

| @@innodb\_buffer\_pool\_size |

+---------------------------+

| 2147483648 |

+---------------------------+

mysql> **SELECT @@innodb\_buffer\_pool\_instances;**

+--------------------------------+

| @@innodb\_buffer\_pool\_instances |

+--------------------------------+

| 4 |

+--------------------------------+

# Chunk size was set to 1GB (1073741824 bytes) on startup but was

# truncated to innodb\_buffer\_pool\_size / innodb\_buffer\_pool\_instances

mysql> **SELECT @@innodb\_buffer\_pool\_chunk\_size;**

+---------------------------------+

| @@innodb\_buffer\_pool\_chunk\_size |

+---------------------------------+

| 536870912 |

+---------------------------------+

Buffer pool size must always be equal to or a multiple of [**innodb\_buffer\_pool\_chunk\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_chunk_size) \* [**innodb\_buffer\_pool\_instances**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_instances). If you alter [**innodb\_buffer\_pool\_chunk\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_chunk_size), [**innodb\_buffer\_pool\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_size) is automatically adjusted to a value that is equal to or a multiple of [**innodb\_buffer\_pool\_chunk\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_chunk_size) \* [**innodb\_buffer\_pool\_instances**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_instances). The adjustment occurs when the buffer pool is initialized. This behavior is demonstrated in the following example:

# The buffer pool has a default size of 128MB (134217728 bytes)

mysql> **SELECT @@innodb\_buffer\_pool\_size;**

+---------------------------+

| @@innodb\_buffer\_pool\_size |

+---------------------------+

| 134217728 |

+---------------------------+

# The chunk size is also 128MB (134217728 bytes)

mysql> **SELECT @@innodb\_buffer\_pool\_chunk\_size;**

+---------------------------------+

| @@innodb\_buffer\_pool\_chunk\_size |

+---------------------------------+

| 134217728 |

+---------------------------------+

# There is a single buffer pool instance

mysql> **SELECT @@innodb\_buffer\_pool\_instances;**

+--------------------------------+

| @@innodb\_buffer\_pool\_instances |

+--------------------------------+

| 1 |

+--------------------------------+

# Chunk size is decreased by 1MB (1048576 bytes) at startup

# (134217728 - 1048576 = 133169152):

shell> **mysqld --innodb-buffer-pool-chunk-size=133169152**

mysql> **SELECT @@innodb\_buffer\_pool\_chunk\_size;**

+---------------------------------+

| @@innodb\_buffer\_pool\_chunk\_size |

+---------------------------------+

| 133169152 |

+---------------------------------+

# Buffer pool size increases from 134217728 to 266338304

# Buffer pool size is automatically adjusted to a value that is equal to

# or a multiple of innodb\_buffer\_pool\_chunk\_size \* innodb\_buffer\_pool\_instances

mysql> **SELECT @@innodb\_buffer\_pool\_size;**

+---------------------------+

| @@innodb\_buffer\_pool\_size |

+---------------------------+

| 266338304 |

+---------------------------+

This example demonstrates the same behavior but with multiple buffer pool instances:

# The buffer pool has a default size of 2GB (2147483648 bytes)

mysql> **SELECT @@innodb\_buffer\_pool\_size;**

+---------------------------+

| @@innodb\_buffer\_pool\_size |

+---------------------------+

| 2147483648 |

+---------------------------+

# The chunk size is .5 GB (536870912 bytes)

mysql> **SELECT @@innodb\_buffer\_pool\_chunk\_size;**

+---------------------------------+

| @@innodb\_buffer\_pool\_chunk\_size |

+---------------------------------+

| 536870912 |

+---------------------------------+

# There are 4 buffer pool instances

mysql> **SELECT @@innodb\_buffer\_pool\_instances;**

+--------------------------------+

| @@innodb\_buffer\_pool\_instances |

+--------------------------------+

| 4 |

+--------------------------------+

# Chunk size is decreased by 1MB (1048576 bytes) at startup

# (536870912 - 1048576 = 535822336):

shell> **mysqld --innodb-buffer-pool-chunk-size=535822336**

mysql> **SELECT @@innodb\_buffer\_pool\_chunk\_size;**

+---------------------------------+

| @@innodb\_buffer\_pool\_chunk\_size |

+---------------------------------+

| 535822336 |

+---------------------------------+

# Buffer pool size increases from 2147483648 to 4286578688

# Buffer pool size is automatically adjusted to a value that is equal to

# or a multiple of innodb\_buffer\_pool\_chunk\_size \* innodb\_buffer\_pool\_instances

mysql> **SELECT @@innodb\_buffer\_pool\_size;**

+---------------------------+

| @@innodb\_buffer\_pool\_size |

+---------------------------+

| 4286578688 |

+---------------------------+

Care should be taken when changing [**innodb\_buffer\_pool\_chunk\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_chunk_size), as changing this value can increase the size of the buffer pool, as shown in the examples above. Before you change [**innodb\_buffer\_pool\_chunk\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_chunk_size), calculate the effect on [**innodb\_buffer\_pool\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_size) to ensure that the resulting buffer pool size is acceptable.

**Note**

To avoid potential performance issues, the number of chunks ([**innodb\_buffer\_pool\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_size) / [**innodb\_buffer\_pool\_chunk\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_chunk_size)) should not exceed 1000.

##### Configuring InnoDB Buffer Pool Size Online

The [**innodb\_buffer\_pool\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_size) configuration option can be set dynamically using a [**SET**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-types.html#set) statement, allowing you to resize the buffer pool without restarting the server. For example:

mysql> **SET GLOBAL innodb\_buffer\_pool\_size=402653184;**

**Note**

The buffer pool size must be equal to or a multiple of [**innodb\_buffer\_pool\_chunk\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_chunk_size) \* [**innodb\_buffer\_pool\_instances**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_instances). Changing those variable settings requires restarting the server.

Active transactions and operations performed through **InnoDB** APIs should be completed before resizing the buffer pool. When initiating a resizing operation, the operation does not start until all active transactions are completed. Once the resizing operation is in progress, new transactions and operations that require access to the buffer pool must wait until the resizing operation finishes. The exception to the rule is that concurrent access to the buffer pool is permitted while the buffer pool is defragmented and pages are withdrawn when buffer pool size is decreased. A drawback of allowing concurrent access is that it could result in a temporary shortage of available pages while pages are being withdrawn.

**Note**

Nested transactions could fail if initiated after the buffer pool resizing operation begins.

##### Monitoring Online Buffer Pool Resizing Progress

The [**Innodb\_buffer\_pool\_resize\_status**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#statvar_Innodb_buffer_pool_resize_status) reports buffer pool resizing progress. For example:

mysql> **SHOW STATUS WHERE Variable\_name='InnoDB\_buffer\_pool\_resize\_status';**

+----------------------------------+----------------------------------+

| Variable\_name | Value |

+----------------------------------+----------------------------------+

| Innodb\_buffer\_pool\_resize\_status | Resizing also other hash tables. |

+----------------------------------+----------------------------------+

Buffer pool resizing progress is also logged in the server error log. This example shows notes that are logged when increasing the size of the buffer pool:

[Note] InnoDB: Resizing buffer pool from 134217728 to 4294967296. (unit=134217728)

[Note] InnoDB: disabled adaptive hash index.

[Note] InnoDB: buffer pool 0 : 31 chunks (253952 blocks) was added.

[Note] InnoDB: buffer pool 0 : hash tables were resized.

[Note] InnoDB: Resized hash tables at lock\_sys, adaptive hash index, dictionary.

[Note] InnoDB: completed to resize buffer pool from 134217728 to 4294967296.

[Note] InnoDB: re-enabled adaptive hash index.

This example shows notes that are logged when decreasing the size of the buffer pool:

[Note] InnoDB: Resizing buffer pool from 4294967296 to 134217728. (unit=134217728)

[Note] InnoDB: disabled adaptive hash index.

[Note] InnoDB: buffer pool 0 : start to withdraw the last 253952 blocks.

[Note] InnoDB: buffer pool 0 : withdrew 253952 blocks from free list. tried to relocate 0 pages.

(253952/253952)

[Note] InnoDB: buffer pool 0 : withdrawn target 253952 blocks.

[Note] InnoDB: buffer pool 0 : 31 chunks (253952 blocks) was freed.

[Note] InnoDB: buffer pool 0 : hash tables were resized.

[Note] InnoDB: Resized hash tables at lock\_sys, adaptive hash index, dictionary.

[Note] InnoDB: completed to resize buffer pool from 4294967296 to 134217728.

[Note] InnoDB: re-enabled adaptive hash index.

##### Online Buffer Pool Resizing Internals

The resizing operation is performed by a background thread. When increasing the size of the buffer pool, the resizing operation:

Adds pages in **chunks** (chunk size is defined by [**innodb\_buffer\_pool\_chunk\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_chunk_size))

Coverts hash tables, lists, and pointers to use new addresses in memory

Adds new pages to the free list

While these operations are in progress, other threads are blocked from accessing the buffer pool.

When decreasing the size of the buffer pool, the resizing operation:

Defragments the buffer pool and withdraws (frees) pages

Removes pages in **chunks** (chunk size is defined by [**innodb\_buffer\_pool\_chunk\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_chunk_size))

Converts hash tables, lists, and pointers to use new addresses in memory

Of these operations, only defragmenting the buffer pool and withdrawing pages allow other threads to access to the buffer pool concurrently.

#### 15.8.3.2 Configuring Multiple Buffer Pool Instances

For systems with buffer pools in the multi-gigabyte range, dividing the buffer pool into separate instances can improve concurrency, by reducing contention as different threads read and write to cached pages. This feature is typically intended for systems with a [buffer pool](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_buffer_pool) size in the multi-gigabyte range. Multiple buffer pool instances are configured using the [**innodb\_buffer\_pool\_instances**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_instances) configuration option, and you might also adjust the [**innodb\_buffer\_pool\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_size) value.

When the **InnoDB** buffer pool is large, many data requests can be satisfied by retrieving from memory. You might encounter bottlenecks from multiple threads trying to access the buffer pool at once. You can enable multiple buffer pools to minimize this contention. Each page that is stored in or read from the buffer pool is assigned to one of the buffer pools randomly, using a hashing function. Each buffer pool manages its own free lists, flush lists, LRUs, and all other data structures connected to a buffer pool. Prior to MySQL 8.0, each buffer pool was protected by its own buffer pool mutex. In MySQL 8.0 and later, the buffer pool mutex was replaced by several list and hash protecting mutexes, to reduce contention.

To enable multiple buffer pool instances, set the **innodb\_buffer\_pool\_instances** configuration option to a value greater than 1 (the default) up to 64 (the maximum). This option takes effect only when you set **innodb\_buffer\_pool\_size** to a size of 1GB or more. The total size you specify is divided among all the buffer pools. For best efficiency, specify a combination of [**innodb\_buffer\_pool\_instances**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_instances) and [**innodb\_buffer\_pool\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_size) so that each buffer pool instance is at least 1GB.

For information about modifying **InnoDB** buffer pool size, see [Section 15.8.3.1, “Configuring InnoDB Buffer Pool Size”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-buffer-pool-resize).

#### 15.8.3.3 Making the Buffer Pool Scan Resistant

Rather than using a strict [LRU](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_lru) algorithm, **InnoDB** uses a technique to minimize the amount of data that is brought into the [buffer pool](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_buffer_pool) and never accessed again. The goal is to make sure that frequently accessed (“hot”) pages remain in the buffer pool, even as [read-ahead](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_read_ahead) and [full table scans](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_full_table_scan) bring in new blocks that might or might not be accessed afterward.

Newly read blocks are inserted into the middle of the LRU list. All newly read pages are inserted at a location that by default is **3/8** from the tail of the LRU list. The pages are moved to the front of the list (the most-recently used end) when they are accessed in the buffer pool for the first time. Thus, pages that are never accessed never make it to the front portion of the LRU list, and “age out” sooner than with a strict LRU approach. This arrangement divides the LRU list into two segments, where the pages downstream of the insertion point are considered “old” and are desirable victims for LRU eviction.

For an explanation of the inner workings of the **InnoDB** buffer pool and specifics about the LRU algorithm, see [Section 15.5.1, “Buffer Pool”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-buffer-pool).

You can control the insertion point in the LRU list and choose whether **InnoDB** applies the same optimization to blocks brought into the buffer pool by table or index scans. The configuration parameter [**innodb\_old\_blocks\_pct**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_old_blocks_pct) controls the percentage of “old” blocks in the LRU list. The default value of [**innodb\_old\_blocks\_pct**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_old_blocks_pct) is **37**, corresponding to the original fixed ratio of 3/8. The value range is **5** (new pages in the buffer pool age out very quickly) to **95** (only 5% of the buffer pool is reserved for hot pages, making the algorithm close to the familiar LRU strategy).

The optimization that keeps the buffer pool from being churned by read-ahead can avoid similar problems due to table or index scans. In these scans, a data page is typically accessed a few times in quick succession and is never touched again. The configuration parameter [**innodb\_old\_blocks\_time**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_old_blocks_time) specifies the time window (in milliseconds) after the first access to a page during which it can be accessed without being moved to the front (most-recently used end) of the LRU list. The default value of [**innodb\_old\_blocks\_time**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_old_blocks_time) is **1000**. Increasing this value makes more and more blocks likely to age out faster from the buffer pool.

Both [**innodb\_old\_blocks\_pct**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_old_blocks_pct) and [**innodb\_old\_blocks\_time**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_old_blocks_time) can be specified in the MySQL option file (**my.cnf** or **my.ini**) or changed at runtime with the [**SET GLOBAL**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#set-variable) statement. Changing the value at runtime requires privileges sufficient to set global system variables. See [Section 5.1.9.1, “System Variable Privileges”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#system-variable-privileges).

To help you gauge the effect of setting these parameters, the **SHOW ENGINE INNODB STATUS** command reports buffer pool statistics. For details, see [Monitoring the Buffer Pool Using the InnoDB Standard Monitor](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-buffer-pool-monitoring).

Because the effects of these parameters can vary widely based on your hardware configuration, your data, and the details of your workload, always benchmark to verify the effectiveness before changing these settings in any performance-critical or production environment.

In mixed workloads where most of the activity is OLTP type with periodic batch reporting queries which result in large scans, setting the value of [**innodb\_old\_blocks\_time**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_old_blocks_time) during the batch runs can help keep the working set of the normal workload in the buffer pool.

When scanning large tables that cannot fit entirely in the buffer pool, setting [**innodb\_old\_blocks\_pct**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_old_blocks_pct) to a small value keeps the data that is only read once from consuming a significant portion of the buffer pool. For example, setting **innodb\_old\_blocks\_pct=5** restricts this data that is only read once to 5% of the buffer pool.

When scanning small tables that do fit into memory, there is less overhead for moving pages around within the buffer pool, so you can leave [**innodb\_old\_blocks\_pct**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_old_blocks_pct) at its default value, or even higher, such as **innodb\_old\_blocks\_pct=50**.

The effect of the [**innodb\_old\_blocks\_time**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_old_blocks_time) parameter is harder to predict than the [**innodb\_old\_blocks\_pct**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_old_blocks_pct) parameter, is relatively small, and varies more with the workload. To arrive at an optimal value, conduct your own benchmarks if the performance improvement from adjusting [**innodb\_old\_blocks\_pct**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_old_blocks_pct) is not sufficient.

#### 15.8.3.4 Configuring InnoDB Buffer Pool Prefetching (Read-Ahead)

A [read-ahead](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_read_ahead) request is an I/O request to prefetch multiple pages in the [buffer pool](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_buffer_pool) asynchronously, in anticipation of impending need for these pages. The requests bring in all the pages in one [extent](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_extent). **InnoDB** uses two read-ahead algorithms to improve I/O performance:

**Linear** read-ahead is a technique that predicts what pages might be needed soon based on pages in the buffer pool being accessed sequentially. You control when **InnoDB** performs a read-ahead operation by adjusting the number of sequential page accesses required to trigger an asynchronous read request, using the configuration parameter [**innodb\_read\_ahead\_threshold**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_read_ahead_threshold). Before this parameter was added, **InnoDB** would only calculate whether to issue an asynchronous prefetch request for the entire next extent when it read the last page of the current extent.

The configuration parameter [**innodb\_read\_ahead\_threshold**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_read_ahead_threshold) controls how sensitive **InnoDB** is in detecting patterns of sequential page access. If the number of pages read sequentially from an extent is greater than or equal to [**innodb\_read\_ahead\_threshold**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_read_ahead_threshold), **InnoDB** initiates an asynchronous read-ahead operation of the entire following extent. [**innodb\_read\_ahead\_threshold**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_read_ahead_threshold) can be set to any value from 0-64. The default value is 56. The higher the value, the more strict the access pattern check. For example, if you set the value to 48, **InnoDB** triggers a linear read-ahead request only when 48 pages in the current extent have been accessed sequentially. If the value is 8, **InnoDB** triggers an asynchronous read-ahead even if as few as 8 pages in the extent are accessed sequentially. You can set the value of this parameter in the MySQL [configuration file](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_configuration_file), or change it dynamically with the [**SET GLOBAL**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#set-variable) statement, which requires privileges sufficient to set global system variables. See [Section 5.1.9.1, “System Variable Privileges”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#system-variable-privileges).

**Random** read-ahead is a technique that predicts when pages might be needed soon based on pages already in the buffer pool, regardless of the order in which those pages were read. If 13 consecutive pages from the same extent are found in the buffer pool, **InnoDB** asynchronously issues a request to prefetch the remaining pages of the extent. To enable this feature, set the configuration variable [**innodb\_random\_read\_ahead**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_random_read_ahead) to **ON**.

The **SHOW ENGINE INNODB STATUS** command displays statistics to help you evaluate the effectiveness of the read-ahead algorithm. Statistics include counter information for the following global status variables:

[**Innodb\_buffer\_pool\_read\_ahead**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#statvar_Innodb_buffer_pool_read_ahead)

[**Innodb\_buffer\_pool\_read\_ahead\_evicted**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#statvar_Innodb_buffer_pool_read_ahead_evicted)

[**Innodb\_buffer\_pool\_read\_ahead\_rnd**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#statvar_Innodb_buffer_pool_read_ahead_rnd)

This information can be useful when fine-tuning the [**innodb\_random\_read\_ahead**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_random_read_ahead) setting.

For more information about I/O performance, see [Section 8.5.8, “Optimizing InnoDB Disk I/O”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizing-innodb-diskio) and [Section 8.12.1, “Optimizing Disk I/O”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#disk-issues).

#### 15.8.3.5 Configuring Buffer Pool Flushing

**InnoDB** performs certain tasks in the background, including flushing of dirty pages from the buffer pool. Dirty pages are those that have been modified but are not yet written to the data files on disk.

In MySQL 8.0, buffer pool flushing is performed by page cleaner threads. The number of page cleaner threads is controlled by the [**innodb\_page\_cleaners**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_page_cleaners) variable, which has a default value of 4. However, if the number of page cleaner threads exceeds the number of buffer pool instances, [**innodb\_page\_cleaners**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_page_cleaners) is automatically set to the same value as [**innodb\_buffer\_pool\_instances**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_instances).

Buffer pool flushing is initiated when the percentage of dirty pages reaches the low water mark value defined by the [**innodb\_max\_dirty\_pages\_pct\_lwm**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_max_dirty_pages_pct_lwm) variable. The default low water mark is 10% of buffer pool pages. A [**innodb\_max\_dirty\_pages\_pct\_lwm**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_max_dirty_pages_pct_lwm) value of 0 disables this early flushing behaviour.

The purpose of the [**innodb\_max\_dirty\_pages\_pct\_lwm**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_max_dirty_pages_pct_lwm) threshold is to control the percentage dirty pages in the buffer pool and to prevent the amount of dirty pages from reaching the threshold defined by the [**innodb\_max\_dirty\_pages\_pct**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_max_dirty_pages_pct) variable, which has a default value of 90. **InnoDB** aggressively flushes buffer pool pages if the percentage of dirty pages in the buffer pool reaches the [**innodb\_max\_dirty\_pages\_pct**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_max_dirty_pages_pct) threshold.

When configuring [**innodb\_max\_dirty\_pages\_pct\_lwm**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_max_dirty_pages_pct_lwm), the value should always be lower than the [**innodb\_max\_dirty\_pages\_pct**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_max_dirty_pages_pct) value.

Additional variables permit fine-tuning of buffer pool flushing behavior:

The [**innodb\_flush\_neighbors**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_flush_neighbors) variable defines whether flushing a page from the buffer pool also flushes other dirty pages in the same extent.

The default setting of 0 disables [**innodb\_flush\_neighbors**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_flush_neighbors). Dirty pages in the same extent are not flushed. This setting is recommended for non-rotational storage (SSD) devices where seek time is not a significant factor.

A setting of 1 flushes contiguous dirty pages in the same extent.

A setting of 2 flushes dirty pages in the same extent.

When table data is stored on a traditional [HDD](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_hdd) storage device, flushing neighbor pages in one operation reduces I/O overhead (primarily for disk seek operations) compared to flushing individual pages at different times. For table data stored on [SSD](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_ssd), seek time is not a significant factor and you can disable this setting to spread out write operations.

The [**innodb\_lru\_scan\_depth**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_lru_scan_depth) variable specifies, per buffer pool instance, how far down the buffer pool LRU list the page cleaner thread scans looking for dirty pages to flush. This is a background operation performed by a page cleaner thread once per second.

A setting smaller than the default is generally suitable for most workloads. A value that is significantly higher than necessary may impact performance. Only consider increasing the value if you have spare I/O capacity under a typical workload. Conversely, if a write-intensive workload saturates your I/O capacity, decrease the value, especially in the case of a large buffer pool.

When tuning [**innodb\_lru\_scan\_depth**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_lru_scan_depth), start with a low value and configure the setting upward with the goal of rarely seeing zero free pages. Also, consider adjusting [**innodb\_lru\_scan\_depth**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_lru_scan_depth) when changing the number of buffer pool instances, since [**innodb\_lru\_scan\_depth**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_lru_scan_depth) \* [**innodb\_buffer\_pool\_instances**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_instances) defines the amount of work performed by the page cleaner thread each second.

The [**innodb\_flush\_neighbors**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_flush_neighbors) and [**innodb\_lru\_scan\_depth**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_lru_scan_depth) variables are primarily intended for write-intensive workloads. With heavy DML activity, flushing can fall behind if it is not aggressive enough, or disk writes can saturate I/O capacity if flushing is too aggressive. The ideal settings depend on your workload, data access patterns, and storage configuration (for example, whether data is stored on HDD or SSD devices).

##### Adaptive Flushing

**InnoDB** uses an adaptive flushing algorithm to dynamically adjust the rate of flushing based on the speed of redo log generation and the current rate of flushing. The intent is to smooth overall performance by ensuring that flushing activity keeps pace with the current workload. Automatically adjusting the flushing rate helps avoid sudden dips in throughput that can occur when bursts of I/O activity due to buffer pool flushing affects the I/O capacity available for ordinary read and write activity.

Sharp checkpoints, which are typically associated with write-intensive workloads that generate a lot of redo entries, can cause a sudden change in throughput, for example. A sharp checkpoint occurs when **InnoDB** wants to reuse a portion of a log file. Before doing so, all dirty pages with redo entries in that portion of the log file must be flushed. If log files become full, a sharp checkpoint occurs, causing a temporary reduction in throughput. This scenario can occur even if [**innodb\_max\_dirty\_pages\_pct**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_max_dirty_pages_pct) threshold is not reached.

The adaptive flushing algorithm helps avoid such scenarios by tracking the number of dirty pages in the buffer pool and the rate at which redo log records are being generated. Based on this information, it decides how many dirty pages to flush from the buffer pool each second, which permits it to manage sudden changes in workload.

The [**innodb\_adaptive\_flushing\_lwm**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_adaptive_flushing_lwm) variable defines a low water mark for redo log capacity. When that threshold is crossed, adaptive flushing is enabled, even if the [**innodb\_adaptive\_flushing**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_adaptive_flushing) variable is disabled.

Internal benchmarking has shown that the algorithm not only maintains throughput over time, but can also improve overall throughput significantly. However, adaptive flushing can affect the I/O pattern of a workload significantly and may not be appropriate in all cases. It gives the most benefit when the redo log is in danger of filling up. If adaptive flushing is not appropriate to the characteristics of your workload, you can disable it. Adaptive flushing controlled by the [**innodb\_adaptive\_flushing**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_adaptive_flushing) variable, which is enabled by default.

[**innodb\_flushing\_avg\_loops**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_flushing_avg_loops) defines the number of iterations that **InnoDB** keeps the previously calculated snapshot of the flushing state, controlling how quickly adaptive flushing responds to foreground workload changes. A high [**innodb\_flushing\_avg\_loops**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_flushing_avg_loops) value means that **InnoDB** keeps the previously calculated snapshot longer, so adaptive flushing responds more slowly. When setting a high value it is important to ensure that redo log utilization does not reach 75% (the hardcoded limit at which asynchronous flushing starts), and that the [**innodb\_max\_dirty\_pages\_pct**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_max_dirty_pages_pct) threshold keeps the number of dirty pages to a level that is appropriate for the workload.

Systems with consistent workloads, a large log file size ([**innodb\_log\_file\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_log_file_size)), and small spikes that do not reach 75% log space utilization should use a high [**innodb\_flushing\_avg\_loops**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_flushing_avg_loops) value to keep flushing as smooth as possible. For systems with extreme load spikes or log files that do not provide a lot of space, a smaller value allows flushing to closely track workload changes, and helps to avoid reaching 75% log space utilization.

Be aware that if flushing falls behind, the rate of buffer pool flushing can exceed the I/O capacity available to **InnoDB**, as defined by [**innodb\_io\_capacity**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_io_capacity) setting. The [**innodb\_io\_capacity\_max**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_io_capacity_max) value defines an upper limit on I/O capacity in such situations, so that a spike in I/O activity does not consume the entire I/O capacity of the server.

The [**innodb\_io\_capacity**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_io_capacity) setting is applicable to all buffer pool instances. When dirty pages are flushed, I/O capacity is divided equally among buffer pool instances.

##### Limiting Buffer Flushing During Idle Periods

As of MySQL 8.0.18, you can use the [**innodb\_idle\_flush\_pct**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_idle_flush_pct) variable to limit the rate of buffer pool flushing during idle periods, which are periods of time that database pages are not modified. The [**innodb\_idle\_flush\_pct**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_idle_flush_pct) value is a percentage of the [**innodb\_io\_capacity**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_io_capacity) setting, which defines the number of I/O operations per second available to **InnoDB**. The default [**innodb\_idle\_flush\_pct**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_idle_flush_pct) value is 100, which is 100 percent of the [**innodb\_io\_capacity**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_io_capacity) setting. To limit flushing during idle periods, define an [**innodb\_idle\_flush\_pct**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_idle_flush_pct) value less than 100.

Limiting page flushing during idle periods can help extend the life of solid state storage devices. Side effects of limiting page flushing during idle periods may include a longer shutdown time following a lengthy idle period, and a longer recovery period should a server failure occur.

#### 15.8.3.6 Saving and Restoring the Buffer Pool State

To reduce the [warmup](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_warm_up) period after restarting the server, **InnoDB** saves a percentage of the most recently used pages for each buffer pool at server shutdown and restores these pages at server startup. The percentage of recently used pages that is stored is defined by the [**innodb\_buffer\_pool\_dump\_pct**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_dump_pct) configuration option.

After restarting a busy server, there is typically a warmup period with steadily increasing throughput, as disk pages that were in the buffer pool are brought back into memory (as the same data is queried, updated, and so on). The ability to restore the buffer pool at startup shortens the warmup period by reloading disk pages that were in the buffer pool before the restart rather than waiting for DML operations to access corresponding rows. Also, I/O requests can be performed in large batches, making the overall I/O faster. Page loading happens in the background, and does not delay database startup.

In addition to saving the buffer pool state at shutdown and restoring it at startup, you can save and restore the buffer pool state at any time, while the server is running. For example, you can save the state of the buffer pool after reaching a stable throughput under a steady workload. You could also restore the previous buffer pool state after running reports or maintenance jobs that bring data pages into the buffer pool that are only requited for those operations, or after running some other non-typical workload.

Even though a buffer pool can be many gigabytes in size, the buffer pool data that **InnoDB** saves to disk is tiny by comparison. Only tablespace IDs and page IDs necessary to locate the appropriate pages are saved to disk. This information is derived from the [**INNODB\_BUFFER\_PAGE\_LRU**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-buffer-page-lru-table) **INFORMATION\_SCHEMA** table. By default, tablespace ID and page ID data is saved in a file named ib\_buffer\_pool, which is saved to the **InnoDB** data directory. The file name and location can be modified using the [**innodb\_buffer\_pool\_filename**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_filename) configuration parameter.

Because data is cached in and aged out of the buffer pool as it is with regular database operations, there is no problem if the disk pages are recently updated, or if a DML operation involves data that has not yet been loaded. The loading mechanism skips requested pages that no longer exist.

The underlying mechanism involves a background thread that is dispatched to perform the dump and load operations.

Disk pages from compressed tables are loaded into the buffer pool in their compressed form. Pages are uncompressed as usual when page contents are accessed during DML operations. Because uncompressing pages is a CPU-intensive process, it is more efficient for concurrency to perform the operation in a connection thread rather than in the single thread that performs the buffer pool restore operation.

Operations related to saving and restoring the buffer pool state are described in the following topics:

[Configuring the Dump Percentage for Buffer Pool Pages](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-preload-buffer-pool-dump-pct)

[Saving the Buffer Pool State at Shutdown and Restoring it at Startup](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-preload-buffer-pool-offline)

[Saving and Restoring the Buffer Pool State Online](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-preload-buffer-pool-online)

[Displaying Buffer Pool Dump Progress](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-preload-buffer-pool-dump-progress)

[Displaying Buffer Pool Load Progress](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-preload-buffer-pool-load-progress)

[Aborting a Buffer Pool Load Operation](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-preload-buffer-pool-abort-load)

[Monitoring Buffer Pool Load Progress Using Performance Schema](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#monitor-buffer-pool-load-performance-schema)

##### Configuring the Dump Percentage for Buffer Pool Pages

Before dumping pages from the buffer pool, you can configure the percentage of most-recently-used buffer pool pages that you want to dump by setting the [**innodb\_buffer\_pool\_dump\_pct**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_dump_pct) option. If you plan to dump buffer pool pages while the server is running, you can configure the option dynamically:

SET GLOBAL innodb\_buffer\_pool\_dump\_pct=40;

If you plan to dump buffer pool pages at server shutdown, set [**innodb\_buffer\_pool\_dump\_pct**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_dump_pct) in your configuration file.

[mysqld]

innodb\_buffer\_pool\_dump\_pct=40

The [**innodb\_buffer\_pool\_dump\_pct**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_dump_pct) default value is 25 (dump 25% of most-recently-used pages).

##### Saving the Buffer Pool State at Shutdown and Restoring it at Startup

To save the state of the buffer pool at server shutdown, issue the following statement prior to shutting down the server:

SET GLOBAL innodb\_buffer\_pool\_dump\_at\_shutdown=ON;

[**innodb\_buffer\_pool\_dump\_at\_shutdown**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_dump_at_shutdown) is enabled by default.

To restore the buffer pool state at server startup, specify the **--innodb-buffer-pool-load-at-startup** option when starting the server:

mysqld --innodb-buffer-pool-load-at-startup=ON;

[**innodb\_buffer\_pool\_load\_at\_startup**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_load_at_startup) is enabled by default.

##### Saving and Restoring the Buffer Pool State Online

To save the state of the buffer pool while MySQL server is running, issue the following statement:

SET GLOBAL innodb\_buffer\_pool\_dump\_now=ON;

To restore the buffer pool state while MySQL is running, issue the following statement:

SET GLOBAL innodb\_buffer\_pool\_load\_now=ON;

##### Displaying Buffer Pool Dump Progress

To display progress when saving the buffer pool state to disk, issue the following statement:

SHOW STATUS LIKE 'Innodb\_buffer\_pool\_dump\_status';

If the operation has not yet started, “not started” is returned. If the operation is complete, the completion time is printed (e.g. Finished at 110505 12:18:02). If the operation is in progress, status information is provided (e.g. Dumping buffer pool 5/7, page 237/2873).

##### Displaying Buffer Pool Load Progress

To display progress when loading the buffer pool, issue the following statement:

SHOW STATUS LIKE 'Innodb\_buffer\_pool\_load\_status';

If the operation has not yet started, “not started” is returned. If the operation is complete, the completion time is printed (e.g. Finished at 110505 12:23:24). If the operation is in progress, status information is provided (e.g. Loaded 123/22301 pages).

##### Aborting a Buffer Pool Load Operation

To abort a buffer pool load operation, issue the following statement:

SET GLOBAL innodb\_buffer\_pool\_load\_abort=ON;

##### Monitoring Buffer Pool Load Progress Using Performance Schema

You can monitor buffer pool load progress using [Performance Schema](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html).

The following example demonstrates how to enable the **stage/innodb/buffer pool load** stage event instrument and related consumer tables to monitor buffer pool load progress.

For information about buffer pool dump and load procedures used in this example, see [Section 15.8.3.6, “Saving and Restoring the Buffer Pool State”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-preload-buffer-pool). For information about Performance Schema stage event instruments and related consumers, see [Section 27.12.5, “Performance Schema Stage Event Tables”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html#performance-schema-stage-tables).

Enable the **stage/innodb/buffer pool load** instrument:

mysql> **UPDATE performance\_schema.setup\_instruments SET ENABLED = 'YES'**

**WHERE NAME LIKE 'stage/innodb/buffer%';**

Enable the stage event consumer tables, which include [**events\_stages\_current**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html#performance-schema-events-stages-current-table), [**events\_stages\_history**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html#performance-schema-events-stages-history-table), and [**events\_stages\_history\_long**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html#performance-schema-events-stages-history-long-table).

mysql> **UPDATE performance\_schema.setup\_consumers SET ENABLED = 'YES'**

**WHERE NAME LIKE '%stages%';**

Dump the current buffer pool state by enabling [**innodb\_buffer\_pool\_dump\_now**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_dump_now).

mysql> **SET GLOBAL innodb\_buffer\_pool\_dump\_now=ON;**

Check the buffer pool dump status to ensure that the operation has completed.

mysql> **SHOW STATUS LIKE 'Innodb\_buffer\_pool\_dump\_status'\G**

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\* 1. row \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

Variable\_name: Innodb\_buffer\_pool\_dump\_status

Value: Buffer pool(s) dump completed at 150202 16:38:58

Load the buffer pool by enabling [**innodb\_buffer\_pool\_load\_now**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_load_now):

mysql> **SET GLOBAL innodb\_buffer\_pool\_load\_now=ON;**

Check the current status of the buffer pool load operation by querying the Performance Schema [**events\_stages\_current**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html#performance-schema-events-stages-current-table) table. The **WORK\_COMPLETED** column shows the number of buffer pool pages loaded. The **WORK\_ESTIMATED** column provides an estimate of the remaining work, in pages.

mysql> **SELECT EVENT\_NAME, WORK\_COMPLETED, WORK\_ESTIMATED**

**FROM performance\_schema.events\_stages\_current;**

+-------------------------------+----------------+----------------+

| EVENT\_NAME | WORK\_COMPLETED | WORK\_ESTIMATED |

+-------------------------------+----------------+----------------+

| stage/innodb/buffer pool load | 5353 | 7167 |

+-------------------------------+----------------+----------------+

The [**events\_stages\_current**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html#performance-schema-events-stages-current-table) table returns an empty set if the buffer pool load operation has completed. In this case, you can check the [**events\_stages\_history**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html#performance-schema-events-stages-history-table) table to view data for the completed event. For example:

mysql> **SELECT EVENT\_NAME, WORK\_COMPLETED, WORK\_ESTIMATED**

**FROM performance\_schema.events\_stages\_history;**

+-------------------------------+----------------+----------------+

| EVENT\_NAME | WORK\_COMPLETED | WORK\_ESTIMATED |

+-------------------------------+----------------+----------------+

| stage/innodb/buffer pool load | 7167 | 7167 |

+-------------------------------+----------------+----------------+

**Note**

You can also monitor buffer pool load progress using Performance Schema when loading the buffer pool at startup using [**innodb\_buffer\_pool\_load\_at\_startup**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_load_at_startup). In this case, the **stage/innodb/buffer pool load** instrument and related consumers must be enabled at startup. For more information, see [Section 27.3, “Performance Schema Startup Configuration”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html#performance-schema-startup-configuration).

#### 15.8.3.7 Excluding Buffer Pool Pages from Core Files

A core file records the status and memory image of a running process. Because the buffer pool resides in main memory, and the memory image of a running process is dumped to the core file, systems with large buffer pools can produce large core files when the [**mysqld**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\programs.html#mysqld) process dies.

Large core files can be problematic for a number of reasons including the time it takes to write them, the amount of disk space they consume, and the challenges associated with transferring large files.

To reduce core file size, you can disable the [**innodb\_buffer\_pool\_in\_core\_file**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_in_core_file) variable to omit buffer pool pages from core dumps. The [**innodb\_buffer\_pool\_in\_core\_file**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_in_core_file) variable was introduced in MySQL 8.0.14 and is enabled by default.

Excluding buffer pool pages may also be desirable from a security perspective if you have concerns about dumping database pages to core files that may be shared inside or outside of your organization for debugging purposes.

**Note**

Access to the data present in buffer pool pages at the time the [**mysqld**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\programs.html#mysqld) process died may be beneficial in some debugging scenarios. If in doubt whether to include or exclude buffer pool pages, consult MySQL Support.

Disabling [**innodb\_buffer\_pool\_in\_core\_file**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_in_core_file) takes effect only if the [**core\_file**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_core_file) variable is enabled and the operating system supports the **MADV\_DONTDUMP** non-POSIX extension to the [madvise()](http://man7.org/linux/man-pages/man2/madvise.2.html) system call, which is supported in Linux 3.4 and later. The **MADV\_DONTDUMP** extension causes pages in a specified range to be excluded from core dumps.

Assuming the operating system supports the **MADV\_DONTDUMP** extension, start the server with the [--core-file](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#option_mysqld_core-file) and [**--innodb-buffer-pool-in-core-file=OFF**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_in_core_file) options to generate core files without buffer pool pages.

shell> mysqld --core-file --innodb-buffer-pool-in-core-file=OFF

The [**core\_file**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_core_file) variable is read only and disabled by default. It is enabled by specifying the [--core-file](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#option_mysqld_core-file) option at startup. The [**innodb\_buffer\_pool\_in\_core\_file**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_in_core_file) variable is dynamic. It can be specified at startup or configured at runtime using a [**SET**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#set-variable) statement.

mysql> SET GLOBAL innodb\_buffer\_pool\_in\_core\_file=OFF;

If the [**innodb\_buffer\_pool\_in\_core\_file**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_in_core_file) variable is disabled but **MADV\_DONTDUMP** is not supported by the operating system, or an **madvise()** failure occurs, a warning is written to the MySQL server error log and the [**core\_file**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_core_file) variable is disabled to prevent writing core files that unintentionally include buffer pool pages. If the read-only [**core\_file**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_core_file) variable becomes disabled, the server must be restarted to enable it again.

The following table shows configuration and **MADV\_DONTDUMP** support scenarios that determine whether core files are generated and whether they include buffer pool pages.

**Table 15.4 Core File Configuration Scenarios**

| [**core\_file**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_core_file)**variable** | [**innodb\_buffer\_pool\_in\_core\_file**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_in_core_file)**variable** | **madvise() MADV\_DONTDUMP Support** | **Outcome** |
| --- | --- | --- | --- |
| **OFF (default)** | Not relevant to outcome | Not relevant to outcome | Core file is not generated |
| **ON** | ON (default) | Not relevant to outcome | Core file is generated with buffer pool pages |
| **ON** | OFF | Yes | Core file is generated without buffer pool pages |
| **ON** | OFF | No | Core file is not generated, [**core\_file**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_core_file) is disabled, and a warning is written to the server error log |

The reduction in core file size achieved by disabling the [**innodb\_buffer\_pool\_in\_core\_file**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_in_core_file) variable depends on the size of the buffer pool, but it is also affected by the **InnoDB** page size. A smaller page size means more pages are required for the same amount of data, and more pages means more page metadata. The following table provides size reduction examples that you might see for a 1GB buffer pool with different pages sizes.

**Table 15.5 Core File Size with Buffer Pool Pages Included and Excluded**

| [**innodb\_page\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_page_size)**Setting** | **Buffer Pool Pages Included (**[**innodb\_buffer\_pool\_in\_core\_file=ON**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_in_core_file)**)** | **Buffer Pool Pages Excluded (**[**innodb\_buffer\_pool\_in\_core\_file=OFF**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_in_core_file)**)** |
| --- | --- | --- |
| **4KB** | 2.1GB | 0.9GB |
| **64KB** | 1.7GB | 0.7GB |

### 15.8.4 Configuring Thread Concurrency for InnoDB

**InnoDB** uses operating system [threads](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_thread) to process requests from user transactions. (Transactions may issue many requests to **InnoDB** before they commit or roll back.) On modern operating systems and servers with multi-core processors, where context switching is efficient, most workloads run well without any limit on the number of concurrent threads.

In situations where it is helpful to minimize context switching between threads, **InnoDB** can use a number of techniques to limit the number of concurrently executing operating system threads (and thus the number of requests that are processed at any one time). When **InnoDB** receives a new request from a user session, if the number of threads concurrently executing is at a pre-defined limit, the new request sleeps for a short time before it tries again. A request that cannot be rescheduled after the sleep is put in a first-in/first-out queue and eventually is processed. Threads waiting for locks are not counted in the number of concurrently executing threads.

You can limit the number of concurrent threads by setting the configuration parameter [**innodb\_thread\_concurrency**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_thread_concurrency). Once the number of executing threads reaches this limit, additional threads sleep for a number of microseconds, set by the configuration parameter [**innodb\_thread\_sleep\_delay**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_thread_sleep_delay), before being placed into the queue.

You can set the configuration option [**innodb\_adaptive\_max\_sleep\_delay**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_adaptive_max_sleep_delay) to the highest value you would allow for [**innodb\_thread\_sleep\_delay**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_thread_sleep_delay), and **InnoDB** automatically adjusts [**innodb\_thread\_sleep\_delay**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_thread_sleep_delay) up or down depending on the current thread-scheduling activity. This dynamic adjustment helps the thread scheduling mechanism to work smoothly during times when the system is lightly loaded and when it is operating near full capacity.

The default value for [**innodb\_thread\_concurrency**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_thread_concurrency) and the implied default limit on the number of concurrent threads has been changed in various releases of MySQL and **InnoDB**. The default value of [**innodb\_thread\_concurrency**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_thread_concurrency) is **0**, so that by default there is no limit on the number of concurrently executing threads.

**InnoDB** causes threads to sleep only when the number of concurrent threads is limited. When there is no limit on the number of threads, all contend equally to be scheduled. That is, if [**innodb\_thread\_concurrency**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_thread_concurrency) is **0**, the value of [**innodb\_thread\_sleep\_delay**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_thread_sleep_delay) is ignored.

When there is a limit on the number of threads (when [**innodb\_thread\_concurrency**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_thread_concurrency) is > 0), **InnoDB** reduces context switching overhead by permitting multiple requests made during the execution of a single SQL statement to enter **InnoDB** without observing the limit set by [**innodb\_thread\_concurrency**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_thread_concurrency). Since an SQL statement (such as a join) may comprise multiple row operations within **InnoDB**, **InnoDB** assigns a specified number of “tickets” that allow a thread to be scheduled repeatedly with minimal overhead.

When a new SQL statement starts, a thread has no tickets, and it must observe [**innodb\_thread\_concurrency**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_thread_concurrency). Once the thread is entitled to enter **InnoDB**, it is assigned a number of tickets that it can use for subsequently entering **InnoDB** to perform row operations. If the tickets run out, the thread is evicted, and [**innodb\_thread\_concurrency**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_thread_concurrency) is observed again which may place the thread back into the first-in/first-out queue of waiting threads. When the thread is once again entitled to enter **InnoDB**, tickets are assigned again. The number of tickets assigned is specified by the global option [**innodb\_concurrency\_tickets**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_concurrency_tickets), which is 5000 by default. A thread that is waiting for a lock is given one ticket once the lock becomes available.

The correct values of these variables depend on your environment and workload. Try a range of different values to determine what value works for your applications. Before limiting the number of concurrently executing threads, review configuration options that may improve the performance of **InnoDB** on multi-core and multi-processor computers, such as [**innodb\_adaptive\_hash\_index**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_adaptive_hash_index).

For general performance information about MySQL thread handling, see [Section 5.1.12.1, “Connection Interfaces”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#connection-interfaces).

### 15.8.5 Configuring the Number of Background InnoDB I/O Threads

**InnoDB** uses background [threads](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_thread) to service various types of I/O requests. You can configure the number of background threads that service read and write I/O on data pages using the [**innodb\_read\_io\_threads**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_read_io_threads) and [**innodb\_write\_io\_threads**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_write_io_threads) configuration parameters. These parameters signify the number of background threads used for read and write requests, respectively. They are effective on all supported platforms. You can set values for these parameters in the MySQL option file (**my.cnf** or **my.ini**); you cannot change values dynamically. The default value for these parameters is **4** and permissible values range from **1-64**.

The purpose of these configuration options to make **InnoDB** more scalable on high end systems. Each background thread can handle up to 256 pending I/O requests. A major source of background I/O is [read-ahead](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_read_ahead) requests. **InnoDB** tries to balance the load of incoming requests in such way that most background threads share work equally. **InnoDB** also attempts to allocate read requests from the same extent to the same thread, to increase the chances of coalescing the requests. If you have a high end I/O subsystem and you see more than 64 × [**innodb\_read\_io\_threads**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_read_io_threads) pending read requests in **SHOW ENGINE INNODB STATUS** output, you might improve performance by increasing the value of [**innodb\_read\_io\_threads**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_read_io_threads).

On Linux systems, **InnoDB** uses the asynchronous I/O subsystem by default to perform read-ahead and write requests for data file pages, which changes the way that **InnoDB** background threads service these types of I/O requests. For more information, see [Section 15.8.6, “Using Asynchronous I/O on Linux”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-linux-native-aio).

For more information about **InnoDB** I/O performance, see [Section 8.5.8, “Optimizing InnoDB Disk I/O”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizing-innodb-diskio).

### 15.8.6 Using Asynchronous I/O on Linux

**InnoDB** uses the asynchronous I/O subsystem (native AIO) on Linux to perform read-ahead and write requests for data file pages. This behavior is controlled by the [**innodb\_use\_native\_aio**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_use_native_aio) configuration option, which applies to Linux systems only and is enabled by default. On other Unix-like systems, **InnoDB** uses synchronous I/O only. Historically, **InnoDB** only used asynchronous I/O on Windows systems. Using the asynchronous I/O subsystem on Linux requires the **libaio** library.

With synchronous I/O, query threads queue I/O requests, and **InnoDB** background threads retrieve the queued requests one at a time, issuing a synchronous I/O call for each. When an I/O request is completed and the I/O call returns, the **InnoDB** background thread that is handling the request calls an I/O completion routine and returns to process the next request. The number of requests that can be processed in parallel is ***n***, where ***n*** is the number of **InnoDB** background threads. The number of **InnoDB** background threads is controlled by [**innodb\_read\_io\_threads**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_read_io_threads) and [**innodb\_write\_io\_threads**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_write_io_threads). See [Section 15.8.5, “Configuring the Number of Background InnoDB I/O Threads”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-performance-multiple_io_threads).

With native AIO, query threads dispatch I/O requests directly to the operating system, thereby removing the limit imposed by the number of background threads. **InnoDB** background threads wait for I/O events to signal completed requests. When a request is completed, a background thread calls an I/O completion routine and resumes waiting for I/O events.

The advantage of native AIO is scalability for heavily I/O-bound systems that typically show many pending reads/writes in **SHOW ENGINE INNODB STATUS\G** output. The increase in parallel processing when using native AIO means that the type of I/O scheduler or properties of the disk array controller have a greater influence on I/O performance.

A potential disadvantage of native AIO for heavily I/O-bound systems is lack of control over the number of I/O write requests dispatched to the operating system at once. Too many I/O write requests dispatched to the operating system for parallel processing could, in some cases, result in I/O read starvation, depending on the amount of I/O activity and system capabilities.

If a problem with the asynchronous I/O subsystem in the OS prevents **InnoDB** from starting, you can start the server with [**innodb\_use\_native\_aio=0**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_use_native_aio). This option may also be disabled automatically during startup if **InnoDB** detects a potential problem such as a combination of **tmpdir** location, **tmpfs** file system, and Linux kernel that does not support asynchronous I/O on **tmpfs**.

### 15.8.7 Configuring InnoDB I/O Capacity

The **InnoDB** master thread and other threads perform various tasks in the background, most of which are I/O related, such as flushing dirty pages from the buffer pool and writing changes from the change buffer to the appropriate secondary indexes. **InnoDB** attempts to perform these tasks in a way that does not adversely affect the normal working of the server. It tries to estimate the available I/O bandwidth and tune its activities to take advantage of available capacity.

The [**innodb\_io\_capacity**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_io_capacity) variable defines the overall I/O capacity available to **InnoDB**. It should be set to approximately the number of I/O operations that the system can perform per second (IOPS). When [**innodb\_io\_capacity**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_io_capacity) is set, **InnoDB** estimates the I/O bandwidth available for background tasks based on the set value.

You can set [**innodb\_io\_capacity**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_io_capacity) to a value of 100 or greater. The default value is **200**. Typically, values around 100 are appropriate for consumer-level storage devices, such as hard drives up to 7200 RPMs. Faster hard drives, RAID configurations, and solid state drives (SSDs) benefit from higher values.

Ideally, keep the setting as low as practical, but not so low that background activities fall behind. If the value is too high, data is removed from the buffer pool and change buffer too quickly for caching to provide a significant benefit. For busy systems capable of higher I/O rates, you can set a higher value to help the server handle the background maintenance work associated with a high rate of row changes. Generally, you can increase the value as a function of the number of drives used for **InnoDB** I/O. For example, you can increase the value on systems that use multiple disks or SSDs.

The default setting of 200 is generally sufficient for a lower-end SSD. For a higher-end, bus-attached SSD, consider a higher setting such as 1000, for example. For systems with individual 5400 RPM or 7200 RPM drives, you might lower the value to 100, which represents an estimated proportion of the I/O operations per second (IOPS) available to older-generation disk drives that can perform about 100 IOPS.

Although you can specify a high value such as a million, in practice such large values have little benefit. Generally, a value higher than 20000 is not recommended unless you are certain that lower values are insufficient for your workload.

Consider write workload when tuning [**innodb\_io\_capacity**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_io_capacity). Systems with large write workloads are likely to benefit from a higher setting. A lower setting may be sufficient for systems with a small write workload.

The [**innodb\_io\_capacity**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_io_capacity) setting is not a per buffer pool instance setting. Available I/O capacity is distributed equally among buffer pool instances for flushing activities.

You can set the [**innodb\_io\_capacity**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_io_capacity) value in the MySQL option file (**my.cnf** or **my.ini**) or modify it at runtime using a [**SET GLOBAL**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#set-variable) statement, which requires privileges sufficient to set global system variables. See [Section 5.1.9.1, “System Variable Privileges”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#system-variable-privileges).

#### Ignoring I/O Capacity at Checkpoints

The [**innodb\_flush\_sync**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_flush_sync) variable, which is enabled by default, causes the [**innodb\_io\_capacity**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_io_capacity) setting to be ignored during bursts of I/O activity that occur at [checkpoints](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_checkpoint). To adhere to the I/O rate defined by the [**innodb\_io\_capacity**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_io_capacity) setting, disable [**innodb\_flush\_sync**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_flush_sync).

You can set the [**innodb\_flush\_sync**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_flush_sync) value in the MySQL option file (**my.cnf** or **my.ini**) or modify it at runtime using a [**SET GLOBAL**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#set-variable) statement, which requires privileges sufficient to set global system variables. See [Section 5.1.9.1, “System Variable Privileges”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#system-variable-privileges).

#### Configuring an I/O Capacity Maximum

If flushing activity falls behind, **InnoDB** can flush more aggressively, at a higher rate of I/O operations per second (IOPS) than defined by the [**innodb\_io\_capacity**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_io_capacity) variable. The [**innodb\_io\_capacity\_max**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_io_capacity_max) variable defines a maximum number of IOPS performed by **InnoDB** background tasks in such situations.

If you specify an [**innodb\_io\_capacity**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_io_capacity) setting at startup but do not specify a value for [**innodb\_io\_capacity\_max**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_io_capacity_max), [**innodb\_io\_capacity\_max**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_io_capacity_max) defaults to twice the value of [**innodb\_io\_capacity**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_io_capacity) or 2000, whichever value is greater.

When configuring [**innodb\_io\_capacity\_max**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_io_capacity_max), twice the [**innodb\_io\_capacity**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_io_capacity) is often a good starting point. The default value of 2000 is intended for workloads that use an SSD or more than one regular disk drive. A setting of 2000 is likely too high for workloads that do not use SSDs or multiple disk drives, and could allow too much flushing. For a single regular disk drive, a setting between 200 and 400 is recommended. For a high-end, bus-attached SSD, consider a higher setting such as 2500. As with the [**innodb\_io\_capacity**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_io_capacity) setting, keep the setting as low as practical, but not so low that **InnoDB** cannot sufficiently extend rate of IOPS beyond the [**innodb\_io\_capacity**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_io_capacity) setting.

Consider write workload when tuning [**innodb\_io\_capacity\_max**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_io_capacity_max). Systems with large write workloads may benefit from a higher setting. A lower setting may be sufficient for systems with a small write workload.

[**innodb\_io\_capacity\_max**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_io_capacity_max) cannot be set to a value lower than the [**innodb\_io\_capacity**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_io_capacity) value.

Setting [**innodb\_io\_capacity\_max**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_io_capacity_max) to **DEFAULT** using a [**SET**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#set-variable) statement (**SET GLOBAL innodb\_io\_capacity\_max=DEFAULT**) sets [**innodb\_io\_capacity\_max**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_io_capacity_max) to the maximum value.

The [**innodb\_io\_capacity\_max**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_io_capacity_max) limit applies to all buffer pool instances. It is not a per buffer pool instance setting.

### 15.8.8 Configuring Spin Lock Polling

**InnoDB** [mutexes](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_mutex) and [rw-locks](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_rw_lock) are typically reserved for short intervals. On a multi-core system, it can be more efficient for a thread to continuously check if it can acquire a mutex or rw-lock for a period of time before it sleeps. If the mutex or rw-lock becomes available during this period, the thread can continue immediately, in the same time slice. However, too-frequent polling of a shared object such as a mutex or rw-lock by multiple threads can cause “cache ping pong”, which results in processors invalidating portions of each other's cache. **InnoDB** minimizes this issue by forcing a random delay between polls to desychronize polling activity. The random delay is implemented as a spin-wait loop.

The duration of a spin-wait loop is determined by the number of PAUSE instructions that occur in the loop. That number is generated by randomly selecting an integer ranging from 0 up to but not including the [**innodb\_spin\_wait\_delay**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_spin_wait_delay) value, and multiplying that value by 50. (The multiplier value, 50, is hardcoded before MySQL 8.0.16, and configurable thereafter.) For example, an integer is randomly selected from the following range for an [**innodb\_spin\_wait\_delay**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_spin_wait_delay) setting of 6:

{0,1,2,3,4,5}

The selected integer is multiplied by 50, resulting in one of six possible PAUSE instruction values:

{0,50,100,150,200,250}

For that set of values, 250 is the maximum number of PAUSE instructions that can occur in a spin-wait loop. An [**innodb\_spin\_wait\_delay**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_spin_wait_delay) setting of 5 results in a set of five possible values **{0,50,100,150,200}**, where 200 is the maximum number of PAUSE instructions, and so on. In this way, the [**innodb\_spin\_wait\_delay**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_spin_wait_delay) setting controls the maximum delay between spin lock polls.

On a system where all processor cores share a fast cache memory, you might reduce the maximum delay or disable the busy loop altogether by setting [**innodb\_spin\_wait\_delay=0**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_spin_wait_delay). On a system with multiple processor chips, the effect of cache invalidation can be more significant and you might increase the maximum delay.

In the 100MHz Pentium era, an [**innodb\_spin\_wait\_delay**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_spin_wait_delay) unit was calibrated to be equivalent to one microsecond. That time equivalence did not hold, but PAUSE instruction duration remained fairly constant in terms of processor cycles relative to other CPU instructions until the introduction of the Skylake generation of processors, which have a comparatively longer PAUSE instruction. The [**innodb\_spin\_wait\_pause\_multiplier**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_spin_wait_pause_multiplier) variable was introduced in MySQL 8.0.16 to provide a way to account for differences in PAUSE instruction duration.

The [**innodb\_spin\_wait\_pause\_multiplier**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_spin_wait_pause_multiplier) variable controls the size of PAUSE instruction values. For example, assuming an [**innodb\_spin\_wait\_delay**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_spin_wait_delay) setting of 6, decreasing the [**innodb\_spin\_wait\_pause\_multiplier**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_spin_wait_pause_multiplier) value from 50 (the default and previously hardcoded value) to 5 generates a set of smaller PAUSE instruction values:

{0,5,10,15,20,25}

The ability to increase or decrease PAUSE instruction values permits fine tuning **InnoDB** for different processor architectures. Smaller PAUSE instruction values would be appropriate for processor architectures with a comparatively longer PAUSE instruction, for example.

The [**innodb\_spin\_wait\_delay**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_spin_wait_delay) and [**innodb\_spin\_wait\_pause\_multiplier**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_spin_wait_pause_multiplier) variables are dynamic. They can be specified in a MySQL option file or modified at runtime using a [**SET GLOBAL**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#set-variable) statement. Modifying the variables at runtime requires privileges sufficient to set global system variables. See [Section 5.1.9.1, “System Variable Privileges”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#system-variable-privileges).

### 15.8.9 Purge Configuration

**InnoDB** does not physically remove a row from the database immediately when you delete it with an SQL statement. A row and its index records are only physically removed when **InnoDB** discards the undo log record written for the deletion. This removal operation, which only occurs after the row is no longer required for multi-version concurrency control (MVCC) or rollback, is called a purge.

Purge runs on a periodic schedule. It parses and processes undo log pages from the history list, which is a list of undo log pages for committed transactions that is maintained by the **InnoDB** transaction system. Purge frees the undo log pages from the history list after processing them.

#### Configuring Purge Threads

Purge operations are performed in the background by one or more purge threads. The number of purge threads is controlled by the [**innodb\_purge\_threads**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_purge_threads) variable. The default value is 4. If DML action is concentrated on a single table or a few tables, keep the setting low so that the threads do not contend with each other for access to the tables. If DML operations are spread across many tables, increase the setting. The maximum number of purge threads is 32.

The [**innodb\_purge\_threads**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_purge_threads) setting is the maximum number of purge threads permitted. The purge system automatically adjusts the number of purge threads as necessary.

#### Configuring Purge Batch Size

The [**innodb\_purge\_batch\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_purge_batch_size) variable defines the number of undo log pages that purge parses and processes in one batch from the history list. The default value is 300. In a multithreaded purge configuration, the coordinator purge thread divides [**innodb\_purge\_batch\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_purge_batch_size) by [**innodb\_purge\_threads**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_purge_threads) and assigns that number of pages to each purge thread.

The purge system also frees the undo log pages that are no longer required. It does so every 128 iterations through the undo logs. In addition to defining the number of undo log pages parsed and processed in a batch, the [**innodb\_purge\_batch\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_purge_batch_size) variable defines the number of undo log pages that purge frees every 128 iterations through the undo logs.

The [**innodb\_purge\_batch\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_purge_batch_size) variable is intended for advanced performance tuning and experimentation. Most users need not change [**innodb\_purge\_batch\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_purge_batch_size) from its default value.

#### Configuring the Maximum Purge Lag

The [**innodb\_max\_purge\_lag**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_max_purge_lag) variable defines the desired maximum purge lag. When the purge lag exceeds the [**innodb\_max\_purge\_lag**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_max_purge_lag) threshold, a delay is imposed on [**INSERT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#insert), [**UPDATE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#update), and [**DELETE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#delete) operations to allow time for purge operations to catch up. The default value is 0, which means there is no maximum purge lag and no delay.

The **InnoDB** transaction system maintains a list of transactions that have index records delete-marked by [**UPDATE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#update) or [**DELETE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#delete) operations. The length of the list is the purge lag. Prior to MySQL 8.0.14, the purge lag delay is calculated by the following formula, which results in a minimum delay of 5000 microseconds:

(purge lag/innodb\_max\_purge\_lag - 0.5) \* 10000

As of MySQL 8.0.14, the purge lag delay is calculated by the following revised formula, which reduces the minimum delay to 5 microseconds. A delay of 5 microseconds is more appropriate for modern systems.

(purge\_lag/innodb\_max\_purge\_lag - 0.9995) \* 10000

The delay is calculated at the beginning of a purge batch.

A typical [**innodb\_max\_purge\_lag**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_max_purge_lag) setting for a problematic workload might be 1000000 (1 million), assuming that transactions are small, only 100 bytes in size, and it is permissible to have 100MB of unpurged table rows.

The purge lag is presented as the **History list length** value in the **TRANSACTIONS** section of [**SHOW ENGINE INNODB STATUS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#show-engine) output.

mysql> SHOW ENGINE INNODB STATUS;

...

------------

TRANSACTIONS

------------

Trx id counter 0 290328385

Purge done for trx's n:o < 0 290315608 undo n:o < 0 17

History list length 20

The **History list length** is typically a low value, usually less than a few thousand, but a write-heavy workload or long running transactions can cause it to increase, even for transactions that are read only. The reason that a long running transaction can cause the **History list length** to increase is that under a consistent read transaction isolation level such as **REPEATABLE READ**, a transaction must return the same result as when the read view for that transaction was created. Consequently, the **InnoDB** multi-version concurrency control (MVCC) system must keep a copy of the data in the undo log until all transactions that depend on that data have completed. The following are examples of long running transactions that could cause the **History list length** to increase:

A [**mysqldump**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\programs.html#mysqldump) operation that uses the [--single-transaction](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\programs.html#option_mysqldump_single-transaction) option while there is a significant amount of concurrent DML.

Running a [**SELECT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#select) query after disabling [**autocommit**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_autocommit), and forgetting to issue an explicit **COMMIT** or **ROLLBACK**.

To prevent excessive delays in extreme situations where the purge lag becomes huge, you can limit the delay by setting the [**innodb\_max\_purge\_lag\_delay**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_max_purge_lag_delay) variable. The [**innodb\_max\_purge\_lag\_delay**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_max_purge_lag_delay) variable specifies the maximum delay in microseconds for the delay imposed when the [**innodb\_max\_purge\_lag**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_max_purge_lag) threshold is exceeded. The specified [**innodb\_max\_purge\_lag\_delay**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_max_purge_lag_delay) value is an upper limit on the delay period calculated by the [**innodb\_max\_purge\_lag**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_max_purge_lag) formula.

#### Purge and Undo Tablespace Truncation

The purge system is also responsible for truncating undo tablespaces. You can configure the [**innodb\_purge\_rseg\_truncate\_frequency**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_purge_rseg_truncate_frequency) variable to control the frequency with which the purge system looks for undo tablespaces to truncate. For more information, see [Truncating Undo Tablespaces](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#truncate-undo-tablespace).

### 15.8.10 Configuring Optimizer Statistics for InnoDB

[15.8.10.1 Configuring Persistent Optimizer Statistics Parameters](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-persistent-stats)

[15.8.10.2 Configuring Non-Persistent Optimizer Statistics Parameters](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-statistics-estimation)

[15.8.10.3 Estimating ANALYZE TABLE Complexity for InnoDB Tables](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-analyze-table-complexity)

This section describes how to configure persistent and non-persistent optimizer statistics for **InnoDB** tables.

Persistent optimizer statistics are persisted across server restarts, allowing for greater [plan stability](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_plan_stability) and more consistent query performance. Persistent optimizer statistics also provide control and flexibility with these additional benefits:

You can use the [**innodb\_stats\_auto\_recalc**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_stats_auto_recalc) configuration option to control whether statistics are updated automatically after substantial changes to a table.

You can use the **STATS\_PERSISTENT**, **STATS\_AUTO\_RECALC**, and **STATS\_SAMPLE\_PAGES** clauses with [**CREATE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-table) and [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) statements to configure optimizer statistics for individual tables.

You can query optimizer statistics data in the **mysql.innodb\_table\_stats** and **mysql.innodb\_index\_stats** tables.

You can view the **last\_update** column of the **mysql.innodb\_table\_stats** and **mysql.innodb\_index\_stats** tables to see when statistics were last updated.

You can manually modify the **mysql.innodb\_table\_stats** and **mysql.innodb\_index\_stats** tables to force a specific query optimization plan or to test alternative plans without modifying the database.

The persistent optimizer statistics feature is enabled by default ([**innodb\_stats\_persistent=ON**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_stats_persistent)).

Non-persistent optimizer statistics are cleared on each server restart and after some other operations, and recomputed on the next table access. As a result, different estimates could be produced when recomputing statistics, leading to different choices in execution plans and variations in query performance.

This section also provides information about estimating [**ANALYZE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#analyze-table) complexity, which may be useful when attempting to achieve a balance between accurate statistics and [**ANALYZE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#analyze-table) execution time.

#### 15.8.10.1 Configuring Persistent Optimizer Statistics Parameters

The persistent optimizer statistics feature improves [plan stability](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_plan_stability) by storing statistics to disk and making them persistent across server restarts so that the [optimizer](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_optimizer) is more likely to make consistent choices each time for a given query.

Optimizer statistics are persisted to disk when [**innodb\_stats\_persistent=ON**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_stats_persistent) or when individual tables are defined with [**STATS\_PERSISTENT=1**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-table). [**innodb\_stats\_persistent**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_stats_persistent) is enabled by default.

Formerly, optimizer statistics were cleared when restarting the server and after some other types of operations, and recomputed on the next table access. Consequently, different estimates could be produced when recalculating statistics leading to different choices in query execution plans and variation in query performance.

Persistent statistics are stored in the **mysql.innodb\_table\_stats** and **mysql.innodb\_index\_stats** tables. See [Section 15.8.10.1.5, “InnoDB Persistent Statistics Tables”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-persistent-stats-tables).

If you prefer not to persist optimizer statistics to disk, see [Section 15.8.10.2, “Configuring Non-Persistent Optimizer Statistics Parameters”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-statistics-estimation)

##### 15.8.10.1.1 Configuring Automatic Statistics Calculation for Persistent Optimizer Statistics

The [**innodb\_stats\_auto\_recalc**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_stats_auto_recalc) variable, which is enabled by default, controls whether statistics are calculated automatically when a table undergoes changes to more than 10% of its rows. You can also configure automatic statistics recalculation for individual tables by specifying the **STATS\_AUTO\_RECALC** clause when creating or altering a table.

Because of the asynchronous nature of automatic statistics recalculation, which occurs in the background, statistics may not be recalculated instantly after running a DML operation that affects more than 10% of a table, even when [**innodb\_stats\_auto\_recalc**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_stats_auto_recalc) is enabled. Statistics recalculation can be delayed by few seconds in some cases. If up-to-date statistics are required immediately, run [**ANALYZE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#analyze-table) to initiate a synchronous (foreground) recalculation of statistics.

If [**innodb\_stats\_auto\_recalc**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_stats_auto_recalc) is disabled, you can ensure the accuracy of optimizer statistics by executing the [**ANALYZE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#analyze-table) statement after making substantial changes to indexed columns. You might also consider adding [**ANALYZE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#analyze-table) to setup scripts that you run after loading data, and running [**ANALYZE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#analyze-table) on a schedule at times of low activity.

When an index is added to an existing table, or when a column is added or dropped, index statistics are calculated and added to the **innodb\_index\_stats** table regardless of the value of [**innodb\_stats\_auto\_recalc**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_stats_auto_recalc).

##### 15.8.10.1.2 Configuring Optimizer Statistics Parameters for Individual Tables

[**innodb\_stats\_persistent**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_stats_persistent), [**innodb\_stats\_auto\_recalc**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_stats_auto_recalc), and [**innodb\_stats\_persistent\_sample\_pages**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_stats_persistent_sample_pages) are global variables. To override these system-wide settings and configure optimizer statistics parameters for individual tables, you can define **STATS\_PERSISTENT**, **STATS\_AUTO\_RECALC**, and **STATS\_SAMPLE\_PAGES** clauses in [**CREATE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-table) or [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) statements.

**STATS\_PERSISTENT** specifies whether to enable [persistent statistics](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_persistent_statistics) for an **InnoDB** table. The value **DEFAULT** causes the persistent statistics setting for the table to be determined by the [**innodb\_stats\_persistent**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_stats_persistent) setting. A value of **1** enables persistent statistics for the table, while a value of **0** disables the feature. After enabling persistent statistics for an individual table, use [**ANALYZE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#analyze-table) to calculate statistics after table data is loaded.

**STATS\_AUTO\_RECALC** specifies whether to automatically recalculate [persistent statistics](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_persistent_statistics). The value **DEFAULT** causes the persistent statistics setting for the table to be determined by the [**innodb\_stats\_auto\_recalc**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_stats_auto_recalc) setting. A value of **1** causes statistics to be recalculated when 10% of table data has changed. A value **0** prevents automatic recalculation for the table. When using a value of 0, use [**ANALYZE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#analyze-table) to recalculate statistics after making substantial changes to the table.

**STATS\_SAMPLE\_PAGES** specifies the number of index pages to sample when cardinality and other statistics are calculated for an indexed column, by an [**ANALYZE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#analyze-table) operation, for example.

All three clauses are specified in the following [**CREATE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-table) example:

CREATE TABLE `t1` (

`id` int(8) NOT NULL auto\_increment,

`data` varchar(255),

`date` datetime,

PRIMARY KEY (`id`),

INDEX `DATE\_IX` (`date`)

) ENGINE=InnoDB,

STATS\_PERSISTENT=1,

STATS\_AUTO\_RECALC=1,

STATS\_SAMPLE\_PAGES=25;

##### 15.8.10.1.3 Configuring the Number of Sampled Pages for InnoDB Optimizer Statistics

The optimizer uses estimated [statistics](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_statistics) about key distributions to choose the indexes for an execution plan, based on the relative [selectivity](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_selectivity) of the index. Operations such as [**ANALYZE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#analyze-table) cause **InnoDB** to sample random pages from each index on a table to estimate the [cardinality](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_cardinality) of the index. This sampling technique is known as a [random dive](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_random_dive).

The [**innodb\_stats\_persistent\_sample\_pages**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_stats_persistent_sample_pages) controls the number of sampled pages. You can adjust the setting at runtime to manage the quality of statistics estimates used by the optimizer. The default value is 20. Consider modifying the setting when encountering the following issues:

Statistics are not accurate enough and the optimizer chooses suboptimal plans, as shown in [**EXPLAIN**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#explain) output. You can check the accuracy of statistics by comparing the actual cardinality of an index (determined by running [**SELECT DISTINCT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#select) on the index columns) with the estimates in the **mysql.innodb\_index\_stats** table.

If it is determined that statistics are not accurate enough, the value of [**innodb\_stats\_persistent\_sample\_pages**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_stats_persistent_sample_pages) should be increased until the statistics estimates are sufficiently accurate. Increasing [**innodb\_stats\_persistent\_sample\_pages**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_stats_persistent_sample_pages) too much, however, could cause [**ANALYZE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#analyze-table) to run slowly.

[***ANALYZE TABLE***](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#analyze-table) is too slow. In this case [**innodb\_stats\_persistent\_sample\_pages**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_stats_persistent_sample_pages) should be decreased until [**ANALYZE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#analyze-table) execution time is acceptable. Decreasing the value too much, however, could lead to the first problem of inaccurate statistics and suboptimal query execution plans.

If a balance cannot be achieved between accurate statistics and [**ANALYZE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#analyze-table) execution time, consider decreasing the number of indexed columns in the table or limiting the number of partitions to reduce [**ANALYZE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#analyze-table) complexity. The number of columns in the table's primary key is also important to consider, as primary key columns are appended to each nonunique index.

For related information, see [Section 15.8.10.3, “Estimating ANALYZE TABLE Complexity for InnoDB Tables”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-analyze-table-complexity).

##### 15.8.10.1.4 Including Delete-marked Records in Persistent Statistics Calculations

By default, **InnoDB** reads uncommitted data when calculating statistics. In the case of an uncommitted transaction that deletes rows from a table, delete-marked records are excluded when calculating row estimates and index statistics, which can lead to non-optimal execution plans for other transactions that are operating on the table concurrently using a transaction isolation level other than [**READ UNCOMMITTED**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#isolevel_read-uncommitted). To avoid this scenario, [**innodb\_stats\_include\_delete\_marked**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_stats_include_delete_marked) can be enabled to ensure that delete-marked records are included when calculating persistent optimizer statistics.

When [**innodb\_stats\_include\_delete\_marked**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_stats_include_delete_marked) is enabled, [**ANALYZE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#analyze-table) considers delete-marked records when recalculating statistics.

[**innodb\_stats\_include\_delete\_marked**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_stats_include_delete_marked) is a global setting that affects all **InnoDB** tables, and it is only applicable to persistent optimizer statistics.

##### 15.8.10.1.5 InnoDB Persistent Statistics Tables

The persistent statistics feature relies on the internally managed tables in the **mysql** database, named **innodb\_table\_stats** and **innodb\_index\_stats**. These tables are set up automatically in all install, upgrade, and build-from-source procedures.

**Table 15.6 Columns of innodb\_table\_stats**

| **Column name** | **Description** |
| --- | --- |
| **database\_name** | Database name |
| **table\_name** | Table name, partition name, or subpartition name |
| **last\_update** | A timestamp indicating the last time that **InnoDB** updated this row |
| **n\_rows** | The number of rows in the table |
| **clustered\_index\_size** | The size of the primary index, in pages |
| **sum\_of\_other\_index\_sizes** | The total size of other (non-primary) indexes, in pages |

**Table 15.7 Columns of innodb\_index\_stats**

| **Column name** | **Description** |
| --- | --- |
| **database\_name** | Database name |
| **table\_name** | Table name, partition name, or subpartition name |
| **index\_name** | Index name |
| **last\_update** | A timestamp indicating the last time the row was updated |
| **stat\_name** | The name of the statistic, whose value is reported in the **stat\_value** column |
| **stat\_value** | The value of the statistic that is named in **stat\_name** column |
| **sample\_size** | The number of pages sampled for the estimate provided in the **stat\_value** column |
| **stat\_description** | Description of the statistic that is named in the **stat\_name** column |

The **innodb\_table\_stats** and **innodb\_index\_stats** tables include a **last\_update** column that shows when index statistics were last updated:

mysql> **SELECT \* FROM innodb\_table\_stats \G**

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\* 1. row \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

database\_name: sakila

table\_name: actor

last\_update: 2014-05-28 16:16:44

n\_rows: 200

clustered\_index\_size: 1

sum\_of\_other\_index\_sizes: 1

...

mysql> **SELECT \* FROM innodb\_index\_stats \G**

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\* 1. row \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

database\_name: sakila

table\_name: actor

index\_name: PRIMARY

last\_update: 2014-05-28 16:16:44

stat\_name: n\_diff\_pfx01

stat\_value: 200

sample\_size: 1

...

The **innodb\_table\_stats** and **innodb\_index\_stats** tables can be updated manually, which makes it possible to force a specific query optimization plan or test alternative plans without modifying the database. If you manually update statistics, use the **FLUSH TABLE *tbl\_name*** statement to load the updated statistics.

Persistent statistics are considered local information, because they relate to the server instance. The **innodb\_table\_stats** and **innodb\_index\_stats** tables are therefore not replicated when automatic statistics recalculation takes place. If you run [**ANALYZE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#analyze-table) to initiate a synchronous recalculation of statistics, the statement is replicated (unless you suppressed logging for it), and recalculation takes place on replicas.

##### 15.8.10.1.6 InnoDB Persistent Statistics Tables Example

The **innodb\_table\_stats** table contains one row for each table. The following example demonstrates the type of data collected.

Table **t1** contains a primary index (columns **a**, **b**) secondary index (columns **c**, **d**), and unique index (columns **e**,**f**):

CREATE TABLE t1 (

a INT, b INT, c INT, d INT, e INT, f INT,

PRIMARY KEY (a, b), KEY i1 (c, d), UNIQUE KEY i2uniq (e, f)

) ENGINE=INNODB;

After inserting five rows of sample data, table **t1** appears as follows:

mysql> **SELECT \* FROM t1;**

+---+---+------+------+------+------+

| a | b | c | d | e | f |

+---+---+------+------+------+------+

| 1 | 1 | 10 | 11 | 100 | 101 |

| 1 | 2 | 10 | 11 | 200 | 102 |

| 1 | 3 | 10 | 11 | 100 | 103 |

| 1 | 4 | 10 | 12 | 200 | 104 |

| 1 | 5 | 10 | 12 | 100 | 105 |

+---+---+------+------+------+------+

To immediately update statistics, run [**ANALYZE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#analyze-table) (if [**innodb\_stats\_auto\_recalc**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_stats_auto_recalc) is enabled, statistics are updated automatically within a few seconds assuming that the 10% threshold for changed table rows is reached):

mysql> **ANALYZE TABLE t1;**

+---------+---------+----------+----------+

| Table | Op | Msg\_type | Msg\_text |

+---------+---------+----------+----------+

| test.t1 | analyze | status | OK |

+---------+---------+----------+----------+

Table statistics for table **t1** show the last time **InnoDB** updated the table statistics (**2014-03-14 14:36:34**), the number of rows in the table (**5**), the clustered index size (**1** page), and the combined size of the other indexes (**2** pages).

mysql> **SELECT \* FROM mysql.innodb\_table\_stats WHERE table\_name like 't1'\G**

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\* 1. row \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

database\_name: test

table\_name: t1

last\_update: 2014-03-14 14:36:34

n\_rows: 5

clustered\_index\_size: 1

sum\_of\_other\_index\_sizes: 2

The **innodb\_index\_stats** table contains multiple rows for each index. Each row in the **innodb\_index\_stats** table provides data related to a particular index statistic which is named in the **stat\_name** column and described in the **stat\_description** column. For example:

mysql> **SELECT index\_name, stat\_name, stat\_value, stat\_description**

**FROM mysql.innodb\_index\_stats WHERE table\_name like 't1';**

+------------+--------------+------------+-----------------------------------+

| index\_name | stat\_name | stat\_value | stat\_description |

+------------+--------------+------------+-----------------------------------+

| PRIMARY | n\_diff\_pfx01 | 1 | a |

| PRIMARY | n\_diff\_pfx02 | 5 | a,b |

| PRIMARY | n\_leaf\_pages | 1 | Number of leaf pages in the index |

| PRIMARY | size | 1 | Number of pages in the index |

| i1 | n\_diff\_pfx01 | 1 | c |

| i1 | n\_diff\_pfx02 | 2 | c,d |

| i1 | n\_diff\_pfx03 | 2 | c,d,a |

| i1 | n\_diff\_pfx04 | 5 | c,d,a,b |

| i1 | n\_leaf\_pages | 1 | Number of leaf pages in the index |

| i1 | size | 1 | Number of pages in the index |

| i2uniq | n\_diff\_pfx01 | 2 | e |

| i2uniq | n\_diff\_pfx02 | 5 | e,f |

| i2uniq | n\_leaf\_pages | 1 | Number of leaf pages in the index |

| i2uniq | size | 1 | Number of pages in the index |

+------------+--------------+------------+-----------------------------------+

The **stat\_name** column shows the following types of statistics:

**size**: Where **stat\_name**=**size**, the **stat\_value** column displays the total number of pages in the index.

**n\_leaf\_pages**: Where **stat\_name**=**n\_leaf\_pages**, the **stat\_value** column displays the number of leaf pages in the index.

**n\_diff\_pfx*NN***: Where **stat\_name**=**n\_diff\_pfx01**, the **stat\_value** column displays the number of distinct values in the first column of the index. Where **stat\_name**=**n\_diff\_pfx02**, the **stat\_value** column displays the number of distinct values in the first two columns of the index, and so on. Where **stat\_name**=**n\_diff\_pfx*NN***, the **stat\_description** column shows a comma separated list of the index columns that are counted.

To further illustrate the **n\_diff\_pfx*NN*** statistic, which provides cardinality data, consider once again the **t1** table example that was introduced previously. As shown below, the **t1** table is created with a primary index (columns **a**, **b**), a secondary index (columns **c**, **d**), and a unique index (columns **e**, **f**):

CREATE TABLE t1 (

a INT, b INT, c INT, d INT, e INT, f INT,

PRIMARY KEY (a, b), KEY i1 (c, d), UNIQUE KEY i2uniq (e, f)

) ENGINE=INNODB;

After inserting five rows of sample data, table **t1** appears as follows:

mysql> **SELECT \* FROM t1;**

+---+---+------+------+------+------+

| a | b | c | d | e | f |

+---+---+------+------+------+------+

| 1 | 1 | 10 | 11 | 100 | 101 |

| 1 | 2 | 10 | 11 | 200 | 102 |

| 1 | 3 | 10 | 11 | 100 | 103 |

| 1 | 4 | 10 | 12 | 200 | 104 |

| 1 | 5 | 10 | 12 | 100 | 105 |

+---+---+------+------+------+------+

When you query the **index\_name**, **stat\_name**, **stat\_value**, and **stat\_description**, where **stat\_name LIKE 'n\_diff%'**, the following result set is returned:

mysql> **SELECT index\_name, stat\_name, stat\_value, stat\_description**

**FROM mysql.innodb\_index\_stats**

**WHERE table\_name like 't1' AND stat\_name LIKE 'n\_diff%';**

+------------+--------------+------------+------------------+

| index\_name | stat\_name | stat\_value | stat\_description |

+------------+--------------+------------+------------------+

| PRIMARY | n\_diff\_pfx01 | 1 | a |

| PRIMARY | n\_diff\_pfx02 | 5 | a,b |

| i1 | n\_diff\_pfx01 | 1 | c |

| i1 | n\_diff\_pfx02 | 2 | c,d |

| i1 | n\_diff\_pfx03 | 2 | c,d,a |

| i1 | n\_diff\_pfx04 | 5 | c,d,a,b |

| i2uniq | n\_diff\_pfx01 | 2 | e |

| i2uniq | n\_diff\_pfx02 | 5 | e,f |

+------------+--------------+------------+------------------+

For the **PRIMARY** index, there are two **n\_diff%** rows. The number of rows is equal to the number of columns in the index.

**Note**

For nonunique indexes, **InnoDB** appends the columns of the primary key.

Where **index\_name**=**PRIMARY** and **stat\_name**=**n\_diff\_pfx01**, the **stat\_value** is **1**, which indicates that there is a single distinct value in the first column of the index (column **a**). The number of distinct values in column **a** is confirmed by viewing the data in column **a** in table **t1**, in which there is a single distinct value (**1**). The counted column (**a**) is shown in the **stat\_description** column of the result set.

Where **index\_name**=**PRIMARY** and **stat\_name**=**n\_diff\_pfx02**, the **stat\_value** is **5**, which indicates that there are five distinct values in the two columns of the index (**a,b**). The number of distinct values in columns **a** and **b** is confirmed by viewing the data in columns **a** and **b** in table **t1**, in which there are five distinct values: (**1,1**), (**1,2**), (**1,3**), (**1,4**) and (**1,5**). The counted columns (**a,b**) are shown in the **stat\_description** column of the result set.

For the secondary index (**i1**), there are four **n\_diff%** rows. Only two columns are defined for the secondary index (**c,d**) but there are four **n\_diff%** rows for the secondary index because **InnoDB** suffixes all nonunique indexes with the primary key. As a result, there are four **n\_diff%** rows instead of two to account for the both the secondary index columns (**c,d**) and the primary key columns (**a,b**).

Where **index\_name**=**i1** and **stat\_name**=**n\_diff\_pfx01**, the **stat\_value** is **1**, which indicates that there is a single distinct value in the first column of the index (column **c**). The number of distinct values in column **c** is confirmed by viewing the data in column **c** in table **t1**, in which there is a single distinct value: (**10**). The counted column (**c**) is shown in the **stat\_description** column of the result set.

Where **index\_name**=**i1** and **stat\_name**=**n\_diff\_pfx02**, the **stat\_value** is **2**, which indicates that there are two distinct values in the first two columns of the index (**c,d**). The number of distinct values in columns **c** an **d** is confirmed by viewing the data in columns **c** and **d** in table **t1**, in which there are two distinct values: (**10,11**) and (**10,12**). The counted columns (**c,d**) are shown in the **stat\_description** column of the result set.

Where **index\_name**=**i1** and **stat\_name**=**n\_diff\_pfx03**, the **stat\_value** is **2**, which indicates that there are two distinct values in the first three columns of the index (**c,d,a**). The number of distinct values in columns **c**, **d**, and **a** is confirmed by viewing the data in column **c**, **d**, and **a** in table **t1**, in which there are two distinct values: (**10,11,1**) and (**10,12,1**). The counted columns (**c,d,a**) are shown in the **stat\_description** column of the result set.

Where **index\_name**=**i1** and **stat\_name**=**n\_diff\_pfx04**, the **stat\_value** is **5**, which indicates that there are five distinct values in the four columns of the index (**c,d,a,b**). The number of distinct values in columns **c**, **d**, **a** and **b** is confirmed by viewing the data in columns **c**, **d**, **a**, and **b** in table **t1**, in which there are five distinct values: (**10,11,1,1**), (**10,11,1,2**), (**10,11,1,3**), (**10,12,1,4**), and (**10,12,1,5**). The counted columns (**c,d,a,b**) are shown in the **stat\_description** column of the result set.

For the unique index (**i2uniq**), there are two **n\_diff%** rows.

Where **index\_name**=**i2uniq** and **stat\_name**=**n\_diff\_pfx01**, the **stat\_value** is **2**, which indicates that there are two distinct values in the first column of the index (column **e**). The number of distinct values in column **e** is confirmed by viewing the data in column **e** in table **t1**, in which there are two distinct values: (**100**) and (**200**). The counted column (**e**) is shown in the **stat\_description** column of the result set.

Where **index\_name**=**i2uniq** and **stat\_name**=**n\_diff\_pfx02**, the **stat\_value** is **5**, which indicates that there are five distinct values in the two columns of the index (**e,f**). The number of distinct values in columns **e** and **f** is confirmed by viewing the data in columns **e** and **f** in table **t1**, in which there are five distinct values: (**100,101**), (**200,102**), (**100,103**), (**200,104**), and (**100,105**). The counted columns (**e,f**) are shown in the **stat\_description** column of the result set.

##### 15.8.10.1.7 Retrieving Index Size Using the innodb\_index\_stats Table

You can retrieve the index size for tables, partitions, or subpartitions can using the **innodb\_index\_stats** table. In the following example, index sizes are retrieved for table **t1**. For a definition of table **t1** and corresponding index statistics, see [Section 15.8.10.1.6, “InnoDB Persistent Statistics Tables Example”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-persistent-stats-tables-example).

mysql> **SELECT SUM(stat\_value) pages, index\_name,**

**SUM(stat\_value)\*@@innodb\_page\_size size**

**FROM mysql.innodb\_index\_stats WHERE table\_name='t1'**

**AND stat\_name = 'size' GROUP BY index\_name;**

+-------+------------+-------+

| pages | index\_name | size |

+-------+------------+-------+

| 1 | PRIMARY | 16384 |

| 1 | i1 | 16384 |

| 1 | i2uniq | 16384 |

+-------+------------+-------+

For partitions or subpartitions, you can use the same query with a modified **WHERE** clause to retrieve index sizes. For example, the following query retrieves index sizes for partitions of table **t1**:

mysql> **SELECT SUM(stat\_value) pages, index\_name,**

**SUM(stat\_value)\*@@innodb\_page\_size size**

**FROM mysql.innodb\_index\_stats WHERE table\_name like 't1#P%'**

**AND stat\_name = 'size' GROUP BY index\_name;**

#### 15.8.10.2 Configuring Non-Persistent Optimizer Statistics Parameters

This section describes how to configure non-persistent optimizer statistics. Optimizer statistics are not persisted to disk when [**innodb\_stats\_persistent=OFF**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_stats_persistent) or when individual tables are created or altered with [**STATS\_PERSISTENT=0**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-table). Instead, statistics are stored in memory, and are lost when the server is shut down. Statistics are also updated periodically by certain operations and under certain conditions.

Optimizer statistics are persisted to disk by default, enabled by the [**innodb\_stats\_persistent**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_stats_persistent) configuration option. For information about persistent optimizer statistics, see [Section 15.8.10.1, “Configuring Persistent Optimizer Statistics Parameters”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-persistent-stats).

##### Optimizer Statistics Updates

Non-persistent optimizer statistics are updated when:

Running [**ANALYZE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#analyze-table).

Running [**SHOW TABLE STATUS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#show-table-status), [**SHOW INDEX**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#show-index), or querying the [**INFORMATION\_SCHEMA.TABLES**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-tables-table) or [**INFORMATION\_SCHEMA.STATISTICS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-statistics-table) tables with the [**innodb\_stats\_on\_metadata**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_stats_on_metadata) option enabled.

The default setting for [**innodb\_stats\_on\_metadata**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_stats_on_metadata) is **OFF**. Enabling [**innodb\_stats\_on\_metadata**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_stats_on_metadata) may reduce access speed for schemas that have a large number of tables or indexes, and reduce stability of execution plans for queries that involve **InnoDB** tables. [**innodb\_stats\_on\_metadata**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_stats_on_metadata) is configured globally using a [**SET**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-types.html#set) statement.

SET GLOBAL innodb\_stats\_on\_metadata=ON

**Note**

[**innodb\_stats\_on\_metadata**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_stats_on_metadata) only applies when optimizer [statistics](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_statistics) are configured to be non-persistent (when [**innodb\_stats\_persistent**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_stats_persistent) is disabled).

Starting a [**mysql**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\programs.html#mysql) client with the [--auto-rehash](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\programs.html#option_mysql_auto-rehash) option enabled, which is the default. The [auto-rehash](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\programs.html#option_mysql_auto-rehash) option causes all **InnoDB** tables to be opened, and the open table operations cause statistics to be recalculated.

To improve the start up time of the [**mysql**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\programs.html#mysql) client and to updating statistics, you can turn off [auto-rehash](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\programs.html#option_mysql_auto-rehash) using the [--disable-auto-rehash](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\programs.html#option_mysql_auto-rehash) option. The [auto-rehash](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\programs.html#option_mysql_auto-rehash) feature enables automatic name completion of database, table, and column names for interactive users.

A table is first opened.

**InnoDB** detects that 1 / 16 of table has been modified since the last time statistics were updated.

##### Configuring the Number of Sampled Pages

The MySQL query optimizer uses estimated [statistics](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_statistics) about key distributions to choose the indexes for an execution plan, based on the relative [selectivity](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_selectivity) of the index. When **InnoDB** updates optimizer statistics, it samples random pages from each index on a table to estimate the [cardinality](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_cardinality) of the index. (This technique is known as [random dives](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_random_dive).)

To give you control over the quality of the statistics estimate (and thus better information for the query optimizer), you can change the number of sampled pages using the parameter [**innodb\_stats\_transient\_sample\_pages**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_stats_transient_sample_pages). The default number of sampled pages is 8, which could be insufficient to produce an accurate estimate, leading to poor index choices by the query optimizer. This technique is especially important for large tables and tables used in [joins](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_join). Unnecessary [full table scans](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_full_table_scan) for such tables can be a substantial performance issue. See [Section 8.2.1.23, “Avoiding Full Table Scans”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#table-scan-avoidance) for tips on tuning such queries. [**innodb\_stats\_transient\_sample\_pages**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_stats_transient_sample_pages) is a global parameter that can be set at runtime.

The value of [**innodb\_stats\_transient\_sample\_pages**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_stats_transient_sample_pages) affects the index sampling for all **InnoDB** tables and indexes when [**innodb\_stats\_persistent=0**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_stats_persistent). Be aware of the following potentially significant impacts when you change the index sample size:

Small values like 1 or 2 can result in inaccurate estimates of cardinality.

Increasing the [**innodb\_stats\_transient\_sample\_pages**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_stats_transient_sample_pages) value might require more disk reads. Values much larger than 8 (say, 100), can cause a significant slowdown in the time it takes to open a table or execute **SHOW TABLE STATUS**.

The optimizer might choose very different query plans based on different estimates of index selectivity.

Whatever value of [**innodb\_stats\_transient\_sample\_pages**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_stats_transient_sample_pages) works best for a system, set the option and leave it at that value. Choose a value that results in reasonably accurate estimates for all tables in your database without requiring excessive I/O. Because the statistics are automatically recalculated at various times other than on execution of [**ANALYZE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#analyze-table), it does not make sense to increase the index sample size, run [**ANALYZE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#analyze-table), then decrease sample size again.

Smaller tables generally require fewer index samples than larger tables. If your database has many large tables, consider using a higher value for [**innodb\_stats\_transient\_sample\_pages**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_stats_transient_sample_pages) than if you have mostly smaller tables.

#### 15.8.10.3 Estimating ANALYZE TABLE Complexity for InnoDB Tables

[**ANALYZE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#analyze-table) complexity for **InnoDB** tables is dependent on:

The number of pages sampled, as defined by [**innodb\_stats\_persistent\_sample\_pages**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_stats_persistent_sample_pages).

The number of indexed columns in a table

The number of partitions. If a table has no partitions, the number of partitions is considered to be 1.

Using these parameters, an approximate formula for estimating [**ANALYZE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#analyze-table) complexity would be:

The value of [**innodb\_stats\_persistent\_sample\_pages**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_stats_persistent_sample_pages) \* number of indexed columns in a table \* the number of partitions

Typically, the greater the resulting value, the greater the execution time for [**ANALYZE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#analyze-table).

**Note**

[**innodb\_stats\_persistent\_sample\_pages**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_stats_persistent_sample_pages) defines the number of pages sampled at a global level. To set the number of pages sampled for an individual table, use the **STATS\_SAMPLE\_PAGES** option with [**CREATE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-table) or [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table). For more information, see [Section 15.8.10.1, “Configuring Persistent Optimizer Statistics Parameters”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-persistent-stats).

If [**innodb\_stats\_persistent=OFF**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_stats_persistent), the number of pages sampled is defined by [**innodb\_stats\_transient\_sample\_pages**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_stats_transient_sample_pages). See [Section 15.8.10.2, “Configuring Non-Persistent Optimizer Statistics Parameters”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-statistics-estimation) for additional information.

For a more in-depth approach to estimating **ANALYZE TABLE** complexity, consider the following example.

In [Big O notation](http://en.wikipedia.org/wiki/Big_O_notation), [**ANALYZE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#analyze-table) complexity is described as:

O(n\_sample

\* (n\_cols\_in\_uniq\_i

+ n\_cols\_in\_non\_uniq\_i

+ n\_cols\_in\_pk \* (1 + n\_non\_uniq\_i))

\* n\_part)

where:

**n\_sample** is the number of pages sampled (defined by [**innodb\_stats\_persistent\_sample\_pages**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_stats_persistent_sample_pages))

**n\_cols\_in\_uniq\_i** is total number of all columns in all unique indexes (not counting the primary key columns)

**n\_cols\_in\_non\_uniq\_i** is the total number of all columns in all nonunique indexes

**n\_cols\_in\_pk** is the number of columns in the primary key (if a primary key is not defined, **InnoDB** creates a single column primary key internally)

**n\_non\_uniq\_i** is the number of nonunique indexes in the table

**n\_part** is the number of partitions. If no partitions are defined, the table is considered to be a single partition.

Now, consider the following table (table **t**), which has a primary key (2 columns), a unique index (2 columns), and two nonunique indexes (two columns each):

CREATE TABLE t (

a INT,

b INT,

c INT,

d INT,

e INT,

f INT,

g INT,

h INT,

PRIMARY KEY (a, b),

UNIQUE KEY i1uniq (c, d),

KEY i2nonuniq (e, f),

KEY i3nonuniq (g, h)

);

For the column and index data required by the algorithm described above, query the **mysql.innodb\_index\_stats** persistent index statistics table for table **t**. The **n\_diff\_pfx%** statistics show the columns that are counted for each index. For example, columns **a** and **b** are counted for the primary key index. For the nonunique indexes, the primary key columns (a,b) are counted in addition to the user defined columns.

**Note**

For additional information about the **InnoDB** persistent statistics tables, see [Section 15.8.10.1, “Configuring Persistent Optimizer Statistics Parameters”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-persistent-stats)

mysql> **SELECT index\_name, stat\_name, stat\_description**

**FROM mysql.innodb\_index\_stats WHERE**

**database\_name='test' AND**

**table\_name='t' AND**

**stat\_name like 'n\_diff\_pfx%';**

+------------+--------------+------------------+

| index\_name | stat\_name | stat\_description |

+------------+--------------+------------------+

| PRIMARY | n\_diff\_pfx01 | a |

| PRIMARY | n\_diff\_pfx02 | a,b |

| i1uniq | n\_diff\_pfx01 | c |

| i1uniq | n\_diff\_pfx02 | c,d |

| i2nonuniq | n\_diff\_pfx01 | e |

| i2nonuniq | n\_diff\_pfx02 | e,f |

| i2nonuniq | n\_diff\_pfx03 | e,f,a |

| i2nonuniq | n\_diff\_pfx04 | e,f,a,b |

| i3nonuniq | n\_diff\_pfx01 | g |

| i3nonuniq | n\_diff\_pfx02 | g,h |

| i3nonuniq | n\_diff\_pfx03 | g,h,a |

| i3nonuniq | n\_diff\_pfx04 | g,h,a,b |

+------------+--------------+------------------+

Based on the index statistics data shown above and the table definition, the following values can be determined:

**n\_cols\_in\_uniq\_i**, the total number of all columns in all unique indexes not counting the primary key columns, is 2 (**c** and **d**)

**n\_cols\_in\_non\_uniq\_i**, the total number of all columns in all nonunique indexes, is 4 (**e**, **f**, **g** and **h**)

**n\_cols\_in\_pk**, the number of columns in the primary key, is 2 (**a** and **b**)

**n\_non\_uniq\_i**, the number of nonunique indexes in the table, is 2 (**i2nonuniq** and **i3nonuniq**))

**n\_part**, the number of partitions, is 1.

You can now calculate **innodb\_stats\_persistent\_sample\_pages** \* (2 + 4 + 2 \* (1 + 2)) \* 1 to determine the number of leaf pages that are scanned. With **innodb\_stats\_persistent\_sample\_pages** set to the default value of **20**, and with a default page size of 16 **KiB** ([**innodb\_page\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_page_size)=16384), you can then estimate that 20 \* 12 \* 16384 **bytes** are read for table **t**, or about 4 **MiB**.

