

MySQL Enterprise Backup User's Guide (Version 4.1.5)

Abstract

This is the user manual for MySQL Enterprise Backup, a commercially licensed backup utility for MySQL databases. It explains the different kinds of backup and restore that can be performed with MySQL Enterprise Backup, and describes the commands for performing them. Strategies for optimizing backup and restore operations are also discussed.

For notes detailing the changes in each release, see the [MySQL Enterprise Backup 4.1 Release Notes](#).

For legal information, including licensing information, see the [Preface and Legal Notices](#).

For help with using MySQL, please visit the [MySQL Forums](#), where you can discuss your issues with other MySQL users.

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Preface and Legal Notices

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Part I Getting Started with MySQL Enterprise Backup

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Chapter 1 Introduction to MySQL Enterprise Backup

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MySQL Enterprise Backup is a backup utility for MySQL servers. It is a multi-platform, high-performance tool, offering rich features like “hot” (online) backup, incremental and differential backup, selective backup and restore, support for direct cloud storage backup, backup encryption and compression, and many other valuable features.

While optimized for use with InnoDB tables, MySQL Enterprise Backup is capable of backing up and restoring all kinds of tables created by any kinds of storage engines supported by MySQL. The parallelism of its read and write processes (performed in independent, multiple threads) and its block-level parallelism (different threads can read, process, or write different chunks within a single file) allow backup and restore processes to be completed with great speed, and often with a significant performance gain when compared to a [logical backup](#) using tools like [mysqldump](#).

MySQL Enterprise Backup is a valuable tool for maintaining and safeguarding your MySQL data, and for quick and reliable recovery when accidents or disasters strike. It is part of the MySQL Enterprise Edition, available to subscribers under a commercial license.

Among other things, this manual explains:

- How to install MySQL Enterprise Backup.
- The different kinds of backups that can be performed with MySQL Enterprise Backup, how to perform them, and some tips on choosing the right kind of backups for your system.
- How to restore backups created by MySQL Enterprise Backup.
- How to use MySQL Enterprise Backup in special situations or for special purposes (for example, setting up replication, using Media Management Software (MMS) products, or using a Distributed File System (DFS)).
- The [mysqlbackup](#) client, its commands and command options.

1.1 The mysqlbackup Client

All MySQL Enterprise Backup functions are executed with the [mysqlbackup](#) client. It is used for performing different types of backup and restore operations, as well as other related tasks like backup compression, decompression, validation, and so on.

Use of the [mysqlbackup](#) client and the related commands are explained and illustrated throughout this manual. For detailed information on the [mysqlbackup](#) commands and command options, see [Part III](#), “[mysqlbackup Command Reference](#)”.

1.2 Overview of Backup Types

When it comes to formulating your backup strategy, performance and storage space are the key considerations. You want the backup to complete quickly, with as little CPU overhead on the database server as possible. You also want the backup data to be compact, so you can keep multiple backups on hand to restore at a moment's notice. Transferring the backup data to a different system should be quick and convenient. Under such considerations, various strategies for backing up your database often give you different advantages, for the different trade-offs you make when choosing a particular strategy. To choose the strategy that best fits your needs, you have to understand the nature of each kind of backups that MySQL Enterprise Backup can perform, for which this section is giving a brief overview.

Kinds of backups according to the level of service disruption

Depending on how the database operations would be disrupted during a backup, the backup is classified as “hot,” “warm,” or “cold”:

- *Very Low to Low Level of Disruption:* A [hot backup](#) is a backup performed while the database is running. This type of backups does not block normal database operations. It captures even changes that occur while the backup is happening. Comparing to the other backup types, it causes the least disruption to the database server, and it is a desirable backup option when you want to avoid taking your application, web site, or web service offline. However, before a hot backup can be restored, there needs to be an extra process of preparing the backup to make it consistent (i.e., correctly reflecting the state of the state of the database at the time the backup was completed). See [Section 5.1.7, “Advanced: Preparing and Restoring a Directory Backup”](#) for more explanations.

When connected to a running MySQL server, MySQL Enterprise Backup performs hot backup for InnoDB tables.

- *Medium to High Level of Disruption:* A [warm backup](#) is a backup performed with the database put under a read-only state. This type of backups blocks any write operations to the tables during the backup process, but still allow tables to be read.

When connected to a running MySQL server, MySQL Enterprise Backup backs up all MyISAM and other non-InnoDB tables using the [warm backup](#) technique after all InnoDB tables have already been backed up with the [hot backup](#) method. Therefore, to back up as much data as possible during the hot backup phase, you should designate InnoDB as the default storage engine for new tables (which has been the default setting since MySQL 5.5), or convert existing tables to use the InnoDB storage engine.

- *High to Very High Level of Disruption:* A [cold backup](#) is a backup created while the database is stopped. Not only is it most disruptive to the database service, it also renders a lot of MySQL Enterprise Backup features unusable (for example, the ability to retrieve information about the structure of the database automatically through a database connection, so they do not have to be supplied to MySQL Enterprise Backup by a configuration file or command-line options).

To avoid service disruption, you would typically perform a cold backup on a replica, which can be stopped without taking down the entire application or web site.

Kinds of backups according to whether all data, or recent changes only are backed up

According to whether you want to include all data into your backup or only the recent changes, and according to recent changes since when, you can perform either a full backup, a differential backup, or an incremental backup. The three types of backups have different levels of requirements for CPU overhead and disk space, thus are suitable for different situations:

- A [full backup](#) includes the complete data from the database (except in cases where some tables are excluded with the [partial backup options](#)).

- A [differential backup](#) includes all changes to the data since the last full backup. It is faster than a full backup, saves storage space on the database server, and saves on network traffic when the backup is being transferred to a different server. However, it requires additional processing to make the backup ready for restore, which you can perform on a different system to minimize CPU overhead on the database server.
- An [Incremental backup](#) includes all changes to the data since the last backup. It offers similar advantages over a full backup as a differential backup does, and often to a even greater extent by further decreasing the backup size. But it might also require more preparations on a longer series of backups, before a restore can be performed.

Compressed versus uncompressed backups

Backup compression saves you storage space and network traffic to transfer the backup data onto a different server. Compression does add some CPU overhead, but the overhead is algorithm dependent and it is fairly low for the default algorithm used by MySQL Enterprise Backup. Also, compression often reduces the IO overhead by a great deal, which might shorten the restore time, especially for slower IO devices. However, during the restore process, you need time for decompression and also storage space for both the compressed and decompressed data at the same time. So, take into account the additional storage space and the extra time needed during a restore when considering whether to create compressed backups.

When streaming backup data to another server, you might want to compress the backup either on the original server or the destination server, depending on which server has more spare