**Note**

All 4 **MiB** may not be read from disk, as some leaf pages may already be cached in the buffer pool.

### 15.8.11 Configuring the Merge Threshold for Index Pages

You can configure the **MERGE\_THRESHOLD** value for index pages. If the “page-full” percentage for an index page falls below the **MERGE\_THRESHOLD** value when a row is deleted or when a row is shortened by an [**UPDATE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#update) operation, **InnoDB** attempts to merge the index page with a neighboring index page. The default **MERGE\_THRESHOLD** value is 50, which is the previously hardcoded value. The minimum **MERGE\_THRESHOLD** value is 1 and the maximum value is 50.

When the “page-full” percentage for an index page falls below 50%, which is the default **MERGE\_THRESHOLD** setting, **InnoDB** attempts to merge the index page with a neighboring page. If both pages are close to 50% full, a page split can occur soon after the pages are merged. If this merge-split behavior occurs frequently, it can have an adverse affect on performance. To avoid frequent merge-splits, you can lower the **MERGE\_THRESHOLD** value so that **InnoDB** attempts page merges at a lower “page-full” percentage. Merging pages at a lower page-full percentage leaves more room in index pages and helps reduce merge-split behavior.

The **MERGE\_THRESHOLD** for index pages can be defined for a table or for individual indexes. A **MERGE\_THRESHOLD** value defined for an individual index takes priority over a **MERGE\_THRESHOLD** value defined for the table. If undefined, the **MERGE\_THRESHOLD** value defaults to 50.

#### Setting MERGE\_THRESHOLD for a Table

You can set the **MERGE\_THRESHOLD** value for a table using the ***table\_option*** **COMMENT** clause of the [**CREATE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-table) statement. For example:

CREATE TABLE t1 (

id INT,

KEY id\_index (id)

) COMMENT='MERGE\_THRESHOLD=45';

You can also set the **MERGE\_THRESHOLD** value for an existing table using the ***table\_option*** **COMMENT** clause with [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table):

CREATE TABLE t1 (

id INT,

KEY id\_index (id)

);

ALTER TABLE t1 COMMENT='MERGE\_THRESHOLD=40';

#### Setting MERGE\_THRESHOLD for Individual Indexes

To set the **MERGE\_THRESHOLD** value for an individual index, you can use the ***index\_option*** **COMMENT** clause with [**CREATE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-table), [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table), or [**CREATE INDEX**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-index), as shown in the following examples:

Setting **MERGE\_THRESHOLD** for an individual index using [**CREATE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-table):

CREATE TABLE t1 (

id INT,

KEY id\_index (id) COMMENT 'MERGE\_THRESHOLD=40'

);

Setting **MERGE\_THRESHOLD** for an individual index using [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table):

CREATE TABLE t1 (

id INT,

KEY id\_index (id)

);

ALTER TABLE t1 DROP KEY id\_index;

ALTER TABLE t1 ADD KEY id\_index (id) COMMENT 'MERGE\_THRESHOLD=40';

Setting **MERGE\_THRESHOLD** for an individual index using [**CREATE INDEX**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-index):

CREATE TABLE t1 (id INT);

CREATE INDEX id\_index ON t1 (id) COMMENT 'MERGE\_THRESHOLD=40';

**Note**

You cannot modify the **MERGE\_THRESHOLD** value at the index level for **GEN\_CLUST\_INDEX**, which is the clustered index created by **InnoDB** when an **InnoDB** table is created without a primary key or unique key index. You can only modify the **MERGE\_THRESHOLD** value for **GEN\_CLUST\_INDEX** by setting **MERGE\_THRESHOLD** for the table.

#### Querying the MERGE\_THRESHOLD Value for an Index

The current **MERGE\_THRESHOLD** value for an index can be obtained by querying the [**INNODB\_INDEXES**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-indexes-table) table. For example:

mysql> **SELECT \* FROM INFORMATION\_SCHEMA.INNODB\_INDEXES WHERE NAME='id\_index' \G**

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\* 1. row \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

INDEX\_ID: 91

NAME: id\_index

TABLE\_ID: 68

TYPE: 0

N\_FIELDS: 1

PAGE\_NO: 4

SPACE: 57

MERGE\_THRESHOLD: 40

You can use [**SHOW CREATE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#show-create-table) to view the **MERGE\_THRESHOLD** value for a table, if explicitly defined using the ***table\_option*** **COMMENT** clause:

mysql> **SHOW CREATE TABLE t2 \G**

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\* 1. row \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

Table: t2

Create Table: CREATE TABLE `t2` (

`id` int(11) DEFAULT NULL,

KEY `id\_index` (`id`) COMMENT 'MERGE\_THRESHOLD=40'

) ENGINE=InnoDB DEFAULT CHARSET=utf8mb4

**Note**

A **MERGE\_THRESHOLD** value defined at the index level takes priority over a **MERGE\_THRESHOLD** value defined for the table. If undefined, **MERGE\_THRESHOLD** defaults to 50% (**MERGE\_THRESHOLD=50**, which is the previously hardcoded value.

Likewise, you can use [**SHOW INDEX**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#show-index) to view the **MERGE\_THRESHOLD** value for an index, if explicitly defined using the ***index\_option*** **COMMENT** clause:

mysql> **SHOW INDEX FROM t2 \G**

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\* 1. row \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

Table: t2

Non\_unique: 1

Key\_name: id\_index

Seq\_in\_index: 1

Column\_name: id

Collation: A

Cardinality: 0

Sub\_part: NULL

Packed: NULL

Null: YES

Index\_type: BTREE

Comment:

Index\_comment: MERGE\_THRESHOLD=40

#### Measuring the Effect of MERGE\_THRESHOLD Settings

The [**INNODB\_METRICS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-metrics-table) table provides two counters that can be used to measure the effect of a **MERGE\_THRESHOLD** setting on index page merges.

mysql> **SELECT NAME, COMMENT FROM INFORMATION\_SCHEMA.INNODB\_METRICS**

**WHERE NAME like '%index\_page\_merge%';**

+-----------------------------+----------------------------------------+

| NAME | COMMENT |

+-----------------------------+----------------------------------------+

| index\_page\_merge\_attempts | Number of index page merge attempts |

| index\_page\_merge\_successful | Number of successful index page merges |

+-----------------------------+----------------------------------------+

When lowering the **MERGE\_THRESHOLD** value, the objectives are:

A smaller number of page merge attempts and successful page merges

A similar number of page merge attempts and successful page merges

A **MERGE\_THRESHOLD** setting that is too small could result in large data files due to an excessive amount of empty page space.

For information about using [**INNODB\_METRICS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-metrics-table) counters, see [Section 15.15.6, “InnoDB INFORMATION\_SCHEMA Metrics Table”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-information-schema-metrics-table).

### 15.8.12 Enabling Automatic Configuration for a Dedicated MySQL Server

When [**innodb\_dedicated\_server**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_dedicated_server) is enabled, **InnoDB** automatically configures the following variables:

[**innodb\_buffer\_pool\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_size)

[**innodb\_log\_file\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_log_file_size)

[**innodb\_log\_files\_in\_group**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_log_files_in_group) (as of MySQL 8.0.14)

[**innodb\_flush\_method**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_flush_method)

Only consider enabling [**innodb\_dedicated\_server**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_dedicated_server) if the MySQL instance resides on a dedicated server where it can use all available system resources. For example, consider enabling if you run MySQL Server in a Docker container or dedicated VM that only runs MySQL. Enabling [**innodb\_dedicated\_server**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_dedicated_server) is not recommended if the MySQL instance shares system resources with other applications.

The information that follows describes how each variable is automatically configured.

[**innodb\_buffer\_pool\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_size)

Buffer pool size is configured according to the amount of memory detected on the server.

**Table 15.8 Automatically Configured Buffer Pool Size**

| **Detected Server Memory** | **Buffer Pool Size** |
| --- | --- |
| Less than 1GB | 128MiB (the default value) |
| 1GB to 4GB | ***detected server memory*** \* 0.5 |
| Greater than 4GB | ***detected server memory*** \* 0.75 |

[**innodb\_log\_file\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_log_file_size)

As of MySQL 8.0.14, log file size is configured according to the automatically configured buffer pool size.

**Table 15.9 Automatically Configured Log File Size**

| **Buffer Pool Size** | **Log File Size** |
| --- | --- |
| Less than 8GB | 512MiB |
| 8GB to 128GB | 1024MiB |
| Greater than 128GB | 2048MiB |

**Note**

Prior to MySQL 8.0.14, the [**innodb\_log\_file\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_log_file_size) variable was automatically configured according to the amount of memory detected on the server, as shown below:

**Table 15.10 Automatically Configured Log File Size (MySQL 8.0.13 and Earlier)**

| **Detected Server Memory** | **Log File Size** |
| --- | --- |
| < 1GB | 48MiB (the default value) |
| <= 4GB | 128MiB |
| <= 8GB | 512MiB |
| <= 16GB | 1024MiB |
| > 16GB | 2048MiB |

[**innodb\_log\_files\_in\_group**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_log_files_in_group)

The number of log files is configured according to the automatically configured buffer pool size (in gigabytes). Automatic configuration of the [**innodb\_log\_files\_in\_group**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_log_files_in_group) variable was added in MySQL 8.0.14.

**Table 15.11 Automatically Configured Number of Log Files**

| **Buffer Pool Size** | **Number of Log Files** |
| --- | --- |
| Less than 8GB | ROUND(***buffer pool size***) |
| 8GB to 128GB | ROUND(***buffer pool size*** \* 0.75) |
| Greater than 128GB | 64 |

**Note**

The minimum [**innodb\_log\_files\_in\_group**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_log_files_in_group) value of 2 is enforced if the rounded buffer pool size value is less than 2GB.

[**innodb\_flush\_method**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_flush_method)

The flush method is set to **O\_DIRECT\_NO\_FSYNC** when [**innodb\_dedicated\_server**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_dedicated_server) is enabled. If the **O\_DIRECT\_NO\_FSYNC** setting is not available, the default [**innodb\_flush\_method**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_flush_method) setting is used.

**InnoDB** uses **O\_DIRECT** during flushing I/O, but skips the **fsync()** system call after each write operation.

**Warning**

Prior to MySQL 8.0.14, this setting is not suitable for file systems such as XFS and EXT4, which require an **fsync()** system call to synchronize file system metadata changes.

As of MySQL 8.0.14, **fsync()** is called after creating a new file, after increasing file size, and after closing a file, to ensure that file system metadata changes are synchronized. The **fsync()** system call is still skipped after each write operation.

Data loss is possible if redo log files and data files reside on different storage devices, and an unexpected exit occurs before data file writes are flushed from a device cache that is not battery-backed. If you use or intend to use different storage devices for redo log files and data files, and your data files reside on a device with a cache that is not battery-backed, use **O\_DIRECT** instead.

If an automatically configured option is configured explicitly in an option file or elsewhere, the explicitly specified setting is used, and a startup warning similar to this is printed to **stderr**:

[Warning] [000000] InnoDB: Option innodb\_dedicated\_server is ignored for innodb\_buffer\_pool\_size because innodb\_buffer\_pool\_size=134217728 is specified explicitly.

Explicit configuration of one option does not prevent the automatic configuration of other options.

If [**innodb\_dedicated\_server**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_dedicated_server) is enabled and [**innodb\_buffer\_pool\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_size) is configured explicitly in an option file, [**innodb\_log\_file\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_log_file_size) and [**innodb\_log\_files\_in\_group**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_log_files_in_group) are still automatically configured based on a buffer pool size value calculated according to the amount of memory detected on the server, even though that value is not used to configure the size of the buffer pool.

Automatically configured settings are evaluated and reconfigured if necessary each time the MySQL server is started.

## 15.9 InnoDB Table and Page Compression

[15.9.1 InnoDB Table Compression](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-table-compression)

[15.9.2 InnoDB Page Compression](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-page-compression)

This section provides information about the **InnoDB** table compression and **InnoDB** page compression features. The page compression feature is also referred to as [transparent page compression](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_transparent_page_compression).

Using the compression features of **InnoDB**, you can create tables where the data is stored in compressed form. Compression can help to improve both raw performance and scalability. The compression means less data is transferred between disk and memory, and takes up less space on disk and in memory. The benefits are amplified for tables with [secondary indexes](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_secondary_index), because index data is compressed also. Compression can be especially important for [SSD](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_ssd) storage devices, because they tend to have lower capacity than [HDD](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_hdd) devices.

### 15.9.1 InnoDB Table Compression

[15.9.1.1 Overview of Table Compression](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-compression-background)

[15.9.1.2 Creating Compressed Tables](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-compression-usage)

[15.9.1.3 Tuning Compression for InnoDB Tables](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-compression-tuning)

[15.9.1.4 Monitoring InnoDB Table Compression at Runtime](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-compression-tuning-monitoring)

[15.9.1.5 How Compression Works for InnoDB Tables](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-compression-internals)

[15.9.1.6 Compression for OLTP Workloads](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-performance-compression-oltp)

[15.9.1.7 SQL Compression Syntax Warnings and Errors](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-compression-syntax-warnings)

This section describes **InnoDB** table compression, which is supported with **InnoDB** tables that reside in [file\_per\_table](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_file_per_table) tablespaces or [general tablespaces](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_general_tablespace). Table compression is enabled using the **ROW\_FORMAT=COMPRESSED** attribute with [**CREATE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-table) or [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table).

#### 15.9.1.1 Overview of Table Compression

Because processors and cache memories have increased in speed more than disk storage devices, many workloads are [disk-bound](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_disk_bound). Data [compression](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_compression) enables smaller database size, reduced I/O, and improved throughput, at the small cost of increased CPU utilization. Compression is especially valuable for read-intensive applications, on systems with enough RAM to keep frequently used data in memory.

An **InnoDB** table created with **ROW\_FORMAT=COMPRESSED** can use a smaller [page size](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_page_size) on disk than the configured [**innodb\_page\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_page_size) value. Smaller pages require less I/O to read from and write to disk, which is especially valuable for [SSD](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_ssd) devices.

The compressed page size is specified through the [**CREATE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-table) or [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) **KEY\_BLOCK\_SIZE** parameter. The different page size requires that the table be placed in a [file-per-table](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_file_per_table) tablespace or [general tablespace](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_general_tablespace) rather than in the [system tablespace](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_system_tablespace), as the system tablespace cannot store compressed tables. For more information, see [Section 15.6.3.2, “File-Per-Table Tablespaces”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-file-per-table-tablespaces), and [Section 15.6.3.3, “General Tablespaces”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#general-tablespaces).

The level of compression is the same regardless of the **KEY\_BLOCK\_SIZE** value. As you specify smaller values for **KEY\_BLOCK\_SIZE**, you get the I/O benefits of increasingly smaller pages. But if you specify a value that is too small, there is additional overhead to reorganize the pages when data values cannot be compressed enough to fit multiple rows in each page. There is a hard limit on how small **KEY\_BLOCK\_SIZE** can be for a table, based on the lengths of the key columns for each of its indexes. Specify a value that is too small, and the [**CREATE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-table) or [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) statement fails.

In the buffer pool, the compressed data is held in small pages, with a page size based on the **KEY\_BLOCK\_SIZE** value. For extracting or updating the column values, MySQL also creates an uncompressed page in the buffer pool with the uncompressed data. Within the buffer pool, any updates to the uncompressed page are also re-written back to the equivalent compressed page. You might need to size your buffer pool to accommodate the additional data of both compressed and uncompressed pages, although the uncompressed pages are [evicted](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_eviction) from the buffer pool when space is needed, and then uncompressed again on the next access.

#### 15.9.1.2 Creating Compressed Tables

Compressed tables can be created in [file-per-table](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_file_per_table) tablespaces or in [general tablespaces](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_general_tablespace). Table compression is not available for the InnoDB [system tablespace](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_system_tablespace). The system tablespace (space 0, the [.ibdata files](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_ibd_file)) can contain user-created tables, but it also contains internal system data, which is never compressed. Thus, compression applies only to tables (and indexes) stored in file-per-table or general tablespaces.

##### Creating a Compressed Table in File-Per-Table Tablespace

To create a compressed table in a file-per-table tablespace, [**innodb\_file\_per\_table**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_file_per_table) must be enabled (the default). You can set this parameter in the MySQL configuration file (my.cnf or my.ini) or dynamically, using a [**SET**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#set-variable) statement.

After the [**innodb\_file\_per\_table**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_file_per_table) option is configured, specify the **ROW\_FORMAT=COMPRESSED** clause or **KEY\_BLOCK\_SIZE** clause, or both, in a [**CREATE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-table) or [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) statement to create a compressed table in a file-per-table tablespace.

For example, you might use the following statements:

SET GLOBAL innodb\_file\_per\_table=1;

CREATE TABLE t1

(c1 INT PRIMARY KEY)

ROW\_FORMAT=COMPRESSED

KEY\_BLOCK\_SIZE=8;

##### Creating a Compressed Table in a General Tablespace

To create a compressed table in a general tablespace, **FILE\_BLOCK\_SIZE** must be defined for the general tablespace, which is specified when the tablespace is created. The **FILE\_BLOCK\_SIZE** value must be a valid compressed page size in relation to the [**innodb\_page\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_page_size) value, and the page size of the compressed table, defined by the [**CREATE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-table) or [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) **KEY\_BLOCK\_SIZE** clause, must be equal to **FILE\_BLOCK\_SIZE/1024**. For example, if [**innodb\_page\_size=16384**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_page_size) and **FILE\_BLOCK\_SIZE=8192**, the **KEY\_BLOCK\_SIZE** of the table must be 8. For more information, see [Section 15.6.3.3, “General Tablespaces”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#general-tablespaces).

The following example demonstrates creating a general tablespace and adding a compressed table. The example assumes a default [**innodb\_page\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_page_size) of 16K. The **FILE\_BLOCK\_SIZE** of 8192 requires that the compressed table have a **KEY\_BLOCK\_SIZE** of 8.

mysql> **CREATE TABLESPACE `ts2` ADD DATAFILE 'ts2.ibd' FILE\_BLOCK\_SIZE = 8192 Engine=InnoDB;**

mysql> **CREATE TABLE t4 (c1 INT PRIMARY KEY) TABLESPACE ts2 ROW\_FORMAT=COMPRESSED KEY\_BLOCK\_SIZE=8;**

##### Notes

As of MySQL 8.0, the tablespace file for a compressed table is created using the physical page size instead of the **InnoDB** page size, which makes the initial size of a tablespace file for an empty compressed table smaller than in previous MySQL releases.

If you specify **ROW\_FORMAT=COMPRESSED**, you can omit **KEY\_BLOCK\_SIZE**; the **KEY\_BLOCK\_SIZE** setting defaults to half the [**innodb\_page\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_page_size) value.

If you specify a valid **KEY\_BLOCK\_SIZE** value, you can omit **ROW\_FORMAT=COMPRESSED**; compression is enabled automatically.

To determine the best value for **KEY\_BLOCK\_SIZE,** typically you create several copies of the same table with different values for this clause, then measure the size of the resulting .ibd files and see how well each performs with a realistic [workload](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_workload). For general tablespaces, keep in mind that dropping a table does not reduce the size of the general tablespace .ibd file, nor does it return disk space to the operating system. For more information, see [Section 15.6.3.3, “General Tablespaces”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#general-tablespaces).

The **KEY\_BLOCK\_SIZE** value is treated as a hint; a different size could be used by **InnoDB** if necessary. For file-per-table tablespaces, the **KEY\_BLOCK\_SIZE** can only be less than or equal to the [**innodb\_page\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_page_size) value. If you specify a value greater than the [**innodb\_page\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_page_size) value, the specified value is ignored, a warning is issued, and **KEY\_BLOCK\_SIZE** is set to half of the [**innodb\_page\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_page_size) value. If **innodb\_strict\_mode=ON**, specifying an invalid **KEY\_BLOCK\_SIZE** value returns an error. For general tablespaces, valid **KEY\_BLOCK\_SIZE** values depend on the **FILE\_BLOCK\_SIZE** setting of the tablespace. For more information, see [Section 15.6.3.3, “General Tablespaces”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#general-tablespaces).

**InnoDB** supports 32KB and 64KB page sizes but these page sizes do not support compression. For more information, refer to the [**innodb\_page\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_page_size) documentation.

The default uncompressed size of **InnoDB** data [pages](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_page) is 16KB. Depending on the combination of option values, MySQL uses a page size of 1KB, 2KB, 4KB, 8KB, or 16KB for the tablespace data file (.ibd file). The actual compression algorithm is not affected by the **KEY\_BLOCK\_SIZE** value; the value determines how large each compressed chunk is, which in turn affects how many rows can be packed into each compressed page.

When creating a compressed table in a file-per-table tablespace, setting **KEY\_BLOCK\_SIZE** equal to the **InnoDB** [page size](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_page_size) does not typically result in much compression. For example, setting **KEY\_BLOCK\_SIZE=16** typically would not result in much compression, since the normal **InnoDB** page size is 16KB. This setting may still be useful for tables with many long [**BLOB**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-types.html#blob), [**VARCHAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-types.html#char) or [**TEXT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-types.html#blob) columns, because such values often do compress well, and might therefore require fewer [overflow pages](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_overflow_page) as described in [Section 15.9.1.5, “How Compression Works for InnoDB Tables”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-compression-internals). For general tablespaces, a **KEY\_BLOCK\_SIZE** value equal to the **InnoDB** page size is not permitted. For more information, see [Section 15.6.3.3, “General Tablespaces”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#general-tablespaces).

All indexes of a table (including the [clustered index](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_clustered_index)) are compressed using the same page size, as specified in the **CREATE TABLE** or **ALTER TABLE** statement. Table attributes such as **ROW\_FORMAT** and **KEY\_BLOCK\_SIZE** are not part of the **CREATE INDEX** syntax for **InnoDB** tables, and are ignored if they are specified (although, if specified, they appear in the output of the [**SHOW CREATE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#show-create-table) statement).

For performance-related configuration options, see [Section 15.9.1.3, “Tuning Compression for InnoDB Tables”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-compression-tuning).

##### Restrictions on Compressed Tables

Compressed tables cannot be stored in the **InnoDB** system tablespace.

General tablespaces can contain multiple tables, but compressed and uncompressed tables cannot coexist within the same general tablespace.

Compression applies to an entire table and all its associated indexes, not to individual rows, despite the clause name **ROW\_FORMAT**.

**InnoDB** does not support compressed temporary tables. When [**innodb\_strict\_mode**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_strict_mode) is enabled (the default), [**CREATE TEMPORARY TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-table) returns errors if **ROW\_FORMAT=COMPRESSED** or **KEY\_BLOCK\_SIZE** is specified. If [**innodb\_strict\_mode**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_strict_mode) is disabled, warnings are issued and the temporary table is created using a non-compressed row format. The same restrictions apply to [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) operations on temporary tables.

#### 15.9.1.3 Tuning Compression for InnoDB Tables

Most often, the internal optimizations described in [InnoDB Data Storage and Compression](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-compression-internals-storage) ensure that the system runs well with compressed data. However, because the efficiency of compression depends on the nature of your data, you can make decisions that affect the performance of compressed tables:

Which tables to compress.

What compressed page size to use.

Whether to adjust the size of the buffer pool based on run-time performance characteristics, such as the amount of time the system spends compressing and uncompressing data. Whether the workload is more like a [data warehouse](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_data_warehouse) (primarily queries) or an [OLTP](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_oltp) system (mix of queries and [DML](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_dml)).

If the system performs DML operations on compressed tables, and the way the data is distributed leads to expensive [compression failures](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_compression_failure) at runtime, you might adjust additional advanced configuration options.

Use the guidelines in this section to help make those architectural and configuration choices. When you are ready to conduct long-term testing and put compressed tables into production, see [Section 15.9.1.4, “Monitoring InnoDB Table Compression at Runtime”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-compression-tuning-monitoring) for ways to verify the effectiveness of those choices under real-world conditions.

##### When to Use Compression

In general, compression works best on tables that include a reasonable number of character string columns and where the data is read far more often than it is written. Because there are no guaranteed ways to predict whether or not compression benefits a particular situation, always test with a specific [workload](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_workload) and data set running on a representative configuration. Consider the following factors when deciding which tables to compress.

##### Data Characteristics and Compression

A key determinant of the efficiency of compression in reducing the size of data files is the nature of the data itself. Recall that compression works by identifying repeated strings of bytes in a block of data. Completely randomized data is the worst case. Typical data often has repeated values, and so compresses effectively. Character strings often compress well, whether defined in **CHAR**, **VARCHAR**, **TEXT** or **BLOB** columns. On the other hand, tables containing mostly binary data (integers or floating point numbers) or data that is previously compressed (for example JPEG or PNG images) may not generally compress well, significantly or at all.

You choose whether to turn on compression for each InnoDB table. A table and all of its indexes use the same (compressed) [page size](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_page_size). It might be that the [primary key](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_primary_key) (clustered) index, which contains the data for all columns of a table, compresses more effectively than the secondary indexes. For those cases where there are long rows, the use of compression might result in long column values being stored “off-page”, as discussed in [DYNAMIC Row Format](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-row-format-dynamic). Those overflow pages may compress well. Given these considerations, for many applications, some tables compress more effectively than others, and you might find that your workload performs best only with a subset of tables compressed.

To determine whether or not to compress a particular table, conduct experiments. You can get a rough estimate of how efficiently your data can be compressed by using a utility that implements LZ77 compression (such as **gzip** or WinZip) on a copy of the [.ibd file](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_ibd_file) for an uncompressed table. You can expect less compression from a MySQL compressed table than from file-based compression tools, because MySQL compresses data in chunks based on the [page size](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_page_size), 16KB by default. In addition to user data, the page format includes some internal system data that is not compressed. File-based compression utilities can examine much larger chunks of data, and so might find more repeated strings in a huge file than MySQL can find in an individual page.

Another way to test compression on a specific table is to copy some data from your uncompressed table to a similar, compressed table (having all the same indexes) in a [file-per-table](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_file_per_table) tablespace and look at the size of the resulting **.ibd** file. For example:

USE test;

SET GLOBAL innodb\_file\_per\_table=1;

SET GLOBAL autocommit=0;

-- Create an uncompressed table with a million or two rows.

CREATE TABLE big\_table AS SELECT \* FROM information\_schema.columns;

INSERT INTO big\_table SELECT \* FROM big\_table;

INSERT INTO big\_table SELECT \* FROM big\_table;

INSERT INTO big\_table SELECT \* FROM big\_table;

INSERT INTO big\_table SELECT \* FROM big\_table;

INSERT INTO big\_table SELECT \* FROM big\_table;

INSERT INTO big\_table SELECT \* FROM big\_table;

INSERT INTO big\_table SELECT \* FROM big\_table;

INSERT INTO big\_table SELECT \* FROM big\_table;

INSERT INTO big\_table SELECT \* FROM big\_table;

INSERT INTO big\_table SELECT \* FROM big\_table;

COMMIT;

ALTER TABLE big\_table ADD id int unsigned NOT NULL PRIMARY KEY auto\_increment;

SHOW CREATE TABLE big\_table\G

select count(id) from big\_table;

-- Check how much space is needed for the uncompressed table.

\! ls -l data/test/big\_table.ibd

CREATE TABLE key\_block\_size\_4 LIKE big\_table;

ALTER TABLE key\_block\_size\_4 key\_block\_size=4 row\_format=compressed;

INSERT INTO key\_block\_size\_4 SELECT \* FROM big\_table;

commit;

-- Check how much space is needed for a compressed table

-- with particular compression settings.

\! ls -l data/test/key\_block\_size\_4.ibd

This experiment produced the following numbers, which of course could vary considerably depending on your table structure and data:

-rw-rw---- 1 cirrus staff 310378496 Jan 9 13:44 data/test/big\_table.ibd

-rw-rw---- 1 cirrus staff 83886080 Jan 9 15:10 data/test/key\_block\_size\_4.ibd

To see whether compression is efficient for your particular [workload](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_workload):

For simple tests, use a MySQL instance with no other compressed tables and run queries against the [**INFORMATION\_SCHEMA.INNODB\_CMP**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-cmp-table) table.

For more elaborate tests involving workloads with multiple compressed tables, run queries against the [**INFORMATION\_SCHEMA.INNODB\_CMP\_PER\_INDEX**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-cmp-per-index-table) table. Because the statistics in the **INNODB\_CMP\_PER\_INDEX** table are expensive to collect, you must enable the configuration option [**innodb\_cmp\_per\_index\_enabled**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_cmp_per_index_enabled) before querying that table, and you might restrict such testing to a development server or a non-critical replica server.

Run some typical SQL statements against the compressed table you are testing.

Examine the ratio of successful compression operations to overall compression operations by querying the [**INFORMATION\_SCHEMA.INNODB\_CMP**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-cmp-table) or [**INFORMATION\_SCHEMA.INNODB\_CMP\_PER\_INDEX**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-cmp-per-index-table) table, and comparing **COMPRESS\_OPS** to **COMPRESS\_OPS\_OK**.

If a high percentage of compression operations complete successfully, the table might be a good candidate for compression.

If you get a high proportion of [compression failures](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_compression_failure), you can adjust [**innodb\_compression\_level**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_compression_level), [**innodb\_compression\_failure\_threshold\_pct**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_compression_failure_threshold_pct), and [**innodb\_compression\_pad\_pct\_max**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_compression_pad_pct_max) options as described in [Section 15.9.1.6, “Compression for OLTP Workloads”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-performance-compression-oltp), and try further tests.

##### Database Compression versus Application Compression

Decide whether to compress data in your application or in the table; do not use both types of compression for the same data. When you compress the data in the application and store the results in a compressed table, extra space savings are extremely unlikely, and the double compression just wastes CPU cycles.

##### Compressing in the Database

When enabled, MySQL table compression is automatic and applies to all columns and index values. The columns can still be tested with operators such as **LIKE**, and sort operations can still use indexes even when the index values are compressed. Because indexes are often a significant fraction of the total size of a database, compression could result in significant savings in storage, I/O or processor time. The compression and decompression operations happen on the database server, which likely is a powerful system that is sized to handle the expected load.

##### Compressing in the Application

If you compress data such as text in your application, before it is inserted into the database, You might save overhead for data that does not compress well by compressing some columns and not others. This approach uses CPU cycles for compression and uncompression on the client machine rather than the database server, which might be appropriate for a distributed application with many clients, or where the client machine has spare CPU cycles.

##### Hybrid Approach

Of course, it is possible to combine these approaches. For some applications, it may be appropriate to use some compressed tables and some uncompressed tables. It may be best to externally compress some data (and store it in uncompressed tables) and allow MySQL to compress (some of) the other tables in the application. As always, up-front design and real-life testing are valuable in reaching the right decision.

##### Workload Characteristics and Compression

In addition to choosing which tables to compress (and the page size), the workload is another key determinant of performance. If the application is dominated by reads, rather than updates, fewer pages need to be reorganized and recompressed after the index page runs out of room for the per-page “modification log” that MySQL maintains for compressed data. If the updates predominantly change non-indexed columns or those containing **BLOB**s or large strings that happen to be stored “off-page”, the overhead of compression may be acceptable. If the only changes to a table are **INSERT**s that use a monotonically increasing primary key, and there are few secondary indexes, there is little need to reorganize and recompress index pages. Since MySQL can “delete-mark” and delete rows on compressed pages “in place” by modifying uncompressed data, **DELETE** operations on a table are relatively efficient.

For some environments, the time it takes to load data can be as important as run-time retrieval. Especially in data warehouse environments, many tables may be read-only or read-mostly. In those cases, it might or might not be acceptable to pay the price of compression in terms of increased load time, unless the resulting savings in fewer disk reads or in storage cost is significant.

Fundamentally, compression works best when the CPU time is available for compressing and uncompressing data. Thus, if your workload is I/O bound, rather than CPU-bound, you might find that compression can improve overall performance. When you test your application performance with different compression configurations, test on a platform similar to the planned configuration of the production system.

##### Configuration Characteristics and Compression

Reading and writing database [pages](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_page) from and to disk is the slowest aspect of system performance. Compression attempts to reduce I/O by using CPU time to compress and uncompress data, and is most effective when I/O is a relatively scarce resource compared to processor cycles.

This is often especially the case when running in a multi-user environment with fast, multi-core CPUs. When a page of a compressed table is in memory, MySQL often uses additional memory, typically 16KB, in the [buffer pool](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_buffer_pool) for an uncompressed copy of the page. The adaptive LRU algorithm attempts to balance the use of memory between compressed and uncompressed pages to take into account whether the workload is running in an I/O-bound or CPU-bound manner. Still, a configuration with more memory dedicated to the buffer pool tends to run better when using compressed tables than a configuration where memory is highly constrained.

##### Choosing the Compressed Page Size

The optimal setting of the compressed page size depends on the type and distribution of data that the table and its indexes contain. The compressed page size should always be bigger than the maximum record size, or operations may fail as noted in [Compression of B-Tree Pages](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-compression-internals-storage-btree).

Setting the compressed page size too large wastes some space, but the pages do not have to be compressed as often. If the compressed page size is set too small, inserts or updates may require time-consuming recompression, and the [B-tree](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_b_tree) nodes may have to be split more frequently, leading to bigger data files and less efficient indexing.

Typically, you set the compressed page size to 8K or 4K bytes. Given that the maximum row size for an InnoDB table is around 8K, **KEY\_BLOCK\_SIZE=8** is usually a safe choice.

#### 15.9.1.4 Monitoring InnoDB Table Compression at Runtime

Overall application performance, CPU and I/O utilization and the size of disk files are good indicators of how effective compression is for your application. This section builds on the performance tuning advice from [Section 15.9.1.3, “Tuning Compression for InnoDB Tables”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-compression-tuning), and shows how to find problems that might not turn up during initial testing.

To dig deeper into performance considerations for compressed tables, you can monitor compression performance at runtime using the [Information Schema](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_information_schema) tables described in [Example 15.1, “Using the Compression Information Schema Tables”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-information-schema-examples-compression). These tables reflect the internal use of memory and the rates of compression used overall.

The [**INNODB\_CMP**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-cmp-table) table reports information about compression activity for each compressed page size (**KEY\_BLOCK\_SIZE**) in use. The information in these tables is system-wide: it summarizes the compression statistics across all compressed tables in your database. You can use this data to help decide whether or not to compress a table by examining these tables when no other compressed tables are being accessed. It involves relatively low overhead on the server, so you might query it periodically on a production server to check the overall efficiency of the compression feature.

The [**INNODB\_CMP\_PER\_INDEX**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-cmp-per-index-table) table reports information about compression activity for individual tables and indexes. This information is more targeted and more useful for evaluating compression efficiency and diagnosing performance issues one table or index at a time. (Because that each **InnoDB** table is represented as a clustered index, MySQL does not make a big distinction between tables and indexes in this context.) The [**INNODB\_CMP\_PER\_INDEX**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-cmp-per-index-table) table does involve substantial overhead, so it is more suitable for development servers, where you can compare the effects of different [workloads](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_workload), data, and compression settings in isolation. To guard against imposing this monitoring overhead by accident, you must enable the [**innodb\_cmp\_per\_index\_enabled**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_cmp_per_index_enabled) configuration option before you can query the [**INNODB\_CMP\_PER\_INDEX**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-cmp-per-index-table) table.

The key statistics to consider are the number of, and amount of time spent performing, compression and uncompression operations. Since MySQL splits [B-tree](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_b_tree) nodes when they are too full to contain the compressed data following a modification, compare the number of “successful” compression operations with the number of such operations overall. Based on the information in the [**INNODB\_CMP**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-cmp-table) and [**INNODB\_CMP\_PER\_INDEX**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-cmp-per-index-table) tables and overall application performance and hardware resource utilization, you might make changes in your hardware configuration, adjust the size of the buffer pool, choose a different page size, or select a different set of tables to compress.

If the amount of CPU time required for compressing and uncompressing is high, changing to faster or multi-core CPUs can help improve performance with the same data, application workload and set of compressed tables. Increasing the size of the buffer pool might also help performance, so that more uncompressed pages can stay in memory, reducing the need to uncompress pages that exist in memory only in compressed form.

A large number of compression operations overall (compared to the number of **INSERT**, **UPDATE** and **DELETE** operations in your application and the size of the database) could indicate that some of your compressed tables are being updated too heavily for effective compression. If so, choose a larger page size, or be more selective about which tables you compress.

If the number of “successful” compression operations (**COMPRESS\_OPS\_OK**) is a high percentage of the total number of compression operations (**COMPRESS\_OPS**), then the system is likely performing well. If the ratio is low, then MySQL is reorganizing, recompressing, and splitting B-tree nodes more often than is desirable. In this case, avoid compressing some tables, or increase **KEY\_BLOCK\_SIZE** for some of the compressed tables. You might turn off compression for tables that cause the number of “compression failures” in your application to be more than 1% or 2% of the total. (Such a failure ratio might be acceptable during a temporary operation such as a data load).

#### 15.9.1.5 How Compression Works for InnoDB Tables

This section describes some internal implementation details about [compression](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_compression) for InnoDB tables. The information presented here may be helpful in tuning for performance, but is not necessary to know for basic use of compression.

##### Compression Algorithms

Some operating systems implement compression at the file system level. Files are typically divided into fixed-size blocks that are compressed into variable-size blocks, which easily leads into fragmentation. Every time something inside a block is modified, the whole block is recompressed before it is written to disk. These properties make this compression technique unsuitable for use in an update-intensive database system.

MySQL implements compression with the help of the well-known [zlib library](http://www.zlib.net/), which implements the LZ77 compression algorithm. This compression algorithm is mature, robust, and efficient in both CPU utilization and in reduction of data size. The algorithm is “lossless”, so that the original uncompressed data can always be reconstructed from the compressed form. LZ77 compression works by finding sequences of data that are repeated within the data to be compressed. The patterns of values in your data determine how well it compresses, but typical user data often compresses by 50% or more.

**Note**

**InnoDB** supports the **zlib** library up to version 1.2.11, which is the version bundled with MySQL 8.0.

Unlike compression performed by an application, or compression features of some other database management systems, InnoDB compression applies both to user data and to indexes. In many cases, indexes can constitute 40-50% or more of the total database size, so this difference is significant. When compression is working well for a data set, the size of the InnoDB data files (the [file-per-table](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_file_per_table) tablespace or [general tablespace](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_general_tablespace) **.ibd** files) is 25% to 50% of the uncompressed size or possibly smaller. Depending on the [workload](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_workload), this smaller database can in turn lead to a reduction in I/O, and an increase in throughput, at a modest cost in terms of increased CPU utilization. You can adjust the balance between compression level and CPU overhead by modifying the [**innodb\_compression\_level**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_compression_level) configuration option.

##### InnoDB Data Storage and Compression

All user data in InnoDB tables is stored in pages comprising a [B-tree](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_b_tree) index (the [clustered index](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_clustered_index)). In some other database systems, this type of index is called an “index-organized table”. Each row in the index node contains the values of the (user-specified or system-generated) [primary key](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_primary_key) and all the other columns of the table.

[Secondary indexes](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_secondary_index) in InnoDB tables are also B-trees, containing pairs of values: the index key and a pointer to a row in the clustered index. The pointer is in fact the value of the primary key of the table, which is used to access the clustered index if columns other than the index key and primary key are required. Secondary index records must always fit on a single B-tree page.

The compression of B-tree nodes (of both clustered and secondary indexes) is handled differently from compression of [overflow pages](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_overflow_page) used to store long **VARCHAR**, **BLOB**, or **TEXT** columns, as explained in the following sections.

##### Compression of B-Tree Pages

Because they are frequently updated, B-tree pages require special treatment. It is important to minimize the number of times B-tree nodes are split, as well as to minimize the need to uncompress and recompress their content.

One technique MySQL uses is to maintain some system information in the B-tree node in uncompressed form, thus facilitating certain in-place updates. For example, this allows rows to be delete-marked and deleted without any compression operation.

In addition, MySQL attempts to avoid unnecessary uncompression and recompression of index pages when they are changed. Within each B-tree page, the system keeps an uncompressed “modification log” to record changes made to the page. Updates and inserts of small records may be written to this modification log without requiring the entire page to be completely reconstructed.

When the space for the modification log runs out, InnoDB uncompresses the page, applies the changes and recompresses the page. If recompression fails (a situation known as a [compression failure](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_compression_failure)), the B-tree nodes are split and the process is repeated until the update or insert succeeds.

To avoid frequent compression failures in write-intensive workloads, such as for [OLTP](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_oltp) applications, MySQL sometimes reserves some empty space (padding) in the page, so that the modification log fills up sooner and the page is recompressed while there is still enough room to avoid splitting it. The amount of padding space left in each page varies as the system keeps track of the frequency of page splits. On a busy server doing frequent writes to compressed tables, you can adjust the [**innodb\_compression\_failure\_threshold\_pct**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_compression_failure_threshold_pct), and [**innodb\_compression\_pad\_pct\_max**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_compression_pad_pct_max) configuration options to fine-tune this mechanism.

Generally, MySQL requires that each B-tree page in an InnoDB table can accommodate at least two records. For compressed tables, this requirement has been relaxed. Leaf pages of B-tree nodes (whether of the primary key or secondary indexes) only need to accommodate one record, but that record must fit, in uncompressed form, in the per-page modification log. If [**innodb\_strict\_mode**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_strict_mode) is **ON**, MySQL checks the maximum row size during [**CREATE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-table) or [**CREATE INDEX**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-index). If the row does not fit, the following error message is issued: **ERROR HY000: Too big row**.

If you create a table when [**innodb\_strict\_mode**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_strict_mode) is OFF, and a subsequent **INSERT** or **UPDATE** statement attempts to create an index entry that does not fit in the size of the compressed page, the operation fails with **ERROR 42000: Row size too large**. (This error message does not name the index for which the record is too large, or mention the length of the index record or the maximum record size on that particular index page.) To solve this problem, rebuild the table with [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) and select a larger compressed page size (**KEY\_BLOCK\_SIZE**), shorten any column prefix indexes, or disable compression entirely with **ROW\_FORMAT=DYNAMIC** or **ROW\_FORMAT=COMPACT**.

[**innodb\_strict\_mode**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_strict_mode) is not applicable to general tablespaces, which also support compressed tables. Tablespace management rules for general tablespaces are strictly enforced independently of [**innodb\_strict\_mode**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_strict_mode). For more information, see [Section 13.1.21, “CREATE TABLESPACE Statement”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-tablespace).

##### Compressing BLOB, VARCHAR, and TEXT Columns

In an InnoDB table, [**BLOB**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-types.html#blob), [**VARCHAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-types.html#char), and [**TEXT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-types.html#blob) columns that are not part of the primary key may be stored on separately allocated [overflow pages](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_overflow_page). We refer to these columns as [off-page columns](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_off_page_column). Their values are stored on singly-linked lists of overflow pages.

For tables created in **ROW\_FORMAT=DYNAMIC** or **ROW\_FORMAT=COMPRESSED**, the values of [**BLOB**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-types.html#blob), [**TEXT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-types.html#blob), or [**VARCHAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-types.html#char) columns may be stored fully off-page, depending on their length and the length of the entire row. For columns that are stored off-page, the clustered index record only contains 20-byte pointers to the overflow pages, one per column. Whether any columns are stored off-page depends on the page size and the total size of the row. When the row is too long to fit entirely within the page of the clustered index, MySQL chooses the longest columns for off-page storage until the row fits on the clustered index page. As noted above, if a row does not fit by itself on a compressed page, an error occurs.

**Note**

For tables created in **ROW\_FORMAT=DYNAMIC** or **ROW\_FORMAT=COMPRESSED**, [**TEXT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-types.html#blob) and [**BLOB**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-types.html#blob) columns that are less than or equal to 40 bytes are always stored in-line.

Tables that use **ROW\_FORMAT=REDUNDANT** and **ROW\_FORMAT=COMPACT** store the first 768 bytes of [**BLOB**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-types.html#blob), [**VARCHAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-types.html#char), and [**TEXT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-types.html#blob) columns in the clustered index record along with the primary key. The 768-byte prefix is followed by a 20-byte pointer to the overflow pages that contain the rest of the column value.

When a table is in **COMPRESSED** format, all data written to overflow pages is compressed “as is”; that is, MySQL applies the zlib compression algorithm to the entire data item. Other than the data, compressed overflow pages contain an uncompressed header and trailer comprising a page checksum and a link to the next overflow page, among other things. Therefore, very significant storage savings can be obtained for longer **BLOB**, **TEXT**, or **VARCHAR** columns if the data is highly compressible, as is often the case with text data. Image data, such as **JPEG**, is typically already compressed and so does not benefit much from being stored in a compressed table; the double compression can waste CPU cycles for little or no space savings.

The overflow pages are of the same size as other pages. A row containing ten columns stored off-page occupies ten overflow pages, even if the total length of the columns is only 8K bytes. In an uncompressed table, ten uncompressed overflow pages occupy 160K bytes. In a compressed table with an 8K page size, they occupy only 80K bytes. Thus, it is often more efficient to use compressed table format for tables with long column values.

For [file-per-table](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_file_per_table) tablespaces, using a 16K compressed page size can reduce storage and I/O costs for [**BLOB**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-types.html#blob), [**VARCHAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-types.html#char), or [**TEXT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-types.html#blob) columns, because such data often compress well, and might therefore require fewer overflow pages, even though the B-tree nodes themselves take as many pages as in the uncompressed form. General tablespaces do not support a 16K compressed page size (**KEY\_BLOCK\_SIZE**). For more information, see [Section 15.6.3.3, “General Tablespaces”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#general-tablespaces).

##### Compression and the InnoDB Buffer Pool

In a compressed **InnoDB** table, every compressed page (whether 1K, 2K, 4K or 8K) corresponds to an uncompressed page of 16K bytes (or a smaller size if [**innodb\_page\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_page_size) is set). To access the data in a page, MySQL reads the compressed page from disk if it is not already in the [buffer pool](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_buffer_pool), then uncompresses the page to its original form. This section describes how **InnoDB** manages the buffer pool with respect to pages of compressed tables.

To minimize I/O and to reduce the need to uncompress a page, at times the buffer pool contains both the compressed and uncompressed form of a database page. To make room for other required database pages, MySQL can [evict](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_eviction) from the buffer pool an uncompressed page, while leaving the compressed page in memory. Or, if a page has not been accessed in a while, the compressed form of the page might be written to disk, to free space for other data. Thus, at any given time, the buffer pool might contain both the compressed and uncompressed forms of the page, or only the compressed form of the page, or neither.

MySQL keeps track of which pages to keep in memory and which to evict using a least-recently-used ([LRU](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_lru)) list, so that [hot](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_hot) (frequently accessed) data tends to stay in memory. When compressed tables are accessed, MySQL uses an adaptive LRU algorithm to achieve an appropriate balance of compressed and uncompressed pages in memory. This adaptive algorithm is sensitive to whether the system is running in an [I/O-bound](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_io_bound) or [CPU-bound](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_cpu_bound) manner. The goal is to avoid spending too much processing time uncompressing pages when the CPU is busy, and to avoid doing excess I/O when the CPU has spare cycles that can be used for uncompressing compressed pages (that may already be in memory). When the system is I/O-bound, the algorithm prefers to evict the uncompressed copy of a page rather than both copies, to make more room for other disk pages to become memory resident. When the system is CPU-bound, MySQL prefers to evict both the compressed and uncompressed page, so that more memory can be used for “hot” pages and reducing the need to uncompress data in memory only in compressed form.

##### Compression and the InnoDB Redo Log Files

Before a compressed page is written to a [data file](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_data_files), MySQL writes a copy of the page to the redo log (if it has been recompressed since the last time it was written to the database). This is done to ensure that redo logs are usable for [crash recovery](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_crash_recovery), even in the unlikely case that the **zlib** library is upgraded and that change introduces a compatibility problem with the compressed data. Therefore, some increase in the size of [log files](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_log_file), or a need for more frequent [checkpoints](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_checkpoint), can be expected when using compression. The amount of increase in the log file size or checkpoint frequency depends on the number of times compressed pages are modified in a way that requires reorganization and recompression.

To create a compressed table in a file-per-table tablespace, [**innodb\_file\_per\_table**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_file_per_table) must be enabled. There is no dependence on the [**innodb\_file\_per\_table**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_file_per_table) setting when creating a compressed table in a general tablespace. For more information, see [Section 15.6.3.3, “General Tablespaces”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#general-tablespaces).

#### 15.9.1.6 Compression for OLTP Workloads

Traditionally, the **InnoDB** [compression](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_compression) feature was recommended primarily for read-only or read-mostly [workloads](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_workload), such as in a [data warehouse](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_data_warehouse) configuration. The rise of [SSD](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_ssd) storage devices, which are fast but relatively small and expensive, makes compression attractive also for **OLTP** workloads: high-traffic, interactive websites can reduce their storage requirements and their I/O operations per second ([IOPS](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_iops)) by using compressed tables with applications that do frequent [**INSERT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#insert), [**UPDATE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#update), and [**DELETE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#delete) operations.

These configuration options let you adjust the way compression works for a particular MySQL instance, with an emphasis on performance and scalability for write-intensive operations:

[**innodb\_compression\_level**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_compression_level) lets you turn the degree of compression up or down. A higher value lets you fit more data onto a storage device, at the expense of more CPU overhead during compression. A lower value lets you reduce CPU overhead when storage space is not critical, or you expect the data is not especially compressible.

[**innodb\_compression\_failure\_threshold\_pct**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_compression_failure_threshold_pct) specifies a cutoff point for [compression failures](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_compression_failure) during updates to a compressed table. When this threshold is passed, MySQL begins to leave additional free space within each new compressed page, dynamically adjusting the amount of free space up to the percentage of page size specified by [**innodb\_compression\_pad\_pct\_max**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_compression_pad_pct_max)

[**innodb\_compression\_pad\_pct\_max**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_compression_pad_pct_max) lets you adjust the maximum amount of space reserved within each [page](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_page) to record changes to compressed rows, without needing to compress the entire page again. The higher the value, the more changes can be recorded without recompressing the page. MySQL uses a variable amount of free space for the pages within each compressed table, only when a designated percentage of compression operations “[fail](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_compression_failure)” at runtime, requiring an expensive operation to split the compressed page.

[**innodb\_log\_compressed\_pages**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_log_compressed_pages) lets you disable writing of images of [re-compressed](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_compression) [pages](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_page) to the [redo log](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_redo_log). Re-compression may occur when changes are made to compressed data. This option is enabled by default to prevent corruption that could occur if a different version of the **zlib** compression algorithm is used during recovery. If you are certain that the **zlib** version is not subject to change, disable [**innodb\_log\_compressed\_pages**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_log_compressed_pages) to reduce redo log generation for workloads that modify compressed data.

Because working with compressed data sometimes involves keeping both compressed and uncompressed versions of a page in memory at the same time, when using compression with an OLTP-style workload, be prepared to increase the value of the [**innodb\_buffer\_pool\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_size) configuration option.

#### 15.9.1.7 SQL Compression Syntax Warnings and Errors

This section describes syntax warnings and errors that you may encounter when using the table compression feature with [file-per-table](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_file_per_table) tablespaces and [general tablespaces](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_general_tablespace).

##### SQL Compression Syntax Warnings and Errors for File-Per-Table Tablespaces

When [**innodb\_strict\_mode**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_strict_mode) is enabled (the default), specifying **ROW\_FORMAT=COMPRESSED** or **KEY\_BLOCK\_SIZE** in [**CREATE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-table) or [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) statements produces the following error if [**innodb\_file\_per\_table**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_file_per_table) is disabled.

ERROR 1031 (HY000): Table storage engine for 't1' doesn't have this option

**Note**

The table is not created if the current configuration does not permit using compressed tables.

When [**innodb\_strict\_mode**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_strict_mode) is disabled, specifying **ROW\_FORMAT=COMPRESSED** or **KEY\_BLOCK\_SIZE** in [**CREATE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-table) or [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) statements produces the following warnings if [**innodb\_file\_per\_table**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_file_per_table) is disabled.

mysql> **SHOW WARNINGS;**

+---------+------+---------------------------------------------------------------+

| Level | Code | Message |

+---------+------+---------------------------------------------------------------+

| Warning | 1478 | InnoDB: KEY\_BLOCK\_SIZE requires innodb\_file\_per\_table. |

| Warning | 1478 | InnoDB: ignoring KEY\_BLOCK\_SIZE=4. |

| Warning | 1478 | InnoDB: ROW\_FORMAT=COMPRESSED requires innodb\_file\_per\_table. |

| Warning | 1478 | InnoDB: assuming ROW\_FORMAT=DYNAMIC. |

+---------+------+---------------------------------------------------------------+

**Note**

These messages are only warnings, not errors, and the table is created without compression, as if the options were not specified.

The “non-strict” behavior lets you import a **mysqldump** file into a database that does not support compressed tables, even if the source database contained compressed tables. In that case, MySQL creates the table in **ROW\_FORMAT=DYNAMIC** instead of preventing the operation.

To import the dump file into a new database, and have the tables re-created as they exist in the original database, ensure the server has the proper setting for the [**innodb\_file\_per\_table**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_file_per_table) configuration parameter.

The attribute **KEY\_BLOCK\_SIZE** is permitted only when **ROW\_FORMAT** is specified as **COMPRESSED** or is omitted. Specifying a **KEY\_BLOCK\_SIZE** with any other **ROW\_FORMAT** generates a warning that you can view with **SHOW WARNINGS**. However, the table is non-compressed; the specified **KEY\_BLOCK\_SIZE** is ignored).

| **Level** | **Code** | **Message** |
| --- | --- | --- |
| **Warning** | 1478 | **InnoDB: ignoring KEY\_BLOCK\_SIZE=*n* unless ROW\_FORMAT=COMPRESSED.** |

If you are running with [**innodb\_strict\_mode**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_strict_mode) enabled, the combination of a **KEY\_BLOCK\_SIZE** with any **ROW\_FORMAT** other than **COMPRESSED** generates an error, not a warning, and the table is not created.

[Table 15.12, “ROW\_FORMAT and KEY\_BLOCK\_SIZE Options”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-compression-create-and-alter-options-table) provides an overview the **ROW\_FORMAT** and **KEY\_BLOCK\_SIZE** options that are used with [**CREATE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-table) or [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table).

**Table 15.12 ROW\_FORMAT and KEY\_BLOCK\_SIZE Options**

| **Option** | **Usage Notes** | **Description** |
| --- | --- | --- |
| **ROW\_FORMAT=​REDUNDANT** | Storage format used prior to MySQL 5.0.3 | Less efficient than **ROW\_FORMAT=COMPACT**; for backward compatibility |
| **ROW\_FORMAT=​COMPACT** | Default storage format since MySQL 5.0.3 | Stores a prefix of 768 bytes of long column values in the clustered index page, with the remaining bytes stored in an overflow page |
| **ROW\_FORMAT=​DYNAMIC** |  | Store values within the clustered index page if they fit; if not, stores only a 20-byte pointer to an overflow page (no prefix) |
| **ROW\_FORMAT=​COMPRESSED** |  | Compresses the table and indexes using zlib |
| **KEY\_BLOCK\_​SIZE=*n*** |  | Specifies compressed page size of 1, 2, 4, 8 or 16 kilobytes; implies **ROW\_FORMAT=COMPRESSED**. For general tablespaces, a **KEY\_BLOCK\_SIZE** value equal to the **InnoDB** page size is not permitted. |

[Table 15.13, “CREATE/ALTER TABLE Warnings and Errors when InnoDB Strict Mode is OFF”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-compression-create-and-alter-errors-table) summarizes error conditions that occur with certain combinations of configuration parameters and options on the [**CREATE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-table) or [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) statements, and how the options appear in the output of **SHOW TABLE STATUS**.

When [**innodb\_strict\_mode**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_strict_mode) is **OFF**, MySQL creates or alters the table, but ignores certain settings as shown below. You can see the warning messages in the MySQL error log. When [**innodb\_strict\_mode**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_strict_mode) is **ON**, these specified combinations of options generate errors, and the table is not created or altered. To see the full description of the error condition, issue the **SHOW ERRORS** statement: example:

mysql> **CREATE TABLE x (id INT PRIMARY KEY, c INT)**

-> **ENGINE=INNODB KEY\_BLOCK\_SIZE=33333;**

ERROR 1005 (HY000): Can't create table 'test.x' (errno: 1478)

mysql> **SHOW ERRORS;**

+-------+------+-------------------------------------------+

| Level | Code | Message |

+-------+------+-------------------------------------------+

| Error | 1478 | InnoDB: invalid KEY\_BLOCK\_SIZE=33333. |

| Error | 1005 | Can't create table 'test.x' (errno: 1478) |

+-------+------+-------------------------------------------+

**Table 15.13 CREATE/ALTER TABLE Warnings and Errors when InnoDB Strict Mode is OFF**

| **Syntax** | **Warning or Error Condition** | **Resulting ROW\_FORMAT, as shown in SHOW TABLE STATUS** |
| --- | --- | --- |
| **ROW\_FORMAT=REDUNDANT** | None | **REDUNDANT** |
| **ROW\_FORMAT=COMPACT** | None | **COMPACT** |
| **ROW\_FORMAT=COMPRESSED or ROW\_FORMAT=DYNAMIC or KEY\_BLOCK\_SIZE is specified** | Ignored for file-per-table tablespaces unless [**innodb\_file\_per\_table**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_file_per_table) is enabled. General tablespaces support all row formats. See [Section 15.6.3.3, “General Tablespaces”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#general-tablespaces). | **the default row format for file-per-table tablespaces; the specified row format for general tablespaces** |
| **Invalid KEY\_BLOCK\_SIZE is specified (not 1, 2, 4, 8 or 16)** | **KEY\_BLOCK\_SIZE** is ignored | the specified row format, or the default row format |
| **ROW\_FORMAT=COMPRESSED and valid KEY\_BLOCK\_SIZE are specified** | None; **KEY\_BLOCK\_SIZE** specified is used | **COMPRESSED** |
| **KEY\_BLOCK\_SIZE is specified with REDUNDANT, COMPACT or DYNAMIC row format** | **KEY\_BLOCK\_SIZE** is ignored | **REDUNDANT**, **COMPACT** or **DYNAMIC** |
| **ROW\_FORMAT is not one of REDUNDANT, COMPACT, DYNAMIC or COMPRESSED** | Ignored if recognized by the MySQL parser. Otherwise, an error is issued. | the default row format or N/A |

When **innodb\_strict\_mode** is **ON**, MySQL rejects invalid **ROW\_FORMAT** or **KEY\_BLOCK\_SIZE** parameters and issues errors. Strict mode is **ON** by default. When **innodb\_strict\_mode** is **OFF**, MySQL issues warnings instead of errors for ignored invalid parameters.

It is not possible to see the chosen **KEY\_BLOCK\_SIZE** using **SHOW TABLE STATUS**. The statement **SHOW CREATE TABLE** displays the **KEY\_BLOCK\_SIZE** (even if it was ignored when creating the table). The real compressed page size of the table cannot be displayed by MySQL.

##### SQL Compression Syntax Warnings and Errors for General Tablespaces

If **FILE\_BLOCK\_SIZE** was not defined for the general tablespace when the tablespace was created, the tablespace cannot contain compressed tables. If you attempt to add a compressed table, an error is returned, as shown in the following example:

mysql> **CREATE TABLESPACE `ts1` ADD DATAFILE 'ts1.ibd' Engine=InnoDB;**

mysql> **CREATE TABLE t1 (c1 INT PRIMARY KEY) TABLESPACE ts1 ROW\_FORMAT=COMPRESSED**

**KEY\_BLOCK\_SIZE=8;**

ERROR 1478 (HY000): InnoDB: Tablespace `ts1` cannot contain a COMPRESSED table

Attempting to add a table with an invalid **KEY\_BLOCK\_SIZE** to a general tablespace returns an error, as shown in the following example:

mysql> **CREATE TABLESPACE `ts2` ADD DATAFILE 'ts2.ibd' FILE\_BLOCK\_SIZE = 8192 Engine=InnoDB;**

mysql> **CREATE TABLE t2 (c1 INT PRIMARY KEY) TABLESPACE ts2 ROW\_FORMAT=COMPRESSED**

**KEY\_BLOCK\_SIZE=4;**

ERROR 1478 (HY000): InnoDB: Tablespace `ts2` uses block size 8192 and cannot

contain a table with physical page size 4096

For general tablespaces, the **KEY\_BLOCK\_SIZE** of the table must be equal to the **FILE\_BLOCK\_SIZE** of the tablespace divided by 1024. For example, if the **FILE\_BLOCK\_SIZE** of the tablespace is 8192, the **KEY\_BLOCK\_SIZE** of the table must be 8.

Attempting to add a table with an uncompressed row format to a general tablespace configured to store compressed tables returns an error, as shown in the following example:

mysql> **CREATE TABLESPACE `ts3` ADD DATAFILE 'ts3.ibd' FILE\_BLOCK\_SIZE = 8192 Engine=InnoDB;**

mysql> **CREATE TABLE t3 (c1 INT PRIMARY KEY) TABLESPACE ts3 ROW\_FORMAT=COMPACT;**

ERROR 1478 (HY000): InnoDB: Tablespace `ts3` uses block size 8192 and cannot

contain a table with physical page size 16384

[**innodb\_strict\_mode**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_strict_mode) is not applicable to general tablespaces. Tablespace management rules for general tablespaces are strictly enforced independently of [**innodb\_strict\_mode**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_strict_mode). For more information, see [Section 13.1.21, “CREATE TABLESPACE Statement”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-tablespace).

For more information about using compressed tables with general tablespaces, see [Section 15.6.3.3, “General Tablespaces”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#general-tablespaces).

### 15.9.2 InnoDB Page Compression

**InnoDB** supports page-level compression for tables that reside in [file-per-table](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_file_per_table) tablespaces. This feature is referred to as Transparent Page Compression. Page compression is enabled by specifying the **COMPRESSION** attribute with [**CREATE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-table) or [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table). Supported compression algorithms include **Zlib** and **LZ4**.

#### Supported Platforms

Page compression requires sparse file and hole punching support. Page compression is supported on Windows with NTFS, and on the following subset of MySQL-supported Linux platforms where the kernel level provides hole punching support:

RHEL 7 and derived distributions that use kernel version 3.10.0-123 or higher

OEL 5.10 (UEK2) kernel version 2.6.39 or higher

OEL 6.5 (UEK3) kernel version 3.8.13 or higher

OEL 7.0 kernel version 3.8.13 or higher

SLE11 kernel version 3.0-x

SLE12 kernel version 3.12-x

OES11 kernel version 3.0-x

Ubuntu 14.0.4 LTS kernel version 3.13 or higher

Ubuntu 12.0.4 LTS kernel version 3.2 or higher

Debian 7 kernel version 3.2 or higher

**Note**

All of the available file systems for a given Linux distribution may not support hole punching.

#### How Page Compression Works

When a page is written, it is compressed using the specified compression algorithm. The compressed data is written to disk, where the hole punching mechanism releases empty blocks from the end of the page. If compression fails, data is written out as-is.

#### Hole Punch Size on Linux

On Linux systems, the file system block size is the unit size used for hole punching. Therefore, page compression only works if page data can be compressed to a size that is less than or equal to the **InnoDB** page size minus the file system block size. For example, if [**innodb\_page\_size=16K**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_page_size) and the file system block size is 4K, page data must compress to less than or equal to 12K to make hole punching possible.

#### Hole Punch Size on Windows

On Windows systems, the underlying infrastructure for sparse files is based on NTFS compression. Hole punching size is the NTFS compression unit, which is 16 times the NTFS cluster size. Cluster sizes and their compression units are shown in the following table:

**Table 15.14 Windows NTFS Cluster Size and Compression Units**

| **Cluster Size** | **Compression Unit** |
| --- | --- |
| 512 Bytes | 8 KB |
| 1 KB | 16 KB |
| 2 KB | 32 KB |
| 4 KB | 64 KB |

Page compression on Windows systems only works if page data can be compressed to a size that is less than or equal to the **InnoDB** page size minus the compression unit size.

The default NTFS cluster size is 4KB, for which the compression unit size is 64KB. This means that page compression has no benefit for an out-of-the box Windows NTFS configuration, as the maximum [**innodb\_page\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_page_size) is also 64KB.

For page compression to work on Windows, the file system must be created with a cluster size smaller than 4K, and the [**innodb\_page\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_page_size) must be at least twice the size of the compression unit. For example, for page compression to work on Windows, you could build the file system with a cluster size of 512 Bytes (which has a compression unit of 8KB) and initialize **InnoDB** with an [**innodb\_page\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_page_size) value of 16K or greater.

#### Enabling Page Compression

To enable page compression, specify the **COMPRESSION** attribute in the [**CREATE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-table) statement. For example:

CREATE TABLE t1 (c1 INT) COMPRESSION="zlib";

You can also enable page compression in an [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) statement. However, [**ALTER TABLE ... COMPRESSION**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) only updates the tablespace compression attribute. Writes to the tablespace that occur after setting the new compression algorithm use the new setting, but to apply the new compression algorithm to existing pages, you must rebuild the table using [**OPTIMIZE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#optimize-table).

ALTER TABLE t1 COMPRESSION="zlib";

OPTIMIZE TABLE t1;

#### Disabling Page Compression

To disable page compression, set **COMPRESSION=None** using [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table). Writes to the tablespace that occur after setting **COMPRESSION=None** no longer use page compression. To uncompress existing pages, you must rebuild the table using [**OPTIMIZE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#optimize-table) after setting **COMPRESSION=None**.

ALTER TABLE t1 COMPRESSION="None";

OPTIMIZE TABLE t1;

#### Page Compression Metadata

Page compression metadata is found in the [**INFORMATION\_SCHEMA.INNODB\_TABLESPACES**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-tablespaces-table) table, in the following columns:

**FS\_BLOCK\_SIZE**: The file system block size, which is the unit size used for hole punching.

**FILE\_SIZE**: The apparent size of the file, which represents the maximum size of the file, uncompressed.

**ALLOCATED\_SIZE**: The actual size of the file, which is the amount of space allocated on disk.

**Note**

On Unix-like systems, **ls -l *tablespace\_name*.ibd** shows the apparent file size (equivalent to **FILE\_SIZE**) in bytes. To view the actual amount of space allocated on disk (equivalent to **ALLOCATED\_SIZE**), use **du --block-size=1 *tablespace\_name*.ibd**. The **--block-size=1** option prints the allocated space in bytes instead of blocks, so that it can be compared to **ls -l** output.

Use [**SHOW CREATE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#show-create-table) to view the current page compression setting (**Zlib**, **Lz4**, or **None**). A table may contain a mix of pages with different compression settings.

In the following example, page compression metadata for the employees table is retrieved from the [**INFORMATION\_SCHEMA.INNODB\_TABLESPACES**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-tablespaces-table) table.

# Create the employees table with Zlib page compression

CREATE TABLE employees (

emp\_no INT NOT NULL,

birth\_date DATE NOT NULL,

first\_name VARCHAR(14) NOT NULL,

last\_name VARCHAR(16) NOT NULL,

gender ENUM ('M','F') NOT NULL,

hire\_date DATE NOT NULL,

PRIMARY KEY (emp\_no)

) COMPRESSION="zlib";

# Insert data (not shown)

# Query page compression metadata in INFORMATION\_SCHEMA.INNODB\_TABLESPACES

mysql> **SELECT SPACE, NAME, FS\_BLOCK\_SIZE, FILE\_SIZE, ALLOCATED\_SIZE FROM**

**INFORMATION\_SCHEMA.INNODB\_TABLESPACES WHERE NAME='employees/employees'\G**

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\* 1. row \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

SPACE: 45

NAME: employees/employees

FS\_BLOCK\_SIZE: 4096

FILE\_SIZE: 23068672

ALLOCATED\_SIZE: 19415040

Page compression metadata for the employees table shows that the apparent file size is 23068672 bytes while the actual file size (with page compression) is 19415040 bytes. The file system block size is 4096 bytes, which is the block size used for hole punching.

#### Identifying Tables Using Page Compression

To identify tables for which page compression is enabled, you can query the [**INFORMATION\_SCHEMA.TABLES**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-tables-table) **CREATE\_OPTIONS** column for tables defined with the **COMPRESSION** attribute:

mysql> **SELECT TABLE\_NAME, TABLE\_SCHEMA, CREATE\_OPTIONS FROM INFORMATION\_SCHEMA.TABLES**

**WHERE CREATE\_OPTIONS LIKE '%COMPRESSION=%';**

+------------+--------------+--------------------+

| TABLE\_NAME | TABLE\_SCHEMA | CREATE\_OPTIONS |

+------------+--------------+--------------------+

| employees | test | COMPRESSION="zlib" |

+------------+--------------+--------------------+

[**SHOW CREATE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#show-create-table) also shows the **COMPRESSION** attribute, if used.

#### Page Compression Limitations and Usage Notes

Page compression is disabled if the file system block size (or compression unit size on Windows) \* 2 > [**innodb\_page\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_page_size).

Page compression is not supported for tables that reside in shared tablespaces, which include the system tablespace, temporary tablespaces, and general tablespaces.

Page compression is not supported for undo log tablespaces.

Page compression is not supported for redo log pages.

R-tree pages, which are used for spatial indexes, are not compressed.

Pages that belong to compressed tables (**ROW\_FORMAT=COMPRESSED**) are left as-is.

During recovery, updated pages are written out in an uncompressed form.

Loading a page-compressed tablespace on a server that does not support the compression algorithm that was used causes an I/O error.

Before downgrading to an earlier version of MySQL that does not support page compression, uncompress the tables that use the page compression feature. To uncompress a table, run [**ALTER TABLE ... COMPRESSION=None**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) and [**OPTIMIZE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#optimize-table).

Page-compressed tablespaces can be copied between Linux and Windows servers if the compression algorithm that was used is available on both servers.

Preserving page compression when moving a page-compressed tablespace file from one host to another requires a utility that preserves sparse files.

Better page compression may be achieved on Fusion-io hardware with NVMFS than on other platforms, as NVMFS is designed to take advantage of punch hole functionality.

Using the page compression feature with a large **InnoDB** page size and relatively small file system block size could result in write amplification. For example, a maximum **InnoDB** page size of 64KB with a 4KB file system block size may improve compression but may also increase demand on the buffer pool, leading to increased I/O and potential write amplification.

## 15.10 InnoDB Row Formats

The row format of a table determines how its rows are physically stored, which in turn can affect the performance of queries and DML operations. As more rows fit into a single disk page, queries and index lookups can work faster, less cache memory is required in the buffer pool, and less I/O is required to write out updated values.

The data in each table is divided into pages. The pages that make up each table are arranged in a tree data structure called a B-tree index. Table data and secondary indexes both use this type of structure. The B-tree index that represents an entire table is known as the clustered index, which is organized according to the primary key columns. The nodes of a clustered index data structure contain the values of all columns in the row. The nodes of a secondary index structure contain the values of index columns and primary key columns.

Variable-length columns are an exception to the rule that column values are stored in B-tree index nodes. Variable-length columns that are too long to fit on a B-tree page are stored on separately allocated disk pages called overflow pages. Such columns are referred to as off-page columns. The values of off-page columns are stored in singly-linked lists of overflow pages, with each such column having its own list of one or more overflow pages. Depending on column length, all or a prefix of variable-length column values are stored in the B-tree to avoid wasting storage and having to read a separate page.

The **InnoDB** storage engine supports four row formats: **REDUNDANT**, **COMPACT**, **DYNAMIC**, and **COMPRESSED**.

**Table 15.15 InnoDB Row Format Overview**

| **Row Format** | **Compact Storage Characteristics** | **Enhanced Variable-Length Column Storage** | **Large Index Key Prefix Support** | **Compression Support** | **Supported Tablespace Types** |
| --- | --- | --- | --- | --- | --- |
| **REDUNDANT** | No | No | No | No | system, file-per-table, general |
| **COMPACT** | Yes | No | No | No | system, file-per-table, general |
| **DYNAMIC** | Yes | Yes | Yes | No | system, file-per-table, general |
| **COMPRESSED** | Yes | Yes | Yes | Yes | file-per-table, general |

The topics that follow describe row format storage characteristics and how to define and determine the row format of a table.

[REDUNDANT Row Format](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-row-format-redundant)

[COMPACT Row Format](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-row-format-compact)

[DYNAMIC Row Format](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-row-format-dynamic)

[COMPRESSED Row Format](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-row-format-compressed)

[Defining the Row Format of a Table](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-row-format-defining)

[Determining the Row Format of a Table](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-row-format-detrmining)

### REDUNDANT Row Format

The **REDUNDANT** format provides compatibility with older versions of MySQL.

Tables that use the **REDUNDANT** row format store the first 768 bytes of variable-length column values ([**VARCHAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-types.html#char), [**VARBINARY**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-types.html#binary-varbinary), and [**BLOB**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-types.html#blob) and [**TEXT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-types.html#blob) types) in the index record within the B-tree node, with the remainder stored on overflow pages. Fixed-length columns greater than or equal to 768 bytes are encoded as variable-length columns, which can be stored off-page. For example, a **CHAR(255)** column can exceed 768 bytes if the maximum byte length of the character set is greater than 3, as it is with **utf8mb4**.

If the value of a column is 768 bytes or less, an overflow page is not used, and some savings in I/O may result, since the value is stored entirely in the B-tree node. This works well for relatively short **BLOB** column values, but may cause B-tree nodes to fill with data rather than key values, reducing their efficiency. Tables with many **BLOB** columns could cause B-tree nodes to become too full, and contain too few rows, making the entire index less efficient than if rows were shorter or column values were stored off-page.

#### REDUNDANT Row Format Storage Characteristics

The **REDUNDANT** row format has the following storage characteristics:

Each index record contains a 6-byte header. The header is used to link together consecutive records, and for row-level locking.

Records in the clustered index contain fields for all user-defined columns. In addition, there is a 6-byte transaction ID field and a 7-byte roll pointer field.

If no primary key is defined for a table, each clustered index record also contains a 6-byte row ID field.

Each secondary index record contains all the primary key columns defined for the clustered index key that are not in the secondary index.

A record contains a pointer to each field of the record. If the total length of the fields in a record is less than 128 bytes, the pointer is one byte; otherwise, two bytes. The array of pointers is called the record directory. The area where the pointers point is the data part of the record.

Internally, fixed-length character columns such as [**CHAR(10)**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-types.html#char) in stored in fixed-length format. Trailing spaces are not truncated from [**VARCHAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-types.html#char) columns.

Fixed-length columns greater than or equal to 768 bytes are encoded as variable-length columns, which can be stored off-page. For example, a **CHAR(255)** column can exceed 768 bytes if the maximum byte length of the character set is greater than 3, as it is with **utf8mb4**.

An SQL **NULL** value reserves one or two bytes in the record directory. An SQL **NULL** value reserves zero bytes in the data part of the record if stored in a variable-length column. For a fixed-length column, the fixed length of the column is reserved in the data part of the record. Reserving fixed space for **NULL** values permits columns to be updated in place from **NULL** to non-**NULL** values without causing index page fragmentation.

### COMPACT Row Format

The **COMPACT** row format reduces row storage space by about 20% compared to the **REDUNDANT** row format, at the cost of increasing CPU use for some operations. If your workload is a typical one that is limited by cache hit rates and disk speed, **COMPACT** format is likely to be faster. If the workload is limited by CPU speed, compact format might be slower.

Tables that use the **COMPACT** row format store the first 768 bytes of variable-length column values ([**VARCHAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-types.html#char), [**VARBINARY**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-types.html#binary-varbinary), and [**BLOB**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-types.html#blob) and [**TEXT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-types.html#blob) types) in the index record within the [B-tree](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_b_tree) node, with the remainder stored on overflow pages. Fixed-length columns greater than or equal to 768 bytes are encoded as variable-length columns, which can be stored off-page. For example, a **CHAR(255)** column can exceed 768 bytes if the maximum byte length of the character set is greater than 3, as it is with **utf8mb4**.

If the value of a column is 768 bytes or less, an overflow page is not used, and some savings in I/O may result, since the value is stored entirely in the B-tree node. This works well for relatively short **BLOB** column values, but may cause B-tree nodes to fill with data rather than key values, reducing their efficiency. Tables with many **BLOB** columns could cause B-tree nodes to become too full, and contain too few rows, making the entire index less efficient than if rows were shorter or column values were stored off-page.

#### COMPACT Row Format Storage Characteristics

The **COMPACT** row format has the following storage characteristics:

Each index record contains a 5-byte header that may be preceded by a variable-length header. The header is used to link together consecutive records, and for row-level locking.

The variable-length part of the record header contains a bit vector for indicating **NULL** columns. If the number of columns in the index that can be **NULL** is ***N***, the bit vector occupies **CEILING(*N*/8)** bytes. (For example, if there are anywhere from 9 to 16 columns that can be **NULL**, the bit vector uses two bytes.) Columns that are **NULL** do not occupy space other than the bit in this vector. The variable-length part of the header also contains the lengths of variable-length columns. Each length takes one or two bytes, depending on the maximum length of the column. If all columns in the index are **NOT NULL** and have a fixed length, the record header has no variable-length part.

For each non-**NULL** variable-length field, the record header contains the length of the column in one or two bytes. Two bytes are only needed if part of the column is stored externally in overflow pages or the maximum length exceeds 255 bytes and the actual length exceeds 127 bytes. For an externally stored column, the 2-byte length indicates the length of the internally stored part plus the 20-byte pointer to the externally stored part. The internal part is 768 bytes, so the length is 768+20. The 20-byte pointer stores the true length of the column.

The record header is followed by the data contents of non-**NULL** columns.

Records in the clustered index contain fields for all user-defined columns. In addition, there is a 6-byte transaction ID field and a 7-byte roll pointer field.

If no primary key is defined for a table, each clustered index record also contains a 6-byte row ID field.

Each secondary index record contains all the primary key columns defined for the clustered index key that are not in the secondary index. If any of the primary key columns are variable length, the record header for each secondary index has a variable-length part to record their lengths, even if the secondary index is defined on fixed-length columns.

Internally, for nonvariable-length character sets, fixed-length character columns such as [**CHAR(10)**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-types.html#char) are stored in a fixed-length format.

Trailing spaces are not truncated from [**VARCHAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-types.html#char) columns.

Internally, for variable-length character sets such as **utf8mb3** and **utf8mb4**, **InnoDB** attempts to store [**CHAR(*N*)**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-types.html#char) in ***N*** bytes by trimming trailing spaces. If the byte length of a [**CHAR(*N*)**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-types.html#char) column value exceeds ***N*** bytes, trailing spaces are trimmed to a minimum of the column value byte length. The maximum length of a [**CHAR(*N*)**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-types.html#char) column is the maximum character byte length × ***N***.

A minimum of ***N*** bytes is reserved for [**CHAR(*N*)**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-types.html#char). Reserving the minimum space ***N*** in many cases enables column updates to be done in place without causing index page fragmentation. By comparison, [**CHAR(*N*)**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-types.html#char) columns occupy the maximum character byte length × ***N*** when using the **REDUNDANT** row format.

Fixed-length columns greater than or equal to 768 bytes are encoded as variable-length fields, which can be stored off-page. For example, a **CHAR(255)** column can exceed 768 bytes if the maximum byte length of the character set is greater than 3, as it is with **utf8mb4**.

### DYNAMIC Row Format

The **DYNAMIC** row format offers the same storage characteristics as the **COMPACT** row format but adds enhanced storage capabilities for long variable-length columns and supports large index key prefixes.

When a table is created with **ROW\_FORMAT=DYNAMIC**, **InnoDB** can store long variable-length column values (for [**VARCHAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-types.html#char), [**VARBINARY**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-types.html#binary-varbinary), and [**BLOB**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-types.html#blob) and [**TEXT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-types.html#blob) types) fully off-page, with the clustered index record containing only a 20-byte pointer to the overflow page. Fixed-length fields greater than or equal to 768 bytes are encoded as variable-length fields. For example, a **CHAR(255)** column can exceed 768 bytes if the maximum byte length of the character set is greater than 3, as it is with **utf8mb4**.

Whether columns are stored off-page depends on the page size and the total size of the row. When a row is too long, the longest columns are chosen for off-page storage until the clustered index record fits on the [B-tree](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_b_tree) page. [**TEXT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-types.html#blob) and [**BLOB**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-types.html#blob) columns that are less than or equal to 40 bytes are stored in line.

The **DYNAMIC** row format maintains the efficiency of storing the entire row in the index node if it fits (as do the **COMPACT** and **REDUNDANT** formats), but the **DYNAMIC** row format avoids the problem of filling B-tree nodes with a large number of data bytes of long columns. The **DYNAMIC** row format is based on the idea that if a portion of a long data value is stored off-page, it is usually most efficient to store the entire value off-page. With **DYNAMIC** format, shorter columns are likely to remain in the B-tree node, minimizing the number of overflow pages required for a given row.

The **DYNAMIC** row format supports index key prefixes up to 3072 bytes.

Tables that use the **DYNAMIC** row format can be stored in the system tablespace, file-per-table tablespaces, and general tablespaces. To store **DYNAMIC** tables in the system tablespace, either disable [**innodb\_file\_per\_table**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_file_per_table) and use a regular **CREATE TABLE** or **ALTER TABLE** statement, or use the **TABLESPACE [=] innodb\_system** table option with **CREATE TABLE** or **ALTER TABLE**. The [**innodb\_file\_per\_table**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_file_per_table) variable is not applicable to general tablespaces, nor is it applicable when using the **TABLESPACE [=] innodb\_system** table option to store **DYNAMIC** tables in the system tablespace.

#### DYNAMIC Row Format Storage Characteristics

The **DYNAMIC** row format is a variation of the **COMPACT** row format. For storage characteristics, see [COMPACT Row Format Storage Characteristics](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-compact-row-format-characteristics).

### COMPRESSED Row Format

The **COMPRESSED** row format offers the same storage characteristics and capabilities as the **DYNAMIC** row format but adds support for table and index data compression.

The **COMPRESSED** row format uses similar internal details for off-page storage as the **DYNAMIC** row format, with additional storage and performance considerations from the table and index data being compressed and using smaller page sizes. With the **COMPRESSED** row format, the **KEY\_BLOCK\_SIZE** option controls how much column data is stored in the clustered index, and how much is placed on overflow pages. For more information about the **COMPRESSED** row format, see [Section 15.9, “InnoDB Table and Page Compression”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-compression).

The **COMPRESSED** row format supports index key prefixes up to 3072 bytes.

Tables that use the **COMPRESSED** row format can be created in file-per-table tablespaces or general tablespaces. The system tablespace does not support the **COMPRESSED** row format. To store a **COMPRESSED** table in a file-per-table tablespace, the [**innodb\_file\_per\_table**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_file_per_table) variable must be enabled. The [**innodb\_file\_per\_table**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_file_per_table) variable is not applicable to general tablespaces. General tablespaces support all row formats with the caveat that compressed and uncompressed tables cannot coexist in the same general tablespace due to different physical page sizes. For more information, see [Section 15.6.3.3, “General Tablespaces”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#general-tablespaces).

#### Compressed Row Format Storage Characteristics

The **COMPRESSED** row format is a variation of the **COMPACT** row format. For storage characteristics, see [COMPACT Row Format Storage Characteristics](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-compact-row-format-characteristics).

### Defining the Row Format of a Table

The default row format for **InnoDB** tables is defined by [**innodb\_default\_row\_format**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_default_row_format) variable, which has a default value of **DYNAMIC**. The default row format is used when the **ROW\_FORMAT** table option is not defined explicitly or when **ROW\_FORMAT=DEFAULT** is specified.

The row format of a table can be defined explicitly using the **ROW\_FORMAT** table option in a [**CREATE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-table) or [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) statement. For example:

CREATE TABLE t1 (c1 INT) ROW\_FORMAT=DYNAMIC;

An explicitly defined **ROW\_FORMAT** setting overrides the default row format. Specifying **ROW\_FORMAT=DEFAULT** is equivalent to using the implicit default.

The [**innodb\_default\_row\_format**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_default_row_format) variable can be set dynamically:

mysql> **SET GLOBAL innodb\_default\_row\_format=DYNAMIC;**

Valid [**innodb\_default\_row\_format**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_default_row_format) options include **DYNAMIC**, **COMPACT**, and **REDUNDANT**. The **COMPRESSED** row format, which is not supported for use in the system tablespace, cannot be defined as the default. It can only be specified explicitly in a [**CREATE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-table) or [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) statement. Attempting to set the [**innodb\_default\_row\_format**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_default_row_format) variable to **COMPRESSED** returns an error:

mysql> **SET GLOBAL innodb\_default\_row\_format=COMPRESSED;**

ERROR 1231 (42000): Variable 'innodb\_default\_row\_format'

can't be set to the value of 'COMPRESSED'

Newly created tables use the row format defined by the [**innodb\_default\_row\_format**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_default_row_format) variable when a **ROW\_FORMAT** option is not specified explicitly, or when **ROW\_FORMAT=DEFAULT** is used. For example, the following [**CREATE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-table) statements use the row format defined by the [**innodb\_default\_row\_format**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_default_row_format) variable.

CREATE TABLE t1 (c1 INT);

CREATE TABLE t2 (c1 INT) ROW\_FORMAT=DEFAULT;

When a **ROW\_FORMAT** option is not specified explicitly, or when **ROW\_FORMAT=DEFAULT** is used, an operation that rebuilds a table silently changes the row format of the table to the format defined by the [**innodb\_default\_row\_format**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_default_row_format) variable.

Table-rebuilding operations include [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) operations that use **ALGORITHM=COPY** or **ALGORITHM=INPLACE** where table rebuilding is required. See [Section 15.12.1, “Online DDL Operations”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-online-ddl-operations) for more information. [**OPTIMIZE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#optimize-table) is also a table-rebuilding operation.

The following example demonstrates a table-rebuilding operation that silently changes the row format of a table created without an explicitly defined row format.

mysql> **SELECT @@innodb\_default\_row\_format;**

+-----------------------------+

| @@innodb\_default\_row\_format |

+-----------------------------+

| dynamic |

+-----------------------------+

mysql> **CREATE TABLE t1 (c1 INT);**

mysql> **SELECT \* FROM INFORMATION\_SCHEMA.INNODB\_TABLES WHERE NAME LIKE 'test/t1' \G**

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\* 1. row \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

TABLE\_ID: 54

NAME: test/t1

FLAG: 33

N\_COLS: 4

SPACE: 35

ROW\_FORMAT: Dynamic

ZIP\_PAGE\_SIZE: 0

SPACE\_TYPE: Single

mysql> **SET GLOBAL innodb\_default\_row\_format=COMPACT;**

mysql> **ALTER TABLE t1 ADD COLUMN (c2 INT);**

mysql> **SELECT \* FROM INFORMATION\_SCHEMA.INNODB\_TABLES WHERE NAME LIKE 'test/t1' \G**

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\* 1. row \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

TABLE\_ID: 55

NAME: test/t1

FLAG: 1

N\_COLS: 5

SPACE: 36

ROW\_FORMAT: Compact

ZIP\_PAGE\_SIZE: 0

SPACE\_TYPE: Single

Consider the following potential issues before changing the row format of existing tables from **REDUNDANT** or **COMPACT** to **DYNAMIC**.

The **REDUNDANT** and **COMPACT** row formats support a maximum index key prefix length of 767 bytes whereas **DYNAMIC** and **COMPRESSED** row formats support an index key prefix length of 3072 bytes. In a replication environment, if the [**innodb\_default\_row\_format**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_default_row_format) variable is set to **DYNAMIC** on the source, and set to **COMPACT** on the replica, the following DDL statement, which does not explicitly define a row format, succeeds on the source but fails on the replica:

CREATE TABLE t1 (c1 INT PRIMARY KEY, c2 VARCHAR(5000), KEY i1(c2(3070)));

For related information, see [Section 15.22, “InnoDB Limits”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-limits).

Importing a table that does not explicitly define a row format results in a schema mismatch error if the [**innodb\_default\_row\_format**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_default_row_format) setting on the source server differs from the setting on the destination server. For more information, see [Section 15.6.1.3, “Importing InnoDB Tables”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-table-import).

### Determining the Row Format of a Table

To determine the row format of a table, use [**SHOW TABLE STATUS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#show-table-status):

mysql> **SHOW TABLE STATUS IN test1\G**

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\* 1. row \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

Name: t1

Engine: InnoDB

Version: 10

Row\_format: Dynamic

Rows: 0

Avg\_row\_length: 0

Data\_length: 16384

Max\_data\_length: 0

Index\_length: 16384

Data\_free: 0

Auto\_increment: 1

Create\_time: 2016-09-14 16:29:38

Update\_time: NULL

Check\_time: NULL

Collation: utf8mb4\_0900\_ai\_ci

Checksum: NULL

Create\_options:

Comment:

Alternatively, query the [**INFORMATION\_SCHEMA.INNODB\_TABLES**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-tables-table) table:

mysql> **SELECT NAME, ROW\_FORMAT FROM INFORMATION\_SCHEMA.INNODB\_TABLES WHERE NAME='test1/t1';**

+----------+------------+

| NAME | ROW\_FORMAT |

+----------+------------+

| test1/t1 | Dynamic |

+----------+------------+

## 15.11 InnoDB Disk I/O and File Space Management

[15.11.1 InnoDB Disk I/O](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-disk-io)

[15.11.2 File Space Management](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-file-space)

[15.11.3 InnoDB Checkpoints](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-checkpoints)

[15.11.4 Defragmenting a Table](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-file-defragmenting)

[15.11.5 Reclaiming Disk Space with TRUNCATE TABLE](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-truncate-table-reclaim-space)

As a DBA, you must manage disk I/O to keep the I/O subsystem from becoming saturated, and manage disk space to avoid filling up storage devices. The [ACID](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_acid) design model requires a certain amount of I/O that might seem redundant, but helps to ensure data reliability. Within these constraints, **InnoDB** tries to optimize the database work and the organization of disk files to minimize the amount of disk I/O. Sometimes, I/O is postponed until the database is not busy, or until everything needs to be brought to a consistent state, such as during a database restart after a [fast shutdown](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_fast_shutdown).

This section discusses the main considerations for I/O and disk space with the default kind of MySQL tables (also known as **InnoDB** tables):

Controlling the amount of background I/O used to improve query performance.

Enabling or disabling features that provide extra durability at the expense of additional I/O.

Organizing tables into many small files, a few larger files, or a combination of both.

Balancing the size of redo log files against the I/O activity that occurs when the log files become full.

How to reorganize a table for optimal query performance.

### 15.11.1 InnoDB Disk I/O

**InnoDB** uses asynchronous disk I/O where possible, by creating a number of threads to handle I/O operations, while permitting other database operations to proceed while the I/O is still in progress. On Linux and Windows platforms, **InnoDB** uses the available OS and library functions to perform “native” asynchronous I/O. On other platforms, **InnoDB** still uses I/O threads, but the threads may actually wait for I/O requests to complete; this technique is known as “simulated” asynchronous I/O.

#### Read-Ahead

If **InnoDB** can determine there is a high probability that data might be needed soon, it performs read-ahead operations to bring that data into the buffer pool so that it is available in memory. Making a few large read requests for contiguous data can be more efficient than making several small, spread-out requests. There are two read-ahead heuristics in **InnoDB**:

In sequential read-ahead, if **InnoDB** notices that the access pattern to a segment in the tablespace is sequential, it posts in advance a batch of reads of database pages to the I/O system.

In random read-ahead, if **InnoDB** notices that some area in a tablespace seems to be in the process of being fully read into the buffer pool, it posts the remaining reads to the I/O system.

For information about configuring read-ahead heuristics, see [Section 15.8.3.4, “Configuring InnoDB Buffer Pool Prefetching (Read-Ahead)”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-performance-read_ahead).

#### Doublewrite Buffer

**InnoDB** uses a novel file flush technique involving a structure called the [doublewrite buffer](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_doublewrite_buffer), which is enabled by default in most cases ([**innodb\_doublewrite=ON**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_doublewrite)). It adds safety to recovery following an unexpected exit or power outage, and improves performance on most varieties of Unix by reducing the need for **fsync()** operations.

Before writing pages to a data file, **InnoDB** first writes them to a storage area called the doublewrite buffer. Only after the write and the flush to the doublewrite buffer has completed does **InnoDB** write the pages to their proper positions in the data file. If there is an operating system, storage subsystem, or unexpected [**mysqld**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\programs.html#mysqld) process exit in the middle of a page write (causing a [torn page](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_torn_page) condition), **InnoDB** can later find a good copy of the page from the doublewrite buffer during recovery.

For more information about the doublewrite buffer, see [Section 15.6.4, “Doublewrite Buffer”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-doublewrite-buffer).

### 15.11.2 File Space Management

The data files that you define in the configuration file using the [**innodb\_data\_file\_path**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_data_file_path) configuration option form the **InnoDB** [system tablespace](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_system_tablespace). The files are logically concatenated to form the system tablespace. There is no striping in use. You cannot define where within the system tablespace your tables are allocated. In a newly created system tablespace, **InnoDB** allocates space starting from the first data file.

To avoid the issues that come with storing all tables and indexes inside the system tablespace, you can enable the [**innodb\_file\_per\_table**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_file_per_table) configuration option (the default), which stores each newly created table in a separate tablespace file (with extension **.ibd**). For tables stored this way, there is less fragmentation within the disk file, and when the table is truncated, the space is returned to the operating system rather than still being reserved by InnoDB within the system tablespace. For more information, see [Section 15.6.3.2, “File-Per-Table Tablespaces”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-file-per-table-tablespaces).

You can also store tables in [general tablespaces](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_general_tablespace). General tablespaces are shared tablespaces created using [**CREATE TABLESPACE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-tablespace) syntax. They can be created outside of the MySQL data directory, are capable of holding multiple tables, and support tables of all row formats. For more information, see [Section 15.6.3.3, “General Tablespaces”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#general-tablespaces).

#### Pages, Extents, Segments, and Tablespaces

Each tablespace consists of database [pages](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_page). Every tablespace in a MySQL instance has the same [page size](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_page_size). By default, all tablespaces have a page size of 16KB; you can reduce the page size to 8KB or 4KB by specifying the [**innodb\_page\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_page_size) option when you create the MySQL instance. You can also increase the page size to 32KB or 64KB. For more information, refer to the [**innodb\_page\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_page_size) documentation.

The pages are grouped into [extents](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_extent) of size 1MB for pages up to 16KB in size (64 consecutive 16KB pages, or 128 8KB pages, or 256 4KB pages). For a page size of 32KB, extent size is 2MB. For page size of 64KB, extent size is 4MB. The “files” inside a tablespace are called [segments](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_segment) in **InnoDB**. (These segments are different from the [rollback segment](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_rollback_segment), which actually contains many tablespace segments.)

When a segment grows inside the tablespace, **InnoDB** allocates the first 32 pages to it one at a time. After that, **InnoDB** starts to allocate whole extents to the segment. **InnoDB** can add up to 4 extents at a time to a large segment to ensure good sequentiality of data.

Two segments are allocated for each index in **InnoDB**. One is for nonleaf nodes of the [B-tree](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_b_tree), the other is for the leaf nodes. Keeping the leaf nodes contiguous on disk enables better sequential I/O operations, because these leaf nodes contain the actual table data.

Some pages in the tablespace contain bitmaps of other pages, and therefore a few extents in an **InnoDB** tablespace cannot be allocated to segments as a whole, but only as individual pages.

When you ask for available free space in the tablespace by issuing a [**SHOW TABLE STATUS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#show-table-status) statement, **InnoDB** reports the extents that are definitely free in the tablespace. **InnoDB** always reserves some extents for cleanup and other internal purposes; these reserved extents are not included in the free space.

When you delete data from a table, **InnoDB** contracts the corresponding B-tree indexes. Whether the freed space becomes available for other users depends on whether the pattern of deletes frees individual pages or extents to the tablespace. Dropping a table or deleting all rows from it is guaranteed to release the space to other users, but remember that deleted rows are physically removed only by the [purge](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_purge) operation, which happens automatically some time after they are no longer needed for transaction rollbacks or consistent reads. (See [Section 15.3, “InnoDB Multi-Versioning”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-multi-versioning).)

#### How Pages Relate to Table Rows

The maximum row length is slightly less than half a database page for 4KB, 8KB, 16KB, and 32KB [**innodb\_page\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_page_size) settings. For example, the maximum row length is slightly less than 8KB for the default 16KB **InnoDB** page size. For 64KB pages, the maximum row length is slightly less than 16KB.

If a row does not exceed the maximum row length, all of it is stored locally within the page. If a row exceeds the maximum row length, [variable-length columns](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_variable_length_type) are chosen for external off-page storage until the row fits within the maximum row length limit. External off-page storage for variable-length columns differs by row format:

COMPACT and REDUNDANT Row Formats

When a variable-length column is chosen for external off-page storage, **InnoDB** stores the first 768 bytes locally in the row, and the rest externally into overflow pages. Each such column has its own list of overflow pages. The 768-byte prefix is accompanied by a 20-byte value that stores the true length of the column and points into the overflow list where the rest of the value is stored. See [Section 15.10, “InnoDB Row Formats”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-row-format).

DYNAMIC and COMPRESSED Row Formats

When a variable-length column is chosen for external off-page storage, **InnoDB** stores a 20-byte pointer locally in the row, and the rest externally into overflow pages. See [Section 15.10, “InnoDB Row Formats”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-row-format).

[**LONGBLOB**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-types.html#blob) and [**LONGTEXT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-types.html#blob) columns must be less than 4GB, and the total row length, including [**BLOB**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-types.html#blob) and [**TEXT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-types.html#blob) columns, must be less than 4GB.

### 15.11.3 InnoDB Checkpoints

Making your [log files](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_log_file) very large may reduce disk I/O during [checkpointing](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_checkpoint). It often makes sense to set the total size of the log files as large as the buffer pool or even larger.

#### How Checkpoint Processing Works

**InnoDB** implements a [checkpoint](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_checkpoint) mechanism known as [fuzzy checkpointing](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_fuzzy_checkpointing). **InnoDB** flushes modified database pages from the buffer pool in small batches. There is no need to flush the buffer pool in one single batch, which would disrupt processing of user SQL statements during the checkpointing process.

During [crash recovery](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_crash_recovery), **InnoDB** looks for a checkpoint label written to the log files. It knows that all modifications to the database before the label are present in the disk image of the database. Then **InnoDB** scans the log files forward from the checkpoint, applying the logged modifications to the database.

### 15.11.4 Defragmenting a Table

Random insertions into or deletions from a secondary index can cause the index to become fragmented. Fragmentation means that the physical ordering of the index pages on the disk is not close to the index ordering of the records on the pages, or that there are many unused pages in the 64-page blocks that were allocated to the index.

One symptom of fragmentation is that a table takes more space than it “should” take. How much that is exactly, is difficult to determine. All **InnoDB** data and indexes are stored in [B-trees](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_b_tree), and their [fill factor](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_fill_factor) may vary from 50% to 100%. Another symptom of fragmentation is that a table scan such as this takes more time than it “should” take:

SELECT COUNT(\*) FROM t WHERE ***non\_indexed\_column*** <> 12345;

The preceding query requires MySQL to perform a full table scan, the slowest type of query for a large table.

To speed up index scans, you can periodically perform a “null” [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) operation, which causes MySQL to rebuild the table:

ALTER TABLE ***tbl\_name*** ENGINE=INNODB

You can also use [**ALTER TABLE *tbl\_name* FORCE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) to perform a “null” alter operation that rebuilds the table.

Both [**ALTER TABLE *tbl\_name* ENGINE=INNODB**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) and [**ALTER TABLE *tbl\_name* FORCE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) use [online DDL](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-online-ddl). For more information, see [Section 15.12, “InnoDB and Online DDL”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-online-ddl).

Another way to perform a defragmentation operation is to use [**mysqldump**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\programs.html#mysqldump) to dump the table to a text file, drop the table, and reload it from the dump file.

If the insertions into an index are always ascending and records are deleted only from the end, the **InnoDB** filespace management algorithm guarantees that fragmentation in the index does not occur.

### 15.11.5 Reclaiming Disk Space with TRUNCATE TABLE

To reclaim operating system disk space when [truncating](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_truncate) an **InnoDB** table, the table must be stored in its own [.ibd](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_ibd_file) file. For a table to be stored in its own [.ibd](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_ibd_file) file, [**innodb\_file\_per\_table**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_file_per_table) must enabled when the table is created. Additionally, there cannot be a [foreign key](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_foreign_key) constraint between the table being truncated and other tables, otherwise the **TRUNCATE TABLE** operation fails. A foreign key constraint between two columns in the same table, however, is permitted.

When a table is truncated, it is dropped and re-created in a new .ibd file, and the freed space is returned to the operating system. This is in contrast to truncating **InnoDB** tables that are stored within the **InnoDB** [system tablespace](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_system_tablespace) (tables created when **innodb\_file\_per\_table=OFF**) and tables stored in shared [general tablespaces](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_general_tablespace), where only **InnoDB** can use the freed space after the table is truncated.

The ability to truncate tables and return disk space to the operating system also means that [physical backups](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_physical_backup) can be smaller. Truncating tables that are stored in the system tablespace (tables created when **innodb\_file\_per\_table=OFF**) or in a general tablespace leaves blocks of unused space in the tablespace.

## 15.12 InnoDB and Online DDL

[15.12.1 Online DDL Operations](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-online-ddl-operations)

[15.12.2 Online DDL Performance and Concurrency](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-online-ddl-performance)

[15.12.3 Online DDL Space Requirements](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-online-ddl-space-requirements)

[15.12.4 Simplifying DDL Statements with Online DDL](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-online-ddl-single-multi)

[15.12.5 Online DDL Failure Conditions](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-online-ddl-failure-conditions)

[15.12.6 Online DDL Limitations](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-online-ddl-limitations)

The online DDL feature provides support for instant and in-place table alterations and concurrent DML. Benefits of this feature include:

Improved responsiveness and availability in busy production environments, where making a table unavailable for minutes or hours is not practical.

For in-place operations, the ability to adjust the balance between performance and concurrency during DDL operations using the **LOCK** clause. See [The LOCK clause](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-online-ddl-locking-options).

Less disk space usage and I/O overhead than the table-copy method.

**Note**

**ALGORITHM=INSTANT** support is available for **ADD COLUMN** and other operations in MySQL 8.0.12.

Typically, you do not need to do anything special to enable online DDL. By default, MySQL performs the operation instantly or in place, as permitted, with as little locking as possible.

You can control aspects of a DDL operation using the **ALGORITHM** and **LOCK** clauses of the [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) statement. These clauses are placed at the end of the statement, separated from the table and column specifications by commas. For example:

ALTER TABLE ***tbl\_name*** ADD PRIMARY KEY (***column***), ALGORITHM=INPLACE, LOCK=NONE;

The **LOCK** clause may be used for operations that are performed in place and is useful for fine-tuning the degree of concurrent access to the table during operations. Only **LOCK=DEFAULT** is supported for operations that are performed instantly. The **ALGORITHM** clause is primarily intended for performance comparisons and as a fallback to the older table-copying behavior in case you encounter any issues. For example:

To avoid accidentally making the table unavailable for reads, writes, or both, during an in-place [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) operation, specify a clause on the [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) statement such as **LOCK=NONE** (permit reads and writes) or **LOCK=SHARED** (permit reads). The operation halts immediately if the requested level of concurrency is not available.

To compare performance between algorithms, run a statement with **ALGORITHM=INSTANT**, **ALGORITHM=INPLACE** and **ALGORITHM=COPY**. You can also run a statement with the [**old\_alter\_table**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_old_alter_table) configuration option enabled to force the use of **ALGORITHM=COPY**.

To avoid tying up the server with an [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) operation that copies the table, include **ALGORITHM=INSTANT** or **ALGORITHM=INPLACE**. The statement halts immediately if it cannot use the specified algorithm.

### 15.12.1 Online DDL Operations

Online support details, syntax examples, and usage notes for DDL operations are provided under the following topics in this section.

[Index Operations](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#online-ddl-index-operations)

[Primary Key Operations](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#online-ddl-primary-key-operations)

[Column Operations](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#online-ddl-column-operations)

[Generated Column Operations](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#online-ddl-generated-column-operations)

[Foreign Key Operations](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#online-ddl-foreign-key-operations)

[Table Operations](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#online-ddl-table-operations)

[Tablespace Operations](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#online-ddl-tablespace-operations)

[Partitioning Operations](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#online-ddl-partitioning)

#### Index Operations

The following table provides an overview of online DDL support for index operations. An asterisk indicates additional information, an exception, or a dependency. For details, see [Syntax and Usage Notes](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#online-ddl-index-syntax-notes).

**Table 15.16 Online DDL Support for Index Operations**

| **Operation** | **Instant** | **In Place** | **Rebuilds Table** | **Permits Concurrent DML** | **Only Modifies Metadata** |
| --- | --- | --- | --- | --- | --- |
| **Creating or adding a secondary index** | No | Yes | No | Yes | No |
| **Dropping an index** | No | Yes | No | Yes | Yes |
| **Renaming an index** | No | Yes | No | Yes | Yes |
| **Adding a FULLTEXT index** | No | Yes\* | No\* | No | No |
| **Adding a SPATIAL index** | No | Yes | No | No | No |
| **Changing the index type** | Yes | Yes | No | Yes | Yes |

##### Syntax and Usage Notes

Creating or adding a secondary index

CREATE INDEX ***name*** ON ***table*** (***col\_list***);

ALTER TABLE ***tbl\_name*** ADD INDEX ***name*** (***col\_list***);

The table remains available for read and write operations while the index is being created. The [**CREATE INDEX**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-index) statement only finishes after all transactions that are accessing the table are completed, so that the initial state of the index reflects the most recent contents of the table.

Online DDL support for adding secondary indexes means that you can generally speed the overall process of creating and loading a table and associated indexes by creating the table without secondary indexes, then adding secondary indexes after the data is loaded.

A newly created secondary index contains only the committed data in the table at the time the [**CREATE INDEX**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-index) or [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) statement finishes executing. It does not contain any uncommitted values, old versions of values, or values marked for deletion but not yet removed from the old index.

Some factors affect the performance, space usage, and semantics of this operation. For details, see [Section 15.12.6, “Online DDL Limitations”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-online-ddl-limitations).

Dropping an index

DROP INDEX ***name*** ON ***table***;

ALTER TABLE ***tbl\_name*** DROP INDEX ***name***;

The table remains available for read and write operations while the index is being dropped. The [**DROP INDEX**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#drop-index) statement only finishes after all transactions that are accessing the table are completed, so that the initial state of the index reflects the most recent contents of the table.

Renaming an index

ALTER TABLE ***tbl\_name*** RENAME INDEX ***old\_index\_name*** TO ***new\_index\_name***, ALGORITHM=INPLACE, LOCK=NONE;

Adding a **FULLTEXT** index

CREATE FULLTEXT INDEX ***name*** ON table(***column***);

Adding the first **FULLTEXT** index rebuilds the table if there is no user-defined **FTS\_DOC\_ID** column. Additional **FULLTEXT** indexes may be added without rebuilding the table.

Adding a **SPATIAL** index

CREATE TABLE geom (g GEOMETRY NOT NULL);

ALTER TABLE geom ADD SPATIAL INDEX(g), ALGORITHM=INPLACE, LOCK=SHARED;

Changing the index type (**USING {BTREE | HASH}**)

ALTER TABLE ***tbl\_name*** DROP INDEX i1, ADD INDEX i1(***key\_part,...***) USING BTREE, ALGORITHM=INSTANT;

#### Primary Key Operations

The following table provides an overview of online DDL support for primary key operations. An asterisk indicates additional information, an exception, or a dependency. See [Syntax and Usage Notes](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#online-ddl-primary-key-syntax-notes).

**Table 15.17 Online DDL Support for Primary Key Operations**

| **Operation** | **Instant** | **In Place** | **Rebuilds Table** | **Permits Concurrent DML** | **Only Modifies Metadata** |
| --- | --- | --- | --- | --- | --- |
| **Adding a primary key** | No | Yes\* | Yes\* | Yes | No |
| **Dropping a primary key** | No | No | Yes | No | No |
| **Dropping a primary key and adding another** | No | Yes | Yes | Yes | No |

##### Syntax and Usage Notes

Adding a primary key

ALTER TABLE ***tbl\_name*** ADD PRIMARY KEY (***column***), ALGORITHM=INPLACE, LOCK=NONE;

Rebuilds the table in place. Data is reorganized substantially, making it an expensive operation. **ALGORITHM=INPLACE** is not permitted under certain conditions if columns have to be converted to **NOT NULL**.

Restructuring the [clustered index](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_clustered_index) always requires copying of table data. Thus, it is best to define the [primary key](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_primary_key) when you create a table, rather than issuing **ALTER TABLE ... ADD PRIMARY KEY** later.

When you create a **UNIQUE** or **PRIMARY KEY** index, MySQL must do some extra work. For **UNIQUE** indexes, MySQL checks that the table contains no duplicate values for the key. For a **PRIMARY KEY** index, MySQL also checks that none of the **PRIMARY KEY** columns contains a **NULL**.

When you add a primary key using the **ALGORITHM=COPY** clause, MySQL converts **NULL** values in the associated columns to default values: 0 for numbers, an empty string for character-based columns and BLOBs, and 0000-00-00 00:00:00 for **DATETIME**. This is a non-standard behavior that Oracle recommends you not rely on. Adding a primary key using **ALGORITHM=INPLACE** is only permitted when the [**SQL\_MODE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_sql_mode) setting includes the **strict\_trans\_tables** or **strict\_all\_tables** flags; when the **SQL\_MODE** setting is strict, **ALGORITHM=INPLACE** is permitted, but the statement can still fail if the requested primary key columns contain **NULL** values. The **ALGORITHM=INPLACE** behavior is more standard-compliant.

If you create a table without a primary key, **InnoDB** chooses one for you, which can be the first **UNIQUE** key defined on **NOT NULL** columns, or a system-generated key. To avoid uncertainty and the potential space requirement for an extra hidden column, specify the **PRIMARY KEY** clause as part of the [**CREATE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-table) statement.

MySQL creates a new clustered index by copying the existing data from the original table to a temporary table that has the desired index structure. Once the data is completely copied to the temporary table, the original table is renamed with a different temporary table name. The temporary table comprising the new clustered index is renamed with the name of the original table, and the original table is dropped from the database.

The online performance enhancements that apply to operations on secondary indexes do not apply to the primary key index. The rows of an InnoDB table are stored in a [clustered index](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_clustered_index) organized based on the [primary key](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_primary_key), forming what some database systems call an “index-organized table”. Because the table structure is closely tied to the primary key, redefining the primary key still requires copying the data.

When an operation on the primary key uses **ALGORITHM=INPLACE**, even though the data is still copied, it is more efficient than using **ALGORITHM=COPY** because:

No undo logging or associated redo logging is required for **ALGORITHM=INPLACE**. These operations add overhead to DDL statements that use **ALGORITHM=COPY**.

The secondary index entries are pre-sorted, and so can be loaded in order.

The change buffer is not used, because there are no random-access inserts into the secondary indexes.

Dropping a primary key

ALTER TABLE ***tbl\_name*** DROP PRIMARY KEY, ALGORITHM=COPY;

Only **ALGORITHM=COPY** supports dropping a primary key without adding a new one in the same **ALTER TABLE** statement.

Dropping a primary key and adding another

ALTER TABLE ***tbl\_name*** DROP PRIMARY KEY, ADD PRIMARY KEY (***column***), ALGORITHM=INPLACE, LOCK=NONE;

Data is reorganized substantially, making it an expensive operation.

#### Column Operations

The following table provides an overview of online DDL support for column operations. An asterisk indicates additional information, an exception, or a dependency. For details, see [Syntax and Usage Notes](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#online-ddl-column-syntax-notes).

**Table 15.18 Online DDL Support for Column Operations**

| **Operation** | **Instant** | **In Place** | **Rebuilds Table** | **Permits Concurrent DML** | **Only Modifies Metadata** |
| --- | --- | --- | --- | --- | --- |
| **Adding a column** | Yes\* | Yes | No\* | Yes\* | No |
| **Dropping a column** | No | Yes | Yes | Yes | No |
| **Renaming a column** | No | Yes | No | Yes\* | Yes |
| **Reordering columns** | No | Yes | Yes | Yes | No |
| **Setting a column default value** | Yes | Yes | No | Yes | Yes |
| **Changing the column data type** | No | No | Yes | No | No |
| **Extending VARCHAR column size** | No | Yes | No | Yes | Yes |
| **Dropping the column default value** | Yes | Yes | No | Yes | Yes |
| **Changing the auto-increment value** | No | Yes | No | Yes | No\* |
| **Making a column NULL** | No | Yes | Yes\* | Yes | No |
| **Making a column NOT NULL** | No | Yes\* | Yes\* | Yes | No |
| **Modifying the definition of an ENUM or SET column** | Yes | Yes | No | Yes | Yes |

##### Syntax and Usage Notes

Adding a column

ALTER TABLE ***tbl\_name*** ADD COLUMN ***column\_name*** ***column\_definition***, ALGORITHM=INSTANT;

The following limitations apply when the **INSTANT** algorithm is used to add a column:

Adding a column cannot be combined in the same statement with other **ALTER TABLE** actions that do not support **ALGORITHM=INSTANT**.

A column can only be added as the last column of the table. Adding a column to any other position among other columns is not supported.

Columns cannot be added to tables that use **ROW\_FORMAT=COMPRESSED**.

Columns cannot be added to tables that include a **FULLTEXT** index.

Columns cannot be added to temporary tables. Temporary tables only support **ALGORITHM=COPY**.

Columns cannot be added to tables that reside in the data dictionary tablespace.

Row size limits are not evaluated when adding a column. However, row size limits are checked during DML operations that insert and update rows in the table.

Multiple columns may be added in the same [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) statement. For example:

ALTER TABLE t1 ADD COLUMN c2 INT, ADD COLUMN c3 INT, ALGORITHM=INSTANT;

[**INFORMATION\_SCHEMA.INNODB\_TABLES**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-tables-table) and [**INFORMATION\_SCHEMA.INNODB\_COLUMNS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-columns-table) provide metadata for instantly added columns. **INFORMATION\_SCHEMA.INNODB\_TABLES.INSTANT\_COLS** shows number of columns in the table prior to adding the first instant column. **INFORMATION\_SCHEMA.INNODB\_COLUMNS.HAS\_DEFAULT** and **DEFAULT\_VALUE** provide metadata about default values for instantly added columns.

Concurrent DML is not permitted when adding an [auto-increment](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_auto_increment) column. Data is reorganized substantially, making it an expensive operation. At a minimum, **ALGORITHM=INPLACE, LOCK=SHARED** is required.

The table is rebuilt if **ALGORITHM=INPLACE** is used to add a column.

Dropping a column

ALTER TABLE ***tbl\_name*** DROP COLUMN ***column\_name***, ALGORITHM=INPLACE, LOCK=NONE;

Data is reorganized substantially, making it an expensive operation.

Renaming a column

ALTER TABLE ***tbl*** CHANGE ***old\_col\_name*** ***new\_col\_name*** ***data\_type***, ALGORITHM=INPLACE, LOCK=NONE;

To permit concurrent DML, keep the same data type and only change the column name.

When you keep the same data type and **[NOT] NULL** attribute, only changing the column name, the operation can always be performed online.

You can also rename a column that is part of a foreign key constraint. The foreign key definition is automatically updated to use the new column name. Renaming a column participating in a foreign key only works with **ALGORITHM=INPLACE**. If you use the **ALGORITHM=COPY** clause, or some other condition causes the command to use **ALGORITHM=COPY** behind the scenes, the **ALTER TABLE** statement fails.

**ALGORITHM=INPLACE** is not supported for renaming a [generated column](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_generated_column).

Reordering columns

To reorder columns, use **FIRST** or **AFTER** in **CHANGE** or **MODIFY** operations.

ALTER TABLE ***tbl\_name*** MODIFY COLUMN ***col\_name*** ***column\_definition*** FIRST, ALGORITHM=INPLACE, LOCK=NONE;

Data is reorganized substantially, making it an expensive operation.

Changing the column data type

ALTER TABLE ***tbl\_name*** CHANGE c1 c1 BIGINT, ALGORITHM=COPY;

Changing the column data type is only supported with **ALGORITHM=COPY**.

Extending **VARCHAR** column size

ALTER TABLE ***tbl\_name*** CHANGE COLUMN c1 c1 VARCHAR(255), ALGORITHM=INPLACE, LOCK=NONE;

The number of length bytes required by a [**VARCHAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-types.html#char) column must remain the same. For [**VARCHAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-types.html#char) columns of 0 to 255 bytes in size, one length byte is required to encode the value. For [**VARCHAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-types.html#char) columns of 256 bytes in size or more, two length bytes are required. As a result, in-place [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) only supports increasing [**VARCHAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-types.html#char) column size from 0 to 255 bytes, or from 256 bytes to a greater size. In-place [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) does not support increasing the size of a [**VARCHAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-types.html#char) column from less than 256 bytes to a size equal to or greater than 256 bytes. In this case, the number of required length bytes changes from 1 to 2, which is only supported by a table copy (**ALGORITHM=COPY**). For example, attempting to change [**VARCHAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-types.html#char) column size for a single byte character set from VARCHAR(255) to VARCHAR(256) using in-place [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) returns this error:

ALTER TABLE ***tbl\_name*** ALGORITHM=INPLACE, CHANGE COLUMN c1 c1 VARCHAR(256);

ERROR 0A000: ALGORITHM=INPLACE is not supported. Reason: Cannot change

column type INPLACE. Try ALGORITHM=COPY.

**Note**

The byte length of a **VARCHAR** column is dependant on the byte length of the character set.

Decreasing [**VARCHAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-types.html#char) size using in-place [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) is not supported. Decreasing [**VARCHAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-types.html#char) size requires a table copy (**ALGORITHM=COPY**).

Setting a column default value

ALTER TABLE ***tbl\_name*** ALTER COLUMN ***col*** SET DEFAULT ***literal***, ALGORITHM=INSTANT;

Only modifies table metadata. Default column values are stored in the [data dictionary](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_data_dictionary).

Dropping a column default value

ALTER TABLE ***tbl*** ALTER COLUMN ***col*** DROP DEFAULT, ALGORITHM=INSTANT;

Changing the auto-increment value

ALTER TABLE ***table*** AUTO\_INCREMENT=***next\_value***, ALGORITHM=INPLACE, LOCK=NONE;

Modifies a value stored in memory, not the data file.

In a distributed system using replication or sharding, you sometimes reset the auto-increment counter for a table to a specific value. The next row inserted into the table uses the specified value for its auto-increment column. You might also use this technique in a data warehousing environment where you periodically empty all the tables and reload them, and restart the auto-increment sequence from 1.

Making a column **NULL**

ALTER TABLE tbl\_name MODIFY COLUMN ***column\_name*** ***data\_type*** NULL, ALGORITHM=INPLACE, LOCK=NONE;

Rebuilds the table in place. Data is reorganized substantially, making it an expensive operation.

Making a column **NOT NULL**

ALTER TABLE ***tbl\_name*** MODIFY COLUMN ***column\_name*** ***data\_type*** NOT NULL, ALGORITHM=INPLACE, LOCK=NONE;

Rebuilds the table in place. **STRICT\_ALL\_TABLES** or **STRICT\_TRANS\_TABLES** [**SQL\_MODE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_sql_mode) is required for the operation to succeed. The operation fails if the column contains NULL values. The server prohibits changes to foreign key columns that have the potential to cause loss of referential integrity. See [Section 13.1.9, “ALTER TABLE Statement”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table). Data is reorganized substantially, making it an expensive operation.

Modifying the definition of an **ENUM** or **SET** column

CREATE TABLE t1 (c1 ENUM('a', 'b', 'c'));

ALTER TABLE t1 MODIFY COLUMN c1 ENUM('a', 'b', 'c', 'd'), ALGORITHM=INSTANT;

Modifying the definition of an [**ENUM**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-types.html#enum) or [**SET**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-types.html#set) column by adding new enumeration or set members to the end of the list of valid member values may be performed instantly or in place, as long as the storage size of the data type does not change. For example, adding a member to a [**SET**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-types.html#set) column that has 8 members changes the required storage per value from 1 byte to 2 bytes; this requires a table copy. Adding members in the middle of the list causes renumbering of existing members, which requires a table copy.

#### Generated Column Operations

The following table provides an overview of online DDL support for generated column operations. For details, see [Syntax and Usage Notes](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#online-ddl-generated-column-syntax-notes).

**Table 15.19 Online DDL Support for Generated Column Operations**

| **Operation** | **Instant** | **In Place** | **Rebuilds Table** | **Permits Concurrent DML** | **Only Modifies Metadata** |
| --- | --- | --- | --- | --- | --- |
| **Adding a STORED column** | No | No | Yes | No | No |
| **Modifying STORED column order** | No | No | Yes | No | No |
| **Dropping a STORED column** | No | Yes | Yes | Yes | No |
| **Adding a VIRTUAL column** | Yes | Yes | No | Yes | Yes |
| **Modifying VIRTUAL column order** | No | No | Yes | No | No |
| **Dropping a VIRTUAL column** | Yes | Yes | No | Yes | Yes |

##### Syntax and Usage Notes

Adding a **STORED** column

ALTER TABLE t1 ADD COLUMN (c2 INT GENERATED ALWAYS AS (c1 + 1) STORED), ALGORITHM=COPY;

**ADD COLUMN** is not an in-place operation for stored columns (done without using a temporary table) because the expression must be evaluated by the server.

Modifying **STORED** column order

ALTER TABLE t1 MODIFY COLUMN c2 INT GENERATED ALWAYS AS (c1 + 1) STORED FIRST, ALGORITHM=COPY;

Rebuilds the table in place.

Dropping a **STORED** column

ALTER TABLE t1 DROP COLUMN c2, ALGORITHM=INPLACE, LOCK=NONE;

Rebuilds the table in place.

Adding a **VIRTUAL** column

ALTER TABLE t1 ADD COLUMN (c2 INT GENERATED ALWAYS AS (c1 + 1) VIRTUAL), ALGORITHM=INSTANT;

Adding a virtual column can be performed instantly or in place for non-partitioned tables.

Adding a **VIRTUAL** is not an in-place operation for partitioned tables.

Modifying **VIRTUAL** column order

ALTER TABLE t1 MODIFY COLUMN c2 INT GENERATED ALWAYS AS (c1 + 1) VIRTUAL FIRST, ALGORITHM=COPY;

Dropping a **VIRTUAL** column

ALTER TABLE t1 DROP COLUMN c2, ALGORITHM=INSTANT;

Dropping a **VIRTUAL** column can be performed instantly or in place for non-partitioned tables.

#### Foreign Key Operations

The following table provides an overview of online DDL support for foreign key operations. An asterisk indicates additional information, an exception, or a dependency. For details, see [Syntax and Usage Notes](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#online-ddl-foreign-key-syntax-notes).

**Table 15.20 Online DDL Support for Foreign Key Operations**

| **Operation** | **Instant** | **In Place** | **Rebuilds Table** | **Permits Concurrent DML** | **Only Modifies Metadata** |
| --- | --- | --- | --- | --- | --- |
| **Adding a foreign key constraint** | No | Yes\* | No | Yes | Yes |
| **Dropping a foreign key constraint** | No | Yes | No | Yes | Yes |

##### Syntax and Usage Notes

Adding a foreign key constraint

The **INPLACE** algorithm is supported when [**foreign\_key\_checks**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_foreign_key_checks) is disabled. Otherwise, only the **COPY** algorithm is supported.

ALTER TABLE ***tbl1*** ADD CONSTRAINT ***fk\_name*** FOREIGN KEY ***index*** (***col1***)

REFERENCES ***tbl2***(***col2***) ***referential\_actions***;

Dropping a foreign key constraint

ALTER TABLE ***tbl*** DROP FOREIGN KEY ***fk\_name***;

Dropping a foreign key can be performed online with the [**foreign\_key\_checks**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_foreign_key_checks) option enabled or disabled.

If you do not know the names of the foreign key constraints on a particular table, issue the following statement and find the constraint name in the **CONSTRAINT** clause for each foreign key:

SHOW CREATE TABLE ***table***\G

Or, query the [**INFORMATION\_SCHEMA.TABLE\_CONSTRAINTS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-table-constraints-table) table and use the **CONSTRAINT\_NAME** and **CONSTRAINT\_TYPE** columns to identify the foreign key names.

You can also drop a foreign key and its associated index in a single statement:

ALTER TABLE ***table*** DROP FOREIGN KEY ***constraint***, DROP INDEX ***index***;

**Note**

If [foreign keys](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_foreign_key) are already present in the table being altered (that is, it is a [child table](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_child_table) containing a **FOREIGN KEY ... REFERENCE** clause), additional restrictions apply to online DDL operations, even those not directly involving the foreign key columns:

An [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) on the child table could wait for another transaction to commit, if a change to the parent table causes associated changes in the child table through an **ON UPDATE** or **ON DELETE** clause using the **CASCADE** or **SET NULL** parameters.

In the same way, if a table is the [parent table](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_parent_table) in a foreign key relationship, even though it does not contain any **FOREIGN KEY** clauses, it could wait for the [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) to complete if an [**INSERT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#insert), [**UPDATE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#update), or [**DELETE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#delete) statement causes an **ON UPDATE** or **ON DELETE** action in the child table.

#### Table Operations

The following table provides an overview of online DDL support for table operations. An asterisk indicates additional information, an exception, or a dependency. For details, see [Syntax and Usage Notes](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#online-ddl-table-syntax-notes).

**Table 15.21 Online DDL Support for Table Operations**

| **Operation** | **Instant** | **In Place** | **Rebuilds Table** | **Permits Concurrent DML** | **Only Modifies Metadata** |
| --- | --- | --- | --- | --- | --- |
| **Changing the ROW\_FORMAT** | No | Yes | Yes | Yes | No |
| **Changing the KEY\_BLOCK\_SIZE** | No | Yes | Yes | Yes | No |
| **Setting persistent table statistics** | No | Yes | No | Yes | Yes |
| **Specifying a character set** | No | Yes | Yes\* | No | No |
| **Converting a character set** | No | No | Yes\* | No | No |
| **Optimizing a table** | No | Yes\* | Yes | Yes | No |
| **Rebuilding with the FORCE option** | No | Yes\* | Yes | Yes | No |
| **Performing a null rebuild** | No | Yes\* | Yes | Yes | No |
| **Renaming a table** | Yes | Yes | No | Yes | Yes |

##### Syntax and Usage Notes

Changing the **ROW\_FORMAT**

ALTER TABLE ***tbl\_name*** ROW\_FORMAT = ***row\_format***, ALGORITHM=INPLACE, LOCK=NONE;

Data is reorganized substantially, making it an expensive operation.

For additional information about the **ROW\_FORMAT** option, see [Table Options](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-table-options).

Changing the **KEY\_BLOCK\_SIZE**

ALTER TABLE ***tbl\_name*** KEY\_BLOCK\_SIZE = ***value***, ALGORITHM=INPLACE, LOCK=NONE;

Data is reorganized substantially, making it an expensive operation.

For additional information about the **KEY\_BLOCK\_SIZE** option, see [Table Options](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-table-options).

Setting persistent table statistics options

ALTER TABLE ***tbl\_name*** STATS\_PERSISTENT=0, STATS\_SAMPLE\_PAGES=20, STATS\_AUTO\_RECALC=1, ALGORITHM=INPLACE, LOCK=NONE;

Only modifies table metadata.

Persistent statistics include **STATS\_PERSISTENT**, **STATS\_AUTO\_RECALC**, and **STATS\_SAMPLE\_PAGES**. For more information, see [Section 15.8.10.1, “Configuring Persistent Optimizer Statistics Parameters”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-persistent-stats).

Specifying a character set

ALTER TABLE ***tbl\_name*** CHARACTER SET = ***charset\_name***, ALGORITHM=INPLACE, LOCK=NONE;

Rebuilds the table if the new character encoding is different.

Converting a character set

ALTER TABLE ***tbl\_name*** CONVERT TO CHARACTER SET ***charset\_name***, ALGORITHM=COPY;

Rebuilds the table if the new character encoding is different.

Optimizing a table

OPTIMIZE TABLE ***tbl\_name***;

In-place operation is not supported for tables with **FULLTEXT** indexes. The operation uses the **INPLACE** algorithm, but **ALGORITHM** and **LOCK** syntax is not permitted.

Rebuilding a table with the **FORCE** option

ALTER TABLE ***tbl\_name*** FORCE, ALGORITHM=INPLACE, LOCK=NONE;

Uses **ALGORITHM=INPLACE** as of MySQL 5.6.17. **ALGORITHM=INPLACE** is not supported for tables with **FULLTEXT** indexes.

Performing a "null" rebuild

ALTER TABLE ***tbl\_name*** ENGINE=InnoDB, ALGORITHM=INPLACE, LOCK=NONE;

Uses **ALGORITHM=INPLACE** as of MySQL 5.6.17. **ALGORITHM=INPLACE** is not supported for tables with **FULLTEXT** indexes.

Renaming a table

ALTER TABLE ***old\_tbl\_name*** RENAME TO ***new\_tbl\_name***, ALGORITHM=INSTANT;

Renaming a table can be performed instantly or in place. MySQL renames files that correspond to the table ***tbl\_name*** without making a copy. (You can also use the [**RENAME TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#rename-table) statement to rename tables. See [Section 13.1.36, “RENAME TABLE Statement”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#rename-table).) Privileges granted specifically for the renamed table are not migrated to the new name. They must be changed manually.

#### Tablespace Operations

The following table provides an overview of online DDL support for tablespace operations. For details, see [Syntax and Usage Notes](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#online-ddl-tablespace-syntax-notes).

**Table 15.22 Online DDL Support for Tablespace Operations**

| **Operation** | **Instant** | **In Place** | **Rebuilds Table** | **Permits Concurrent DML** | **Only Modifies Metadata** |
| --- | --- | --- | --- | --- | --- |
| **Renaming a general tablespace** | No | Yes | No | Yes | Yes |
| **Enabling or disabling general tablespace encryption** | No | Yes | No | Yes | No |
| **Enabling or disabling file-per-table tablespace encryption** | No | No | Yes | No | No |

##### Syntax and Usage Notes

Renaming a general tablespace

ALTER TABLESPACE ***tablespace\_name*** RENAME TO ***new\_tablespace\_name***;

[**ALTER TABLESPACE ... RENAME TO**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-tablespace) uses the **INPLACE** algorithm but does not support the **ALGORITHM** clause.

Enabling or disabling general tablespace encryption

ALTER TABLESPACE ***tablespace\_name*** ENCRYPTION='Y';

[**ALTER TABLESPACE ... ENCRYPTION**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-tablespace) uses the **INPLACE** algorithm but does not support the **ALGORITHM** clause.

For related information, see [Section 15.13, “InnoDB Data-at-Rest Encryption”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-data-encryption).

Enabling or disabling file-per-table tablespace encryption

ALTER TABLE ***tbl\_name*** ENCRYPTION='Y', ALGORITHM=COPY;

For related information, see [Section 15.13, “InnoDB Data-at-Rest Encryption”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-data-encryption).

#### Partitioning Operations

With the exception of some [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) partitioning clauses, online DDL operations for partitioned **InnoDB** tables follow the same rules that apply to regular **InnoDB** tables.

Some [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) partitioning clauses do not go through the same internal online DDL API as regular non-partitioned **InnoDB** tables. As a result, online support for [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) partitioning clauses varies.

The following table shows the online status for each **ALTER TABLE** partitioning statement. Regardless of the online DDL API that is used, MySQL attempts to minimize data copying and locking where possible.

[**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) partitioning options that use **ALGORITHM=COPY** or that only permit “**ALGORITHM=DEFAULT, LOCK=DEFAULT**”, repartition the table using the **COPY** algorithm. In other words, a new partitioned table is created with the new partitioning scheme. The newly created table includes any changes applied by the [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) statement, and table data is copied into the new table structure.

**Table 15.23 Online DDL Support for Partitioning Operations**

| **Partitioning Clause** | **Instant** | **In Place** | **Permits DML** | **Notes** |
| --- | --- | --- | --- | --- |
| [**PARTITION BY**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) | No | No | No | Permits **ALGORITHM=COPY**, **LOCK={DEFAULT|SHARED|EXCLUSIVE}** |
| [**ADD PARTITION**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) | No | Yes\* | Yes\* | **ALGORITHM=INPLACE, LOCK={DEFAULT|NONE|SHARED|EXCLUSISVE}** is supported for **RANGE** and **LIST** partitions, **ALGORITHM=INPLACE, LOCK={DEFAULT|SHARED|EXCLUSISVE}** for **HASH** and **KEY** partitions, and **ALGORITHM=COPY, LOCK={SHARED|EXCLUSIVE}** for all partition types. Does not copy existing data for tables partitioned by **RANGE** or **LIST**. Concurrent queries are permitted with **ALGORITHM=COPY** for tables partitioned by **HASH** or **LIST**, as MySQL copies the data while holding a shared lock. |
| [**DROP PARTITION**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) | No | Yes\* | Yes\* | **ALGORITHM=INPLACE, LOCK={DEFAULT|NONE|SHARED|EXCLUSIVE}** is supported. Does not copy data for tables partitioned by **RANGE** or **LIST**.  **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**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_old_alter_table) 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. |
| [**DISCARD PARTITION**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) | No | No | No | Only permits **ALGORITHM=DEFAULT**, **LOCK=DEFAULT** |
| [**IMPORT PARTITION**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) | No | No | No | Only permits **ALGORITHM=DEFAULT**, **LOCK=DEFAULT** |
| [**TRUNCATE PARTITION**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) | No | Yes | Yes | Does not copy existing data. It merely deletes rows; it does not alter the definition of the table itself, or of any of its partitions. |
| [**COALESCE PARTITION**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) | No | Yes\* | No | **ALGORITHM=INPLACE, LOCK={DEFAULT|SHARED|EXCLUSIVE}** is supported. |
| [**REORGANIZE PARTITION**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) | No | Yes\* | No | **ALGORITHM=INPLACE, LOCK={DEFAULT|SHARED|EXCLUSIVE}** is supported. |
| [**EXCHANGE PARTITION**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) | No | Yes | Yes |  |
| [**ANALYZE PARTITION**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) | No | Yes | Yes |  |
| [**CHECK PARTITION**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) | No | Yes | Yes |  |
| [**OPTIMIZE PARTITION**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) | No | No | No | **ALGORITHM** and **LOCK** clauses are ignored. Rebuilds the entire table. See [Section 24.3.4, “Maintenance of Partitions”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\partitioning.html#partitioning-maintenance). |
| [**REBUILD PARTITION**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) | No | Yes\* | No | **ALGORITHM=INPLACE, LOCK={DEFAULT|SHARED|EXCLUSIVE}** is supported. |
| [**REPAIR PARTITION**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) | No | Yes | Yes |  |
| [**REMOVE PARTITIONING**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) | No | No | No | Permits **ALGORITHM=COPY**, **LOCK={DEFAULT|SHARED|EXCLUSIVE}** |

Non-partitioning online [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) operations on partitioned tables follow the same rules that apply to regular tables. However, [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) performs online operations on each table partition, which causes increased demand on system resources due to operations being performed on multiple partitions.

For additional information about [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) partitioning clauses, see [Partitioning Options](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table-partition-options), and [Section 13.1.9.1, “ALTER TABLE Partition Operations”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table-partition-operations). For information about partitioning in general, see [Chapter 24, *Partitioning*](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\partitioning.html).

### 15.12.2 Online DDL Performance and Concurrency

Online DDL improves several aspects of MySQL operation:

Applications that access the table are more responsive because queries and DML operations on the table can proceed while the DDL operation is in progress. Reduced locking and waiting for MySQL server resources leads to greater scalability, even for operations that are not involved in the DDL operation.

Instant operations only modify metadata in the data dictionary. No metadata locks are taken on the table, and table data is unaffected, making operations instantaneous. Concurrent DML is unaffected.

Online operations avoid the disk I/O and CPU cycles associated with the table-copy method, which minimizes overall load on the database. Minimizing load helps maintain good performance and high throughput during the DDL operation.

Online operations read less data into the buffer pool than table-copy operations, which reduces purging of frequently accessed data from memory. Purging of frequently accessed data can cause a temporary performance dip after a DDL operation.

#### The LOCK clause

By default, MySQL uses as little locking as possible during a DDL operation. The **LOCK** clause can be specified for in-place operations and some copy operations to enforce more restrictive locking, if required. If the **LOCK** clause specifies a less restrictive level of locking than is permitted for a particular DDL operation, the statement fails with an error. **LOCK** clauses are described below, in order of least to most restrictive:

**LOCK=NONE**:

Permits concurrent queries and DML.

For example, use this clause for tables involving customer signups or purchases, to avoid making the tables unavailable during lengthy DDL operations.

**LOCK=SHARED**:

Permits concurrent queries but blocks DML.

For example, use this clause on data warehouse tables, where you can delay data load operations until the DDL operation is finished, but queries cannot be delayed for long periods.

**LOCK=DEFAULT**:

Permits as much concurrency as possible (concurrent queries, DML, or both). Omitting the **LOCK** clause is the same as specifying **LOCK=DEFAULT**.

Use this clause when you do not expect the default locking level of the DDL statement to cause any availability problems for the table.

**LOCK=EXCLUSIVE**:

Blocks concurrent queries and DML.

Use this clause if the primary concern is finishing the DDL operation in the shortest amount of time possible, and concurrent query and DML access is not necessary. You might also use this clause if the server is supposed to be idle, to avoid unexpected table accesses.

#### Online DDL and Metadata Locks

Online DDL operations can be viewed as having three phases:

Phase 1: Initialization

In the initialization phase, the server determines how much concurrency is permitted during the operation, taking into account storage engine capabilities, operations specified in the statement, and user-specified **ALGORITHM** and **LOCK** options. During this phase, a shared upgradeable metadata lock is taken to protect the current table definition.

Phase 2: Execution

In this phase, the statement is prepared and executed. Whether the metadata lock is upgraded to exclusive depends on the factors assessed in the initialization phase. If an exclusive metadata lock is required, it is only taken briefly during statement preparation.

Phase 3: Commit Table Definition

In the commit table definition phase, the metadata lock is upgraded to exclusive to evict the old table definition and commit the new one. Once granted, the duration of the exclusive metadata lock is brief.

Due to the exclusive metadata lock requirements outlined above, an online DDL operation may have to wait for concurrent transactions that hold metadata locks on the table to commit or rollback. Transactions started before or during the DDL operation can hold metadata locks on the table being altered. In the case of a long running or inactive transaction, an online DDL operation can time out waiting for an exclusive metadata lock. Additionally, a pending exclusive metadata lock requested by an online DDL operation blocks subsequent transactions on the table.

The following example demonstrates an online DDL operation waiting for an exclusive metadata lock, and how a pending metadata lock blocks subsequent transactions on the table.

Session 1:

mysql> CREATE TABLE t1 (c1 INT) ENGINE=InnoDB;

mysql> START TRANSACTION;

mysql> SELECT \* FROM t1;

The session 1 [**SELECT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#select) statement takes a shared metadata lock on table t1.

Session 2:

mysql> ALTER TABLE t1 ADD COLUMN x INT, ALGORITHM=INPLACE, LOCK=NONE;

The online DDL operation in session 2, which requires an exclusive metadata lock on table t1 to commit table definition changes, must wait for the session 1 transaction to commit or roll back.

Session 3:

mysql> SELECT \* FROM t1;

The [**SELECT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#select) statement issued in session 3 is blocked waiting for the exclusive metadata lock requested by the [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) operation in session 2 to be granted.

You can use [**SHOW FULL PROCESSLIST**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#show-processlist) to determine if transactions are waiting for a metadata lock.

mysql> **SHOW FULL PROCESSLIST\G**

...

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\* 2. row \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

Id: 5

User: root

Host: localhost

db: test

Command: Query

Time: 44

State: Waiting for table metadata lock

Info: ALTER TABLE t1 ADD COLUMN x INT, ALGORITHM=INPLACE, LOCK=NONE

...

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\* 4. row \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

Id: 7

User: root

Host: localhost

db: test

Command: Query

Time: 5

State: Waiting for table metadata lock

Info: SELECT \* FROM t1

4 rows in set (0.00 sec)

Metadata lock information is also exposed through the Performance Schema [**metadata\_locks**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html#performance-schema-metadata-locks-table) table, which provides information about metadata lock dependencies between sessions, the metadata lock a session is waiting for, and the session that currently holds the metadata lock. For more information, see [Section 27.12.13.3, “The metadata\_locks Table”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html#performance-schema-metadata-locks-table).

#### Online DDL Performance

The performance of a DDL operation is largely determined by whether the operation is performed instantly, in place, and whether it rebuilds the table.

To assess the relative performance of a DDL operation, you can compare results using **ALGORITHM=INSTANT**, **ALGORITHM=INPLACE**, and **ALGORITHM=COPY**. A statement can also be run with [**old\_alter\_table**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_old_alter_table) enabled to force the use of **ALGORITHM=COPY**.

For DDL operations that modify table data, you can determine whether a DDL operation performs changes in place or performs a table copy by looking at the “rows affected” value displayed after the command finishes. For example:

Changing the default value of a column (fast, does not affect the table data):

Query OK, 0 rows affected (0.07 sec)

Adding an index (takes time, but **0 rows affected** shows that the table is not copied):

Query OK, 0 rows affected (21.42 sec)

Changing the data type of a column (takes substantial time and requires rebuilding all the rows of the table):

Query OK, 1671168 rows affected (1 min 35.54 sec)

Before running a DDL operation on a large table, check whether the operation is fast or slow as follows:

Clone the table structure.

Populate the cloned table with a small amount of data.

Run the DDL operation on the cloned table.

Check whether the “rows affected” value is zero or not. A nonzero value means the operation copies table data, which might require special planning. For example, you might do the DDL operation during a period of scheduled downtime, or on each replica server one at a time.

**Note**

For a greater understanding of the MySQL processing associated with a DDL operation, examine Performance Schema and **INFORMATION\_SCHEMA** tables related to **InnoDB** before and after DDL operations to see the number of physical reads, writes, memory allocations, and so on.

Performance Schema stage events can be used to monitor [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) progress. See [Section 15.16.1, “Monitoring ALTER TABLE Progress for InnoDB Tables Using Performance Schema”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#monitor-alter-table-performance-schema).

Because there is some processing work involved with recording the changes made by concurrent DML operations, then applying those changes at the end, an online DDL operation could take longer overall than the table-copy mechanism that blocks table access from other sessions. The reduction in raw performance is balanced against better responsiveness for applications that use the table. When evaluating the techniques for changing table structure, consider end-user perception of performance, based on factors such as load times for web pages.

### 15.12.3 Online DDL Space Requirements

Space requirements for in-place online DDL operations are outlined below. Space requirements do not apply to operations that are performed instantly.

Space for temporary log files

A temporary log file records concurrent DML when an online DDL operation creates an index or alters a table. The temporary log file is extended as required by the value of [**innodb\_sort\_buffer\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_sort_buffer_size) up to a maximum specified by [**innodb\_online\_alter\_log\_max\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_online_alter_log_max_size). If a temporary log file exceeds the size limit, the online DDL operation fails, and uncommitted concurrent DML operations are rolled back. A large [**innodb\_online\_alter\_log\_max\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_online_alter_log_max_size) setting permits more DML during an online DDL operation, but it also extends the period of time at the end of the DDL operation when the table is locked to apply logged DML.

If the operation takes a long time and concurrent DML modifies the table so much that the size of the temporary log file exceeds the value of [**innodb\_online\_alter\_log\_max\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_online_alter_log_max_size), the online DDL operation fails with a **DB\_ONLINE\_LOG\_TOO\_BIG** error.

Space for temporary sort files

Online DDL operations that rebuild the table write temporary sort files to the MySQL temporary directory (**$TMPDIR** on Unix, **%TEMP%** on Windows, or the directory specified by [**--tmpdir**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_tmpdir)) during index creation. Temporary sort files are not created in the directory that contains the original table. Each temporary sort file is large enough to hold one column of data, and each sort file is removed when its data is merged into the final table or index. Operations involving temporary sort files may require temporary space equal to the amount of data in the table plus indexes. An error is reported if online DDL operation uses all of the available disk space on the file system where the data directory resides.

If the MySQL temporary directory is not large enough to hold the sort files, set [**tmpdir**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_tmpdir) to a different directory. Alternatively, define a separate temporary directory for online DDL operations using [**innodb\_tmpdir**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_tmpdir). This option was introduced to help avoid temporary directory overflows that could occur as a result of large temporary sort files.

Space for an intermediate table file

Some online DDL operations that rebuild the table create a temporary intermediate table file in the same directory as the original table. An intermediate table file may require space equal to the size of the original table. Intermediate table file names begin with #sql-ib prefix and only appear briefly during the online DDL operation.

The [**innodb\_tmpdir**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_tmpdir) option is not applicable to intermediate table files.

### 15.12.4 Simplifying DDL Statements with Online DDL

Before the introduction of [online DDL](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_online_ddl), it was common practice to combine many DDL operations into a single [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) statement. Because each [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) statement involved copying and rebuilding the table, it was more efficient to make several changes to the same table at once, since those changes could all be done with a single rebuild operation for the table. The downside was that SQL code involving DDL operations was harder to maintain and to reuse in different scripts. If the specific changes were different each time, you might have to construct a new complex [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) for each slightly different scenario.

For DDL operations that can be done online, you can separate them into individual [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) statements for easier scripting and maintenance, without sacrificing efficiency. For example, you might take a complicated statement such as:

ALTER TABLE t1 ADD INDEX i1(c1), ADD UNIQUE INDEX i2(c2),

CHANGE c4\_old\_name c4\_new\_name INTEGER UNSIGNED;

and break it down into simpler parts that can be tested and performed independently, such as:

ALTER TABLE t1 ADD INDEX i1(c1);

ALTER TABLE t1 ADD UNIQUE INDEX i2(c2);

ALTER TABLE t1 CHANGE c4\_old\_name c4\_new\_name INTEGER UNSIGNED NOT NULL;

You might still use multi-part [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) statements for:

Operations that must be performed in a specific sequence, such as creating an index followed by a foreign key constraint that uses that index.

Operations all using the same specific **LOCK** clause, that you want to either succeed or fail as a group.

Operations that cannot be performed online, that is, that still use the table-copy method.

Operations for which you specify **ALGORITHM=COPY** or [**old\_alter\_table=1**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_old_alter_table), to force the table-copying behavior if needed for precise backward-compatibility in specialized scenarios.

### 15.12.5 Online DDL Failure Conditions

The failure of an online DDL operation is typically due to one of the following conditions:

An **ALGORITHM** clause specifies an algorithm that is not compatible with the particular type of DDL operation or storage engine.

A **LOCK** clause specifies a low degree of locking (**SHARED** or **NONE**) that is not compatible with the particular type of DDL operation.

A timeout occurs while waiting for an [exclusive lock](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_exclusive_lock) on the table, which may be needed briefly during the initial and final phases of the DDL operation.

The [**tmpdir**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_tmpdir) or [**innodb\_tmpdir**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_tmpdir) file system runs out of disk space, while MySQL writes temporary sort files on disk during index creation. For more information, see [Section 15.12.3, “Online DDL Space Requirements”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-online-ddl-space-requirements).

The operation takes a long time and concurrent DML modifies the table so much that the size of the temporary online log exceeds the value of the [**innodb\_online\_alter\_log\_max\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_online_alter_log_max_size) configuration option. This condition causes a **DB\_ONLINE\_LOG\_TOO\_BIG** error.

Concurrent DML makes changes to the table that are allowed with the original table definition, but not with the new one. The operation only fails at the very end, when MySQL tries to apply all the changes from concurrent DML statements. For example, you might insert duplicate values into a column while a unique index is being created, or you might insert **NULL** values into a column while creating a [primary key](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_primary_key) index on that column. The changes made by the concurrent DML take precedence, and the [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) operation is effectively [rolled back](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_rollback).

### 15.12.6 Online DDL Limitations

The following limitations apply to online DDL operations:

The table is copied when creating an index on a **TEMPORARY TABLE**.

The [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) clause **LOCK=NONE** is not permitted if there are **ON...CASCADE** or **ON...SET NULL** constraints on the table.

Before an in-place online DDL operation can finish, it must wait for transactions that hold metadata locks on the table to commit or roll back. An online DDL operation may briefly require an exclusive metadata lock on the table during its execution phase, and always requires one in the final phase of the operation when updating the table definition. Consequently, transactions holding metadata locks on the table can cause an online DDL operation to block. The transactions that hold metadata locks on the table may have been started before or during the online DDL operation. A long running or inactive transaction that holds a metadata lock on the table can cause an online DDL operation to timeout.

When running an in-place online DDL operation, the thread that runs the [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) statement applies an online log of DML operations that were run concurrently on the same table from other connection threads. When the DML operations are applied, it is possible to encounter a duplicate key entry error (ERROR 1062 (23000): Duplicate entry), even if the duplicate entry is only temporary and would be reverted by a later entry in the online log. This is similar to the idea of a foreign key constraint check in **InnoDB** in which constraints must hold during a transaction.

[**OPTIMIZE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#optimize-table) for an **InnoDB** table is mapped to an [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) operation to rebuild the table and update index statistics and free unused space in the clustered index. Secondary indexes are not created as efficiently because keys are inserted in the order they appeared in the primary key. [**OPTIMIZE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#optimize-table) is supported with the addition of online DDL support for rebuilding regular and partitioned **InnoDB** tables.

Tables created before MySQL 5.6 that include temporal columns ([**DATE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-types.html#datetime), [**DATETIME**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-types.html#datetime) or [**TIMESTAMP**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-types.html#datetime)) and have not been rebuilt using **ALGORITHM=COPY** do not support **ALGORITHM=INPLACE**. In this case, an [**ALTER TABLE ... ALGORITHM=INPLACE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) operation returns the following error:

ERROR 1846 (0A000): ALGORITHM=INPLACE is not supported.

Reason: Cannot change column type INPLACE. Try ALGORITHM=COPY.

The following limitations are generally applicable to online DDL operations on large tables that involve rebuilding the table:

There is no mechanism to pause an online DDL operation or to throttle I/O or CPU usage for an online DDL operation.

Rollback of an online DDL operation can be expensive should the operation fail.

Long running online DDL operations can cause replication lag. An online DDL operation must finish running on the source before it is run on the replica. Also, DML that was processed concurrently on the source is only processed on the replica after the DDL operation on the replica is completed.

For additional information related to running online DDL operations on large tables, see [Section 15.12.2, “Online DDL Performance and Concurrency”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-online-ddl-performance).

## 15.13 InnoDB Data-at-Rest Encryption

**InnoDB** supports data-at-rest encryption for [file-per-table](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_file_per_table) tablespaces, [general](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_general_tablespace) tablespaces, the **mysql** system tablespace, redo logs, and undo logs.

As of MySQL 8.0.16, setting an encryption default for schemas and general tablespaces is also supported, which permits DBAs to control whether tables created in those schemas and tablespaces are encrypted.

**InnoDB** data-at-rest encryption features and capabilities are described under the following topics in this section.

[About Data-at-Rest Encryption](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-data-encryption-about)

[Encryption Prerequisites](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-data-encryption-encryption-prerequisites)

[Defining an Encryption Default for Schemas and General Tablespaces](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-schema-tablespace-encryption-default)

[File-Per-Table Tablespace Encryption](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-data-encryption-enabling-disabling)

[General Tablespace Encryption](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-general-tablespace-encryption-enabling-disabling)

[Doublewrite File Encryption](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-doublewrite-file-encryption)

[mysql System Tablespace Encryption](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-mysql-tablespace-encryption-enabling-disabling)

[Redo Log Encryption](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-data-encryption-redo-log)

[Undo Log Encryption](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-data-encryption-undo-log)

[Master Key Rotation](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-data-encryption-master-key-rotation)

[Encryption and Recovery](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-data-encryption-recovery)

[Exporting Encrypted Tablespaces](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-data-encryption-exporting)

[Encryption and Replication](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-data-encryption-replication)

[Identifying Encrypted Tablespaces and Schemas](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-data-encryption-identifying)

[Monitoring Encryption Progress](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-data-encryption-progress-monitoring)

[Encryption Usage Notes](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-data-encryption-usage-notes)

[Encryption Limitations](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-data-encryption-limitations)

### About Data-at-Rest Encryption

**InnoDB** uses a two tier encryption key architecture, consisting of a master encryption key and tablespace keys. When a tablespace is encrypted, a tablespace key is encrypted and stored in the tablespace header. When an application or authenticated user wants to access encrypted tablespace data, **InnoDB** uses a master encryption key to decrypt the tablespace key. The decrypted version of a tablespace key never changes, but the master encryption key can be changed as required. This action is referred to as master key rotation.

The data-at-rest encryption feature relies on a keyring component or plugin for master encryption key management.

All MySQL editions provide a **component\_keyring\_file** component and **keyring\_file** plugin, each of which stores keyring data in a file local to the server host.

MySQL Enterprise Edition offers additional keyring components and plugins:

**component\_keyring\_encrypted\_file**: Stores keyring data in an encrypted, password-protected file local to the server host.

**keyring\_encrypted\_file**: Stores keyring data in an encrypted, password-protected file local to the server host.

**keyring\_okv**: A KMIP 1.1 plugin for use with KMIP-compatible back end keyring storage products. Supported KMIP-compatible products include centralized key management solutions such as Oracle Key Vault, Gemalto KeySecure, Thales Vormetric key management server, and Fornetix Key Orchestration.

**keyring\_aws**: Communicates with the Amazon Web Services Key Management Service (AWS KMS) as a back end for key generation and uses a local file for key storage.

**keyring\_hashicorp**: Communicates with HashiCorp Vault for back end storage.

**Warning**

For encryption key management, the **component\_keyring\_file** and **component\_keyring\_encrypted\_file** components, and the **keyring\_file** and **keyring\_encrypted\_file** plugins are not intended as a regulatory compliance solution. Security standards such as PCI, FIPS, and others require use of key management systems to secure, manage, and protect encryption keys in key vaults or hardware security modules (HSMs).

A secure and robust encryption key management solution is critical for security and for compliance with various security standards. When the data-at-rest encryption feature uses a centralized key management solution, the feature is referred to as “MySQL Enterprise Transparent Data Encryption (TDE)”.

The data-at-rest encryption feature supports the Advanced Encryption Standard (AES) block-based encryption algorithm. It uses Electronic Codebook (ECB) block encryption mode for tablespace key encryption and Cipher Block Chaining (CBC) block encryption mode for data encryption.

For frequently asked questions about the data-at-rest encryption feature, see [Section A.17, “MySQL 8.0 FAQ: InnoDB Data-at-Rest Encryption”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\faqs.html#faqs-tablespace-encryption).

### Encryption Prerequisites

A keyring component or plugin must be installed and configured at startup. Early loading ensures that the component or plugin is available prior to initialization of the **InnoDB** storage engine. For keyring installation and configuration instructions, see [Section 6.4.4, “The MySQL Keyring”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\security.html#keyring). The instructions show how to ensure that the chosen component or plugin is active.

Only one keyring component or plugin should be enabled at a time. Enabling multiple keyring components or plugins is unsupported and results may not be as anticipated.

**Important**

Once encrypted tablespaces are created in a MySQL instance, the keyring component or plugin that was loaded when creating the encrypted tablespace must continue to be loaded at startup. Failing to do so results in errors when starting the server and during **InnoDB** recovery.

When encrypting production data, ensure that you take steps to prevent loss of the master encryption key. If the master encryption key is lost, data stored in encrypted tablespace files is unrecoverable. If you use the **component\_keyring\_file** or **component\_keyring\_encrypted\_file** component, or the **keyring\_file** or **keyring\_encrypted\_file** plugin, create a backup of the keyring data file immediately after creating the first encrypted tablespace, before master key rotation, and after master key rotation. For each component, its configuration file indicates the data file location. The [**keyring\_file\_data**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\security.html#sysvar_keyring_file_data) configuration option defines the keyring data file location for the **keyring\_file** plugin. The [**keyring\_encrypted\_file\_data**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\security.html#sysvar_keyring_encrypted_file_data) configuration option defines the keyring data file location for the **keyring\_encrypted\_file** plugin. If you use the **keyring\_okv** or **keyring\_aws** plugin, ensure that you have performed the necessary configuration. For instructions, see [Section 6.4.4, “The MySQL Keyring”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\security.html#keyring).

### Defining an Encryption Default for Schemas and General Tablespaces

As of MySQL 8.0.16, the [**default\_table\_encryption**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_default_table_encryption) system variable defines the default encryption setting for schemas and general tablespaces. [**CREATE TABLESPACE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-tablespace) and [**CREATE SCHEMA**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-database) operations apply the [**default\_table\_encryption**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_default_table_encryption) setting when an **ENCRYPTION** clause is not specified explicitly.

[**ALTER SCHEMA**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-database) and [**ALTER TABLESPACE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-tablespace) operations do not apply the [**default\_table\_encryption**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_default_table_encryption) setting. An **ENCRYPTION** clause must be specified explicitly to alter the encryption of an existing schema or general tablespace.

The [**default\_table\_encryption**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_default_table_encryption) variable can be set for an individual client connection or globally using [**SET**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#set-variable) syntax. For example, the following statement enables default schema and tablespace encryption globally:

mysql> SET GLOBAL default\_table\_encryption=ON;

The default encryption setting for a schema can also be defined using the **DEFAULT ENCRYPTION** clause when creating or altering a schema, as in this example:

mysql> CREATE SCHEMA test DEFAULT ENCRYPTION = 'Y';

If the **DEFAULT ENCRYPTION** clause is not specified when creating a schema, the [**default\_table\_encryption**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_default_table_encryption) setting is applied. The **DEFAULT ENCRYPTION** clause must be specified to alter the default encryption of an existing schema. Otherwise, the schema retains its current encryption setting.

By default, a table inherits the encryption setting of the schema or general tablespace it is created in. For example, a table created in an encryption-enabled schema is encrypted by default. This behavior enables a DBA to control table encryption usage by defining and enforcing schema and general tablespace encryption defaults.

Encryption defaults are enforced by enabling the [**table\_encryption\_privilege\_check**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_table_encryption_privilege_check) system variable. When [**table\_encryption\_privilege\_check**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_table_encryption_privilege_check) is enabled, a privilege check occurs when creating or altering a schema or general tablespace with an encryption setting that differs from the [**default\_table\_encryption**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_default_table_encryption) setting, or when creating or altering a table with an encryption setting that differs from the default schema encryption. When [**table\_encryption\_privilege\_check**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_table_encryption_privilege_check) is disabled (the default), the privilege check does not occur and the previously mentioned operations are permitted to proceed with a warning.

The [**TABLE\_ENCRYPTION\_ADMIN**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\security.html#priv_table-encryption-admin) privilege is required to override default encryption settings when [**table\_encryption\_privilege\_check**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_table_encryption_privilege_check) is enabled. A DBA can grant this privilege to enable a user to deviate from the [**default\_table\_encryption**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_default_table_encryption) setting when creating or altering a schema or general tablespace, or to deviate from the default schema encryption when creating or altering a table. This privilege does not permit deviating from the encryption of a general tablespace when creating or altering a table. A table must have the same encryption setting as the general tablespace it resides in.

### File-Per-Table Tablespace Encryption

As of MySQL 8.0.16, a file-per-table tablespace inherits the default encryption of the schema in which the table is created unless an **ENCRYPTION** clause is specified explcitly in the [**CREATE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-table) statement. Prior to MySQL 8.0.16, the **ENCRYPTION** clause must be specified to enable encryption.

mysql> **CREATE TABLE t1 (c1 INT) ENCRYPTION = 'Y';**

To alter the encryption of an existing file-per-table tablespace, an **ENCRYPTION** clause must be specified.

mysql> **ALTER TABLE t1 ENCRYPTION = 'Y';**

As of MySQL 8.0.16, if the [**table\_encryption\_privilege\_check**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_table_encryption_privilege_check) variable is enabled, specifying an **ENCRYPTION** clause with a setting that differs from the default schema encryption requires the [**TABLE\_ENCRYPTION\_ADMIN**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\security.html#priv_table-encryption-admin) privilege. See [Defining an Encryption Default for Schemas and General Tablespaces](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-schema-tablespace-encryption-default).

### General Tablespace Encryption

As of MySQL 8.0.16, the [**default\_table\_encryption**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_default_table_encryption) variable determines the encryption of a newly created general tablespace unless an **ENCRYPTION** clause is specified explicitly in the [**CREATE TABLESPACE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-tablespace) statement. Prior to MySQL 8.0.16, an **ENCRYPTION** clause must be specified to enable encryption.

mysql> **CREATE TABLESPACE `ts1` ADD DATAFILE 'ts1.ibd' ENCRYPTION = 'Y' Engine=InnoDB;**

To alter the encryption of an existing general tablespace, an **ENCRYPTION** clause must be specified.

mysql> **ALTER TABLESPACE ts1 ENCRYPTION = 'Y';**

As of MySQL 8.0.16, if the [**table\_encryption\_privilege\_check**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_table_encryption_privilege_check) variable is enabled, specifying an **ENCRYPTION** clause with a setting that differs from the [**default\_table\_encryption**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_default_table_encryption) setting requires the [**TABLE\_ENCRYPTION\_ADMIN**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\security.html#priv_table-encryption-admin) privilege. See [Defining an Encryption Default for Schemas and General Tablespaces](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-schema-tablespace-encryption-default).

### Doublewrite File Encryption

Encryption support for doublewrite files is available as of MySQL 8.0.23. **InnoDB** automatically encrypts doublewrite file pages that belong to encrypted tablespaces. No action is required. Doublewrite file pages are encrypted using the encryption key of the associated tablespace. The same encrypted page written to a tablespace data file is also written to a doublewrite file. Doublewrite file pages that belong to an unencrypted tablespace remain unencrypted.

During recovery, encrypted doublewrite file pages are unencrypted and checked for corruption.

### mysql System Tablespace Encryption

Encryption support for the **mysql** system tablespace is available as of MySQL 8.0.16.

The **mysql** system tablespace contains the **mysql** system database and MySQL data dictionary tables. It is unencrypted by default. To enable encryption for the **mysql** system tablespace, specify the tablespace name and the **ENCRYPTION** option in an [**ALTER TABLESPACE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-tablespace) statement.

mysql> ALTER TABLESPACE mysql ENCRYPTION = 'Y';

To disable encryption for the **mysql** system tablespace, set **ENCRYPTION = 'N'** using an [**ALTER TABLESPACE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-tablespace) statement.

mysql> ALTER TABLESPACE mysql ENCRYPTION = 'N';

Enabling or disabling encryption for the **mysql** system tablespace requires the [**CREATE TABLESPACE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\security.html#priv_create-tablespace) privilege on all tables in the instance (**CREATE TABLESPACE on \*.\*)**.

### Redo Log Encryption

Redo log data encryption is enabled using the [**innodb\_redo\_log\_encrypt**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_redo_log_encrypt) configuration option. Redo log encryption is disabled by default.

As with tablespace data, redo log data encryption occurs when redo log data is written to disk, and decryption occurs when redo log data is read from disk. Once redo log data is read into memory, it is in unencrypted form. Redo log data is encrypted and decrypted using the tablespace encryption key.

When [**innodb\_redo\_log\_encrypt**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_redo_log_encrypt) is enabled, unencrypted redo log pages that are present on disk remain unencrypted, and new redo log pages are written to disk in encrypted form. Likewise, when [**innodb\_redo\_log\_encrypt**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_redo_log_encrypt) is disabled, encrypted redo log pages that are present on disk remain encrypted, and new redo log pages are written to disk in unencrypted form.

Redo log encryption metadata, including the tablespace encryption key, is stored in the header of the first redo log file (ib\_logfile0). If this file is removed, redo log encryption is disabled.

Once redo log encryption is enabled, a normal restart without the keyring component or plugin or without the encryption key is not possible, as **InnoDB** must be able to scan redo pages during startup, which is not possible if redo log pages are encrypted. Without the keyring component or plugin or the encryption key, only a forced startup without the redo logs (**SRV\_FORCE\_NO\_LOG\_REDO**) is possible. See [Section 15.21.2, “Forcing InnoDB Recovery”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#forcing-innodb-recovery).

### Undo Log Encryption

Undo log data encryption is enabled using the [**innodb\_undo\_log\_encrypt**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_undo_log_encrypt) configuration option. Undo log encryption applies to undo logs that reside in [undo tablespaces](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_undo_tablespace). See [Section 15.6.3.4, “Undo Tablespaces”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-undo-tablespaces). Undo log data encryption is disabled by default.

As with tablespace data, undo log data encryption occurs when undo log data is written to disk, and decryption occurs when undo log data is read from disk. Once undo log data is read into memory, it is in unencrypted form. Undo log data is encrypted and decrypted using the tablespace encryption key.

When [**innodb\_undo\_log\_encrypt**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_undo_log_encrypt) is enabled, unencrypted undo log pages that are present on disk remain unencrypted, and new undo log pages are written to disk in encrypted form. Likewise, when [**innodb\_undo\_log\_encrypt**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_undo_log_encrypt) is disabled, encrypted undo log pages that are present on disk remain encrypted, and new undo log pages are written to disk in unencrypted form.

Undo log encryption metadata, including the tablespace encryption key, is stored in the header of the undo log file.

**Note**

When undo log encryption is disabled, the server continues to require the keyring component or plugin that was used to encrypt undo log data until the undo tablespaces that contained the encrypted undo log data are truncated. (An encryption header is only removed from an undo tablespace when the undo tablespace is truncated.) For information about truncating undo tablespaces, see [Truncating Undo Tablespaces](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#truncate-undo-tablespace).

### Master Key Rotation

The master encryption key should be rotated periodically and whenever you suspect that the key has been compromised.

Master key rotation is an atomic, instance-level operation. Each time the master encryption key is rotated, all tablespace keys in the MySQL instance are re-encrypted and saved back to their respective tablespace headers. As an atomic operation, re-encryption must succeed for all tablespace keys once a rotation operation is initiated. If master key rotation is interrupted by a server failure, **InnoDB** rolls the operation forward on server restart. For more information, see [Encryption and Recovery](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-data-encryption-recovery).

Rotating the master encryption key only changes the master encryption key and re-encrypts tablespace keys. It does not decrypt or re-encrypt associated tablespace data.

Rotating the master encryption key requires the [**ENCRYPTION\_KEY\_ADMIN**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\security.html#priv_encryption-key-admin) privilege (or the deprecated [**SUPER**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\security.html#priv_super) privilege).

To rotate the master encryption key, run:

mysql> **ALTER INSTANCE ROTATE INNODB MASTER KEY;**

[**ALTER INSTANCE ROTATE INNODB MASTER KEY**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-instance-rotate-innodb-master-key) supports concurrent DML. However, it cannot be run concurrently with tablespace encryption operations, and locks are taken to prevent conflicts that could arise from concurrent execution. If an [**ALTER INSTANCE ROTATE INNODB MASTER KEY**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-instance-rotate-innodb-master-key) operation is running, it must finish before a tablespace encryption operation can proceed, and vice versa.

### Encryption and Recovery

If a server failure occurs during an encryption operation, the operation is rolled forward when the server is restarted. For general tablespaces, the encryption operation is resumed in a background thread from the last processed page.

If a server failure occurs during master key rotation, **InnoDB** continues the operation on server restart.

The keyring component or plugin must be loaded prior to storage engine initialization so that the information necessary to decrypt tablespace data pages can be retrieved from tablespace headers before **InnoDB** initialization and recovery activities access tablespace data. (See [Encryption Prerequisites](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-data-encryption-encryption-prerequisites).)

When **InnoDB** initialization and recovery begin, the master key rotation operation resumes. Due to the server failure, some tablespace keys may already be encrypted using the new master encryption key. **InnoDB** reads the encryption data from each tablespace header, and if the data indicates that the tablespace key is encrypted using the old master encryption key, **InnoDB** retrieves the old key from the keyring and uses it to decrypt the tablespace key. **InnoDB** then re-encrypts the tablespace key using the new master encryption key and saves the re-encrypted tablespace key back to the tablespace header.

### Exporting Encrypted Tablespaces

Tablespace export is only supported for file-per-table tablespaces.

When an encrypted tablespace is exported, **InnoDB** generates a transfer key that is used to encrypt the tablespace key. The encrypted tablespace key and transfer key are stored in a ***tablespace\_name***.cfp file. This file together with the encrypted tablespace file is required to perform an import operation. On import, **InnoDB** uses the transfer key to decrypt the tablespace key in the ***tablespace\_name***.cfp file. For related information, see [Section 15.6.1.3, “Importing InnoDB Tables”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-table-import).

### Encryption and Replication

The [**ALTER INSTANCE ROTATE INNODB MASTER KEY**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-instance-rotate-innodb-master-key) statement is only supported in replication environments where the source and replica run a version of MySQL that supports tablespace encryption.

Successful [**ALTER INSTANCE ROTATE INNODB MASTER KEY**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-instance-rotate-innodb-master-key) statements are written to the binary log for replication on replicas.

If an [**ALTER INSTANCE ROTATE INNODB MASTER KEY**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-instance-rotate-innodb-master-key) statement fails, it is not logged to the binary log and is not replicated on replicas.

Replication of an [**ALTER INSTANCE ROTATE INNODB MASTER KEY**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-instance-rotate-innodb-master-key) operation fails if the keyring component or plugin is installed on the source but not on the replica.

If the **keyring\_file** or **keyring\_encrypted\_file** plugin is installed on both the source and a replica but the replica does not have a keyring data file, the replicated [**ALTER INSTANCE ROTATE INNODB MASTER KEY**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-instance-rotate-innodb-master-key) statement creates the keyring data file on the replica, assuming the keyring file data is not cached in memory. [**ALTER INSTANCE ROTATE INNODB MASTER KEY**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-instance-rotate-innodb-master-key) uses keyring file data that is cached in memory, if available.

### Identifying Encrypted Tablespaces and Schemas

The [**INFORMATION\_SCHEMA.INNODB\_TABLESPACES**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-tablespaces-table) table, introduced in MySQL 8.0.13, includes an **ENCRYPTION** column that can be used to identify encrypted tablespaces.

mysql> **SELECT SPACE, NAME, SPACE\_TYPE, ENCRYPTION FROM INFORMATION\_SCHEMA.INNODB\_TABLESPACES**

**WHERE ENCRYPTION='Y'\G**

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\* 1. row \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

SPACE: 4294967294

NAME: mysql

SPACE\_TYPE: General

ENCRYPTION: Y

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\* 2. row \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

SPACE: 2

NAME: test/t1

SPACE\_TYPE: Single

ENCRYPTION: Y

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\* 3. row \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

SPACE: 3

NAME: ts1

SPACE\_TYPE: General

ENCRYPTION: Y

When the **ENCRYPTION** option is specified in a [**CREATE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-table) or [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) statement, it is recorded in the **CREATE\_OPTIONS** column of [**INFORMATION\_SCHEMA.TABLES**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-tables-table). This column can be queried to identify tables that reside in encrypted file-per-table tablespaces.

mysql> **SELECT TABLE\_SCHEMA, TABLE\_NAME, CREATE\_OPTIONS FROM INFORMATION\_SCHEMA.TABLES**

**WHERE CREATE\_OPTIONS LIKE '%ENCRYPTION%';**

+--------------+------------+----------------+

| TABLE\_SCHEMA | TABLE\_NAME | CREATE\_OPTIONS |

+--------------+------------+----------------+

| test | t1 | ENCRYPTION="Y" |

+--------------+------------+----------------+

Query [**INFORMATION\_SCHEMA.INNODB\_TABLESPACES**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-tablespaces-table) to retrieve information about the tablespace associated with a particular schema and table.

mysql> **SELECT SPACE, NAME, SPACE\_TYPE FROM INFORMATION\_SCHEMA.INNODB\_TABLESPACES WHERE NAME='test/t1';**

+-------+---------+------------+

| SPACE | NAME | SPACE\_TYPE |

+-------+---------+------------+

| 3 | test/t1 | Single |

+-------+---------+------------+

You can identify encryption-enabled schemas by querying the [**INFORMATION\_SCHEMA.SCHEMATA**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-schemata-table) table.

mysql> **SELECT SCHEMA\_NAME, DEFAULT\_ENCRYPTION FROM INFORMATION\_SCHEMA.SCHEMATA**

**WHERE DEFAULT\_ENCRYPTION='YES';**

+-------------+--------------------+

| SCHEMA\_NAME | DEFAULT\_ENCRYPTION |

+-------------+--------------------+

| test | YES |

+-------------+--------------------+

[**SHOW CREATE SCHEMA**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#show-create-database) also shows the **DEFAULT ENCRYPTION** clause.

### Monitoring Encryption Progress

You can monitor general tablespace and **mysql** system tablespace encryption progress using [Performance Schema](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html).

The **stage/innodb/alter tablespace (encryption)** stage event instrument reports **WORK\_ESTIMATED** and **WORK\_COMPLETED** information for general tablespace encryption operations.

The following example demonstrates how to enable the **stage/innodb/alter tablespace (encryption)** stage event instrument and related consumer tables to monitor general tablespace or **mysql** system tablespace encryption progress. For information about Performance Schema stage event instruments and related consumers, see [Section 27.12.5, “Performance Schema Stage Event Tables”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html#performance-schema-stage-tables).

Enable the **stage/innodb/alter tablespace (encryption)** instrument:

mysql> **USE performance\_schema;**

mysql> **UPDATE setup\_instruments SET ENABLED = 'YES'**

**WHERE NAME LIKE 'stage/innodb/alter tablespace (encryption)';**

Enable the stage event consumer tables, which include [**events\_stages\_current**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html#performance-schema-events-stages-current-table), [**events\_stages\_history**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html#performance-schema-events-stages-history-table), and [**events\_stages\_history\_long**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html#performance-schema-events-stages-history-long-table).

mysql> **UPDATE setup\_consumers SET ENABLED = 'YES' WHERE NAME LIKE '%stages%';**

Run a tablespace encryption operation. In this example, a general tablespace named **ts1** is encrypted.

mysql> **ALTER TABLESPACE ts1 ENCRYPTION = 'Y';**

Check the progress of the encryption operation by querying the Performance Schema [**events\_stages\_current**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html#performance-schema-events-stages-current-table) table. **WORK\_ESTIMATED** reports the total number of pages in the tablespace. **WORK\_COMPLETED** reports the number of pages processed.

mysql> **SELECT EVENT\_NAME, WORK\_ESTIMATED, WORK\_COMPLETED FROM events\_stages\_current;**

+--------------------------------------------+----------------+----------------+

| EVENT\_NAME | WORK\_COMPLETED | WORK\_ESTIMATED |

+--------------------------------------------+----------------+----------------+

| stage/innodb/alter tablespace (encryption) | 1056 | 1407 |

+--------------------------------------------+----------------+----------------+

The [**events\_stages\_current**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html#performance-schema-events-stages-current-table) table returns an empty set if the encryption operation has completed. In this case, you can check the [**events\_stages\_history**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html#performance-schema-events-stages-history-table) table to view event data for the completed operation. For example:

mysql> **SELECT EVENT\_NAME, WORK\_COMPLETED, WORK\_ESTIMATED FROM events\_stages\_history;**

+--------------------------------------------+----------------+----------------+

| EVENT\_NAME | WORK\_COMPLETED | WORK\_ESTIMATED |

+--------------------------------------------+----------------+----------------+

| stage/innodb/alter tablespace (encryption) | 1407 | 1407 |

+--------------------------------------------+----------------+----------------+

### Encryption Usage Notes

Plan appropriately when altering an existing file-per-table tablespace with the **ENCRYPTION** option. Tables residing in file-per-table tablespaces are rebuilt using the **COPY** algorithm. The **INPLACE** algorithm is used when altering the **ENCRYPTION** attribute of a general tablespace or the **mysql** system tablespace. The **INPLACE** algorithm permits concurrent DML on tables that reside in the general tablespace. Concurrent DDL is blocked.

When a general tablespace or the **mysql** system tablespace is encrypted, all tables residing in the tablespace are encrypted. Likewise, a table created in an encrypted tablespace is encrypted.

If the server exits or is stopped during normal operation, it is recommended to restart the server using the same encryption settings that were configured previously.

The first master encryption key is generated when the first new or existing tablespace is encrypted.

Master key rotation re-encrypts tablespaces keys but does not change the tablespace key itself. To change a tablespace key, you must disable and re-enable encryption. For file-per-table tablespaces, re-encrypting the tablespace is an **ALGORITHM=COPY** operation that rebuilds the table. For general tablespaces and the **mysql** system tablespace, it is an **ALGORITHM=INPLACE** operation, which does not require rebuilding tables that reside in the tablespace.

If a table is created with both the [**COMPRESSION**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-table) and [**ENCRYPTION**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-table) options, compression is performed before tablespace data is encrypted.

If a keyring data file (the file named by [**keyring\_file\_data**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\security.html#sysvar_keyring_file_data) or [**keyring\_encrypted\_file\_data**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\security.html#sysvar_keyring_encrypted_file_data)) is empty or missing, the first execution of [**ALTER INSTANCE ROTATE INNODB MASTER KEY**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-instance-rotate-innodb-master-key) creates a master encryption key.

Uninstalling the **component\_keyring\_file** or **component\_keyring\_encrypted\_file** component does not remove an existing keyring data file. Uninstalling the **keyring\_file** or **keyring\_encrypted\_file** plugin does not remove an existing keyring data file.

It is recommended that you not place a keyring data file under the same directory as tablespace data files.

Modifying the [**keyring\_file\_data**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\security.html#sysvar_keyring_file_data) or [**keyring\_encrypted\_file\_data**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\security.html#sysvar_keyring_encrypted_file_data) setting at runtime or when restarting the server can cause previously encrypted tablespaces to become inaccessible, resulting in lost data.

Encryption is supported for the **InnoDB** **FULLTEXT** index tables that are created implicitly when adding a **FULLTEXT** index, but only if the **FULLTEXT** index is created on a table that resides in an encrypted general tablespace. In this case, the **FULLTEXT** index tables are created in the same encrypted general tablespace. For related information, see [InnoDB Full-Text Index Tables](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-fulltext-index-tables).

### Encryption Limitations

Advanced Encryption Standard (AES) is the only supported encryption algorithm. **InnoDB** tablespace encryption uses Electronic Codebook (ECB) block encryption mode for tablespace key encryption and Cipher Block Chaining (CBC) block encryption mode for data encryption. Padding is not used with CBC block encryption mode. Instead, **InnoDB** ensures that the text to be encrypted is a multiple of the block size.

Encryption is only supported for [file-per-table](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_file_per_table) tablespaces, [general](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_general_tablespace) tablespaces, and the **mysql** system tablespace. Encryption support for general tablespaces was introduced in MySQL 8.0.13. Encryption support for the **mysql** system tablespace is available as of MySQL 8.0.16. Encryption is not supported for other tablespace types including the **InnoDB** [system tablespace](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_system_tablespace).

You cannot move or copy a table from an encrypted [file-per-table](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_file_per_table) tablespace, [general](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_general_tablespace) tablespace, or the **mysql** system tablespace to a tablespace type that does not support encryption.

You cannot move or copy a table from an encrypted tablespace to an unencrypted tablespace. However, moving a table from an unencrypted tablespace to an encrypted one is permitted. For example, you can move or copy a table from a unencrypted [file-per-table](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_file_per_table) or [general](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_general_tablespace) tablespace to an encrypted general tablespace.

By default, tablespace encryption only applies to data in the tablespace. Redo log and undo log data can be encrypted by enabling [**innodb\_redo\_log\_encrypt**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_redo_log_encrypt) and [**innodb\_undo\_log\_encrypt**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_undo_log_encrypt). See [Redo Log Encryption](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-data-encryption-redo-log), and [Undo Log Encryption](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-data-encryption-undo-log). For information about binary log file and relay log file encryption, see [Section 17.3.2, “Encrypting Binary Log Files and Relay Log Files”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\replication.html#replication-binlog-encryption).

It is not permitted to change the storage engine of a table that resides in, or previously resided in, an encrypted tablespace.

## 15.14 InnoDB Startup Options and System Variables

System variables that are true or false can be enabled at server startup by naming them, or disabled by using a **--skip-** prefix. For example, to enable or disable the **InnoDB** adaptive hash index, you can use [--innodb-adaptive-hash-index](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_adaptive_hash_index) or [--skip-innodb-adaptive-hash-index](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_adaptive_hash_index) on the command line, or [**innodb\_adaptive\_hash\_index**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_adaptive_hash_index) or **skip\_innodb\_adaptive\_hash\_index** in an option file.

System variables that take a numeric value can be specified as --***var\_name***=***value*** on the command line or as ***var\_name*=*value*** in option files.

Many system variables can be changed at runtime (see [Section 5.1.9.2, “Dynamic System Variables”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#dynamic-system-variables)).

For information about **GLOBAL** and **SESSION** variable scope modifiers, refer to the [**SET**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#set-variable) statement documentation.

Certain options control the locations and layout of the **InnoDB** data files. [Section 15.8.1, “InnoDB Startup Configuration”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-init-startup-configuration) explains how to use these options.

Some options, which you might not use initially, help tune **InnoDB** performance characteristics based on machine capacity and your database [workload](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_workload).

For more information on specifying options and system variables, see [Section 4.2.2, “Specifying Program Options”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\programs.html#program-options).

**Table 15.24 InnoDB Option and Variable Reference**

| **Name** | **Cmd-Line** | **Option File** | **System Var** | **Status Var** | **Var Scope** | **Dynamic** |
| --- | --- | --- | --- | --- | --- | --- |
| [**daemon\_memcached\_enable\_binlog**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_daemon_memcached_enable_binlog) | Yes | Yes | Yes |  | Global | No |
| [**daemon\_memcached\_engine\_lib\_name**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_daemon_memcached_engine_lib_name) | Yes | Yes | Yes |  | Global | No |
| [**daemon\_memcached\_engine\_lib\_path**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_daemon_memcached_engine_lib_path) | Yes | Yes | Yes |  | Global | No |
| [**daemon\_memcached\_option**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_daemon_memcached_option) | Yes | Yes | Yes |  | Global | No |
| [**daemon\_memcached\_r\_batch\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_daemon_memcached_r_batch_size) | Yes | Yes | Yes |  | Global | No |
| [**daemon\_memcached\_w\_batch\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_daemon_memcached_w_batch_size) | Yes | Yes | Yes |  | Global | No |
| [**foreign\_key\_checks**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_foreign_key_checks) |  |  | Yes |  | Both | Yes |
| [**innodb**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#option_mysqld_innodb) | Yes | Yes |  |  |  |  |
| [**innodb\_adaptive\_flushing**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_adaptive_flushing) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_adaptive\_flushing\_lwm**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_adaptive_flushing_lwm) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_adaptive\_hash\_index**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_adaptive_hash_index) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_adaptive\_hash\_index\_parts**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_adaptive_hash_index_parts) | Yes | Yes | Yes |  | Global | No |
| [**innodb\_adaptive\_max\_sleep\_delay**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_adaptive_max_sleep_delay) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_api\_bk\_commit\_interval**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_api_bk_commit_interval) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_api\_disable\_rowlock**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_api_disable_rowlock) | Yes | Yes | Yes |  | Global | No |
| [**innodb\_api\_enable\_binlog**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_api_enable_binlog) | Yes | Yes | Yes |  | Global | No |
| [**innodb\_api\_enable\_mdl**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_api_enable_mdl) | Yes | Yes | Yes |  | Global | No |
| [**innodb\_api\_trx\_level**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_api_trx_level) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_autoextend\_increment**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_autoextend_increment) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_autoinc\_lock\_mode**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_autoinc_lock_mode) | Yes | Yes | Yes |  | Global | No |
| [**innodb\_background\_drop\_list\_empty**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_background_drop_list_empty) | Yes | Yes | Yes |  | Global | Yes |
| [**Innodb\_buffer\_pool\_bytes\_data**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#statvar_Innodb_buffer_pool_bytes_data) |  |  |  | Yes | Global | No |
| [**Innodb\_buffer\_pool\_bytes\_dirty**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#statvar_Innodb_buffer_pool_bytes_dirty) |  |  |  | Yes | Global | No |
| [**innodb\_buffer\_pool\_chunk\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_chunk_size) | Yes | Yes | Yes |  | Global | No |
| [**innodb\_buffer\_pool\_debug**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_debug) | Yes | Yes | Yes |  | Global | No |
| [**innodb\_buffer\_pool\_dump\_at\_shutdown**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_dump_at_shutdown) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_buffer\_pool\_dump\_now**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_dump_now) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_buffer\_pool\_dump\_pct**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_dump_pct) | Yes | Yes | Yes |  | Global | Yes |
| [**Innodb\_buffer\_pool\_dump\_status**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#statvar_Innodb_buffer_pool_dump_status) |  |  |  | Yes | Global | No |
| [**innodb\_buffer\_pool\_filename**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_filename) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_buffer\_pool\_in\_core\_file**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_in_core_file) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_buffer\_pool\_instances**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_instances) | Yes | Yes | Yes |  | Global | No |
| [**innodb\_buffer\_pool\_load\_abort**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_load_abort) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_buffer\_pool\_load\_at\_startup**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_load_at_startup) | Yes | Yes | Yes |  | Global | No |
| [**innodb\_buffer\_pool\_load\_now**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_load_now) | Yes | Yes | Yes |  | Global | Yes |
| [**Innodb\_buffer\_pool\_load\_status**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#statvar_Innodb_buffer_pool_load_status) |  |  |  | Yes | Global | No |
| [**Innodb\_buffer\_pool\_pages\_data**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#statvar_Innodb_buffer_pool_pages_data) |  |  |  | Yes | Global | No |
| [**Innodb\_buffer\_pool\_pages\_dirty**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#statvar_Innodb_buffer_pool_pages_dirty) |  |  |  | Yes | Global | No |
| [**Innodb\_buffer\_pool\_pages\_flushed**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#statvar_Innodb_buffer_pool_pages_flushed) |  |  |  | Yes | Global | No |
| [**Innodb\_buffer\_pool\_pages\_free**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#statvar_Innodb_buffer_pool_pages_free) |  |  |  | Yes | Global | No |
| [**Innodb\_buffer\_pool\_pages\_latched**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#statvar_Innodb_buffer_pool_pages_latched) |  |  |  | Yes | Global | No |
| [**Innodb\_buffer\_pool\_pages\_misc**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#statvar_Innodb_buffer_pool_pages_misc) |  |  |  | Yes | Global | No |
| [**Innodb\_buffer\_pool\_pages\_total**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#statvar_Innodb_buffer_pool_pages_total) |  |  |  | Yes | Global | No |
| [**Innodb\_buffer\_pool\_read\_ahead**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#statvar_Innodb_buffer_pool_read_ahead) |  |  |  | Yes | Global | No |
| [**Innodb\_buffer\_pool\_read\_ahead\_evicted**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#statvar_Innodb_buffer_pool_read_ahead_evicted) |  |  |  | Yes | Global | No |
| [**Innodb\_buffer\_pool\_read\_ahead\_rnd**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#statvar_Innodb_buffer_pool_read_ahead_rnd) |  |  |  | Yes | Global | No |
| [**Innodb\_buffer\_pool\_read\_requests**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#statvar_Innodb_buffer_pool_read_requests) |  |  |  | Yes | Global | No |
| [**Innodb\_buffer\_pool\_reads**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#statvar_Innodb_buffer_pool_reads) |  |  |  | Yes | Global | No |
| [**Innodb\_buffer\_pool\_resize\_status**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#statvar_Innodb_buffer_pool_resize_status) |  |  |  | Yes | Global | No |
| [**innodb\_buffer\_pool\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_size) | Yes | Yes | Yes |  | Global | Yes |
| [**Innodb\_buffer\_pool\_wait\_free**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#statvar_Innodb_buffer_pool_wait_free) |  |  |  | Yes | Global | No |
| [**Innodb\_buffer\_pool\_write\_requests**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#statvar_Innodb_buffer_pool_write_requests) |  |  |  | Yes | Global | No |
| [**innodb\_change\_buffer\_max\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_change_buffer_max_size) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_change\_buffering**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_change_buffering) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_change\_buffering\_debug**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_change_buffering_debug) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_checkpoint\_disabled**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_checkpoint_disabled) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_checksum\_algorithm**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_checksum_algorithm) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_cmp\_per\_index\_enabled**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_cmp_per_index_enabled) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_commit\_concurrency**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_commit_concurrency) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_compress\_debug**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_compress_debug) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_compression\_failure\_threshold\_pct**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_compression_failure_threshold_pct) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_compression\_level**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_compression_level) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_compression\_pad\_pct\_max**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_compression_pad_pct_max) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_concurrency\_tickets**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_concurrency_tickets) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_data\_file\_path**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_data_file_path) | Yes | Yes | Yes |  | Global | No |
| [**Innodb\_data\_fsyncs**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#statvar_Innodb_data_fsyncs) |  |  |  | Yes | Global | No |
| [**innodb\_data\_home\_dir**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_data_home_dir) | Yes | Yes | Yes |  | Global | No |
| [**Innodb\_data\_pending\_fsyncs**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#statvar_Innodb_data_pending_fsyncs) |  |  |  | Yes | Global | No |
| [**Innodb\_data\_pending\_reads**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#statvar_Innodb_data_pending_reads) |  |  |  | Yes | Global | No |
| [**Innodb\_data\_pending\_writes**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#statvar_Innodb_data_pending_writes) |  |  |  | Yes | Global | No |
| [**Innodb\_data\_read**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#statvar_Innodb_data_read) |  |  |  | Yes | Global | No |
| [**Innodb\_data\_reads**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#statvar_Innodb_data_reads) |  |  |  | Yes | Global | No |
| [**Innodb\_data\_writes**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#statvar_Innodb_data_writes) |  |  |  | Yes | Global | No |
| [**Innodb\_data\_written**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#statvar_Innodb_data_written) |  |  |  | Yes | Global | No |
| [**Innodb\_dblwr\_pages\_written**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#statvar_Innodb_dblwr_pages_written) |  |  |  | Yes | Global | No |
| [**Innodb\_dblwr\_writes**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#statvar_Innodb_dblwr_writes) |  |  |  | Yes | Global | No |
| [**innodb\_ddl\_log\_crash\_reset\_debug**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_ddl_log_crash_reset_debug) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_deadlock\_detect**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_deadlock_detect) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_dedicated\_server**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_dedicated_server) | Yes | Yes | Yes |  | Global | No |
| [**innodb\_default\_row\_format**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_default_row_format) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_directories**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_directories) | Yes | Yes | Yes |  | Global | No |
| [**innodb\_disable\_sort\_file\_cache**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_disable_sort_file_cache) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_doublewrite**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_doublewrite) | Yes | Yes | Yes |  | Global | No |
| [**innodb\_doublewrite\_batch\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_doublewrite_batch_size) | Yes | Yes | Yes |  | Global | No |
| [**innodb\_doublewrite\_dir**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_doublewrite_dir) | Yes | Yes | Yes |  | Global | No |
| [**innodb\_doublewrite\_files**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_doublewrite_files) | Yes | Yes | Yes |  | Global | No |
| [**innodb\_doublewrite\_pages**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_doublewrite_pages) | Yes | Yes | Yes |  | Global | No |
| [**innodb\_fast\_shutdown**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_fast_shutdown) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_fil\_make\_page\_dirty\_debug**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_fil_make_page_dirty_debug) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_file\_per\_table**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_file_per_table) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_fill\_factor**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_fill_factor) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_flush\_log\_at\_timeout**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_flush_log_at_timeout) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_flush\_log\_at\_trx\_commit**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_flush_log_at_trx_commit) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_flush\_method**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_flush_method) | Yes | Yes | Yes |  | Global | No |
| [**innodb\_flush\_neighbors**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_flush_neighbors) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_flush\_sync**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_flush_sync) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_flushing\_avg\_loops**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_flushing_avg_loops) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_force\_load\_corrupted**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_force_load_corrupted) | Yes | Yes | Yes |  | Global | No |
| [**innodb\_force\_recovery**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_force_recovery) | Yes | Yes | Yes |  | Global | No |
| [**innodb\_fsync\_threshold**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_fsync_threshold) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_ft\_aux\_table**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_ft_aux_table) |  |  | Yes |  | Global | Yes |
| [**innodb\_ft\_cache\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_ft_cache_size) | Yes | Yes | Yes |  | Global | No |
| [**innodb\_ft\_enable\_diag\_print**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_ft_enable_diag_print) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_ft\_enable\_stopword**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_ft_enable_stopword) | Yes | Yes | Yes |  | Both | Yes |
| [**innodb\_ft\_max\_token\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_ft_max_token_size) | Yes | Yes | Yes |  | Global | No |
| [**innodb\_ft\_min\_token\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_ft_min_token_size) | Yes | Yes | Yes |  | Global | No |
| [**innodb\_ft\_num\_word\_optimize**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_ft_num_word_optimize) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_ft\_result\_cache\_limit**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_ft_result_cache_limit) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_ft\_server\_stopword\_table**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_ft_server_stopword_table) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_ft\_sort\_pll\_degree**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_ft_sort_pll_degree) | Yes | Yes | Yes |  | Global | No |
| [**innodb\_ft\_total\_cache\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_ft_total_cache_size) | Yes | Yes | Yes |  | Global | No |
| [**innodb\_ft\_user\_stopword\_table**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_ft_user_stopword_table) | Yes | Yes | Yes |  | Both | Yes |
| [**Innodb\_have\_atomic\_builtins**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#statvar_Innodb_have_atomic_builtins) |  |  |  | Yes | Global | No |
| [**innodb\_idle\_flush\_pct**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_idle_flush_pct) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_io\_capacity**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_io_capacity) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_io\_capacity\_max**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_io_capacity_max) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_limit\_optimistic\_insert\_debug**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_limit_optimistic_insert_debug) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_lock\_wait\_timeout**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_lock_wait_timeout) | Yes | Yes | Yes |  | Both | Yes |
| [**innodb\_log\_buffer\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_log_buffer_size) | Yes | Yes | Yes |  | Global | Varies |
| [**innodb\_log\_checkpoint\_fuzzy\_now**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_log_checkpoint_fuzzy_now) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_log\_checkpoint\_now**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_log_checkpoint_now) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_log\_checksums**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_log_checksums) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_log\_compressed\_pages**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_log_compressed_pages) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_log\_file\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_log_file_size) | Yes | Yes | Yes |  | Global | No |
| [**innodb\_log\_files\_in\_group**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_log_files_in_group) | Yes | Yes | Yes |  | Global | No |
| [**innodb\_log\_group\_home\_dir**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_log_group_home_dir) | Yes | Yes | Yes |  | Global | No |
| [**innodb\_log\_spin\_cpu\_abs\_lwm**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_log_spin_cpu_abs_lwm) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_log\_spin\_cpu\_pct\_hwm**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_log_spin_cpu_pct_hwm) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_log\_wait\_for\_flush\_spin\_hwm**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_log_wait_for_flush_spin_hwm) | Yes | Yes | Yes |  | Global | Yes |
| [**Innodb\_log\_waits**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#statvar_Innodb_log_waits) |  |  |  | Yes | Global | No |
| [**innodb\_log\_write\_ahead\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_log_write_ahead_size) | Yes | Yes | Yes |  | Global | Yes |
| [**Innodb\_log\_write\_requests**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#statvar_Innodb_log_write_requests) |  |  |  | Yes | Global | No |
| [**innodb\_log\_writer\_threads**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_log_writer_threads) | Yes | Yes | Yes |  | Global | Yes |
| [**Innodb\_log\_writes**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#statvar_Innodb_log_writes) |  |  |  | Yes | Global | No |
| [**innodb\_lru\_scan\_depth**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_lru_scan_depth) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_max\_dirty\_pages\_pct**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_max_dirty_pages_pct) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_max\_dirty\_pages\_pct\_lwm**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_max_dirty_pages_pct_lwm) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_max\_purge\_lag**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_max_purge_lag) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_max\_purge\_lag\_delay**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_max_purge_lag_delay) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_max\_undo\_log\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_max_undo_log_size) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_merge\_threshold\_set\_all\_debug**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_merge_threshold_set_all_debug) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_monitor\_disable**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_monitor_disable) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_monitor\_enable**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_monitor_enable) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_monitor\_reset**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_monitor_reset) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_monitor\_reset\_all**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_monitor_reset_all) | Yes | Yes | Yes |  | Global | Yes |
| [**Innodb\_num\_open\_files**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#statvar_Innodb_num_open_files) |  |  |  | Yes | Global | No |
| [**innodb\_numa\_interleave**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_numa_interleave) | Yes | Yes | Yes |  | Global | No |
| [**innodb\_old\_blocks\_pct**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_old_blocks_pct) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_old\_blocks\_time**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_old_blocks_time) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_online\_alter\_log\_max\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_online_alter_log_max_size) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_open\_files**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_open_files) | Yes | Yes | Yes |  | Global | No |
| [**innodb\_optimize\_fulltext\_only**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_optimize_fulltext_only) | Yes | Yes | Yes |  | Global | Yes |
| [**Innodb\_os\_log\_fsyncs**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#statvar_Innodb_os_log_fsyncs) |  |  |  | Yes | Global | No |
| [**Innodb\_os\_log\_pending\_fsyncs**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#statvar_Innodb_os_log_pending_fsyncs) |  |  |  | Yes | Global | No |
| [**Innodb\_os\_log\_pending\_writes**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#statvar_Innodb_os_log_pending_writes) |  |  |  | Yes | Global | No |
| [**Innodb\_os\_log\_written**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#statvar_Innodb_os_log_written) |  |  |  | Yes | Global | No |
| [**innodb\_page\_cleaners**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_page_cleaners) | Yes | Yes | Yes |  | Global | No |
| [**Innodb\_page\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#statvar_Innodb_page_size) |  |  |  | Yes | Global | No |
| [**innodb\_page\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_page_size) | Yes | Yes | Yes |  | Global | No |
| [**Innodb\_pages\_created**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#statvar_Innodb_pages_created) |  |  |  | Yes | Global | No |
| [**Innodb\_pages\_read**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#statvar_Innodb_pages_read) |  |  |  | Yes | Global | No |
| [**Innodb\_pages\_written**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#statvar_Innodb_pages_written) |  |  |  | Yes | Global | No |
| [**innodb\_parallel\_read\_threads**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_parallel_read_threads) | Yes | Yes | Yes |  | Session | Yes |
| [**innodb\_print\_all\_deadlocks**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_print_all_deadlocks) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_print\_ddl\_logs**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_print_ddl_logs) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_purge\_batch\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_purge_batch_size) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_purge\_rseg\_truncate\_frequency**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_purge_rseg_truncate_frequency) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_purge\_threads**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_purge_threads) | Yes | Yes | Yes |  | Global | No |
| [**innodb\_random\_read\_ahead**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_random_read_ahead) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_read\_ahead\_threshold**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_read_ahead_threshold) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_read\_io\_threads**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_read_io_threads) | Yes | Yes | Yes |  | Global | No |
| [**innodb\_read\_only**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_read_only) | Yes | Yes | Yes |  | Global | No |
| [**innodb\_redo\_log\_archive\_dirs**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_redo_log_archive_dirs) | Yes | Yes | Yes |  | Global | Yes |
| [**Innodb\_redo\_log\_enabled**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#statvar_Innodb_redo_log_enabled) |  |  |  | Yes | Global | No |
| [**innodb\_redo\_log\_encrypt**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_redo_log_encrypt) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_replication\_delay**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_replication_delay) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_rollback\_on\_timeout**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_rollback_on_timeout) | Yes | Yes | Yes |  | Global | No |
| [**innodb\_rollback\_segments**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_rollback_segments) | Yes | Yes | Yes |  | Global | Yes |
| [**Innodb\_row\_lock\_current\_waits**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#statvar_Innodb_row_lock_current_waits) |  |  |  | Yes | Global | No |
| [**Innodb\_row\_lock\_time**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#statvar_Innodb_row_lock_time) |  |  |  | Yes | Global | No |
| [**Innodb\_row\_lock\_time\_avg**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#statvar_Innodb_row_lock_time_avg) |  |  |  | Yes | Global | No |
| [**Innodb\_row\_lock\_time\_max**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#statvar_Innodb_row_lock_time_max) |  |  |  | Yes | Global | No |
| [**Innodb\_row\_lock\_waits**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#statvar_Innodb_row_lock_waits) |  |  |  | Yes | Global | No |
| [**Innodb\_rows\_deleted**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#statvar_Innodb_rows_deleted) |  |  |  | Yes | Global | No |
| [**Innodb\_rows\_inserted**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#statvar_Innodb_rows_inserted) |  |  |  | Yes | Global | No |
| [**Innodb\_rows\_read**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#statvar_Innodb_rows_read) |  |  |  | Yes | Global | No |
| [**Innodb\_rows\_updated**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#statvar_Innodb_rows_updated) |  |  |  | Yes | Global | No |
| [**innodb\_saved\_page\_number\_debug**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_saved_page_number_debug) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_segment\_reserve\_factor**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_segment_reserve_factor) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_sort\_buffer\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_sort_buffer_size) | Yes | Yes | Yes |  | Global | No |
| [**innodb\_spin\_wait\_delay**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_spin_wait_delay) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_spin\_wait\_pause\_multiplier**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_spin_wait_pause_multiplier) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_stats\_auto\_recalc**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_stats_auto_recalc) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_stats\_include\_delete\_marked**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_stats_include_delete_marked) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_stats\_method**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_stats_method) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_stats\_on\_metadata**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_stats_on_metadata) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_stats\_persistent**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_stats_persistent) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_stats\_persistent\_sample\_pages**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_stats_persistent_sample_pages) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_stats\_transient\_sample\_pages**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_stats_transient_sample_pages) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb-status-file**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#option_mysqld_innodb-status-file) | Yes | Yes |  |  |  |  |
| [**innodb\_status\_output**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_status_output) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_status\_output\_locks**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_status_output_locks) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_strict\_mode**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_strict_mode) | Yes | Yes | Yes |  | Both | Yes |
| [**innodb\_sync\_array\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_sync_array_size) | Yes | Yes | Yes |  | Global | No |
| [**innodb\_sync\_debug**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_sync_debug) | Yes | Yes | Yes |  | Global | No |
| [**innodb\_sync\_spin\_loops**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_sync_spin_loops) | Yes | Yes | Yes |  | Global | Yes |
| [**Innodb\_system\_rows\_deleted**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#statvar_Innodb_system_rows_deleted) |  |  |  | Yes | Global | No |
| [**Innodb\_system\_rows\_inserted**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#statvar_Innodb_system_rows_inserted) |  |  |  | Yes | Global | No |
| [**Innodb\_system\_rows\_read**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#statvar_Innodb_system_rows_read) |  |  |  | Yes | Global | No |
| [**innodb\_table\_locks**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_table_locks) | Yes | Yes | Yes |  | Both | Yes |
| [**innodb\_temp\_data\_file\_path**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_temp_data_file_path) | Yes | Yes | Yes |  | Global | No |
| [**innodb\_temp\_tablespaces\_dir**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_temp_tablespaces_dir) | Yes | Yes | Yes |  | Global | No |
| [**innodb\_thread\_concurrency**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_thread_concurrency) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_thread\_sleep\_delay**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_thread_sleep_delay) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_tmpdir**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_tmpdir) | Yes | Yes | Yes |  | Both | Yes |
| [**Innodb\_truncated\_status\_writes**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#statvar_Innodb_truncated_status_writes) |  |  |  | Yes | Global | No |
| [**innodb\_trx\_purge\_view\_update\_only\_debug**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_trx_purge_view_update_only_debug) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_trx\_rseg\_n\_slots\_debug**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_trx_rseg_n_slots_debug) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_undo\_directory**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_undo_directory) | Yes | Yes | Yes |  | Global | No |
| [**innodb\_undo\_log\_encrypt**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_undo_log_encrypt) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_undo\_log\_truncate**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_undo_log_truncate) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_undo\_tablespaces**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_undo_tablespaces) | Yes | Yes | Yes |  | Global | Varies |
| [**Innodb\_undo\_tablespaces\_active**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#statvar_Innodb_undo_tablespaces_active) |  |  |  | Yes | Global | No |
| [**Innodb\_undo\_tablespaces\_explicit**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#statvar_Innodb_undo_tablespaces_explicit) |  |  |  | Yes | Global | No |
| [**Innodb\_undo\_tablespaces\_implicit**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#statvar_Innodb_undo_tablespaces_implicit) |  |  |  | Yes | Global | No |
| [**Innodb\_undo\_tablespaces\_total**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#statvar_Innodb_undo_tablespaces_total) |  |  |  | Yes | Global | No |
| [**innodb\_use\_fdatasync**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_use_fdatasync) | Yes | Yes | Yes |  | Global | Yes |
| [**innodb\_use\_native\_aio**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_use_native_aio) | Yes | Yes | Yes |  | Global | No |
| [**innodb\_validate\_tablespace\_paths**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_validate_tablespace_paths) | Yes | Yes | Yes |  | Global | No |
| [**innodb\_version**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_version) |  |  | Yes |  | Global | No |
| [**innodb\_write\_io\_threads**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_write_io_threads) | Yes | Yes | Yes |  | Global | No |
| [**unique\_checks**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_unique_checks) |  |  | Yes |  | Both | Yes |

### InnoDB Command Options

[--innodb[=](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "option_mysqld_innodb)***[value](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "option_mysqld_innodb)***[]](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "option_mysqld_innodb)

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb[=value]** |
| **Deprecated** | Yes |
| **Type** | Enumeration |
| **Default Value** | **ON** |
| **Valid Values** | **OFF**  **ON**  **FORCE** |

Controls loading of the **InnoDB** storage engine, if the server was compiled with **InnoDB** support. This option has a tristate format, with possible values of **OFF**, **ON**, or **FORCE**. See [Section 5.6.1, “Installing and Uninstalling Plugins”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#plugin-loading).

To disable **InnoDB**, use [--innodb=OFF](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#option_mysqld_innodb) or [--skip-innodb](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#option_mysqld_innodb). In this case, because the default storage engine is [**InnoDB**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html), the server does not start unless you also use [--default-storage-engine](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_default_storage_engine) and [--default-tmp-storage-engine](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_default_tmp_storage_engine) to set the default to some other engine for both permanent and **TEMPORARY** tables.

The **InnoDB** storage engine can no longer be disabled, and the [--innodb=OFF](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#option_mysqld_innodb) and [--skip-innodb](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#option_mysqld_innodb) options are deprecated and have no effect. Their use results in a warning. Expect these options to be removed in a future MySQL release.

[--innodb-status-file](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "option_mysqld_innodb-status-file)

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-status-file[={OFF|ON}]** |
| **Type** | Boolean |
| **Default Value** | **OFF** |

The --innodb-status-file startup option controls whether **InnoDB** creates a file named innodb\_status.***pid*** in the data directory and writes [**SHOW ENGINE INNODB STATUS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#show-engine) output to it every 15 seconds, approximately.

The innodb\_status.***pid*** file is not created by default. To create it, start [**mysqld**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\programs.html#mysqld) with the --innodb-status-file option. **InnoDB** removes the file when the server is shut down normally. If an abnormal shutdown occurs, the status file may have to be removed manually.

The --innodb-status-file option is intended for temporary use, as [**SHOW ENGINE INNODB STATUS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#show-engine) output generation can affect performance, and the innodb\_status.***pid*** file can become quite large over time.

For related information, see [Section 15.17.2, “Enabling InnoDB Monitors”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-enabling-monitors).

[--skip-innodb](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#option_mysqld_innodb)

Disable the **InnoDB** storage engine. See the description of [--innodb](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#option_mysqld_innodb).

### InnoDB System Variables

**[daemon\_memcached\_enable\_binlog](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_daemon_memcached_enable_binlog)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--daemon-memcached-enable-binlog[={OFF|ON}]** |
| **System Variable** | [**daemon\_memcached\_enable\_binlog**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_daemon_memcached_enable_binlog) |
| **Scope** | Global |
| **Dynamic** | No |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Boolean |
| **Default Value** | **OFF** |

Enable this option on the source server to use the **InnoDB** **memcached** plugin (**daemon\_memcached**) with the MySQL [binary log](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_binary_log). This option can only be set at server startup. You must also enable the MySQL binary log on the source server using the [**--log-bin**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\replication.html#sysvar_log_bin) option.

For more information, see [Section 15.20.7, “The InnoDB memcached Plugin and Replication”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-memcached-replication).

**[daemon\_memcached\_engine\_lib\_name](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_daemon_memcached_engine_lib_name)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--daemon-memcached-engine-lib-name=file\_name** |
| **System Variable** | [**daemon\_memcached\_engine\_lib\_name**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_daemon_memcached_engine_lib_name) |
| **Scope** | Global |
| **Dynamic** | No |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | File name |
| **Default Value** | **innodb\_engine.so** |

Specifies the shared library that implements the **InnoDB** **memcached** plugin.

For more information, see [Section 15.20.3, “Setting Up the InnoDB memcached Plugin”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-memcached-setup).

**[daemon\_memcached\_engine\_lib\_path](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_daemon_memcached_engine_lib_path)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--daemon-memcached-engine-lib-path=dir\_name** |
| **System Variable** | [**daemon\_memcached\_engine\_lib\_path**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_daemon_memcached_engine_lib_path) |
| **Scope** | Global |
| **Dynamic** | No |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Directory name |
| **Default Value** | **NULL** |

The path of the directory containing the shared library that implements the **InnoDB** **memcached** plugin. The default value is NULL, representing the MySQL plugin directory. You should not need to modify this parameter unless specifying a **memcached** plugin for a different storage engine that is located outside of the MySQL plugin directory.

For more information, see [Section 15.20.3, “Setting Up the InnoDB memcached Plugin”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-memcached-setup).

**[daemon\_memcached\_option](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_daemon_memcached_option)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--daemon-memcached-option=options** |
| **System Variable** | [**daemon\_memcached\_option**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_daemon_memcached_option) |
| **Scope** | Global |
| **Dynamic** | No |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | String |
| **Default Value** |  |

Used to pass space-separated memcached options to the underlying **memcached** memory object caching daemon on startup. For example, you might change the port that **memcached** listens on, reduce the maximum number of simultaneous connections, change the maximum memory size for a key-value pair, or enable debugging messages for the error log.

See [Section 15.20.3, “Setting Up the InnoDB memcached Plugin”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-memcached-setup) for usage details. For information about **memcached** options, refer to the **memcached** man page.

**[daemon\_memcached\_r\_batch\_size](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_daemon_memcached_r_batch_size)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--daemon-memcached-r-batch-size=#** |
| **System Variable** | [**daemon\_memcached\_r\_batch\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_daemon_memcached_r_batch_size) |
| **Scope** | Global |
| **Dynamic** | No |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Integer |
| **Default Value** | **1** |

Specifies how many **memcached** read operations (**get** operations) to perform before doing a [**COMMIT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#commit) to start a new transaction. Counterpart of [**daemon\_memcached\_w\_batch\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_daemon_memcached_w_batch_size).

This value is set to 1 by default, so that any changes made to the table through SQL statements are immediately visible to **memcached** operations. You might increase it to reduce the overhead from frequent commits on a system where the underlying table is only being accessed through the **memcached** interface. If you set the value too large, the amount of undo or redo data could impose some storage overhead, as with any long-running transaction.

For more information, see [Section 15.20.3, “Setting Up the InnoDB memcached Plugin”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-memcached-setup).

**[daemon\_memcached\_w\_batch\_size](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_daemon_memcached_w_batch_size)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--daemon-memcached-w-batch-size=#** |
| **System Variable** | [**daemon\_memcached\_w\_batch\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_daemon_memcached_w_batch_size) |
| **Scope** | Global |
| **Dynamic** | No |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Integer |
| **Default Value** | **1** |

Specifies how many **memcached** write operations, such as **add**, **set**, and **incr**, to perform before doing a [**COMMIT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#commit) to start a new transaction. Counterpart of [**daemon\_memcached\_r\_batch\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_daemon_memcached_r_batch_size).

This value is set to 1 by default, on the assumption that data being stored is important to preserve in case of an outage and should immediately be committed. When storing non-critical data, you might increase this value to reduce the overhead from frequent commits; but then the last ***N***-1 uncommitted write operations could be lost if an unexpected exit occurs.

For more information, see [Section 15.20.3, “Setting Up the InnoDB memcached Plugin”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-memcached-setup).

**[innodb\_adaptive\_flushing](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_adaptive_flushing)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-adaptive-flushing[={OFF|ON}]** |
| **System Variable** | [**innodb\_adaptive\_flushing**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_adaptive_flushing) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Boolean |
| **Default Value** | **ON** |

Specifies whether to dynamically adjust the rate of flushing [dirty pages](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_dirty_page) in the **InnoDB** [buffer pool](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_buffer_pool) based on the workload. Adjusting the flush rate dynamically is intended to avoid bursts of I/O activity. This setting is enabled by default. See [Section 15.8.3.5, “Configuring Buffer Pool Flushing”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-buffer-pool-flushing) for more information. For general I/O tuning advice, see [Section 8.5.8, “Optimizing InnoDB Disk I/O”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizing-innodb-diskio).

**[innodb\_adaptive\_flushing\_lwm](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_adaptive_flushing_lwm)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-adaptive-flushing-lwm=#** |
| **System Variable** | [**innodb\_adaptive\_flushing\_lwm**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_adaptive_flushing_lwm) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Integer |
| **Default Value** | **10** |
| **Minimum Value** | **0** |
| **Maximum Value** | **70** |

Defines the low water mark representing percentage of [redo log](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_redo_log) capacity at which [adaptive flushing](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_adaptive_flushing) is enabled. For more information, see [Section 15.8.3.5, “Configuring Buffer Pool Flushing”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-buffer-pool-flushing).

**[innodb\_adaptive\_hash\_index](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_adaptive_hash_index)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-adaptive-hash-index[={OFF|ON}]** |
| **System Variable** | [**innodb\_adaptive\_hash\_index**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_adaptive_hash_index) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Boolean |
| **Default Value** | **ON** |

Whether the **InnoDB** [adaptive hash index](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_adaptive_hash_index) is enabled or disabled. It may be desirable, depending on your workload, to dynamically enable or disable [adaptive hash indexing](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_adaptive_hash_index) to improve query performance. Because the adaptive hash index may not be useful for all workloads, conduct benchmarks with it both enabled and disabled, using realistic workloads. See [Section 15.5.3, “Adaptive Hash Index”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-adaptive-hash) for details.

This variable is enabled by default. You can modify this parameter using the **SET GLOBAL** statement, without restarting the server. Changing the setting at runtime requires privileges sufficient to set global system variables. See [Section 5.1.9.1, “System Variable Privileges”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#system-variable-privileges). You can also use --skip-innodb-adaptive-hash-index at server startup to disable it.

Disabling the adaptive hash index empties the hash table immediately. Normal operations can continue while the hash table is emptied, and executing queries that were using the hash table access the index B-trees directly instead. When the adaptive hash index is re-enabled, the hash table is populated again during normal operation.

**[innodb\_adaptive\_hash\_index\_parts](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_adaptive_hash_index_parts)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-adaptive-hash-index-parts=#** |
| **System Variable** | [**innodb\_adaptive\_hash\_index\_parts**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_adaptive_hash_index_parts) |
| **Scope** | Global |
| **Dynamic** | No |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Numeric |
| **Default Value** | **8** |
| **Minimum Value** | **1** |
| **Maximum Value** | **512** |

Partitions the adaptive hash index search system. Each index is bound to a specific partition, with each partition protected by a separate latch.

The adaptive hash index search system is partitioned into 8 parts by default. The maximum setting is 512.

For related information, see [Section 15.5.3, “Adaptive Hash Index”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-adaptive-hash).

**[innodb\_adaptive\_max\_sleep\_delay](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_adaptive_max_sleep_delay)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-adaptive-max-sleep-delay=#** |
| **System Variable** | [**innodb\_adaptive\_max\_sleep\_delay**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_adaptive_max_sleep_delay) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Integer |
| **Default Value** | **150000** |
| **Minimum Value** | **0** |
| **Maximum Value** | **1000000** |

Permits **InnoDB** to automatically adjust the value of [**innodb\_thread\_sleep\_delay**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_thread_sleep_delay) up or down according to the current workload. Any nonzero value enables automated, dynamic adjustment of the [**innodb\_thread\_sleep\_delay**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_thread_sleep_delay) value, up to the maximum value specified in the [**innodb\_adaptive\_max\_sleep\_delay**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_adaptive_max_sleep_delay) option. The value represents the number of microseconds. This option can be useful in busy systems, with greater than 16 **InnoDB** threads. (In practice, it is most valuable for MySQL systems with hundreds or thousands of simultaneous connections.)

For more information, see [Section 15.8.4, “Configuring Thread Concurrency for InnoDB”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-performance-thread_concurrency).

**[innodb\_api\_bk\_commit\_interval](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_api_bk_commit_interval)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-api-bk-commit-interval=#** |
| **System Variable** | [**innodb\_api\_bk\_commit\_interval**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_api_bk_commit_interval) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Integer |
| **Default Value** | **5** |
| **Minimum Value** | **1** |
| **Maximum Value** | **1073741824** |

How often to auto-commit idle connections that use the **InnoDB** **memcached** interface, in seconds. For more information, see [Section 15.20.6.4, “Controlling Transactional Behavior of the InnoDB memcached Plugin”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-memcached-txn).

**[innodb\_api\_disable\_rowlock](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_api_disable_rowlock)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-api-disable-rowlock[={OFF|ON}]** |
| **System Variable** | [**innodb\_api\_disable\_rowlock**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_api_disable_rowlock) |
| **Scope** | Global |
| **Dynamic** | No |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Boolean |
| **Default Value** | **OFF** |

Use this option to disable row locks when **InnoDB** **memcached** performs DML operations. By default, [**innodb\_api\_disable\_rowlock**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_api_disable_rowlock) is disabled, which means that **memcached** requests row locks for **get** and **set** operations. When [**innodb\_api\_disable\_rowlock**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_api_disable_rowlock) is enabled, **memcached** requests a table lock instead of row locks.

[**innodb\_api\_disable\_rowlock**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_api_disable_rowlock) is not dynamic. It must be specified on the [**mysqld**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\programs.html#mysqld) command line or entered in the MySQL configuration file. Configuration takes effect when the plugin is installed, which occurs when the MySQL server is started.

For more information, see [Section 15.20.6.4, “Controlling Transactional Behavior of the InnoDB memcached Plugin”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-memcached-txn).

**[innodb\_api\_enable\_binlog](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_api_enable_binlog)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-api-enable-binlog[={OFF|ON}]** |
| **System Variable** | [**innodb\_api\_enable\_binlog**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_api_enable_binlog) |
| **Scope** | Global |
| **Dynamic** | No |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Boolean |
| **Default Value** | **OFF** |

Lets you use the **InnoDB** **memcached** plugin with the MySQL [binary log](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_binary_log). For more information, see [Enabling the InnoDB memcached Binary Log](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-memcached-replication-enable-binlog).

**[innodb\_api\_enable\_mdl](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_api_enable_mdl)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-api-enable-mdl[={OFF|ON}]** |
| **System Variable** | [**innodb\_api\_enable\_mdl**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_api_enable_mdl) |
| **Scope** | Global |
| **Dynamic** | No |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Boolean |
| **Default Value** | **OFF** |

Locks the table used by the **InnoDB** **memcached** plugin, so that it cannot be dropped or altered by [DDL](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_ddl) through the SQL interface. For more information, see [Section 15.20.6.4, “Controlling Transactional Behavior of the InnoDB memcached Plugin”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-memcached-txn).

**[innodb\_api\_trx\_level](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_api_trx_level)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-api-trx-level=#** |
| **System Variable** | [**innodb\_api\_trx\_level**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_api_trx_level) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Integer |
| **Default Value** | **0** |

Controls the transaction [isolation level](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_isolation_level) on queries processed by the **memcached** interface. The constants corresponding to the familiar names are:

0 = [**READ UNCOMMITTED**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#isolevel_read-uncommitted)

1 = [**READ COMMITTED**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#isolevel_read-committed)

2 = [**REPEATABLE READ**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#isolevel_repeatable-read)

3 = [**SERIALIZABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#isolevel_serializable)

For more information, see [Section 15.20.6.4, “Controlling Transactional Behavior of the InnoDB memcached Plugin”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-memcached-txn).

**[innodb\_autoextend\_increment](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_autoextend_increment)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-autoextend-increment=#** |
| **System Variable** | [**innodb\_autoextend\_increment**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_autoextend_increment) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Integer |
| **Default Value** | **64** |
| **Minimum Value** | **1** |
| **Maximum Value** | **1000** |

The increment size (in megabytes) for extending the size of an auto-extending **InnoDB** [system tablespace](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_system_tablespace) file when it becomes full. The default value is 64. For related information, see [System Tablespace Data File Configuration](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-startup-data-file-configuration), and [Resizing the System Tablespace](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-resize-system-tablespace).

The [**innodb\_autoextend\_increment**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_autoextend_increment) setting does not affect [file-per-table](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_file_per_table) tablespace files or [general tablespace](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_general_tablespace) files. These files are auto-extending regardless of the [**innodb\_autoextend\_increment**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_autoextend_increment) setting. The initial extensions are by small amounts, after which extensions occur in increments of 4MB.

**[innodb\_autoinc\_lock\_mode](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_autoinc_lock_mode)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-autoinc-lock-mode=#** |
| **System Variable** | [**innodb\_autoinc\_lock\_mode**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_autoinc_lock_mode) |
| **Scope** | Global |
| **Dynamic** | No |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Integer |
| **Default Value** | **2** |
| **Valid Values** | **0**  **1**  **2** |

The [lock mode](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_lock_mode) to use for generating [auto-increment](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_auto_increment) values. Permissible values are 0, 1, or 2, for traditional, consecutive, or interleaved, respectively.

The default setting is 2 (interleaved) as of MySQL 8.0, and 1 (consecutive) before that. The change to interleaved lock mode as the default setting reflects the change from statement-based to row-based replication as the default replication type, which occurred in MySQL 5.7. Statement-based replication requires the consecutive auto-increment lock mode to ensure that auto-increment values are assigned in a predictable and repeatable order for a given sequence of SQL statements, whereas row-based replication is not sensitive to the execution order of SQL statements.

For the characteristics of each lock mode, see [InnoDB AUTO\_INCREMENT Lock Modes](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-auto-increment-lock-modes).

**[innodb\_background\_drop\_list\_empty](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_background_drop_list_empty)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-background-drop-list-empty[={OFF|ON}]** |
| **System Variable** | [**innodb\_background\_drop\_list\_empty**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_background_drop_list_empty) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Boolean |
| **Default Value** | **OFF** |

Enabling the [**innodb\_background\_drop\_list\_empty**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_background_drop_list_empty) debug option helps avoid test case failures by delaying table creation until the background drop list is empty. For example, if test case A places table **t1** on the background drop list, test case B waits until the background drop list is empty before creating table **t1**.

**[innodb\_buffer\_pool\_chunk\_size](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_buffer_pool_chunk_size)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-buffer-pool-chunk-size=#** |
| **System Variable** | [**innodb\_buffer\_pool\_chunk\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_chunk_size) |
| **Scope** | Global |
| **Dynamic** | No |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Integer |
| **Default Value** | **134217728** |
| **Minimum Value** | **1048576** |
| **Maximum Value** | **innodb\_buffer\_pool\_size / innodb\_buffer\_pool\_instances** |

[**innodb\_buffer\_pool\_chunk\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_chunk_size) defines the chunk size for **InnoDB** buffer pool resizing operations.

To avoid copying all buffer pool pages during resizing operations, the operation is performed in “chunks”. By default, [**innodb\_buffer\_pool\_chunk\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_chunk_size) is 128MB (134217728 bytes). The number of pages contained in a chunk depends on the value of [**innodb\_page\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_page_size). [**innodb\_buffer\_pool\_chunk\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_chunk_size) can be increased or decreased in units of 1MB (1048576 bytes).

The following conditions apply when altering the [**innodb\_buffer\_pool\_chunk\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_chunk_size) value:

If [**innodb\_buffer\_pool\_chunk\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_chunk_size) \* [**innodb\_buffer\_pool\_instances**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_instances) is larger than the current buffer pool size when the buffer pool is initialized, [**innodb\_buffer\_pool\_chunk\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_chunk_size) is truncated to [**innodb\_buffer\_pool\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_size) / [**innodb\_buffer\_pool\_instances**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_instances).

Buffer pool size must always be equal to or a multiple of [**innodb\_buffer\_pool\_chunk\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_chunk_size) \* [**innodb\_buffer\_pool\_instances**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_instances). If you alter [**innodb\_buffer\_pool\_chunk\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_chunk_size), [**innodb\_buffer\_pool\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_size) is automatically rounded to a value that is equal to or a multiple of [**innodb\_buffer\_pool\_chunk\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_chunk_size) \* [**innodb\_buffer\_pool\_instances**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_instances). The adjustment occurs when the buffer pool is initialized.

**Important**

Care should be taken when changing [**innodb\_buffer\_pool\_chunk\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_chunk_size), as changing this value can automatically increase the size of the buffer pool. Before changing [**innodb\_buffer\_pool\_chunk\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_chunk_size), calculate its effect on [**innodb\_buffer\_pool\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_size) to ensure that the resulting buffer pool size is acceptable.

To avoid potential performance issues, the number of chunks ([**innodb\_buffer\_pool\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_size) / [**innodb\_buffer\_pool\_chunk\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_chunk_size)) should not exceed 1000.

The [**innodb\_buffer\_pool\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_size) variable is dynamic, which permits resizing the buffer pool while the server is online. However, the buffer pool size must be equal to or a multiple of [**innodb\_buffer\_pool\_chunk\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_chunk_size) \* [**innodb\_buffer\_pool\_instances**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_instances), and changing either of those variable settings requires restarting the server.

See [Section 15.8.3.1, “Configuring InnoDB Buffer Pool Size”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-buffer-pool-resize) for more information.

**[innodb\_buffer\_pool\_debug](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_buffer_pool_debug)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-buffer-pool-debug[={OFF|ON}]** |
| **System Variable** | [**innodb\_buffer\_pool\_debug**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_debug) |
| **Scope** | Global |
| **Dynamic** | No |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Boolean |
| **Default Value** | **OFF** |

Enabling this option permits multiple buffer pool instances when the buffer pool is less than 1GB in size, ignoring the 1GB minimum buffer pool size constraint imposed on [**innodb\_buffer\_pool\_instances**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_instances). The [**innodb\_buffer\_pool\_debug**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_debug) option is only available if debugging support is compiled in using the [WITH\_DEBUG](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\installing.html#option_cmake_with_debug) **CMake** option.

**[innodb\_buffer\_pool\_dump\_at\_shutdown](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_buffer_pool_dump_at_shutdown)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-buffer-pool-dump-at-shutdown[={OFF|ON}]** |
| **System Variable** | [**innodb\_buffer\_pool\_dump\_at\_shutdown**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_dump_at_shutdown) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Boolean |
| **Default Value** | **ON** |

Specifies whether to record the pages cached in the **InnoDB** [buffer pool](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_buffer_pool) when the MySQL server is shut down, to shorten the [warmup](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_warm_up) process at the next restart. Typically used in combination with [**innodb\_buffer\_pool\_load\_at\_startup**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_load_at_startup). The [**innodb\_buffer\_pool\_dump\_pct**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_dump_pct) option defines the percentage of most recently used buffer pool pages to dump.

Both [**innodb\_buffer\_pool\_dump\_at\_shutdown**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_dump_at_shutdown) and [**innodb\_buffer\_pool\_load\_at\_startup**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_load_at_startup) are enabled by default.

For more information, see [Section 15.8.3.6, “Saving and Restoring the Buffer Pool State”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-preload-buffer-pool).

**[innodb\_buffer\_pool\_dump\_now](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_buffer_pool_dump_now)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-buffer-pool-dump-now[={OFF|ON}]** |
| **System Variable** | [**innodb\_buffer\_pool\_dump\_now**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_dump_now) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Boolean |
| **Default Value** | **OFF** |

Immediately records the pages cached in the **InnoDB** [buffer pool](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_buffer_pool). Typically used in combination with [**innodb\_buffer\_pool\_load\_now**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_load_now).

For more information, see [Section 15.8.3.6, “Saving and Restoring the Buffer Pool State”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-preload-buffer-pool).

**[innodb\_buffer\_pool\_dump\_pct](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_buffer_pool_dump_pct)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-buffer-pool-dump-pct=#** |
| **System Variable** | [**innodb\_buffer\_pool\_dump\_pct**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_dump_pct) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Integer |
| **Default Value** | **25** |
| **Minimum Value** | **1** |
| **Maximum Value** | **100** |

Specifies the percentage of the most recently used pages for each buffer pool to read out and dump. The range is 1 to 100. The default value is 25. For example, if there are 4 buffer pools with 100 pages each, and [**innodb\_buffer\_pool\_dump\_pct**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_dump_pct) is set to 25, the 25 most recently used pages from each buffer pool are dumped.

**[innodb\_buffer\_pool\_filename](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_buffer_pool_filename)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-buffer-pool-filename=file\_name** |
| **System Variable** | [**innodb\_buffer\_pool\_filename**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_filename) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | File name |
| **Default Value** | **ib\_buffer\_pool** |

Specifies the name of the file that holds the list of tablespace IDs and page IDs produced by [**innodb\_buffer\_pool\_dump\_at\_shutdown**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_dump_at_shutdown) or [**innodb\_buffer\_pool\_dump\_now**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_dump_now). Tablespace IDs and page IDs are saved in the following format: **space, page\_id**. By default, the file is named ib\_buffer\_pool and is located in the **InnoDB** data directory. A non-default location must be specified relative to the data directory.

A file name can be specified at runtime, using a [**SET**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#set-variable) statement:

SET GLOBAL innodb\_buffer\_pool\_filename=***'file\_name'***;

You can also specify a file name at startup, in a startup string or MySQL configuration file. When specifying a file name at startup, the file must exist or **InnoDB** returns a startup error indicating that there is no such file or directory.

For more information, see [Section 15.8.3.6, “Saving and Restoring the Buffer Pool State”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-preload-buffer-pool).

**[innodb\_buffer\_pool\_in\_core\_file](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_buffer_pool_in_core_file)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-buffer-pool-in-core-file[={OFF|ON}]** |
| **Introduced** | 8.0.14 |
| **System Variable** | [**innodb\_buffer\_pool\_in\_core\_file**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_in_core_file) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Boolean |
| **Default Value** | **ON** |

Disabling the [**innodb\_buffer\_pool\_in\_core\_file**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_in_core_file) variable reduces the size of core files by excluding **InnoDB** buffer pool pages. To use this variable, the [**core\_file**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_core_file) variable must be enabled and the operating system must support the **MADV\_DONTDUMP** non-POSIX extension to **madvise()**, which is supported in Linux 3.4 and later. For more information, see [Section 15.8.3.7, “Excluding Buffer Pool Pages from Core Files”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-buffer-pool-in-core-file).

**[innodb\_buffer\_pool\_instances](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_buffer_pool_instances)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-buffer-pool-instances=#** |
| **System Variable** | [**innodb\_buffer\_pool\_instances**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_instances) |
| **Scope** | Global |
| **Dynamic** | No |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Integer |
| **Default Value (Other)** | **8 (or 1 if innodb\_buffer\_pool\_size < 1GB** |
| **Default Value (Windows, 32-bit platforms)** | **(autosized)** |
| **Minimum Value** | **1** |
| **Maximum Value** | **64** |

The number of regions that the **InnoDB** [buffer pool](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_buffer_pool) is divided into. For systems with buffer pools in the multi-gigabyte range, dividing the buffer pool into separate instances can improve concurrency, by reducing contention as different threads read and write to cached pages. Each page that is stored in or read from the buffer pool is assigned to one of the buffer pool instances randomly, using a hashing function. Each buffer pool manages its own free lists, [flush lists](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_flush_list), [LRUs](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_lru), and all other data structures connected to a buffer pool, and is protected by its own buffer pool [mutex](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_mutex).

This option only takes effect when setting [**innodb\_buffer\_pool\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_size) to 1GB or more. The total buffer pool size is divided among all the buffer pools. For best efficiency, specify a combination of [**innodb\_buffer\_pool\_instances**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_instances) and [**innodb\_buffer\_pool\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_size) so that each buffer pool instance is at least 1GB.

The default value on 32-bit Windows systems depends on the value of [**innodb\_buffer\_pool\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_size), as described below:

If [**innodb\_buffer\_pool\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_size) is greater than 1.3GB, the default for [**innodb\_buffer\_pool\_instances**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_instances) is [**innodb\_buffer\_pool\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_size)/128MB, with individual memory allocation requests for each chunk. 1.3GB was chosen as the boundary at which there is significant risk for 32-bit Windows to be unable to allocate the contiguous address space needed for a single buffer pool.

Otherwise, the default is 1.

On all other platforms, the default value is 8 when [**innodb\_buffer\_pool\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_size) is greater than or equal to 1GB. Otherwise, the default is 1.

For related information, see [Section 15.8.3.1, “Configuring InnoDB Buffer Pool Size”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-buffer-pool-resize).

**[innodb\_buffer\_pool\_load\_abort](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_buffer_pool_load_abort)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-buffer-pool-load-abort[={OFF|ON}]** |
| **System Variable** | [**innodb\_buffer\_pool\_load\_abort**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_load_abort) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Boolean |
| **Default Value** | **OFF** |

Interrupts the process of restoring **InnoDB** [buffer pool](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_buffer_pool) contents triggered by [**innodb\_buffer\_pool\_load\_at\_startup**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_load_at_startup) or [**innodb\_buffer\_pool\_load\_now**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_load_now).

For more information, see [Section 15.8.3.6, “Saving and Restoring the Buffer Pool State”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-preload-buffer-pool).

**[innodb\_buffer\_pool\_load\_at\_startup](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_buffer_pool_load_at_startup)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-buffer-pool-load-at-startup[={OFF|ON}]** |
| **System Variable** | [**innodb\_buffer\_pool\_load\_at\_startup**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_load_at_startup) |
| **Scope** | Global |
| **Dynamic** | No |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Boolean |
| **Default Value** | **ON** |

Specifies that, on MySQL server startup, the **InnoDB** [buffer pool](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_buffer_pool) is automatically [warmed up](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_warm_up) by loading the same pages it held at an earlier time. Typically used in combination with [**innodb\_buffer\_pool\_dump\_at\_shutdown**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_dump_at_shutdown).

Both [**innodb\_buffer\_pool\_dump\_at\_shutdown**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_dump_at_shutdown) and [**innodb\_buffer\_pool\_load\_at\_startup**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_load_at_startup) are enabled by default.

For more information, see [Section 15.8.3.6, “Saving and Restoring the Buffer Pool State”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-preload-buffer-pool).

**[innodb\_buffer\_pool\_load\_now](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_buffer_pool_load_now)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-buffer-pool-load-now[={OFF|ON}]** |
| **System Variable** | [**innodb\_buffer\_pool\_load\_now**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_load_now) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Boolean |
| **Default Value** | **OFF** |

Immediately [warms up](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_warm_up) the **InnoDB** [buffer pool](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_buffer_pool) by loading a set of data pages, without waiting for a server restart. Can be useful to bring cache memory back to a known state during benchmarking, or to ready the MySQL server to resume its normal workload after running queries for reports or maintenance.

For more information, see [Section 15.8.3.6, “Saving and Restoring the Buffer Pool State”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-preload-buffer-pool).

**[innodb\_buffer\_pool\_size](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_buffer_pool_size)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-buffer-pool-size=#** |
| **System Variable** | [**innodb\_buffer\_pool\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_size) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Integer |
| **Default Value** | **134217728** |
| **Minimum Value** | **5242880** |
| **Maximum Value (64-bit platforms)** | **2\*\*64-1** |
| **Maximum Value (32-bit platforms)** | **2\*\*32-1** |

The size in bytes of the [buffer pool](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_buffer_pool), the memory area where **InnoDB** caches table and index data. The default value is 134217728 bytes (128MB). The maximum value depends on the CPU architecture; the maximum is 4294967295 (232-1) on 32-bit systems and 18446744073709551615 (264-1) on 64-bit systems. On 32-bit systems, the CPU architecture and operating system may impose a lower practical maximum size than the stated maximum. When the size of the buffer pool is greater than 1GB, setting [**innodb\_buffer\_pool\_instances**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_instances) to a value greater than 1 can improve the scalability on a busy server.

A larger buffer pool requires less disk I/O to access the same table data more than once. On a dedicated database server, you might set the buffer pool size to 80% of the machine's physical memory size. Be aware of the following potential issues when configuring buffer pool size, and be prepared to scale back the size of the buffer pool if necessary.

Competition for physical memory can cause paging in the operating system.

**InnoDB** reserves additional memory for buffers and control structures, so that the total allocated space is approximately 10% greater than the specified buffer pool size.

Address space for the buffer pool must be contiguous, which can be an issue on Windows systems with DLLs that load at specific addresses.

The time to initialize the buffer pool is roughly proportional to its size. On instances with large buffer pools, initialization time might be significant. To reduce the initialization period, you can save the buffer pool state at server shutdown and restore it at server startup. See [Section 15.8.3.6, “Saving and Restoring the Buffer Pool State”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-preload-buffer-pool).

When you increase or decrease buffer pool size, the operation is performed in chunks. Chunk size is defined by the [**innodb\_buffer\_pool\_chunk\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_chunk_size) variable, which has a default of 128 MB.

Buffer pool size must always be equal to or a multiple of [**innodb\_buffer\_pool\_chunk\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_chunk_size) \* [**innodb\_buffer\_pool\_instances**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_instances). If you alter the buffer pool size to a value that is not equal to or a multiple of [**innodb\_buffer\_pool\_chunk\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_chunk_size) \* [**innodb\_buffer\_pool\_instances**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_instances), buffer pool size is automatically adjusted to a value that is equal to or a multiple of [**innodb\_buffer\_pool\_chunk\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_chunk_size) \* [**innodb\_buffer\_pool\_instances**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_instances).

[**innodb\_buffer\_pool\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_size) can be set dynamically, which allows you to resize the buffer pool without restarting the server. The [**Innodb\_buffer\_pool\_resize\_status**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#statvar_Innodb_buffer_pool_resize_status) status variable reports the status of online buffer pool resizing operations. See [Section 15.8.3.1, “Configuring InnoDB Buffer Pool Size”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-buffer-pool-resize) for more information.

If [**innodb\_dedicated\_server**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_dedicated_server) is enabled, the [**innodb\_buffer\_pool\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_size) value is automatically configured if it is not explicitly defined. For more information, see [Section 15.8.12, “Enabling Automatic Configuration for a Dedicated MySQL Server”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-dedicated-server).

**[innodb\_change\_buffer\_max\_size](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_change_buffer_max_size)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-change-buffer-max-size=#** |
| **System Variable** | [**innodb\_change\_buffer\_max\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_change_buffer_max_size) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Integer |
| **Default Value** | **25** |
| **Minimum Value** | **0** |
| **Maximum Value** | **50** |

Maximum size for the **InnoDB** [change buffer](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_change_buffer), as a percentage of the total size of the [buffer pool](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_buffer_pool). You might increase this value for a MySQL server with heavy insert, update, and delete activity, or decrease it for a MySQL server with unchanging data used for reporting. For more information, see [Section 15.5.2, “Change Buffer”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-change-buffer). For general I/O tuning advice, see [Section 8.5.8, “Optimizing InnoDB Disk I/O”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizing-innodb-diskio).

**[innodb\_change\_buffering](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_change_buffering)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-change-buffering=value** |
| **System Variable** | [**innodb\_change\_buffering**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_change_buffering) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Enumeration |
| **Default Value** | **all** |
| **Valid Values** | **none**  **inserts**  **deletes**  **changes**  **purges**  **all** |

Whether **InnoDB** performs [change buffering](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_change_buffering), an optimization that delays write operations to secondary indexes so that the I/O operations can be performed sequentially. Permitted values are described in the following table. Values may also be specified numerically.

**Table 15.25 Permitted Values for innodb\_change\_buffering**

| **Value** | **Numeric Value** | **Description** |
| --- | --- | --- |
| **none** | **0** | Do not buffer any operations. |
| **inserts** | **1** | Buffer insert operations. |
| **deletes** | **2** | Buffer delete marking operations; strictly speaking, the writes that mark index records for later deletion during a purge operation. |
| **changes** | **3** | Buffer inserts and delete-marking operations. |
| **purges** | **4** | Buffer the physical deletion operations that happen in the background. |
| **all** | **5** | The default. Buffer inserts, delete-marking operations, and purges. |

For more information, see [Section 15.5.2, “Change Buffer”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-change-buffer). For general I/O tuning advice, see [Section 8.5.8, “Optimizing InnoDB Disk I/O”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizing-innodb-diskio).

**[innodb\_change\_buffering\_debug](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_change_buffering_debug)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-change-buffering-debug=#** |
| **System Variable** | [**innodb\_change\_buffering\_debug**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_change_buffering_debug) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Integer |
| **Default Value** | **0** |
| **Maximum Value** | **2** |

Sets a debug flag for **InnoDB** change buffering. A value of 1 forces all changes to the change buffer. A value of 2 causes an unexpected exit at merge. A default value of 0 indicates that the change buffering debug flag is not set. This option is only available when debugging support is compiled in using the [WITH\_DEBUG](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\installing.html#option_cmake_with_debug) **CMake** option.

**[innodb\_checkpoint\_disabled](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_checkpoint_disabled)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-checkpoint-disabled[={OFF|ON}]** |
| **System Variable** | [**innodb\_checkpoint\_disabled**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_checkpoint_disabled) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Boolean |
| **Default Value** | **OFF** |

This is a debug option that is only intended for expert debugging use. It disables checkpoints so that a deliberate server exit always initiates **InnoDB** recovery. It should only be enabled for a short interval, typically before running DML operations that write redo log entries that would require recovery following a server exit. This option is only available if debugging support is compiled in using the [WITH\_DEBUG](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\installing.html#option_cmake_with_debug) **CMake** option.

**[innodb\_checksum\_algorithm](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_checksum_algorithm)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-checksum-algorithm=value** |
| **System Variable** | [**innodb\_checksum\_algorithm**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_checksum_algorithm) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Enumeration |
| **Default Value** | **crc32** |
| **Valid Values** | **innodb**  **crc32**  **none**  **strict\_innodb**  **strict\_crc32**  **strict\_none** |

Specifies how to generate and verify the [checksum](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_checksum) stored in the disk blocks of **InnoDB** [tablespaces](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_tablespace). The default value for [**innodb\_checksum\_algorithm**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_checksum_algorithm) is **crc32**.

Versions of [MySQL Enterprise Backup](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\mysql-enterprise.html#mysql-enterprise-backup) up to 3.8.0 do not support backing up tablespaces that use CRC32 checksums. [MySQL Enterprise Backup](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\mysql-enterprise.html#mysql-enterprise-backup) adds CRC32 checksum support in 3.8.1, with some limitations. Refer to the [MySQL Enterprise Backup](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\mysql-enterprise.html#mysql-enterprise-backup) 3.8.1 Change History for more information.

The value **innodb** is backward-compatible with earlier versions of MySQL. The value **crc32** uses an algorithm that is faster to compute the checksum for every modified block, and to check the checksums for each disk read. It scans blocks 32 bits at a time, which is faster than the **innodb** checksum algorithm, which scans blocks 8 bits at a time. The value **none** writes a constant value in the checksum field rather than computing a value based on the block data. The blocks in a tablespace can use a mix of old, new, and no checksum values, being updated gradually as the data is modified; once blocks in a tablespace are modified to use the **crc32** algorithm, the associated tables cannot be read by earlier versions of MySQL.

The strict form of a checksum algorithm reports an error if it encounters a valid but non-matching checksum value in a tablespace. It is recommended that you only use strict settings in a new instance, to set up tablespaces for the first time. Strict settings are somewhat faster, because they do not need to compute all checksum values during disk reads.

The following table shows the difference between the **none**, **innodb**, and **crc32** option values, and their strict counterparts. **none**, **innodb**, and **crc32** write the specified type of checksum value into each data block, but for compatibility accept other checksum values when verifying a block during a read operation. Strict settings also accept valid checksum values but print an error message when a valid non-matching checksum value is encountered. Using the strict form can make verification faster if all **InnoDB** data files in an instance are created under an identical [**innodb\_checksum\_algorithm**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_checksum_algorithm) value.

**Table 15.26 Permitted innodb\_checksum\_algorithm Values**

| **Value** | **Generated checksum (when writing)** | **Permitted checksums (when reading)** |
| --- | --- | --- |
| **none** | A constant number. | Any of the checksums generated by **none**, **innodb**, or **crc32**. |
| **innodb** | A checksum calculated in software, using the original algorithm from **InnoDB**. | Any of the checksums generated by **none**, **innodb**, or **crc32**. |
| **crc32** | A checksum calculated using the **crc32** algorithm, possibly done with a hardware assist. | Any of the checksums generated by **none**, **innodb**, or **crc32**. |
| **strict\_none** | A constant number | Any of the checksums generated by **none**, **innodb**, or **crc32**. **InnoDB** prints an error message if a valid but non-matching checksum is encountered. |
| **strict\_innodb** | A checksum calculated in software, using the original algorithm from **InnoDB**. | Any of the checksums generated by **none**, **innodb**, or **crc32**. **InnoDB** prints an error message if a valid but non-matching checksum is encountered. |
| **strict\_crc32** | A checksum calculated using the **crc32** algorithm, possibly done with a hardware assist. | Any of the checksums generated by **none**, **innodb**, or **crc32**. **InnoDB** prints an error message if a valid but non-matching checksum is encountered. |

**[innodb\_cmp\_per\_index\_enabled](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_cmp_per_index_enabled)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-cmp-per-index-enabled[={OFF|ON}]** |
| **System Variable** | [**innodb\_cmp\_per\_index\_enabled**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_cmp_per_index_enabled) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Boolean |
| **Default Value** | **OFF** |

Enables per-index compression-related statistics in the [**INFORMATION\_SCHEMA.INNODB\_CMP\_PER\_INDEX**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-cmp-per-index-table) table. Because these statistics can be expensive to gather, only enable this option on development, test, or replica instances during performance tuning related to **InnoDB** [compressed](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_compression) tables.

For more information, see [Section 26.4.8, “The INFORMATION\_SCHEMA INNODB\_CMP\_PER\_INDEX and INNODB\_CMP\_PER\_INDEX\_RESET Tables”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-cmp-per-index-table), and [Section 15.9.1.4, “Monitoring InnoDB Table Compression at Runtime”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-compression-tuning-monitoring).

**[innodb\_commit\_concurrency](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_commit_concurrency)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-commit-concurrency=#** |
| **System Variable** | [**innodb\_commit\_concurrency**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_commit_concurrency) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Integer |
| **Default Value** | **0** |
| **Minimum Value** | **0** |
| **Maximum Value** | **1000** |

The number of [threads](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_thread) that can [commit](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_commit) at the same time. A value of 0 (the default) permits any number of [transactions](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_transaction) to commit simultaneously.

The value of [**innodb\_commit\_concurrency**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_commit_concurrency) cannot be changed at runtime from zero to nonzero or vice versa. The value can be changed from one nonzero value to another.

**[innodb\_compress\_debug](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_compress_debug)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-compress-debug=value** |
| **System Variable** | [**innodb\_compress\_debug**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_compress_debug) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Enumeration |
| **Default Value** | **none** |
| **Valid Values** | **none**  **zlib**  **lz4**  **lz4hc** |

Compresses all tables using a specified compression algorithm without having to define a **COMPRESSION** attribute for each table. This option is only available if debugging support is compiled in using the [WITH\_DEBUG](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\installing.html#option_cmake_with_debug) **CMake** option.

For related information, see [Section 15.9.2, “InnoDB Page Compression”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-page-compression).

**[innodb\_compression\_failure\_threshold\_pct](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_compression_failure_threshold_pct)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-compression-failure-threshold-pct=#** |
| **System Variable** | [**innodb\_compression\_failure\_threshold\_pct**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_compression_failure_threshold_pct) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Integer |
| **Default Value** | **5** |
| **Minimum Value** | **0** |
| **Maximum Value** | **100** |

Defines the compression failure rate threshold for a table, as a percentage, at which point MySQL begins adding padding within [compressed](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_compression) pages to avoid expensive [compression failures](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_compression_failure). When this threshold is passed, MySQL begins to leave additional free space within each new compressed page, dynamically adjusting the amount of free space up to the percentage of page size specified by [**innodb\_compression\_pad\_pct\_max**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_compression_pad_pct_max). A value of zero disables the mechanism that monitors compression efficiency and dynamically adjusts the padding amount.

For more information, see [Section 15.9.1.6, “Compression for OLTP Workloads”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-performance-compression-oltp).

**[innodb\_compression\_level](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_compression_level)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-compression-level=#** |
| **System Variable** | [**innodb\_compression\_level**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_compression_level) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Integer |
| **Default Value** | **6** |
| **Minimum Value** | **0** |
| **Maximum Value** | **9** |

Specifies the level of zlib compression to use for **InnoDB** [compressed](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_compression) tables and indexes. A higher value lets you fit more data onto a storage device, at the expense of more CPU overhead during compression. A lower value lets you reduce CPU overhead when storage space is not critical, or you expect the data is not especially compressible.

For more information, see [Section 15.9.1.6, “Compression for OLTP Workloads”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-performance-compression-oltp).

**[innodb\_compression\_pad\_pct\_max](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_compression_pad_pct_max)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-compression-pad-pct-max=#** |
| **System Variable** | [**innodb\_compression\_pad\_pct\_max**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_compression_pad_pct_max) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Integer |
| **Default Value** | **50** |
| **Minimum Value** | **0** |
| **Maximum Value** | **75** |

Specifies the maximum percentage that can be reserved as free space within each compressed [page](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_page), allowing room to reorganize the data and modification log within the page when a [compressed](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_compression) table or index is updated and the data might be recompressed. Only applies when [**innodb\_compression\_failure\_threshold\_pct**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_compression_failure_threshold_pct) is set to a nonzero value, and the rate of [compression failures](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_compression_failure) passes the cutoff point.

For more information, see [Section 15.9.1.6, “Compression for OLTP Workloads”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-performance-compression-oltp).

**[innodb\_concurrency\_tickets](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_concurrency_tickets)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-concurrency-tickets=#** |
| **System Variable** | [**innodb\_concurrency\_tickets**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_concurrency_tickets) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Integer |
| **Default Value** | **5000** |
| **Minimum Value** | **1** |
| **Maximum Value** | **4294967295** |

Determines the number of [threads](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_thread) that can enter **InnoDB** concurrently. A thread is placed in a queue when it tries to enter **InnoDB** if the number of threads has already reached the concurrency limit. When a thread is permitted to enter **InnoDB**, it is given a number of “ tickets” equal to the value of [**innodb\_concurrency\_tickets**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_concurrency_tickets), and the thread can enter and leave **InnoDB** freely until it has used up its tickets. After that point, the thread again becomes subject to the concurrency check (and possible queuing) the next time it tries to enter **InnoDB**. The default value is 5000.

With a small [**innodb\_concurrency\_tickets**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_concurrency_tickets) value, small transactions that only need to process a few rows compete fairly with larger transactions that process many rows. The disadvantage of a small [**innodb\_concurrency\_tickets**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_concurrency_tickets) value is that large transactions must loop through the queue many times before they can complete, which extends the amount of time required to complete their task.

With a large [**innodb\_concurrency\_tickets**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_concurrency_tickets) value, large transactions spend less time waiting for a position at the end of the queue (controlled by [**innodb\_thread\_concurrency**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_thread_concurrency)) and more time retrieving rows. Large transactions also require fewer trips through the queue to complete their task. The disadvantage of a large [**innodb\_concurrency\_tickets**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_concurrency_tickets) value is that too many large transactions running at the same time can starve smaller transactions by making them wait a longer time before executing.

With a nonzero [**innodb\_thread\_concurrency**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_thread_concurrency) value, you may need to adjust the [**innodb\_concurrency\_tickets**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_concurrency_tickets) value up or down to find the optimal balance between larger and smaller transactions. The **SHOW ENGINE INNODB STATUS** report shows the number of tickets remaining for an executing transaction in its current pass through the queue. This data may also be obtained from the **TRX\_CONCURRENCY\_TICKETS** column of the [**INFORMATION\_SCHEMA.INNODB\_TRX**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-trx-table) table.

For more information, see [Section 15.8.4, “Configuring Thread Concurrency for InnoDB”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-performance-thread_concurrency).

**[innodb\_data\_file\_path](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_data_file_path)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-data-file-path=file\_name** |
| **System Variable** | [**innodb\_data\_file\_path**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_data_file_path) |
| **Scope** | Global |
| **Dynamic** | No |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | String |
| **Default Value** | **ibdata1:12M:autoextend** |

Defines the name, size, and attributes of **InnoDB** system tablespace data files. If you do not specify a value for [**innodb\_data\_file\_path**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_data_file_path), the default behavior is to create a single auto-extending data file, slightly larger than 12MB, named ibdata1.

The full syntax for a data file specification includes the file name, file size, **autoextend** attribute, and **max** attribute:

***file\_name***:***file\_size***[:autoextend[:max:***max\_file\_size***]]

File sizes are specified in kilobytes, megabytes, or gigabytes by appending **K**, **M** or **G** to the size value. If specifying the data file size in kilobytes, do so in multiples of 1024. Otherwise, KB values are rounded to nearest megabyte (MB) boundary. The sum of file sizes must be, at a minimum, slightly larger than 12MB.

For additional configuration information, see [System Tablespace Data File Configuration](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-startup-data-file-configuration). For resizing instructions, see [Resizing the System Tablespace](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-resize-system-tablespace).

**[innodb\_data\_home\_dir](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_data_home_dir)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-data-home-dir=dir\_name** |
| **System Variable** | [**innodb\_data\_home\_dir**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_data_home_dir) |
| **Scope** | Global |
| **Dynamic** | No |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Directory name |

The common part of the directory path for **InnoDB** [system tablespace](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_system_tablespace) data files. The default value is the MySQL data directory. The setting is concatenated with the [**innodb\_data\_file\_path**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_data_file_path) setting, unless that setting is defined with an absolute path.

A trailing slash is required when specifying a value for [**innodb\_data\_home\_dir**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_data_home_dir). For example:

[mysqld]

innodb\_data\_home\_dir = /path/to/myibdata/

This setting does not affect the location of [file-per-table](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_file_per_table) tablespaces.

For related information, see [Section 15.8.1, “InnoDB Startup Configuration”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-init-startup-configuration).

**[innodb\_ddl\_log\_crash\_reset\_debug](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_ddl_log_crash_reset_debug)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-ddl-log-crash-reset-debug[={OFF|ON}]** |
| **System Variable** | [**innodb\_ddl\_log\_crash\_reset\_debug**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_ddl_log_crash_reset_debug) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Boolean |
| **Default Value** | **OFF** |

Enable this debug option to reset DDL log crash injection counters to 1. This option is only available when debugging support is compiled in using the [WITH\_DEBUG](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\installing.html#option_cmake_with_debug) **CMake** option.

**[innodb\_deadlock\_detect](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_deadlock_detect)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-deadlock-detect[={OFF|ON}]** |
| **System Variable** | [**innodb\_deadlock\_detect**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_deadlock_detect) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Boolean |
| **Default Value** | **ON** |

This option is used to disable deadlock detection. On high concurrency systems, deadlock detection can cause a slowdown when numerous threads wait for the same lock. At times, it may be more efficient to disable deadlock detection and rely on the [**innodb\_lock\_wait\_timeout**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_lock_wait_timeout) setting for transaction rollback when a deadlock occurs.

For related information, see [Section 15.7.5.2, “Deadlock Detection”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-deadlock-detection).

**[innodb\_dedicated\_server](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_dedicated_server)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-dedicated-server[={OFF|ON}]** |
| **System Variable** | [**innodb\_dedicated\_server**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_dedicated_server) |
| **Scope** | Global |
| **Dynamic** | No |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Boolean |
| **Default Value** | **OFF** |

When [**innodb\_dedicated\_server**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_dedicated_server) is enabled, **InnoDB** automatically configures the following variables:

[**innodb\_buffer\_pool\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_size)

[**innodb\_log\_file\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_log_file_size)

[**innodb\_log\_files\_in\_group**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_log_files_in_group) (as of MySQL 8.0.14)

[**innodb\_flush\_method**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_flush_method)

Only consider enabling [**innodb\_dedicated\_server**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_dedicated_server) if the MySQL instance resides on a dedicated server where it can use all available system resources. Enabling [**innodb\_dedicated\_server**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_dedicated_server) is not recommended if the MySQL instance shares system resources with other applications.

For more information, see [Section 15.8.12, “Enabling Automatic Configuration for a Dedicated MySQL Server”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-dedicated-server).

**[innodb\_default\_row\_format](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_default_row_format)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-default-row-format=value** |
| **System Variable** | [**innodb\_default\_row\_format**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_default_row_format) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Enumeration |
| **Default Value** | **DYNAMIC** |
| **Valid Values** | **DYNAMIC**  **COMPACT**  **REDUNDANT** |

The [**innodb\_default\_row\_format**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_default_row_format) option defines the default row format for **InnoDB** tables and user-created temporary tables. The default setting is **DYNAMIC**. Other permitted values are **COMPACT** and **REDUNDANT**. The **COMPRESSED** row format, which is not supported for use in the [system tablespace](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_system_tablespace), cannot be defined as the default.

Newly created tables use the row format defined by [**innodb\_default\_row\_format**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_default_row_format) when a **ROW\_FORMAT** option is not specified explicitly or when **ROW\_FORMAT=DEFAULT** is used.

When a **ROW\_FORMAT** option is not specified explicitly or when **ROW\_FORMAT=DEFAULT** is used, any operation that rebuilds a table also silently changes the row format of the table to the format defined by [**innodb\_default\_row\_format**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_default_row_format). For more information, see [Defining the Row Format of a Table](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-row-format-defining).

Internal **InnoDB** temporary tables created by the server to process queries use the **DYNAMIC** row format, regardless of the [**innodb\_default\_row\_format**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_default_row_format) setting.

**[innodb\_directories](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_directories)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-directories=dir\_name** |
| **System Variable** | [**innodb\_directories**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_directories) |
| **Scope** | Global |
| **Dynamic** | No |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Directory name |
| **Default Value** | **NULL** |

Defines directories to scan at startup for tablespace files. This option is used when moving or restoring tablespace files to a new location while the server is offline. It is also used to specify directories of tablespace files created using an absolute path or that reside outside of the data directory.

Tablespace discovery during crash recovery relies on the [**innodb\_directories**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_directories) setting to identify tablespaces referenced in the redo logs. For more information, see [Tablespace Discovery During Crash Recovery](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-recovery-tablespace-discovery).

The default value is NULL, but directories defined by [**innodb\_data\_home\_dir**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_data_home_dir), [**innodb\_undo\_directory**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_undo_directory), and [**datadir**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_datadir) are always appended to the [**innodb\_directories**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_directories) argument value when **InnoDB** builds a list of directories to scan at startup. These directories are appended regardless of whether an [**innodb\_directories**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_directories) setting is specified explicitly.

[**innodb\_directories**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_directories) may be specified as an option in a startup command or in a MySQL option file. Quotes surround the argument value because otherwise some command interpreters interpret semicolon (**;**) as a special character. (For example, Unix shells treat it as a command terminator.)

Startup command:

mysqld --innodb-directories="***directory\_path\_1***;***directory\_path\_2***"

MySQL option file:

[mysqld]

innodb\_directories="***directory\_path\_1***;***directory\_path\_2***"

Wildcard expressions cannot be used to specify directories.

The [**innodb\_directories**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_directories) scan also traverses the subdirectories of specified directories. Duplicate directories and subdirectories are discarded from the list of directories to be scanned.

For more information, see [Section 15.6.3.6, “Moving Tablespace Files While the Server is Offline”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-moving-data-files-offline).

**[innodb\_disable\_sort\_file\_cache](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_disable_sort_file_cache)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-disable-sort-file-cache[={OFF|ON}]** |
| **System Variable** | [**innodb\_disable\_sort\_file\_cache**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_disable_sort_file_cache) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Boolean |
| **Default Value** | **OFF** |

Disables the operating system file system cache for merge-sort temporary files. The effect is to open such files with the equivalent of **O\_DIRECT**.

**[innodb\_doublewrite](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_doublewrite)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-doublewrite[={OFF|ON}]** |
| **System Variable** | [**innodb\_doublewrite**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_doublewrite) |
| **Scope** | Global |
| **Dynamic** | No |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Boolean |
| **Default Value** | **ON** |

The [**innodb\_doublewrite**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_doublewrite) variable controls whether the doublwrite buffer is enabled. It is enabled by default in most cases. To disable the doublewrite buffer, set [**innodb\_doublewrite**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_doublewrite) to 0 or start the server with **--skip-innodb-doublewrite**. You might consider disabling the doublewrite buffer if you are more concerned with performance than data integrity, as may be the case when performing benchmarks, for example.

If the doublewrite buffer is located on a Fusion-io device that supports atomic writes, the doublewrite buffer is automatically disabled and data file writes are performed using Fusion-io atomic writes instead. However, be aware that the [**innodb\_doublewrite**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_doublewrite) setting is global. When the doublewrite buffer is disabled, it is disabled for all data files including those that do not reside on Fusion-io hardware. This feature is only supported on Fusion-io hardware and is only enabled for Fusion-io NVMFS on Linux. To take full advantage of this feature, an [**innodb\_flush\_method**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_flush_method) setting of **O\_DIRECT** is recommended.

For related information, see [Section 15.6.4, “Doublewrite Buffer”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-doublewrite-buffer).

**[innodb\_doublewrite\_batch\_size](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_doublewrite_batch_size)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-doublewrite-batch-size=#** |
| **Introduced** | 8.0.20 |
| **System Variable** | [**innodb\_doublewrite\_batch\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_doublewrite_batch_size) |
| **Scope** | Global |
| **Dynamic** | No |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Integer |
| **Default Value** | **0** |
| **Minimum Value** | **0** |
| **Maximum Value** | **256** |

Defines the number of doublewrite pages to write in a batch.

For more information, see [Section 15.6.4, “Doublewrite Buffer”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-doublewrite-buffer).

**[innodb\_doublewrite\_dir](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_doublewrite_dir)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-doublewrite-dir=dir\_name** |
| **Introduced** | 8.0.20 |
| **System Variable** | [**innodb\_doublewrite\_dir**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_doublewrite_dir) |
| **Scope** | Global |
| **Dynamic** | No |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Directory name |

Defines the directory for doublewrite files. If no directory is specified, doublewrite files are created in the [**innodb\_data\_home\_dir**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_data_home_dir) directory, which defaults to the data directory if unspecified.

For more information, see [Section 15.6.4, “Doublewrite Buffer”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-doublewrite-buffer).

**[innodb\_doublewrite\_files](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_doublewrite_files)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-doublewrite-files=#** |
| **Introduced** | 8.0.20 |
| **System Variable** | [**innodb\_doublewrite\_files**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_doublewrite_files) |
| **Scope** | Global |
| **Dynamic** | No |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Integer |
| **Default Value** | **innodb\_buffer\_pool\_instances \* 2** |
| **Minimum Value** | **2** |
| **Maximum Value** | **256** |

Defines the number of doublewrite files. By default, two doublewrite files are created for each buffer pool instance.

At a minimum, there are two doublewrite files. The maximum number of doublewrite files is two times the number of buffer pool instances. (The number of buffer pool instances is controlled by the [**innodb\_buffer\_pool\_instances**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_instances) variable.)

For more information, see [Section 15.6.4, “Doublewrite Buffer”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-doublewrite-buffer).

**[innodb\_doublewrite\_pages](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_doublewrite_pages)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-doublewrite-pages=#** |
| **Introduced** | 8.0.20 |
| **System Variable** | [**innodb\_doublewrite\_pages**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_doublewrite_pages) |
| **Scope** | Global |
| **Dynamic** | No |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Integer |
| **Default Value** | **innodb\_write\_io\_threads value** |
| **Minimum Value** | **innodb\_write\_io\_threads value** |
| **Maximum Value** | **512** |

Defines the maximum number of doublewrite pages per thread for a batch write. If no value is specified, [**innodb\_doublewrite\_pages**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_doublewrite_pages) is set to the [**innodb\_write\_io\_threads**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_write_io_threads) value.

For more information, see [Section 15.6.4, “Doublewrite Buffer”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-doublewrite-buffer).

**[innodb\_extend\_and\_initialize](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_extend_and_initialize)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb=extend-and-initialize[={OFF|ON}]** |
| **Introduced** | 8.0.22 |
| **System Variable** | [**innodb\_extend\_and\_initialize**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_extend_and_initialize) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Boolean |
| **Default Value** | **ON** |

Controls how space is allocated to file-per-table and general tablespaces on Linux systems.

When enabled, **InnoDB** writes NULLs to newly allocated pages. When disabled, space is allocated using **posix\_fallocate()** calls, which reserve space without physically writing NULLs.

For more information, see [Section 15.6.3.8, “Optimizing Tablespace Space Allocation on Linux”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-optimize-tablespace-page-allocation).

**[innodb\_fast\_shutdown](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_fast_shutdown)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-fast-shutdown=#** |
| **System Variable** | [**innodb\_fast\_shutdown**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_fast_shutdown) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Integer |
| **Default Value** | **1** |
| **Valid Values** | **0**  **1**  **2** |

The **InnoDB** [shutdown](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_shutdown) mode. If the value is 0, **InnoDB** does a [slow shutdown](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_slow_shutdown), a full [purge](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_purge) and a change buffer merge before shutting down. If the value is 1 (the default), **InnoDB** skips these operations at shutdown, a process known as a [fast shutdown](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_fast_shutdown). If the value is 2, **InnoDB** flushes its logs and shuts down cold, as if MySQL had crashed; no committed transactions are lost, but the [crash recovery](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_crash_recovery) operation makes the next startup take longer.

The slow shutdown can take minutes, or even hours in extreme cases where substantial amounts of data are still buffered. Use the slow shutdown technique before upgrading or downgrading between MySQL major releases, so that all data files are fully prepared in case the upgrade process updates the file format.

Use [**innodb\_fast\_shutdown=2**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_fast_shutdown) in emergency or troubleshooting situations, to get the absolute fastest shutdown if data is at risk of corruption.

**[innodb\_fil\_make\_page\_dirty\_debug](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_fil_make_page_dirty_debug)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-fil-make-page-dirty-debug=#** |
| **System Variable** | [**innodb\_fil\_make\_page\_dirty\_debug**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_fil_make_page_dirty_debug) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Integer |
| **Default Value** | **0** |
| **Maximum Value** | **2\*\*32-1** |

By default, setting [**innodb\_fil\_make\_page\_dirty\_debug**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_fil_make_page_dirty_debug) to the ID of a tablespace immediately dirties the first page of the tablespace. If [**innodb\_saved\_page\_number\_debug**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_saved_page_number_debug) is set to a non-default value, setting [**innodb\_fil\_make\_page\_dirty\_debug**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_fil_make_page_dirty_debug) dirties the specified page. The [**innodb\_fil\_make\_page\_dirty\_debug**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_fil_make_page_dirty_debug) option is only available if debugging support is compiled in using the [WITH\_DEBUG](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\installing.html#option_cmake_with_debug) **CMake** option.

**[innodb\_file\_per\_table](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_file_per_table)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-file-per-table[={OFF|ON}]** |
| **System Variable** | [**innodb\_file\_per\_table**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_file_per_table) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Boolean |
| **Default Value** | **ON** |

When [**innodb\_file\_per\_table**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_file_per_table) is enabled, tables are created in file-per-table tablespaces by default. When disabled, tables are created in the system tablespace by default. For information about file-per-table tablespaces, see [Section 15.6.3.2, “File-Per-Table Tablespaces”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-file-per-table-tablespaces). For information about the **InnoDB** system tablespace, see [Section 15.6.3.1, “The System Tablespace”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-system-tablespace).

The [**innodb\_file\_per\_table**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_file_per_table) variable can be configured at runtime using a [**SET GLOBAL**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#set-variable) statement, specified on the command line at startup, or specified in an option file. Configuration at runtime requires privileges sufficient to set global system variables (see [Section 5.1.9.1, “System Variable Privileges”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#system-variable-privileges)) and immediately affects the operation of all connections.

When a table that resides in a file-per-table tablespace is truncated or dropped, the freed space is returned to the operating system. Truncating or dropping a table that resides in the system tablespace only frees space in the system tablespace. Freed space in the system tablespace can be used again for **InnoDB** data but is not returned to the operating system, as system tablespace data files never shrink.

The [**innodb\_file\_per-table**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_file_per_table) setting does not affect the creation of temporary tables. As of MySQL 8.0.14, temporary tables are created in session temporary tablespaces, and in the global temporary tablespace before that. See [Section 15.6.3.5, “Temporary Tablespaces”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-temporary-tablespace).

**[innodb\_fill\_factor](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_fill_factor)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-fill-factor=#** |
| **System Variable** | [**innodb\_fill\_factor**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_fill_factor) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Integer |
| **Default Value** | **100** |
| **Minimum Value** | **10** |
| **Maximum Value** | **100** |

**InnoDB** performs a bulk load when creating or rebuilding indexes. This method of index creation is known as a “sorted index build”.

[**innodb\_fill\_factor**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_fill_factor) defines the percentage of space on each B-tree page that is filled during a sorted index build, with the remaining space reserved for future index growth. For example, setting [**innodb\_fill\_factor**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_fill_factor) to 80 reserves 20 percent of the space on each B-tree page for future index growth. Actual percentages may vary. The [**innodb\_fill\_factor**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_fill_factor) setting is interpreted as a hint rather than a hard limit.

An [**innodb\_fill\_factor**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_fill_factor) setting of 100 leaves 1/16 of the space in clustered index pages free for future index growth.

[**innodb\_fill\_factor**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_fill_factor) applies to both B-tree leaf and non-leaf pages. It does not apply to external pages used for [**TEXT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-types.html#blob) or [**BLOB**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-types.html#blob) entries.

For more information, see [Section 15.6.2.3, “Sorted Index Builds”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sorted-index-builds).

**[innodb\_flush\_log\_at\_timeout](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_flush_log_at_timeout)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-flush-log-at-timeout=#** |
| **System Variable** | [**innodb\_flush\_log\_at\_timeout**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_flush_log_at_timeout) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Integer |
| **Default Value** | **1** |
| **Minimum Value** | **1** |
| **Maximum Value** | **2700** |

Write and flush the logs every ***N*** seconds. [**innodb\_flush\_log\_at\_timeout**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_flush_log_at_timeout) allows the timeout period between flushes to be increased in order to reduce flushing and avoid impacting performance of binary log group commit. The default setting for [**innodb\_flush\_log\_at\_timeout**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_flush_log_at_timeout) is once per second.

**[innodb\_flush\_log\_at\_trx\_commit](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_flush_log_at_trx_commit)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-flush-log-at-trx-commit=#** |
| **System Variable** | [**innodb\_flush\_log\_at\_trx\_commit**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_flush_log_at_trx_commit) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Enumeration |
| **Default Value** | **1** |
| **Valid Values** | **0**  **1**  **2** |

Controls the balance between strict [ACID](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_acid) compliance for [commit](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_commit) operations and higher performance that is possible when commit-related I/O operations are rearranged and done in batches. You can achieve better performance by changing the default value but then you can lose transactions in a crash.

The default setting of 1 is required for full ACID compliance. Logs are written and flushed to disk at each transaction commit.

With a setting of 0, logs are written and flushed to disk once per second. Transactions for which logs have not been flushed can be lost in a crash.

With a setting of 2, logs are written after each transaction commit and flushed to disk once per second. Transactions for which logs have not been flushed can be lost in a crash.

For settings 0 and 2, once-per-second flushing is not 100% guaranteed. Flushing may occur more frequently due to DDL changes and other internal **InnoDB** activities that cause logs to be flushed independently of the [**innodb\_flush\_log\_at\_trx\_commit**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_flush_log_at_trx_commit) setting, and sometimes less frequently due to scheduling issues. If logs are flushed once per second, up to one second of transactions can be lost in a crash. If logs are flushed more or less frequently than once per second, the amount of transactions that can be lost varies accordingly.

Log flushing frequency is controlled by [**innodb\_flush\_log\_at\_timeout**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_flush_log_at_timeout), which allows you to set log flushing frequency to ***N*** seconds (where ***N*** is **1 ... 2700**, with a default value of 1). However, any unexpected [**mysqld**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\programs.html#mysqld) process exit can erase up to ***N*** seconds of transactions.

DDL changes and other internal **InnoDB** activities flush the log independently of the [**innodb\_flush\_log\_at\_trx\_commit**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_flush_log_at_trx_commit) setting.

**InnoDB** [crash recovery](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_crash_recovery) works regardless of the [**innodb\_flush\_log\_at\_trx\_commit**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_flush_log_at_trx_commit) setting. Transactions are either applied entirely or erased entirely.

For durability and consistency in a replication setup that uses **InnoDB** with transactions:

If binary logging is enabled, set **sync\_binlog=1**.

Always set [**innodb\_flush\_log\_at\_trx\_commit=1**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_flush_log_at_trx_commit).

For information on the combination of settings on a replica that is most resilient to unexpected halts, see [Section 17.4.2, “Handling an Unexpected Halt of a Replica”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\replication.html#replication-solutions-unexpected-replica-halt).

**Caution**

Many operating systems and some disk hardware fool the flush-to-disk operation. They may tell [**mysqld**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\programs.html#mysqld) that the flush has taken place, even though it has not. In this case, the durability of transactions is not guaranteed even with the recommended settings, and in the worst case, a power outage can corrupt **InnoDB** data. Using a battery-backed disk cache in the SCSI disk controller or in the disk itself speeds up file flushes, and makes the operation safer. You can also try to disable the caching of disk writes in hardware caches.

**[innodb\_flush\_method](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_flush_method)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-flush-method=value** |
| **System Variable** | [**innodb\_flush\_method**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_flush_method) |
| **Scope** | Global |
| **Dynamic** | No |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | String |
| **Default Value (Windows)** | **unbuffered** |
| **Default Value (Unix)** | **fsync** |
| **Valid Values (Windows)** | **unbuffered**  **normal** |
| **Valid Values (Unix)** | **fsync**  **O\_DSYNC**  **littlesync**  **nosync**  **O\_DIRECT**  **O\_DIRECT\_NO\_FSYNC** |

Defines the method used to [flush](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_flush) data to **InnoDB** [data files](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_data_files) and [log files](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_log_file), which can affect I/O throughput.

On Unix-like systems, the default value is **fsync**. On Windows, the default value is **unbuffered**.

**Note**

In MySQL 8.0, [**innodb\_flush\_method**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_flush_method) options may be specified numerically.

The [**innodb\_flush\_method**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_flush_method) options for Unix-like systems include:

**fsync** or **0**: **InnoDB** uses the **fsync()** system call to flush both the data and log files. **fsync** is the default setting.

**O\_DSYNC** or **1**: **InnoDB** uses **O\_SYNC** to open and flush the log files, and **fsync()** to flush the data files. **InnoDB** does not use **O\_DSYNC** directly because there have been problems with it on many varieties of Unix.

**littlesync** or **2**: This option is used for internal performance testing and is currently unsupported. Use at your own risk.

**nosync** or **3**: This option is used for internal performance testing and is currently unsupported. Use at your own risk.

**O\_DIRECT** or **4**: **InnoDB** uses **O\_DIRECT** (or **directio()** on Solaris) to open the data files, and uses **fsync()** to flush both the data and log files. This option is available on some GNU/Linux versions, FreeBSD, and Solaris.

**O\_DIRECT\_NO\_FSYNC**: **InnoDB** uses **O\_DIRECT** during flushing I/O, but skips the **fsync()** system call after each write operation.

Prior to MySQL 8.0.14, this setting is not suitable for file systems such as XFS and EXT4, which require an **fsync()** system call to synchronize file system metadata changes. If you are not sure whether your file system requires an **fsync()** system call to synchronize file system metadata changes, use **O\_DIRECT** instead.

As of MySQL 8.0.14, **fsync()** is called after creating a new file, after increasing file size, and after closing a file, to ensure that file system metadata changes are synchronized. The **fsync()** system call is still skipped after each write operation.

Data loss is possible if redo log files and data files reside on different storage devices, and an unexpected exit occurs before data file writes are flushed from a device cache that is not battery-backed. If you use or intend to use different storage devices for redo log files and data files, and your data files reside on a device with a cache that is not battery-backed, use **O\_DIRECT** instead.

The [**innodb\_flush\_method**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_flush_method) options for Windows systems include:

**unbuffered** or **0**: **InnoDB** uses simulated asynchronous I/O and non-buffered I/O.

**normal** or **1**: **InnoDB** uses simulated asynchronous I/O and buffered I/O.

How each setting affects performance depends on hardware configuration and workload. Benchmark your particular configuration to decide which setting to use, or whether to keep the default setting. Examine the [**Innodb\_data\_fsyncs**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#statvar_Innodb_data_fsyncs) status variable to see the overall number of **fsync()** calls for each setting. The mix of read and write operations in your workload can affect how a setting performs. For example, on a system with a hardware RAID controller and battery-backed write cache, **O\_DIRECT** can help to avoid double buffering between the **InnoDB** buffer pool and the operating system file system cache. On some systems where **InnoDB** data and log files are located on a SAN, the default value or **O\_DSYNC** might be faster for a read-heavy workload with mostly **SELECT** statements. Always test this parameter with hardware and workload that reflect your production environment. For general I/O tuning advice, see [Section 8.5.8, “Optimizing InnoDB Disk I/O”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizing-innodb-diskio).

If [**innodb\_dedicated\_server**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_dedicated_server) is enabled, the [**innodb\_flush\_method**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_flush_method) value is automatically configured if it is not explicitly defined. For more information, see [Section 15.8.12, “Enabling Automatic Configuration for a Dedicated MySQL Server”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-dedicated-server).

**[innodb\_flush\_neighbors](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_flush_neighbors)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-flush-neighbors=#** |
| **System Variable** | [**innodb\_flush\_neighbors**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_flush_neighbors) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Enumeration |
| **Default Value** | **0** |
| **Valid Values** | **0**  **1**  **2** |

Specifies whether [flushing](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_flush) a page from the **InnoDB** [buffer pool](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_buffer_pool) also flushes other [dirty pages](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_dirty_page) in the same [extent](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_extent).

A setting of 0 disables [**innodb\_flush\_neighbors**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_flush_neighbors). Dirty pages in the same extent are not flushed.

A setting of 1 flushes contiguous dirty pages in the same extent.

A setting of 2 flushes dirty pages in the same extent.

When the table data is stored on a traditional [HDD](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_hdd) storage device, flushing such [neighbor pages](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_neighbor_page) in one operation reduces I/O overhead (primarily for disk seek operations) compared to flushing individual pages at different times. For table data stored on [SSD](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_ssd), seek time is not a significant factor and you can set this option to 0 to spread out write operations. For related information, see [Section 15.8.3.5, “Configuring Buffer Pool Flushing”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-buffer-pool-flushing).

**[innodb\_flush\_sync](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_flush_sync)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-flush-sync[={OFF|ON}]** |
| **System Variable** | [**innodb\_flush\_sync**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_flush_sync) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Boolean |
| **Default Value** | **ON** |

The [**innodb\_flush\_sync**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_flush_sync) variable, which is enabled by default, causes the [**innodb\_io\_capacity**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_io_capacity) setting to be ignored during bursts of I/O activity that occur at [checkpoints](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_checkpoint). To adhere to the I/O rate defined by the [**innodb\_io\_capacity**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_io_capacity) setting, disable [**innodb\_flush\_sync**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_flush_sync).

For information about configuring the [**innodb\_flush\_sync**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_flush_sync) variable, see [Section 15.8.7, “Configuring InnoDB I/O Capacity”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-configuring-io-capacity).

**[innodb\_flushing\_avg\_loops](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_flushing_avg_loops)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-flushing-avg-loops=#** |
| **System Variable** | [**innodb\_flushing\_avg\_loops**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_flushing_avg_loops) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Integer |
| **Default Value** | **30** |
| **Minimum Value** | **1** |
| **Maximum Value** | **1000** |

Number of iterations for which **InnoDB** keeps the previously calculated snapshot of the flushing state, controlling how quickly [adaptive flushing](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_adaptive_flushing) responds to changing [workloads](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_workload). Increasing the value makes the rate of [flush](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_flush) operations change smoothly and gradually as the workload changes. Decreasing the value makes adaptive flushing adjust quickly to workload changes, which can cause spikes in flushing activity if the workload increases and decreases suddenly.

For related information, see [Section 15.8.3.5, “Configuring Buffer Pool Flushing”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-buffer-pool-flushing).

**[innodb\_force\_load\_corrupted](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_force_load_corrupted)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-force-load-corrupted[={OFF|ON}]** |
| **System Variable** | [**innodb\_force\_load\_corrupted**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_force_load_corrupted) |
| **Scope** | Global |
| **Dynamic** | No |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Boolean |
| **Default Value** | **OFF** |

Permits **InnoDB** to load tables at startup that are marked as corrupted. Use only during troubleshooting, to recover data that is otherwise inaccessible. When troubleshooting is complete, disable this setting and restart the server.

**[innodb\_force\_recovery](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_force_recovery)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-force-recovery=#** |
| **System Variable** | [**innodb\_force\_recovery**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_force_recovery) |
| **Scope** | Global |
| **Dynamic** | No |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Integer |
| **Default Value** | **0** |
| **Minimum Value** | **0** |
| **Maximum Value** | **6** |

The [crash recovery](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_crash_recovery) mode, typically only changed in serious troubleshooting situations. Possible values are from 0 to 6. For the meanings of these values and important information about [**innodb\_force\_recovery**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_force_recovery), see [Section 15.21.2, “Forcing InnoDB Recovery”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#forcing-innodb-recovery).

**Warning**

Only set this variable to a value greater than 0 in an emergency situation so that you can start **InnoDB** and dump your tables. As a safety measure, **InnoDB** prevents [**INSERT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#insert), [**UPDATE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#update), or [**DELETE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#delete) operations when [**innodb\_force\_recovery**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_force_recovery) is greater than 0. An [**innodb\_force\_recovery**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_force_recovery) setting of 4 or greater places **InnoDB** into read-only mode.

These restrictions may cause replication administration commands to fail with an error, as replication stores the replica status logs in **InnoDB** tables.

**[innodb\_fsync\_threshold](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_fsync_threshold)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-fsync-threshold=#** |
| **Introduced** | 8.0.13 |
| **System Variable** | [**innodb\_fsync\_threshold**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_fsync_threshold) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Integer |
| **Default Value** | **0** |
| **Minimum Value** | **0** |
| **Maximum Value** | **2\*\*64-1** |

By default, when **InnoDB** creates a new data file, such as a new log file or tablespace file, the file is fully written to the operating system cache before it is flushed to disk, which can cause a large amount of disk write activity to occur at once. To force smaller, periodic flushes of data from the operating system cache, you can use the [**innodb\_fsync\_threshold**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_fsync_threshold) variable to define a threshold value, in bytes. When the byte threshold is reached, the contents of the operating system cache are flushed to disk. The default value of 0 forces the default behavior, which is to flush data to disk only after a file is fully written to the cache.

Specifying a threshold to force smaller, periodic flushes may be beneficial in cases where multiple MySQL instances use the same storage devices. For example, creating a new MySQL instance and its associated data files could cause large surges of disk write activity, impeding the performance of other MySQL instances that use the same storage devices. Configuring a threshold helps avoid such surges in write activity.

**[innodb\_ft\_aux\_table](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_ft_aux_table)**

|  |  |
| --- | --- |
| **System Variable** | [**innodb\_ft\_aux\_table**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_ft_aux_table) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | String |

Specifies the qualified name of an **InnoDB** table containing a **FULLTEXT** index. This variable is intended for diagnostic purposes and can only be set at runtime. For example:

SET GLOBAL innodb\_ft\_aux\_table = 'test/t1';

After you set this variable to a name in the format ***db\_name*/*table\_name***, the **INFORMATION\_SCHEMA** tables [**INNODB\_FT\_INDEX\_TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-ft-index-table-table), [**INNODB\_FT\_INDEX\_CACHE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-ft-index-cache-table), [**INNODB\_FT\_CONFIG**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-ft-config-table), [**INNODB\_FT\_DELETED**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-ft-deleted-table), and [**INNODB\_FT\_BEING\_DELETED**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-ft-being-deleted-table) show information about the search index for the specified table.

For more information, see [Section 15.15.4, “InnoDB INFORMATION\_SCHEMA FULLTEXT Index Tables”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-information-schema-fulltext_index-tables).

**[innodb\_ft\_cache\_size](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_ft_cache_size)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-ft-cache-size=#** |
| **System Variable** | [**innodb\_ft\_cache\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_ft_cache_size) |
| **Scope** | Global |
| **Dynamic** | No |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Integer |
| **Default Value** | **8000000** |
| **Minimum Value** | **1600000** |
| **Maximum Value** | **80000000** |

The memory allocated, in bytes, for the **InnoDB** **FULLTEXT** search index cache, which holds a parsed document in memory while creating an **InnoDB** **FULLTEXT** index. Index inserts and updates are only committed to disk when the [**innodb\_ft\_cache\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_ft_cache_size) size limit is reached. [**innodb\_ft\_cache\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_ft_cache_size) defines the cache size on a per table basis. To set a global limit for all tables, see [**innodb\_ft\_total\_cache\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_ft_total_cache_size).

For more information, see [InnoDB Full-Text Index Cache](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-fulltext-index-cache).

**[innodb\_ft\_enable\_diag\_print](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_ft_enable_diag_print)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-ft-enable-diag-print[={OFF|ON}]** |
| **System Variable** | [**innodb\_ft\_enable\_diag\_print**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_ft_enable_diag_print) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Boolean |
| **Default Value** | **OFF** |

Whether to enable additional full-text search (FTS) diagnostic output. This option is primarily intended for advanced FTS debugging and is not of interest to most users. Output is printed to the error log and includes information such as:

FTS index sync progress (when the FTS cache limit is reached). For example:

FTS SYNC for table test, deleted count: 100 size: 10000 bytes

SYNC words: 100

FTS optimize progress. For example:

FTS start optimize test

FTS\_OPTIMIZE: optimize "mysql"

FTS\_OPTIMIZE: processed "mysql"

FTS index build progress. For example:

Number of doc processed: 1000

For FTS queries, the query parsing tree, word weight, query processing time, and memory usage are printed. For example:

FTS Search Processing time: 1 secs: 100 millisec: row(s) 10000

Full Search Memory: 245666 (bytes), Row: 10000

**[innodb\_ft\_enable\_stopword](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_ft_enable_stopword)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-ft-enable-stopword[={OFF|ON}]** |
| **System Variable** | [**innodb\_ft\_enable\_stopword**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_ft_enable_stopword) |
| **Scope** | Global, Session |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Boolean |
| **Default Value** | **ON** |

Specifies that a set of [stopwords](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_stopword) is associated with an **InnoDB** **FULLTEXT** index at the time the index is created. If the [**innodb\_ft\_user\_stopword\_table**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_ft_user_stopword_table) option is set, the stopwords are taken from that table. Else, if the [**innodb\_ft\_server\_stopword\_table**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_ft_server_stopword_table) option is set, the stopwords are taken from that table. Otherwise, a built-in set of default stopwords is used.

For more information, see [Section 12.10.4, “Full-Text Stopwords”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\functions.html#fulltext-stopwords).

**[innodb\_ft\_max\_token\_size](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_ft_max_token_size)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-ft-max-token-size=#** |
| **System Variable** | [**innodb\_ft\_max\_token\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_ft_max_token_size) |
| **Scope** | Global |
| **Dynamic** | No |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Integer |
| **Default Value** | **84** |
| **Minimum Value** | **10** |
| **Maximum Value** | **84** |

Maximum character length of words that are stored in an **InnoDB** **FULLTEXT** index. Setting a limit on this value reduces the size of the index, thus speeding up queries, by omitting long keywords or arbitrary collections of letters that are not real words and are not likely to be search terms.

For more information, see [Section 12.10.6, “Fine-Tuning MySQL Full-Text Search”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\functions.html#fulltext-fine-tuning).

**[innodb\_ft\_min\_token\_size](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_ft_min_token_size)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-ft-min-token-size=#** |
| **System Variable** | [**innodb\_ft\_min\_token\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_ft_min_token_size) |
| **Scope** | Global |
| **Dynamic** | No |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Integer |
| **Default Value** | **3** |
| **Minimum Value** | **0** |
| **Maximum Value** | **16** |

Minimum length of words that are stored in an **InnoDB** **FULLTEXT** index. Increasing this value reduces the size of the index, thus speeding up queries, by omitting common words that are unlikely to be significant in a search context, such as the English words “a” and “to”. For content using a CJK (Chinese, Japanese, Korean) character set, specify a value of 1.

For more information, see [Section 12.10.6, “Fine-Tuning MySQL Full-Text Search”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\functions.html#fulltext-fine-tuning).

**[innodb\_ft\_num\_word\_optimize](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_ft_num_word_optimize)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-ft-num-word-optimize=#** |
| **System Variable** | [**innodb\_ft\_num\_word\_optimize**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_ft_num_word_optimize) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Integer |
| **Default Value** | **2000** |
| **Minimum Value** | **1000** |
| **Maximum Value** | **10000** |

Number of words to process during each [**OPTIMIZE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#optimize-table) operation on an **InnoDB** **FULLTEXT** index. Because a bulk insert or update operation to a table containing a full-text search index could require substantial index maintenance to incorporate all changes, you might do a series of [**OPTIMIZE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#optimize-table) statements, each picking up where the last left off.

For more information, see [Section 12.10.6, “Fine-Tuning MySQL Full-Text Search”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\functions.html#fulltext-fine-tuning).

**[innodb\_ft\_result\_cache\_limit](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_ft_result_cache_limit)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-ft-result-cache-limit=#** |
| **System Variable** | [**innodb\_ft\_result\_cache\_limit**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_ft_result_cache_limit) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Integer |
| **Default Value** | **2000000000** |
| **Minimum Value** | **1000000** |
| **Maximum Value** | **2\*\*32-1** |

The **InnoDB** full-text search query result cache limit (defined in bytes) per full-text search query or per thread. Intermediate and final **InnoDB** full-text search query results are handled in memory. Use [**innodb\_ft\_result\_cache\_limit**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_ft_result_cache_limit) to place a size limit on the full-text search query result cache to avoid excessive memory consumption in case of very large **InnoDB** full-text search query results (millions or hundreds of millions of rows, for example). Memory is allocated as required when a full-text search query is processed. If the result cache size limit is reached, an error is returned indicating that the query exceeds the maximum allowed memory.

The maximum value of [**innodb\_ft\_result\_cache\_limit**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_ft_result_cache_limit) for all platform types and bit sizes is 2\*\*32-1.

**[innodb\_ft\_server\_stopword\_table](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_ft_server_stopword_table)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-ft-server-stopword-table=db\_name/table\_name** |
| **System Variable** | [**innodb\_ft\_server\_stopword\_table**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_ft_server_stopword_table) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | String |
| **Default Value** | **NULL** |

This option is used to specify your own **InnoDB** **FULLTEXT** index stopword list for all **InnoDB** tables. To configure your own stopword list for a specific **InnoDB** table, use [**innodb\_ft\_user\_stopword\_table**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_ft_user_stopword_table).

Set [**innodb\_ft\_server\_stopword\_table**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_ft_server_stopword_table) to the name of the table containing a list of stopwords, in the format ***db\_name*/*table\_name***.

The stopword table must exist before you configure [**innodb\_ft\_server\_stopword\_table**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_ft_server_stopword_table). [**innodb\_ft\_enable\_stopword**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_ft_enable_stopword) must be enabled and [**innodb\_ft\_server\_stopword\_table**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_ft_server_stopword_table) option must be configured before you create the **FULLTEXT** index.

The stopword table must be an **InnoDB** table, containing a single **VARCHAR** column named **value**.

For more information, see [Section 12.10.4, “Full-Text Stopwords”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\functions.html#fulltext-stopwords).

**[innodb\_ft\_sort\_pll\_degree](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_ft_sort_pll_degree)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-ft-sort-pll-degree=#** |
| **System Variable** | [**innodb\_ft\_sort\_pll\_degree**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_ft_sort_pll_degree) |
| **Scope** | Global |
| **Dynamic** | No |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Integer |
| **Default Value** | **2** |
| **Minimum Value** | **1** |
| **Maximum Value** | **32** |

Number of threads used in parallel to index and tokenize text in an **InnoDB** **FULLTEXT** index when building a [search index](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_search_index).

For related information, see [Section 15.6.2.4, “InnoDB Full-Text Indexes”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-fulltext-index), and [**innodb\_sort\_buffer\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_sort_buffer_size).

**[innodb\_ft\_total\_cache\_size](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_ft_total_cache_size)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-ft-total-cache-size=#** |
| **System Variable** | [**innodb\_ft\_total\_cache\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_ft_total_cache_size) |
| **Scope** | Global |
| **Dynamic** | No |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Integer |
| **Default Value** | **640000000** |
| **Minimum Value** | **32000000** |
| **Maximum Value** | **1600000000** |

The total memory allocated, in bytes, for the **InnoDB** full-text search index cache for all tables. Creating numerous tables, each with a **FULLTEXT** search index, could consume a significant portion of available memory. [**innodb\_ft\_total\_cache\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_ft_total_cache_size) defines a global memory limit for all full-text search indexes to help avoid excessive memory consumption. If the global limit is reached by an index operation, a forced sync is triggered.

For more information, see [InnoDB Full-Text Index Cache](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-fulltext-index-cache).

**[innodb\_ft\_user\_stopword\_table](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_ft_user_stopword_table)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-ft-user-stopword-table=db\_name/table\_name** |
| **System Variable** | [**innodb\_ft\_user\_stopword\_table**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_ft_user_stopword_table) |
| **Scope** | Global, Session |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | String |
| **Default Value** | **NULL** |

This option is used to specify your own **InnoDB** **FULLTEXT** index stopword list on a specific table. To configure your own stopword list for all **InnoDB** tables, use [**innodb\_ft\_server\_stopword\_table**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_ft_server_stopword_table).

Set [**innodb\_ft\_user\_stopword\_table**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_ft_user_stopword_table) to the name of the table containing a list of stopwords, in the format ***db\_name*/*table\_name***.

The stopword table must exist before you configure [**innodb\_ft\_user\_stopword\_table**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_ft_user_stopword_table). [**innodb\_ft\_enable\_stopword**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_ft_enable_stopword) must be enabled and [**innodb\_ft\_user\_stopword\_table**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_ft_user_stopword_table) must be configured before you create the **FULLTEXT** index.

The stopword table must be an **InnoDB** table, containing a single **VARCHAR** column named **value**.

For more information, see [Section 12.10.4, “Full-Text Stopwords”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\functions.html#fulltext-stopwords).

**[innodb\_idle\_flush\_pct](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_idle_flush_pct)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-idle-flush-pct=#** |
| **Introduced** | 8.0.18 |
| **System Variable** | [**innodb\_idle\_flush\_pct**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_idle_flush_pct) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Integer |
| **Default Value** | **100** |
| **Minimum Value** | **0** |
| **Maximum Value** | **100** |

Limits page flushing when **InnoDB** is idle. The [**innodb\_idle\_flush\_pct**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_idle_flush_pct) value is a percentage of the [**innodb\_io\_capacity**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_io_capacity) setting, which defines the number of I/O operations per second available to **InnoDB**. For more information, see [Limiting Buffer Flushing During Idle Periods](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-limit-flushing-rate).

**[innodb\_io\_capacity](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_io_capacity)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-io-capacity=#** |
| **System Variable** | [**innodb\_io\_capacity**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_io_capacity) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Integer |
| **Default Value** | **200** |
| **Minimum Value** | **100** |
| **Maximum Value (64-bit platforms)** | **2\*\*64-1** |
| **Maximum Value (32-bit platforms)** | **2\*\*32-1** |

The [**innodb\_io\_capacity**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_io_capacity) variable defines the number of I/O operations per second (IOPS) available to **InnoDB** background tasks, such as [flushing](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_flush) pages from the [buffer pool](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_buffer_pool) and merging data from the [change buffer](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_change_buffer).

For information about configuring the [**innodb\_io\_capacity**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_io_capacity) variable, see [Section 15.8.7, “Configuring InnoDB I/O Capacity”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-configuring-io-capacity).

**[innodb\_io\_capacity\_max](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_io_capacity_max)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-io-capacity-max=#** |
| **System Variable** | [**innodb\_io\_capacity\_max**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_io_capacity_max) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Integer |
| **Default Value** | **see description** |
| **Minimum Value** | **100** |
| **Maximum Value (Windows, 64-bit platforms)** | **2\*\*32-1** |
| **Maximum Value (Unix, 64-bit platforms)** | **2\*\*64-1** |
| **Maximum Value (32-bit platforms)** | **2\*\*32-1** |

If flushing activity falls behind, **InnoDB** can flush more aggressively, at a higher rate of I/O operations per second (IOPS) than defined by the [**innodb\_io\_capacity**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_io_capacity) variable. The [**innodb\_io\_capacity\_max**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_io_capacity_max) variable defines a maximum number of IOPS performed by **InnoDB** background tasks in such situations.

For information about configuring the [**innodb\_io\_capacity\_max**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_io_capacity_max) variable, see [Section 15.8.7, “Configuring InnoDB I/O Capacity”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-configuring-io-capacity).

**[innodb\_limit\_optimistic\_insert\_debug](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_limit_optimistic_insert_debug)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-limit-optimistic-insert-debug=#** |
| **System Variable** | [**innodb\_limit\_optimistic\_insert\_debug**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_limit_optimistic_insert_debug) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Integer |
| **Default Value** | **0** |
| **Minimum Value** | **0** |
| **Maximum Value** | **2\*\*32-1** |

Limits the number of records per [B-tree](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_b_tree) page. A default value of 0 means that no limit is imposed. This option is only available if debugging support is compiled in using the [WITH\_DEBUG](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\installing.html#option_cmake_with_debug) **CMake** option.

**[innodb\_lock\_wait\_timeout](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_lock_wait_timeout)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-lock-wait-timeout=#** |
| **System Variable** | [**innodb\_lock\_wait\_timeout**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_lock_wait_timeout) |
| **Scope** | Global, Session |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Integer |
| **Default Value** | **50** |
| **Minimum Value** | **1** |
| **Maximum Value** | **1073741824** |

The length of time in seconds an **InnoDB** [transaction](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_transaction) waits for a [row lock](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_row_lock) before giving up. The default value is 50 seconds. A transaction that tries to access a row that is locked by another **InnoDB** transaction waits at most this many seconds for write access to the row before issuing the following error:

ERROR 1205 (HY000): Lock wait timeout exceeded; try restarting transaction

When a lock wait timeout occurs, the current statement is [rolled back](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_rollback) (not the entire transaction). To have the entire transaction roll back, start the server with the [--innodb-rollback-on-timeout](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_rollback_on_timeout) option. See also [Section 15.21.4, “InnoDB Error Handling”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-error-handling).

You might decrease this value for highly interactive applications or [OLTP](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_oltp) systems, to display user feedback quickly or put the update into a queue for processing later. You might increase this value for long-running back-end operations, such as a transform step in a data warehouse that waits for other large insert or update operations to finish.

[**innodb\_lock\_wait\_timeout**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_lock_wait_timeout) applies to **InnoDB** row locks. A MySQL [table lock](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_table_lock) does not happen inside **InnoDB** and this timeout does not apply to waits for table locks.

The lock wait timeout value does not apply to [deadlocks](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_deadlock) when [**innodb\_deadlock\_detect**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_deadlock_detect) is enabled (the default) because **InnoDB** detects deadlocks immediately and rolls back one of the deadlocked transactions. When [**innodb\_deadlock\_detect**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_deadlock_detect) is disabled, **InnoDB** relies on [**innodb\_lock\_wait\_timeout**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_lock_wait_timeout) for transaction rollback when a deadlock occurs. See [Section 15.7.5.2, “Deadlock Detection”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-deadlock-detection).

[**innodb\_lock\_wait\_timeout**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_lock_wait_timeout) can be set at runtime with the **SET GLOBAL** or **SET SESSION** statement. Changing the **GLOBAL** setting requires privileges sufficient to set global system variables (see [Section 5.1.9.1, “System Variable Privileges”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#system-variable-privileges)) and affects the operation of all clients that subsequently connect. Any client can change the **SESSION** setting for [**innodb\_lock\_wait\_timeout**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_lock_wait_timeout), which affects only that client.

**[innodb\_log\_buffer\_size](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_log_buffer_size)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-log-buffer-size=#** |
| **System Variable** | [**innodb\_log\_buffer\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_log_buffer_size) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Integer |
| **Default Value** | **16777216** |
| **Minimum Value** | **1048576** |
| **Maximum Value** | **4294967295** |

The size in bytes of the buffer that **InnoDB** uses to write to the [log files](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_log_file) on disk. The default is 16MB. A large [log buffer](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_log_buffer) enables large [transactions](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_transaction) to run without the need to write the log to disk before the transactions [commit](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_commit). Thus, if you have transactions that update, insert, or delete many rows, making the log buffer larger saves disk I/O. For related information, see [Memory Configuration](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-startup-memory-configuration), and [Section 8.5.4, “Optimizing InnoDB Redo Logging”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizing-innodb-logging). For general I/O tuning advice, see [Section 8.5.8, “Optimizing InnoDB Disk I/O”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizing-innodb-diskio).

**[innodb\_log\_checkpoint\_fuzzy\_now](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_log_checkpoint_fuzzy_now)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-log-checkpoint-fuzzy-now[={OFF|ON}]** |
| **Introduced** | 8.0.13 |
| **System Variable** | [**innodb\_log\_checkpoint\_fuzzy\_now**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_log_checkpoint_fuzzy_now) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Boolean |
| **Default Value** | **OFF** |

Enable this debug option to force **InnoDB** to write a fuzzy checkpoint. This option is only available if debugging support is compiled in using the [WITH\_DEBUG](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\installing.html#option_cmake_with_debug) **CMake** option.

**[innodb\_log\_checkpoint\_now](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_log_checkpoint_now)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-log-checkpoint-now[={OFF|ON}]** |
| **System Variable** | [**innodb\_log\_checkpoint\_now**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_log_checkpoint_now) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Boolean |
| **Default Value** | **OFF** |

Enable this debug option to force **InnoDB** to write a checkpoint. This option is only available if debugging support is compiled in using the [WITH\_DEBUG](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\installing.html#option_cmake_with_debug) **CMake** option.

**[innodb\_log\_checksums](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_log_checksums)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-log-checksums[={OFF|ON}]** |
| **System Variable** | [**innodb\_log\_checksums**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_log_checksums) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Boolean |
| **Default Value** | **ON** |

Enables or disables checksums for redo log pages.

[**innodb\_log\_checksums=ON**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_log_checksums) enables the **CRC-32C** checksum algorithm for redo log pages. When [**innodb\_log\_checksums**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_log_checksums) is disabled, the contents of the redo log page checksum field are ignored.

Checksums on the redo log header page and redo log checkpoint pages are never disabled.

**[innodb\_log\_compressed\_pages](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_log_compressed_pages)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-log-compressed-pages[={OFF|ON}]** |
| **System Variable** | [**innodb\_log\_compressed\_pages**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_log_compressed_pages) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Boolean |
| **Default Value** | **ON** |

Specifies whether images of [re-compressed](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_compression) [pages](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_page) are written to the [redo log](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_redo_log). Re-compression may occur when changes are made to compressed data.

[**innodb\_log\_compressed\_pages**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_log_compressed_pages) is enabled by default to prevent corruption that could occur if a different version of the **zlib** compression algorithm is used during recovery. If you are certain that the **zlib** version is not subject to change, you can disable [**innodb\_log\_compressed\_pages**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_log_compressed_pages) to reduce redo log generation for workloads that modify compressed data.

To measure the effect of enabling or disabling [**innodb\_log\_compressed\_pages**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_log_compressed_pages), compare redo log generation for both settings under the same workload. Options for measuring redo log generation include observing the **Log sequence number** (LSN) in the **LOG** section of [**SHOW ENGINE INNODB STATUS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#show-engine) output, or monitoring [**Innodb\_os\_log\_written**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#statvar_Innodb_os_log_written) status for the number of bytes written to the redo log files.

For related information, see [Section 15.9.1.6, “Compression for OLTP Workloads”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-performance-compression-oltp).

**[innodb\_log\_file\_size](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_log_file_size)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-log-file-size=#** |
| **System Variable** | [**innodb\_log\_file\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_log_file_size) |
| **Scope** | Global |
| **Dynamic** | No |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Integer |
| **Default Value** | **50331648** |
| **Minimum Value** | **4194304** |
| **Maximum Value** | **512GB / innodb\_log\_files\_in\_group** |

The size in bytes of each [log file](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_log_file) in a [log group](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_log_group). The combined size of log files ([**innodb\_log\_file\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_log_file_size) \* [**innodb\_log\_files\_in\_group**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_log_files_in_group)) cannot exceed a maximum value that is slightly less than 512GB. A pair of 255 GB log files, for example, approaches the limit but does not exceed it. The default value is 48MB.

Generally, the combined size of the log files should be large enough that the server can smooth out peaks and troughs in workload activity, which often means that there is enough redo log space to handle more than an hour of write activity. The larger the value, the less checkpoint flush activity is required in the buffer pool, saving disk I/O. Larger log files also make [crash recovery](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_crash_recovery) slower.

The minimum [**innodb\_log\_file\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_log_file_size) is 4MB.

For related information, see [Redo Log File Configuration](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-startup-log-file-configuration). For general I/O tuning advice, see [Section 8.5.8, “Optimizing InnoDB Disk I/O”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizing-innodb-diskio).

If [**innodb\_dedicated\_server**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_dedicated_server) is enabled, the [**innodb\_log\_file\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_log_file_size) value is automatically configured if it is not explicitly defined. For more information, see [Section 15.8.12, “Enabling Automatic Configuration for a Dedicated MySQL Server”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-dedicated-server).

**[innodb\_log\_files\_in\_group](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_log_files_in_group)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-log-files-in-group=#** |
| **System Variable** | [**innodb\_log\_files\_in\_group**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_log_files_in_group) |
| **Scope** | Global |
| **Dynamic** | No |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Integer |
| **Default Value** | **2** |
| **Minimum Value** | **2** |
| **Maximum Value** | **100** |

The number of [log files](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_log_file) in the [log group](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_log_group). **InnoDB** writes to the files in a circular fashion. The default (and recommended) value is 2. The location of the files is specified by [**innodb\_log\_group\_home\_dir**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_log_group_home_dir). The combined size of log files ([**innodb\_log\_file\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_log_file_size) \* [**innodb\_log\_files\_in\_group**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_log_files_in_group)) can be up to 512GB.

For related information, see [Redo Log File Configuration](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-startup-log-file-configuration).

**[innodb\_log\_group\_home\_dir](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_log_group_home_dir)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-log-group-home-dir=dir\_name** |
| **System Variable** | [**innodb\_log\_group\_home\_dir**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_log_group_home_dir) |
| **Scope** | Global |
| **Dynamic** | No |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Directory name |

The directory path to the **InnoDB** [redo log](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_redo_log) files, whose number is specified by [**innodb\_log\_files\_in\_group**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_log_files_in_group). If you do not specify any **InnoDB** log variables, the default is to create two files named ib\_logfile0 and ib\_logfile1 in the MySQL data directory. Log file size is given by the [**innodb\_log\_file\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_log_file_size) system variable.

For related information, see [Redo Log File Configuration](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-startup-log-file-configuration).

**[innodb\_log\_spin\_cpu\_abs\_lwm](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_log_spin_cpu_abs_lwm)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-log-spin-cpu-abs-lwm=#** |
| **System Variable** | [**innodb\_log\_spin\_cpu\_abs\_lwm**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_log_spin_cpu_abs_lwm) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Integer |
| **Default Value** | **80** |
| **Minimum Value** | **0** |
| **Maximum Value** | **4294967295** |

Defines the minimum amount of CPU usage below which user threads no longer spin while waiting for flushed redo. The value is expressed as a sum of CPU core usage. For example, The default value of 80 is 80% of a single CPU core. On a system with a multi-core processor, a value of 150 represents 100% usage of one CPU core plus 50% usage of a second CPU core.

For related information, see [Section 8.5.4, “Optimizing InnoDB Redo Logging”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizing-innodb-logging).

**[innodb\_log\_spin\_cpu\_pct\_hwm](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_log_spin_cpu_pct_hwm)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-log-spin-cpu-pct-hwm=#** |
| **System Variable** | [**innodb\_log\_spin\_cpu\_pct\_hwm**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_log_spin_cpu_pct_hwm) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Integer |
| **Default Value** | **50** |
| **Minimum Value** | **0** |
| **Maximum Value** | **100** |

Defines the maximum amount of CPU usage above which user threads no longer spin while waiting for flushed redo. The value is expressed as a percentage of the combined total processing power of all CPU cores. The default value is 50%. For example, 100% usage of two CPU cores is 50% of the combined CPU processing power on a server with four CPU cores.

The [**innodb\_log\_spin\_cpu\_pct\_hwm**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_log_spin_cpu_pct_hwm) variable respects processor affinity. For example, if a server has 48 cores but the [**mysqld**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\programs.html#mysqld) process is pinned to only four CPU cores, the other 44 CPU cores are ignored.

For related information, see [Section 8.5.4, “Optimizing InnoDB Redo Logging”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizing-innodb-logging).

**[innodb\_log\_wait\_for\_flush\_spin\_hwm](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_log_wait_for_flush_spin_hwm)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-log-wait-for-flush-spin-hwm=#** |
| **System Variable** | [**innodb\_log\_wait\_for\_flush\_spin\_hwm**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_log_wait_for_flush_spin_hwm) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Integer |
| **Default Value** | **400** |
| **Minimum Value** | **0** |
| **Maximum Value (64-bit platforms)** | **2\*\*64-1** |
| **Maximum Value (32-bit platforms)** | **2\*\*32-1** |

Defines the maximum average log flush time beyond which user threads no longer spin while waiting for flushed redo. The default value is 400 microseconds.

For related information, see [Section 8.5.4, “Optimizing InnoDB Redo Logging”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizing-innodb-logging).

**[innodb\_log\_write\_ahead\_size](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_log_write_ahead_size)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-log-write-ahead-size=#** |
| **System Variable** | [**innodb\_log\_write\_ahead\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_log_write_ahead_size) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Integer |
| **Default Value** | **8192** |
| **Minimum Value** | **512 (log file block size)** |
| **Maximum Value** | **Equal to innodb\_page\_size** |

Defines the write-ahead block size for the redo log, in bytes. To avoid “read-on-write”, set [**innodb\_log\_write\_ahead\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_log_write_ahead_size) to match the operating system or file system cache block size. The default setting is 8192 bytes. Read-on-write occurs when redo log blocks are not entirely cached to the operating system or file system due to a mismatch between write-ahead block size for the redo log and operating system or file system cache block size.

Valid values for [**innodb\_log\_write\_ahead\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_log_write_ahead_size) are multiples of the **InnoDB** log file block size (2n). The minimum value is the **InnoDB** log file block size (512). Write-ahead does not occur when the minimum value is specified. The maximum value is equal to the [**innodb\_page\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_page_size) value. If you specify a value for [**innodb\_log\_write\_ahead\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_log_write_ahead_size) that is larger than the [**innodb\_page\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_page_size) value, the [**innodb\_log\_write\_ahead\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_log_write_ahead_size) setting is truncated to the [**innodb\_page\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_page_size) value.

Setting the [**innodb\_log\_write\_ahead\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_log_write_ahead_size) value too low in relation to the operating system or file system cache block size results in “read-on-write”. Setting the value too high may have a slight impact on **fsync** performance for log file writes due to several blocks being written at once.

For related information, see [Section 8.5.4, “Optimizing InnoDB Redo Logging”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizing-innodb-logging).

**[innodb\_log\_writer\_threads](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_log_writer_threads)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-log-writer-threads[={OFF|ON}]** |
| **Introduced** | 8.0.22 |
| **System Variable** | [**innodb\_log\_writer\_threads**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_log_writer_threads) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Boolean |
| **Default Value** | **ON** |

Enables dedicated log writer threads for writing redo log records from the log buffer to the system buffers and flushing the system buffers to the redo log files. Dedicated log writer threads can improve performance on high-concurrency systems, but for low-concurrency systems, disabling dedicated log writer threads provides better performance.

For more information, see [Section 8.5.4, “Optimizing InnoDB Redo Logging”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizing-innodb-logging).

**[innodb\_lru\_scan\_depth](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_lru_scan_depth)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-lru-scan-depth=#** |
| **System Variable** | [**innodb\_lru\_scan\_depth**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_lru_scan_depth) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Integer |
| **Default Value** | **1024** |
| **Minimum Value** | **100** |
| **Maximum Value (64-bit platforms)** | **2\*\*64-1** |
| **Maximum Value (32-bit platforms)** | **2\*\*32-1** |

A parameter that influences the algorithms and heuristics for the [flush](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_flush) operation for the **InnoDB** [buffer pool](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_buffer_pool). Primarily of interest to performance experts tuning I/O-intensive workloads. It specifies, per buffer pool instance, how far down the buffer pool LRU page list the page cleaner thread scans looking for [dirty pages](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_dirty_page) to flush. This is a background operation performed once per second.

A setting smaller than the default is generally suitable for most workloads. A value that is much higher than necessary may impact performance. Only consider increasing the value if you have spare I/O capacity under a typical workload. Conversely, if a write-intensive workload saturates your I/O capacity, decrease the value, especially in the case of a large buffer pool.

When tuning [**innodb\_lru\_scan\_depth**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_lru_scan_depth), start with a low value and configure the setting upward with the goal of rarely seeing zero free pages. Also, consider adjusting [**innodb\_lru\_scan\_depth**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_lru_scan_depth) when changing the number of buffer pool instances, since [**innodb\_lru\_scan\_depth**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_lru_scan_depth) \* [**innodb\_buffer\_pool\_instances**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_instances) defines the amount of work performed by the page cleaner thread each second.

For related information, see [Section 15.8.3.5, “Configuring Buffer Pool Flushing”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-buffer-pool-flushing). For general I/O tuning advice, see [Section 8.5.8, “Optimizing InnoDB Disk I/O”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizing-innodb-diskio).

**[innodb\_max\_dirty\_pages\_pct](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_max_dirty_pages_pct)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-max-dirty-pages-pct=#** |
| **System Variable** | [**innodb\_max\_dirty\_pages\_pct**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_max_dirty_pages_pct) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Numeric |
| **Default Value** | **90** |
| **Minimum Value** | **0** |
| **Maximum Value** | **99.99** |

**InnoDB** tries to [flush](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_flush) data from the [buffer pool](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_buffer_pool) so that the percentage of [dirty pages](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_dirty_page) does not exceed this value.

The [**innodb\_max\_dirty\_pages\_pct**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_max_dirty_pages_pct) setting establishes a target for flushing activity. It does not affect the rate of flushing. For information about managing the rate of flushing, see [Section 15.8.3.5, “Configuring Buffer Pool Flushing”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-buffer-pool-flushing).

For related information, see [Section 15.8.3.5, “Configuring Buffer Pool Flushing”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-buffer-pool-flushing). For general I/O tuning advice, see [Section 8.5.8, “Optimizing InnoDB Disk I/O”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizing-innodb-diskio).

**[innodb\_max\_dirty\_pages\_pct\_lwm](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_max_dirty_pages_pct_lwm)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-max-dirty-pages-pct-lwm=#** |
| **System Variable** | [**innodb\_max\_dirty\_pages\_pct\_lwm**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_max_dirty_pages_pct_lwm) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Numeric |
| **Default Value** | **10** |
| **Minimum Value** | **0** |
| **Maximum Value** | **99.99** |

Defines a low water mark representing the percentage of [dirty pages](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_dirty_page) at which preflushing is enabled to control the dirty page ratio. A value of 0 disables the pre-flushing behavior entirely. The configured value should always be lower than the [**innodb\_max\_dirty\_pages\_pct**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_max_dirty_pages_pct) value. For more information, see [Section 15.8.3.5, “Configuring Buffer Pool Flushing”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-buffer-pool-flushing).

**[innodb\_max\_purge\_lag](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_max_purge_lag)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-max-purge-lag=#** |
| **System Variable** | [**innodb\_max\_purge\_lag**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_max_purge_lag) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Integer |
| **Default Value** | **0** |
| **Minimum Value** | **0** |
| **Maximum Value** | **4294967295** |

Defines the desired maximum purge lag. If this value is exceeded, a delay is imposed on [**INSERT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#insert), [**UPDATE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#update), and [**DELETE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#delete) operations to allow time for purge to catch up. The default value is 0, which means there is no maximum purge lag and no delay.

For more information, see [Section 15.8.9, “Purge Configuration”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-purge-configuration).

**[innodb\_max\_purge\_lag\_delay](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_max_purge_lag_delay)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-max-purge-lag-delay=#** |
| **System Variable** | [**innodb\_max\_purge\_lag\_delay**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_max_purge_lag_delay) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Integer |
| **Default Value** | **0** |
| **Minimum Value** | **0** |
| **Maximum Value** | **10000000** |

Specifies the maximum delay in microseconds for the delay imposed when the [**innodb\_max\_purge\_lag**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_max_purge_lag) threshold is exceeded. The specified [**innodb\_max\_purge\_lag\_delay**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_max_purge_lag_delay) value is an upper limit on the delay period calculated by the [**innodb\_max\_purge\_lag**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_max_purge_lag) formula.

For more information, see [Section 15.8.9, “Purge Configuration”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-purge-configuration).

**[innodb\_max\_undo\_log\_size](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_max_undo_log_size)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-max-undo-log-size=#** |
| **System Variable** | [**innodb\_max\_undo\_log\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_max_undo_log_size) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Integer |
| **Default Value** | **1073741824** |
| **Minimum Value** | **10485760** |
| **Maximum Value** | **2\*\*64-1** |

Defines a threshold size for undo tablespaces. If an undo tablespace exceeds the threshold, it can be marked for truncation when [**innodb\_undo\_log\_truncate**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_undo_log_truncate) is enabled. The default value is 1073741824 bytes (1024 MiB).

For more information, see [Truncating Undo Tablespaces](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#truncate-undo-tablespace).

**[innodb\_merge\_threshold\_set\_all\_debug](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_merge_threshold_set_all_debug)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-merge-threshold-set-all-debug=#** |
| **System Variable** | [**innodb\_merge\_threshold\_set\_all\_debug**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_merge_threshold_set_all_debug) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Integer |
| **Default Value** | **50** |
| **Minimum Value** | **1** |
| **Maximum Value** | **50** |

Defines a page-full percentage value for index pages that overrides the current **MERGE\_THRESHOLD** setting for all indexes that are currently in the dictionary cache. This option is only available if debugging support is compiled in using the [WITH\_DEBUG](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\installing.html#option_cmake_with_debug) **CMake** option. For related information, see [Section 15.8.11, “Configuring the Merge Threshold for Index Pages”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#index-page-merge-threshold).

**[innodb\_monitor\_disable](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_monitor_disable)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-monitor-disable={counter|module|pattern|all}** |
| **System Variable** | [**innodb\_monitor\_disable**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_monitor_disable) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | String |

Disables **InnoDB** [metrics counters](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_metrics_counter). Counter data may be queried using the [**INFORMATION\_SCHEMA.INNODB\_METRICS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-metrics-table) table. For usage information, see [Section 15.15.6, “InnoDB INFORMATION\_SCHEMA Metrics Table”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-information-schema-metrics-table).

[**innodb\_monitor\_disable='latch'**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_monitor_disable) disables statistics collection for [**SHOW ENGINE INNODB MUTEX**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#show-engine). For more information, see [Section 13.7.7.15, “SHOW ENGINE Statement”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#show-engine).

**[innodb\_monitor\_enable](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_monitor_enable)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-monitor-enable={counter|module|pattern|all}** |
| **System Variable** | [**innodb\_monitor\_enable**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_monitor_enable) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | String |

Enables **InnoDB** [metrics counters](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_metrics_counter). Counter data may be queried using the [**INFORMATION\_SCHEMA.INNODB\_METRICS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-metrics-table) table. For usage information, see [Section 15.15.6, “InnoDB INFORMATION\_SCHEMA Metrics Table”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-information-schema-metrics-table).

[**innodb\_monitor\_enable='latch'**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_monitor_enable) enables statistics collection for [**SHOW ENGINE INNODB MUTEX**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#show-engine). For more information, see [Section 13.7.7.15, “SHOW ENGINE Statement”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#show-engine).

**[innodb\_monitor\_reset](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_monitor_reset)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-monitor-reset={counter|module|pattern|all}** |
| **System Variable** | [**innodb\_monitor\_reset**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_monitor_reset) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Enumeration |
| **Default Value** | **empty string** |
| **Valid Values** | **counter**  **module**  **pattern**  **all** |

Resets the count value for **InnoDB** [metrics counters](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_metrics_counter) to zero. Counter data may be queried using the [**INFORMATION\_SCHEMA.INNODB\_METRICS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-metrics-table) table. For usage information, see [Section 15.15.6, “InnoDB INFORMATION\_SCHEMA Metrics Table”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-information-schema-metrics-table).

[**innodb\_monitor\_reset='latch'**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_monitor_reset) resets statistics reported by [**SHOW ENGINE INNODB MUTEX**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#show-engine). For more information, see [Section 13.7.7.15, “SHOW ENGINE Statement”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#show-engine).

**[innodb\_monitor\_reset\_all](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_monitor_reset_all)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-monitor-reset-all={counter|module|pattern|all}** |
| **System Variable** | [**innodb\_monitor\_reset\_all**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_monitor_reset_all) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Enumeration |
| **Default Value** | **empty string** |
| **Valid Values** | **counter**  **module**  **pattern**  **all** |

Resets all values (minimum, maximum, and so on) for **InnoDB** [metrics counters](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_metrics_counter). Counter data may be queried using the [**INFORMATION\_SCHEMA.INNODB\_METRICS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-metrics-table) table. For usage information, see [Section 15.15.6, “InnoDB INFORMATION\_SCHEMA Metrics Table”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-information-schema-metrics-table).

**[innodb\_numa\_interleave](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_numa_interleave)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-numa-interleave[={OFF|ON}]** |
| **System Variable** | [**innodb\_numa\_interleave**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_numa_interleave) |
| **Scope** | Global |
| **Dynamic** | No |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Boolean |
| **Default Value** | **OFF** |

Enables the NUMA interleave memory policy for allocation of the **InnoDB** buffer pool. When [**innodb\_numa\_interleave**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_numa_interleave) is enabled, the NUMA memory policy is set to **MPOL\_INTERLEAVE** for the [**mysqld**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\programs.html#mysqld) process. After the **InnoDB** buffer pool is allocated, the NUMA memory policy is set back to **MPOL\_DEFAULT**. For the [**innodb\_numa\_interleave**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_numa_interleave) option to be available, MySQL must be compiled on a NUMA-enabled Linux system.

**CMake** sets the default [WITH\_NUMA](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\installing.html#option_cmake_with_numa) value based on whether the current platform has **NUMA** support. For more information, see [Section 2.9.7, “MySQL Source-Configuration Options”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\installing.html#source-configuration-options).

**[innodb\_old\_blocks\_pct](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_old_blocks_pct)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-old-blocks-pct=#** |
| **System Variable** | [**innodb\_old\_blocks\_pct**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_old_blocks_pct) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Integer |
| **Default Value** | **37** |
| **Minimum Value** | **5** |
| **Maximum Value** | **95** |

Specifies the approximate percentage of the **InnoDB** [buffer pool](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_buffer_pool) used for the old block [sublist](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_sublist). The range of values is 5 to 95. The default value is 37 (that is, 3/8 of the pool). Often used in combination with [**innodb\_old\_blocks\_time**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_old_blocks_time).

For more information, see [Section 15.8.3.3, “Making the Buffer Pool Scan Resistant”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-performance-midpoint_insertion). For information about buffer pool management, the [LRU](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_lru) algorithm, and [eviction](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_eviction) policies, see [Section 15.5.1, “Buffer Pool”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-buffer-pool).

**[innodb\_old\_blocks\_time](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_old_blocks_time)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-old-blocks-time=#** |
| **System Variable** | [**innodb\_old\_blocks\_time**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_old_blocks_time) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Integer |
| **Default Value** | **1000** |
| **Minimum Value** | **0** |
| **Maximum Value** | **2\*\*32-1** |

Non-zero values protect against the [buffer pool](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_buffer_pool) being filled by data that is referenced only for a brief period, such as during a [full table scan](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_full_table_scan). Increasing this value offers more protection against full table scans interfering with data cached in the buffer pool.

Specifies how long in milliseconds a block inserted into the old [sublist](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_sublist) must stay there after its first access before it can be moved to the new sublist. If the value is 0, a block inserted into the old sublist moves immediately to the new sublist the first time it is accessed, no matter how soon after insertion the access occurs. If the value is greater than 0, blocks remain in the old sublist until an access occurs at least that many milliseconds after the first access. For example, a value of 1000 causes blocks to stay in the old sublist for 1 second after the first access before they become eligible to move to the new sublist.

The default value is 1000.

This variable is often used in combination with [**innodb\_old\_blocks\_pct**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_old_blocks_pct). For more information, see [Section 15.8.3.3, “Making the Buffer Pool Scan Resistant”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-performance-midpoint_insertion). For information about buffer pool management, the [LRU](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_lru) algorithm, and [eviction](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_eviction) policies, see [Section 15.5.1, “Buffer Pool”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-buffer-pool).

**[innodb\_online\_alter\_log\_max\_size](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_online_alter_log_max_size)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-online-alter-log-max-size=#** |
| **System Variable** | [**innodb\_online\_alter\_log\_max\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_online_alter_log_max_size) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Integer |
| **Default Value** | **134217728** |
| **Minimum Value** | **65536** |
| **Maximum Value** | **2\*\*64-1** |

Specifies an upper limit in bytes on the size of the temporary log files used during [online DDL](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_online_ddl) operations for **InnoDB** tables. There is one such log file for each index being created or table being altered. This log file stores data inserted, updated, or deleted in the table during the DDL operation. The temporary log file is extended when needed by the value of [**innodb\_sort\_buffer\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_sort_buffer_size), up to the maximum specified by [**innodb\_online\_alter\_log\_max\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_online_alter_log_max_size). If a temporary log file exceeds the upper size limit, the [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) operation fails and all uncommitted concurrent DML operations are rolled back. Thus, a large value for this option allows more DML to happen during an online DDL operation, but also extends the period of time at the end of the DDL operation when the table is locked to apply the data from the log.

**[innodb\_open\_files](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_open_files)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-open-files=#** |
| **System Variable** | [**innodb\_open\_files**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_open_files) |
| **Scope** | Global |
| **Dynamic** | No |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Integer |
| **Default Value** | **-1** (signifies autosizing; do not assign this literal value) |
| **Minimum Value** | **10** |
| **Maximum Value** | **4294967295** |

This variable is only relevant if you have numerous **InnoDB** [tablespaces](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_tablespace). It specifies the maximum number of [.ibd files](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_ibd_file) that MySQL can keep open at one time. The minimum value is 10. The default value is 300 if [**innodb\_file\_per\_table**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_file_per_table) is not enabled, and the higher of 300 and [**table\_open\_cache**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_table_open_cache) otherwise.

The file descriptors used for .ibd files are for **InnoDB** tables only. They are independent of those specified by the [**open\_files\_limit**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_open_files_limit) system variable, and do not affect the operation of the table cache. For general I/O tuning advice, see [Section 8.5.8, “Optimizing InnoDB Disk I/O”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizing-innodb-diskio).

Prior to MySQL 8.0.24, temporary tablespaces were counted as open files, which could cause the [**innodb\_open\_files**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_open_files) limit to be exceeded, preventing other files from being opened. As of MySQL 8.0.24, temporary tablespaces are not counted as open files.

**[innodb\_optimize\_fulltext\_only](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_optimize_fulltext_only)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-optimize-fulltext-only[={OFF|ON}]** |
| **System Variable** | [**innodb\_optimize\_fulltext\_only**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_optimize_fulltext_only) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Boolean |
| **Default Value** | **OFF** |

Changes the way [**OPTIMIZE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#optimize-table) operates on **InnoDB** tables. Intended to be enabled temporarily, during maintenance operations for **InnoDB** tables with **FULLTEXT** indexes.

By default, [**OPTIMIZE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#optimize-table) reorganizes data in the [clustered index](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_clustered_index) of the table. When this option is enabled, [**OPTIMIZE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#optimize-table) skips the reorganization of table data, and instead processes newly added, deleted, and updated token data for **InnoDB** **FULLTEXT** indexes. For more information, see [Optimizing InnoDB Full-Text Indexes](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\functions.html#fulltext-optimize).

**[innodb\_page\_cleaners](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_page_cleaners)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-page-cleaners=#** |
| **System Variable** | [**innodb\_page\_cleaners**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_page_cleaners) |
| **Scope** | Global |
| **Dynamic** | No |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Integer |
| **Default Value** | **4** |
| **Minimum Value** | **1** |
| **Maximum Value** | **64** |

The number of page cleaner threads that flush dirty pages from buffer pool instances. Page cleaner threads perform flush list and LRU flushing. When there are multiple page cleaner threads, buffer pool flushing tasks for each buffer pool instance are dispatched to idle page cleaner threads. The [**innodb\_page\_cleaners**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_page_cleaners) default value is 4. If the number of page cleaner threads exceeds the number of buffer pool instances, [**innodb\_page\_cleaners**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_page_cleaners) is automatically set to the same value as [**innodb\_buffer\_pool\_instances**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_instances).

If your workload is write-IO bound when flushing dirty pages from buffer pool instances to data files, and if your system hardware has available capacity, increasing the number of page cleaner threads may help improve write-IO throughput.

Multithreaded page cleaner support extends to shutdown and recovery phases.

The **setpriority()** system call is used on Linux platforms where it is supported, and where the [**mysqld**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\programs.html#mysqld) execution user is authorized to give **page\_cleaner** threads priority over other MySQL and **InnoDB** threads to help page flushing keep pace with the current workload. **setpriority()** support is indicated by this **InnoDB** startup message:

[Note] InnoDB: If the mysqld execution user is authorized, page cleaner

thread priority can be changed. See the man page of setpriority().

For systems where server startup and shutdown is not managed by systemd, [**mysqld**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\programs.html#mysqld) execution user authorization can be configured in /etc/security/limits.conf. For example, if [**mysqld**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\programs.html#mysqld) is run under the **mysql** user, you can authorize the **mysql** user by adding these lines to /etc/security/limits.conf:

mysql hard nice -20

mysql soft nice -20

For systemd managed systems, the same can be achieved by specifying **LimitNICE=-20** in a localized systemd configuration file. For example, create a file named override.conf in /etc/systemd/system/mysqld.service.d/override.conf and add this entry:

[Service]

LimitNICE=-20

After creating or changing override.conf, reload the systemd configuration, then tell systemd to restart the MySQL service:

systemctl daemon-reload

systemctl restart mysqld # RPM platforms

systemctl restart mysql # Debian platforms

For more information about using a localized systemd configuration file, see [Configuring systemd for MySQL](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\installing.html#systemd-mysql-configuration).

After authorizing the [**mysqld**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\programs.html#mysqld) execution user, use the **cat** command to verify the configured **Nice** limits for the [**mysqld**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\programs.html#mysqld) process:

shell> cat /proc/***mysqld\_pid***/limits | grep nice

Max nice priority 18446744073709551596 18446744073709551596

**[innodb\_page\_size](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_page_size)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-page-size=#** |
| **System Variable** | [**innodb\_page\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_page_size) |
| **Scope** | Global |
| **Dynamic** | No |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Enumeration |
| **Default Value** | **16384** |
| **Valid Values** | **4096**  **8192**  **16384**  **32768**  **65536** |

Specifies the [page size](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_page_size) for **InnoDB** [tablespaces](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_tablespace). Values can be specified in bytes or kilobytes. For example, a 16 kilobyte page size value can be specified as 16384, 16KB, or 16k.

[**innodb\_page\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_page_size) can only be configured prior to initializing the MySQL instance and cannot be changed afterward. If no value is specified, the instance is initialized using the default page size. See [Section 15.8.1, “InnoDB Startup Configuration”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-init-startup-configuration).

For both 32KB and 64KB page sizes, the maximum row length is approximately 16000 bytes. **ROW\_FORMAT=COMPRESSED** is not supported when [**innodb\_page\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_page_size) is set to 32KB or 64KB. For [**innodb\_page\_size=32KB**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_page_size), extent size is 2MB. For [**innodb\_page\_size=64KB**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_page_size), extent size is 4MB. [**innodb\_log\_buffer\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_log_buffer_size) should be set to at least 16M (the default) when using 32KB or 64KB page sizes.

The default 16KB page size or larger is appropriate for a wide range of [workloads](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_workload), particularly for queries involving table scans and DML operations involving bulk updates. Smaller page sizes might be more efficient for [OLTP](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_oltp) workloads involving many small writes, where contention can be an issue when single pages contain many rows. Smaller pages might also be efficient with [SSD](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_ssd) storage devices, which typically use small block sizes. Keeping the **InnoDB** page size close to the storage device block size minimizes the amount of unchanged data that is rewritten to disk.

The minimum file size for the first system tablespace data file (**ibdata1**) differs depending on the [**innodb\_page\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_page_size) value. See the [**innodb\_data\_file\_path**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_data_file_path) option description for more information.

A MySQL instance using a particular **InnoDB** page size cannot use data files or log files from an instance that uses a different page size.

For general I/O tuning advice, see [Section 8.5.8, “Optimizing InnoDB Disk I/O”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizing-innodb-diskio).

**[innodb\_parallel\_read\_threads](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_parallel_read_threads)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-parallel-read-threads=#** |
| **Introduced** | 8.0.14 |
| **System Variable** | [**innodb\_parallel\_read\_threads**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_parallel_read_threads) |
| **Scope** | Session |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Integer |
| **Default Value** | **4** |
| **Minimum Value** | **1** |
| **Maximum Value** | **256** |

Defines the number of threads that can be used for parallel clustered index reads. Parallel scanning of partitions is supported as of MySQL 8.0.17. Parallel read threads can improve [**CHECK TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#check-table) performance. **InnoDB** reads the clustered index twice during a [**CHECK TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#check-table) operation. The second read can be performed in parallel. This feature does not apply to secondary index scans. The [**innodb\_parallel\_read\_threads**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_parallel_read_threads) session variable must be set to a value greater than 1 for parallel clustered index reads to occur. The actual number of threads used to perform a parallel clustered index read is determined by the [**innodb\_parallel\_read\_threads**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_parallel_read_threads) setting or the number of index subtrees to scan, whichever is smaller. The pages read into the buffer pool during the scan are kept at the tail of the buffer pool LRU list so that they can be discarded quickly when free buffer pool pages are required.

As of MySQL 8.0.17, the maximum number of parallel read threads (256) is the total number of threads for all client connections. If the thread limit is reached, connections fall back to using a single thread.

**[innodb\_print\_all\_deadlocks](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_print_all_deadlocks)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-print-all-deadlocks[={OFF|ON}]** |
| **System Variable** | [**innodb\_print\_all\_deadlocks**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_print_all_deadlocks) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Boolean |
| **Default Value** | **OFF** |

When this option is enabled, information about all [deadlocks](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_deadlock) in **InnoDB** user transactions is recorded in the **mysqld** [error log](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#error-log). Otherwise, you see information about only the last deadlock, using the **SHOW ENGINE INNODB STATUS** command. An occasional **InnoDB** deadlock is not necessarily an issue, because **InnoDB** detects the condition immediately and rolls back one of the transactions automatically. You might use this option to troubleshoot why deadlocks are occurring if an application does not have appropriate error-handling logic to detect the rollback and retry its operation. A large number of deadlocks might indicate the need to restructure transactions that issue [DML](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_dml) or **SELECT ... FOR UPDATE** statements for multiple tables, so that each transaction accesses the tables in the same order, thus avoiding the deadlock condition.

For related information, see [Section 15.7.5, “Deadlocks in InnoDB”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-deadlocks).

**[innodb\_print\_ddl\_logs](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_print_ddl_logs)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-print-ddl-logs[={OFF|ON}]** |
| **System Variable** | [**innodb\_print\_ddl\_logs**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_print_ddl_logs) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Boolean |
| **Default Value** | **OFF** |

Enabling this option causes MySQL to write DDL logs to **stderr**. For more information, see [Viewing DDL Logs](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#atomic-ddl-view-logs).

**[innodb\_purge\_batch\_size](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_purge_batch_size)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-purge-batch-size=#** |
| **System Variable** | [**innodb\_purge\_batch\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_purge_batch_size) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Integer |
| **Default Value** | **300** |
| **Minimum Value** | **1** |
| **Maximum Value** | **5000** |

Defines the number of undo log pages that purge parses and processes in one batch from the [history list](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_history_list). In a multithreaded purge configuration, the coordinator purge thread divides [**innodb\_purge\_batch\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_purge_batch_size) by [**innodb\_purge\_threads**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_purge_threads) and assigns that number of pages to each purge thread. The [**innodb\_purge\_batch\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_purge_batch_size) variable also defines the number of undo log pages that purge frees after every 128 iterations through the undo logs.

The [**innodb\_purge\_batch\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_purge_batch_size) option is intended for advanced performance tuning in combination with the [**innodb\_purge\_threads**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_purge_threads) setting. Most users need not change [**innodb\_purge\_batch\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_purge_batch_size) from its default value.

For related information, see [Section 15.8.9, “Purge Configuration”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-purge-configuration).

**[innodb\_purge\_threads](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_purge_threads)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-purge-threads=#** |
| **System Variable** | [**innodb\_purge\_threads**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_purge_threads) |
| **Scope** | Global |
| **Dynamic** | No |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Integer |
| **Default Value** | **4** |
| **Minimum Value** | **1** |
| **Maximum Value** | **32** |

The number of background threads devoted to the **InnoDB** [purge](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_purge) operation. Increasing the value creates additional purge threads, which can improve efficiency on systems where [DML](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_dml) operations are performed on multiple tables.

For related information, see [Section 15.8.9, “Purge Configuration”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-purge-configuration).

**[innodb\_purge\_rseg\_truncate\_frequency](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_purge_rseg_truncate_frequency)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-purge-rseg-truncate-frequency=#** |
| **System Variable** | [**innodb\_purge\_rseg\_truncate\_frequency**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_purge_rseg_truncate_frequency) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Integer |
| **Default Value** | **128** |
| **Minimum Value** | **1** |
| **Maximum Value** | **128** |

Defines the frequency with which the purge system frees rollback segments in terms of the number of times that purge is invoked. An undo tablespace cannot be truncated until its rollback segments are freed. Normally, the purge system frees rollback segments once every 128 times that purge is invoked. The default value is 128. Reducing this value increases the frequency with which the purge thread frees rollback segments.

[**innodb\_purge\_rseg\_truncate\_frequency**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_purge_rseg_truncate_frequency) is intended for use with [**innodb\_undo\_log\_truncate**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_undo_log_truncate). For more information, see [Truncating Undo Tablespaces](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#truncate-undo-tablespace).

**[innodb\_random\_read\_ahead](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_random_read_ahead)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-random-read-ahead[={OFF|ON}]** |
| **System Variable** | [**innodb\_random\_read\_ahead**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_random_read_ahead) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Boolean |
| **Default Value** | **OFF** |

Enables the random [read-ahead](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_read_ahead) technique for optimizing **InnoDB** I/O.

For details about performance considerations for different types of read-ahead requests, see [Section 15.8.3.4, “Configuring InnoDB Buffer Pool Prefetching (Read-Ahead)”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-performance-read_ahead). For general I/O tuning advice, see [Section 8.5.8, “Optimizing InnoDB Disk I/O”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizing-innodb-diskio).

**[innodb\_read\_ahead\_threshold](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_read_ahead_threshold)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-read-ahead-threshold=#** |
| **System Variable** | [**innodb\_read\_ahead\_threshold**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_read_ahead_threshold) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Integer |
| **Default Value** | **56** |
| **Minimum Value** | **0** |
| **Maximum Value** | **64** |

Controls the sensitivity of linear [read-ahead](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_read_ahead) that **InnoDB** uses to prefetch pages into the [buffer pool](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_buffer_pool). If **InnoDB** reads at least [**innodb\_read\_ahead\_threshold**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_read_ahead_threshold) pages sequentially from an [extent](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_extent) (64 pages), it initiates an asynchronous read for the entire following extent. The permissible range of values is 0 to 64. A value of 0 disables read-ahead. For the default of 56, **InnoDB** must read at least 56 pages sequentially from an extent to initiate an asynchronous read for the following extent.

Knowing how many pages are read through the read-ahead mechanism, and how many of these pages are evicted from the buffer pool without ever being accessed, can be useful when fine-tuning the [**innodb\_read\_ahead\_threshold**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_read_ahead_threshold) setting. [**SHOW ENGINE INNODB STATUS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#show-engine) output displays counter information from the [**Innodb\_buffer\_pool\_read\_ahead**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#statvar_Innodb_buffer_pool_read_ahead) and [**Innodb\_buffer\_pool\_read\_ahead\_evicted**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#statvar_Innodb_buffer_pool_read_ahead_evicted) global status variables, which report the number of pages brought into the [buffer pool](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_buffer_pool) by read-ahead requests, and the number of such pages [evicted](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_eviction) from the buffer pool without ever being accessed, respectively. The status variables report global values since the last server restart.

[**SHOW ENGINE INNODB STATUS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#show-engine) also shows the rate at which the read-ahead pages are read and the rate at which such pages are evicted without being accessed. The per-second averages are based on the statistics collected since the last invocation of **SHOW ENGINE INNODB STATUS** and are displayed in the **BUFFER POOL AND MEMORY** section of the [**SHOW ENGINE INNODB STATUS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#show-engine) output.

For more information, see [Section 15.8.3.4, “Configuring InnoDB Buffer Pool Prefetching (Read-Ahead)”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-performance-read_ahead). For general I/O tuning advice, see [Section 8.5.8, “Optimizing InnoDB Disk I/O”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizing-innodb-diskio).

**[innodb\_read\_io\_threads](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_read_io_threads)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-read-io-threads=#** |
| **System Variable** | [**innodb\_read\_io\_threads**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_read_io_threads) |
| **Scope** | Global |
| **Dynamic** | No |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Integer |
| **Default Value** | **4** |
| **Minimum Value** | **1** |
| **Maximum Value** | **64** |

The number of I/O threads for read operations in **InnoDB**. Its counterpart for write threads is [**innodb\_write\_io\_threads**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_write_io_threads). For more information, see [Section 15.8.5, “Configuring the Number of Background InnoDB I/O Threads”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-performance-multiple_io_threads). For general I/O tuning advice, see [Section 8.5.8, “Optimizing InnoDB Disk I/O”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizing-innodb-diskio).

**Note**

On Linux systems, running multiple MySQL servers (typically more than 12) with default settings for [**innodb\_read\_io\_threads**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_read_io_threads), [**innodb\_write\_io\_threads**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_write_io_threads), and the Linux **aio-max-nr** setting can exceed system limits. Ideally, increase the **aio-max-nr** setting; as a workaround, you might reduce the settings for one or both of the MySQL variables.

**[innodb\_read\_only](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_read_only)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-read-only[={OFF|ON}]** |
| **System Variable** | [**innodb\_read\_only**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_read_only) |
| **Scope** | Global |
| **Dynamic** | No |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Boolean |
| **Default Value** | **OFF** |

Starts **InnoDB** in read-only mode. For distributing database applications or data sets on read-only media. Can also be used in data warehouses to share the same data directory between multiple instances. For more information, see [Section 15.8.2, “Configuring InnoDB for Read-Only Operation”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-read-only-instance).

Previously, enabling the [**innodb\_read\_only**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_read_only) system variable prevented creating and dropping tables only for the **InnoDB** storage engine. As of MySQL 8.0, enabling [**innodb\_read\_only**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_read_only) prevents these operations for all storage engines. Table creation and drop operations for any storage engine modify data dictionary tables in the **mysql** system database, but those tables use the **InnoDB** storage engine and cannot be modified when [**innodb\_read\_only**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_read_only) is enabled. The same principle applies to other table operations that require modifying data dictionary tables. Examples:

If the [**innodb\_read\_only**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_read_only) system variable is enabled, [**ANALYZE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#analyze-table) may fail because it cannot update statistics tables in the data dictionary, which use **InnoDB**. For [**ANALYZE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#analyze-table) operations that update the key distribution, failure may occur even if the operation updates the table itself (for example, if it is a **MyISAM** table). To obtain the updated distribution statistics, set [**information\_schema\_stats\_expiry=0**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_information_schema_stats_expiry).

[**ALTER TABLE *tbl\_name* ENGINE=*engine\_name***](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) fails because it updates the storage engine designation, which is stored in the data dictionary.

In addition, other tables in the **mysql** system database use the **InnoDB** storage engine in MySQL 8.0. Making those tables read only results in restrictions on operations that modify them. Examples:

Account-management statements such as [**CREATE USER**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-user) and [**GRANT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#grant) fail because the grant tables use **InnoDB**.

The [**INSTALL PLUGIN**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#install-plugin) and [**UNINSTALL PLUGIN**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#uninstall-plugin) plugin-management statements fail because the **mysql.plugin** system table uses **InnoDB**.

The [**CREATE FUNCTION**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-function-udf) and [**DROP FUNCTION**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#drop-function-udf) UDF-management statements fail because the **mysql.func** system table uses **InnoDB**.

**[innodb\_redo\_log\_archive\_dirs](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_redo_log_archive_dirs)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-redo-log-archive-dirs** |
| **Introduced** | 8.0.17 |
| **System Variable** | [**innodb\_redo\_log\_archive\_dirs**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_redo_log_archive_dirs) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | String |
| **Default Value** | **NULL** |

Defines labeled directories where redo log archive files can be created. You can define multiple labeled directories in a semicolon-separated list. For example:

innodb\_redo\_log\_archive\_dirs='label1:/backups1;label2:/backups2'

A label can be any string of characters, with the exception of colons (:), which are not permitted. An empty label is also permitted, but the colon (:) is still required in this case.

A path must be specified, and the directory must exist. The path can contain colons (':'), but semicolons (;) are not permitted.

**[innodb\_redo\_log\_encrypt](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_redo_log_encrypt)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-redo-log-encrypt[={OFF|ON}]** |
| **System Variable** | [**innodb\_redo\_log\_encrypt**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_redo_log_encrypt) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Boolean |
| **Default Value** | **OFF** |

Controls encryption of redo log data for tables encrypted using the **InnoDB** [data-at-rest encryption feature](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-data-encryption). Encryption of redo log data is disabled by default. For more information, see [Redo Log Encryption](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-data-encryption-redo-log).

**[innodb\_replication\_delay](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_replication_delay)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-replication-delay=#** |
| **System Variable** | [**innodb\_replication\_delay**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_replication_delay) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Integer |
| **Default Value** | **0** |
| **Minimum Value** | **0** |
| **Maximum Value** | **4294967295** |

The replication thread delay in milliseconds on a replica server if [**innodb\_thread\_concurrency**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_thread_concurrency) is reached.

**[innodb\_rollback\_on\_timeout](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_rollback_on_timeout)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-rollback-on-timeout[={OFF|ON}]** |
| **System Variable** | [**innodb\_rollback\_on\_timeout**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_rollback_on_timeout) |
| **Scope** | Global |
| **Dynamic** | No |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Boolean |
| **Default Value** | **OFF** |

**InnoDB** [rolls back](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_rollback) only the last statement on a transaction timeout by default. If [--innodb-rollback-on-timeout](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_rollback_on_timeout) is specified, a transaction timeout causes **InnoDB** to abort and roll back the entire transaction.

For more information, see [Section 15.21.4, “InnoDB Error Handling”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-error-handling).

**[innodb\_rollback\_segments](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_rollback_segments)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-rollback-segments=#** |
| **System Variable** | [**innodb\_rollback\_segments**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_rollback_segments) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Integer |
| **Default Value** | **128** |
| **Minimum Value** | **1** |
| **Maximum Value** | **128** |

[**innodb\_rollback\_segments**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_rollback_segments) defines the number of [rollback segments](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_rollback_segment) allocated to each undo tablespace and the global temporary tablespace for transactions that generate undo records. The number of transactions that each rollback segment supports depends on the **InnoDB** page size and the number of undo logs assigned to each transaction. For more information, see [Section 15.6.6, “Undo Logs”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-undo-logs).

For related information, see [Section 15.3, “InnoDB Multi-Versioning”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-multi-versioning). For information about undo tablespaces, see [Section 15.6.3.4, “Undo Tablespaces”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-undo-tablespaces).

**[innodb\_saved\_page\_number\_debug](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_saved_page_number_debug)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-saved-page-number-debug=#** |
| **System Variable** | [**innodb\_saved\_page\_number\_debug**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_saved_page_number_debug) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Integer |
| **Default Value** | **0** |
| **Maximum Value** | **2\*\*23-1** |

Saves a page number. Setting the [**innodb\_fil\_make\_page\_dirty\_debug**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_fil_make_page_dirty_debug) option dirties the page defined by [**innodb\_saved\_page\_number\_debug**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_saved_page_number_debug). The [**innodb\_saved\_page\_number\_debug**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_saved_page_number_debug) option is only available if debugging support is compiled in using the [WITH\_DEBUG](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\installing.html#option_cmake_with_debug) **CMake** option.

**[innodb\_segment\_reserve\_factor](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_segment_reserve_factor)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-segment-reserve-factor=#** |
| **Introduced** | 8.0.25 |
| **System Variable** | [**innodb\_segment\_reserve\_factor**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_segment_reserve_factor) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Numeric |
| **Default Value** | **12.5** |
| **Minimum Value** | **0.03** |
| **Maximum Value** | **40** |

Defines the percentage of tablespace file segment pages reserved as empty pages.

**[innodb\_sort\_buffer\_size](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_sort_buffer_size)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-sort-buffer-size=#** |
| **System Variable** | [**innodb\_sort\_buffer\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_sort_buffer_size) |
| **Scope** | Global |
| **Dynamic** | No |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Integer |
| **Default Value** | **1048576** |
| **Minimum Value** | **65536** |
| **Maximum Value** | **67108864** |

Specifies the size of sort buffers used to sort data during creation of an **InnoDB** index. The specified size defines the amount of data that is read into memory for internal sorting and then written out to disk. This process is referred to as a “run”. During the merge phase, pairs of buffers of the specified size are read and merged. The larger the setting, the fewer runs and merges there are.

This sort area is only used for merge sorts during index creation, not during later index maintenance operations. Buffers are deallocated when index creation completes.

The value of this option also controls the amount by which the temporary log file is extended to record concurrent DML during [online DDL](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_online_ddl) operations.

Before this setting was made configurable, the size was hardcoded to 1048576 bytes (1MB), which remains the default.

During an [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) or [**CREATE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-table) statement that creates an index, 3 buffers are allocated, each with a size defined by this option. Additionally, auxiliary pointers are allocated to rows in the sort buffer so that the sort can run on pointers (as opposed to moving rows during the sort operation).

For a typical sort operation, a formula such as this one can be used to estimate memory consumption:

(6 /\*FTS\_NUM\_AUX\_INDEX\*/ \* (3\*@@GLOBAL.innodb\_sort\_buffer\_size)

+ 2 \* number\_of\_partitions \* number\_of\_secondary\_indexes\_created

\* (@@GLOBAL.innodb\_sort\_buffer\_size/dict\_index\_get\_min\_size(index)\*/)

\* 8 /\*64-bit sizeof \*buf->tuples\*/")

**@@GLOBAL.innodb\_sort\_buffer\_size/dict\_index\_get\_min\_size(index)** indicates the maximum tuples held. **2 \* (@@GLOBAL.innodb\_sort\_buffer\_size/\*dict\_index\_get\_min\_size(index)\*/) \* 8 /\*64-bit size of \*buf->tuples\*/** indicates auxiliary pointers allocated.

**Note**

For 32-bit, multiply by 4 instead of 8.

For parallel sorts on a full-text index, multiply by the [**innodb\_ft\_sort\_pll\_degree**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_ft_sort_pll_degree) setting:

(6 /\*FTS\_NUM\_AUX\_INDEX\*/ \* @@GLOBAL.innodb\_ft\_sort\_pll\_degree)

**[innodb\_spin\_wait\_delay](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_spin_wait_delay)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-spin-wait-delay=#** |
| **System Variable** | [**innodb\_spin\_wait\_delay**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_spin_wait_delay) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Integer |
| **Default Value** | **6** |
| **Minimum Value** | **0** |
| **Maximum Value (64-bit platforms, ≤ 8.0.13)** | **2\*\*64-1** |
| **Maximum Value (32-bit platforms, ≤ 8.0.13)** | **2\*\*32-1** |
| **Maximum Value (≥ 8.0.14)** | **1000** |

The maximum delay between polls for a [spin](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_spin) lock. The low-level implementation of this mechanism varies depending on the combination of hardware and operating system, so the delay does not correspond to a fixed time interval.

Can be used in combination with the [**innodb\_spin\_wait\_pause\_multiplier**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_spin_wait_pause_multiplier) variable for greater control over the duration of spin-lock polling delays.

For more information, see [Section 15.8.8, “Configuring Spin Lock Polling”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-performance-spin_lock_polling).

**[innodb\_spin\_wait\_pause\_multiplier](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_spin_wait_pause_multiplier)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-spin-wait-pause-multiplier=#** |
| **Introduced** | 8.0.16 |
| **System Variable** | [**innodb\_spin\_wait\_pause\_multiplier**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_spin_wait_pause_multiplier) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Integer |
| **Default Value** | **50** |
| **Minimum Value** | **1** |
| **Maximum Value** | **100** |

Defines a multiplier value used to determine the number of PAUSE instructions in spin-wait loops that occur when a thread waits to acquire a mutex or rw-lock.

For more information, see [Section 15.8.8, “Configuring Spin Lock Polling”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-performance-spin_lock_polling).

**[innodb\_stats\_auto\_recalc](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_stats_auto_recalc)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-stats-auto-recalc[={OFF|ON}]** |
| **System Variable** | [**innodb\_stats\_auto\_recalc**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_stats_auto_recalc) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Boolean |
| **Default Value** | **ON** |

Causes **InnoDB** to automatically recalculate [persistent statistics](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_persistent_statistics) after the data in a table is changed substantially. The threshold value is 10% of the rows in the table. This setting applies to tables created when the [**innodb\_stats\_persistent**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_stats_persistent) option is enabled. Automatic statistics recalculation may also be configured by specifying **STATS\_PERSISTENT=1** in a [**CREATE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-table) or [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) statement. The amount of data sampled to produce the statistics is controlled by the [**innodb\_stats\_persistent\_sample\_pages**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_stats_persistent_sample_pages) variable.

For more information, see [Section 15.8.10.1, “Configuring Persistent Optimizer Statistics Parameters”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-persistent-stats).

**[innodb\_stats\_include\_delete\_marked](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_stats_include_delete_marked)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-stats-include-delete-marked[={OFF|ON}]** |
| **System Variable** | [**innodb\_stats\_include\_delete\_marked**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_stats_include_delete_marked) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Boolean |
| **Default Value** | **OFF** |

By default, **InnoDB** reads uncommitted data when calculating statistics. In the case of an uncommitted transaction that deletes rows from a table, **InnoDB** excludes records that are delete-marked when calculating row estimates and index statistics, which can lead to non-optimal execution plans for other transactions that are operating on the table concurrently using a transaction isolation level other than [**READ UNCOMMITTED**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#isolevel_read-uncommitted). To avoid this scenario, [**innodb\_stats\_include\_delete\_marked**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_stats_include_delete_marked) can be enabled to ensure that **InnoDB** includes delete-marked records when calculating persistent optimizer statistics.

When [**innodb\_stats\_include\_delete\_marked**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_stats_include_delete_marked) is enabled, [**ANALYZE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#analyze-table) considers delete-marked records when recalculating statistics.

[**innodb\_stats\_include\_delete\_marked**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_stats_include_delete_marked) is a global setting that affects all **InnoDB** tables. It is only applicable to persistent optimizer statistics.

For related information, see [Section 15.8.10.1, “Configuring Persistent Optimizer Statistics Parameters”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-persistent-stats).

**[innodb\_stats\_method](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_stats_method)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-stats-method=value** |
| **System Variable** | [**innodb\_stats\_method**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_stats_method) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Enumeration |
| **Default Value** | **nulls\_equal** |
| **Valid Values** | **nulls\_equal**  **nulls\_unequal**  **nulls\_ignored** |

How the server treats **NULL** values when collecting [statistics](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_statistics) about the distribution of index values for **InnoDB** tables. Permitted values are **nulls\_equal**, **nulls\_unequal**, and **nulls\_ignored**. For **nulls\_equal**, all **NULL** index values are considered equal and form a single value group with a size equal to the number of **NULL** values. For **nulls\_unequal**, **NULL** values are considered unequal, and each **NULL** forms a distinct value group of size 1. For **nulls\_ignored**, **NULL** values are ignored.

The method used to generate table statistics influences how the optimizer chooses indexes for query execution, as described in [Section 8.3.8, “InnoDB and MyISAM Index Statistics Collection”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#index-statistics).

**[innodb\_stats\_on\_metadata](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_stats_on_metadata)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-stats-on-metadata[={OFF|ON}]** |
| **System Variable** | [**innodb\_stats\_on\_metadata**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_stats_on_metadata) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Boolean |
| **Default Value** | **OFF** |

This option only applies when optimizer [statistics](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_statistics) are configured to be non-persistent. Optimizer statistics are not persisted to disk when [**innodb\_stats\_persistent**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_stats_persistent) is disabled or when individual tables are created or altered with **STATS\_PERSISTENT=0**. For more information, see [Section 15.8.10.2, “Configuring Non-Persistent Optimizer Statistics Parameters”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-statistics-estimation).

When [**innodb\_stats\_on\_metadata**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_stats_on_metadata) is enabled, **InnoDB** updates non-persistent [statistics](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_statistics) when metadata statements such as [**SHOW TABLE STATUS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#show-table-status) or when accessing the [**INFORMATION\_SCHEMA.TABLES**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-tables-table) or [**INFORMATION\_SCHEMA.STATISTICS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-statistics-table) tables. (These updates are similar to what happens for [**ANALYZE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#analyze-table).) When disabled, **InnoDB** does not update statistics during these operations. Leaving the setting disabled can improve access speed for schemas that have a large number of tables or indexes. It can also improve the stability of [execution plans](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_query_execution_plan) for queries that involve **InnoDB** tables.

To change the setting, issue the statement **SET GLOBAL innodb\_stats\_on\_metadata=*mode***, where ***mode*** is either **ON** or **OFF** (or **1** or **0**). Changing the setting requires privileges sufficient to set global system variables (see [Section 5.1.9.1, “System Variable Privileges”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#system-variable-privileges)) and immediately affects the operation of all connections.

**[innodb\_stats\_persistent](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_stats_persistent)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-stats-persistent[={OFF|ON}]** |
| **System Variable** | [**innodb\_stats\_persistent**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_stats_persistent) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Boolean |
| **Default Value** | **ON** |

Specifies whether **InnoDB** index statistics are persisted to disk. Otherwise, statistics may be recalculated frequently which can lead to variations in [query execution plans](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_query_execution_plan). This setting is stored with each table when the table is created. You can set [**innodb\_stats\_persistent**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_stats_persistent) at the global level before creating a table, or use the **STATS\_PERSISTENT** clause of the [**CREATE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-table) and [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) statements to override the system-wide setting and configure persistent statistics for individual tables.

For more information, see [Section 15.8.10.1, “Configuring Persistent Optimizer Statistics Parameters”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-persistent-stats).

**[innodb\_stats\_persistent\_sample\_pages](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_stats_persistent_sample_pages)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-stats-persistent-sample-pages=#** |
| **System Variable** | [**innodb\_stats\_persistent\_sample\_pages**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_stats_persistent_sample_pages) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Integer |
| **Default Value** | **20** |

The number of index [pages](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_page) to sample when estimating [cardinality](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_cardinality) and other [statistics](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_statistics) for an indexed column, such as those calculated by [**ANALYZE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#analyze-table). Increasing the value improves the accuracy of index statistics, which can improve the [query execution plan](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_query_execution_plan), at the expense of increased I/O during the execution of [**ANALYZE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#analyze-table) for an **InnoDB** table. For more information, see [Section 15.8.10.1, “Configuring Persistent Optimizer Statistics Parameters”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-persistent-stats).

**Note**

Setting a high value for [**innodb\_stats\_persistent\_sample\_pages**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_stats_persistent_sample_pages) could result in lengthy [**ANALYZE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#analyze-table) execution time. To estimate the number of database pages accessed by [**ANALYZE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#analyze-table), see [Section 15.8.10.3, “Estimating ANALYZE TABLE Complexity for InnoDB Tables”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-analyze-table-complexity).

[**innodb\_stats\_persistent\_sample\_pages**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_stats_persistent_sample_pages) only applies when [**innodb\_stats\_persistent**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_stats_persistent) is enabled for a table; when [**innodb\_stats\_persistent**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_stats_persistent) is disabled, [**innodb\_stats\_transient\_sample\_pages**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_stats_transient_sample_pages) applies instead.

**[innodb\_stats\_transient\_sample\_pages](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_stats_transient_sample_pages)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-stats-transient-sample-pages=#** |
| **System Variable** | [**innodb\_stats\_transient\_sample\_pages**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_stats_transient_sample_pages) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Integer |
| **Default Value** | **8** |

The number of index [pages](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_page) to sample when estimating [cardinality](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_cardinality) and other [statistics](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_statistics) for an indexed column, such as those calculated by [**ANALYZE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#analyze-table). The default value is 8. Increasing the value improves the accuracy of index statistics, which can improve the [query execution plan](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_query_execution_plan), at the expense of increased I/O when opening an **InnoDB** table or recalculating statistics. For more information, see [Section 15.8.10.2, “Configuring Non-Persistent Optimizer Statistics Parameters”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-statistics-estimation).

**Note**

Setting a high value for [**innodb\_stats\_transient\_sample\_pages**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_stats_transient_sample_pages) could result in lengthy [**ANALYZE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#analyze-table) execution time. To estimate the number of database pages accessed by [**ANALYZE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#analyze-table), see [Section 15.8.10.3, “Estimating ANALYZE TABLE Complexity for InnoDB Tables”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-analyze-table-complexity).

[**innodb\_stats\_transient\_sample\_pages**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_stats_transient_sample_pages) only applies when [**innodb\_stats\_persistent**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_stats_persistent) is disabled for a table; when [**innodb\_stats\_persistent**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_stats_persistent) is enabled, [**innodb\_stats\_persistent\_sample\_pages**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_stats_persistent_sample_pages) applies instead. Takes the place of [**innodb\_stats\_sample\_pages**](https://dev.mysql.com/doc/refman/5.7/en/innodb-parameters.html#sysvar_innodb_stats_sample_pages). For more information, see [Section 15.8.10.2, “Configuring Non-Persistent Optimizer Statistics Parameters”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-statistics-estimation).

**[innodb\_status\_output](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_status_output)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-status-output[={OFF|ON}]** |
| **System Variable** | [**innodb\_status\_output**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_status_output) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Boolean |
| **Default Value** | **OFF** |

Enables or disables periodic output for the standard **InnoDB** Monitor. Also used in combination with [**innodb\_status\_output\_locks**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_status_output_locks) to enable or disable periodic output for the **InnoDB** Lock Monitor. For more information, see [Section 15.17.2, “Enabling InnoDB Monitors”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-enabling-monitors).

**[innodb\_status\_output\_locks](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_status_output_locks)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-status-output-locks[={OFF|ON}]** |
| **System Variable** | [**innodb\_status\_output\_locks**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_status_output_locks) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Boolean |
| **Default Value** | **OFF** |

Enables or disables the **InnoDB** Lock Monitor. When enabled, the **InnoDB** Lock Monitor prints additional information about locks in **SHOW ENGINE INNODB STATUS** output and in periodic output printed to the MySQL error log. Periodic output for the **InnoDB** Lock Monitor is printed as part of the standard **InnoDB** Monitor output. The standard **InnoDB** Monitor must therefore be enabled for the **InnoDB** Lock Monitor to print data to the MySQL error log periodically. For more information, see [Section 15.17.2, “Enabling InnoDB Monitors”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-enabling-monitors).

**[innodb\_strict\_mode](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_strict_mode)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-strict-mode[={OFF|ON}]** |
| **System Variable** | [**innodb\_strict\_mode**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_strict_mode) |
| **Scope** | Global, Session |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Boolean |
| **Default Value** | **ON** |

When [**innodb\_strict\_mode**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_strict_mode) is enabled, **InnoDB** returns errors rather than warnings for certain conditions.

[Strict mode](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_strict_mode) helps guard against ignored typos and syntax errors in SQL, or other unintended consequences of various combinations of operational modes and SQL statements. When [**innodb\_strict\_mode**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_strict_mode) is enabled, **InnoDB** raises error conditions in certain cases, rather than issuing a warning and processing the specified statement (perhaps with unintended behavior). This is analogous to [**sql\_mode**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sql-mode) in MySQL, which controls what SQL syntax MySQL accepts, and determines whether it silently ignores errors, or validates input syntax and data values.

The [**innodb\_strict\_mode**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_strict_mode) setting affects the handling of syntax errors for [**CREATE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-table), [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table), [**CREATE INDEX**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-index), and [**OPTIMIZE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#optimize-table) statements. [**innodb\_strict\_mode**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_strict_mode) also enables a record size check, so that an **INSERT** or **UPDATE** never fails due to the record being too large for the selected page size.

Oracle recommends enabling [**innodb\_strict\_mode**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_strict_mode) when using **ROW\_FORMAT** and **KEY\_BLOCK\_SIZE** clauses in [**CREATE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-table), [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table), and [**CREATE INDEX**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-index) statements. When [**innodb\_strict\_mode**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_strict_mode) is disabled, **InnoDB** ignores conflicting clauses and creates the table or index with only a warning in the message log. The resulting table might have different characteristics than intended, such as lack of compression support when attempting to create a compressed table. When [**innodb\_strict\_mode**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_strict_mode) is enabled, such problems generate an immediate error and the table or index is not created.

You can enable or disable [**innodb\_strict\_mode**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_strict_mode) on the command line when starting **mysqld**, or in a MySQL [configuration file](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_configuration_file). You can also enable or disable [**innodb\_strict\_mode**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_strict_mode) at runtime with the statement **SET [GLOBAL|SESSION] innodb\_strict\_mode=*mode***, where ***mode*** is either **ON** or **OFF**. Changing the **GLOBAL** setting requires privileges sufficient to set global system variables (see [Section 5.1.9.1, “System Variable Privileges”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#system-variable-privileges)) and affects the operation of all clients that subsequently connect. Any client can change the **SESSION** setting for [**innodb\_strict\_mode**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_strict_mode), and the setting affects only that client.

[**innodb\_strict\_mode**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_strict_mode) is not applicable to [general tablespaces](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_general_tablespace). Tablespace management rules for general tablespaces are strictly enforced independently of [**innodb\_strict\_mode**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_strict_mode). For more information, see [Section 13.1.21, “CREATE TABLESPACE Statement”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-tablespace).

**[innodb\_sync\_array\_size](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_sync_array_size)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-sync-array-size=#** |
| **System Variable** | [**innodb\_sync\_array\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_sync_array_size) |
| **Scope** | Global |
| **Dynamic** | No |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Integer |
| **Default Value** | **1** |
| **Minimum Value** | **1** |
| **Maximum Value** | **1024** |

Defines the size of the mutex/lock wait array. Increasing the value splits the internal data structure used to coordinate threads, for higher concurrency in workloads with large numbers of waiting threads. This setting must be configured when the MySQL instance is starting up, and cannot be changed afterward. Increasing the value is recommended for workloads that frequently produce a large number of waiting threads, typically greater than 768.

**[innodb\_sync\_spin\_loops](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_sync_spin_loops)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-sync-spin-loops=#** |
| **System Variable** | [**innodb\_sync\_spin\_loops**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_sync_spin_loops) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Integer |
| **Default Value** | **30** |
| **Minimum Value** | **0** |
| **Maximum Value** | **4294967295** |

The number of times a thread waits for an **InnoDB** mutex to be freed before the thread is suspended.

**[innodb\_sync\_debug](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_sync_debug)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-sync-debug[={OFF|ON}]** |
| **System Variable** | [**innodb\_sync\_debug**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_sync_debug) |
| **Scope** | Global |
| **Dynamic** | No |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Boolean |
| **Default Value** | **OFF** |

Enables sync debug checking for the **InnoDB** storage engine. This option is only available if debugging support is compiled in using the [WITH\_DEBUG](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\installing.html#option_cmake_with_debug) **CMake** option.

**[innodb\_table\_locks](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_table_locks)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-table-locks[={OFF|ON}]** |
| **System Variable** | [**innodb\_table\_locks**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_table_locks) |
| **Scope** | Global, Session |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Boolean |
| **Default Value** | **ON** |

If [**autocommit = 0**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_autocommit), **InnoDB** honors [**LOCK TABLES**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#lock-tables); MySQL does not return from **LOCK TABLES ... WRITE** until all other threads have released all their locks to the table. The default value of [**innodb\_table\_locks**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_table_locks) is 1, which means that [**LOCK TABLES**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#lock-tables) causes InnoDB to lock a table internally if [**autocommit = 0**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_autocommit).

[**innodb\_table\_locks = 0**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_table_locks) has no effect for tables locked explicitly with [**LOCK TABLES ... WRITE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#lock-tables). It does have an effect for tables locked for read or write by [**LOCK TABLES ... WRITE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#lock-tables) implicitly (for example, through triggers) or by [**LOCK TABLES ... READ**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#lock-tables).

For related information, see [Section 15.7, “InnoDB Locking and Transaction Model”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-locking-transaction-model).

**[innodb\_temp\_data\_file\_path](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_temp_data_file_path)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-temp-data-file-path=file\_name** |
| **System Variable** | [**innodb\_temp\_data\_file\_path**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_temp_data_file_path) |
| **Scope** | Global |
| **Dynamic** | No |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | String |
| **Default Value** | **ibtmp1:12M:autoextend** |

Defines the relative path, name, size, and attributes of global temporary tablespace data files. The global temporary tablespace stores rollback segments for changes made to user-created temporary tables.

If no value is specified for [**innodb\_temp\_data\_file\_path**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_temp_data_file_path), the default behavior is to create a single auto-extending data file named ibtmp1 in the [**innodb\_data\_home\_dir**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_data_home_dir) directory. The initial file size is slightly larger than 12MB.

The syntax for a global temporary tablespace data file specification includes the file name, file size, and **autoextend** and **max** attributes:

***file\_name***:***file\_size***[:autoextend[:max:***max\_file\_size***]]

The global temporary tablespace data file cannot have the same name as another **InnoDB** data file. Any inability or error creating the global temporary tablespace data file is treated as fatal and server startup is refused.

File sizes are specified in KB, MB, or GB by appending **K**, **M** or **G** to the size value. The sum of file sizes must be slightly larger than 12MB.

The size limit of individual files is determined by the operating system. File size can be more than 4GB on operating systems that support large files. Use of raw disk partitions for global temporary tablespace data files is not supported.

The **autoextend** and **max** attributes can be used only for the data file specified last in the [**innodb\_temp\_data\_file\_path**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_temp_data_file_path) setting. For example:

[mysqld]

innodb\_temp\_data\_file\_path=ibtmp1:50M;ibtmp2:12M:autoextend:max:500MB

The **autoextend** option causes the data file to automatically increase in size when it runs out of free space. The **autoextend** increment is 64MB by default. To modify the increment, change the [**innodb\_autoextend\_increment**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_autoextend_increment) variable setting.

The directory path for global temporary tablespace data files is formed by concatenating the paths defined by [**innodb\_data\_home\_dir**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_data_home_dir) and [**innodb\_temp\_data\_file\_path**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_temp_data_file_path).

Before running **InnoDB** in read-only mode, set [**innodb\_temp\_data\_file\_path**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_temp_data_file_path) to a location outside of the data directory. The path must be relative to the data directory. For example:

--innodb-temp-data-file-path=../../../tmp/ibtmp1:12M:autoextend

For more information, see [Global Temporary Tablespace](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-global-temporary-tablespace).

**[innodb\_temp\_tablespaces\_dir](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_temp_tablespaces_dir)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-temp-tablespaces-dir=dir\_name** |
| **Introduced** | 8.0.13 |
| **System Variable** | [**innodb\_temp\_tablespaces\_dir**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_temp_tablespaces_dir) |
| **Scope** | Global |
| **Dynamic** | No |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Directory name |
| **Default Value** | **#innodb\_temp** |

Defines the location where **InnoDB** creates a pool of session temporary tablespaces at startup. The default location is the #innodb\_temp directory in the data directory. A fully qualified path or path relative to the data directory is permitted.

As of MySQL 8.0.16, session temporary tablespaces always store user-created temporary tables and internal temporary tables created by the optimizer using **InnoDB**. (Previously, the on-disk storage engine for internal temporary tables was determined by the [**internal\_tmp\_disk\_storage\_engine**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_internal_tmp_disk_storage_engine) system variable, which is no longer supported. See [Storage Engine for On-Disk Internal Temporary Tables](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#internal-temporary-tables-engines-disk).)

For more information, see [Session Temporary Tablespaces](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-session-temporary-tablespaces).

**[innodb\_thread\_concurrency](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_thread_concurrency)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-thread-concurrency=#** |
| **System Variable** | [**innodb\_thread\_concurrency**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_thread_concurrency) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Integer |
| **Default Value** | **0** |
| **Minimum Value** | **0** |
| **Maximum Value** | **1000** |

Defines the maximum number of threads permitted inside of **InnoDB**. A value of 0 (the default) is interpreted as infinite concurrency (no limit). This variable is intended for performance tuning on high concurrency systems.

**InnoDB** tries to keep the number of threads inside **InnoDB** less than or equal to the [**innodb\_thread\_concurrency**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_thread_concurrency) limit. Once the limit is reached, additional threads are placed into a “First In, First Out” (FIFO) queue for waiting threads. Threads waiting for locks are not counted in the number of concurrently executing threads.

The correct setting depends on workload and computing environment. Consider setting this variable if your MySQL instance shares CPU resources with other applications or if your workload or number of concurrent users is growing. Test a range of values to determine the setting that provides the best performance. [**innodb\_thread\_concurrency**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_thread_concurrency) is a dynamic variable, which permits experimenting with different settings on a live test system. If a particular setting performs poorly, you can quickly set [**innodb\_thread\_concurrency**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_thread_concurrency) back to 0.

Use the following guidelines to help find and maintain an appropriate setting:

If the number of concurrent user threads for a workload is consistently small and does not affect performance, set [**innodb\_thread\_concurrency=0**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_thread_concurrency) (no limit).

If your workload is consistently heavy or occasionally spikes, set an [**innodb\_thread\_concurrency**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_thread_concurrency) value and adjust it until you find the number of threads that provides the best performance. For example, suppose that your system typically has 40 to 50 users, but periodically the number increases to 60, 70, or more. Through testing, you find that performance remains largely stable with a limit of 80 concurrent users. In this case, set [**innodb\_thread\_concurrency**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_thread_concurrency) to 80.

If you do not want **InnoDB** to use more than a certain number of virtual CPUs for user threads (20 virtual CPUs, for example), set [**innodb\_thread\_concurrency**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_thread_concurrency) to this number (or possibly lower, depending on performance testing). If your goal is to isolate MySQL from other applications, consider binding the **mysqld** process exclusively to the virtual CPUs. Be aware, however, that exclusive binding can result in non-optimal hardware usage if the **mysqld** process is not consistently busy. In this case, you can bind the **mysqld** process to the virtual CPUs but allow other applications to use some or all of the virtual CPUs.

**Note**

From an operating system perspective, using a resource management solution to manage how CPU time is shared among applications may be preferable to binding the **mysqld** process. For example, you could assign 90% of virtual CPU time to a given application while other critical processes are not running, and scale that value back to 40% when other critical processes are running.

In some cases, the optimal [**innodb\_thread\_concurrency**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_thread_concurrency) setting can be smaller than the number of virtual CPUs.

An [**innodb\_thread\_concurrency**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_thread_concurrency) value that is too high can cause performance regression due to increased contention on system internals and resources.

Monitor and analyze your system regularly. Changes to workload, number of users, or computing environment may require that you adjust the [**innodb\_thread\_concurrency**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_thread_concurrency) setting.

A value of 0 disables the **queries inside InnoDB** and **queries in queue**counters in the **ROW OPERATIONS** section of **SHOW ENGINE INNODB STATUS** output.

For related information, see [Section 15.8.4, “Configuring Thread Concurrency for InnoDB”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-performance-thread_concurrency).

**[innodb\_thread\_sleep\_delay](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_thread_sleep_delay)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-thread-sleep-delay=#** |
| **System Variable** | [**innodb\_thread\_sleep\_delay**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_thread_sleep_delay) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Integer |
| **Default Value** | **10000** |
| **Minimum Value** | **0** |
| **Maximum Value** | **1000000** |

How long **InnoDB** threads sleep before joining the **InnoDB** queue, in microseconds. The default value is 10000. A value of 0 disables sleep. You can set [**innodb\_adaptive\_max\_sleep\_delay**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_adaptive_max_sleep_delay) to the highest value you would allow for [**innodb\_thread\_sleep\_delay**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_thread_sleep_delay), and **InnoDB** automatically adjusts [**innodb\_thread\_sleep\_delay**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_thread_sleep_delay) up or down depending on current thread-scheduling activity. This dynamic adjustment helps the thread scheduling mechanism to work smoothly during times when the system is lightly loaded or when it is operating near full capacity.

For more information, see [Section 15.8.4, “Configuring Thread Concurrency for InnoDB”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-performance-thread_concurrency).

**[innodb\_tmpdir](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_tmpdir)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-tmpdir=dir\_name** |
| **System Variable** | [**innodb\_tmpdir**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_tmpdir) |
| **Scope** | Global, Session |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Directory name |
| **Default Value** | **NULL** |

Used to define an alternate directory for temporary sort files created during online [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) operations that rebuild the table.

Online [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) operations that rebuild the table also create an intermediate table file in the same directory as the original table. The [**innodb\_tmpdir**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_tmpdir) option is not applicable to intermediate table files.

A valid value is any directory path other than the MySQL data directory path. If the value is NULL (the default), temporary files are created MySQL temporary directory (**$TMPDIR** on Unix, **%TEMP%** on Windows, or the directory specified by the [**--tmpdir**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_tmpdir) configuration option). If a directory is specified, existence of the directory and permissions are only checked when [**innodb\_tmpdir**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_tmpdir) is configured using a [**SET**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#set-variable) statement. If a symlink is provided in a directory string, the symlink is resolved and stored as an absolute path. The path should not exceed 512 bytes. An online [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) operation reports an error if [**innodb\_tmpdir**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_tmpdir) is set to an invalid directory. [**innodb\_tmpdir**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_tmpdir) overrides the MySQL [**tmpdir**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_tmpdir) setting but only for online [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) operations.

The **FILE** privilege is required to configure [**innodb\_tmpdir**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_tmpdir).

The [**innodb\_tmpdir**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_tmpdir) option was introduced to help avoid overflowing a temporary file directory located on a **tmpfs** file system. Such overflows could occur as a result of large temporary sort files created during online [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) operations that rebuild the table.

In replication environments, only consider replicating the [**innodb\_tmpdir**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_tmpdir) setting if all servers have the same operating system environment. Otherwise, replicating the [**innodb\_tmpdir**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_tmpdir) setting could result in a replication failure when running online [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) operations that rebuild the table. If server operating environments differ, it is recommended that you configure [**innodb\_tmpdir**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_tmpdir) on each server individually.

For more information, see [Section 15.12.3, “Online DDL Space Requirements”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-online-ddl-space-requirements). For information about online [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) operations, see [Section 15.12, “InnoDB and Online DDL”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-online-ddl).

**[innodb\_trx\_purge\_view\_update\_only\_debug](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_trx_purge_view_update_only_debug)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-trx-purge-view-update-only-debug[={OFF|ON}]** |
| **System Variable** | [**innodb\_trx\_purge\_view\_update\_only\_debug**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_trx_purge_view_update_only_debug) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Boolean |
| **Default Value** | **OFF** |

Pauses purging of delete-marked records while allowing the purge view to be updated. This option artificially creates a situation in which the purge view is updated but purges have not yet been performed. This option is only available if debugging support is compiled in using the [WITH\_DEBUG](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\installing.html#option_cmake_with_debug) **CMake** option.

**[innodb\_trx\_rseg\_n\_slots\_debug](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_trx_rseg_n_slots_debug)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-trx-rseg-n-slots-debug=#** |
| **System Variable** | [**innodb\_trx\_rseg\_n\_slots\_debug**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_trx_rseg_n_slots_debug) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Integer |
| **Default Value** | **0** |
| **Maximum Value** | **1024** |

Sets a debug flag that limits **TRX\_RSEG\_N\_SLOTS** to a given value for the **trx\_rsegf\_undo\_find\_free** function that looks for free slots for undo log segments. This option is only available if debugging support is compiled in using the [WITH\_DEBUG](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\installing.html#option_cmake_with_debug) **CMake** option.

**[innodb\_undo\_directory](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_undo_directory)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-undo-directory=dir\_name** |
| **System Variable** | [**innodb\_undo\_directory**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_undo_directory) |
| **Scope** | Global |
| **Dynamic** | No |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Directory name |

The path where **InnoDB** creates undo tablespaces. Typically used to place undo tablespaces on a different storage device.

There is no default value (it is NULL). If the [**innodb\_undo\_directory**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_undo_directory) variable is undefined, undo tablespaces are created in the data directory.

The default undo tablespaces (innodb\_undo\_001 and innodb\_undo\_002) created when the MySQL instance is initialized always reside in the directory defined by the [**innodb\_undo\_directory**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_undo_directory) variable.

Undo tablespaces created using [**CREATE UNDO TABLESPACE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-tablespace) syntax are created in the directory defined by the [**innodb\_undo\_directory**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_undo_directory) variable if a different path is not specified.

For more information, see [Section 15.6.3.4, “Undo Tablespaces”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-undo-tablespaces).

**[innodb\_undo\_log\_encrypt](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_undo_log_encrypt)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-undo-log-encrypt[={OFF|ON}]** |
| **System Variable** | [**innodb\_undo\_log\_encrypt**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_undo_log_encrypt) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Boolean |
| **Default Value** | **OFF** |

Controls encryption of undo log data for tables encrypted using the **InnoDB** [data-at-rest encryption feature](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-data-encryption). Only applies to undo logs that reside in separate [undo tablespaces](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_undo_tablespace). See [Section 15.6.3.4, “Undo Tablespaces”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-undo-tablespaces). Encryption is not supported for undo log data that resides in the system tablespace. For more information, see [Undo Log Encryption](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-data-encryption-undo-log).

**[innodb\_undo\_log\_truncate](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_undo_log_truncate)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-undo-log-truncate[={OFF|ON}]** |
| **System Variable** | [**innodb\_undo\_log\_truncate**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_undo_log_truncate) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Boolean |
| **Default Value** | **ON** |

When enabled, undo tablespaces that exceed the threshold value defined by [**innodb\_max\_undo\_log\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_max_undo_log_size) are marked for truncation. Only undo tablespaces can be truncated. Truncating undo logs that reside in the system tablespace is not supported. For truncation to occur, there must be at least two undo tablespaces.

The [**innodb\_purge\_rseg\_truncate\_frequency**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_purge_rseg_truncate_frequency) variable can be used to expedite truncation of undo tablespaces.

For more information, see [Truncating Undo Tablespaces](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#truncate-undo-tablespace).

**[innodb\_undo\_tablespaces](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_undo_tablespaces)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-undo-tablespaces=#** |
| **Deprecated** | Yes |
| **System Variable** | [**innodb\_undo\_tablespaces**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_undo_tablespaces) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Integer |
| **Default Value** | **2** |
| **Minimum Value** | **2** |
| **Maximum Value** | **127** |

Defines the number of [undo tablespaces](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_undo_tablespace) used by **InnoDB**. The default and minimum value is 2.

**Note**

The [**innodb\_undo\_tablespaces**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_undo_tablespaces) variable is deprecated and is no longer configurable as of MySQL 8.0.14. Expect it to be removed in a future release.

For more information, see [Section 15.6.3.4, “Undo Tablespaces”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-undo-tablespaces).

**[innodb\_use\_fdatasync](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_use_fdatasync)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-use-fdatasync[={OFF|ON}]** |
| **Introduced** | 8.0.25 |
| **System Variable** | [**innodb\_use\_fdatasync**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_use_fdatasync) |
| **Scope** | Global |
| **Dynamic** | Yes |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Boolean |
| **Default Value** | **OFF** |

When enabled, **InnoDB** uses **fdatasync()** instead of **fsync()** when flushing data to the operating system. Unlike **fsync()**, which is used by default, **fdatasync()** only flushes the metadata of accessed files as necessary, providing a performance benefit in certain scenarios.

**[innodb\_use\_native\_aio](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_use_native_aio)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-use-native-aio[={OFF|ON}]** |
| **System Variable** | [**innodb\_use\_native\_aio**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_use_native_aio) |
| **Scope** | Global |
| **Dynamic** | No |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Boolean |
| **Default Value** | **ON** |

Specifies whether to use the Linux asynchronous I/O subsystem. This variable applies to Linux systems only, and cannot be changed while the server is running. Normally, you do not need to configure this option, because it is enabled by default.

The [asynchronous I/O](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_asynchronous_io) capability that **InnoDB** has on Windows systems is available on Linux systems. (Other Unix-like systems continue to use synchronous I/O calls.) This feature improves the scalability of heavily I/O-bound systems, which typically show many pending reads/writes in **SHOW ENGINE INNODB STATUS\G** output.

Running with a large number of **InnoDB** I/O threads, and especially running multiple such instances on the same server machine, can exceed capacity limits on Linux systems. In this case, you may receive the following error:

EAGAIN: The specified maxevents exceeds the user's limit of available events.

You can typically address this error by writing a higher limit to **/proc/sys/fs/aio-max-nr**.

However, if a problem with the asynchronous I/O subsystem in the OS prevents **InnoDB** from starting, you can start the server with [**innodb\_use\_native\_aio=0**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_use_native_aio). This option may also be disabled automatically during startup if **InnoDB** detects a potential problem such as a combination of **tmpdir** location, **tmpfs** file system, and Linux kernel that does not support AIO on **tmpfs**.

For more information, see [Section 15.8.6, “Using Asynchronous I/O on Linux”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-linux-native-aio).

**innodb\_validate\_tablespace\_paths**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-validate-tablespace-paths[={OFF|ON}]** |
| **Introduced** | 8.0.21 |
| **System Variable** | [**innodb\_validate\_tablespace\_paths**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_validate_tablespace_paths) |
| **Scope** | Global |
| **Dynamic** | No |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Boolean |
| **Default Value** | **ON** |

Controls tablespace file path validation. At startup, **InnoDB** validates the paths of known tablespace files against tablespace file paths stored in the data dictionary in case tablespace files have been moved to a different location. The [**innodb\_validate\_tablespace\_paths**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_validate_tablespace_paths) variable permits disabling tablespace path validation. This feature is intended for environments where tablespaces files are not moved. Disabling path validation improves startup time on systems with a large number of tablespace files.

**Warning**

Starting the server with tablespace path validation disabled after moving tablespace files can lead to undefined behavior.

For more information, see [Section 15.6.3.7, “Disabling Tablespace Path Validation”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-disabling-tablespace-path-validation).

**[innodb\_version](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_version)**

The **InnoDB** version number. In MySQL 8.0, separate version numbering for **InnoDB** does not apply and this value is the same the [**version**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_version) number of the server.

**[innodb\_write\_io\_threads](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\innodb-storage-engine.html" \l "sysvar_innodb_write_io_threads)**

|  |  |
| --- | --- |
| **Command-Line Format** | **--innodb-write-io-threads=#** |
| **System Variable** | [**innodb\_write\_io\_threads**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_write_io_threads) |
| **Scope** | Global |
| **Dynamic** | No |
| [**SET\_VAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizer-hints-set-var)**Hint Applies** | No |
| **Type** | Integer |
| **Default Value** | **4** |
| **Minimum Value** | **1** |
| **Maximum Value** | **64** |

The number of I/O threads for write operations in **InnoDB**. The default value is 4. Its counterpart for read threads is [**innodb\_read\_io\_threads**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_read_io_threads). For more information, see [Section 15.8.5, “Configuring the Number of Background InnoDB I/O Threads”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-performance-multiple_io_threads). For general I/O tuning advice, see [Section 8.5.8, “Optimizing InnoDB Disk I/O”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizing-innodb-diskio).

**Note**

On Linux systems, running multiple MySQL servers (typically more than 12) with default settings for [**innodb\_read\_io\_threads**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_read_io_threads), [**innodb\_write\_io\_threads**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_write_io_threads), and the Linux **aio-max-nr** setting can exceed system limits. Ideally, increase the **aio-max-nr** setting; as a workaround, you might reduce the settings for one or both of the MySQL variables.

Also take into consideration the value of [**sync\_binlog**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\replication.html#sysvar_sync_binlog), which controls synchronization of the binary log to disk.

For general I/O tuning advice, see [Section 8.5.8, “Optimizing InnoDB Disk I/O”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizing-innodb-diskio).

## 15.15 InnoDB INFORMATION\_SCHEMA Tables

[15.15.1 InnoDB INFORMATION\_SCHEMA Tables about Compression](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-information-schema-compression-tables)

[15.15.2 InnoDB INFORMATION\_SCHEMA Transaction and Locking Information](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-information-schema-transactions)

[15.15.3 InnoDB INFORMATION\_SCHEMA Schema Object Tables](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-information-schema-system-tables)

[15.15.4 InnoDB INFORMATION\_SCHEMA FULLTEXT Index Tables](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-information-schema-fulltext_index-tables)

[15.15.5 InnoDB INFORMATION\_SCHEMA Buffer Pool Tables](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-information-schema-buffer-pool-tables)

[15.15.6 InnoDB INFORMATION\_SCHEMA Metrics Table](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-information-schema-metrics-table)

[15.15.7 InnoDB INFORMATION\_SCHEMA Temporary Table Info Table](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-information-schema-temp-table-info)

[15.15.8 Retrieving InnoDB Tablespace Metadata from INFORMATION\_SCHEMA.FILES](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-information-schema-files-table)

This section provides information and usage examples for **InnoDB** [**INFORMATION\_SCHEMA**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html) tables.

**InnoDB** **INFORMATION\_SCHEMA** tables provide metadata, status information, and statistics about various aspects of the **InnoDB** storage engine. You can view a list of **InnoDB** **INFORMATION\_SCHEMA** tables by issuing a [**SHOW TABLES**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#show-tables) statement on the **INFORMATION\_SCHEMA** database:

mysql> **SHOW TABLES FROM INFORMATION\_SCHEMA LIKE 'INNODB%';**

For table definitions, see [Section 26.4, “INFORMATION\_SCHEMA InnoDB Tables”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#innodb-information-schema-tables). For general information regarding the **MySQL** **INFORMATION\_SCHEMA** database, see [Chapter 26, *INFORMATION\_SCHEMA Tables*](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html).

### 15.15.1 InnoDB INFORMATION\_SCHEMA Tables about Compression

[15.15.1.1 INNODB\_CMP and INNODB\_CMP\_RESET](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-information-schema-innodb_cmp)

[15.15.1.2 INNODB\_CMPMEM and INNODB\_CMPMEM\_RESET](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-information-schema-innodb_cmpmem)

[15.15.1.3 Using the Compression Information Schema Tables](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-information-schema-examples-compression-sect)

There are two pairs of **InnoDB** **INFORMATION\_SCHEMA** tables about compression that can provide insight into how well compression is working overall:

[**INNODB\_CMP**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-cmp-table) and [**INNODB\_CMP\_RESET**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-cmp-table) provide information about the number of compression operations and the amount of time spent performing compression.

[**INNODB\_CMPMEM**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-cmpmem-table) and [**INNODB\_CMPMEM\_RESET**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-cmpmem-table) provide information about the way memory is allocated for compression.

#### 15.15.1.1 INNODB\_CMP and INNODB\_CMP\_RESET

The [**INNODB\_CMP**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-cmp-table) and [**INNODB\_CMP\_RESET**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-cmp-table) tables provide status information about operations related to compressed tables, which are described in [Section 15.9, “InnoDB Table and Page Compression”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-compression). The **PAGE\_SIZE** column reports the compressed [page size](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_page_size).

These two tables have identical contents, but reading from [**INNODB\_CMP\_RESET**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-cmp-table) resets the statistics on compression and uncompression operations. For example, if you archive the output of [**INNODB\_CMP\_RESET**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-cmp-table) every 60 minutes, you see the statistics for each hourly period. If you monitor the output of [**INNODB\_CMP**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-cmp-table) (making sure never to read [**INNODB\_CMP\_RESET**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-cmp-table)), you see the cumulative statistics since InnoDB was started.

For the table definition, see [Section 26.4.6, “The INFORMATION\_SCHEMA INNODB\_CMP and INNODB\_CMP\_RESET Tables”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-cmp-table).

#### 15.15.1.2 INNODB\_CMPMEM and INNODB\_CMPMEM\_RESET

The [**INNODB\_CMPMEM**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-cmpmem-table) and [**INNODB\_CMPMEM\_RESET**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-cmpmem-table) tables provide status information about compressed pages that reside in the buffer pool. Please consult [Section 15.9, “InnoDB Table and Page Compression”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-compression) for further information on compressed tables and the use of the buffer pool. The [**INNODB\_CMP**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-cmp-table) and [**INNODB\_CMP\_RESET**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-cmp-table) tables should provide more useful statistics on compression.

##### Internal Details

**InnoDB** uses a [buddy allocator](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_buddy_allocator) system to manage memory allocated to [pages of various sizes](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_page_size), from 1KB to 16KB. Each row of the two tables described here corresponds to a single page size.

The [**INNODB\_CMPMEM**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-cmpmem-table) and [**INNODB\_CMPMEM\_RESET**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-cmpmem-table) tables have identical contents, but reading from [**INNODB\_CMPMEM\_RESET**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-cmpmem-table) resets the statistics on relocation operations. For example, if every 60 minutes you archived the output of [**INNODB\_CMPMEM\_RESET**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-cmpmem-table), it would show the hourly statistics. If you never read [**INNODB\_CMPMEM\_RESET**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-cmpmem-table) and monitored the output of [**INNODB\_CMPMEM**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-cmpmem-table) instead, it would show the cumulative statistics since **InnoDB** was started.

For the table definition, see [Section 26.4.7, “The INFORMATION\_SCHEMA INNODB\_CMPMEM and INNODB\_CMPMEM\_RESET Tables”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-cmpmem-table).

#### 15.15.1.3 Using the Compression Information Schema Tables

**Example 15.1 Using the Compression Information Schema Tables**

The following is sample output from a database that contains compressed tables (see [Section 15.9, “InnoDB Table and Page Compression”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-compression), [**INNODB\_CMP**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-cmp-table), [**INNODB\_CMP\_PER\_INDEX**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-cmp-per-index-table), and [**INNODB\_CMPMEM**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-cmpmem-table)).

The following table shows the contents of [**INFORMATION\_SCHEMA.INNODB\_CMP**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-cmp-table) under a light [workload](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_workload). The only compressed page size that the buffer pool contains is 8K. Compressing or uncompressing pages has consumed less than a second since the time the statistics were reset, because the columns **COMPRESS\_TIME** and **UNCOMPRESS\_TIME** are zero.

| **page size** | **compress ops** | **compress ops ok** | **compress time** | **uncompress ops** | **uncompress time** |
| --- | --- | --- | --- | --- | --- |
| **1024** | 0 | 0 | 0 | 0 | 0 |
| **2048** | 0 | 0 | 0 | 0 | 0 |
| **4096** | 0 | 0 | 0 | 0 | 0 |
| **8192** | 1048 | 921 | 0 | 61 | 0 |
| **16384** | 0 | 0 | 0 | 0 | 0 |

According to [**INNODB\_CMPMEM**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-cmpmem-table), there are 6169 compressed 8KB pages in the [buffer pool](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_buffer_pool). The only other allocated block size is 64 bytes. The smallest **PAGE\_SIZE** in [**INNODB\_CMPMEM**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-cmpmem-table) is used for block descriptors of those compressed pages for which no uncompressed page exists in the buffer pool. We see that there are 5910 such pages. Indirectly, we see that 259 (6169-5910) compressed pages also exist in the buffer pool in uncompressed form.

The following table shows the contents of [**INFORMATION\_SCHEMA.INNODB\_CMPMEM**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-cmpmem-table) under a light [workload](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_workload). Some memory is unusable due to fragmentation of the memory allocator for compressed pages: **SUM(PAGE\_SIZE\*PAGES\_FREE)=6784**. This is because small memory allocation requests are fulfilled by splitting bigger blocks, starting from the 16K blocks that are allocated from the main buffer pool, using the buddy allocation system. The fragmentation is this low because some allocated blocks have been relocated (copied) to form bigger adjacent free blocks. This copying of **SUM(PAGE\_SIZE\*RELOCATION\_OPS)** bytes has consumed less than a second **(SUM(RELOCATION\_TIME)=0)**.

| **page size** | **pages used** | **pages free** | **relocation ops** | **relocation time** |
| --- | --- | --- | --- | --- |
| **64** | 5910 | 0 | 2436 | 0 |
| **128** | 0 | 1 | 0 | 0 |
| **256** | 0 | 0 | 0 | 0 |
| **512** | 0 | 1 | 0 | 0 |
| **1024** | 0 | 0 | 0 | 0 |
| **2048** | 0 | 1 | 0 | 0 |
| **4096** | 0 | 1 | 0 | 0 |
| **8192** | 6169 | 0 | 5 | 0 |
| **16384** | 0 | 0 | 0 | 0 |

### 15.15.2 InnoDB INFORMATION\_SCHEMA Transaction and Locking Information

[15.15.2.1 Using InnoDB Transaction and Locking Information](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-information-schema-examples)

[15.15.2.2 InnoDB Lock and Lock-Wait Information](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-information-schema-understanding-innodb-locking)

[15.15.2.3 Persistence and Consistency of InnoDB Transaction and Locking Information](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-information-schema-internal-data)

**Note**

This section describes locking information as exposed by the Performance Schema [**data\_locks**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html#performance-schema-data-locks-table) and [**data\_lock\_waits**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html#performance-schema-data-lock-waits-table) tables, which supersede the **INFORMATION\_SCHEMA** [**INNODB\_LOCKS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-locks-table) and [**INNODB\_LOCK\_WAITS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-lock-waits-table) tables in MySQL 8.0. For similar discussion written in terms of the older **INFORMATION\_SCHEMA** tables, see [InnoDB INFORMATION\_SCHEMA Transaction and Locking Information](https://dev.mysql.com/doc/refman/5.7/en/innodb-information-schema-transactions.html), in [MySQL 5.7 Reference Manual](https://dev.mysql.com/doc/refman/5.7/en/).

One **INFORMATION\_SCHEMA** table and two Performance Schema tables enable you to monitor **InnoDB** transactions and diagnose potential locking problems:

[**INNODB\_TRX**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-trx-table): This **INFORMATION\_SCHEMA** table provides information about every transaction currently executing inside **InnoDB**, including the transaction state (for example, whether it is running or waiting for a lock), when the transaction started, and the particular SQL statement the transaction is executing.

**[data\_locks](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\performance-schema.html" \l "performance-schema-data-locks-table" \o "27.12.13.1 The data_locks Table)**: This Performance Schema table contains a row for each hold lock and each lock request that is blocked waiting for a held lock to be released:

There is one row for each held lock, whatever the state of the transaction that holds the lock (**INNODB\_TRX.TRX\_STATE** is **RUNNING**, **LOCK WAIT**, **ROLLING BACK** or **COMMITTING**).

Each transaction in InnoDB that is waiting for another transaction to release a lock (**INNODB\_TRX.TRX\_STATE** is **LOCK WAIT**) is blocked by exactly one blocking lock request. That blocking lock request is for a row or table lock held by another transaction in an incompatible mode. A lock request always has a mode that is incompatible with the mode of the held lock that blocks the request (read vs. write, shared vs. exclusive).

The blocked transaction cannot proceed until the other transaction commits or rolls back, thereby releasing the requested lock. For every blocked transaction, [**data\_locks**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html#performance-schema-data-locks-table) contains one row that describes each lock the transaction has requested, and for which it is waiting.

**[data\_lock\_waits](file:///E:\\backup\\%E4%B8%8B%E8%BD%BD\\refman-8.0-en.html-chapter\\refman-8.0-en.html-chapter\\performance-schema.html" \l "performance-schema-data-lock-waits-table" \o "27.12.13.2 The data_lock_waits Table)**: This Performance Schema table indicates which transactions are waiting for a given lock, or for which lock a given transaction is waiting. This table contains one or more rows for each blocked transaction, indicating the lock it has requested and any locks that are blocking that request. The **REQUESTING\_ENGINE\_LOCK\_ID** value refers to the lock requested by a transaction, and the **BLOCKING\_ENGINE\_LOCK\_ID** value refers to the lock (held by another transaction) that prevents the first transaction from proceeding. For any given blocked transaction, all rows in [**data\_lock\_waits**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html#performance-schema-data-lock-waits-table) have the same value for **REQUESTING\_ENGINE\_LOCK\_ID** and different values for **BLOCKING\_ENGINE\_LOCK\_ID**.

For more information about the preceding tables, see [Section 26.4.30, “The INFORMATION\_SCHEMA INNODB\_TRX Table”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-trx-table), [Section 27.12.13.1, “The data\_locks Table”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html#performance-schema-data-locks-table), and [Section 27.12.13.2, “The data\_lock\_waits Table”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html#performance-schema-data-lock-waits-table).

#### 15.15.2.1 Using InnoDB Transaction and Locking Information

**Note**

This section describes locking information as exposed by the Performance Schema [**data\_locks**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html#performance-schema-data-locks-table) and [**data\_lock\_waits**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html#performance-schema-data-lock-waits-table) tables, which supersede the **INFORMATION\_SCHEMA** [**INNODB\_LOCKS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-locks-table) and [**INNODB\_LOCK\_WAITS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-lock-waits-table) tables in MySQL 8.0. For similar discussion written in terms of the older **INFORMATION\_SCHEMA** tables, see [Using InnoDB Transaction and Locking Information](https://dev.mysql.com/doc/refman/5.7/en/innodb-information-schema-examples.html), in [MySQL 5.7 Reference Manual](https://dev.mysql.com/doc/refman/5.7/en/).

##### Identifying Blocking Transactions

It is sometimes helpful to identify which transaction blocks another. The tables that contain information about **InnoDB** transactions and data locks enable you to determine which transaction is waiting for another, and which resource is being requested. (For descriptions of these tables, see [Section 15.15.2, “InnoDB INFORMATION\_SCHEMA Transaction and Locking Information”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-information-schema-transactions).)

Suppose that three sessions are running concurrently. Each session corresponds to a MySQL thread, and executes one transaction after another. Consider the state of the system when these sessions have issued the following statements, but none has yet committed its transaction:

Session A:

BEGIN;

SELECT a FROM t FOR UPDATE;

SELECT SLEEP(100);

Session B:

SELECT b FROM t FOR UPDATE;

Session C:

SELECT c FROM t FOR UPDATE;

In this scenario, use the following query to see which transactions are waiting and which transactions are blocking them:

SELECT

r.trx\_id waiting\_trx\_id,

r.trx\_mysql\_thread\_id waiting\_thread,

r.trx\_query waiting\_query,

b.trx\_id blocking\_trx\_id,

b.trx\_mysql\_thread\_id blocking\_thread,

b.trx\_query blocking\_query

FROM performance\_schema.data\_lock\_waits w

INNER JOIN information\_schema.innodb\_trx b

ON b.trx\_id = w.blocking\_engine\_transaction\_id

INNER JOIN information\_schema.innodb\_trx r

ON r.trx\_id = w.requesting\_engine\_transaction\_id;

Or, more simply, use the **sys** schema [**innodb\_lock\_waits**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sys-schema.html#sys-innodb-lock-waits) view:

SELECT

waiting\_trx\_id,

waiting\_pid,

waiting\_query,

blocking\_trx\_id,

blocking\_pid,

blocking\_query

FROM sys.innodb\_lock\_waits;

If a NULL value is reported for the blocking query, see [Identifying a Blocking Query After the Issuing Session Becomes Idle](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-information-schema-examples-null-blocking-query).

| **waiting trx id** | **waiting thread** | **waiting query** | **blocking trx id** | **blocking thread** | **blocking query** |
| --- | --- | --- | --- | --- | --- |
| **A4** | **6** | **SELECT b FROM t FOR UPDATE** | **A3** | **5** | **SELECT SLEEP(100)** |
| **A5** | **7** | **SELECT c FROM t FOR UPDATE** | **A3** | **5** | **SELECT SLEEP(100)** |
| **A5** | **7** | **SELECT c FROM t FOR UPDATE** | **A4** | **6** | **SELECT b FROM t FOR UPDATE** |

In the preceding table, you can identify sessions by the “waiting query” or “blocking query” columns. As you can see:

Session B (trx id **A4**, thread **6**) and Session C (trx id **A5**, thread **7**) are both waiting for Session A (trx id **A3**, thread **5**).

Session C is waiting for Session B as well as Session A.

You can see the underlying data in the **INFORMATION\_SCHEMA** [**INNODB\_TRX**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-trx-table) table and Performance Schema [**data\_locks**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html#performance-schema-data-locks-table) and [**data\_lock\_waits**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html#performance-schema-data-lock-waits-table) tables.

The following table shows some sample contents of the [**INNODB\_TRX**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-trx-table) table.

| **trx id** | **trx state** | **trx started** | **trx requested lock id** | **trx wait started** | **trx weight** | **trx mysql thread id** | **trx query** |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **A3** | **RUN­NING** | **2008-01-15 16:44:54** | **NULL** | **NULL** | **2** | **5** | **SELECT SLEEP(100)** |
| **A4** | **LOCK WAIT** | **2008-01-15 16:45:09** | **A4:1:3:2** | **2008-01-15 16:45:09** | **2** | **6** | **SELECT b FROM t FOR UPDATE** |
| **A5** | **LOCK WAIT** | **2008-01-15 16:45:14** | **A5:1:3:2** | **2008-01-15 16:45:14** | **2** | **7** | **SELECT c FROM t FOR UPDATE** |

The following table shows some sample contents of the [**data\_locks**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html#performance-schema-data-locks-table) table.

| **lock id** | **lock trx id** | **lock mode** | **lock type** | **lock schema** | **lock table** | **lock index** | **lock data** |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **A3:1:3:2** | **A3** | **X** | **RECORD** | **test** | **t** | **PRIMARY** | **0x0200** |
| **A4:1:3:2** | **A4** | **X** | **RECORD** | **test** | **t** | **PRIMARY** | **0x0200** |
| **A5:1:3:2** | **A5** | **X** | **RECORD** | **test** | **t** | **PRIMARY** | **0x0200** |

The following table shows some sample contents of the [**data\_lock\_waits**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html#performance-schema-data-lock-waits-table) table.

| **requesting trx id** | **requested lock id** | **blocking trx id** | **blocking lock id** |
| --- | --- | --- | --- |
| **A4** | **A4:1:3:2** | **A3** | **A3:1:3:2** |
| **A5** | **A5:1:3:2** | **A3** | **A3:1:3:2** |
| **A5** | **A5:1:3:2** | **A4** | **A4:1:3:2** |

##### Identifying a Blocking Query After the Issuing Session Becomes Idle

When identifying blocking transactions, a NULL value is reported for the blocking query if the session that issued the query has become idle. In this case, use the following steps to determine the blocking query:

Identify the processlist ID of the blocking transaction. In the [**sys.innodb\_lock\_waits**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sys-schema.html#sys-innodb-lock-waits) table, the processlist ID of the blocking transaction is the **blocking\_pid** value.

Using the **blocking\_pid**, query the MySQL Performance Schema [**threads**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html#performance-schema-threads-table) table to determine the **THREAD\_ID** of the blocking transaction. For example, if the **blocking\_pid** is 6, issue this query:

SELECT THREAD\_ID FROM performance\_schema.threads WHERE PROCESSLIST\_ID = 6;

Using the **THREAD\_ID**, query the Performance Schema [**events\_statements\_current**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html#performance-schema-events-statements-current-table) table to determine the last query executed by the thread. For example, if the **THREAD\_ID** is 28, issue this query:

SELECT THREAD\_ID, SQL\_TEXT FROM performance\_schema.events\_statements\_current

WHERE THREAD\_ID = 28\G

If the last query executed by the thread is not enough information to determine why a lock is held, you can query the Performance Schema [**events\_statements\_history**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html#performance-schema-events-statements-history-table) table to view the last 10 statements executed by the thread.

SELECT THREAD\_ID, SQL\_TEXT FROM performance\_schema.events\_statements\_history

WHERE THREAD\_ID = 28 ORDER BY EVENT\_ID;

##### Correlating InnoDB Transactions with MySQL Sessions

Sometimes it is useful to correlate internal **InnoDB** locking information with the session-level information maintained by MySQL. For example, you might like to know, for a given **InnoDB** transaction ID, the corresponding MySQL session ID and name of the session that may be holding a lock, and thus blocking other transactions.

The following output from the **INFORMATION\_SCHEMA** [**INNODB\_TRX**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-trx-table) table and Performance Schema [**data\_locks**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html#performance-schema-data-locks-table) and [**data\_lock\_waits**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html#performance-schema-data-lock-waits-table) tables is taken from a somewhat loaded system. As can be seen, there are several transactions running.

The following [**data\_locks**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html#performance-schema-data-locks-table) and [**data\_lock\_waits**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html#performance-schema-data-lock-waits-table) tables show that:

Transaction **77F** (executing an [**INSERT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#insert)) is waiting for transactions **77E**, **77D**, and **77B** to commit.

Transaction **77E** (executing an [**INSERT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#insert)) is waiting for transactions **77D** and **77B** to commit.

Transaction **77D** (executing an [**INSERT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#insert)) is waiting for transaction **77B** to commit.

Transaction **77B** (executing an [**INSERT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#insert)) is waiting for transaction **77A** to commit.

Transaction **77A** is running, currently executing [**SELECT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#select).

Transaction **E56** (executing an [**INSERT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#insert)) is waiting for transaction **E55** to commit.

Transaction **E55** (executing an [**INSERT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#insert)) is waiting for transaction **19C** to commit.

Transaction **19C** is running, currently executing an [**INSERT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#insert).

**Note**

There may be inconsistencies between queries shown in the **INFORMATION\_SCHEMA** [**PROCESSLIST**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-processlist-table) and [**INNODB\_TRX**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-trx-table) tables. For an explanation, see [Section 15.15.2.3, “Persistence and Consistency of InnoDB Transaction and Locking Information”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-information-schema-internal-data).

The following table shows the contents of the [**PROCESSLIST**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-processlist-table) table for a system running a heavy [workload](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_workload).

| **ID** | **USER** | **HOST** | **DB** | **COMMAND** | **TIME** | **STATE** | **INFO** |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **384** | **root** | **localhost** | **test** | **Query** | **10** | **update** | **INSERT INTO t2 VALUES …** |
| **257** | **root** | **localhost** | **test** | **Query** | **3** | **update** | **INSERT INTO t2 VALUES …** |
| **130** | **root** | **localhost** | **test** | **Query** | **0** | **update** | **INSERT INTO t2 VALUES …** |
| **61** | **root** | **localhost** | **test** | **Query** | **1** | **update** | **INSERT INTO t2 VALUES …** |
| **8** | **root** | **localhost** | **test** | **Query** | **1** | **update** | **INSERT INTO t2 VALUES …** |
| **4** | **root** | **localhost** | **test** | **Query** | **0** | **preparing** | **SELECT \* FROM PROCESSLIST** |
| **2** | **root** | **localhost** | **test** | **Sleep** | **566** |  | **NULL** |

The following table shows the contents of the [**INNODB\_TRX**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-trx-table) table for a system running a heavy [workload](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_workload).

| **trx id** | **trx state** | **trx started** | **trx requested lock id** | **trx wait started** | **trx weight** | **trx mysql thread id** | **trx query** |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **77F** | **LOCK WAIT** | **2008-01-15 13:10:16** | **77F** | **2008-01-15 13:10:16** | **1** | **876** | **INSERT INTO t09 (D, B, C) VALUES …** |
| **77E** | **LOCK WAIT** | **2008-01-15 13:10:16** | **77E** | **2008-01-15 13:10:16** | **1** | **875** | **INSERT INTO t09 (D, B, C) VALUES …** |
| **77D** | **LOCK WAIT** | **2008-01-15 13:10:16** | **77D** | **2008-01-15 13:10:16** | **1** | **874** | **INSERT INTO t09 (D, B, C) VALUES …** |
| **77B** | **LOCK WAIT** | **2008-01-15 13:10:16** | **77B:733:12:1** | **2008-01-15 13:10:16** | **4** | **873** | **INSERT INTO t09 (D, B, C) VALUES …** |
| **77A** | **RUN­NING** | **2008-01-15 13:10:16** | **NULL** | **NULL** | **4** | **872** | **SELECT b, c FROM t09 WHERE …** |
| **E56** | **LOCK WAIT** | **2008-01-15 13:10:06** | **E56:743:6:2** | **2008-01-15 13:10:06** | **5** | **384** | **INSERT INTO t2 VALUES …** |
| **E55** | **LOCK WAIT** | **2008-01-15 13:10:06** | **E55:743:38:2** | **2008-01-15 13:10:13** | **965** | **257** | **INSERT INTO t2 VALUES …** |
| **19C** | **RUN­NING** | **2008-01-15 13:09:10** | **NULL** | **NULL** | **2900** | **130** | **INSERT INTO t2 VALUES …** |
| **E15** | **RUN­NING** | **2008-01-15 13:08:59** | **NULL** | **NULL** | **5395** | **61** | **INSERT INTO t2 VALUES …** |
| **51D** | **RUN­NING** | **2008-01-15 13:08:47** | **NULL** | **NULL** | **9807** | **8** | **INSERT INTO t2 VALUES …** |

The following table shows the contents of the [**data\_lock\_waits**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html#performance-schema-data-lock-waits-table) table for a system running a heavy [workload](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_workload).

| **requesting trx id** | **requested lock id** | **blocking trx id** | **blocking lock id** |
| --- | --- | --- | --- |
| **77F** | **77F:806** | **77E** | **77E:806** |
| **77F** | **77F:806** | **77D** | **77D:806** |
| **77F** | **77F:806** | **77B** | **77B:806** |
| **77E** | **77E:806** | **77D** | **77D:806** |
| **77E** | **77E:806** | **77B** | **77B:806** |
| **77D** | **77D:806** | **77B** | **77B:806** |
| **77B** | **77B:733:12:1** | **77A** | **77A:733:12:1** |
| **E56** | **E56:743:6:2** | **E55** | **E55:743:6:2** |
| **E55** | **E55:743:38:2** | **19C** | **19C:743:38:2** |

The following table shows the contents of the [**data\_locks**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html#performance-schema-data-locks-table) table for a system running a heavy [workload](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_workload).

| **lock id** | **lock trx id** | **lock mode** | **lock type** | **lock schema** | **lock table** | **lock index** | **lock data** |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **77F:806** | **77F** | **AUTO\_INC** | **TABLE** | **test** | **t09** | **NULL** | **NULL** |
| **77E:806** | **77E** | **AUTO\_INC** | **TABLE** | **test** | **t09** | **NULL** | **NULL** |
| **77D:806** | **77D** | **AUTO\_INC** | **TABLE** | **test** | **t09** | **NULL** | **NULL** |
| **77B:806** | **77B** | **AUTO\_INC** | **TABLE** | **test** | **t09** | **NULL** | **NULL** |
| **77B:733:12:1** | **77B** | **X** | **RECORD** | **test** | **t09** | **PRIMARY** | **supremum pseudo-record** |
| **77A:733:12:1** | **77A** | **X** | **RECORD** | **test** | **t09** | **PRIMARY** | **supremum pseudo-record** |
| **E56:743:6:2** | **E56** | **S** | **RECORD** | **test** | **t2** | **PRIMARY** | **0, 0** |
| **E55:743:6:2** | **E55** | **X** | **RECORD** | **test** | **t2** | **PRIMARY** | **0, 0** |
| **E55:743:38:2** | **E55** | **S** | **RECORD** | **test** | **t2** | **PRIMARY** | **1922, 1922** |
| **19C:743:38:2** | **19C** | **X** | **RECORD** | **test** | **t2** | **PRIMARY** | **1922, 1922** |

#### 15.15.2.2 InnoDB Lock and Lock-Wait Information

**Note**

This section describes locking information as exposed by the Performance Schema [**data\_locks**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html#performance-schema-data-locks-table) and [**data\_lock\_waits**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html#performance-schema-data-lock-waits-table) tables, which supersede the **INFORMATION\_SCHEMA** [**INNODB\_LOCKS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-locks-table) and [**INNODB\_LOCK\_WAITS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-lock-waits-table) tables in MySQL 8.0. For similar discussion written in terms of the older **INFORMATION\_SCHEMA** tables, see [InnoDB Lock and Lock-Wait Information](https://dev.mysql.com/doc/refman/5.7/en/innodb-information-schema-understanding-innodb-locking.html), in [MySQL 5.7 Reference Manual](https://dev.mysql.com/doc/refman/5.7/en/).

When a transaction updates a row in a table, or locks it with **SELECT FOR UPDATE**, **InnoDB** establishes a list or queue of locks on that row. Similarly, **InnoDB** maintains a list of locks on a table for table-level locks. If a second transaction wants to update a row or lock a table already locked by a prior transaction in an incompatible mode, **InnoDB** adds a lock request for the row to the corresponding queue. For a lock to be acquired by a transaction, all incompatible lock requests previously entered into the lock queue for that row or table must be removed (which occurs when the transactions holding or requesting those locks either commit or roll back).

A transaction may have any number of lock requests for different rows or tables. At any given time, a transaction may request a lock that is held by another transaction, in which case it is blocked by that other transaction. The requesting transaction must wait for the transaction that holds the blocking lock to commit or roll back. If a transaction is not waiting for a lock, it is in a **RUNNING** state. If a transaction is waiting for a lock, it is in a **LOCK WAIT** state. (The **INFORMATION\_SCHEMA** [**INNODB\_TRX**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-trx-table) table indicates transaction state values.)

The Performance Schema [**data\_locks**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html#performance-schema-data-locks-table) table holds one or more rows for each **LOCK WAIT** transaction, indicating any lock requests that prevent its progress. This table also contains one row describing each lock in a queue of locks pending for a given row or table. The Performance Schema [**data\_lock\_waits**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html#performance-schema-data-lock-waits-table) table shows which locks already held by a transaction are blocking locks requested by other transactions.

#### 15.15.2.3 Persistence and Consistency of InnoDB Transaction and Locking Information

**Note**

This section describes locking information as exposed by the Performance Schema [**data\_locks**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html#performance-schema-data-locks-table) and [**data\_lock\_waits**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html#performance-schema-data-lock-waits-table) tables, which supersede the **INFORMATION\_SCHEMA** [**INNODB\_LOCKS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-locks-table) and [**INNODB\_LOCK\_WAITS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-lock-waits-table) tables in MySQL 8.0. For similar discussion written in terms of the older **INFORMATION\_SCHEMA** tables, see [Persistence and Consistency of InnoDB Transaction and Locking Information](https://dev.mysql.com/doc/refman/5.7/en/innodb-information-schema-internal-data.html), in [MySQL 5.7 Reference Manual](https://dev.mysql.com/doc/refman/5.7/en/).

The data exposed by the transaction and locking tables (**INFORMATION\_SCHEMA** [**INNODB\_TRX**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-trx-table) table, Performance Schema [**data\_locks**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html#performance-schema-data-locks-table) and [**data\_lock\_waits**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html#performance-schema-data-lock-waits-table) tables) represents a glimpse into fast-changing data. This is not like user tables, where the data changes only when application-initiated updates occur. The underlying data is internal system-managed data, and can change very quickly:

Data might not be consistent between the [**INNODB\_TRX**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-trx-table), [**data\_locks**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html#performance-schema-data-locks-table), and [**data\_lock\_waits**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html#performance-schema-data-lock-waits-table) tables.

The [**data\_locks**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html#performance-schema-data-locks-table) and [**data\_lock\_waits**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html#performance-schema-data-lock-waits-table) tables expose live data from the **InnoDB** storage engine, to provide lock inormation about the transactions in the [**INNODB\_TRX**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-trx-table) table. Data retrieved from the lock tables exists when the [**SELECT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#select) is executed, but might be gone or changed by the time the query result is consumed by the client.

Joining [**data\_locks**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html#performance-schema-data-locks-table) with [**data\_lock\_waits**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html#performance-schema-data-lock-waits-table) can show rows in [**data\_lock\_waits**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html#performance-schema-data-lock-waits-table) that identify a parent row in [**data\_locks**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html#performance-schema-data-locks-table) that no longer exists or does not exist yet.

Data in the transaction and locking tables might not be consistent with data in the **INFORMATION\_SCHEMA** [**PROCESSLIST**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-processlist-table) table or Performance Schema [**threads**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html#performance-schema-threads-table) table.

For example, you should be careful when comparing data in the **InnoDB** transaction and locking tables with data in the [**PROCESSLIST**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-processlist-table) table. Even if you issue a single **SELECT** (joining [**INNODB\_TRX**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-trx-table) and [**PROCESSLIST**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-processlist-table), for example), the content of those tables is generally not consistent. It is possible for [**INNODB\_TRX**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-trx-table) to reference rows that are not present in [**PROCESSLIST**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-processlist-table) or for the currently executing SQL query of a transaction shown in **INNODB\_TRX.TRX\_QUERY** to differ from the one in **PROCESSLIST.INFO**.

### 15.15.3 InnoDB INFORMATION\_SCHEMA Schema Object Tables

You can extract metadata about schema objects managed by **InnoDB** using **InnoDB** **INFORMATION\_SCHEMA** tables. This information comes from the data dictionary. Traditionally, you would get this type of information using the techniques from [Section 15.17, “InnoDB Monitors”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-monitors), setting up **InnoDB** monitors and parsing the output from the [**SHOW ENGINE INNODB STATUS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#show-engine) statement. The **InnoDB** **INFORMATION\_SCHEMA** table interface allows you to query this data using SQL.

**InnoDB** **INFORMATION\_SCHEMA** schema object tables include the tables listed below.

INNODB\_DATAFILES

INNODB\_TABLESTATS

INNODB\_FOREIGN

INNODB\_COLUMNS

INNODB\_INDEXES

INNODB\_FIELDS

INNODB\_TABLESPACES

INNODB\_TABLESPACES\_BRIEF

INNODB\_FOREIGN\_COLS

INNODB\_TABLES

The table names are indicative of the type of data provided:

[**INNODB\_TABLES**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-tables-table) provides metadata about **InnoDB** tables.

[**INNODB\_COLUMNS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-columns-table) provides metadata about **InnoDB** table columns.

[**INNODB\_INDEXES**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-indexes-table) provides metadata about **InnoDB** indexes.

[**INNODB\_FIELDS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-fields-table) provides metadata about the key columns (fields) of **InnoDB** indexes.

[**INNODB\_TABLESTATS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-tablestats-table) provides a view of low-level status information about **InnoDB** tables that is derived from in-memory data structures.

[**INNODB\_DATAFILES**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-datafiles-table) provides data file path information for **InnoDB** file-per-table and general tablespaces.

[**INNODB\_TABLESPACES**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-tablespaces-table) provides metadata about **InnoDB** file-per-table, general, and undo tablespaces.

[**INNODB\_TABLESPACES\_BRIEF**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-tablespaces-brief-table) provides a subset of metadata about **InnoDB** tablespaces.

[**INNODB\_FOREIGN**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-foreign-table) provides metadata about foreign keys defined on **InnoDB** tables.

[**INNODB\_FOREIGN\_COLS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-foreign-cols-table) provides metadata about the columns of foreign keys that are defined on **InnoDB** tables.

**InnoDB** **INFORMATION\_SCHEMA** schema object tables can be joined together through fields such as **TABLE\_ID**, **INDEX\_ID**, and **SPACE**, allowing you to easily retrieve all available data for an object you want to study or monitor.

Refer to the **InnoDB** [INFORMATION\_SCHEMA](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#innodb-information-schema-tables) documentation for information about the columns of each table.

**Example 15.2 InnoDB INFORMATION\_SCHEMA Schema Object Tables**

This example uses a simple table (**t1**) with a single index (**i1**) to demonstrate the type of metadata found in the **InnoDB** **INFORMATION\_SCHEMA** schema object tables.

Create a test database and table **t1**:

mysql> **CREATE DATABASE test;**

mysql> **USE test;**

mysql> **CREATE TABLE t1 (**

**col1 INT,**

**col2 CHAR(10),**

**col3 VARCHAR(10))**

**ENGINE = InnoDB;**

mysql> **CREATE INDEX i1 ON t1(col1);**

After creating the table **t1**, query [**INNODB\_TABLES**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-tables-table) to locate the metadata for **test/t1**:

mysql> **SELECT \* FROM INFORMATION\_SCHEMA.INNODB\_TABLES WHERE NAME='test/t1' \G**

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\* 1. row \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

TABLE\_ID: 71

NAME: test/t1

FLAG: 1

N\_COLS: 6

SPACE: 57

ROW\_FORMAT: Compact

ZIP\_PAGE\_SIZE: 0

INSTANT\_COLS: 0

Table **t1** has a **TABLE\_ID** of 71. The **FLAG** field provides bit level information about table format and storage characteristics. There are six columns, three of which are hidden columns created by **InnoDB** (**DB\_ROW\_ID**, **DB\_TRX\_ID**, and **DB\_ROLL\_PTR**). The ID of the table's **SPACE** is 57 (a value of 0 would indicate that the table resides in the system tablespace). The **ROW\_FORMAT** is Compact. **ZIP\_PAGE\_SIZE** only applies to tables with a **Compressed** row format. **INSTANT\_COLS** shows number of columns in the table prior to adding the first instant column using **ALTER TABLE ... ADD COLUMN** with **ALGORITHM=INSTANT**.

Using the **TABLE\_ID** information from [**INNODB\_TABLES**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-tables-table), query the [**INNODB\_COLUMNS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-columns-table) table for information about the table's columns.

mysql> **SELECT \* FROM INFORMATION\_SCHEMA.INNODB\_COLUMNS where TABLE\_ID = 71\G**

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\* 1. row \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

TABLE\_ID: 71

NAME: col1

POS: 0

MTYPE: 6

PRTYPE: 1027

LEN: 4

HAS\_DEFAULT: 0

DEFAULT\_VALUE: NULL

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\* 2. row \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

TABLE\_ID: 71

NAME: col2

POS: 1

MTYPE: 2

PRTYPE: 524542

LEN: 10

HAS\_DEFAULT: 0

DEFAULT\_VALUE: NULL

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\* 3. row \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

TABLE\_ID: 71

NAME: col3

POS: 2

MTYPE: 1

PRTYPE: 524303

LEN: 10

HAS\_DEFAULT: 0

DEFAULT\_VALUE: NULL

In addition to the **TABLE\_ID** and column **NAME**, [**INNODB\_COLUMNS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-columns-table) provides the ordinal position (**POS**) of each column (starting from 0 and incrementing sequentially), the column **MTYPE** or “main type” (6 = INT, 2 = CHAR, 1 = VARCHAR), the **PRTYPE** or “precise type” (a binary value with bits that represent the MySQL data type, character set code, and nullability), and the column length (**LEN**). The **HAS\_DEFAULT** and **DEFAULT\_VALUE** columns only apply to columns added instantly using **ALTER TABLE ... ADD COLUMN** with **ALGORITHM=INSTANT**.

Using the **TABLE\_ID** information from [**INNODB\_TABLES**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-tables-table) once again, query [**INNODB\_INDEXES**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-indexes-table) for information about the indexes associated with table **t1**.

mysql> **SELECT \* FROM INFORMATION\_SCHEMA.INNODB\_INDEXES WHERE TABLE\_ID = 71 \G**

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\* 1. row \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

INDEX\_ID: 111

NAME: GEN\_CLUST\_INDEX

TABLE\_ID: 71

TYPE: 1

N\_FIELDS: 0

PAGE\_NO: 3

SPACE: 57

MERGE\_THRESHOLD: 50

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\* 2. row \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

INDEX\_ID: 112

NAME: i1

TABLE\_ID: 71

TYPE: 0

N\_FIELDS: 1

PAGE\_NO: 4

SPACE: 57

MERGE\_THRESHOLD: 50

[**INNODB\_INDEXES**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-indexes-table) returns data for two indexes. The first index is **GEN\_CLUST\_INDEX**, which is a clustered index created by **InnoDB** if the table does not have a user-defined clustered index. The second index (**i1**) is the user-defined secondary index.

The **INDEX\_ID** is an identifier for the index that is unique across all databases in an instance. The **TABLE\_ID** identifies the table that the index is associated with. The index **TYPE** value indicates the type of index (1 = Clustered Index, 0 = Secondary index). The **N\_FILEDS** value is the number of fields that comprise the index. **PAGE\_NO** is the root page number of the index B-tree, and **SPACE** is the ID of the tablespace where the index resides. A nonzero value indicates that the index does not reside in the system tablespace. **MERGE\_THRESHOLD** defines a percentage threshold value for the amount of data in an index page. If the amount of data in an index page falls below the this value (the default is 50%) when a row is deleted or when a row is shortened by an update operation, **InnoDB** attempts to merge the index page with a neighboring index page.

Using the **INDEX\_ID** information from [**INNODB\_INDEXES**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-indexes-table), query [**INNODB\_FIELDS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-fields-table) for information about the fields of index **i1**.

mysql> **SELECT \* FROM INFORMATION\_SCHEMA.INNODB\_FIELDS where INDEX\_ID = 112 \G**

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\* 1. row \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

INDEX\_ID: 112

NAME: col1

POS: 0

[**INNODB\_FIELDS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-fields-table) provides the **NAME** of the indexed field and its ordinal position within the index. If the index (i1) had been defined on multiple fields, [**INNODB\_FIELDS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-fields-table) would provide metadata for each of the indexed fields.

Using the **SPACE** information from [**INNODB\_TABLES**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-tables-table), query [**INNODB\_TABLESPACES**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-tablespaces-table) table for information about the table's tablespace.

mysql> **SELECT \* FROM INFORMATION\_SCHEMA.INNODB\_TABLESPACES WHERE SPACE = 57 \G**

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\* 1. row \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

SPACE: 57

NAME: test/t1

FLAG: 16417

ROW\_FORMAT: Dynamic

PAGE\_SIZE: 16384

ZIP\_PAGE\_SIZE: 0

SPACE\_TYPE: Single

FS\_BLOCK\_SIZE: 4096

FILE\_SIZE: 114688

ALLOCATED\_SIZE: 98304

AUTOEXTEND\_SIZE: 0

SERVER\_VERSION: 8.0.23

SPACE\_VERSION: 1

ENCRYPTION: N

STATE: normal

In addition to the **SPACE** ID of the tablespace and the **NAME** of the associated table, [**INNODB\_TABLESPACES**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-tablespaces-table) provides tablespace **FLAG** data, which is bit level information about tablespace format and storage characteristics. Also provided are tablespace **ROW\_FORMAT**, **PAGE\_SIZE**, and several other tablespace metadata items.

Using the **SPACE** information from [**INNODB\_TABLES**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-tables-table) once again, query [**INNODB\_DATAFILES**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-datafiles-table) for the location of the tablespace data file.

mysql> **SELECT \* FROM INFORMATION\_SCHEMA.INNODB\_DATAFILES WHERE SPACE = 57 \G**

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\* 1. row \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

SPACE: 57

PATH: ./test/t1.ibd

The datafile is located in the **test** directory under MySQL's **data** directory. If a [file-per-table](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_file_per_table) tablespace were created in a location outside the MySQL data directory using the **DATA DIRECTORY** clause of the [**CREATE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-table) statement, the tablespace **PATH** would be a fully qualified directory path.

As a final step, insert a row into table **t1** (**TABLE\_ID = 71**) and view the data in the [**INNODB\_TABLESTATS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-tablestats-table) table. The data in this table is used by the MySQL optimizer to calculate which index to use when querying an **InnoDB** table. This information is derived from in-memory data structures.

mysql> **INSERT INTO t1 VALUES(5, 'abc', 'def');**

Query OK, 1 row affected (0.06 sec)

mysql> **SELECT \* FROM INFORMATION\_SCHEMA.INNODB\_TABLESTATS where TABLE\_ID = 71 \G**

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\* 1. row \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

TABLE\_ID: 71

NAME: test/t1

STATS\_INITIALIZED: Initialized

NUM\_ROWS: 1

CLUST\_INDEX\_SIZE: 1

OTHER\_INDEX\_SIZE: 0

MODIFIED\_COUNTER: 1

AUTOINC: 0

REF\_COUNT: 1

The **STATS\_INITIALIZED** field indicates whether or not statistics have been collected for the table. **NUM\_ROWS** is the current estimated number of rows in the table. The **CLUST\_INDEX\_SIZE** and **OTHER\_INDEX\_SIZE** fields report the number of pages on disk that store clustered and secondary indexes for the table, respectively. The **MODIFIED\_COUNTER** value shows the number of rows modified by DML operations and cascade operations from foreign keys. The **AUTOINC** value is the next number to be issued for any autoincrement-based operation. There are no autoincrement columns defined on table **t1**, so the value is 0. The **REF\_COUNT** value is a counter. When the counter reaches 0, it signifies that the table metadata can be evicted from the table cache.

**Example 15.3 Foreign Key INFORMATION\_SCHEMA Schema Object Tables**

The [**INNODB\_FOREIGN**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-foreign-table) and [**INNODB\_FOREIGN\_COLS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-foreign-cols-table) tables provide data about foreign key relationships. This example uses a parent table and child table with a foreign key relationship to demonstrate the data found in the [**INNODB\_FOREIGN**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-foreign-table) and [**INNODB\_FOREIGN\_COLS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-foreign-cols-table) tables.

Create the test database with parent and child tables:

mysql> **CREATE DATABASE test;**

mysql> **USE test;**

mysql> **CREATE TABLE parent (id INT NOT NULL,**

**PRIMARY KEY (id)) ENGINE=INNODB;**

mysql> **CREATE TABLE child (id INT, parent\_id INT,**

**INDEX par\_ind (parent\_id),**

**CONSTRAINT fk1**

**FOREIGN KEY (parent\_id) REFERENCES parent(id)**

**ON DELETE CASCADE) ENGINE=INNODB;**

After the parent and child tables are created, query [**INNODB\_FOREIGN**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-foreign-table) and locate the foreign key data for the **test/child** and **test/parent** foreign key relationship:

mysql> **SELECT \* FROM INFORMATION\_SCHEMA.INNODB\_FOREIGN \G**

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\* 1. row \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

ID: test/fk1

FOR\_NAME: test/child

REF\_NAME: test/parent

N\_COLS: 1

TYPE: 1

Metadata includes the foreign key **ID** (**fk1**), which is named for the **CONSTRAINT** that was defined on the child table. The **FOR\_NAME** is the name of the child table where the foreign key is defined. **REF\_NAME** is the name of the parent table (the “referenced” table). **N\_COLS** is the number of columns in the foreign key index. **TYPE** is a numerical value representing bit flags that provide additional information about the foreign key column. In this case, the **TYPE** value is 1, which indicates that the **ON DELETE CASCADE** option was specified for the foreign key. See the [**INNODB\_FOREIGN**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-foreign-table) table definition for more information about **TYPE** values.

Using the foreign key **ID**, query [**INNODB\_FOREIGN\_COLS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-foreign-cols-table) to view data about the columns of the foreign key.

mysql> **SELECT \* FROM INFORMATION\_SCHEMA.INNODB\_FOREIGN\_COLS WHERE ID = 'test/fk1' \G**

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\* 1. row \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

ID: test/fk1

FOR\_COL\_NAME: parent\_id

REF\_COL\_NAME: id

POS: 0

**FOR\_COL\_NAME** is the name of the foreign key column in the child table, and **REF\_COL\_NAME** is the name of the referenced column in the parent table. The **POS** value is the ordinal position of the key field within the foreign key index, starting at zero.

**Example 15.4 Joining InnoDB INFORMATION\_SCHEMA Schema Object Tables**

This example demonstrates joining three **InnoDB** **INFORMATION\_SCHEMA** schema object tables ([**INNODB\_TABLES**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-tables-table), [**INNODB\_TABLESPACES**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-tablespaces-table), and [**INNODB\_TABLESTATS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-tablestats-table)) to gather file format, row format, page size, and index size information about tables in the employees sample database.

The following table name aliases are used to shorten the query string:

[**INFORMATION\_SCHEMA.INNODB\_TABLES**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-tables-table): a

[**INFORMATION\_SCHEMA.INNODB\_TABLESPACES**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-tablespaces-table): b

[**INFORMATION\_SCHEMA.INNODB\_TABLESTATS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-tablestats-table): c

An [**IF()**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\functions.html#function_if) control flow function is used to account for compressed tables. If a table is compressed, the index size is calculated using **ZIP\_PAGE\_SIZE** rather than **PAGE\_SIZE**. **CLUST\_INDEX\_SIZE** and **OTHER\_INDEX\_SIZE**, which are reported in bytes, are divided by **1024\*1024** to provide index sizes in megabytes (MBs). MB values are rounded to zero decimal spaces using the [**ROUND()**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\functions.html#function_round) function.

mysql> **SELECT a.NAME, a.ROW\_FORMAT,**

**@page\_size :=**

**IF(a.ROW\_FORMAT='Compressed',**

**b.ZIP\_PAGE\_SIZE, b.PAGE\_SIZE)**

**AS page\_size,**

**ROUND((@page\_size \* c.CLUST\_INDEX\_SIZE)**

**/(1024\*1024)) AS pk\_mb,**

**ROUND((@page\_size \* c.OTHER\_INDEX\_SIZE)**

**/(1024\*1024)) AS secidx\_mb**

**FROM INFORMATION\_SCHEMA.INNODB\_TABLES a**

**INNER JOIN INFORMATION\_SCHEMA.INNODB\_TABLESPACES b on a.NAME = b.NAME**

**INNER JOIN INFORMATION\_SCHEMA.INNODB\_TABLESTATS c on b.NAME = c.NAME**

**WHERE a.NAME LIKE 'employees/%'**

**ORDER BY a.NAME DESC;**

+------------------------+------------+-----------+-------+-----------+

| NAME | ROW\_FORMAT | page\_size | pk\_mb | secidx\_mb |

+------------------------+------------+-----------+-------+-----------+

| employees/titles | Dynamic | 16384 | 20 | 11 |

| employees/salaries | Dynamic | 16384 | 93 | 34 |

| employees/employees | Dynamic | 16384 | 15 | 0 |

| employees/dept\_manager | Dynamic | 16384 | 0 | 0 |

| employees/dept\_emp | Dynamic | 16384 | 12 | 10 |

| employees/departments | Dynamic | 16384 | 0 | 0 |

+------------------------+------------+-----------+-------+-----------+

### 15.15.4 InnoDB INFORMATION\_SCHEMA FULLTEXT Index Tables

The following tables provide metadata for **FULLTEXT** indexes:

mysql> **SHOW TABLES FROM INFORMATION\_SCHEMA LIKE 'INNODB\_FT%';**

+-------------------------------------------+

| Tables\_in\_INFORMATION\_SCHEMA (INNODB\_FT%) |

+-------------------------------------------+

| INNODB\_FT\_CONFIG |

| INNODB\_FT\_BEING\_DELETED |

| INNODB\_FT\_DELETED |

| INNODB\_FT\_DEFAULT\_STOPWORD |

| INNODB\_FT\_INDEX\_TABLE |

| INNODB\_FT\_INDEX\_CACHE |

+-------------------------------------------+

#### Table Overview

[**INNODB\_FT\_CONFIG**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-ft-config-table): Provides metadata about the **FULLTEXT** index and associated processing for an **InnoDB** table.

[**INNODB\_FT\_BEING\_DELETED**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-ft-being-deleted-table): Provides a snapshot of the [**INNODB\_FT\_DELETED**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-ft-deleted-table) table; it is used only during an [**OPTIMIZE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#optimize-table) maintenance operation. When [**OPTIMIZE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#optimize-table) is run, the [**INNODB\_FT\_BEING\_DELETED**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-ft-being-deleted-table) table is emptied, and **DOC\_ID** values are removed from the [**INNODB\_FT\_DELETED**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-ft-deleted-table) table. Because the contents of [**INNODB\_FT\_BEING\_DELETED**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-ft-being-deleted-table) typically have a short lifetime, this table has limited utility for monitoring or debugging. For information about running [**OPTIMIZE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#optimize-table) on tables with **FULLTEXT** indexes, see [Section 12.10.6, “Fine-Tuning MySQL Full-Text Search”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\functions.html#fulltext-fine-tuning).

[**INNODB\_FT\_DELETED**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-ft-deleted-table): Stores rows that are deleted from the **FULLTEXT** index for an **InnoDB** table. To avoid expensive index reorganization during DML operations for an **InnoDB** **FULLTEXT** index, the information about newly deleted words is stored separately, filtered out of search results when you do a text search, and removed from the main search index only when you issue an [**OPTIMIZE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#optimize-table) statement for the **InnoDB** table.

[**INNODB\_FT\_DEFAULT\_STOPWORD**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-ft-default-stopword-table): Holds a list of [stopwords](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_stopword) that are used by default when creating a **FULLTEXT** index on **InnoDB** tables.

For information about the [**INNODB\_FT\_DEFAULT\_STOPWORD**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-ft-default-stopword-table) table, see [Section 12.10.4, “Full-Text Stopwords”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\functions.html#fulltext-stopwords).

[**INNODB\_FT\_INDEX\_TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-ft-index-table-table): Provides information about the inverted index used to process text searches against the **FULLTEXT** index of an **InnoDB** table.

[**INNODB\_FT\_INDEX\_CACHE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-ft-index-cache-table): Provides token information about newly inserted rows in a **FULLTEXT** index. To avoid expensive index reorganization during DML operations, the information about newly indexed words is stored separately, and combined with the main search index only when [**OPTIMIZE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#optimize-table) is run, when the server is shut down, or when the cache size exceeds a limit defined by the [**innodb\_ft\_cache\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_ft_cache_size) or [**innodb\_ft\_total\_cache\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_ft_total_cache_size) system variable.

**Note**

With the exception of the [**INNODB\_FT\_DEFAULT\_STOPWORD**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-ft-default-stopword-table) table, these tables are empty initially. Before querying any of them, set the value of the [**innodb\_ft\_aux\_table**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_ft_aux_table) system variable to the name (including the database name) of the table that contains the **FULLTEXT** index (for example, **test/articles**).

**Example 15.5 InnoDB FULLTEXT Index INFORMATION\_SCHEMA Tables**

This example uses a table with a **FULLTEXT** index to demonstrate the data contained in the **FULLTEXT** index **INFORMATION\_SCHEMA** tables.

Create a table with a **FULLTEXT** index and insert some data:

mysql> **CREATE TABLE articles (**

**id INT UNSIGNED AUTO\_INCREMENT NOT NULL PRIMARY KEY,**

**title VARCHAR(200),**

**body TEXT,**

**FULLTEXT (title,body)**

**) ENGINE=InnoDB;**

mysql> **INSERT INTO articles (title,body) VALUES**

**('MySQL Tutorial','DBMS stands for DataBase ...'),**

**('How To Use MySQL Well','After you went through a ...'),**

**('Optimizing MySQL','In this tutorial we show ...'),**

**('1001 MySQL Tricks','1. Never run mysqld as root. 2. ...'),**

**('MySQL vs. YourSQL','In the following database comparison ...'),**

**('MySQL Security','When configured properly, MySQL ...');**

Set the [**innodb\_ft\_aux\_table**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_ft_aux_table) variable to the name of the table with the **FULLTEXT** index. If this variable is not set, the **InnoDB** **FULLTEXT** **INFORMATION\_SCHEMA** tables are empty, with the exception of [**INNODB\_FT\_DEFAULT\_STOPWORD**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-ft-default-stopword-table).

mysql> **SET GLOBAL innodb\_ft\_aux\_table = 'test/articles';**

Query the [**INNODB\_FT\_INDEX\_CACHE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-ft-index-cache-table) table, which shows information about newly inserted rows in a **FULLTEXT** index. To avoid expensive index reorganization during DML operations, data for newly inserted rows remains in the **FULLTEXT** index cache until [**OPTIMIZE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#optimize-table) is run (or until the server is shut down or cache limits are exceeded).

mysql> **SELECT \* FROM INFORMATION\_SCHEMA.INNODB\_FT\_INDEX\_CACHE LIMIT 5;**

+------------+--------------+-------------+-----------+--------+----------+

| WORD | FIRST\_DOC\_ID | LAST\_DOC\_ID | DOC\_COUNT | DOC\_ID | POSITION |

+------------+--------------+-------------+-----------+--------+----------+

| 1001 | 5 | 5 | 1 | 5 | 0 |

| after | 3 | 3 | 1 | 3 | 22 |

| comparison | 6 | 6 | 1 | 6 | 44 |

| configured | 7 | 7 | 1 | 7 | 20 |

| database | 2 | 6 | 2 | 2 | 31 |

+------------+--------------+-------------+-----------+--------+----------+

Enable the [**innodb\_optimize\_fulltext\_only**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_optimize_fulltext_only) system variable and run [**OPTIMIZE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#optimize-table) on the table that contains the **FULLTEXT** index. This operation flushes the contents of the **FULLTEXT** index cache to the main **FULLTEXT** index. [**innodb\_optimize\_fulltext\_only**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_optimize_fulltext_only) changes the way the [**OPTIMIZE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#optimize-table) statement operates on **InnoDB** tables, and is intended to be enabled temporarily, during maintenance operations on **InnoDB** tables with **FULLTEXT** indexes.

mysql> **SET GLOBAL innodb\_optimize\_fulltext\_only=ON;**

mysql> **OPTIMIZE TABLE articles;**

+---------------+----------+----------+----------+

| Table | Op | Msg\_type | Msg\_text |

+---------------+----------+----------+----------+

| test.articles | optimize | status | OK |

+---------------+----------+----------+----------+

Query the [**INNODB\_FT\_INDEX\_TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-ft-index-table-table) table to view information about data in the main **FULLTEXT** index, including information about the data that was just flushed from the **FULLTEXT** index cache.

mysql> **SELECT \* FROM INFORMATION\_SCHEMA.INNODB\_FT\_INDEX\_TABLE LIMIT 5;**

+------------+--------------+-------------+-----------+--------+----------+

| WORD | FIRST\_DOC\_ID | LAST\_DOC\_ID | DOC\_COUNT | DOC\_ID | POSITION |

+------------+--------------+-------------+-----------+--------+----------+

| 1001 | 5 | 5 | 1 | 5 | 0 |

| after | 3 | 3 | 1 | 3 | 22 |

| comparison | 6 | 6 | 1 | 6 | 44 |

| configured | 7 | 7 | 1 | 7 | 20 |

| database | 2 | 6 | 2 | 2 | 31 |

+------------+--------------+-------------+-----------+--------+----------+

The [**INNODB\_FT\_INDEX\_CACHE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-ft-index-cache-table) table is now empty since the [**OPTIMIZE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#optimize-table) operation flushed the **FULLTEXT** index cache.

mysql> **SELECT \* FROM INFORMATION\_SCHEMA.INNODB\_FT\_INDEX\_CACHE LIMIT 5;**

Empty set (0.00 sec)

Delete some records from the **test/articles** table.

mysql> **DELETE FROM test.articles WHERE id < 4;**

Query the [**INNODB\_FT\_DELETED**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-ft-deleted-table) table. This table records rows that are deleted from the **FULLTEXT** index. To avoid expensive index reorganization during DML operations, information about newly deleted records is stored separately, filtered out of search results when you do a text search, and removed from the main search index when you run [**OPTIMIZE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#optimize-table).

mysql> **SELECT \* FROM INFORMATION\_SCHEMA.INNODB\_FT\_DELETED;**

+--------+

| DOC\_ID |

+--------+

| 2 |

| 3 |

| 4 |

+--------+

Run [**OPTIMIZE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#optimize-table) to remove the deleted records.

mysql> **OPTIMIZE TABLE articles;**

+---------------+----------+----------+----------+

| Table | Op | Msg\_type | Msg\_text |

+---------------+----------+----------+----------+

| test.articles | optimize | status | OK |

+---------------+----------+----------+----------+

The [**INNODB\_FT\_DELETED**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-ft-deleted-table) table should now be empty.

mysql> **SELECT \* FROM INFORMATION\_SCHEMA.INNODB\_FT\_DELETED;**

Empty set (0.00 sec)

Query the [**INNODB\_FT\_CONFIG**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-ft-config-table) table. This table contains metadata about the **FULLTEXT** index and related processing:

**optimize\_checkpoint\_limit**: The number of seconds after which an [**OPTIMIZE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#optimize-table) run stops.

**synced\_doc\_id**: The next **DOC\_ID** to be issued.

**stopword\_table\_name**: The ***database/table*** name for a user-defined stopword table. The **VALUE** column is empty if there is no user-defined stopword table.

**use\_stopword**: Indicates whether a stopword table is used, which is defined when the **FULLTEXT** index is created.

mysql> **SELECT \* FROM INFORMATION\_SCHEMA.INNODB\_FT\_CONFIG;**

+---------------------------+-------+

| KEY | VALUE |

+---------------------------+-------+

| optimize\_checkpoint\_limit | 180 |

| synced\_doc\_id | 8 |

| stopword\_table\_name | |

| use\_stopword | 1 |

+---------------------------+-------+

Disable [**innodb\_optimize\_fulltext\_only**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_optimize_fulltext_only), since it is intended to be enabled only temporarily:

mysql> **SET GLOBAL innodb\_optimize\_fulltext\_only=OFF;**

### 15.15.5 InnoDB INFORMATION\_SCHEMA Buffer Pool Tables

The **InnoDB** **INFORMATION\_SCHEMA** buffer pool tables provide buffer pool status information and metadata about the pages within the **InnoDB** buffer pool.

The **InnoDB** **INFORMATION\_SCHEMA** buffer pool tables include those listed below:

mysql> **SHOW TABLES FROM INFORMATION\_SCHEMA LIKE 'INNODB\_BUFFER%';**

+-----------------------------------------------+

| Tables\_in\_INFORMATION\_SCHEMA (INNODB\_BUFFER%) |

+-----------------------------------------------+

| INNODB\_BUFFER\_PAGE\_LRU |

| INNODB\_BUFFER\_PAGE |

| INNODB\_BUFFER\_POOL\_STATS |

+-----------------------------------------------+

#### Table Overview

[**INNODB\_BUFFER\_PAGE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-buffer-page-table): Holds information about each page in the **InnoDB** buffer pool.

[**INNODB\_BUFFER\_PAGE\_LRU**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-buffer-page-lru-table): Holds information about the pages in the **InnoDB** buffer pool, in particular how they are ordered in the LRU list that determines which pages to evict from the buffer pool when it becomes full. The [**INNODB\_BUFFER\_PAGE\_LRU**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-buffer-page-lru-table) table has the same columns as the [**INNODB\_BUFFER\_PAGE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-buffer-page-table) table, except that the [**INNODB\_BUFFER\_PAGE\_LRU**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-buffer-page-lru-table) table has an **LRU\_POSITION** column instead of a **BLOCK\_ID** column.

[**INNODB\_BUFFER\_POOL\_STATS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-buffer-pool-stats-table): Provides buffer pool status information. Much of the same information is provided by [**SHOW ENGINE INNODB STATUS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#show-engine) output, or may be obtained using **InnoDB** buffer pool server status variables.

**Warning**

Querying the [**INNODB\_BUFFER\_PAGE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-buffer-page-table) or [**INNODB\_BUFFER\_PAGE\_LRU**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-buffer-page-lru-table) table can affect performance. Do not query these tables on a production system unless you are aware of the performance impact and have determined it to be acceptable. To avoid impacting performance on a production system, reproduce the issue you want to investigate and query buffer pool statistics on a test instance.

**Example 15.6 Querying System Data in the INNODB\_BUFFER\_PAGE Table**

This query provides an approximate count of pages that contain system data by excluding pages where the **TABLE\_NAME** value is either **NULL** or includes a slash **/** or period **.** in the table name, which indicates a user-defined table.

mysql> **SELECT COUNT(\*) FROM INFORMATION\_SCHEMA.INNODB\_BUFFER\_PAGE**

**WHERE TABLE\_NAME IS NULL OR (INSTR(TABLE\_NAME, '/') = 0 AND INSTR(TABLE\_NAME, '.') = 0);**

+----------+

| COUNT(\*) |

+----------+

| 1516 |

+----------+

This query returns the approximate number of pages that contain system data, the total number of buffer pool pages, and an approximate percentage of pages that contain system data.

mysql> **SELECT**

**(SELECT COUNT(\*) FROM INFORMATION\_SCHEMA.INNODB\_BUFFER\_PAGE**

**WHERE TABLE\_NAME IS NULL OR (INSTR(TABLE\_NAME, '/') = 0 AND INSTR(TABLE\_NAME, '.') = 0)**

**) AS system\_pages,**

**(**

**SELECT COUNT(\*)**

**FROM INFORMATION\_SCHEMA.INNODB\_BUFFER\_PAGE**

**) AS total\_pages,**

**(**

**SELECT ROUND((system\_pages/total\_pages) \* 100)**

**) AS system\_page\_percentage;**

+--------------+-------------+------------------------+

| system\_pages | total\_pages | system\_page\_percentage |

+--------------+-------------+------------------------+

| 295 | 8192 | 4 |

+--------------+-------------+------------------------+

The type of system data in the buffer pool can be determined by querying the **PAGE\_TYPE** value. For example, the following query returns eight distinct **PAGE\_TYPE** values among the pages that contain system data:

mysql> **SELECT DISTINCT PAGE\_TYPE FROM INFORMATION\_SCHEMA.INNODB\_BUFFER\_PAGE**

**WHERE TABLE\_NAME IS NULL OR (INSTR(TABLE\_NAME, '/') = 0 AND INSTR(TABLE\_NAME, '.') = 0);**

+-------------------+

| PAGE\_TYPE |

+-------------------+

| SYSTEM |

| IBUF\_BITMAP |

| UNKNOWN |

| FILE\_SPACE\_HEADER |

| INODE |

| UNDO\_LOG |

| ALLOCATED |

+-------------------+

**Example 15.7 Querying User Data in the INNODB\_BUFFER\_PAGE Table**

This query provides an approximate count of pages containing user data by counting pages where the **TABLE\_NAME** value is **NOT NULL** and **NOT LIKE '%INNODB\_TABLES%'**.

mysql> **SELECT COUNT(\*) FROM INFORMATION\_SCHEMA.INNODB\_BUFFER\_PAGE**

**WHERE TABLE\_NAME IS NOT NULL AND TABLE\_NAME NOT LIKE '%INNODB\_TABLES%';**

+----------+

| COUNT(\*) |

+----------+

| 7897 |

+----------+

This query returns the approximate number of pages that contain user data, the total number of buffer pool pages, and an approximate percentage of pages that contain user data.

mysql> **SELECT**

**(SELECT COUNT(\*) FROM INFORMATION\_SCHEMA.INNODB\_BUFFER\_PAGE**

WHERE TABLE\_NAME IS NOT NULL AND (INSTR(TABLE\_NAME, '/') > 0 OR INSTR(TABLE\_NAME, '.') > 0)

**) AS user\_pages,**

**(**

**SELECT COUNT(\*)**

**FROM information\_schema.INNODB\_BUFFER\_PAGE**

**) AS total\_pages,**

**(**

**SELECT ROUND((user\_pages/total\_pages) \* 100)**

**) AS user\_page\_percentage;**

+------------+-------------+----------------------+

| user\_pages | total\_pages | user\_page\_percentage |

+------------+-------------+----------------------+

| 7897 | 8192 | 96 |

+------------+-------------+----------------------+

This query identifies user-defined tables with pages in the buffer pool:

mysql> **SELECT DISTINCT TABLE\_NAME FROM INFORMATION\_SCHEMA.INNODB\_BUFFER\_PAGE**

**WHERE TABLE\_NAME IS NOT NULL AND (INSTR(TABLE\_NAME, '/') > 0 OR INSTR(TABLE\_NAME, '.') > 0)**

**AND TABLE\_NAME NOT LIKE '`mysql`.`innodb\_%';**

+-------------------------+

| TABLE\_NAME |

+-------------------------+

| `employees`.`salaries` |

| `employees`.`employees` |

+-------------------------+

**Example 15.8 Querying Index Data in the INNODB\_BUFFER\_PAGE Table**

For information about index pages, query the **INDEX\_NAME** column using the name of the index. For example, the following query returns the number of pages and total data size of pages for the **emp\_no** index that is defined on the **employees.salaries** table:

mysql> **SELECT INDEX\_NAME, COUNT(\*) AS Pages,**

**ROUND(SUM(IF(COMPRESSED\_SIZE = 0, @@GLOBAL.innodb\_page\_size, COMPRESSED\_SIZE))/1024/1024)**

**AS 'Total Data (MB)'**

**FROM INFORMATION\_SCHEMA.INNODB\_BUFFER\_PAGE**

**WHERE INDEX\_NAME='emp\_no' AND TABLE\_NAME = '`employees`.`salaries`';**

+------------+-------+-----------------+

| INDEX\_NAME | Pages | Total Data (MB) |

+------------+-------+-----------------+

| emp\_no | 1609 | 25 |

+------------+-------+-----------------+

This query returns the number of pages and total data size of pages for all indexes defined on the **employees.salaries** table:

mysql> **SELECT INDEX\_NAME, COUNT(\*) AS Pages,**

**ROUND(SUM(IF(COMPRESSED\_SIZE = 0, @@GLOBAL.innodb\_page\_size, COMPRESSED\_SIZE))/1024/1024)**

**AS 'Total Data (MB)'**

**FROM INFORMATION\_SCHEMA.INNODB\_BUFFER\_PAGE**

**WHERE TABLE\_NAME = '`employees`.`salaries`'**

**GROUP BY INDEX\_NAME;**

+------------+-------+-----------------+

| INDEX\_NAME | Pages | Total Data (MB) |

+------------+-------+-----------------+

| emp\_no | 1608 | 25 |

| PRIMARY | 6086 | 95 |

+------------+-------+-----------------+

**Example 15.9 Querying LRU\_POSITION Data in the INNODB\_BUFFER\_PAGE\_LRU Table**

The [**INNODB\_BUFFER\_PAGE\_LRU**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-buffer-page-lru-table) table holds information about the pages in the **InnoDB** buffer pool, in particular how they are ordered that determines which pages to evict from the buffer pool when it becomes full. The definition for this page is the same as for [**INNODB\_BUFFER\_PAGE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-buffer-page-table), except this table has an **LRU\_POSITION** column instead of a **BLOCK\_ID** column.

This query counts the number of positions at a specific location in the LRU list occupied by pages of the **employees.employees** table.

mysql> **SELECT COUNT(LRU\_POSITION) FROM INFORMATION\_SCHEMA.INNODB\_BUFFER\_PAGE\_LRU**

**WHERE TABLE\_NAME='`employees`.`employees`' AND LRU\_POSITION < 3072;**

+---------------------+

| COUNT(LRU\_POSITION) |

+---------------------+

| 548 |

+---------------------+

**Example 15.10 Querying the INNODB\_BUFFER\_POOL\_STATS Table**

The [**INNODB\_BUFFER\_POOL\_STATS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-buffer-pool-stats-table) table provides information similar to [**SHOW ENGINE INNODB STATUS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#show-engine) and **InnoDB** buffer pool status variables.

mysql> **SELECT \* FROM information\_schema.INNODB\_BUFFER\_POOL\_STATS \G**

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\* 1. row \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

POOL\_ID: 0

POOL\_SIZE: 8192

FREE\_BUFFERS: 1

DATABASE\_PAGES: 8173

OLD\_DATABASE\_PAGES: 3014

MODIFIED\_DATABASE\_PAGES: 0

PENDING\_DECOMPRESS: 0

PENDING\_READS: 0

PENDING\_FLUSH\_LRU: 0

PENDING\_FLUSH\_LIST: 0

PAGES\_MADE\_YOUNG: 15907

PAGES\_NOT\_MADE\_YOUNG: 3803101

PAGES\_MADE\_YOUNG\_RATE: 0

PAGES\_MADE\_NOT\_YOUNG\_RATE: 0

NUMBER\_PAGES\_READ: 3270

NUMBER\_PAGES\_CREATED: 13176

NUMBER\_PAGES\_WRITTEN: 15109

PAGES\_READ\_RATE: 0

PAGES\_CREATE\_RATE: 0

PAGES\_WRITTEN\_RATE: 0

NUMBER\_PAGES\_GET: 33069332

HIT\_RATE: 0

YOUNG\_MAKE\_PER\_THOUSAND\_GETS: 0

NOT\_YOUNG\_MAKE\_PER\_THOUSAND\_GETS: 0

NUMBER\_PAGES\_READ\_AHEAD: 2713

NUMBER\_READ\_AHEAD\_EVICTED: 0

READ\_AHEAD\_RATE: 0

READ\_AHEAD\_EVICTED\_RATE: 0

LRU\_IO\_TOTAL: 0

LRU\_IO\_CURRENT: 0

UNCOMPRESS\_TOTAL: 0

UNCOMPRESS\_CURRENT: 0

For comparison, [**SHOW ENGINE INNODB STATUS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#show-engine) output and **InnoDB** buffer pool status variable output is shown below, based on the same data set.

For more information about [**SHOW ENGINE INNODB STATUS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#show-engine) output, see [Section 15.17.3, “InnoDB Standard Monitor and Lock Monitor Output”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-standard-monitor).

mysql> **SHOW ENGINE INNODB STATUS \G**

...

----------------------

BUFFER POOL AND MEMORY

----------------------

Total large memory allocated 137428992

Dictionary memory allocated 579084

Buffer pool size 8192

Free buffers 1

Database pages 8173

Old database pages 3014

Modified db pages 0

Pending reads 0

Pending writes: LRU 0, flush list 0, single page 0

Pages made young 15907, not young 3803101

0.00 youngs/s, 0.00 non-youngs/s

Pages read 3270, created 13176, written 15109

0.00 reads/s, 0.00 creates/s, 0.00 writes/s

No buffer pool page gets since the last printout

Pages read ahead 0.00/s, evicted without access 0.00/s, Random read ahead 0.00/s

LRU len: 8173, unzip\_LRU len: 0

I/O sum[0]:cur[0], unzip sum[0]:cur[0]

...

For status variable descriptions, see [Section 5.1.10, “Server Status Variables”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#server-status-variables).

mysql> **SHOW STATUS LIKE 'Innodb\_buffer%';**

+---------------------------------------+-------------+

| Variable\_name | Value |

+---------------------------------------+-------------+

| Innodb\_buffer\_pool\_dump\_status | not started |

| Innodb\_buffer\_pool\_load\_status | not started |

| Innodb\_buffer\_pool\_resize\_status | not started |

| Innodb\_buffer\_pool\_pages\_data | 8173 |

| Innodb\_buffer\_pool\_bytes\_data | 133906432 |

| Innodb\_buffer\_pool\_pages\_dirty | 0 |

| Innodb\_buffer\_pool\_bytes\_dirty | 0 |

| Innodb\_buffer\_pool\_pages\_flushed | 15109 |

| Innodb\_buffer\_pool\_pages\_free | 1 |

| Innodb\_buffer\_pool\_pages\_misc | 18 |

| Innodb\_buffer\_pool\_pages\_total | 8192 |

| Innodb\_buffer\_pool\_read\_ahead\_rnd | 0 |

| Innodb\_buffer\_pool\_read\_ahead | 2713 |

| Innodb\_buffer\_pool\_read\_ahead\_evicted | 0 |

| Innodb\_buffer\_pool\_read\_requests | 33069332 |

| Innodb\_buffer\_pool\_reads | 558 |

| Innodb\_buffer\_pool\_wait\_free | 0 |

| Innodb\_buffer\_pool\_write\_requests | 11985961 |

+---------------------------------------+-------------+

### 15.15.6 InnoDB INFORMATION\_SCHEMA Metrics Table

The [**INNODB\_METRICS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-metrics-table) table provides information about **InnoDB** performance and resource-related counters.

[**INNODB\_METRICS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-metrics-table) table columns are shown below. For column descriptions, see [Section 26.4.23, “The INFORMATION\_SCHEMA INNODB\_METRICS Table”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-metrics-table).

mysql> **SELECT \* FROM INFORMATION\_SCHEMA.INNODB\_METRICS WHERE NAME="dml\_inserts" \G**

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\* 1. row \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

NAME: dml\_inserts

SUBSYSTEM: dml

COUNT: 46273

MAX\_COUNT: 46273

MIN\_COUNT: NULL

AVG\_COUNT: 492.2659574468085

COUNT\_RESET: 46273

MAX\_COUNT\_RESET: 46273

MIN\_COUNT\_RESET: NULL

AVG\_COUNT\_RESET: NULL

TIME\_ENABLED: 2014-11-28 16:07:53

TIME\_DISABLED: NULL

TIME\_ELAPSED: 94

TIME\_RESET: NULL

STATUS: enabled

TYPE: status\_counter

COMMENT: Number of rows inserted

#### Enabling, Disabling, and Resetting Counters

You can enable, disable, and reset counters using the following variables:

[**innodb\_monitor\_enable**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_monitor_enable): Enables counters.

SET GLOBAL innodb\_monitor\_enable = [counter-name|module\_name|pattern|all];

[**innodb\_monitor\_disable**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_monitor_disable): Disables counters.

SET GLOBAL innodb\_monitor\_disable = [counter-name|module\_name|pattern|all];

[**innodb\_monitor\_reset**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_monitor_reset): Resets counter values to zero.

SET GLOBAL innodb\_monitor\_reset = [counter-name|module\_name|pattern|all];

[**innodb\_monitor\_reset\_all**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_monitor_reset_all): Resets all counter values. A counter must be disabled before using [**innodb\_monitor\_reset\_all**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_monitor_reset_all).

SET GLOBAL innodb\_monitor\_reset\_all = [counter-name|module\_name|pattern|all];

Counters and counter modules can also be enabled at startup using the MySQL server configuration file. For example, to enable the **log** module, **metadata\_table\_handles\_opened** and **metadata\_table\_handles\_closed** counters, enter the following line in the **[mysqld]** section of the MySQL server configuration file.

[mysqld]

innodb\_monitor\_enable = module\_recovery,metadata\_table\_handles\_opened,metadata\_table\_handles\_closed

When enabling multiple counters or modules in a configuration file, specify the [**innodb\_monitor\_enable**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_monitor_enable) variable followed by counter and module names separated by a comma, as shown above. Only the [**innodb\_monitor\_enable**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_monitor_enable) variable can be used in a configuration file. The [**innodb\_monitor\_disable**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_monitor_disable) and [**innodb\_monitor\_reset**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_monitor_reset) variables are supported on the command line only.

**Note**

Because each counter adds a degree of runtime overhead, use counters conservatively on production servers to diagnose specific issues or monitor specific functionality. A test or development server is recommended for more extensive use of counters.

#### Counters

The list of available counters is subject to change. Query the [**INFORMATION\_SCHEMA.INNODB\_METRICS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-metrics-table) table for counters available in your MySQL server version.

The counters enabled by default correspond to those shown in [**SHOW ENGINE INNODB STATUS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#show-engine) output. Counters shown in [**SHOW ENGINE INNODB STATUS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#show-engine) output are always enabled at a system level but can be disable for the [**INNODB\_METRICS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-metrics-table) table. Counter status is not persistent. Unless configured otherwise, counters revert to their default enabled or disabled status when the server is restarted.

If you run programs that would be affected by the addition or removal of counters, it is recommended that you review the releases notes and query the [**INNODB\_METRICS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-metrics-table) table to identify those changes as part of your upgrade process.

mysql> **SELECT name, subsystem, status FROM INFORMATION\_SCHEMA.INNODB\_METRICS ORDER BY NAME;**

+------------------------------------------+---------------------+----------+

| name | subsystem | status |

+------------------------------------------+---------------------+----------+

| adaptive\_hash\_pages\_added | adaptive\_hash\_index | disabled |

| adaptive\_hash\_pages\_removed | adaptive\_hash\_index | disabled |

| adaptive\_hash\_rows\_added | adaptive\_hash\_index | disabled |

| adaptive\_hash\_rows\_deleted\_no\_hash\_entry | adaptive\_hash\_index | disabled |

| adaptive\_hash\_rows\_removed | adaptive\_hash\_index | disabled |

| adaptive\_hash\_rows\_updated | adaptive\_hash\_index | disabled |

| adaptive\_hash\_searches | adaptive\_hash\_index | enabled |

| adaptive\_hash\_searches\_btree | adaptive\_hash\_index | enabled |

| buffer\_data\_reads | buffer | enabled |

| buffer\_data\_written | buffer | enabled |

| buffer\_flush\_adaptive | buffer | disabled |

| buffer\_flush\_adaptive\_avg\_pass | buffer | disabled |

| buffer\_flush\_adaptive\_avg\_time\_est | buffer | disabled |

| buffer\_flush\_adaptive\_avg\_time\_slot | buffer | disabled |

| buffer\_flush\_adaptive\_avg\_time\_thread | buffer | disabled |

| buffer\_flush\_adaptive\_pages | buffer | disabled |

| buffer\_flush\_adaptive\_total\_pages | buffer | disabled |

| buffer\_flush\_avg\_page\_rate | buffer | disabled |

| buffer\_flush\_avg\_pass | buffer | disabled |

| buffer\_flush\_avg\_time | buffer | disabled |

| buffer\_flush\_background | buffer | disabled |

| buffer\_flush\_background\_pages | buffer | disabled |

| buffer\_flush\_background\_total\_pages | buffer | disabled |

| buffer\_flush\_batches | buffer | disabled |

| buffer\_flush\_batch\_num\_scan | buffer | disabled |

| buffer\_flush\_batch\_pages | buffer | disabled |

| buffer\_flush\_batch\_scanned | buffer | disabled |

| buffer\_flush\_batch\_scanned\_per\_call | buffer | disabled |

| buffer\_flush\_batch\_total\_pages | buffer | disabled |

| buffer\_flush\_lsn\_avg\_rate | buffer | disabled |

| buffer\_flush\_neighbor | buffer | disabled |

| buffer\_flush\_neighbor\_pages | buffer | disabled |

| buffer\_flush\_neighbor\_total\_pages | buffer | disabled |

| buffer\_flush\_n\_to\_flush\_by\_age | buffer | disabled |

| buffer\_flush\_n\_to\_flush\_requested | buffer | disabled |

| buffer\_flush\_pct\_for\_dirty | buffer | disabled |

| buffer\_flush\_pct\_for\_lsn | buffer | disabled |

| buffer\_flush\_sync | buffer | disabled |

| buffer\_flush\_sync\_pages | buffer | disabled |

| buffer\_flush\_sync\_total\_pages | buffer | disabled |

| buffer\_flush\_sync\_waits | buffer | disabled |

| buffer\_LRU\_batches\_evict | buffer | disabled |

| buffer\_LRU\_batches\_flush | buffer | disabled |

| buffer\_LRU\_batch\_evict\_pages | buffer | disabled |

| buffer\_LRU\_batch\_evict\_total\_pages | buffer | disabled |

| buffer\_LRU\_batch\_flush\_avg\_pass | buffer | disabled |

| buffer\_LRU\_batch\_flush\_avg\_time\_est | buffer | disabled |

| buffer\_LRU\_batch\_flush\_avg\_time\_slot | buffer | disabled |

| buffer\_LRU\_batch\_flush\_avg\_time\_thread | buffer | disabled |

| buffer\_LRU\_batch\_flush\_pages | buffer | disabled |

| buffer\_LRU\_batch\_flush\_total\_pages | buffer | disabled |

| buffer\_LRU\_batch\_num\_scan | buffer | disabled |

| buffer\_LRU\_batch\_scanned | buffer | disabled |

| buffer\_LRU\_batch\_scanned\_per\_call | buffer | disabled |

| buffer\_LRU\_get\_free\_loops | buffer | disabled |

| buffer\_LRU\_get\_free\_search | Buffer | disabled |

| buffer\_LRU\_get\_free\_waits | buffer | disabled |

| buffer\_LRU\_search\_num\_scan | buffer | disabled |

| buffer\_LRU\_search\_scanned | buffer | disabled |

| buffer\_LRU\_search\_scanned\_per\_call | buffer | disabled |

| buffer\_LRU\_single\_flush\_failure\_count | Buffer | disabled |

| buffer\_LRU\_single\_flush\_num\_scan | buffer | disabled |

| buffer\_LRU\_single\_flush\_scanned | buffer | disabled |

| buffer\_LRU\_single\_flush\_scanned\_per\_call | buffer | disabled |

| buffer\_LRU\_unzip\_search\_num\_scan | buffer | disabled |

| buffer\_LRU\_unzip\_search\_scanned | buffer | disabled |

| buffer\_LRU\_unzip\_search\_scanned\_per\_call | buffer | disabled |

| buffer\_pages\_created | buffer | enabled |

| buffer\_pages\_read | buffer | enabled |

| buffer\_pages\_written | buffer | enabled |

| buffer\_page\_read\_blob | buffer\_page\_io | disabled |

| buffer\_page\_read\_fsp\_hdr | buffer\_page\_io | disabled |

| buffer\_page\_read\_ibuf\_bitmap | buffer\_page\_io | disabled |

| buffer\_page\_read\_ibuf\_free\_list | buffer\_page\_io | disabled |

| buffer\_page\_read\_index\_ibuf\_leaf | buffer\_page\_io | disabled |

| buffer\_page\_read\_index\_ibuf\_non\_leaf | buffer\_page\_io | disabled |

| buffer\_page\_read\_index\_inode | buffer\_page\_io | disabled |

| buffer\_page\_read\_index\_leaf | buffer\_page\_io | disabled |

| buffer\_page\_read\_index\_non\_leaf | buffer\_page\_io | disabled |

| buffer\_page\_read\_other | buffer\_page\_io | disabled |

| buffer\_page\_read\_system\_page | buffer\_page\_io | disabled |

| buffer\_page\_read\_trx\_system | buffer\_page\_io | disabled |

| buffer\_page\_read\_undo\_log | buffer\_page\_io | disabled |

| buffer\_page\_read\_xdes | buffer\_page\_io | disabled |

| buffer\_page\_read\_zblob | buffer\_page\_io | disabled |

| buffer\_page\_read\_zblob2 | buffer\_page\_io | disabled |

| buffer\_page\_written\_blob | buffer\_page\_io | disabled |

| buffer\_page\_written\_fsp\_hdr | buffer\_page\_io | disabled |

| buffer\_page\_written\_ibuf\_bitmap | buffer\_page\_io | disabled |

| buffer\_page\_written\_ibuf\_free\_list | buffer\_page\_io | disabled |

| buffer\_page\_written\_index\_ibuf\_leaf | buffer\_page\_io | disabled |

| buffer\_page\_written\_index\_ibuf\_non\_leaf | buffer\_page\_io | disabled |

| buffer\_page\_written\_index\_inode | buffer\_page\_io | disabled |

| buffer\_page\_written\_index\_leaf | buffer\_page\_io | disabled |

| buffer\_page\_written\_index\_non\_leaf | buffer\_page\_io | disabled |

| buffer\_page\_written\_other | buffer\_page\_io | disabled |

| buffer\_page\_written\_system\_page | buffer\_page\_io | disabled |

| buffer\_page\_written\_trx\_system | buffer\_page\_io | disabled |

| buffer\_page\_written\_undo\_log | buffer\_page\_io | disabled |

| buffer\_page\_written\_xdes | buffer\_page\_io | disabled |

| buffer\_page\_written\_zblob | buffer\_page\_io | disabled |

| buffer\_page\_written\_zblob2 | buffer\_page\_io | disabled |

| buffer\_pool\_bytes\_data | buffer | enabled |

| buffer\_pool\_bytes\_dirty | buffer | enabled |

| buffer\_pool\_pages\_data | buffer | enabled |

| buffer\_pool\_pages\_dirty | buffer | enabled |

| buffer\_pool\_pages\_free | buffer | enabled |

| buffer\_pool\_pages\_misc | buffer | enabled |

| buffer\_pool\_pages\_total | buffer | enabled |

| buffer\_pool\_reads | buffer | enabled |

| buffer\_pool\_read\_ahead | buffer | enabled |

| buffer\_pool\_read\_ahead\_evicted | buffer | enabled |

| buffer\_pool\_read\_requests | buffer | enabled |

| buffer\_pool\_size | server | enabled |

| buffer\_pool\_wait\_free | buffer | enabled |

| buffer\_pool\_write\_requests | buffer | enabled |

| compression\_pad\_decrements | compression | disabled |

| compression\_pad\_increments | compression | disabled |

| compress\_pages\_compressed | compression | disabled |

| compress\_pages\_decompressed | compression | disabled |

| ddl\_background\_drop\_indexes | ddl | disabled |

| ddl\_background\_drop\_tables | ddl | disabled |

| ddl\_log\_file\_alter\_table | ddl | disabled |

| ddl\_online\_create\_index | ddl | disabled |

| ddl\_pending\_alter\_table | ddl | disabled |

| ddl\_sort\_file\_alter\_table | ddl | disabled |

| dml\_deletes | dml | enabled |

| dml\_inserts | dml | enabled |

| dml\_reads | dml | disabled |

| dml\_updates | dml | enabled |

| file\_num\_open\_files | file\_system | enabled |

| ibuf\_merges | change\_buffer | enabled |

| ibuf\_merges\_delete | change\_buffer | enabled |

| ibuf\_merges\_delete\_mark | change\_buffer | enabled |

| ibuf\_merges\_discard\_delete | change\_buffer | enabled |

| ibuf\_merges\_discard\_delete\_mark | change\_buffer | enabled |

| ibuf\_merges\_discard\_insert | change\_buffer | enabled |

| ibuf\_merges\_insert | change\_buffer | enabled |

| ibuf\_size | change\_buffer | enabled |

| icp\_attempts | icp | disabled |

| icp\_match | icp | disabled |

| icp\_no\_match | icp | disabled |

| icp\_out\_of\_range | icp | disabled |

| index\_page\_discards | index | disabled |

| index\_page\_merge\_attempts | index | disabled |

| index\_page\_merge\_successful | index | disabled |

| index\_page\_reorg\_attempts | index | disabled |

| index\_page\_reorg\_successful | index | disabled |

| index\_page\_splits | index | disabled |

| innodb\_activity\_count | server | enabled |

| innodb\_background\_drop\_table\_usec | server | disabled |

| innodb\_checkpoint\_usec | server | disabled |

| innodb\_dblwr\_pages\_written | server | enabled |

| innodb\_dblwr\_writes | server | enabled |

| innodb\_dict\_lru\_count | server | disabled |

| innodb\_dict\_lru\_usec | server | disabled |

| innodb\_ibuf\_merge\_usec | server | disabled |

| innodb\_log\_flush\_usec | server | disabled |

| innodb\_master\_active\_loops | server | disabled |

| innodb\_master\_idle\_loops | server | disabled |

| innodb\_master\_purge\_usec | server | disabled |

| innodb\_master\_thread\_sleeps | server | disabled |

| innodb\_mem\_validate\_usec | server | disabled |

| innodb\_page\_size | server | enabled |

| innodb\_rwlock\_sx\_os\_waits | server | enabled |

| innodb\_rwlock\_sx\_spin\_rounds | server | enabled |

| innodb\_rwlock\_sx\_spin\_waits | server | enabled |

| innodb\_rwlock\_s\_os\_waits | server | enabled |

| innodb\_rwlock\_s\_spin\_rounds | server | enabled |

| innodb\_rwlock\_s\_spin\_waits | server | enabled |

| innodb\_rwlock\_x\_os\_waits | server | enabled |

| innodb\_rwlock\_x\_spin\_rounds | server | enabled |

| innodb\_rwlock\_x\_spin\_waits | server | enabled |

| lock\_deadlocks | lock | enabled |

| lock\_rec\_locks | lock | disabled |

| lock\_rec\_lock\_created | lock | disabled |

| lock\_rec\_lock\_removed | lock | disabled |

| lock\_rec\_lock\_requests | lock | disabled |

| lock\_rec\_lock\_waits | lock | disabled |

| lock\_row\_lock\_current\_waits | lock | enabled |

| lock\_row\_lock\_time | lock | enabled |

| lock\_row\_lock\_time\_avg | lock | enabled |

| lock\_row\_lock\_time\_max | lock | enabled |

| lock\_row\_lock\_waits | lock | enabled |

| lock\_table\_locks | lock | disabled |

| lock\_table\_lock\_created | lock | disabled |

| lock\_table\_lock\_removed | lock | disabled |

| lock\_table\_lock\_waits | lock | disabled |

| lock\_timeouts | lock | enabled |

| log\_checkpoints | recovery | disabled |

| log\_lsn\_buf\_pool\_oldest | recovery | disabled |

| log\_lsn\_checkpoint\_age | recovery | disabled |

| log\_lsn\_current | recovery | disabled |

| log\_lsn\_last\_checkpoint | recovery | disabled |

| log\_lsn\_last\_flush | recovery | disabled |

| log\_max\_modified\_age\_async | recovery | disabled |

| log\_max\_modified\_age\_sync | recovery | disabled |

| log\_num\_log\_io | recovery | disabled |

| log\_padded | recovery | enabled |

| log\_pending\_checkpoint\_writes | recovery | disabled |

| log\_pending\_log\_flushes | recovery | disabled |

| log\_waits | recovery | enabled |

| log\_writes | recovery | enabled |

| log\_write\_requests | recovery | enabled |

| metadata\_table\_handles\_closed | metadata | disabled |

| metadata\_table\_handles\_opened | metadata | disabled |

| metadata\_table\_reference\_count | metadata | disabled |

| os\_data\_fsyncs | os | enabled |

| os\_data\_reads | os | enabled |

| os\_data\_writes | os | enabled |

| os\_log\_bytes\_written | os | enabled |

| os\_log\_fsyncs | os | enabled |

| os\_log\_pending\_fsyncs | os | enabled |

| os\_log\_pending\_writes | os | enabled |

| os\_pending\_reads | os | disabled |

| os\_pending\_writes | os | disabled |

| purge\_del\_mark\_records | purge | disabled |

| purge\_dml\_delay\_usec | purge | disabled |

| purge\_invoked | purge | disabled |

| purge\_resume\_count | purge | disabled |

| purge\_stop\_count | purge | disabled |

| purge\_undo\_log\_pages | purge | disabled |

| purge\_upd\_exist\_or\_extern\_records | purge | disabled |

| trx\_active\_transactions | transaction | disabled |

| trx\_commits\_insert\_update | transaction | disabled |

| trx\_nl\_ro\_commits | transaction | disabled |

| trx\_rollbacks | transaction | disabled |

| trx\_rollbacks\_savepoint | transaction | disabled |

| trx\_rollback\_active | transaction | disabled |

| trx\_ro\_commits | transaction | disabled |

| trx\_rseg\_current\_size | transaction | disabled |

| trx\_rseg\_history\_len | transaction | enabled |

| trx\_rw\_commits | transaction | disabled |

| trx\_undo\_slots\_cached | transaction | disabled |

| trx\_undo\_slots\_used | transaction | disabled |

+------------------------------------------+---------------------+----------+

235 rows in set (0.01 sec)

#### Counter Modules

Each counter is associated with a particular module. Module names can be used to enable, disable, or reset all counters for a particular subsystem. For example, use **module\_dml** to enable all counters associated with the **dml** subsystem.

mysql> **SET GLOBAL innodb\_monitor\_enable = module\_dml;**

mysql> **SELECT name, subsystem, status FROM INFORMATION\_SCHEMA.INNODB\_METRICS**

**WHERE subsystem ='dml';**

+-------------+-----------+---------+

| name | subsystem | status |

+-------------+-----------+---------+

| dml\_reads | dml | enabled |

| dml\_inserts | dml | enabled |

| dml\_deletes | dml | enabled |

| dml\_updates | dml | enabled |

+-------------+-----------+---------+

Module names can be used with [**innodb\_monitor\_enable**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_monitor_enable) and related variables.

Module names and corresponding **SUBSYSTEM** names are listed below.

**module\_adaptive\_hash** (subsystem = **adaptive\_hash\_index**)

**module\_buffer** (subsystem = **buffer**)

**module\_buffer\_page** (subsystem = **buffer\_page\_io**)

**module\_compress** (subsystem = **compression**)

**module\_ddl** (subsystem = **ddl**)

**module\_dml** (subsystem = **dml**)

**module\_file** (subsystem = **file\_system**)

**module\_ibuf\_system** (subsystem = **change\_buffer**)

**module\_icp** (subsystem = **icp**)

**module\_index** (subsystem = **index**)

**module\_innodb** (subsystem = **innodb**)

**module\_lock** (subsystem = **lock**)

**module\_log** (subsystem = **recovery**)

**module\_metadata** (subsystem = **metadata**)

**module\_os** (subsystem = **os**)

**module\_purge** (subsystem = **purge**)

**module\_trx** (subsystem = **transaction**)

**module\_undo** (subsystem = **undo**)

**Example 15.11 Working with INNODB\_METRICS Table Counters**

This example demonstrates enabling, disabling, and resetting a counter, and querying counter data in the [**INNODB\_METRICS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-metrics-table) table.

Create a simple **InnoDB** table:

mysql> **USE test;**

Database changed

mysql> **CREATE TABLE t1 (c1 INT) ENGINE=INNODB;**

Query OK, 0 rows affected (0.02 sec)

Enable the **dml\_inserts** counter.

mysql> **SET GLOBAL innodb\_monitor\_enable = dml\_inserts;**

Query OK, 0 rows affected (0.01 sec)

A description of the **dml\_inserts** counter can be found in the **COMMENT** column of the **INNODB\_METRICS** table:

mysql> **SELECT NAME, COMMENT FROM INFORMATION\_SCHEMA.INNODB\_METRICS WHERE NAME="dml\_inserts";**

+-------------+-------------------------+

| NAME | COMMENT |

+-------------+-------------------------+

| dml\_inserts | Number of rows inserted |

+-------------+-------------------------+

Query the [**INNODB\_METRICS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-metrics-table) table for the **dml\_inserts** counter data. Because no DML operations have been performed, the counter values are zero or NULL. The **TIME\_ENABLED** and **TIME\_ELAPSED** values indicate when the counter was last enabled and how many seconds have elapsed since that time.

mysql> **SELECT \* FROM INFORMATION\_SCHEMA.INNODB\_METRICS WHERE NAME="dml\_inserts" \G**

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\* 1. row \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

NAME: dml\_inserts

SUBSYSTEM: dml

COUNT: 0

MAX\_COUNT: 0

MIN\_COUNT: NULL

AVG\_COUNT: 0

COUNT\_RESET: 0

MAX\_COUNT\_RESET: 0

MIN\_COUNT\_RESET: NULL

AVG\_COUNT\_RESET: NULL

TIME\_ENABLED: 2014-12-04 14:18:28

TIME\_DISABLED: NULL

TIME\_ELAPSED: 28

TIME\_RESET: NULL

STATUS: enabled

TYPE: status\_counter

COMMENT: Number of rows inserted

Insert three rows of data into the table.

mysql> **INSERT INTO t1 values(1);**

Query OK, 1 row affected (0.00 sec)

mysql> **INSERT INTO t1 values(2);**

Query OK, 1 row affected (0.00 sec)

mysql> **INSERT INTO t1 values(3);**

Query OK, 1 row affected (0.00 sec)

Query the [**INNODB\_METRICS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-metrics-table) table again for the **dml\_inserts** counter data. A number of counter values have now incremented including **COUNT**, **MAX\_COUNT**, **AVG\_COUNT**, and **COUNT\_RESET**. Refer to the [**INNODB\_METRICS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-metrics-table) table definition for descriptions of these values.

mysql> **SELECT \* FROM INFORMATION\_SCHEMA.INNODB\_METRICS WHERE NAME="dml\_inserts"\G**

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\* 1. row \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

NAME: dml\_inserts

SUBSYSTEM: dml

COUNT: 3

MAX\_COUNT: 3

MIN\_COUNT: NULL

AVG\_COUNT: 0.046153846153846156

COUNT\_RESET: 3

MAX\_COUNT\_RESET: 3

MIN\_COUNT\_RESET: NULL

AVG\_COUNT\_RESET: NULL

TIME\_ENABLED: 2014-12-04 14:18:28

TIME\_DISABLED: NULL

TIME\_ELAPSED: 65

TIME\_RESET: NULL

STATUS: enabled

TYPE: status\_counter

COMMENT: Number of rows inserted

Reset the **dml\_inserts** counter and query the [**INNODB\_METRICS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-metrics-table) table again for the **dml\_inserts** counter data. The **%\_RESET** values that were reported previously, such as **COUNT\_RESET** and **MAX\_RESET**, are set back to zero. Values such as **COUNT**, **MAX\_COUNT**, and **AVG\_COUNT**, which cumulatively collect data from the time the counter is enabled, are unaffected by the reset.

mysql> **SET GLOBAL innodb\_monitor\_reset = dml\_inserts;**

Query OK, 0 rows affected (0.00 sec)

mysql> **SELECT \* FROM INFORMATION\_SCHEMA.INNODB\_METRICS WHERE NAME="dml\_inserts"\G**

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\* 1. row \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

NAME: dml\_inserts

SUBSYSTEM: dml

COUNT: 3

MAX\_COUNT: 3

MIN\_COUNT: NULL

AVG\_COUNT: 0.03529411764705882

COUNT\_RESET: 0

MAX\_COUNT\_RESET: 0

MIN\_COUNT\_RESET: NULL

AVG\_COUNT\_RESET: 0

TIME\_ENABLED: 2014-12-04 14:18:28

TIME\_DISABLED: NULL

TIME\_ELAPSED: 85

TIME\_RESET: 2014-12-04 14:19:44

STATUS: enabled

TYPE: status\_counter

COMMENT: Number of rows inserted

To reset all counter values, you must first disable the counter. Disabling the counter sets the **STATUS** value to **disabled**.

mysql> **SET GLOBAL innodb\_monitor\_disable = dml\_inserts;**

Query OK, 0 rows affected (0.00 sec)

mysql> **SELECT \* FROM INFORMATION\_SCHEMA.INNODB\_METRICS WHERE NAME="dml\_inserts"\G**

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\* 1. row \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

NAME: dml\_inserts

SUBSYSTEM: dml

COUNT: 3

MAX\_COUNT: 3

MIN\_COUNT: NULL

AVG\_COUNT: 0.030612244897959183

COUNT\_RESET: 0

MAX\_COUNT\_RESET: 0

MIN\_COUNT\_RESET: NULL

AVG\_COUNT\_RESET: 0

TIME\_ENABLED: 2014-12-04 14:18:28

TIME\_DISABLED: 2014-12-04 14:20:06

TIME\_ELAPSED: 98

TIME\_RESET: NULL

STATUS: disabled

TYPE: status\_counter

COMMENT: Number of rows inserted

**Note**

Wildcard match is supported for counter and module names. For example, instead of specifying the full **dml\_inserts** counter name, you can specify **dml\_i%**. You can also enable, disable, or reset multiple counters or modules at once using a wildcard match. For example, specify **dml\_%** to enable, disable, or reset all counters that begin with **dml\_**.

After the counter is disabled, you can reset all counter values using the [**innodb\_monitor\_reset\_all**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_monitor_reset_all) option. All values are set to zero or NULL.

mysql> **SET GLOBAL innodb\_monitor\_reset\_all = dml\_inserts;**

Query OK, 0 rows affected (0.00 sec)

mysql> **SELECT \* FROM INFORMATION\_SCHEMA.INNODB\_METRICS WHERE NAME="dml\_inserts"\G**

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\* 1. row \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

NAME: dml\_inserts

SUBSYSTEM: dml

COUNT: 0

MAX\_COUNT: NULL

MIN\_COUNT: NULL

AVG\_COUNT: NULL

COUNT\_RESET: 0

MAX\_COUNT\_RESET: NULL

MIN\_COUNT\_RESET: NULL

AVG\_COUNT\_RESET: NULL

TIME\_ENABLED: NULL

TIME\_DISABLED: NULL

TIME\_ELAPSED: NULL

TIME\_RESET: NULL

STATUS: disabled

TYPE: status\_counter

COMMENT: Number of rows inserted

### 15.15.7 InnoDB INFORMATION\_SCHEMA Temporary Table Info Table

[**INNODB\_TEMP\_TABLE\_INFO**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-temp-table-info-table) provides information about user-created **InnoDB** temporary tables that are active in the **InnoDB** instance. It does not provide information about internal **InnoDB** temporary tables used by the optimizer.

mysql> **SHOW TABLES FROM INFORMATION\_SCHEMA LIKE 'INNODB\_TEMP%';**

+---------------------------------------------+

| Tables\_in\_INFORMATION\_SCHEMA (INNODB\_TEMP%) |

+---------------------------------------------+

| INNODB\_TEMP\_TABLE\_INFO |

+---------------------------------------------+

For the table definition, see [Section 26.4.29, “The INFORMATION\_SCHEMA INNODB\_TEMP\_TABLE\_INFO Table”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-temp-table-info-table).

**Example 15.12 INNODB\_TEMP\_TABLE\_INFO**

This example demonstrates characteristics of the [**INNODB\_TEMP\_TABLE\_INFO**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-temp-table-info-table) table.

Create a simple **InnoDB** temporary table:

mysql> **CREATE TEMPORARY TABLE t1 (c1 INT PRIMARY KEY) ENGINE=INNODB;**

Query [**INNODB\_TEMP\_TABLE\_INFO**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-temp-table-info-table) to view the temporary table metadata.

mysql> **SELECT \* FROM INFORMATION\_SCHEMA.INNODB\_TEMP\_TABLE\_INFO\G**

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\* 1. row \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

TABLE\_ID: 194

NAME: #sql7a79\_1\_0

N\_COLS: 4

SPACE: 182

The **TABLE\_ID**is a unique identifier for the temporary table. The **NAME** column displays the system-generated name for the temporary table, which is prefixed with “#sql”. The number of columns (**N\_COLS**) is 4 rather than 1 because **InnoDB** always creates three hidden table columns (**DB\_ROW\_ID**, **DB\_TRX\_ID**, and **DB\_ROLL\_PTR**).

Restart MySQL and query [**INNODB\_TEMP\_TABLE\_INFO**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-temp-table-info-table).

mysql> **SELECT \* FROM INFORMATION\_SCHEMA.INNODB\_TEMP\_TABLE\_INFO\G**

An empty set is returned because [**INNODB\_TEMP\_TABLE\_INFO**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-temp-table-info-table) and its data are not persisted to disk when the server is shut down.

Create a new temporary table.

mysql> **CREATE TEMPORARY TABLE t1 (c1 INT PRIMARY KEY) ENGINE=INNODB;**

Query [**INNODB\_TEMP\_TABLE\_INFO**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-temp-table-info-table) to view the temporary table metadata.

mysql> **SELECT \* FROM INFORMATION\_SCHEMA.INNODB\_TEMP\_TABLE\_INFO\G**

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\* 1. row \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

TABLE\_ID: 196

NAME: #sql7b0e\_1\_0

N\_COLS: 4

SPACE: 184

The **SPACE** ID may be different because it is dynamically generated when the server is started.

### 15.15.8 Retrieving InnoDB Tablespace Metadata from INFORMATION\_SCHEMA.FILES

The [**INFORMATION\_SCHEMA.FILES**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-files-table) table provides metadata about all **InnoDB** tablespace types including [file-per-table tablespaces](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_file_per_table), [general tablespaces](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_general_tablespace), the [system tablespace](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_system_tablespace), [temporary table tablespaces](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_temporary_tablespace), and [undo tablespaces](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_undo_tablespace) (if present).

This section provides **InnoDB**-specific usage examples. For more information about data provided by the [**INFORMATION\_SCHEMA.FILES**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-files-table) table, see [Section 26.3.15, “The INFORMATION\_SCHEMA FILES Table”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-files-table).

**Note**

The [**INNODB\_TABLESPACES**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-tablespaces-table) and [**INNODB\_DATAFILES**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-innodb-datafiles-table) tables also provide metadata about **InnoDB** tablespaces, but data is limited to file-per-table, general, and undo tablespaces.

This query retrieves metadata about the **InnoDB** system tablespace from fields of the [**INFORMATION\_SCHEMA.FILES**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-files-table) table that are pertinent to **InnoDB** tablespaces. [**INFORMATION\_SCHEMA.FILES**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\information-schema.html#information-schema-files-table) fields that are not relevant to **InnoDB** always return NULL, and are excluded from the query.

mysql> **SELECT FILE\_ID, FILE\_NAME, FILE\_TYPE, TABLESPACE\_NAME, FREE\_EXTENTS,**

**TOTAL\_EXTENTS, EXTENT\_SIZE, INITIAL\_SIZE, MAXIMUM\_SIZE, AUTOEXTEND\_SIZE, DATA\_FREE, STATUS ENGINE**

**FROM INFORMATION\_SCHEMA.FILES WHERE TABLESPACE\_NAME LIKE 'innodb\_system' \G**

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\* 1. row \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

FILE\_ID: 0

FILE\_NAME: ./ibdata1

FILE\_TYPE: TABLESPACE

TABLESPACE\_NAME: innodb\_system

FREE\_EXTENTS: 0

TOTAL\_EXTENTS: 12

EXTENT\_SIZE: 1048576

INITIAL\_SIZE: 12582912

MAXIMUM\_SIZE: NULL

AUTOEXTEND\_SIZE: 67108864

DATA\_FREE: 4194304

ENGINE: NORMAL

This query retrieves the **FILE\_ID** (equivalent to the space ID) and the **FILE\_NAME** (which includes path information) for **InnoDB** file-per-table and general tablespaces. File-per-table and general tablespaces have a .ibd file extension.

mysql> **SELECT FILE\_ID, FILE\_NAME FROM INFORMATION\_SCHEMA.FILES**

**WHERE FILE\_NAME LIKE '%.ibd%' ORDER BY FILE\_ID;**

+---------+---------------------------------------+

| FILE\_ID | FILE\_NAME |

+---------+---------------------------------------+

| 2 | ./mysql/plugin.ibd |

| 3 | ./mysql/servers.ibd |

| 4 | ./mysql/help\_topic.ibd |

| 5 | ./mysql/help\_category.ibd |

| 6 | ./mysql/help\_relation.ibd |

| 7 | ./mysql/help\_keyword.ibd |

| 8 | ./mysql/time\_zone\_name.ibd |

| 9 | ./mysql/time\_zone.ibd |

| 10 | ./mysql/time\_zone\_transition.ibd |

| 11 | ./mysql/time\_zone\_transition\_type.ibd |

| 12 | ./mysql/time\_zone\_leap\_second.ibd |

| 13 | ./mysql/innodb\_table\_stats.ibd |

| 14 | ./mysql/innodb\_index\_stats.ibd |

| 15 | ./mysql/slave\_relay\_log\_info.ibd |

| 16 | ./mysql/slave\_master\_info.ibd |

| 17 | ./mysql/slave\_worker\_info.ibd |

| 18 | ./mysql/gtid\_executed.ibd |

| 19 | ./mysql/server\_cost.ibd |

| 20 | ./mysql/engine\_cost.ibd |

| 21 | ./sys/sys\_config.ibd |

| 23 | ./test/t1.ibd |

| 26 | /home/user/test/test/t2.ibd |

+---------+---------------------------------------+

This query retrieves the **FILE\_ID** and **FILE\_NAME** for the **InnoDB** global temporary tablespace. Global temporary tablespace file names are prefixed by **ibtmp**.

mysql> **SELECT FILE\_ID, FILE\_NAME FROM INFORMATION\_SCHEMA.FILES**

**WHERE FILE\_NAME LIKE '%ibtmp%';**

+---------+-----------+

| FILE\_ID | FILE\_NAME |

+---------+-----------+

| 22 | ./ibtmp1 |

+---------+-----------+

Similarly, **InnoDB** undo tablespace file names are prefixed by **undo**. The following query returns the **FILE\_ID** and **FILE\_NAME** for **InnoDB** undo tablespaces.

mysql> **SELECT FILE\_ID, FILE\_NAME FROM INFORMATION\_SCHEMA.FILES**

**WHERE FILE\_NAME LIKE '%undo%';**

## 15.16 InnoDB Integration with MySQL Performance Schema

[15.16.1 Monitoring ALTER TABLE Progress for InnoDB Tables Using Performance Schema](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#monitor-alter-table-performance-schema)

[15.16.2 Monitoring InnoDB Mutex Waits Using Performance Schema](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#monitor-innodb-mutex-waits-performance-schema)

This section provides a brief introduction to **InnoDB** integration with Performance Schema. For comprehensive Performance Schema documentation, see [Chapter 27, *MySQL Performance Schema*](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html).

You can profile certain internal **InnoDB** operations using the MySQL [Performance Schema feature](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html). This type of tuning is primarily for expert users who evaluate optimization strategies to overcome performance bottlenecks. DBAs can also use this feature for capacity planning, to see whether their typical workload encounters any performance bottlenecks with a particular combination of CPU, RAM, and disk storage; and if so, to judge whether performance can be improved by increasing the capacity of some part of the system.

To use this feature to examine **InnoDB** performance:

You must be generally familiar with how to use the [Performance Schema feature](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html). For example, you should know how enable instruments and consumers, and how to query **performance\_schema** tables to retrieve data. For an introductory overview, see [Section 27.1, “Performance Schema Quick Start”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html#performance-schema-quick-start).

You should be familiar with Performance Schema instruments that are available for **InnoDB**. To view **InnoDB**-related instruments, you can query the [**setup\_instruments**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html#performance-schema-setup-instruments-table) table for instrument names that contain '**innodb**'.

mysql> **SELECT \***

**FROM performance\_schema.setup\_instruments**

**WHERE NAME LIKE '%innodb%';**

+-------------------------------------------------------+---------+-------+

| NAME | ENABLED | TIMED |

+-------------------------------------------------------+---------+-------+

| wait/synch/mutex/innodb/commit\_cond\_mutex | NO | NO |

| wait/synch/mutex/innodb/innobase\_share\_mutex | NO | NO |

| wait/synch/mutex/innodb/autoinc\_mutex | NO | NO |

| wait/synch/mutex/innodb/buf\_pool\_mutex | NO | NO |

| wait/synch/mutex/innodb/buf\_pool\_zip\_mutex | NO | NO |

| wait/synch/mutex/innodb/cache\_last\_read\_mutex | NO | NO |

| wait/synch/mutex/innodb/dict\_foreign\_err\_mutex | NO | NO |

| wait/synch/mutex/innodb/dict\_sys\_mutex | NO | NO |

| wait/synch/mutex/innodb/recalc\_pool\_mutex | NO | NO |

...

| wait/io/file/innodb/innodb\_data\_file | YES | YES |

| wait/io/file/innodb/innodb\_log\_file | YES | YES |

| wait/io/file/innodb/innodb\_temp\_file | YES | YES |

| stage/innodb/alter table (end) | YES | YES |

| stage/innodb/alter table (flush) | YES | YES |

| stage/innodb/alter table (insert) | YES | YES |

| stage/innodb/alter table (log apply index) | YES | YES |

| stage/innodb/alter table (log apply table) | YES | YES |

| stage/innodb/alter table (merge sort) | YES | YES |

| stage/innodb/alter table (read PK and internal sort) | YES | YES |

| stage/innodb/buffer pool load | YES | YES |

| memory/innodb/buf\_buf\_pool | NO | NO |

| memory/innodb/dict\_stats\_bg\_recalc\_pool\_t | NO | NO |

| memory/innodb/dict\_stats\_index\_map\_t | NO | NO |

| memory/innodb/dict\_stats\_n\_diff\_on\_level | NO | NO |

| memory/innodb/other | NO | NO |

| memory/innodb/row\_log\_buf | NO | NO |

| memory/innodb/row\_merge\_sort | NO | NO |

| memory/innodb/std | NO | NO |

| memory/innodb/sync\_debug\_latches | NO | NO |

| memory/innodb/trx\_sys\_t::rw\_trx\_ids | NO | NO |

...

+-------------------------------------------------------+---------+-------+

155 rows in set (0.00 sec)

For additional information about the instrumented **InnoDB** objects, you can query Performance Schema [instances tables](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html#performance-schema-instance-tables), which provide additional information about instrumented objects. Instance tables relevant to **InnoDB** include:

The [**mutex\_instances**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html#performance-schema-mutex-instances-table) table

The [**rwlock\_instances**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html#performance-schema-rwlock-instances-table) table

The [**cond\_instances**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html#performance-schema-cond-instances-table) table

The [**file\_instances**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html#performance-schema-file-instances-table) table

**Note**

Mutexes and RW-locks related to the **InnoDB** buffer pool are not included in this coverage; the same applies to the output of the **SHOW ENGINE INNODB MUTEX** command.

For example, to view information about instrumented **InnoDB** file objects seen by the Performance Schema when executing file I/O instrumentation, you might issue the following query:

mysql> **SELECT \***

**FROM performance\_schema.file\_instances**

**WHERE EVENT\_NAME LIKE '%innodb%'\G**

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\* 1. row \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

FILE\_NAME: /path/to/mysql-8.0/data/ibdata1

EVENT\_NAME: wait/io/file/innodb/innodb\_data\_file

OPEN\_COUNT: 3

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\* 2. row \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

FILE\_NAME: /path/to/mysql-8.0/data/ib\_logfile0

EVENT\_NAME: wait/io/file/innodb/innodb\_log\_file

OPEN\_COUNT: 2

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\* 3. row \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

FILE\_NAME: /path/to/mysql-8.0/data/ib\_logfile1

EVENT\_NAME: wait/io/file/innodb/innodb\_log\_file

OPEN\_COUNT: 2

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\* 4. row \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

FILE\_NAME: /path/to/mysql-8.0/data/mysql/engine\_cost.ibd

EVENT\_NAME: wait/io/file/innodb/innodb\_data\_file

OPEN\_COUNT: 3

...

You should be familiar with **performance\_schema** tables that store **InnoDB** event data. Tables relevant to **InnoDB**-related events include:

The [Wait Event](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html#performance-schema-wait-tables) tables, which store wait events.

The [Summary](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html#performance-schema-summary-tables) tables, which provide aggregated information for terminated events over time. Summary tables include [file I/O summary tables](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html#performance-schema-file-summary-tables), which aggregate information about I/O operations.

[Stage Event](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html#performance-schema-stage-tables) tables, which store event data for **InnoDB** [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) and buffer pool load operations. For more information, see [Section 15.16.1, “Monitoring ALTER TABLE Progress for InnoDB Tables Using Performance Schema”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#monitor-alter-table-performance-schema), and [Monitoring Buffer Pool Load Progress Using Performance Schema](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#monitor-buffer-pool-load-performance-schema).

If you are only interested in **InnoDB**-related objects, use the clause **WHERE EVENT\_NAME LIKE '%innodb%'** or **WHERE NAME LIKE '%innodb%'** (as required) when querying these tables.

### 15.16.1 Monitoring ALTER TABLE Progress for InnoDB Tables Using Performance Schema

You can monitor [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) progress for **InnoDB** tables using [Performance Schema](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html).

There are seven stage events that represent different phases of [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table). Each stage event reports a running total of **WORK\_COMPLETED** and **WORK\_ESTIMATED** for the overall [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) operation as it progresses through its different phases. **WORK\_ESTIMATED** is calculated using a formula that takes into account all of the work that [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) performs, and may be revised during [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) processing. **WORK\_COMPLETED** and **WORK\_ESTIMATED** values are an abstract representation of all of the work performed by [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table).

In order of occurrence, [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) stage events include:

**stage/innodb/alter table (read PK and internal sort)**: This stage is active when [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) is in the reading-primary-key phase. It starts with **WORK\_COMPLETED=0** and **WORK\_ESTIMATED** set to the estimated number of pages in the primary key. When the stage is completed, **WORK\_ESTIMATED** is updated to the actual number of pages in the primary key.

**stage/innodb/alter table (merge sort)**: This stage is repeated for each index added by the [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) operation.

**stage/innodb/alter table (insert)**: This stage is repeated for each index added by the [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) operation.

**stage/innodb/alter table (log apply index)**: This stage includes the application of DML log generated while [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) was running.

**stage/innodb/alter table (flush)**: Before this stage begins, **WORK\_ESTIMATED** is updated with a more accurate estimate, based on the length of the flush list.

**stage/innodb/alter table (log apply table)**: This stage includes the application of concurrent DML log generated while [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) was running. The duration of this phase depends on the extent of table changes. This phase is instant if no concurrent DML was run on the table.

**stage/innodb/alter table (end)**: Includes any remaining work that appeared after the flush phase, such as reapplying DML that was executed on the table while [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) was running.

**Note**

**InnoDB** [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) stage events do not currently account for the addition of spatial indexes.

#### ALTER TABLE Monitoring Example Using Performance Schema

The following example demonstrates how to enable the **stage/innodb/alter table%** stage event instruments and related consumer tables to monitor [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) progress. For information about Performance Schema stage event instruments and related consumers, see [Section 27.12.5, “Performance Schema Stage Event Tables”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html#performance-schema-stage-tables).

Enable the **stage/innodb/alter%** instruments:

mysql> **UPDATE performance\_schema.setup\_instruments**

**SET ENABLED = 'YES'**

**WHERE NAME LIKE 'stage/innodb/alter%';**

Query OK, 7 rows affected (0.00 sec)

Rows matched: 7 Changed: 7 Warnings: 0

Enable the stage event consumer tables, which include [**events\_stages\_current**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html#performance-schema-events-stages-current-table), [**events\_stages\_history**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html#performance-schema-events-stages-history-table), and [**events\_stages\_history\_long**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html#performance-schema-events-stages-history-long-table).

mysql> **UPDATE performance\_schema.setup\_consumers**

**SET ENABLED = 'YES'**

**WHERE NAME LIKE '%stages%';**

Query OK, 3 rows affected (0.00 sec)

Rows matched: 3 Changed: 3 Warnings: 0

Run an [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) operation. In this example, a **middle\_name** column is added to the employees table of the employees sample database.

mysql> **ALTER TABLE employees.employees ADD COLUMN middle\_name varchar(14) AFTER first\_name;**

Query OK, 0 rows affected (9.27 sec)

Records: 0 Duplicates: 0 Warnings: 0

Check the progress of the [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) operation by querying the Performance Schema [**events\_stages\_current**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html#performance-schema-events-stages-current-table) table. The stage event shown differs depending on which [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) phase is currently in progress. The **WORK\_COMPLETED** column shows the work completed. The **WORK\_ESTIMATED** column provides an estimate of the remaining work.

mysql> **SELECT EVENT\_NAME, WORK\_COMPLETED, WORK\_ESTIMATED**

**FROM performance\_schema.events\_stages\_current;**

+------------------------------------------------------+----------------+----------------+

| EVENT\_NAME | WORK\_COMPLETED | WORK\_ESTIMATED |

+------------------------------------------------------+----------------+----------------+

| stage/innodb/alter table (read PK and internal sort) | 280 | 1245 |

+------------------------------------------------------+----------------+----------------+

1 row in set (0.01 sec)

The [**events\_stages\_current**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html#performance-schema-events-stages-current-table) table returns an empty set if the [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) operation has completed. In this case, you can check the [**events\_stages\_history**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html#performance-schema-events-stages-history-table) table to view event data for the completed operation. For example:

mysql> **SELECT EVENT\_NAME, WORK\_COMPLETED, WORK\_ESTIMATED**

**FROM performance\_schema.events\_stages\_history;**

+------------------------------------------------------+----------------+----------------+

| EVENT\_NAME | WORK\_COMPLETED | WORK\_ESTIMATED |

+------------------------------------------------------+----------------+----------------+

| stage/innodb/alter table (read PK and internal sort) | 886 | 1213 |

| stage/innodb/alter table (flush) | 1213 | 1213 |

| stage/innodb/alter table (log apply table) | 1597 | 1597 |

| stage/innodb/alter table (end) | 1597 | 1597 |

| stage/innodb/alter table (log apply table) | 1981 | 1981 |

+------------------------------------------------------+----------------+----------------+

5 rows in set (0.00 sec)

As shown above, the **WORK\_ESTIMATED** value was revised during **ALTER TABLE** processing. The estimated work after completion of the initial stage is 1213. When **ALTER TABLE** processing completed, **WORK\_ESTIMATED** was set to the actual value, which is 1981.

### 15.16.2 Monitoring InnoDB Mutex Waits Using Performance Schema

A mutex is a synchronization mechanism used in the code to enforce that only one thread at a given time can have access to a common resource. When two or more threads executing in the server need to access the same resource, the threads compete against each other. The first thread to obtain a lock on the mutex causes the other threads to wait until the lock is released.

For **InnoDB** mutexes that are instrumented, mutex waits can be monitored using [Performance Schema](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html). Wait event data collected in Performance Schema tables can help identify mutexes with the most waits or the greatest total wait time, for example.

The following example demonstrates how to enable **InnoDB** mutex wait instruments, how to enable associated consumers, and how to query wait event data.

To view available **InnoDB** mutex wait instruments, query the Performance Schema [**setup\_instruments**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html#performance-schema-setup-instruments-table) table. All **InnoDB** mutex wait instruments are disabled by default.

mysql> **SELECT \***

**FROM performance\_schema.setup\_instruments**

**WHERE NAME LIKE '%wait/synch/mutex/innodb%';**

+---------------------------------------------------------+---------+-------+

| NAME | ENABLED | TIMED |

+---------------------------------------------------------+---------+-------+

| wait/synch/mutex/innodb/commit\_cond\_mutex | NO | NO |

| wait/synch/mutex/innodb/innobase\_share\_mutex | NO | NO |

| wait/synch/mutex/innodb/autoinc\_mutex | NO | NO |

| wait/synch/mutex/innodb/autoinc\_persisted\_mutex | NO | NO |

| wait/synch/mutex/innodb/buf\_pool\_flush\_state\_mutex | NO | NO |

| wait/synch/mutex/innodb/buf\_pool\_LRU\_list\_mutex | NO | NO |

| wait/synch/mutex/innodb/buf\_pool\_free\_list\_mutex | NO | NO |

| wait/synch/mutex/innodb/buf\_pool\_zip\_free\_mutex | NO | NO |

| wait/synch/mutex/innodb/buf\_pool\_zip\_hash\_mutex | NO | NO |

| wait/synch/mutex/innodb/buf\_pool\_zip\_mutex | NO | NO |

| wait/synch/mutex/innodb/cache\_last\_read\_mutex | NO | NO |

| wait/synch/mutex/innodb/dict\_foreign\_err\_mutex | NO | NO |

| wait/synch/mutex/innodb/dict\_persist\_dirty\_tables\_mutex | NO | NO |

| wait/synch/mutex/innodb/dict\_sys\_mutex | NO | NO |

| wait/synch/mutex/innodb/recalc\_pool\_mutex | NO | NO |

| wait/synch/mutex/innodb/fil\_system\_mutex | NO | NO |

| wait/synch/mutex/innodb/flush\_list\_mutex | NO | NO |

| wait/synch/mutex/innodb/fts\_bg\_threads\_mutex | NO | NO |

| wait/synch/mutex/innodb/fts\_delete\_mutex | NO | NO |

| wait/synch/mutex/innodb/fts\_optimize\_mutex | NO | NO |

| wait/synch/mutex/innodb/fts\_doc\_id\_mutex | NO | NO |

| wait/synch/mutex/innodb/log\_flush\_order\_mutex | NO | NO |

| wait/synch/mutex/innodb/hash\_table\_mutex | NO | NO |

| wait/synch/mutex/innodb/ibuf\_bitmap\_mutex | NO | NO |

| wait/synch/mutex/innodb/ibuf\_mutex | NO | NO |

| wait/synch/mutex/innodb/ibuf\_pessimistic\_insert\_mutex | NO | NO |

| wait/synch/mutex/innodb/log\_sys\_mutex | NO | NO |

| wait/synch/mutex/innodb/log\_sys\_write\_mutex | NO | NO |

| wait/synch/mutex/innodb/mutex\_list\_mutex | NO | NO |

| wait/synch/mutex/innodb/page\_zip\_stat\_per\_index\_mutex | NO | NO |

| wait/synch/mutex/innodb/purge\_sys\_pq\_mutex | NO | NO |

| wait/synch/mutex/innodb/recv\_sys\_mutex | NO | NO |

| wait/synch/mutex/innodb/recv\_writer\_mutex | NO | NO |

| wait/synch/mutex/innodb/redo\_rseg\_mutex | NO | NO |

| wait/synch/mutex/innodb/noredo\_rseg\_mutex | NO | NO |

| wait/synch/mutex/innodb/rw\_lock\_list\_mutex | NO | NO |

| wait/synch/mutex/innodb/rw\_lock\_mutex | NO | NO |

| wait/synch/mutex/innodb/srv\_dict\_tmpfile\_mutex | NO | NO |

| wait/synch/mutex/innodb/srv\_innodb\_monitor\_mutex | NO | NO |

| wait/synch/mutex/innodb/srv\_misc\_tmpfile\_mutex | NO | NO |

| wait/synch/mutex/innodb/srv\_monitor\_file\_mutex | NO | NO |

| wait/synch/mutex/innodb/buf\_dblwr\_mutex | NO | NO |

| wait/synch/mutex/innodb/trx\_undo\_mutex | NO | NO |

| wait/synch/mutex/innodb/trx\_pool\_mutex | NO | NO |

| wait/synch/mutex/innodb/trx\_pool\_manager\_mutex | NO | NO |

| wait/synch/mutex/innodb/srv\_sys\_mutex | NO | NO |

| wait/synch/mutex/innodb/lock\_mutex | NO | NO |

| wait/synch/mutex/innodb/lock\_wait\_mutex | NO | NO |

| wait/synch/mutex/innodb/trx\_mutex | NO | NO |

| wait/synch/mutex/innodb/srv\_threads\_mutex | NO | NO |

| wait/synch/mutex/innodb/rtr\_active\_mutex | NO | NO |

| wait/synch/mutex/innodb/rtr\_match\_mutex | NO | NO |

| wait/synch/mutex/innodb/rtr\_path\_mutex | NO | NO |

| wait/synch/mutex/innodb/rtr\_ssn\_mutex | NO | NO |

| wait/synch/mutex/innodb/trx\_sys\_mutex | NO | NO |

| wait/synch/mutex/innodb/zip\_pad\_mutex | NO | NO |

| wait/synch/mutex/innodb/master\_key\_id\_mutex | NO | NO |

+---------------------------------------------------------+---------+-------+

Some **InnoDB** mutex instances are created at server startup and are only instrumented if the associated instrument is also enabled at server startup. To ensure that all **InnoDB** mutex instances are instrumented and enabled, add the following **performance-schema-instrument** rule to your MySQL configuration file:

performance-schema-instrument='wait/synch/mutex/innodb/%=ON'

If you do not require wait event data for all **InnoDB** mutexes, you can disable specific instruments by adding additional **performance-schema-instrument** rules to your MySQL configuration file. For example, to disable **InnoDB** mutex wait event instruments related to full-text search, add the following rule:

performance-schema-instrument='wait/synch/mutex/innodb/fts%=OFF'

**Note**

Rules with a longer prefix such as **wait/synch/mutex/innodb/fts%** take precedence over rules with shorter prefixes such as **wait/synch/mutex/innodb/%**.

After adding the **performance-schema-instrument** rules to your configuration file, restart the server. All the **InnoDB** mutexes except for those related to full text search are enabled. To verify, query the [**setup\_instruments**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html#performance-schema-setup-instruments-table) table. The **ENABLED** and **TIMED** columns should be set to **YES** for the instruments that you enabled.

mysql> **SELECT \***

**FROM performance\_schema.setup\_instruments**

**WHERE NAME LIKE '%wait/synch/mutex/innodb%';**

+-------------------------------------------------------+---------+-------+

| NAME | ENABLED | TIMED |

+-------------------------------------------------------+---------+-------+

| wait/synch/mutex/innodb/commit\_cond\_mutex | YES | YES |

| wait/synch/mutex/innodb/innobase\_share\_mutex | YES | YES |

| wait/synch/mutex/innodb/autoinc\_mutex | YES | YES |

...

| wait/synch/mutex/innodb/master\_key\_id\_mutex | YES | YES |

+-------------------------------------------------------+---------+-------+

49 rows in set (0.00 sec)

Enable wait event consumers by updating the [**setup\_consumers**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html#performance-schema-setup-consumers-table) table. Wait event consumers are disabled by default.

mysql> **UPDATE performance\_schema.setup\_consumers**

**SET enabled = 'YES'**

**WHERE name like 'events\_waits%';**

Query OK, 3 rows affected (0.00 sec)

Rows matched: 3 Changed: 3 Warnings: 0

You can verify that wait event consumers are enabled by querying the [**setup\_consumers**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html#performance-schema-setup-consumers-table) table. The [**events\_waits\_current**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html#performance-schema-events-waits-current-table), [**events\_waits\_history**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html#performance-schema-events-waits-history-table), and [**events\_waits\_history\_long**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html#performance-schema-events-waits-history-long-table) consumers should be enabled.

mysql> **SELECT \* FROM performance\_schema.setup\_consumers;**

+----------------------------------+---------+

| NAME | ENABLED |

+----------------------------------+---------+

| events\_stages\_current | NO |

| events\_stages\_history | NO |

| events\_stages\_history\_long | NO |

| events\_statements\_current | YES |

| events\_statements\_history | YES |

| events\_statements\_history\_long | NO |

| events\_transactions\_current | YES |

| events\_transactions\_history | YES |

| events\_transactions\_history\_long | NO |

| events\_waits\_current | YES |

| events\_waits\_history | YES |

| events\_waits\_history\_long | YES |

| global\_instrumentation | YES |

| thread\_instrumentation | YES |

| statements\_digest | YES |

+----------------------------------+---------+

15 rows in set (0.00 sec)

Once instruments and consumers are enabled, run the workload that you want to monitor. In this example, the [**mysqlslap**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\programs.html#mysqlslap) load emulation client is used to simulate a workload.

shell> **./mysqlslap --auto-generate-sql --concurrency=100 --iterations=10**

**--number-of-queries=1000 --number-char-cols=6 --number-int-cols=6;**

Query the wait event data. In this example, wait event data is queried from the [**events\_waits\_summary\_global\_by\_event\_name**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html#performance-schema-wait-summary-tables) table which aggregates data found in the [**events\_waits\_current**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html#performance-schema-events-waits-current-table), [**events\_waits\_history**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html#performance-schema-events-waits-history-table), and [**events\_waits\_history\_long**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html#performance-schema-events-waits-history-long-table) tables. Data is summarized by event name (**EVENT\_NAME**), which is the name of the instrument that produced the event. Summarized data includes:

**COUNT\_STAR**

The number of summarized wait events.

**SUM\_TIMER\_WAIT**

The total wait time of the summarized timed wait events.

**MIN\_TIMER\_WAIT**

The minimum wait time of the summarized timed wait events.

**AVG\_TIMER\_WAIT**

The average wait time of the summarized timed wait events.

**MAX\_TIMER\_WAIT**

The maximum wait time of the summarized timed wait events.

The following query returns the instrument name (**EVENT\_NAME**), the number of wait events (**COUNT\_STAR**), and the total wait time for the events for that instrument (**SUM\_TIMER\_WAIT**). Because waits are timed in picoseconds (trillionths of a second) by default, wait times are divided by 1000000000 to show wait times in milliseconds. Data is presented in descending order, by the number of summarized wait events (**COUNT\_STAR**). You can adjust the **ORDER BY** clause to order the data by total wait time.

mysql> **SELECT EVENT\_NAME, COUNT\_STAR, SUM\_TIMER\_WAIT/1000000000 SUM\_TIMER\_WAIT\_MS**

**FROM performance\_schema.events\_waits\_summary\_global\_by\_event\_name**

**WHERE SUM\_TIMER\_WAIT > 0 AND EVENT\_NAME LIKE 'wait/synch/mutex/innodb/%'**

**ORDER BY COUNT\_STAR DESC;**

+---------------------------------------------------------+------------+-------------------+

| EVENT\_NAME | COUNT\_STAR | SUM\_TIMER\_WAIT\_MS |

+---------------------------------------------------------+------------+-------------------+

| wait/synch/mutex/innodb/trx\_mutex | 201111 | 23.4719 |

| wait/synch/mutex/innodb/fil\_system\_mutex | 62244 | 9.6426 |

| wait/synch/mutex/innodb/redo\_rseg\_mutex | 48238 | 3.1135 |

| wait/synch/mutex/innodb/log\_sys\_mutex | 46113 | 2.0434 |

| wait/synch/mutex/innodb/trx\_sys\_mutex | 35134 | 1068.1588 |

| wait/synch/mutex/innodb/lock\_mutex | 34872 | 1039.2589 |

| wait/synch/mutex/innodb/log\_sys\_write\_mutex | 17805 | 1526.0490 |

| wait/synch/mutex/innodb/dict\_sys\_mutex | 14912 | 1606.7348 |

| wait/synch/mutex/innodb/trx\_undo\_mutex | 10634 | 1.1424 |

| wait/synch/mutex/innodb/rw\_lock\_list\_mutex | 8538 | 0.1960 |

| wait/synch/mutex/innodb/buf\_pool\_free\_list\_mutex | 5961 | 0.6473 |

| wait/synch/mutex/innodb/trx\_pool\_mutex | 4885 | 8821.7496 |

| wait/synch/mutex/innodb/buf\_pool\_LRU\_list\_mutex | 4364 | 0.2077 |

| wait/synch/mutex/innodb/innobase\_share\_mutex | 3212 | 0.2650 |

| wait/synch/mutex/innodb/flush\_list\_mutex | 3178 | 0.2349 |

| wait/synch/mutex/innodb/trx\_pool\_manager\_mutex | 2495 | 0.1310 |

| wait/synch/mutex/innodb/buf\_pool\_flush\_state\_mutex | 1318 | 0.2161 |

| wait/synch/mutex/innodb/log\_flush\_order\_mutex | 1250 | 0.0893 |

| wait/synch/mutex/innodb/buf\_dblwr\_mutex | 951 | 0.0918 |

| wait/synch/mutex/innodb/recalc\_pool\_mutex | 670 | 0.0942 |

| wait/synch/mutex/innodb/dict\_persist\_dirty\_tables\_mutex | 345 | 0.0414 |

| wait/synch/mutex/innodb/lock\_wait\_mutex | 303 | 0.1565 |

| wait/synch/mutex/innodb/autoinc\_mutex | 196 | 0.0213 |

| wait/synch/mutex/innodb/autoinc\_persisted\_mutex | 196 | 0.0175 |

| wait/synch/mutex/innodb/purge\_sys\_pq\_mutex | 117 | 0.0308 |

| wait/synch/mutex/innodb/srv\_sys\_mutex | 94 | 0.0077 |

| wait/synch/mutex/innodb/ibuf\_mutex | 22 | 0.0086 |

| wait/synch/mutex/innodb/recv\_sys\_mutex | 12 | 0.0008 |

| wait/synch/mutex/innodb/srv\_innodb\_monitor\_mutex | 4 | 0.0009 |

| wait/synch/mutex/innodb/recv\_writer\_mutex | 1 | 0.0005 |

+---------------------------------------------------------+------------+-------------------+

**Note**

The preceding result set includes wait event data produced during the startup process. To exclude this data, you can truncate the [**events\_waits\_summary\_global\_by\_event\_name**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\performance-schema.html#performance-schema-wait-summary-tables) table immediately after startup and before running your workload. However, the truncate operation itself may produce a negligible amount wait event data.

mysql> **TRUNCATE performance\_schema.events\_waits\_summary\_global\_by\_event\_name;**

## 15.17 InnoDB Monitors

[15.17.1 InnoDB Monitor Types](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-monitor-types)

[15.17.2 Enabling InnoDB Monitors](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-enabling-monitors)

[15.17.3 InnoDB Standard Monitor and Lock Monitor Output](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-standard-monitor)

**InnoDB** monitors provide information about the **InnoDB** internal state. This information is useful for performance tuning.

### 15.17.1 InnoDB Monitor Types

There are two types of **InnoDB** monitor:

The standard **InnoDB** Monitor displays the following types of information:

Work done by the main background thread

Semaphore waits

Data about the most recent foreign key and deadlock errors

Lock waits for transactions

Table and record locks held by active transactions

Pending I/O operations and related statistics

Insert buffer and adaptive hash index statistics

Redo log data

Buffer pool statistics

Row operation data

The **InnoDB** Lock Monitor prints additional lock information as part of the standard **InnoDB** Monitor output.

### 15.17.2 Enabling InnoDB Monitors

When **InnoDB** monitors are enabled for periodic output, **InnoDB** writes the output to [**mysqld**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\programs.html#mysqld) server standard error output (**stderr**) every 15 seconds, approximately.

**InnoDB** sends the monitor output to **stderr** rather than to **stdout** or fixed-size memory buffers to avoid potential buffer overflows.

On Windows, **stderr** is directed to the default log file unless configured otherwise. If you want to direct the output to the console window rather than to the error log, start the server from a command prompt in a console window with the [--console](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#option_mysqld_console) option. For more information, see [Default Error Log Destination on Windows](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#error-log-destination-configuration-windows).

On Unix and Unix-like systems, **stderr** is typically directed to the terminal unless configured otherwise. For more information, see [Default Error Log Destination on Unix and Unix-Like Systems](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#error-log-destination-configuration-unix).

**InnoDB** monitors should only be enabled when you actually want to see monitor information because output generation causes some performance decrement. Also, if monitor output is directed to the error log, the log may become quite large if you forget to disable the monitor later.

**Note**

To assist with troubleshooting, **InnoDB** temporarily enables standard **InnoDB** Monitor output under certain conditions. For more information, see [Section 15.21, “InnoDB Troubleshooting”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-troubleshooting).

**InnoDB** monitor output begins with a header containing a timestamp and the monitor name. For example:

=====================================

2014-10-16 18:37:29 0x7fc2a95c1700 INNODB MONITOR OUTPUT

=====================================

The header for the standard **InnoDB** Monitor (**INNODB MONITOR OUTPUT**) is also used for the Lock Monitor because the latter produces the same output with the addition of extra lock information.

The [**innodb\_status\_output**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_status_output) and [**innodb\_status\_output\_locks**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_status_output_locks) system variables are used to enable the standard **InnoDB** Monitor and **InnoDB** Lock Monitor.

The [**PROCESS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\security.html#priv_process) privilege is required to enable or disable **InnoDB** Monitors.

#### Enabling the Standard InnoDB Monitor

Enable the standard **InnoDB** Monitor by setting the [**innodb\_status\_output**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_status_output) system variable to **ON**.

SET GLOBAL innodb\_status\_output=ON;

To disable the standard **InnoDB** Monitor, set [**innodb\_status\_output**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_status_output) to **OFF**.

When you shut down the server, the [**innodb\_status\_output**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_status_output) variable is set to the default **OFF** value.

#### Enabling the InnoDB Lock Monitor

**InnoDB** Lock Monitor data is printed with the **InnoDB** Standard Monitor output. Both the **InnoDB** Standard Monitor and **InnoDB** Lock Monitor must be enabled to have **InnoDB** Lock Monitor data printed periodically.

To enable the **InnoDB** Lock Monitor, set the [**innodb\_status\_output\_locks**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_status_output_locks) system variable to **ON**. Both the **InnoDB** standard Monitor and **InnoDB** Lock Monitor must be enabled to have **InnoDB** Lock Monitor data printed periodically:

SET GLOBAL innodb\_status\_output=ON;

SET GLOBAL innodb\_status\_output\_locks=ON;

To disable the **InnoDB** Lock Monitor, set [**innodb\_status\_output\_locks**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_status_output_locks) to **OFF**. Set [**innodb\_status\_output**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_status_output) to **OFF** to also disable the **InnoDB** Standard Monitor.

When you shut down the server, the [**innodb\_status\_output**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_status_output) and [**innodb\_status\_output\_locks**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_status_output_locks) variables are set to the default **OFF** value.

**Note**

To enable the **InnoDB** Lock Monitor for [**SHOW ENGINE INNODB STATUS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#show-engine) output, you are only required to enable [**innodb\_status\_output\_locks**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_status_output_locks).

#### Obtaining Standard InnoDB Monitor Output On Demand

As an alternative to enabling the standard **InnoDB** Monitor for periodic output, you can obtain standard **InnoDB** Monitor output on demand using the [**SHOW ENGINE INNODB STATUS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#show-engine) SQL statement, which fetches the output to your client program. If you are using the [**mysql**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\programs.html#mysql) interactive client, the output is more readable if you replace the usual semicolon statement terminator with **\G**:

mysql> **SHOW ENGINE INNODB STATUS\G**

[**SHOW ENGINE INNODB STATUS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#show-engine) output also includes **InnoDB** Lock Monitor data if the **InnoDB** Lock Monitor is enabled.

#### Directing Standard InnoDB Monitor Output to a Status File

Standard **InnoDB** Monitor output can be enabled and directed to a status file by specifying the --innodb-status-file option at startup. When this option is used, **InnoDB** creates a file named innodb\_status.***pid*** in the data directory and writes output to it every 15 seconds, approximately.

**InnoDB** removes the status file when the server is shut down normally. If an abnormal shutdown occurs, the status file may have to be removed manually.

The --innodb-status-file option is intended for temporary use, as output generation can affect performance, and the innodb\_status.***pid*** file can become quite large over time.

### 15.17.3 InnoDB Standard Monitor and Lock Monitor Output

The Lock Monitor is the same as the Standard Monitor except that it includes additional lock information. Enabling either monitor for periodic output turns on the same output stream, but the stream includes extra information if the Lock Monitor is enabled. For example, if you enable the Standard Monitor and Lock Monitor, that turns on a single output stream. The stream includes extra lock information until you disable the Lock Monitor.

Standard Monitor output is limited to 1MB when produced using the [**SHOW ENGINE INNODB STATUS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#show-engine) statement. This limit does not apply to output written to server standard error output (**stderr**).

Example Standard Monitor output:

mysql> **SHOW ENGINE INNODB STATUS\G**

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\* 1. row \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

Type: InnoDB

Name:

Status:

=====================================

2018-04-12 15:14:08 0x7f971c063700 INNODB MONITOR OUTPUT

=====================================

Per second averages calculated from the last 4 seconds

-----------------

BACKGROUND THREAD

-----------------

srv\_master\_thread loops: 15 srv\_active, 0 srv\_shutdown, 1122 srv\_idle

srv\_master\_thread log flush and writes: 0

----------

SEMAPHORES

----------

OS WAIT ARRAY INFO: reservation count 24

OS WAIT ARRAY INFO: signal count 24

RW-shared spins 4, rounds 8, OS waits 4

RW-excl spins 2, rounds 60, OS waits 2

RW-sx spins 0, rounds 0, OS waits 0

Spin rounds per wait: 2.00 RW-shared, 30.00 RW-excl, 0.00 RW-sx

------------------------

LATEST FOREIGN KEY ERROR

------------------------

2018-04-12 14:57:24 0x7f97a9c91700 Transaction:

TRANSACTION 7717, ACTIVE 0 sec inserting

mysql tables in use 1, locked 1

4 lock struct(s), heap size 1136, 3 row lock(s), undo log entries 3

MySQL thread id 8, OS thread handle 140289365317376, query id 14 localhost root update

INSERT INTO child VALUES (NULL, 1), (NULL, 2), (NULL, 3), (NULL, 4), (NULL, 5), (NULL, 6)

Foreign key constraint fails for table `test`.`child`:

,

CONSTRAINT `child\_ibfk\_1` FOREIGN KEY (`parent\_id`) REFERENCES `parent` (`id`) ON DELETE

CASCADE ON UPDATE CASCADE

Trying to add in child table, in index par\_ind tuple:

DATA TUPLE: 2 fields;

0: len 4; hex 80000003; asc ;;

1: len 4; hex 80000003; asc ;;

But in parent table `test`.`parent`, in index PRIMARY,

the closest match we can find is record:

PHYSICAL RECORD: n\_fields 3; compact format; info bits 0

0: len 4; hex 80000004; asc ;;

1: len 6; hex 000000001e19; asc ;;

2: len 7; hex 81000001110137; asc 7;;

------------

TRANSACTIONS

------------

Trx id counter 7748

Purge done for trx's n:o < 7747 undo n:o < 0 state: running but idle

History list length 19

LIST OF TRANSACTIONS FOR EACH SESSION:

---TRANSACTION 421764459790000, not started

0 lock struct(s), heap size 1136, 0 row lock(s)

---TRANSACTION 7747, ACTIVE 23 sec starting index read

mysql tables in use 1, locked 1

LOCK WAIT 2 lock struct(s), heap size 1136, 1 row lock(s)

MySQL thread id 9, OS thread handle 140286987249408, query id 51 localhost root updating

DELETE FROM t WHERE i = 1

------- TRX HAS BEEN WAITING 23 SEC FOR THIS LOCK TO BE GRANTED:

RECORD LOCKS space id 4 page no 4 n bits 72 index GEN\_CLUST\_INDEX of table `test`.`t`

trx id 7747 lock\_mode X waiting

Record lock, heap no 3 PHYSICAL RECORD: n\_fields 4; compact format; info bits 0

0: len 6; hex 000000000202; asc ;;

1: len 6; hex 000000001e41; asc A;;

2: len 7; hex 820000008b0110; asc ;;

3: len 4; hex 80000001; asc ;;

------------------

TABLE LOCK table `test`.`t` trx id 7747 lock mode IX

RECORD LOCKS space id 4 page no 4 n bits 72 index GEN\_CLUST\_INDEX of table `test`.`t`

trx id 7747 lock\_mode X waiting

Record lock, heap no 3 PHYSICAL RECORD: n\_fields 4; compact format; info bits 0

0: len 6; hex 000000000202; asc ;;

1: len 6; hex 000000001e41; asc A;;

2: len 7; hex 820000008b0110; asc ;;

3: len 4; hex 80000001; asc ;;

--------

FILE I/O

--------

I/O thread 0 state: waiting for i/o request (insert buffer thread)

I/O thread 1 state: waiting for i/o request (log thread)

I/O thread 2 state: waiting for i/o request (read thread)

I/O thread 3 state: waiting for i/o request (read thread)

I/O thread 4 state: waiting for i/o request (read thread)

I/O thread 5 state: waiting for i/o request (read thread)

I/O thread 6 state: waiting for i/o request (write thread)

I/O thread 7 state: waiting for i/o request (write thread)

I/O thread 8 state: waiting for i/o request (write thread)

I/O thread 9 state: waiting for i/o request (write thread)

Pending normal aio reads: [0, 0, 0, 0] , aio writes: [0, 0, 0, 0] ,

ibuf aio reads:, log i/o's:, sync i/o's:

Pending flushes (fsync) log: 0; buffer pool: 0

833 OS file reads, 605 OS file writes, 208 OS fsyncs

0.00 reads/s, 0 avg bytes/read, 0.00 writes/s, 0.00 fsyncs/s

-------------------------------------

INSERT BUFFER AND ADAPTIVE HASH INDEX

-------------------------------------

Ibuf: size 1, free list len 0, seg size 2, 0 merges

merged operations:

insert 0, delete mark 0, delete 0

discarded operations:

insert 0, delete mark 0, delete 0

Hash table size 553253, node heap has 0 buffer(s)

Hash table size 553253, node heap has 1 buffer(s)

Hash table size 553253, node heap has 3 buffer(s)

Hash table size 553253, node heap has 0 buffer(s)

Hash table size 553253, node heap has 0 buffer(s)

Hash table size 553253, node heap has 0 buffer(s)

Hash table size 553253, node heap has 0 buffer(s)

Hash table size 553253, node heap has 0 buffer(s)

0.00 hash searches/s, 0.00 non-hash searches/s

---

LOG

---

Log sequence number 19643450

Log buffer assigned up to 19643450

Log buffer completed up to 19643450

Log written up to 19643450

Log flushed up to 19643450

Added dirty pages up to 19643450

Pages flushed up to 19643450

Last checkpoint at 19643450

129 log i/o's done, 0.00 log i/o's/second

----------------------

BUFFER POOL AND MEMORY

----------------------

Total large memory allocated 2198863872

Dictionary memory allocated 409606

Buffer pool size 131072

Free buffers 130095

Database pages 973

Old database pages 0

Modified db pages 0

Pending reads 0

Pending writes: LRU 0, flush list 0, single page 0

Pages made young 0, not young 0

0.00 youngs/s, 0.00 non-youngs/s

Pages read 810, created 163, written 404

0.00 reads/s, 0.00 creates/s, 0.00 writes/s

Buffer pool hit rate 1000 / 1000, young-making rate 0 / 1000 not 0 / 1000

Pages read ahead 0.00/s, evicted without access 0.00/s, Random read ahead 0.00/s

LRU len: 973, unzip\_LRU len: 0

I/O sum[0]:cur[0], unzip sum[0]:cur[0]

----------------------

INDIVIDUAL BUFFER POOL INFO

----------------------

---BUFFER POOL 0

Buffer pool size 65536

Free buffers 65043

Database pages 491

Old database pages 0

Modified db pages 0

Pending reads 0

Pending writes: LRU 0, flush list 0, single page 0

Pages made young 0, not young 0

0.00 youngs/s, 0.00 non-youngs/s

Pages read 411, created 80, written 210

0.00 reads/s, 0.00 creates/s, 0.00 writes/s

Buffer pool hit rate 1000 / 1000, young-making rate 0 / 1000 not 0 / 1000

Pages read ahead 0.00/s, evicted without access 0.00/s, Random read ahead 0.00/s

LRU len: 491, unzip\_LRU len: 0

I/O sum[0]:cur[0], unzip sum[0]:cur[0]

---BUFFER POOL 1

Buffer pool size 65536

Free buffers 65052

Database pages 482

Old database pages 0

Modified db pages 0

Pending reads 0

Pending writes: LRU 0, flush list 0, single page 0

Pages made young 0, not young 0

0.00 youngs/s, 0.00 non-youngs/s

Pages read 399, created 83, written 194

0.00 reads/s, 0.00 creates/s, 0.00 writes/s

No buffer pool page gets since the last printout

Pages read ahead 0.00/s, evicted without access 0.00/s, Random read ahead 0.00/s

LRU len: 482, unzip\_LRU len: 0

I/O sum[0]:cur[0], unzip sum[0]:cur[0]

--------------

ROW OPERATIONS

--------------

0 queries inside InnoDB, 0 queries in queue

0 read views open inside InnoDB

Process ID=5772, Main thread ID=140286437054208 , state=sleeping

Number of rows inserted 57, updated 354, deleted 4, read 4421

0.00 inserts/s, 0.00 updates/s, 0.00 deletes/s, 0.00 reads/s

----------------------------

END OF INNODB MONITOR OUTPUT

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#### Standard Monitor Output Sections

For a description of each metric reported by the Standard Monitor, refer to the [Metrics](http://dev.mysql.com/doc/mysql-em-plugin/en/myoem-metrics.html) chapter in the [Oracle Enterprise Manager for MySQL Database User's Guide](http://dev.mysql.com/doc/mysql-em-plugin/en/).

**Status**

This section shows the timestamp, the monitor name, and the number of seconds that per-second averages are based on. The number of seconds is the elapsed time between the current time and the last time **InnoDB** Monitor output was printed.

**BACKGROUND THREAD**

The **srv\_master\_thread** lines shows work done by the main background thread.

**SEMAPHORES**

This section reports threads waiting for a semaphore and statistics on how many times threads have needed a spin or a wait on a mutex or a rw-lock semaphore. A large number of threads waiting for semaphores may be a result of disk I/O, or contention problems inside **InnoDB**. Contention can be due to heavy parallelism of queries or problems in operating system thread scheduling. Setting the [**innodb\_thread\_concurrency**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_thread_concurrency) system variable smaller than the default value might help in such situations. The **Spin rounds per wait** line shows the number of spinlock rounds per OS wait for a mutex.

Mutex metrics are reported by [**SHOW ENGINE INNODB MUTEX**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#show-engine).

**LATEST FOREIGN KEY ERROR**

This section provides information about the most recent foreign key constraint error. It is not present if no such error has occurred. The contents include the statement that failed as well as information about the constraint that failed and the referenced and referencing tables.

**LATEST DETECTED DEADLOCK**

This section provides information about the most recent deadlock. It is not present if no deadlock has occurred. The contents show which transactions are involved, the statement each was attempting to execute, the locks they have and need, and which transaction **InnoDB** decided to roll back to break the deadlock. The lock modes reported in this section are explained in [Section 15.7.1, “InnoDB Locking”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-locking).

**TRANSACTIONS**

If this section reports lock waits, your applications might have lock contention. The output can also help to trace the reasons for transaction deadlocks.

**FILE I/O**

This section provides information about threads that **InnoDB** uses to perform various types of I/O. The first few of these are dedicated to general **InnoDB** processing. The contents also display information for pending I/O operations and statistics for I/O performance.

The number of these threads are controlled by the [**innodb\_read\_io\_threads**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_read_io_threads) and [**innodb\_write\_io\_threads**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_write_io_threads) parameters. See [Section 15.14, “InnoDB Startup Options and System Variables”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-parameters).

**INSERT BUFFER AND ADAPTIVE HASH INDEX**

This section shows the status of the **InnoDB** insert buffer (also referred to as the [change buffer](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_change_buffer)) and the adaptive hash index.

For related information, see [Section 15.5.2, “Change Buffer”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-change-buffer), and [Section 15.5.3, “Adaptive Hash Index”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-adaptive-hash).

**LOG**

This section displays information about the **InnoDB** log. The contents include the current log sequence number, how far the log has been flushed to disk, and the position at which **InnoDB** last took a checkpoint. (See [Section 15.11.3, “InnoDB Checkpoints”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-checkpoints).) The section also displays information about pending writes and write performance statistics.

**BUFFER POOL AND MEMORY**

This section gives you statistics on pages read and written. You can calculate from these numbers how many data file I/O operations your queries currently are doing.

For buffer pool statistics descriptions, see [Monitoring the Buffer Pool Using the InnoDB Standard Monitor](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-buffer-pool-monitoring). For additional information about the operation of the buffer pool, see [Section 15.5.1, “Buffer Pool”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-buffer-pool).

**ROW OPERATIONS**

This section shows what the main thread is doing, including the number and performance rate for each type of row operation.

## 15.18 InnoDB Backup and Recovery

[15.18.1 InnoDB Backup](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-backup)

[15.18.2 InnoDB Recovery](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-recovery)

This section covers topics related to **InnoDB** backup and recovery.

For information about backup techniques applicable to **InnoDB**, see [Section 15.18.1, “InnoDB Backup”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-backup).

For information about point-in-time recovery, recovery from disk failure or corruption, and how **InnoDB** performs crash recovery, see [Section 15.18.2, “InnoDB Recovery”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-recovery).

### 15.18.1 InnoDB Backup

The key to safe database management is making regular backups. Depending on your data volume, number of MySQL servers, and database workload, you can use these backup techniques, alone or in combination: [hot backup](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_hot_backup) with MySQL Enterprise Backup; [cold backup](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_cold_backup) by copying files while the MySQL server is shut down; [logical backup](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_logical_backup) with [**mysqldump**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\programs.html#mysqldump) for smaller data volumes or to record the structure of schema objects. Hot and cold backups are [physical backups](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_physical_backup) that copy actual data files, which can be used directly by the [**mysqld**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\programs.html#mysqld) server for faster restore.

Using MySQL Enterprise Backup is the recommended method for backing up **InnoDB** data.

**Note**

**InnoDB** does not support databases that are restored using third-party backup tools.

#### Hot Backups

The **mysqlbackup** command, part of the MySQL Enterprise Backup component, lets you back up a running MySQL instance, including **InnoDB** tables, with minimal disruption to operations while producing a consistent snapshot of the database. When **mysqlbackup** is copying **InnoDB** tables, reads and writes to **InnoDB** tables can continue. MySQL Enterprise Backup can also create compressed backup files, and back up subsets of tables and databases. In conjunction with the MySQL binary log, users can perform point-in-time recovery. MySQL Enterprise Backup is part of the MySQL Enterprise subscription. For more details, see [Section 30.2, “MySQL Enterprise Backup Overview”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\mysql-enterprise.html#mysql-enterprise-backup).

#### Cold Backups

If you can shut down the MySQL server, you can make a physical backup that consists of all files used by **InnoDB** to manage its tables. Use the following procedure:

Perform a [slow shutdown](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_slow_shutdown) of the MySQL server and make sure that it stops without errors.

Copy all **InnoDB** data files (ibdata files and .ibd files) into a safe place.

Copy all **InnoDB** log files (ib\_logfile files) to a safe place.

Copy your my.cnf configuration file or files to a safe place.

#### Logical Backups Using mysqldump

In addition to physical backups, it is recommended that you regularly create logical backups by dumping your tables using [**mysqldump**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\programs.html#mysqldump). A binary file might be corrupted without you noticing it. Dumped tables are stored into text files that are human-readable, so spotting table corruption becomes easier. Also, because the format is simpler, the chance for serious data corruption is smaller. [**mysqldump**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\programs.html#mysqldump) also has a [--single-transaction](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\programs.html#option_mysqldump_single-transaction) option for making a consistent snapshot without locking out other clients. See [Section 7.3.1, “Establishing a Backup Policy”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\backup-and-recovery.html#backup-policy).

Replication works with [**InnoDB**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html) tables, so you can use MySQL replication capabilities to keep a copy of your database at database sites requiring high availability. See [Section 15.19, “InnoDB and MySQL Replication”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-and-mysql-replication).

### 15.18.2 InnoDB Recovery

This section describes **InnoDB** recovery. Topics include:

[Point-in-Time Recovery](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-recovery-point-in-time)

[Recovery from Data Corruption or Disk Failure](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-corruption-disk-failure-recovery)

[InnoDB Crash Recovery](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-crash-recovery)

[Tablespace Discovery During Crash Recovery](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-recovery-tablespace-discovery)

#### Point-in-Time Recovery

To recover an **InnoDB** database to the present from the time at which the physical backup was made, you must run MySQL server with binary logging enabled, even before taking the backup. To achieve point-in-time recovery after restoring a backup, you can apply changes from the binary log that occurred after the backup was made. See [Section 7.5, “Point-in-Time (Incremental) Recovery”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\backup-and-recovery.html#point-in-time-recovery).

#### Recovery from Data Corruption or Disk Failure

If your database becomes corrupted or disk failure occurs, you must perform the recovery using a backup. In the case of corruption, first find a backup that is not corrupted. After restoring the base backup, do a point-in-time recovery from the binary log files using [**mysqlbinlog**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\programs.html#mysqlbinlog) and [**mysql**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\programs.html#mysql) to restore the changes that occurred after the backup was made.

In some cases of database corruption, it is enough to dump, drop, and re-create one or a few corrupt tables. You can use the [**CHECK TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#check-table) statement to check whether a table is corrupt, although [**CHECK TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#check-table) naturally cannot detect every possible kind of corruption.

In some cases, apparent database page corruption is actually due to the operating system corrupting its own file cache, and the data on disk may be okay. It is best to try restarting the computer first. Doing so may eliminate errors that appeared to be database page corruption. If MySQL still has trouble starting because of **InnoDB** consistency problems, see [Section 15.21.2, “Forcing InnoDB Recovery”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#forcing-innodb-recovery) for steps to start the instance in recovery mode, which permits you to dump the data.

#### InnoDB Crash Recovery

To recover from an unexpected MySQL server exit, the only requirement is to restart the MySQL server. **InnoDB** automatically checks the logs and performs a roll-forward of the database to the present. **InnoDB** automatically rolls back uncommitted transactions that were present at the time of the crash. During recovery, [**mysqld**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\programs.html#mysqld) displays output similar to this:

InnoDB: The log sequence number 664050266 in the system tablespace does not match

the log sequence number 685111586 in the ib\_logfiles!

InnoDB: Database was not shutdown normally!

InnoDB: Starting crash recovery.

InnoDB: Using 'tablespaces.open.2' max LSN: 664075228

InnoDB: Doing recovery: scanned up to log sequence number 690354176

InnoDB: Doing recovery: scanned up to log sequence number 695597056

InnoDB: Doing recovery: scanned up to log sequence number 700839936

InnoDB: Doing recovery: scanned up to log sequence number 706082816

InnoDB: Doing recovery: scanned up to log sequence number 711325696

InnoDB: Doing recovery: scanned up to log sequence number 713458156

InnoDB: Applying a batch of 1467 redo log records ...

InnoDB: 10%

InnoDB: 20%

InnoDB: 30%

InnoDB: 40%

InnoDB: 50%

InnoDB: 60%

InnoDB: 70%

InnoDB: 80%

InnoDB: 90%

InnoDB: 100%

InnoDB: Apply batch completed!

InnoDB: 1 transaction(s) which must be rolled back or cleaned up in total 561887 row

operations to undo

InnoDB: Trx id counter is 4096

...

InnoDB: 8.0.1 started; log sequence number 713458156

InnoDB: Waiting for purge to start

InnoDB: Starting in background the rollback of uncommitted transactions

InnoDB: Rolling back trx with id 3596, 561887 rows to undo

...

./mysqld: ready for connections....

**InnoDB** [crash recovery](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_crash_recovery) consists of several steps:

Tablespace discovery

Tablespace discovery is the process that **InnoDB** uses to identify tablespaces that require redo log application. See [Tablespace Discovery During Crash Recovery](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-recovery-tablespace-discovery).

[Redo log](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_redo_log) application

Redo log application is performed during initialization, before accepting any connections. If all changes are flushed from the [buffer pool](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_buffer_pool) to the [tablespaces](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_tablespace) (ibdata\* and \*.ibd files) at the time of the shutdown or crash, redo log application is skipped. **InnoDB** also skips redo log application if redo log files are missing at startup.

The current maximum auto-increment counter value is written to the redo log each time the value changes, which makes it crash-safe. During recovery, **InnoDB** scans the redo log to collect counter value changes and applies the changes to the in-memory table object.

For more information about how **InnoDB** handles auto-increment values, see [Section 15.6.1.6, “AUTO\_INCREMENT Handling in InnoDB”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-auto-increment-handling), and [InnoDB AUTO\_INCREMENT Counter Initialization](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-auto-increment-initialization).

When encountering index tree corruption, **InnoDB** writes a corruption flag to the redo log, which makes the corruption flag crash-safe. **InnoDB** also writes in-memory corruption flag data to an engine-private system table on each checkpoint. During recovery, **InnoDB** reads corruption flags from both locations and merges results before marking in-memory table and index objects as corrupt.

Removing redo logs to speed up recovery is not recommended, even if some data loss is acceptable. Removing redo logs should only be considered after a clean shutdown, with [**innodb\_fast\_shutdown**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_fast_shutdown) set to **0** or **1**.

[Roll back](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_rollback) of incomplete [transactions](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_transaction)

Incomplete transactions are any transactions that were active at the time of unexpected exit or [fast shutdown](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_fast_shutdown). The time it takes to roll back an incomplete transaction can be three or four times the amount of time a transaction is active before it is interrupted, depending on server load.

You cannot cancel transactions that are being rolled back. In extreme cases, when rolling back transactions is expected to take an exceptionally long time, it may be faster to start **InnoDB** with an [**innodb\_force\_recovery**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_force_recovery) setting of **3** or greater. See [Section 15.21.2, “Forcing InnoDB Recovery”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#forcing-innodb-recovery).

[Change buffer](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_change_buffer) merge

Applying changes from the change buffer (part of the [system tablespace](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_system_tablespace)) to leaf pages of secondary indexes, as the index pages are read to the buffer pool.

[Purge](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_purge)

Deleting delete-marked records that are no longer visible to active transactions.

The steps that follow redo log application do not depend on the redo log (other than for logging the writes) and are performed in parallel with normal processing. Of these, only rollback of incomplete transactions is special to crash recovery. The insert buffer merge and the purge are performed during normal processing.

After redo log application, **InnoDB** attempts to accept connections as early as possible, to reduce downtime. As part of crash recovery, **InnoDB** rolls back transactions that were not committed or in **XA PREPARE** state when the server exited. The rollback is performed by a background thread, executed in parallel with transactions from new connections. Until the rollback operation is completed, new connections may encounter locking conflicts with recovered transactions.

In most situations, even if the MySQL server was killed unexpectedly in the middle of heavy activity, the recovery process happens automatically and no action is required of the DBA. If a hardware failure or severe system error corrupted **InnoDB** data, MySQL might refuse to start. In this case, see [Section 15.21.2, “Forcing InnoDB Recovery”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#forcing-innodb-recovery).

For information about the binary log and **InnoDB** crash recovery, see [Section 5.4.4, “The Binary Log”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#binary-log).

#### Tablespace Discovery During Crash Recovery

If, during recovery, **InnoDB** encounters redo logs written since the last checkpoint, the redo logs must be applied to affected tablespaces. The process that identifies affected tablespaces during recovery is referred to as tablespace discovery.

Tablespace discovery relies on the [**innodb\_directories**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_directories) setting, which defines the directories to scan at startup for tablespace files. The [**innodb\_directories**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_directories) default setting is NULL, but the directories defined by [**innodb\_data\_home\_dir**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_data_home_dir), [**innodb\_undo\_directory**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_undo_directory), and [**datadir**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_datadir) are always appended to the [**innodb\_directories**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_directories) argument value when InnoDb builds a list of directories to scan at startup. These directories are appended regardless of whether an [**innodb\_directories**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_directories) setting is specified explicitly. Tablespace files defined with an absolute path or that reside outside of the directories appended to the [**innodb\_directories**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_directories) setting should be added to the [**innodb\_directories**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_directories) setting. Recovery is terminated if any tablespace file referenced in a redo log has not been discovered previously.

## 15.19 InnoDB and MySQL Replication

It is possible to use replication in a way where the storage engine on the replica is not the same as the storage engine on the source. For example, you can replicate modifications to an **InnoDB** table on the source to a **MyISAM** table on the replica. For more information see, [Section 17.4.4, “Using Replication with Different Source and Replica Storage Engines”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\replication.html#replication-solutions-diffengines).

For information about setting up a replica, see [Section 17.1.2.6, “Setting Up Replicas”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\replication.html#replication-setup-replicas), and [Section 17.1.2.5, “Choosing a Method for Data Snapshots”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\replication.html#replication-snapshot-method). To make a new replica without taking down the source or an existing replica, use the [MySQL Enterprise Backup](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\mysql-enterprise.html#mysql-enterprise-backup) product.

Transactions that fail on the source do not affect replication. MySQL replication is based on the binary log where MySQL writes SQL statements that modify data. A transaction that fails (for example, because of a foreign key violation, or because it is rolled back) is not written to the binary log, so it is not sent to replicas. See [Section 13.3.1, “START TRANSACTION, COMMIT, and ROLLBACK Statements”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#commit).

**Replication and CASCADE.** Cascading actions for **InnoDB** tables on the source are replicated on the replica only if the tables sharing the foreign key relation use **InnoDB** on both the source and replica. This is true whether you are using statement-based or row-based replication. Suppose that you have started replication, and then create two tables on the source, where **InnoDB** is defined as the default storage engine, using the following [**CREATE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-table) statements:

CREATE TABLE fc1 (

i INT PRIMARY KEY,

j INT

);

CREATE TABLE fc2 (

m INT PRIMARY KEY,

n INT,

FOREIGN KEY ni (n) REFERENCES fc1 (i)

ON DELETE CASCADE

);

If the replica has **MyISAM** defined as the default storage engine, the same tables are created on the replica, but they use the **MyISAM** storage engine, and the **FOREIGN KEY** option is ignored. Now we insert some rows into the tables on the source:

source> **INSERT INTO fc1 VALUES (1, 1), (2, 2);**

Query OK, 2 rows affected (0.09 sec)

Records: 2 Duplicates: 0 Warnings: 0

source> **INSERT INTO fc2 VALUES (1, 1), (2, 2), (3, 1);**

Query OK, 3 rows affected (0.19 sec)

Records: 3 Duplicates: 0 Warnings: 0

At this point, on both the source and the replica, table **fc1** contains 2 rows, and table **fc2** contains 3 rows, as shown here:

source> **SELECT \* FROM fc1;**

+---+------+

| i | j |

+---+------+

| 1 | 1 |

| 2 | 2 |

+---+------+

2 rows in set (0.00 sec)

source> **SELECT \* FROM fc2;**

+---+------+

| m | n |

+---+------+

| 1 | 1 |

| 2 | 2 |

| 3 | 1 |

+---+------+

3 rows in set (0.00 sec)

replica> **SELECT \* FROM fc1;**

+---+------+

| i | j |

+---+------+

| 1 | 1 |

| 2 | 2 |

+---+------+

2 rows in set (0.00 sec)

replica> **SELECT \* FROM fc2;**

+---+------+

| m | n |

+---+------+

| 1 | 1 |

| 2 | 2 |

| 3 | 1 |

+---+------+

3 rows in set (0.00 sec)

Now suppose that you perform the following [**DELETE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#delete) statement on the source:

source> **DELETE FROM fc1 WHERE i=1;**

Query OK, 1 row affected (0.09 sec)

Due to the cascade, table **fc2** on the source now contains only 1 row:

source> **SELECT \* FROM fc2;**

+---+---+

| m | n |

+---+---+

| 2 | 2 |

+---+---+

1 row in set (0.00 sec)

However, the cascade does not propagate on the replica because on the replica the [**DELETE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#delete) for **fc1** deletes no rows from **fc2**. The replica's copy of **fc2** still contains all of the rows that were originally inserted:

replica> **SELECT \* FROM fc2;**

+---+---+

| m | n |

+---+---+

| 1 | 1 |

| 3 | 1 |

| 2 | 2 |

+---+---+

3 rows in set (0.00 sec)

This difference is due to the fact that the cascading deletes are handled internally by the **InnoDB** storage engine, which means that none of the changes are logged.

## 15.20 InnoDB memcached Plugin

[15.20.1 Benefits of the InnoDB memcached Plugin](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-memcached-benefits)

[15.20.2 InnoDB memcached Architecture](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-memcached-intro)

[15.20.3 Setting Up the InnoDB memcached Plugin](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-memcached-setup)

[15.20.4 InnoDB memcached Multiple get and Range Query Support](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-memcached-multiple-get-range-query)

[15.20.5 Security Considerations for the InnoDB memcached Plugin](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-memcached-security)

[15.20.6 Writing Applications for the InnoDB memcached Plugin](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-memcached-developing)

[15.20.7 The InnoDB memcached Plugin and Replication](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-memcached-replication)

[15.20.8 InnoDB memcached Plugin Internals](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-memcached-internals)

[15.20.9 Troubleshooting the InnoDB memcached Plugin](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-memcached-troubleshoot)

**Note**

The **InnoDB** **memcached** plugin is deprecated as of MySQL 8.0.22; expect support for it to be removed in a future version of MySQL.

The **InnoDB** **memcached** plugin (**daemon\_memcached**) provides an integrated **memcached** daemon that automatically stores and retrieves data from **InnoDB** tables, turning the MySQL server into a fast “key-value store”. Instead of formulating queries in SQL, you can use simple **get**, **set**, and **incr** operations that avoid the performance overhead associated with SQL parsing and constructing a query optimization plan. You can also access the same **InnoDB** tables through SQL for convenience, complex queries, bulk operations, and other strengths of traditional database software.

This “NoSQL-style” interface uses the **memcached** API to speed up database operations, letting **InnoDB** handle memory caching using its [buffer pool](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_buffer_pool) mechanism. Data modified through **memcached** operations such as **add**, **set**, and **incr** are stored to disk, in **InnoDB** tables. The combination of **memcached** simplicity and **InnoDB** reliability and consistency provides users with the best of both worlds, as explained in [Section 15.20.1, “Benefits of the InnoDB memcached Plugin”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-memcached-benefits). For an architectural overview, see [Section 15.20.2, “InnoDB memcached Architecture”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-memcached-intro).

### 15.20.1 Benefits of the InnoDB memcached Plugin

This section outlines advantages the **daemon\_memcached** plugin. The combination of **InnoDB** tables and **memcached** offers advantages over using either by themselves.

Direct access to the **InnoDB** storage engine avoids the parsing and planning overhead of SQL.

Running **memcached** in the same process space as the MySQL server avoids the network overhead of passing requests back and forth.

Data written using the **memcached** protocol is transparently written to an **InnoDB** table, without going through the MySQL SQL layer. You can control frequency of writes to achieve higher raw performance when updating non-critical data.

Data requested through the **memcached** protocol is transparently queried from an **InnoDB** table, without going through the MySQL SQL layer.

Subsequent requests for the same data is served from the **InnoDB** buffer pool. The buffer pool handles the in-memory caching. You can tune performance of data-intensive operations using **InnoDB** configuration options.

Data can be unstructured or structured, depending on the type of application. You can create a new table for data, or use existing tables.

**InnoDB** can handle composing and decomposing multiple column values into a single **memcached** item value, reducing the amount of string parsing and concatenation required in your application. For example, you can store the string value **2|4|6|8** in the **memcached** cache, and have **InnoDB** split the value based on a separator character, then store the result in four numeric columns.

The transfer between memory and disk is handled automatically, simplifying application logic.

Data is stored in a MySQL database to protect against crashes, outages, and corruption.

You can access the underlying **InnoDB** table through SQL for reporting, analysis, ad hoc queries, bulk loading, multi-step transactional computations, set operations such as union and intersection, and other operations suited to the expressiveness and flexibility of SQL.

You can ensure high availability by using the **daemon\_memcached** plugin on a source server in combination with MySQL replication.

The integration of **memcached** with MySQL provides a way to make in-memory data persistent, so you can use it for more significant kinds of data. You can use more **add**, **incr**, and similar write operations in your application without concern that data could be lost. You can stop and start the **memcached** server without losing updates made to cached data. To guard against unexpected outages, you can take advantage of **InnoDB** crash recovery, replication, and backup capabilities.

The way **InnoDB** does fast [primary key](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_primary_key) lookups is a natural fit for **memcached** single-item queries. The direct, low-level database access path used by the **daemon\_memcached** plugin is much more efficient for key-value lookups than equivalent SQL queries.

The serialization features of **memcached**, which can turn complex data structures, binary files, or even code blocks into storeable strings, offer a simple way to get such objects into a database.

Because you can access the underlying data through SQL, you can produce reports, search or update across multiple keys, and call functions such as **AVG()** and **MAX()** on **memcached** data. All of these operations are expensive or complicated using **memcached** by itself.

You do not need to manually load data into **memcached** at startup. As particular keys are requested by an application, values are retrieved from the database automatically, and cached in memory using the **InnoDB** [buffer pool](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_buffer_pool).

Because **memcached** consumes relatively little CPU, and its memory footprint is easy to control, it can run comfortably alongside a MySQL instance on the same system.

Because data consistency is enforced by mechanisms used for regular **InnoDB** tables, you do not have to worry about stale **memcached** data or fallback logic to query the database in the case of a missing key.

### 15.20.2 InnoDB memcached Architecture

The **InnoDB** **memcached** plugin implements **memcached** as a MySQL plugin daemon that accesses the **InnoDB** storage engine directly, bypassing the MySQL SQL layer.

The following diagram illustrates how an application accesses data through the **daemon\_memcached** plugin, compared with SQL.

**Figure 15.4 MySQL Server with Integrated memcached Server**

Features of the **daemon\_memcached** plugin:

**memcached** as a daemon plugin of [**mysqld**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\programs.html#mysqld). Both [**mysqld**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\programs.html#mysqld) and **memcached** run in the same process space, with very low latency access to data.

Direct access to **InnoDB** tables, bypassing the SQL parser, the optimizer, and even the Handler API layer.

Standard **memcached** protocols, including the text-based protocol and the binary protocol. The **daemon\_memcached** plugin passes all 55 compatibility tests of the **memcapable** command.

Multi-column support. You can map multiple columns into the “value” part of the key-value store, with column values delimited by a user-specified separator character.

By default, the **memcached** protocol is used to read and write data directly to **InnoDB**, letting MySQL manage in-memory caching using the **InnoDB** [buffer pool](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_buffer_pool). The default settings represent a combination of high reliability and the fewest surprises for database applications. For example, default settings avoid uncommitted data on the database side, or stale data returned for **memcached** **get** requests.

Advanced users can configure the system as a traditional **memcached** server, with all data cached only in the **memcached** engine (memory caching), or use a combination of the “**memcached** engine” (memory caching) and the **InnoDB** **memcached** engine (**InnoDB** as back-end persistent storage).

Control over how often data is passed back and forth between **InnoDB** and **memcached** operations through the [**innodb\_api\_bk\_commit\_interval**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_api_bk_commit_interval), [**daemon\_memcached\_r\_batch\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_daemon_memcached_r_batch_size), and [**daemon\_memcached\_w\_batch\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_daemon_memcached_w_batch_size) configuration options. Batch size options default to a value of 1 for maximum reliability.

The ability to specify **memcached** options through the [**daemon\_memcached\_option**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_daemon_memcached_option) configuration parameter. For example, you can change the port that **memcached** listens on, reduce the maximum number of simultaneous connections, change the maximum memory size for a key-value pair, or enable debugging messages for the error log.

The [**innodb\_api\_trx\_level**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_api_trx_level) configuration option controls the transaction [isolation level](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_isolation_level) on queries processed by **memcached**. Although **memcached** has no concept of [transactions](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_transaction), you can use this option to control how soon **memcached** sees changes caused by SQL statements issued on the table used by the **daemon\_memcached** plugin. By default, [**innodb\_api\_trx\_level**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_api_trx_level) is set to [**READ UNCOMMITTED**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#isolevel_read-uncommitted).

The [**innodb\_api\_enable\_mdl**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_api_enable_mdl) option can be used to lock the table at the MySQL level, so that the mapped table cannot be dropped or altered by [DDL](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_ddl) through the SQL interface. Without the lock, the table can be dropped from the MySQL layer, but kept in **InnoDB** storage until **memcached** or some other user stops using it. “MDL” stands for “metadata locking”.

#### Differences Between InnoDB memcached and Traditional memcached

You may already be familiar with using **memcached** with MySQL, as described in [Using MySQL with **memcached**](https://dev.mysql.com/doc/refman/5.6/en/ha-memcached.html). This section describes how features of the integrated **InnoDB** **memcached** plugin differ from traditional **memcached**.

Installation: The **memcached** library comes with the MySQL server, making installation and setup relatively easy. Installation involves running the innodb\_memcached\_config.sql script to create a **demo\_test** table for **memcached** to use, issuing an [**INSTALL PLUGIN**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#install-plugin) statement to enable the **daemon\_memcached** plugin, and adding desired **memcached** options to a MySQL configuration file or startup script. You might still install the traditional **memcached** distribution for additional utilities such as **memcp**, **memcat**, and **memcapable**.

For comparison with traditional **memcached**, see [Installing **memcached**](https://dev.mysql.com/doc/refman/5.6/en/ha-memcached-install.html).

Deployment: With traditional **memcached**, it is typical to run large numbers of low-capacity **memcached** servers. A typical deployment of the **daemon\_memcached** plugin, however, involves a smaller number of moderate or high-powered servers that are already running MySQL. The benefit of this configuration is in improving efficiency of individual database servers rather than exploiting unused memory or distributing lookups across large numbers of servers. In the default configuration, very little memory is used for **memcached**, and in-memory lookups are served from the **InnoDB** [buffer pool](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_buffer_pool), which automatically caches the most recently and frequently used data. As with a traditional MySQL server instance, keep the value of the [**innodb\_buffer\_pool\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_size) configuration option as high as practical (without causing paging at the OS level), so that as much work as possible is performed in memory.

For comparison with traditional **memcached**, see [**memcached** Deployment](https://dev.mysql.com/doc/refman/5.6/en/ha-memcached-using-deployment.html).

Expiry: By default (that is, using the **innodb\_only** caching policy), the latest data from the **InnoDB** table is always returned, so the expiry options have no practical effect. If you change the caching policy to **caching** or **cache\_only**, the expiry options work as usual, but requested data might be stale if it is updated in the underlying table before it expires from the memory cache.

For comparison with traditional **memcached**, see [Data Expiry](https://dev.mysql.com/doc/refman/5.6/en/ha-memcached-using-expiry.html).

Namespaces: **memcached** is like a large directory where you give files elaborate names with prefixes and suffixes to keep the files from conflicting. The **daemon\_memcached** plugin lets you use similar naming conventions for keys, with one addition. Key names in the format **@@*table\_id*.*key***.***table\_id*** are decoded to reference a specific a table, using mapping data from the **innodb\_memcache.containers** table. The ***key*** is looked up in or written to the specified table.

The **@@** notation only works for individual calls to **get**, **add**, and **set** functions, but not others such as **incr** or **delete**. To designate a default table for subsequent **memcached** operations within a session, perform a **get** request using the **@@** notation with a ***table\_id***, but without the key portion. For example:

get @@***table\_id***

Subsequent **get**, **set**, **incr**, **delete**, and other operations use the table designated by ***table\_id*** in the **innodb\_memcache.containers.name** column.

For comparison with traditional **memcached**, see [Using Namespaces](https://dev.mysql.com/doc/refman/5.6/en/ha-memcached-using-namespaces.html).

Hashing and distribution: The default configuration, which uses the **innodb\_only** caching policy, is suitable for a traditional deployment configuration where all data is available on all servers, such as a set of replica servers.

If you physically divide data, as in a sharded configuration, you can split data across several machines running the **daemon\_memcached** plugin, and use the traditional **memcached** hashing mechanism to route requests to a particular machine. On the MySQL side, you would typically let all data be inserted by **add** requests to **memcached** so that appropriate values are stored in the database on the appropriate server.

For comparison with traditional **memcached**, see [**memcached** Hashing/Distribution Types](https://dev.mysql.com/doc/refman/5.6/en/ha-memcached-using-hashtypes.html).

Memory usage: By default (with the **innodb\_only** caching policy), the **memcached** protocol passes information back and forth with **InnoDB** tables, and the **InnoDB** buffer pool handles in-memory lookups instead of **memcached** memory usage growing and shrinking. Relatively little memory is used on the **memcached** side.

If you switch the caching policy to **caching** or **cache\_only**, the normal rules of **memcached** memory usage apply. Memory for **memcached** data values is allocated in terms of “slabs”. You can control slab size and maximum memory used for **memcached**.

Either way, you can monitor and troubleshoot the **daemon\_memcached** plugin using the familiar [statistics](https://dev.mysql.com/doc/refman/5.6/en/ha-memcached-stats.html) system, accessed through the standard protocol, over a **telnet** session, for example. Extra utilities are not included with the **daemon\_memcached** plugin. You can use the [**memcached-tool** script](https://dev.mysql.com/doc/refman/5.6/en/ha-memcached-stats-memcached-tool.html) to install a full **memcached** distribution.

For comparison with traditional **memcached**, see [Memory Allocation within **memcached**](https://dev.mysql.com/doc/refman/5.6/en/ha-memcached-using-memory.html).

Thread usage: MySQL threads and **memcached** threads co-exist on the same server. Limits imposed on threads by the operating system apply to the total number of threads.

For comparison with traditional **memcached**, see [**memcached** Thread Support](https://dev.mysql.com/doc/refman/5.6/en/ha-memcached-using-threads.html).

Log usage: Because the **memcached** daemon is run alongside the MySQL server and writes to **stderr**, the **-v**, **-vv**, and **-vvv** options for logging write output to the MySQL [error log](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_error_log).

For comparison with traditional **memcached**, see [**memcached** Logs](https://dev.mysql.com/doc/refman/5.6/en/ha-memcached-using-logs.html).

**memcached** operations: Familiar **memcached** operations such as **get**, **set**, **add**, and **delete** are available. Serialization (that is, the exact string format representing complex data structures) depends on the language interface.

For comparison with traditional **memcached**, see [Basic **memcached** Operations](https://dev.mysql.com/doc/refman/5.6/en/ha-memcached-operations.html).

Using **memcached** as a MySQL front end: This is the primary purpose of the **InnoDB** **memcached** plugin. An integrated **memcached** daemon improves application performance, and having **InnoDB** handle data transfers between memory and disk simplifies application logic.

For comparison with traditional **memcached**, see [Using **memcached** as a MySQL Caching Layer](https://dev.mysql.com/doc/refman/5.6/en/ha-memcached-mysql-frontend.html).

Utilities: The MySQL server includes the **libmemcached** library but not additional command-line utilities. To use commands such as **memcp**, **memcat**, and **memcapable** commands, install a full **memcached** distribution. When **memrm** and **memflush** remove items from the cache, the items are also removed from the underlying **InnoDB** table.

For comparison with traditional **memcached**, see [**libmemcached** Command-Line Utilities](https://dev.mysql.com/doc/refman/5.6/en/ha-memcached-interfaces-libmemcached.html#ha-memcached-interfaces-libmemcached-utilities).

Programming interfaces: You can access the MySQL server through the **daemon\_memcached** plugin using all supported languages: [C and C++](https://dev.mysql.com/doc/refman/5.6/en/ha-memcached-interfaces-libmemcached.html), [Java](https://dev.mysql.com/doc/refman/5.6/en/ha-memcached-interfaces-java.html), [Perl](https://dev.mysql.com/doc/refman/5.6/en/ha-memcached-interfaces-perl.html), [Python](https://dev.mysql.com/doc/refman/5.6/en/ha-memcached-interfaces-python.html), [PHP](https://dev.mysql.com/doc/refman/5.6/en/ha-memcached-interfaces-php.html), and [Ruby](https://dev.mysql.com/doc/refman/5.6/en/ha-memcached-interfaces-ruby.html). Specify the server hostname and port as with a traditional **memcached** server. By default, the **daemon\_memcached** plugin listens on port **11211**. You can use both the [text and binary protocols](https://dev.mysql.com/doc/refman/5.6/en/ha-memcached-interfaces-protocol.html). You can customize the [behavior](https://dev.mysql.com/doc/refman/5.6/en/ha-memcached-interfaces-libmemcached.html#ha-memcached-interfaces-libmemcached-behaviors) of **memcached** functions at runtime. Serialization (that is, the exact string format representing complex data structures) depends on the language interface.

For comparison with traditional **memcached**, see [Developing a **memcached** Application](https://dev.mysql.com/doc/refman/5.6/en/ha-memcached-interfaces.html).

Frequently asked questions: MySQL has an extensive FAQ for traditional **memcached**. The FAQ is mostly applicable, except that using **InnoDB** tables as a storage medium for **memcached** data means that you can use **memcached** for more write-intensive applications than before, rather than as a read-only cache.

See [**memcached** FAQ](https://dev.mysql.com/doc/refman/5.6/en/ha-memcached-faq.html).

### 15.20.3 Setting Up the InnoDB memcached Plugin

This section describes how to set up the **daemon\_memcached** plugin on a MySQL server. Because the **memcached** daemon is tightly integrated with the MySQL server to avoid network traffic and minimize latency, you perform this process on each MySQL instance that uses this feature.

**Note**

Before setting up the **daemon\_memcached** plugin, consult [Section 15.20.5, “Security Considerations for the InnoDB memcached Plugin”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-memcached-security) to understand the security procedures required to prevent unauthorized access.

#### Prerequisites

The **daemon\_memcached** plugin is only supported on Linux, Solaris, and macOS platforms. Other operating systems are not supported.

When building MySQL from source, you must build with [-DWITH\_INNODB\_MEMCACHED=ON](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\installing.html#option_cmake_with_innodb_memcached). This build option generates two shared libraries in the MySQL plugin directory ([**plugin\_dir**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#sysvar_plugin_dir)) that are required to run the **daemon\_memcached** plugin:

libmemcached.so: the **memcached** daemon plugin to MySQL.

innodb\_engine.so: an **InnoDB** API plugin to **memcached**.

**libevent** must be installed.

If you did not build MySQL from source, the **libevent** library is not included in your installation. Use the installation method for your operating system to install **libevent** 1.4.12 or later. For example, depending on the operating system, you might use **apt-get**, **yum**, or **port install**. For example, on Ubuntu Linux, use:

sudo apt-get install libevent-dev

If you installed MySQL from a source code release, **libevent** 1.4.12 is bundled with the package and is located at the top level of the MySQL source code directory. If you use the bundled version of **libevent**, no action is required. If you want to use a local system version of **libevent**, you must build MySQL with the [-DWITH\_LIBEVENT](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\installing.html#option_cmake_with_libevent) build option set to **system** or **yes**.

#### Installing and Configuring the InnoDB memcached Plugin

Configure the **daemon\_memcached** plugin so it can interact with **InnoDB** tables by running the innodb\_memcached\_config.sql configuration script, which is located in ***MYSQL\_HOME***/share. This script installs the **innodb\_memcache** database with three required tables (**cache\_policies**, **config\_options**, and **containers**). It also installs the **demo\_test** sample table in the **test** database.

mysql> **source *MYSQL\_HOME*/share/innodb\_memcached\_config.sql**

Running the innodb\_memcached\_config.sql script is a one-time operation. The tables remain in place if you later uninstall and re-install the **daemon\_memcached** plugin.

mysql> **USE innodb\_memcache;**

mysql> **SHOW TABLES;**

+---------------------------+

| Tables\_in\_innodb\_memcache |

+---------------------------+

| cache\_policies |

| config\_options |

| containers |

+---------------------------+

mysql> **USE test;**

mysql> **SHOW TABLES;**

+----------------+

| Tables\_in\_test |

+----------------+

| demo\_test |

+----------------+

Of these tables, the **innodb\_memcache.containers** table is the most important. Entries in the **containers** table provide a mapping to **InnoDB** table columns. Each **InnoDB** table used with the **daemon\_memcached** plugin requires an entry in the **containers** table.

The innodb\_memcached\_config.sql script inserts a single entry in the **containers** table that provides a mapping for the **demo\_test** table. It also inserts a single row of data into the **demo\_test** table. This data allows you to immediately verify the installation after the setup is completed.

mysql> **SELECT \* FROM innodb\_memcache.containers\G**

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\* 1. row \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

name: aaa

db\_schema: test

db\_table: demo\_test

key\_columns: c1

value\_columns: c2

flags: c3

cas\_column: c4

expire\_time\_column: c5

unique\_idx\_name\_on\_key: PRIMARY

mysql> **SELECT \* FROM test.demo\_test;**

+----+------------------+------+------+------+

| c1 | c2 | c3 | c4 | c5 |

+----+------------------+------+------+------+

| AA | HELLO, HELLO | 8 | 0 | 0 |

+----+------------------+------+------+------+

For more information about **innodb\_memcache** tables and the **demo\_test** sample table, see [Section 15.20.8, “InnoDB memcached Plugin Internals”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-memcached-internals).

Activate the **daemon\_memcached** plugin by running the [**INSTALL PLUGIN**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#install-plugin) statement:

mysql> **INSTALL PLUGIN daemon\_memcached soname "libmemcached.so";**

Once the plugin is installed, it is automatically activated each time the MySQL server is restarted.

#### Verifying the InnoDB and memcached Setup

To verify the **daemon\_memcached** plugin setup, use a **telnet** session to issue **memcached** commands. By default, the **memcached** daemon listens on port 11211.

Retrieve data from the **test.demo\_test** table. The single row of data in the **demo\_test** table has a key value of **AA**.

**telnet localhost 11211**

Trying 127.0.0.1...

Connected to localhost.

Escape character is '^]'.

**get AA**

VALUE AA 8 12

HELLO, HELLO

END

Insert data using a **set** command.

**set BB 10 0 16**

**GOODBYE, GOODBYE**

STORED

where:

**set** is the command to store a value

**BB** is the key

**10** is a flag for the operation; ignored by **memcached** but may be used by the client to indicate any type of information; specify **0** if unused

**0** is the expiration time (TTL); specify **0** if unused

**16** is the length of the supplied value block in bytes

**GOODBYE, GOODBYE** is the value that is stored

Verify that the data inserted is stored in MySQL by connecting to the MySQL server and querying the **test.demo\_test** table.

mysql> **SELECT \* FROM test.demo\_test;**

+----+------------------+------+------+------+

| c1 | c2 | c3 | c4 | c5 |

+----+------------------+------+------+------+

| AA | HELLO, HELLO | 8 | 0 | 0 |

| BB | GOODBYE, GOODBYE | 10 | 1 | 0 |

+----+------------------+------+------+------+

Return to the telnet session and retrieve the data that you inserted earlier using key **BB**.

**get BB**

VALUE BB 10 16

GOODBYE, GOODBYE

END

**quit**

If you shut down the MySQL server, which also shuts off the integrated **memcached** server, further attempts to access the **memcached** data fail with a connection error. Normally, the **memcached** data also disappears at this point, and you would require application logic to load the data back into memory when **memcached** is restarted. However, the **InnoDB** **memcached** plugin automates this process for you.

When you restart MySQL, **get** operations once again return the key-value pairs you stored in the earlier **memcached** session. When a key is requested and the associated value is not already in the memory cache, the value is automatically queried from the MySQL **test.demo\_test** table.

#### Creating a New Table and Column Mapping

This example shows how to setup your own **InnoDB** table with the **daemon\_memcached** plugin.

Create an **InnoDB** table. The table must have a key column with a unique index. The key column of the city table is **city\_id**, which is defined as the primary key. The table must also include columns for **flags**, **cas**, and **expiry** values. There may be one or more value columns. The **city** table has three value columns (**name**, **state**, **country**).

**Note**

There is no special requirement with respect to column names as along as a valid mapping is added to the **innodb\_memcache.containers** table.

mysql> **CREATE TABLE city (**

**city\_id VARCHAR(32),**

**name VARCHAR(1024),**

**state VARCHAR(1024),**

**country VARCHAR(1024),**

**flags INT,**

**cas BIGINT UNSIGNED,**

**expiry INT,**

**primary key(city\_id)**

) **ENGINE=InnoDB;**

Add an entry to the **innodb\_memcache.containers** table so that the **daemon\_memcached** plugin knows how to access the **InnoDB** table. The entry must satisfy the **innodb\_memcache.containers** table definition. For a description of each field, see [Section 15.20.8, “InnoDB memcached Plugin Internals”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-memcached-internals).

mysql> **DESCRIBE innodb\_memcache.containers;**

+------------------------+--------------+------+-----+---------+-------+

| Field | Type | Null | Key | Default | Extra |

+------------------------+--------------+------+-----+---------+-------+

| name | varchar(50) | NO | PRI | NULL | |

| db\_schema | varchar(250) | NO | | NULL | |

| db\_table | varchar(250) | NO | | NULL | |

| key\_columns | varchar(250) | NO | | NULL | |

| value\_columns | varchar(250) | YES | | NULL | |

| flags | varchar(250) | NO | | 0 | |

| cas\_column | varchar(250) | YES | | NULL | |

| expire\_time\_column | varchar(250) | YES | | NULL | |

| unique\_idx\_name\_on\_key | varchar(250) | NO | | NULL | |

+------------------------+--------------+------+-----+---------+-------+

The **innodb\_memcache.containers** table entry for the city table is defined as:

mysql> **INSERT INTO `innodb\_memcache`.`containers` (**

**`name`, `db\_schema`, `db\_table`, `key\_columns`, `value\_columns`,**

**`flags`, `cas\_column`, `expire\_time\_column`, `unique\_idx\_name\_on\_key`)**

**VALUES ('default', 'test', 'city', 'city\_id', 'name|state|country',**

**'flags','cas','expiry','PRIMARY');**

**default** is specified for the **containers.name** column to configure the **city** table as the default **InnoDB** table to be used with the **daemon\_memcached** plugin.

Multiple **InnoDB** table columns (**name**, **state**, **country**) are mapped to **containers.value\_columns** using a “|” delimiter.

The **flags**, **cas\_column**, and **expire\_time\_column** fields of the **innodb\_memcache.containers** table are typically not significant in applications using the **daemon\_memcached** plugin. However, a designated **InnoDB** table column is required for each. When inserting data, specify **0** for these columns if they are unused.

After updating the **innodb\_memcache.containers** table, restart the **daemon\_memcache** plugin to apply the changes.

mysql> **UNINSTALL PLUGIN daemon\_memcached;**

mysql> **INSTALL PLUGIN daemon\_memcached soname "libmemcached.so";**

Using telnet, insert data into the **city** table using a **memcached** **set** command.

**telnet localhost 11211**

Trying 127.0.0.1...

Connected to localhost.

Escape character is '^]'.

**set B 0 0 22**

**BANGALORE|BANGALORE|IN**

STORED

Using MySQL, query the **test.city** table to verify that the data you inserted was stored.

mysql> **SELECT \* FROM test.city;**

+---------+-----------+-----------+---------+-------+------+--------+

| city\_id | name | state | country | flags | cas | expiry |

+---------+-----------+-----------+---------+-------+------+--------+

| B | BANGALORE | BANGALORE | IN | 0 | 3 | 0 |

+---------+-----------+-----------+---------+-------+------+--------+

Using MySQL, insert additional data into the **test.city** table.

mysql> **INSERT INTO city VALUES ('C','CHENNAI','TAMIL NADU','IN', 0, 0 ,0);**

mysql> **INSERT INTO city VALUES ('D','DELHI','DELHI','IN', 0, 0, 0);**

mysql> **INSERT INTO city VALUES ('H','HYDERABAD','TELANGANA','IN', 0, 0, 0);**

mysql> **INSERT INTO city VALUES ('M','MUMBAI','MAHARASHTRA','IN', 0, 0, 0);**

**Note**

It is recommended that you specify a value of **0** for the **flags**, **cas\_column**, and **expire\_time\_column** fields if they are unused.

Using telnet, issue a **memcached** **get** command to retrieve data you inserted using MySQL.

**get H**

VALUE H 0 22

HYDERABAD|TELANGANA|IN

END

#### Configuring the InnoDB memcached Plugin

Traditional **memcached** configuration options may be specified in a MySQL configuration file or a [**mysqld**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\programs.html#mysqld) startup string, encoded in the argument of the [**daemon\_memcached\_option**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_daemon_memcached_option) configuration parameter. **memcached** configuration options take effect when the plugin is loaded, which occurs each time the MySQL server is started.

For example, to make **memcached** listen on port 11222 instead of the default port 11211, specify **-p11222** as an argument of the [**daemon\_memcached\_option**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_daemon_memcached_option) configuration option:

mysqld .... --daemon\_memcached\_option="-p11222"

Other **memcached** options can be encoded in the [**daemon\_memcached\_option**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_daemon_memcached_option) string. For example, you can specify options to reduce the maximum number of simultaneous connections, change the maximum memory size for a key-value pair, or enable debugging messages for the error log, and so on.

There are also configuration options specific to the **daemon\_memcached** plugin. These include:

[**daemon\_memcached\_engine\_lib\_name**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_daemon_memcached_engine_lib_name): Specifies the shared library that implements the **InnoDB** **memcached** plugin. The default setting is innodb\_engine.so.

[**daemon\_memcached\_engine\_lib\_path**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_daemon_memcached_engine_lib_path): The path of the directory containing the shared library that implements the **InnoDB** **memcached** plugin. The default is NULL, representing the plugin directory.

[**daemon\_memcached\_r\_batch\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_daemon_memcached_r_batch_size): Defines the batch commit size for read operations (**get**). It specifies the number of **memcached** read operations after which a [commit](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_commit) occurs. [**daemon\_memcached\_r\_batch\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_daemon_memcached_r_batch_size) is set to 1 by default so that every **get** request accesses the most recently committed data in the **InnoDB** table, whether the data was updated through **memcached** or by SQL. When the value is greater than 1, the counter for read operations is incremented with each **get** call. A **flush\_all** call resets both read and write counters.

[**daemon\_memcached\_w\_batch\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_daemon_memcached_w_batch_size): Defines the batch commit size for write operations (**set**, **replace**, **append**, **prepend**, **incr**, **decr**, and so on). [**daemon\_memcached\_w\_batch\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_daemon_memcached_w_batch_size) is set to 1 by default so that no uncommitted data is lost in case of an outage, and so that SQL queries on the underlying table access the most recent data. When the value is greater than 1, the counter for write operations is incremented for each **add**, **set**, **incr**, **decr**, and **delete** call. A **flush\_all** call resets both read and write counters.

By default, you do not need to modify [**daemon\_memcached\_engine\_lib\_name**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_daemon_memcached_engine_lib_name) or [**daemon\_memcached\_engine\_lib\_path**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_daemon_memcached_engine_lib_path). You might configure these options if, for example, you want to use a different storage engine for **memcached** (such as the NDB **memcached** engine).

**daemon\_memcached** plugin configuration parameters may be specified in the MySQL configuration file or in a [**mysqld**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\programs.html#mysqld) startup string. They take effect when you load the **daemon\_memcached** plugin.

When making changes to **daemon\_memcached** plugin configuration, reload the plugin to apply the changes. To do so, issue the following statements:

mysql> **UNINSTALL PLUGIN daemon\_memcached;**

mysql> **INSTALL PLUGIN daemon\_memcached soname "libmemcached.so";**

Configuration settings, required tables, and data are preserved when the plugin is restarted.

For additional information about enabling and disabling plugins, see [Section 5.6.1, “Installing and Uninstalling Plugins”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#plugin-loading).

### 15.20.4 InnoDB memcached Multiple get and Range Query Support

The **daemon\_memcached** plugin supports multiple get operations (fetching multiple key-value pairs in a single **memcached** query) and range queries.

#### Multiple get Operations

The ability to fetch multiple key-value pairs in a single **memcached** query improves read performance by reducing communication traffic between the client and server. For **InnoDB**, it means fewer transactions and open-table operations.

The following example demonstrates multiple-get support. The example uses the **test.city** table described in [Creating a New Table and Column Mapping](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-memcached-new-table-setup).

mysql> **USE test;**

mysql> **SELECT \* FROM test.city;**

+---------+-----------+-------------+---------+-------+------+--------+

| city\_id | name | state | country | flags | cas | expiry |

+---------+-----------+-------------+---------+-------+------+--------+

| B | BANGALORE | BANGALORE | IN | 0 | 1 | 0 |

| C | CHENNAI | TAMIL NADU | IN | 0 | 0 | 0 |

| D | DELHI | DELHI | IN | 0 | 0 | 0 |

| H | HYDERABAD | TELANGANA | IN | 0 | 0 | 0 |

| M | MUMBAI | MAHARASHTRA | IN | 0 | 0 | 0 |

+---------+-----------+-------------+---------+-------+------+--------+

Run a **get** command to retrieve all values from the **city** table. The results are returned in a key-value pair sequence.

**telnet 127.0.0.1 11211**

Trying 127.0.0.1...

Connected to 127.0.0.1.

Escape character is '^]'.

**get B C D H M**

VALUE B 0 22

BANGALORE|BANGALORE|IN

VALUE C 0 21

CHENNAI|TAMIL NADU|IN

VALUE D 0 14

DELHI|DELHI|IN

VALUE H 0 22

HYDERABAD|TELANGANA|IN

VALUE M 0 21

MUMBAI|MAHARASHTRA|IN

END

When retrieving multiple values in a single **get** command, you can switch tables (using **@@*containers.name*** notation) to retrieve the value for the first key, but you cannot switch tables for subsequent keys. For example, the table switch in this example is valid:

**get @@aaa.AA BB**

VALUE @@aaa.AA 8 12

HELLO, HELLO

VALUE BB 10 16

GOODBYE, GOODBYE

END

Attempting to switch tables again in the same **get** command to retrieve a key value from a different table is not supported.

There is no limit the number of keys that can be retrieved by a multiple get operation, but there is a 128MB memory limit for storing the result.

#### Range Queries

For range queries, the **daemon\_memcached** plugin supports the following comparison operators: **<**, **>**, **<=**, **>=**. An operator must be preceded by an **@** symbol. When a range query finds multiple matching key-value pairs, results are returned in a key-value pair sequence.

The following examples demonstrate range query support. The examples use the **test.city** table described in [Creating a New Table and Column Mapping](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-memcached-new-table-setup).

mysql> **SELECT \* FROM test.city;**

+---------+-----------+-------------+---------+-------+------+--------+

| city\_id | name | state | country | flags | cas | expiry |

+---------+-----------+-------------+---------+-------+------+--------+

| B | BANGALORE | BANGALORE | IN | 0 | 1 | 0 |

| C | CHENNAI | TAMIL NADU | IN | 0 | 0 | 0 |

| D | DELHI | DELHI | IN | 0 | 0 | 0 |

| H | HYDERABAD | TELANGANA | IN | 0 | 0 | 0 |

| M | MUMBAI | MAHARASHTRA | IN | 0 | 0 | 0 |

+---------+-----------+-------------+---------+-------+------+--------+

Open a telnet session:

**telnet 127.0.0.1 11211**

Trying 127.0.0.1...

Connected to 127.0.0.1.

Escape character is '^]'.

To get all values greater than **B**, enter **get @>B**:

**get @>B**

VALUE C 0 21

CHENNAI|TAMIL NADU|IN

VALUE D 0 14

DELHI|DELHI|IN

VALUE H 0 22

HYDERABAD|TELANGANA|IN

VALUE M 0 21

MUMBAI|MAHARASHTRA|IN

END

To get all values less than **M**, enter **get @<M**:

**get @<M**

VALUE B 0 22

BANGALORE|BANGALORE|IN

VALUE C 0 21

CHENNAI|TAMIL NADU|IN

VALUE D 0 14

DELHI|DELHI|IN

VALUE H 0 22

HYDERABAD|TELANGANA|IN

END

To get all values less than and including **M**, enter **get @<=M**:

**get @<=M**

VALUE B 0 22

BANGALORE|BANGALORE|IN

VALUE C 0 21

CHENNAI|TAMIL NADU|IN

VALUE D 0 14

DELHI|DELHI|IN

VALUE H 0 22

HYDERABAD|TELANGANA|IN

VALUE M 0 21

MUMBAI|MAHARASHTRA|IN

To get values greater than **B** but less than **M**, enter **get @>B@<M**:

**get @>B@<M**

VALUE C 0 21

CHENNAI|TAMIL NADU|IN

VALUE D 0 14

DELHI|DELHI|IN

VALUE H 0 22

HYDERABAD|TELANGANA|IN

END

A maximum of two comparison operators can be parsed, one being either a 'less than' (**@<**) or 'less than or equal to' (**@<=**) operator, and the other being either a 'greater than' (**@>**) or 'greater than or equal to' (**@>=**) operator. Any additional operators are assumed to be part of the key. For example, if you issue a **get** command with three operators, the third operator (**@>C**) is treated as part of the key, and the **get** command searches for values smaller than **M** and greater than **B@>C**.

**get @<M@>B@>C**

VALUE C 0 21

CHENNAI|TAMIL NADU|IN

VALUE D 0 14

DELHI|DELHI|IN

VALUE H 0 22

HYDERABAD|TELANGANA|IN

### 15.20.5 Security Considerations for the InnoDB memcached Plugin

**Caution**

Consult this section before deploying the **daemon\_memcached** plugin on a production server, or even on a test server if the MySQL instance contains sensitive data.

Because **memcached** does not use an authentication mechanism by default, and the optional SASL authentication is not as strong as traditional DBMS security measures, only keep non-sensitive data in the MySQL instance that uses the **daemon\_memcached** plugin, and wall off any servers that use this configuration from potential intruders. Do not allow **memcached** access to these servers from the Internet; only allow access from within a firewalled intranet, ideally from a subnet whose membership you can restrict.

#### Password-Protecting memcached Using SASL

SASL support provides the capability to protect your MySQL database from unauthenticated access through **memcached** clients. This section explains how to enable SASL with the **daemon\_memcached** plugin. The steps are almost identical to those performed to enabled SASL for a traditional **memcached** server.

SASL stands for “Simple Authentication and Security Layer”, a standard for adding authentication support to connection-based protocols. **memcached** added SASL support in version 1.4.3.

SASL authentication is only supported with the binary protocol.

**memcached** clients are only able to access **InnoDB** tables that are registered in the **innodb\_memcache.containers** table. Even though a DBA can place access restrictions on such tables, access through **memcached** applications cannot be controlled. For this reason, SASL support is provided to control access to **InnoDB** tables associated with the **daemon\_memcached** plugin.

The following section shows how to build, enable, and test an SASL-enabled **daemon\_memcached** plugin.

#### Building and Enabling SASL with the InnoDB memcached Plugin

By default, an SASL-enabled **daemon\_memcached** plugin is not included in MySQL release packages, since an SASL-enabled **daemon\_memcached** plugin requires building **memcached** with SASL libraries. To enable SASL support, download the MySQL source and rebuild the **daemon\_memcached** plugin after downloading the SASL libraries:

Install the SASL development and utility libraries. For example, on Ubuntu, use **apt-get** to obtain the libraries:

sudo apt-get -f install libsasl2-2 sasl2-bin libsasl2-2 libsasl2-dev libsasl2-modules

Build the **daemon\_memcached** plugin shared libraries with SASL capability by adding **ENABLE\_MEMCACHED\_SASL=1** to your **cmake** options. **memcached** also provides simple cleartext password support, which facilitates testing. To enable simple cleartext password support, specify the **ENABLE\_MEMCACHED\_SASL\_PWDB=1** **cmake** option.

In summary, add following three **cmake** options:

cmake ... -DWITH\_INNODB\_MEMCACHED=1 -DENABLE\_MEMCACHED\_SASL=1 -DENABLE\_MEMCACHED\_SASL\_PWDB=1

Install the **daemon\_memcached** plugin, as described in [Section 15.20.3, “Setting Up the InnoDB memcached Plugin”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-memcached-setup).

Configure a user name and password file. (This example uses **memcached** simple cleartext password support.)

In a file, create a user named **testname** and define the password as **testpasswd**:

echo "testname:testpasswd:::::::" >/home/jy/memcached-sasl-db

Configure the **MEMCACHED\_SASL\_PWDB** environment variable to inform **memcached** of the user name and password file:

export MEMCACHED\_SASL\_PWDB=/home/jy/memcached-sasl-db

Inform **memcached** that a cleartext password is used:

echo "mech\_list: plain" > /home/jy/work2/msasl/clients/memcached.conf

export SASL\_CONF\_PATH=/home/jy/work2/msasl/clients

Enable SASL by restarting the MySQL server with the **memcached** **-S** option encoded in the [**daemon\_memcached\_option**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_daemon_memcached_option) configuration parameter:

mysqld ... --daemon\_memcached\_option="-S"

To test the setup, use an SASL-enabled client such as [SASL-enabled libmemcached](https://code.launchpad.net/~trond-norbye/libmemcached/sasl).

memcp --servers=localhost:11211 --binary  --username=testname

--password=***password*** myfile.txt

memcat --servers=localhost:11211 --binary --username=testname

--password=***password*** myfile.txt

If you specify an incorrect user name or password, the operation is rejected with a **memcache error AUTHENTICATION FAILURE** message. In this case, examine the cleartext password set in the memcached-sasl-db file to verify that the credentials you supplied are correct.

There are other methods to test SASL authentication with **memcached**, but the method described above is the most straightforward.

### 15.20.6 Writing Applications for the InnoDB memcached Plugin

[15.20.6.1 Adapting an Existing MySQL Schema for the InnoDB memcached Plugin](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-memcached-porting-mysql)

[15.20.6.2 Adapting a memcached Application for the InnoDB memcached Plugin](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-memcached-porting-memcached)

[15.20.6.3 Tuning InnoDB memcached Plugin Performance](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-memcached-tuning)

[15.20.6.4 Controlling Transactional Behavior of the InnoDB memcached Plugin](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-memcached-txn)

[15.20.6.5 Adapting DML Statements to memcached Operations](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-memcached-dml)

[15.20.6.6 Performing DML and DDL Statements on the Underlying InnoDB Table](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-memcached-ddl)

Typically, writing an application for the **InnoDB** **memcached** plugin involves some degree of rewriting or adapting existing code that uses MySQL or the **memcached** API.

With the **daemon\_memcached** plugin, instead of many traditional **memcached** servers running on low-powered machines, you have the same number of **memcached** servers as MySQL servers, running on relatively high-powered machines with substantial disk storage and memory. You might reuse some existing code that works with the **memcached** API, but adaptation is likely required due to the different server configuration.

The data stored through the **daemon\_memcached** plugin goes into [**VARCHAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-types.html#char), [**TEXT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-types.html#blob), or [**BLOB**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-types.html#blob) columns, and must be converted to do numeric operations. You can perform the conversion on the application side, or by using the **CAST()** function in queries.

Coming from a database background, you might be used to general-purpose SQL tables with many columns. The tables accessed by **memcached** code likely have only a few or even a single column holding data values.

You might adapt parts of your application that perform single-row queries, inserts, updates, or deletes, to improve performance in critical sections of code. Both [queries](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_query) (read) and [DML](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_dml) (write) operations can be substantially faster when performed through the **InnoDB** **memcached** interface. The performance improvement for writes is typically greater than the performance improvement for reads, so you might focus on adapting code that performs logging or records interactive choices on a website.

The following sections explore these points in more detail.

#### 15.20.6.1 Adapting an Existing MySQL Schema for the InnoDB memcached Plugin

Consider these aspects of **memcached** applications when adapting an existing MySQL schema or application to use the **daemon\_memcached** plugin:

**memcached** keys cannot contain spaces or newlines, because these characters are used as separators in the ASCII protocol. If you are using lookup values that contain spaces, transform or hash them into values without spaces before using them as keys in calls to **add()**, **set()**, **get()**, and so on. Although theoretically these characters are allowed in keys in programs that use the binary protocol, you should restrict the characters used in keys to ensure compatibility with a broad range of clients.

If there is a short numeric [primary key](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_primary_key) column in an **InnoDB** table, use it as the unique lookup key for **memcached** by converting the integer to a string value. If the **memcached** server is used for multiple applications, or with more than one **InnoDB** table, consider modifying the name to ensure that it is unique. For example, prepend the table name, or the database name and the table name, before the numeric value.

**Note**

The **daemon\_memcached** plugin supports inserts and reads on mapped **InnoDB** tables that have an **INTEGER** defined as the primary key.

You cannot use a partitioned table for data queried or stored using **memcached**.

The **memcached** protocol passes numeric values around as strings. To store numeric values in the underlying **InnoDB** table, to implement counters that can be used in SQL functions such as **SUM()** or **AVG()**, for example:

Use [**VARCHAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-types.html#char) columns with enough characters to hold all the digits of the largest expected number (and additional characters if appropriate for the negative sign, decimal point, or both).

In any query that performs arithmetic using column values, use the **CAST()** function to convert the values from string to integer, or to some other numeric type. For example:

# Alphabetic entries are returned as zero.

SELECT CAST(c2 as unsigned integer) FROM demo\_test;

# Since there could be numeric values of 0, can't disqualify them.

# Test the string values to find the ones that are integers, and average only those.

SELECT AVG(cast(c2 as unsigned integer)) FROM demo\_test

WHERE c2 BETWEEN '0' and '9999999999';

# Views let you hide the complexity of queries. The results are already converted;

# no need to repeat conversion functions and WHERE clauses each time.

CREATE VIEW numbers AS SELECT c1 KEY, CAST(c2 AS UNSIGNED INTEGER) val

FROM demo\_test WHERE c2 BETWEEN '0' and '9999999999';

SELECT SUM(val) FROM numbers;

**Note**

Any alphabetic values in the result set are converted into 0 by the call to **CAST()**. When using functions such as **AVG()**, which depend on the number of rows in the result set, include **WHERE** clauses to filter out non-numeric values.

If the **InnoDB** column used as a key could have values longer than 250 bytes, hash the value to less than 250 bytes.

To use an existing table with the **daemon\_memcached** plugin, define an entry for it in the **innodb\_memcache.containers** table. To make that table the default for all **memcached** requests, specify a value of **default** in the **name** column, then restart the MySQL server to make the change take effect. If you use multiple tables for different classes of **memcached** data, set up multiple entries in the **innodb\_memcache.containers** table with **name** values of your choice, then issue a **memcached** request in the form of **get @@*name*** or **set @@*name*** within the application to specify the table to be used for subsequent **memcached** requests.

For an example of using a table other than the predefined **test.demo\_test** table, see [Example 15.13, “Using Your Own Table with an InnoDB memcached Application”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-memcached-tutorial-python). For the required table layout, see [Section 15.20.8, “InnoDB memcached Plugin Internals”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-memcached-internals).

To use multiple **InnoDB** table column values with **memcached** key-value pairs, specify column names separated by comma, semicolon, space, or pipe characters in the **value\_columns** field of the **innodb\_memcache.containers** entry for the **InnoDB** table. For example, specify **col1,col2,col3** or **col1|col2|col3** in the **value\_columns** field.

Concatenate the column values into a single string using the pipe character as a separator before passing the string to **memcached** **add** or **set** calls. The string is unpacked automatically into the correct column. Each **get** call returns a single string containing the column values that is also delimited by the pipe character. You can unpack the values using the appropriate application language syntax.

**Example 15.13 Using Your Own Table with an InnoDB memcached Application**

This example shows how to use your own table with a sample Python application that uses **memcached** for data manipulation.

The example assumes that the **daemon\_memcached** plugin is installed as described in [Section 15.20.3, “Setting Up the InnoDB memcached Plugin”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-memcached-setup). It also assumes that your system is configured to run a Python script that uses the **python-memcache** module.

Create the **multicol** table which stores country information including population, area, and driver side data (**'R'** for right and **'L'** for left).

mysql> **USE test;**

mysql> **CREATE TABLE `multicol` (**

**`country` varchar(128) NOT NULL DEFAULT '',**

**`population` varchar(10) DEFAULT NULL,**

**`area\_sq\_km` varchar(9) DEFAULT NULL,**

**`drive\_side` varchar(1) DEFAULT NULL,**

**`c3` int(11) DEFAULT NULL,**

**`c4` bigint(20) unsigned DEFAULT NULL,**

**`c5` int(11) DEFAULT NULL,**

**PRIMARY KEY (`country`)**

**) ENGINE=InnoDB DEFAULT CHARSET=utf8mb4;**

Insert a record into the **innodb\_memcache.containers** table so that the **daemon\_memcached** plugin can access the **multicol** table.

mysql> **INSERT INTO innodb\_memcache.containers**

**(name,db\_schema,db\_table,key\_columns,value\_columns,flags,cas\_column,**

**expire\_time\_column,unique\_idx\_name\_on\_key)**

**VALUES**

**('bbb','test','multicol','country','population,area\_sq\_km,drive\_side',**

**'c3','c4','c5','PRIMARY');**

mysql> **COMMIT;**

The **innodb\_memcache.containers** record for the **multicol** table specifies a **name** value of **'bbb'**, which is the table identifier.

**Note**

If a single **InnoDB** table is used for all **memcached** applications, the **name** value can be set to **default** to avoid using **@@** notation to switch tables.

The **db\_schema** column is set to **test**, which is the name of the database where the **multicol** table resides.

The **db\_table** column is set to **multicol**, which is the name of the **InnoDB** table.

**key\_columns** is set to the unique **country** column. The **country** column is defined as the primary key in the **multicol** table definition.

Rather than a single **InnoDB** table column to hold a composite data value, data is divided among three table columns (**population**, **area\_sq\_km**, and **drive\_side**). To accommodate multiple value columns, a comma-separated list of columns is specified in the **value\_columns** field. The columns defined in the **value\_columns** field are the columns used when storing or retrieving values.

Values for the **flags**, **expire\_time**, and **cas\_column** fields are based on values used in the **demo.test** sample table. These fields are typically not significant in applications that use the **daemon\_memcached** plugin because MySQL keeps data synchronized, and there is no need to worry about data expiring or becoming stale.

The **unique\_idx\_name\_on\_key** field is set to **PRIMARY**, which refers to the primary index defined on the unique **country** column in the **multicol** table.

Copy the sample Python application into a file. In this example, the sample script is copied to a file named multicol.py.

The sample Python application inserts data into the **multicol** table and retrieves data for all keys, demonstrating how to access an **InnoDB** table through the **daemon\_memcached** plugin.

import sys, os

import memcache

def connect\_to\_memcached():

memc = memcache.Client(['127.0.0.1:11211'], debug=0);

print "Connected to memcached."

return memc

def banner(message):

print

print "=" \* len(message)

print message

print "=" \* len(message)

country\_data = [

("Canada","34820000","9984670","R"),

("USA","314242000","9826675","R"),

("Ireland","6399152","84421","L"),

("UK","62262000","243610","L"),

("Mexico","113910608","1972550","R"),

("Denmark","5543453","43094","R"),

("Norway","5002942","385252","R"),

("UAE","8264070","83600","R"),

("India","1210193422","3287263","L"),

("China","1347350000","9640821","R"),

]

def switch\_table(memc,table):

key = "@@" + table

print "Switching default table to '" + table + "' by issuing GET for '" + key + "'."

result = memc.get(key)

def insert\_country\_data(memc):

banner("Inserting initial data via memcached interface")

for item in country\_data:

country = item[0]

population = item[1]

area = item[2]

drive\_side = item[3]

key = country

value = "|".join([population,area,drive\_side])

print "Key = " + key

print "Value = " + value

if memc.add(key,value):

print "Added new key, value pair."

else:

print "Updating value for existing key."

memc.set(key,value)

def query\_country\_data(memc):

banner("Retrieving data for all keys (country names)")

for item in country\_data:

key = item[0]

result = memc.get(key)

print "Here is the result retrieved from the database for key " + key + ":"

print result

(m\_population, m\_area, m\_drive\_side) = result.split("|")

print "Unpacked population value: " + m\_population

print "Unpacked area value : " + m\_area

print "Unpacked drive side value: " + m\_drive\_side

if \_\_name\_\_ == '\_\_main\_\_':

memc = connect\_to\_memcached()

switch\_table(memc,"bbb")

insert\_country\_data(memc)

query\_country\_data(memc)

sys.exit(0)

Sample Python application notes:

No database authorization is required to run the application, since data manipulation is performed through the **memcached** interface. The only required information is the port number on the local system where the **memcached** daemon listens.

To make sure the application uses the **multicol** table, the **switch\_table()** function is called, which performs a dummy **get** or **set** request using **@@** notation. The **name** value in the request is **bbb**, which is the **multicol** table identifier defined in the **innodb\_memcache.containers.name** field.

A more descriptive **name** value might be used in a real-world application. This example simply illustrates that a table identifier is specified rather than the table name in **get @@...** requests.

The utility functions used to insert and query data demonstrate how to turn a Python data structure into pipe-separated values for sending data to MySQL with **add** or **set** requests, and how to unpack the pipe-separated values returned by **get** requests. This extra processing is only required when mapping a single **memcached** value to multiple MySQL table columns.

Run the sample Python application.

shell> **python multicol.py**

If successful, the sample application returns this output:

Connected to memcached.

Switching default table to 'bbb' by issuing GET for '@@bbb'.

==============================================

Inserting initial data via memcached interface

==============================================

Key = Canada

Value = 34820000|9984670|R

Added new key, value pair.

Key = USA

Value = 314242000|9826675|R

Added new key, value pair.

Key = Ireland

Value = 6399152|84421|L

Added new key, value pair.

Key = UK

Value = 62262000|243610|L

Added new key, value pair.

Key = Mexico

Value = 113910608|1972550|R

Added new key, value pair.

Key = Denmark

Value = 5543453|43094|R

Added new key, value pair.

Key = Norway

Value = 5002942|385252|R

Added new key, value pair.

Key = UAE

Value = 8264070|83600|R

Added new key, value pair.

Key = India

Value = 1210193422|3287263|L

Added new key, value pair.

Key = China

Value = 1347350000|9640821|R

Added new key, value pair.

============================================

Retrieving data for all keys (country names)

============================================

Here is the result retrieved from the database for key Canada:

34820000|9984670|R

Unpacked population value: 34820000

Unpacked area value : 9984670

Unpacked drive side value: R

Here is the result retrieved from the database for key USA:

314242000|9826675|R

Unpacked population value: 314242000

Unpacked area value : 9826675

Unpacked drive side value: R

Here is the result retrieved from the database for key Ireland:

6399152|84421|L

Unpacked population value: 6399152

Unpacked area value : 84421

Unpacked drive side value: L

Here is the result retrieved from the database for key UK:

62262000|243610|L

Unpacked population value: 62262000

Unpacked area value : 243610

Unpacked drive side value: L

Here is the result retrieved from the database for key Mexico:

113910608|1972550|R

Unpacked population value: 113910608

Unpacked area value : 1972550

Unpacked drive side value: R

Here is the result retrieved from the database for key Denmark:

5543453|43094|R

Unpacked population value: 5543453

Unpacked area value : 43094

Unpacked drive side value: R

Here is the result retrieved from the database for key Norway:

5002942|385252|R

Unpacked population value: 5002942

Unpacked area value : 385252

Unpacked drive side value: R

Here is the result retrieved from the database for key UAE:

8264070|83600|R

Unpacked population value: 8264070

Unpacked area value : 83600

Unpacked drive side value: R

Here is the result retrieved from the database for key India:

1210193422|3287263|L

Unpacked population value: 1210193422

Unpacked area value : 3287263

Unpacked drive side value: L

Here is the result retrieved from the database for key China:

1347350000|9640821|R

Unpacked population value: 1347350000

Unpacked area value : 9640821

Unpacked drive side value: R

Query the **innodb\_memcache.containers** table to view the record you inserted earlier for the **multicol** table. The first record is the sample entry for the **demo\_test** table that is created during the initial **daemon\_memcached** plugin setup. The second record is the entry you inserted for the **multicol** table.

mysql> **SELECT \* FROM innodb\_memcache.containers\G**

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\* 1. row \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

name: aaa

db\_schema: test

db\_table: demo\_test

key\_columns: c1

value\_columns: c2

flags: c3

cas\_column: c4

expire\_time\_column: c5

unique\_idx\_name\_on\_key: PRIMARY

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\* 2. row \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

name: bbb

db\_schema: test

db\_table: multicol

key\_columns: country

value\_columns: population,area\_sq\_km,drive\_side

flags: c3

cas\_column: c4

expire\_time\_column: c5

unique\_idx\_name\_on\_key: PRIMARY

Query the **multicol** table to view data inserted by the sample Python application. The data is available for MySQL [queries](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_query), which demonstrates how the same data can be accessed using SQL or through applications (using the appropriate [MySQL Connector or API](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\connectors-apis.html)).

mysql> **SELECT \* FROM test.multicol;**

+---------+------------+------------+------------+------+------+------+

| country | population | area\_sq\_km | drive\_side | c3 | c4 | c5 |

+---------+------------+------------+------------+------+------+------+

| Canada | 34820000 | 9984670 | R | 0 | 11 | 0 |

| China | 1347350000 | 9640821 | R | 0 | 20 | 0 |

| Denmark | 5543453 | 43094 | R | 0 | 16 | 0 |

| India | 1210193422 | 3287263 | L | 0 | 19 | 0 |

| Ireland | 6399152 | 84421 | L | 0 | 13 | 0 |

| Mexico | 113910608 | 1972550 | R | 0 | 15 | 0 |

| Norway | 5002942 | 385252 | R | 0 | 17 | 0 |

| UAE | 8264070 | 83600 | R | 0 | 18 | 0 |

| UK | 62262000 | 243610 | L | 0 | 14 | 0 |

| USA | 314242000 | 9826675 | R | 0 | 12 | 0 |

+---------+------------+------------+------------+------+------+------+

**Note**

Always allow sufficient size to hold necessary digits, decimal points, sign characters, leading zeros, and so on when defining the length for columns that are treated as numbers. Too-long values in a string column such as a **VARCHAR** are truncated by removing some characters, which could produce nonsensical numeric values.

Optionally, run report-type queries on the **InnoDB** table that stores the **memcached** data.

You can produce reports through SQL queries, performing calculations and tests across any columns, not just the **country** key column. (Because the following examples use data from only a few countries, the numbers are for illustration purposes only.) The following queries return the average population of countries where people drive on the right, and the average size of countries whose names start with “U”:

mysql> **SELECT AVG(population) FROM multicol WHERE drive\_side = 'R';**

+-------------------+

| avg(population) |

+-------------------+

| 261304724.7142857 |

+-------------------+

mysql> **SELECT SUM(area\_sq\_km) FROM multicol WHERE country LIKE 'U%';**

+-----------------+

| sum(area\_sq\_km) |

+-----------------+

| 10153885 |

+-----------------+

Because the **population** and **area\_sq\_km** columns store character data rather than strongly typed numeric data, functions such as **AVG()** and **SUM()** work by converting each value to a number first. This approach does not work for operators such as **<** or **>**, for example, when comparing character-based values, **9 > 1000**, which is not expected from a clause such as **ORDER BY population DESC**. For the most accurate type treatment, perform queries against views that cast numeric columns to the appropriate types. This technique lets you issue simple **SELECT \*** queries from database applications, while ensuring that casting, filtering, and ordering is correct. The following example shows a view that can be queried to find the top three countries in descending order of population, with the results reflecting the latest data in the **multicol** table, and with population and area figures treated as numbers:

mysql> **CREATE VIEW populous\_countries AS**

**SELECT**

**country,**

**cast(population as unsigned integer) population,**

**cast(area\_sq\_km as unsigned integer) area\_sq\_km,**

**drive\_side FROM multicol**

**ORDER BY CAST(population as unsigned integer) DESC**

**LIMIT 3;**

mysql> **SELECT \* FROM populous\_countries;**

+---------+------------+------------+------------+

| country | population | area\_sq\_km | drive\_side |

+---------+------------+------------+------------+

| China | 1347350000 | 9640821 | R |

| India | 1210193422 | 3287263 | L |

| USA | 314242000 | 9826675 | R |

+---------+------------+------------+------------+

mysql> **DESC populous\_countries;**

+------------+---------------------+------+-----+---------+-------+

| Field | Type | Null | Key | Default | Extra |

+------------+---------------------+------+-----+---------+-------+

| country | varchar(128) | NO | | | |

| population | bigint(10) unsigned | YES | | NULL | |

| area\_sq\_km | int(9) unsigned | YES | | NULL | |

| drive\_side | varchar(1) | YES | | NULL | |

+------------+---------------------+------+-----+---------+-------+

#### 15.20.6.2 Adapting a memcached Application for the InnoDB memcached Plugin

Consider these aspects of MySQL and **InnoDB** tables when adapting existing **memcached** applications to use the **daemon\_memcached** plugin:

If there are key values longer than a few bytes, it may be more efficient to use a numeric auto-increment column as the [primary key](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_primary_key) of the **InnoDB** table, and to create a unique [secondary index](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_secondary_index) on the column that contains the **memcached** key values. This is because **InnoDB** performs best for large-scale insertions if primary key values are added in sorted order (as they are with auto-increment values). Primary key values are included in secondary indexes, which takes up unnecessary space if the primary key is a long string value.

If you store several different classes of information using **memcached**, consider setting up a separate **InnoDB** table for each type of data. Define additional table identifiers in the **innodb\_memcache.containers** table, and use the **@@*table\_id*.*key*** notation to store and retrieve items from different tables. Physically dividing different types of information allows you tune the characteristics of each table for optimum space utilization, performance, and reliability. For example, you might enable [compression](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_compression) for a table that holds blog posts, but not for a table that holds thumbnail images. You might back up one table more frequently than another because it holds critical data. You might create additional [secondary indexes](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_secondary_index) on tables that are frequently used to generate reports using SQL.

Preferably, configure a stable set of table definitions for use with the **daemon\_memcached** plugin, and leave the tables in place permanently. Changes to the **innodb\_memcache.containers** table take effect the next time the **innodb\_memcache.containers** table is queried. Entries in the containers table are processed at startup, and are consulted whenever an unrecognized table identifier (as defined by **containers.name**) is requested using **@@** notation. Thus, new entries are visible as soon as you use the associated table identifier, but changes to existing entries require a server restart before they take effect.

When you use the default **innodb\_only** caching policy, calls to **add()**, **set()**, **incr()**, and so on can succeed but still trigger debugging messages such as **while expecting 'STORED', got unexpected response 'NOT\_STORED**. Debug messages occur because new and updated values are sent directly to the **InnoDB** table without being saved in the memory cache, due to the **innodb\_only** caching policy.

#### 15.20.6.3 Tuning InnoDB memcached Plugin Performance

Because using **InnoDB** in combination with **memcached** involves writing all data to disk, whether immediately or sometime later, raw performance is expected to be somewhat slower than using **memcached** by itself. When using the **InnoDB** **memcached** plugin, focus tuning goals for **memcached** operations on achieving better performance than equivalent SQL operations.

Benchmarks suggest that queries and [DML](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_dml) operations (inserts, updates, and deletes) that use the **memcached** interface are faster than traditional SQL. DML operations typically see a larger improvements. Therefore, consider adapting write-intensive applications to use the **memcached** interface first. Also consider prioritizing adaptation of write-intensive applications that use fast, lightweight mechanisms that lack reliability.

##### Adapting SQL Queries

The types of queries that are most suited to simple **GET** requests are those with a single clause or a set of **AND** conditions in the **WHERE** clause:

SQL:

SELECT col FROM tbl WHERE key = 'key\_value';

memcached:

get key\_value

SQL:

SELECT col FROM tbl WHERE col1 = val1 and col2 = val2 and col3 = val3;

memcached:

# Since you must always know these 3 values to look up the key,

# combine them into a unique string and use that as the key

# for all ADD, SET, and GET operations.

key\_value = val1 + ":" + val2 + ":" + val3

get key\_value

SQL:

SELECT 'key exists!' FROM tbl

WHERE EXISTS (SELECT col1 FROM tbl WHERE KEY = 'key\_value') LIMIT 1;

memcached:

# Test for existence of key by asking for its value and checking if the call succeeds,

# ignoring the value itself. For existence checking, you typically only store a very

# short value such as "1".

get key\_value

##### Using System Memory

For best performance, deploy the **daemon\_memcached** plugin on machines that are configured as typical database servers, where the majority of system RAM is devoted to the **InnoDB** [buffer pool](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_buffer_pool), through the [**innodb\_buffer\_pool\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_size) configuration option. For systems with multi-gigabyte buffer pools, consider raising the value of [**innodb\_buffer\_pool\_instances**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_buffer_pool_instances) for maximum throughput when most operations involve data that is already cached in memory.

##### Reducing Redundant I/O

**InnoDB** has a number of settings that let you choose the balance between high reliability, in case of a crash, and the amount of I/O overhead during high write workloads. For example, consider setting the [**innodb\_doublewrite**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_doublewrite) to **0** and [**innodb\_flush\_log\_at\_trx\_commit**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_flush_log_at_trx_commit) to **2**. Measure performance with different [**innodb\_flush\_method**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_flush_method) settings.

For other ways to reduce or tune I/O for table operations, see [Section 8.5.8, “Optimizing InnoDB Disk I/O”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#optimizing-innodb-diskio).

##### Reducing Transactional Overhead

A default value of 1 for [**daemon\_memcached\_r\_batch\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_daemon_memcached_r_batch_size) and [**daemon\_memcached\_w\_batch\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_daemon_memcached_w_batch_size) is intended for maximum reliability of results and safety of stored or updated data.

Depending on the type of application, you might increase one or both of these settings to reduce the overhead of frequent [commit](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_commit) operations. On a busy system, you might increase [**daemon\_memcached\_r\_batch\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_daemon_memcached_r_batch_size), knowing that changes to data made through SQL may not become visible to **memcached** immediately (that is, until ***N*** more **get** operations are processed). When processing data where every write operation must be reliably stored, leave [**daemon\_memcached\_w\_batch\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_daemon_memcached_w_batch_size) set to **1**. Increase the setting when processing large numbers of updates intended only for statistical analysis, where losing the last ***N*** updates in an unexpected exit is an acceptable risk.

For example, imagine a system that monitors traffic crossing a busy bridge, recording data for approximately 100,000 vehicles each day. If the application counts different types of vehicles to analyze traffic patterns, changing [**daemon\_memcached\_w\_batch\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_daemon_memcached_w_batch_size) from **1** to **100** reduces I/O overhead for commit operations by 99%. In case of an outage, a maximum of 100 records are lost, which may be an acceptable margin of error. If instead the application performed automated toll collection for each car, you would set [**daemon\_memcached\_w\_batch\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_daemon_memcached_w_batch_size) to **1** to ensure that each toll record is immediately saved to disk.

Because of the way **InnoDB** organizes **memcached** key values on disk, if you have a large number of keys to create, it may be faster to sort the data items by key value in the application and **add** them in sorted order, rather than create keys in arbitrary order.

The **memslap** command, which is part of the regular **memcached** distribution but not included with the **daemon\_memcached** plugin, can be useful for benchmarking different configurations. It can also be used to generate sample key-value pairs to use in your own benchmarks. See [**libmemcached** Command-Line Utilities](https://dev.mysql.com/doc/refman/5.6/en/ha-memcached-interfaces-libmemcached.html#ha-memcached-interfaces-libmemcached-utilities) for details.

#### 15.20.6.4 Controlling Transactional Behavior of the InnoDB memcached Plugin

Unlike traditional **memcached**, the **daemon\_memcached** plugin allows you to control durability of data values produced through calls to **add**, **set**, **incr**, and so on. By default, data written through the **memcached** interface is stored to disk, and calls to **get** return the most recent value from disk. Although the default behavior does not offer the best possible raw performance, it is still fast compared to the SQL interface for **InnoDB** tables.

As you gain experience using the **daemon\_memcached** plugin, you can consider relaxing durability settings for non-critical classes of data, at the risk of losing some updated values in the event of an outage, or returning data that is slightly out-of-date.

##### Frequency of Commits

One tradeoff between durability and raw performance is how frequently new and changed data is [committed](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_commit). If data is critical, is should be committed immediately so that it is safe in case of an unexpected exit or outage. If data is less critical, such as counters that are reset after an unexpected exit or logging data that you can afford to lose, you might prefer higher raw throughput that is available with less frequent commits.

When a **memcached** operation inserts, updates, or deletes data in the underlying **InnoDB** table, the change might be committed to the **InnoDB** table instantly (if [**daemon\_memcached\_w\_batch\_size=1**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_daemon_memcached_w_batch_size)) or some time later (if the [**daemon\_memcached\_w\_batch\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_daemon_memcached_w_batch_size) value is greater than 1). In either case, the change cannot be rolled back. If you increase the value of [**daemon\_memcached\_w\_batch\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_daemon_memcached_w_batch_size) to avoid high I/O overhead during busy times, commits could become infrequent when the workload decreases. As a safety measure, a background thread automatically commits changes made through the **memcached** API at regular intervals. The interval is controlled by the [**innodb\_api\_bk\_commit\_interval**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_api_bk_commit_interval) configuration option, which has a default setting of **5** seconds.

When a **memcached** operation inserts or updates data in the underlying **InnoDB** table, the changed data is immediately visible to other **memcached** requests because the new value remains in the memory cache, even if it is not yet committed on the MySQL side.

##### Transaction Isolation

When a **memcached** operation such as **get** or **incr** causes a query or DML operation on the underlying **InnoDB** table, you can control whether the operation sees the very latest data written to the table, only data that has been committed, or other variations of transaction [isolation level](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_isolation_level). Use the [**innodb\_api\_trx\_level**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_api_trx_level) configuration option to control this feature. The numeric values specified for this option correspond to isolation levels such as [**REPEATABLE READ**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#isolevel_repeatable-read). See the description of the [**innodb\_api\_trx\_level**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_api_trx_level) option for information about other settings.

A strict isolation level ensures that data you retrieve is not rolled back or changed suddenly causing subsequent queries to return different values. However, strict isolation levels require greater [locking](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_locking) overhead, which can cause waits. For a NoSQL-style application that does not use long-running transactions, you can typically use the default isolation level or switch to a less strict isolation level.

##### Disabling Row Locks for memcached DML Operations

The [**innodb\_api\_disable\_rowlock**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_api_disable_rowlock) option can be used to disable row locks when **memcached** requests through the **daemon\_memcached** plugin cause DML operations. By default, **innodb\_api\_disable\_rowlock** is set to **OFF** which means that **memcached** requests row locks for **get** and **set** operations. When **innodb\_api\_disable\_rowlock** is set to **ON**, **memcached** requests a table lock instead of row locks.

The **innodb\_api\_disable\_rowlock** option is not dynamic. It must be specified at startup on the [**mysqld**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\programs.html#mysqld) command line or entered in a MySQL configuration file.

##### Allowing or Disallowing DDL

By default, you can perform [DDL](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_ddl) operations such as [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table) on tables used by the **daemon\_memcached** plugin. To avoid potential slowdowns when these tables are used for high-throughput applications, disable DDL operations on these tables by enabling [**innodb\_api\_enable\_mdl**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_api_enable_mdl) at startup. This option is less appropriate when accessing the same tables through both **memcached** and SQL, because it blocks [**CREATE INDEX**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#create-index) statements on the tables, which could be important for running reporting queries.

##### Storing Data on Disk, in Memory, or Both

The **innodb\_memcache.cache\_policies** table specifies whether to store data written through the **memcached** interface to disk (**innodb\_only**, the default); in memory only, as with traditional **memcached** (**cache\_only**); or both (**caching**).

With the **caching** setting, if **memcached** cannot find a key in memory, it searches for the value in an **InnoDB** table. Values returned from **get** calls under the **caching** setting could be out-of-date if the values were updated on disk in the **InnoDB** table but are not yet expired from the memory cache.

The caching policy can be set independently for **get**, **set** (including **incr** and **decr**), **delete**, and **flush** operations.

For example, you might allow **get** and **set** operations to query or update a table and the **memcached** memory cache at the same time (using the **caching** setting), while making **delete**, **flush**, or both operate only on the in-memory copy (using the **cache\_only** setting). That way, deleting or flushing an item only expires the item from the cache, and the latest value is returned from the **InnoDB** table the next time the item is requested.

mysql> **SELECT \* FROM innodb\_memcache.cache\_policies;**

+--------------+-------------+-------------+---------------+--------------+

| policy\_name | get\_policy | set\_policy | delete\_policy | flush\_policy |

+--------------+-------------+-------------+---------------+--------------+

| cache\_policy | innodb\_only | innodb\_only | innodb\_only | innodb\_only |

+--------------+-------------+-------------+---------------+--------------+

mysql> **UPDATE innodb\_memcache.cache\_policies SET set\_policy = 'caching'**

**WHERE policy\_name = 'cache\_policy';**

**innodb\_memcache.cache\_policies** values are only read at startup. After changing values in this table, uninstall and reinstall the **daemon\_memcached** plugin to ensure that changes take effect.

mysql> **UNINSTALL PLUGIN daemon\_memcached;**

mysql> **INSTALL PLUGIN daemon\_memcached soname "libmemcached.so";**

#### 15.20.6.5 Adapting DML Statements to memcached Operations

Benchmarks suggest that the **daemon\_memcached** plugin speeds up [DML](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_dml) operations (inserts, updates, and deletes) more than it speeds up queries. Therefore, consider focussing initial development efforts on write-intensive applications that are I/O-bound, and look for opportunities to use MySQL with the **daemon\_memcached** plugin for new write-intensive applications.

Single-row DML statements are the easiest types of statements to turn into **memcached** operations. **INSERT** becomes **add**, **UPDATE** becomes **set**, **incr** or **decr**, and **DELETE** becomes **delete**. These operations are guaranteed to only affect one row when issued through the **memcached** interface, because the ***key*** is unique within the table.

In the following SQL examples, **t1** refers to the table used for **memcached** operations, based on the configuration in the **innodb\_memcache.containers** table. **key** refers to the column listed under **key\_columns**, and **val** refers to the column listed under **value\_columns**.

INSERT INTO t1 (key,val) VALUES (***some\_key***,***some\_value***);

SELECT val FROM t1 WHERE key = ***some\_key***;

UPDATE t1 SET val = ***new\_value*** WHERE key = ***some\_key***;

UPDATE t1 SET val = val + x WHERE key = ***some\_key***;

DELETE FROM t1 WHERE key = ***some\_key***;

The following [**TRUNCATE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#truncate-table) and [**DELETE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#delete) statements, which remove all rows from the table, correspond to the **flush\_all** operation, where **t1** is configured as the table for **memcached** operations, as in the previous example.

TRUNCATE TABLE t1;

DELETE FROM t1;

#### 15.20.6.6 Performing DML and DDL Statements on the Underlying InnoDB Table

You can access the underlying **InnoDB** table (which is **test.demo\_test** by default) through standard SQL interfaces. However, there are some restrictions:

When querying a table that is also accessed through the **memcached** interface, remember that **memcached** operations can be configured to be committed periodically rather than after every write operation. This behavior is controlled by the [**daemon\_memcached\_w\_batch\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_daemon_memcached_w_batch_size) option. If this option is set to a value greater than **1**, use [**READ UNCOMMITTED**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#isolevel_read-uncommitted) queries to find rows that were just inserted.

mysql> **SET SESSSION TRANSACTION ISOLATION LEVEL READ UNCOMMITTED;**

mysql> **SELECT \* FROM demo\_test;**

+------+------+------+------+-----------+------+------+------+------+------+------+

| cx   | cy   | c1   | cz   | c2        | ca   | CB   | c3   | cu   | c4   | C5   |

+------+------+------+------+-----------+------+------+------+------+------+------+

| NULL | NULL | a11  | NULL | 123456789 | NULL | NULL |   10 | NULL |    3 | NULL |

+------+------+------+------+-----------+------+------+------+------+------+------+

When modifying a table using SQL that is also accessed through the **memcached** interface, you can configure **memcached** operations to start a new transaction periodically rather than for every read operation. This behavior is controlled by the [**daemon\_memcached\_r\_batch\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_daemon_memcached_r_batch_size) option. If this option is set to a value greater than **1**, changes made to the table using SQL are not immediately visible to **memcached** operations.

The **InnoDB** table is either IS (intention shared) or IX (intention exclusive) locked for all operations in a transaction. If you increase [**daemon\_memcached\_r\_batch\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_daemon_memcached_r_batch_size) and [**daemon\_memcached\_w\_batch\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_daemon_memcached_w_batch_size) substantially from their default value of **1**, the table is most likely locked between each operation, preventing [DDL](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_ddl) statements on the table.

### 15.20.7 The InnoDB memcached Plugin and Replication

Because the **daemon\_memcached** plugin supports the MySQL [binary log](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_binary_log), source server through the **memcached** interface can be replicated for backup, balancing intensive read workloads, and high availability. All **memcached** commands are supported with binary logging.

You do not need to set up the **daemon\_memcached** plugin on replica servers. The primary advantage of this configuration is increased write throughput on the source. The speed of the replication mechanism is not affected.

The following sections show how to use the binary log capability when using the **daemon\_memcached** plugin with MySQL replication. It is assumed that you have completed the setup described in [Section 15.20.3, “Setting Up the InnoDB memcached Plugin”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-memcached-setup).

#### Enabling the InnoDB memcached Binary Log

To use the **daemon\_memcached** plugin with the MySQL [binary log](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_binary_log), enable the [**innodb\_api\_enable\_binlog**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_api_enable_binlog) configuration option on the source server. This option can only be set at server startup. You must also enable the MySQL binary log on the source server using the [**--log-bin**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\replication.html#sysvar_log_bin) option. You can add these options to the MySQL configuration file, or on the [**mysqld**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\programs.html#mysqld) command line.

mysqld ... --log-bin -–innodb\_api\_enable\_binlog=1

Configure the source and replica server, as described in [Section 17.1.2, “Setting Up Binary Log File Position Based Replication”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\replication.html#replication-howto).

Use [**mysqldump**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\programs.html#mysqldump) to create a source data snapshot, and sync the snapshot to the replica server.

source shell> **mysqldump --all-databases --lock-all-tables > dbdump.db**

replica shell> **mysql < dbdump.db**

On the source server, issue [**SHOW MASTER STATUS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#show-master-status) to obtain the source binary log coordinates.

mysql> **SHOW MASTER STATUS;**

On the replica server, use a [**CHANGE REPLICATION SOURCE TO**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#change-replication-source-to) statement (from MySQL 8.0.23) or [**CHANGE MASTER TO**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#change-master-to) statement (before MySQL 8.0.23) to set up a replica server using the source binary log coordinates.

mysql> **CHANGE MASTER TO**

**MASTER\_HOST='localhost',**

**MASTER\_USER='root',**

**MASTER\_PASSWORD='',**

**MASTER\_PORT = 13000,**

**MASTER\_LOG\_FILE='0.000001,**

**MASTER\_LOG\_POS=114;**

Or from MySQL 8.0.23:

mysql> **CHANGE REPLICATION SOURCE TO**

**SOURCE\_HOST='localhost',**

**SOURCE\_USER='root',**

**SOURCE\_PASSWORD='',**

**SOURCE\_PORT = 13000,**

**SOURCE\_LOG\_FILE='0.000001,**

**SOURCE\_LOG\_POS=114;**

Start the replica.

mysql> **START SLAVE;**

Or from MySQL 8.0.22:

mysql> **START REPLICA;**

If the error log prints output similar to the following, the replica is ready for replication.

2013-09-24T13:04:38.639684Z 49 [Note] Replication I/O thread: connected to

source 'root@localhost:13000', replication started in log '0.000001'

at position 114

#### Testing the InnoDB memcached Replication Configuration

This example demonstrates how to test the **InnoDB** **memcached** replication configuration using the **memcached** and telnet to insert, update, and delete data. A MySQL client is used to verify results on the source and replica servers.

The example uses the **demo\_test** table, which was created by the innodb\_memcached\_config.sql configuration script during the initial setup of the **daemon\_memcached** plugin. The **demo\_test** table contains a single example record.

Use the **set** command to insert a record with a key of **test1**, a flag value of **10**, an expiration value of **0**, a cas value of 1, and a value of **t1**.

**telnet 127.0.0.1 11211**

Trying 127.0.0.1...

Connected to 127.0.0.1.

Escape character is '^]'.

**set test1 10 0 1**

**t1**

STORED

On the source server, check that the record was inserted into the **demo\_test** table. Assuming the **demo\_test** table was not previously modified, there should be two records. The example record with a key of **AA**, and the record you just inserted, with a key of **test1**. The **c1** column maps to the key, the **c2** column to the value, the **c3** column to the flag value, the **c4** column to the cas value, and the **c5** column to the expiration time. The expiration time was set to 0, since it is unused.

mysql> **SELECT \* FROM test.demo\_test;**

+-------+--------------+------+------+------+

| c1 | c2 | c3 | c4 | c5 |

+-------+--------------+------+------+------+

| AA | HELLO, HELLO | 8 | 0 | 0 |

| test1 | t1 | 10 | 1 | 0 |

+-------+--------------+------+------+------+

Check to verify that the same record was replicated to the replica server.

mysql> **SELECT \* FROM test.demo\_test;**

+-------+--------------+------+------+------+

| c1 | c2 | c3 | c4 | c5 |

+-------+--------------+------+------+------+

| AA | HELLO, HELLO | 8 | 0 | 0 |

| test1 | t1 | 10 | 1 | 0 |

+-------+--------------+------+------+------+

Use the **set** command to update the key to a value of **new**.

**telnet 127.0.0.1 11211**

Trying 127.0.0.1...

Connected to 127.0.0.1.

Escape character is '^]'.

**set test1 10 0 2**

**new**

STORED

The update is replicated to the replica server (notice that the **cas** value is also updated).

mysql> **SELECT \* FROM test.demo\_test;**

+-------+--------------+------+------+------+

| c1 | c2 | c3 | c4 | c5 |

+-------+--------------+------+------+------+

| AA | HELLO, HELLO | 8 | 0 | 0 |

| test1 | new | 10 | 2 | 0 |

+-------+--------------+------+------+------+

Delete the **test1** record using a **delete** command.

**telnet 127.0.0.1 11211**

Trying 127.0.0.1...

Connected to 127.0.0.1.

Escape character is '^]'.

**delete test1**

DELETED

When the **delete** operation is replicated to the replica, the **test1** record on the replica is also deleted.

mysql> **SELECT \* FROM test.demo\_test;**

+----+--------------+------+------+------+

| c1 | c2 | c3 | c4 | c5 |

+----+--------------+------+------+------+

| AA | HELLO, HELLO | 8 | 0 | 0 |

+----+--------------+------+------+------+

Remove all rows from the table using the **flush\_all** command.

**telnet 127.0.0.1 11211**

Trying 127.0.0.1...

Connected to 127.0.0.1.

Escape character is '^]'.

**flush\_all**

OK

mysql> **SELECT \* FROM test.demo\_test;**

Empty set (0.00 sec)

Telnet to the source server and enter two new records.

**telnet 127.0.0.1 11211**

Trying 127.0.0.1...

Connected to 127.0.0.1.

Escape character is '^]'

**set test2 10 0 4**

**again**

STORED

**set test3 10 0 5**

**again1**

STORED

Confirm that the two records were replicated to the replica server.

mysql> **SELECT \* FROM test.demo\_test;**

+-------+--------------+------+------+------+

| c1 | c2 | c3 | c4 | c5 |

+-------+--------------+------+------+------+

| test2 | again | 10 | 4 | 0 |

| test3 | again1 | 10 | 5 | 0 |

+-------+--------------+------+------+------+

Remove all rows from the table using the **flush\_all** command.

**telnet 127.0.0.1 11211**

Trying 127.0.0.1...

Connected to 127.0.0.1.

Escape character is '^]'.

**flush\_all**

OK

Check to ensure that the **flush\_all** operation was replicated on the replica server.

mysql> **SELECT \* FROM test.demo\_test;**

Empty set (0.00 sec)

#### InnoDB memcached Binary Log Notes

Binary Log Format:

Most **memcached** operations are mapped to [DML](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_dml) statements (analogous to insert, delete, update). Since there is no actual SQL statement being processed by the MySQL server, all **memcached** commands (except for **flush\_all**) use Row-Based Replication (RBR) logging, which is independent of any server [**binlog\_format**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\replication.html#sysvar_binlog_format) setting.

The **memcached** **flush\_all** command is mapped to the [**TRUNCATE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#truncate-table) command in MySQL 5.7 and earlier. Since [DDL](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_ddl) commands can only use statement-based logging, the **flush\_all** command is replicated by sending a [**TRUNCATE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#truncate-table) statement. In MySQL 8.0 and later, **flush\_all** is mapped to **DELETE** but is still replicated by sending a [**TRUNCATE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#truncate-table) statement.

Transactions:

The concept of [transactions](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_transaction) has not typically been part of **memcached** applications. For performance considerations, [**daemon\_memcached\_r\_batch\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_daemon_memcached_r_batch_size) and [**daemon\_memcached\_w\_batch\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_daemon_memcached_w_batch_size) are used to control the batch size for read and write transactions. These settings do not affect replication. Each SQL operation on the underlying **InnoDB** table is replicated after successful completion.

The default value of [**daemon\_memcached\_w\_batch\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_daemon_memcached_w_batch_size) is **1**, which means that each **memcached** write operation is committed immediately. This default setting incurs a certain amount of performance overhead to avoid inconsistencies in the data that is visible on the source and replica servers. The replicated records are always available immediately on the replica server. If you set [**daemon\_memcached\_w\_batch\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_daemon_memcached_w_batch_size) to a value greater than **1**, records inserted or updated through **memcached** are not immediately visible on the source server; to view the records on the source server before they are committed, issue [**SET TRANSACTION ISOLATION LEVEL READ UNCOMMITTED**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#set-transaction).

### 15.20.8 InnoDB memcached Plugin Internals

#### InnoDB API for the InnoDB memcached Plugin

The **InnoDB** **memcached** engine accesses **InnoDB** through **InnoDB** APIs, most of which are directly adopted from embedded **InnoDB**. **InnoDB** API functions are passed to the **InnoDB** **memcached** engine as callback functions. **InnoDB** API functions access the **InnoDB** tables directly, and are mostly DML operations with the exception of [**TRUNCATE TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#truncate-table).

**memcached** commands are implemented through the **InnoDB** **memcached** API. The following table outlines how **memcached** commands are mapped to DML or DDL operations.

**Table 15.27 memcached Commands and Associated DML or DDL Operations**

| **memcached Command** | **DML or DDL Operations** |
| --- | --- |
| **get** | a read/fetch command |
| **set** | a search followed by an **INSERT** or **UPDATE** (depending on whether or not a key exists) |
| **add** | a search followed by an **INSERT** or **UPDATE** |
| **replace** | a search followed by an **UPDATE** |
| **append** | a search followed by an **UPDATE** (appends data to the result before **UPDATE**) |
| **prepend** | a search followed by an **UPDATE** (prepends data to the result before **UPDATE**) |
| **incr** | a search followed by an **UPDATE** |
| **decr** | a search followed by an **UPDATE** |
| **delete** | a search followed by a **DELETE** |
| **flush\_all** | **TRUNCATE TABLE** (DDL) |

#### InnoDB memcached Plugin Configuration Tables

This section describes configuration tables used by the **daemon\_memcached** plugin. The **cache\_policies** table, **config\_options** table, and **containers** table are created by the innodb\_memcached\_config.sql configuration script in the **innodb\_memcache** database.

mysql> **USE innodb\_memcache;**

Database changed

mysql> **SHOW TABLES;**

+---------------------------+

| Tables\_in\_innodb\_memcache |

+---------------------------+

| cache\_policies |

| config\_options |

| containers |

+---------------------------+

#### cache\_policies Table

The **cache\_policies** table defines a cache policy for the **InnoDB** **memcached** installation. You can specify individual policies for **get**, **set**, **delete**, and **flush** operations, within a single cache policy. The default setting for all operations is **innodb\_only**.

**innodb\_only**: Use **InnoDB** as the data store.

**cache\_only**: Use the **memcached** engine as the data store.

**caching**: Use both **InnoDB** and the **memcached** engine as data stores. In this case, if **memcached** cannot find a key in memory, it searches for the value in an **InnoDB** table.

**disable**: Disable caching.

**Table 15.28 cache\_policies Columns**

| **Column** | **Description** |
| --- | --- |
| **policy\_name** | Name of the cache policy. The default cache policy name is **cache\_policy**. |
| **get\_policy** | The cache policy for get operations. Valid values are **innodb\_only**, **cache\_only**, **caching**, or **disabled**. The default setting is **innodb\_only**. |
| **set\_policy** | The cache policy for set operations. Valid values are **innodb\_only**, **cache\_only**, **caching**, or **disabled**. The default setting is **innodb\_only**. |
| **delete\_policy** | The cache policy for delete operations. Valid values are **innodb\_only**, **cache\_only**, **caching**, or **disabled**. The default setting is **innodb\_only**. |
| **flush\_policy** | The cache policy for flush operations. Valid values are **innodb\_only**, **cache\_only**, **caching**, or **disabled**. The default setting is **innodb\_only**. |

#### config\_options Table

The **config\_options** table stores **memcached**-related settings that can be changed at runtime using SQL. Supported configuration options are **separator** and **table\_map\_delimiter**.

**Table 15.29 config\_options Columns**

| **Column** | **Description** |
| --- | --- |
| **Name** | Name of the **memcached**-related configuration option. The following configuration options are supported by the **config\_options** table:  **separator**: Used to separate values of a long string into separate values when there are multiple **value\_columns** defined. By default, the **separator** is a **|** character. For example, if you define **col1, col2** as value columns, and you define **|** as the separator, you can issue the following **memcached** command to insert values into **col1** and **col2**, respectively:  set keyx 10 0 19  valuecolx|valuecoly  **valuecol1x** is stored in **col1** and **valuecoly** is stored in **col2**.  **table\_map\_delimiter**: The character separating the schema name and the table name when you use the **@@** notation in a key name to access a key in a specific table. For example, **@@t1.some\_key** and **@@t2.some\_key** have the same key value, but are stored in different tables. |
| **Value** | The value assigned to the **memcached**-related configuration option. |

#### containers Table

The **containers** table is the most important of the three configuration tables. Each **InnoDB** table that is used to store **memcached** values must have an entry in the **containers** table. The entry provides a mapping between **InnoDB** table columns and container table columns, which is required for **memcached** to work with **InnoDB** tables.

The **containers** table contains a default entry for the **test.demo\_test** table, which is created by the innodb\_memcached\_config.sql configuration script. To use the **daemon\_memcached** plugin with your own **InnoDB** table, you must create an entry in the **containers** table.

**Table 15.30 containers Columns**

| **Column** | **Description** |
| --- | --- |
| **name** | The name given to the container. If an **InnoDB** table is not requested by name using **@@** notation, the **daemon\_memcached** plugin uses the **InnoDB** table with a **containers.name** value of **default**. If there is no such entry, the first entry in the **containers** table, ordered alphabetically by **name** (ascending), determines the default **InnoDB** table. |
| **db\_schema** | The name of the database where the **InnoDB** table resides. This is a required value. |
| **db\_table** | The name of the **InnoDB** table that stores **memcached** values. This is a required value. |
| **key\_columns** | The column in the **InnoDB** table that contains lookup key values for **memcached** operations. This is a required value. |
| **value\_columns** | The **InnoDB** table columns (one or more) that store **memcached** data. Multiple columns can be specified using the separator character specified in the **innodb\_memcached.config\_options** table. By default, the separator is a pipe character (“|”). To specify multiple columns, separate them with the defined separator character. For example: **col1|col2|col3**. This is a required value. |
| **flags** | The **InnoDB** table columns that are used as flags (a user-defined numeric value that is stored and retrieved along with the main value) for **memcached**. A flag value can be used as a column specifier for some operations (such as **incr**, **prepend**) if a **memcached** value is mapped to multiple columns, so that an operation is performed on a specified column. For example, if you have mapped a **value\_columns** to three **InnoDB** table columns, and only want the increment operation performed on one columns, use the **flags** column to specify the column. If you do not use the **flags** column, set a value of **0** to indicate that it is unused. |
| **cas\_column** | The **InnoDB** table column that stores compare-and-swap (cas) values. The **cas\_column** value is related to the way **memcached** hashes requests to different servers and caches data in memory. Because the **InnoDB** **memcached** plugin is tightly integrated with a single **memcached** daemon, and the in-memory caching mechanism is handled by MySQL and the [InnoDB buffer pool](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_buffer_pool), this column is rarely needed. If you do not use this column, set a value of **0** to indicate that it is unused. |
| **expire\_time\_column** | The **InnoDB** table column that stores expiration values. The **expire\_time\_column** value is related to the way **memcached** hashes requests to different servers and caches data in memory. Because the **InnoDB** **memcached** plugin is tightly integrated with a single **memcached** daemon, and the in-memory caching mechanism is handled by MySQL and the [InnoDB buffer pool](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_buffer_pool), this column is rarely needed. If you do not use this column, set a value of **0** to indicate that the column is unused. The maximum expire time is defined as **INT\_MAX32** or 2147483647 seconds (approximately 68 years). |
| **unique\_idx\_name\_on\_key** | The name of the index on the key column. It must be a unique index. It can be the [primary key](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_primary_key) or a [secondary index](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_secondary_index). Preferably, use the primary key of the **InnoDB** table. Using the primary key avoids a lookup that is performed when using a secondary index. You cannot make a [covering index](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_covering_index) for **memcached** lookups; **InnoDB** returns an error if you try to define a composite secondary index over both the key and value columns. |

##### containers Table Column Constraints

You must supply a value for **db\_schema**, **db\_name**, **key\_columns**, **value\_columns** and **unique\_idx\_name\_on\_key**. Specify **0** for **flags**, **cas\_column**, and **expire\_time\_column** if they are unused. Failing to do so could cause your setup to fail.

**key\_columns**: The maximum limit for a **memcached** key is 250 characters, which is enforced by **memcached**. The mapped key must be a non-Null [**CHAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-types.html#char) or [**VARCHAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-types.html#char) type.

**value\_columns**: Must be mapped to a [**CHAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-types.html#char), [**VARCHAR**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-types.html#char), or [**BLOB**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-types.html#blob) column. There is no length restriction and the value can be NULL.

**cas\_column**: The **cas** value is a 64 bit integer. It must be mapped to a [**BIGINT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-types.html#integer-types) of at least 8 bytes. If you do not use this column, set a value of **0** to indicate that it is unused.

**expiration\_time\_column**: Must mapped to an [**INTEGER**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-types.html#integer-types) of at least 4 bytes. Expiration time is defined as a 32-bit integer for Unix time (the number of seconds since January 1, 1970, as a 32-bit value), or the number of seconds starting from the current time. For the latter, the number of seconds may not exceed 60\*60\*24\*30 (the number of seconds in 30 days). If the number sent by a client is larger, the server considers it to be a real Unix time value rather than an offset from the current time. If you do not use this column, set a value of **0** to indicate that it is unused.

**flags**: Must be mapped to an [**INTEGER**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-types.html#integer-types) of at least 32-bits and can be NULL. If you do not use this column, set a value of **0** to indicate that it is unused.

A pre-check is performed at plugin load time to enforce column constraints. If mismatches are found, the plugin is not loaded.

##### Multiple Value Column Mapping

During plugin initialization, when **InnoDB** **memcached** is configured with information defined in the **containers** table, each mapped column defined in **containers.value\_columns** is verified against the mapped **InnoDB** table. If multiple **InnoDB** table columns are mapped, there is a check to ensure that each column exists and is the right type.

At run-time, for **memcached** insert operations, if there are more delimited values than the number of mapped columns, only the number of mapped values are taken. For example, if there are six mapped columns, and seven delimited values are provided, only the first six delimited values are taken. The seventh delimited value is ignored.

If there are fewer delimited values than mapped columns, unfilled columns are set to NULL. If an unfilled column cannot be set to NULL, insert operations fail.

If a table has more columns than mapped values, the extra columns do not affect results.

#### The demo\_test Example Table

The innodb\_memcached\_config.sql configuration script creates a **demo\_test** table in the **test** database, which can be used to verify **InnoDB** **memcached** plugin installation immediately after setup.

The innodb\_memcached\_config.sql configuration script also creates an entry for the **demo\_test** table in the **innodb\_memcache.containers** table.

mysql> **SELECT \* FROM innodb\_memcache.containers\G**

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\* 1. row \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

name: aaa

db\_schema: test

db\_table: demo\_test

key\_columns: c1

value\_columns: c2

flags: c3

cas\_column: c4

expire\_time\_column: c5

unique\_idx\_name\_on\_key: PRIMARY

mysql> **SELECT \* FROM test.demo\_test;**

+----+------------------+------+------+------+

| c1 | c2 | c3 | c4 | c5 |

+----+------------------+------+------+------+

| AA | HELLO, HELLO | 8 | 0 | 0 |

+----+------------------+------+------+------+

### 15.20.9 Troubleshooting the InnoDB memcached Plugin

This section describes issues that you may encounter when using the **InnoDB** **memcached** plugin.

If you encounter the following error in the MySQL error log, the server might fail to start:

failed to set rlimit for open files. Try running as root or requesting smaller maxconns value.

The error message is from the **memcached** daemon. One solution is to raise the OS limit for the number of open files. The commands for checking and increasing the open file limit varies by operating system. This example shows commands for Linux and macOS:

# Linux

shell> **ulimit -n**

1024

shell> **ulimit -n 4096**

shell> **ulimit -n**

4096

# macOS

shell> **ulimit -n**

256

shell> **ulimit -n 4096**

shell> **ulimit -n**

4096

The other solution is to reduce the number of concurrent connections permitted for the **memcached** daemon. To do so, encode the **-c** **memcached** option in the [**daemon\_memcached\_option**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_daemon_memcached_option) configuration parameter in the MySQL configuration file. The **-c** option has a default value of 1024.

[mysqld]

...

loose-daemon\_memcached\_option='-c 64'

To troubleshoot problems where the **memcached** daemon is unable to store or retrieve **InnoDB** table data, encode the **-vvv** **memcached** option in the [**daemon\_memcached\_option**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_daemon_memcached_option) configuration parameter in the MySQL configuration file. Examine the MySQL error log for debug output related to **memcached** operations.

[mysqld]

...

loose-daemon\_memcached\_option='-vvv'

If columns specified to hold **memcached** values are the wrong data type, such as a numeric type instead of a string type, attempts to store key-value pairs fail with no specific error code or message.

If the **daemon\_memcached** plugin causes MySQL server startup issues, you can temporarily disable the **daemon\_memcached** plugin while troubleshooting by adding this line under the **[mysqld]** group in the MySQL configuration file:

daemon\_memcached=OFF

For example, if you run the [**INSTALL PLUGIN**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#install-plugin) statement before running the innodb\_memcached\_config.sql configuration script to set up the necessary database and tables, the server might unexpectedly exit and fail to start. The server could also fail to start if you incorrectly configure an entry in the **innodb\_memcache.containers** table.

To uninstall the **memcached** plugin for a MySQL instance, issue the following statement:

mysql> **UNINSTALL PLUGIN daemon\_memcached;**

If you run more than one instance of MySQL on the same machine with the **daemon\_memcached** plugin enabled in each instance, use the [**daemon\_memcached\_option**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_daemon_memcached_option) configuration parameter to specify a unique **memcached** port for each **daemon\_memcached** plugin.

If an SQL statement cannot find the **InnoDB** table or finds no data in the table, but **memcached** API calls retrieve the expected data, you may be missing an entry for the **InnoDB** table in the **innodb\_memcache.containers** table, or you may have not switched to the correct **InnoDB** table by issuing a **get** or **set** request using **@@*table\_id*** notation. This problem could also occur if you change an existing entry in the **innodb\_memcache.containers** table without restarting the MySQL server afterward. The free-form storage mechanism is flexible enough that your requests to store or retrieve a multi-column value such as **col1|col2|col3** may still work, even if the daemon is using the **test.demo\_test** table which stores values in a single column.

When defining your own **InnoDB** table for use with the **daemon\_memcached** plugin, and columns in the table are defined as **NOT NULL**, ensure that values are supplied for the **NOT NULL** columns when inserting a record for the table into the **innodb\_memcache.containers** table. If the [**INSERT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#insert) statement for the **innodb\_memcache.containers** record contains fewer delimited values than there are mapped columns, unfilled columns are set to **NULL**. Attempting to insert a **NULL** value into a **NOT NULL** column causes the [**INSERT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#insert) to fail, which may only become evident after you reinitialize the **daemon\_memcached** plugin to apply changes to the **innodb\_memcache.containers** table.

If **cas\_column** and **expire\_time\_column** fields of the **innodb\_memcached.containers** table are set to **NULL**, the following error is returned when attempting to load the **memcached** plugin:

InnoDB\_Memcached: column 6 in the entry for config table 'containers' in

database 'innodb\_memcache' has an invalid NULL value.

The **memcached** plugin rejects usage of **NULL** in the **cas\_column** and **expire\_time\_column** columns. Set the value of these columns to **0** when the columns are unused.

As the length of the **memcached** key and values increase, you might encounter size and length limits.

When the key exceeds 250 bytes, **memcached** operations return an error. This is currently a fixed limit within **memcached**.

**InnoDB** table limits may be encountered if values exceed 768 bytes in size, 3072 bytes in size, or half of the [**innodb\_page\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_page_size) value. These limits primarily apply if you intend to create an index on a value column to run report-generating queries on that column using SQL. See [Section 15.22, “InnoDB Limits”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-limits) for details.

The maximum size for the key-value combination is 1 MB.

If you share configuration files across MySQL servers of different versions, using the latest configuration options for the **daemon\_memcached** plugin could cause startup errors on older MySQL versions. To avoid compatibility problems, use the **loose** prefix with option names. For example, use **loose-daemon\_memcached\_option='-c 64'** instead of **daemon\_memcached\_option='-c 64'**.

There is no restriction or check in place to validate character set settings. **memcached** stores and retrieves keys and values in bytes and is therefore not character set sensitive. However, you must ensure that the **memcached** client and the MySQL table use the same character set.

**memcached** connections are blocked from accessing tables that contain an indexed virtual column. Accessing an indexed virtual column requires a callback to the server, but a **memcached** connection does not have access to the server code.

## 15.21 InnoDB Troubleshooting

[15.21.1 Troubleshooting InnoDB I/O Problems](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#error-creating-innodb)

[15.21.2 Forcing InnoDB Recovery](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#forcing-innodb-recovery)

[15.21.3 Troubleshooting InnoDB Data Dictionary Operations](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-troubleshooting-datadict)

[15.21.4 InnoDB Error Handling](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-error-handling)

The following general guidelines apply to troubleshooting **InnoDB** problems:

When an operation fails or you suspect a bug, look at the MySQL server error log (see [Section 5.4.2, “The Error Log”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#error-log)). [Server Error Message Reference](https://dev.mysql.com/doc/mysql-errors/8.0/en/server-error-reference.html) provides troubleshooting information for some of the common **InnoDB**-specific errors that you may encounter.

If the failure is related to a [deadlock](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_deadlock), run with the [**innodb\_print\_all\_deadlocks**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_print_all_deadlocks) option enabled so that details about each deadlock are printed to the MySQL server error log. For information about deadlocks, see [Section 15.7.5, “Deadlocks in InnoDB”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-deadlocks).

If the issue is related to the **InnoDB** data dictionary, see [Section 15.21.3, “Troubleshooting InnoDB Data Dictionary Operations”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-troubleshooting-datadict).

When troubleshooting, it is usually best to run the MySQL server from the command prompt, rather than through [**mysqld\_safe**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\programs.html#mysqld-safe) or as a Windows service. You can then see what [**mysqld**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\programs.html#mysqld) prints to the console, and so have a better grasp of what is going on. On Windows, start [**mysqld**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\programs.html#mysqld) with the [--console](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\server-administration.html#option_mysqld_console) option to direct the output to the console window.

Enable the **InnoDB** Monitors to obtain information about a problem (see [Section 15.17, “InnoDB Monitors”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-monitors)). If the problem is performance-related, or your server appears to be hung, you should enable the standard Monitor to print information about the internal state of **InnoDB**. If the problem is with locks, enable the Lock Monitor. If the problem is with table creation, tablespaces, or data dictionary operations, refer to the [InnoDB Information Schema system tables](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-information-schema-system-tables) to examine contents of the **InnoDB** internal data dictionary.

**InnoDB** temporarily enables standard **InnoDB** Monitor output under the following conditions:

A long semaphore wait

**InnoDB** cannot find free blocks in the buffer pool

Over 67% of the buffer pool is occupied by lock heaps or the adaptive hash index

If you suspect that a table is corrupt, run [**CHECK TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#check-table) on that table.

### 15.21.1 Troubleshooting InnoDB I/O Problems

The troubleshooting steps for **InnoDB** I/O problems depend on when the problem occurs: during startup of the MySQL server, or during normal operations when a DML or DDL statement fails due to problems at the file system level.

#### Initialization Problems

If something goes wrong when **InnoDB** attempts to initialize its tablespace or its log files, delete all files created by **InnoDB**: all ibdata files and all ib\_logfile files. If you already created some **InnoDB** tables, also delete any .ibd files from the MySQL database directories. Then try the **InnoDB** database creation again. For easiest troubleshooting, start the MySQL server from a command prompt so that you see what is happening.

#### Runtime Problems

If **InnoDB** prints an operating system error during a file operation, usually the problem has one of the following solutions:

Make sure the **InnoDB** data file directory and the **InnoDB** log directory exist.

Make sure [**mysqld**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\programs.html#mysqld) has access rights to create files in those directories.

Make sure [**mysqld**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\programs.html#mysqld) can read the proper my.cnf or my.ini option file, so that it starts with the options that you specified.

Make sure the disk is not full and you are not exceeding any disk quota.

Make sure that the names you specify for subdirectories and data files do not clash.

Doublecheck the syntax of the [**innodb\_data\_home\_dir**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_data_home_dir) and [**innodb\_data\_file\_path**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_data_file_path) values. In particular, any **MAX** value in the [**innodb\_data\_file\_path**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_data_file_path) option is a hard limit, and exceeding that limit causes a fatal error.

### 15.21.2 Forcing InnoDB Recovery

To investigate database page corruption, you might dump your tables from the database with [**SELECT ... INTO OUTFILE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#select-into). Usually, most of the data obtained in this way is intact. Serious corruption might cause **SELECT \* FROM *tbl\_name*** statements or **InnoDB** background operations to unexpectedly exit or assert, or even cause **InnoDB** roll-forward recovery to crash. In such cases, you can use the [**innodb\_force\_recovery**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_force_recovery) option to force the **InnoDB** storage engine to start up while preventing background operations from running, so that you can dump your tables. For example, you can add the following line to the **[mysqld]** section of your option file before restarting the server:

[mysqld]

innodb\_force\_recovery = 1

For information about using option files, see [Section 4.2.2.2, “Using Option Files”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\programs.html#option-files).

**Warning**

Only set [**innodb\_force\_recovery**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_force_recovery) to a value greater than 0 in an emergency situation, so that you can start **InnoDB** and dump your tables. Before doing so, ensure that you have a backup copy of your database in case you need to recreate it. Values of 4 or greater can permanently corrupt data files. Only use an [**innodb\_force\_recovery**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_force_recovery) setting of 4 or greater on a production server instance after you have successfully tested the setting on a separate physical copy of your database. When forcing **InnoDB** recovery, you should always start with [**innodb\_force\_recovery=1**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_force_recovery) and only increase the value incrementally, as necessary.

[**innodb\_force\_recovery**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_force_recovery) is 0 by default (normal startup without forced recovery). The permissible nonzero values for [**innodb\_force\_recovery**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_force_recovery) are 1 to 6. A larger value includes the functionality of lesser values. For example, a value of 3 includes all of the functionality of values 1 and 2.

If you are able to dump your tables with an [**innodb\_force\_recovery**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_force_recovery) value of 3 or less, then you are relatively safe that only some data on corrupt individual pages is lost. A value of 4 or greater is considered dangerous because data files can be permanently corrupted. A value of 6 is considered drastic because database pages are left in an obsolete state, which in turn may introduce more corruption into [B-trees](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_b_tree) and other database structures.

As a safety measure, **InnoDB** prevents [**INSERT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#insert), [**UPDATE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#update), or [**DELETE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#delete) operations when [**innodb\_force\_recovery**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_force_recovery) is greater than 0. An [**innodb\_force\_recovery**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_force_recovery) setting of 4 or greater places **InnoDB** in read-only mode.

**1** (**SRV\_FORCE\_IGNORE\_CORRUPT**)

Lets the server run even if it detects a corrupt [page](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_page). Tries to make **SELECT \* FROM *tbl\_name*** jump over corrupt index records and pages, which helps in dumping tables.

**2** (**SRV\_FORCE\_NO\_BACKGROUND**)

Prevents the [master thread](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_master_thread) and any [purge threads](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_purge_thread) from running. If an unexpected exit would occur during the [purge](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_purge) operation, this recovery value prevents it.

**3** (**SRV\_FORCE\_NO\_TRX\_UNDO**)

Does not run transaction [rollbacks](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_rollback) after [crash recovery](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_crash_recovery).

**4** (**SRV\_FORCE\_NO\_IBUF\_MERGE**)

Prevents [insert buffer](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_insert_buffer) merge operations. If they would cause a crash, does not do them. Does not calculate table [statistics](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_statistics). This value can permanently corrupt data files. After using this value, be prepared to drop and recreate all secondary indexes. Sets **InnoDB** to read-only.

**5** (**SRV\_FORCE\_NO\_UNDO\_LOG\_SCAN**)

Does not look at [undo logs](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_undo_log) when starting the database: **InnoDB** treats even incomplete transactions as committed. This value can permanently corrupt data files. Sets **InnoDB** to read-only.

**6** (**SRV\_FORCE\_NO\_LOG\_REDO**)

Does not do the [redo log](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_redo_log) roll-forward in connection with recovery. This value can permanently corrupt data files. Leaves database pages in an obsolete state, which in turn may introduce more corruption into B-trees and other database structures. Sets **InnoDB** to read-only.

You can [**SELECT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#select) from tables to dump them. With an [**innodb\_force\_recovery**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_force_recovery) value of 3 or less you can **DROP** or **CREATE** tables. [**DROP TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#drop-table) is also supported with an [**innodb\_force\_recovery**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_force_recovery) value greater than 3. [**DROP TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#drop-table) is not permitted with an [**innodb\_force\_recovery**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_force_recovery) value greater than 4.

If you know that a given table is causing an unexpected exit on rollback, you can drop it. If you encounter a runaway rollback caused by a failing mass import or [**ALTER TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#alter-table), you can kill the [**mysqld**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\programs.html#mysqld) process and set [**innodb\_force\_recovery**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_force_recovery) to **3** to bring the database up without the rollback, and then **DROP** the table that is causing the runaway rollback.

If corruption within the table data prevents you from dumping the entire table contents, a query with an **ORDER BY *primary\_key* DESC** clause might be able to dump the portion of the table after the corrupted part.

If a high [**innodb\_force\_recovery**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_force_recovery) value is required to start **InnoDB**, there may be corrupted data structures that could cause complex queries (queries containing **WHERE**, **ORDER BY**, or other clauses) to fail. In this case, you may only be able to run basic **SELECT \* FROM t** queries.

### 15.21.3 Troubleshooting InnoDB Data Dictionary Operations

Information about table definitions is stored in the InnoDB [data dictionary](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_data_dictionary). If you move data files around, dictionary data can become inconsistent.

If a data dictionary corruption or consistency issue prevents you from starting **InnoDB**, see [Section 15.21.2, “Forcing InnoDB Recovery”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#forcing-innodb-recovery) for information about manual recovery.

#### Cannot Open Datafile

With [**innodb\_file\_per\_table**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_file_per_table) enabled (the default), the following messages may appear at startup if a [file-per-table](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_file_per_table) tablespace file (**.ibd** file) is missing:

[ERROR] InnoDB: Operating system error number 2 in a file operation.

[ERROR] InnoDB: The error means the system cannot find the path specified.

[ERROR] InnoDB: Cannot open datafile for read-only: './test/t1.ibd' OS error: 71

[Warning] InnoDB: Ignoring tablespace `test/t1` because it could not be opened.

To address these messages, issue [**DROP TABLE**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#drop-table) statement to remove data about the missing table from the data dictionary.

#### Restoring Orphan File-Per-Table ibd Files

This procedure describes how to restore orphan [file-per-table](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_file_per_table) .ibd files to another MySQL instance. You might use this procedure if the system tablespace is lost or unrecoverable and you want to restore .ibd file backups on a new MySQL instance.

The procedure is not supported for [general tablespace](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_general_tablespace) .ibd files.

The procedure assumes that you only have .ibd file backups, you are recovering to the same version of MySQL that initially created the orphan .ibd files, and that .ibd file backups are clean. See [Section 15.6.1.4, “Moving or Copying InnoDB Tables”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-migration) for information about creating clean backups.

Table import limitations outlined in [Section 15.6.1.3, “Importing InnoDB Tables”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-table-import) are applicable to this procedure.

On the new MySQL instance, recreate the table in a database of the same name.

mysql> **CREATE DATABASE sakila;**

mysql> **USE sakila;**

mysql> **CREATE TABLE actor (**

**actor\_id SMALLINT UNSIGNED NOT NULL AUTO\_INCREMENT,**

**first\_name VARCHAR(45) NOT NULL,**

**last\_name VARCHAR(45) NOT NULL,**

**last\_update TIMESTAMP NOT NULL DEFAULT CURRENT\_TIMESTAMP ON UPDATE CURRENT\_TIMESTAMP,**

**PRIMARY KEY (actor\_id),**

**KEY idx\_actor\_last\_name (last\_name)**

**)ENGINE=InnoDB DEFAULT CHARSET=utf8;**

Discard the tablespace of the newly created table.

mysql> **ALTER TABLE sakila.actor DISCARD TABLESPACE;**

Copy the orphan **.ibd** file from your backup directory to the new database directory.

shell> **cp /backup\_directory/actor.ibd *path/to/mysql-5.7/data*/sakila/**

Ensure that the .ibd file has the necessary file permissions.

Import the orphan **.ibd** file. A warning is issued indicating that **InnoDB** is attempting to import the file without schema verification.

mysql> **ALTER TABLE sakila.actor IMPORT TABLESPACE; SHOW WARNINGS;**

Query OK, 0 rows affected, 1 warning (0.15 sec)

Warning | 1810 | InnoDB: IO Read error: (2, No such file or directory)

Error opening './sakila/actor.cfg', will attempt to import

without schema verification

Query the table to verify that the **.ibd** file was successfully restored.

mysql> **SELECT COUNT(\*) FROM sakila.actor;**

+----------+

| count(\*) |

+----------+

| 200 |

+----------+

### 15.21.4 InnoDB Error Handling

The following items describe how **InnoDB** performs error handling. **InnoDB** sometimes rolls back only the statement that failed, other times it rolls back the entire transaction.

If you run out of file space in a [tablespace](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_tablespace), a MySQL **Table is full** error occurs and **InnoDB** rolls back the SQL statement.

A transaction [deadlock](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_deadlock) causes **InnoDB** to [roll back](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_rollback) the entire [transaction](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_transaction). Retry the entire transaction when this happens.

A lock wait timeout causes **InnoDB** to roll back the current statement (the statement that was waiting for the lock and encountered the timeout). To have the entire transaction roll back, start the server with [--innodb-rollback-on-timeout](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_rollback_on_timeout) enabled. Retry the statement if using the default behavior, or the entire transaction if [--innodb-rollback-on-timeout](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_rollback_on_timeout) is enabled.

Both deadlocks and lock wait timeouts are normal on busy servers and it is necessary for applications to be aware that they may happen and handle them by retrying. You can make them less likely by doing as little work as possible between the first change to data during a transaction and the commit, so the locks are held for the shortest possible time and for the smallest possible number of rows. Sometimes splitting work between different transactions may be practical and helpful.

A duplicate-key error rolls back the SQL statement, if you have not specified the **IGNORE** option in your statement.

A **row too long error** rolls back the SQL statement.

Other errors are mostly detected by the MySQL layer of code (above the **InnoDB** storage engine level), and they roll back the corresponding SQL statement. Locks are not released in a rollback of a single SQL statement.

During implicit rollbacks, as well as during the execution of an explicit [**ROLLBACK**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#commit) SQL statement, [**SHOW PROCESSLIST**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#show-processlist) displays **Rolling back** in the **State** column for the relevant connection.

## 15.22 InnoDB Limits

This section describes limits for **InnoDB** tables, indexes, tablespaces, and other aspects of the **InnoDB** storage engine.

A table can contain a maximum of 1017 columns. Virtual generated columns are included in this limit.

A table can contain a maximum of 64 [secondary indexes](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_secondary_index).

The index key prefix length limit is 3072 bytes for **InnoDB** tables that use [**DYNAMIC**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_dynamic_row_format) or [**COMPRESSED**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_compressed_row_format) row format.

The index key prefix length limit is 767 bytes for **InnoDB** tables that use the [**REDUNDANT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_redundant_row_format) or [**COMPACT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_compact_row_format) row format. For example, you might hit this limit with a [column prefix](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_column_prefix) index of more than 191 characters on a **TEXT** or **VARCHAR** column, assuming a **utf8mb4** character set and the maximum of 4 bytes for each character.

Attempting to use an index key prefix length that exceeds the limit returns an error.

If you reduce the **InnoDB** [page size](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\glossary.html#glos_page_size) to 8KB or 4KB by specifying the [**innodb\_page\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_page_size) option when creating the MySQL instance, the maximum length of the index key is lowered proportionally, based on the limit of 3072 bytes for a 16KB page size. That is, the maximum index key length is 1536 bytes when the page size is 8KB, and 768 bytes when the page size is 4KB.

The limits that apply to index key prefixes also apply to full-column index keys.

A maximum of 16 columns is permitted for multicolumn indexes. Exceeding the limit returns an error.

ERROR 1070 (42000): Too many key parts specified; max 16 parts allowed

The maximum row size, excluding any variable-length columns that are stored off-page, is slightly less than half of a page for 4KB, 8KB, 16KB, and 32KB page sizes. For example, the maximum row size for the default [**innodb\_page\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_page_size) of 16KB is about 8000 bytes. However, for an **InnoDB** page size of 64KB, the maximum row size is approximately 16000 bytes. [**LONGBLOB**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-types.html#blob) and [**LONGTEXT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-types.html#blob) columns must be less than 4GB, and the total row size, including [**BLOB**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-types.html#blob) and [**TEXT**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-types.html#blob) columns, must be less than 4GB.

If a row is less than half a page long, all of it is stored locally within the page. If it exceeds half a page, variable-length columns are chosen for external off-page storage until the row fits within half a page, as described in [Section 15.11.2, “File Space Management”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-file-space).

Although **InnoDB** supports row sizes larger than 65,535 bytes internally, MySQL itself imposes a row-size limit of 65,535 for the combined size of all columns. See [Section 8.4.7, “Limits on Table Column Count and Row Size”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\optimization.html#column-count-limit).

On some older operating systems, files must be less than 2GB. This is not an **InnoDB** limitation. If you require a large system tablespace, configure it using several smaller data files rather than one large data file, or distribute table data across file-per-table and general tablespace data files.

The combined maximum size for **InnoDB** log files is 512GB.

The minimum tablespace size is slightly larger than 10MB. The maximum tablespace size depends on the **InnoDB** page size.

**Table 15.31 InnoDB Maximum Tablespace Size**

| **InnoDB Page Size** | **Maximum Tablespace Size** |
| --- | --- |
| 4KB | 16TB |
| 8KB | 32TB |
| 16KB | 64TB |
| 32KB | 128TB |
| 64KB | 256TB |

The maximum tablespace size is also the maximum size for a table.

The path of a tablespace file, including the file name, cannot exceed the **MAX\_PATH** limit on Windows. Prior to Windows 10, the **MAX\_PATH** limit is 260 characters. As of Windows 10, version 1607, **MAX\_PATH** limitations are removed from common Win32 file and directory functions, but you must enable the new behavior.

For limits associated with concurrent read-write transactions, see [Section 15.6.6, “Undo Logs”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-undo-logs).

## 15.23 InnoDB Restrictions and Limitations

This section describes restrictions and limitations of the **InnoDB** storage engine.

You cannot create a table with a column name that matches the name of an internal **InnoDB** column (including **DB\_ROW\_ID**, **DB\_TRX\_ID**, and **DB\_ROLL\_PTR**. This restriction applies to use of the names in any lettercase.

mysql> **CREATE TABLE t1 (c1 INT, db\_row\_id INT) ENGINE=INNODB;**

ERROR 1166 (42000): Incorrect column name 'db\_row\_id'

[**SHOW TABLE STATUS**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\sql-statements.html#show-table-status) does not provide accurate statistics for **InnoDB** tables except for the physical size reserved by the table. The row count is only a rough estimate used in SQL optimization.

**InnoDB** does not keep an internal count of rows in a table because concurrent transactions might “see” different numbers of rows at the same time. Consequently, **SELECT COUNT(\*)** statements only count rows visible to the current transaction.

For information about how **InnoDB** processes **SELECT COUNT(\*)** statements, refer to the [**COUNT()**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\functions.html#function_count) description in [Section 12.20.1, “Aggregate Function Descriptions”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\functions.html#aggregate-functions).

**ROW\_FORMAT=COMPRESSED** is unsupported for page sizes greater than 16KB.

A MySQL instance using a particular **InnoDB** page size ([**innodb\_page\_size**](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#sysvar_innodb_page_size)) cannot use data files or log files from an instance that uses a different page size.

For limitations associated with importing tables using the Transportable Tablespaces feature, see [Table Import Limitations](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-statistics-estimation).

For limitations associated with online DDL, see [Section 15.12.6, “Online DDL Limitations”](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-online-ddl-limitations).

For limitations associated with general tablespaces, see [General Tablespace Limitations](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#general-tablespaces-limitations).

For limitations associated with data-at-rest encryption, see [Encryption Limitations](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\innodb-storage-engine.html#innodb-data-encryption-limitations).

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| [Prev](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\data-dictionary.html) | Up | [Next](file:///E:\backup\%E4%B8%8B%E8%BD%BD\refman-8.0-en.html-chapter\refman-8.0-en.html-chapter\storage-engines.html) |
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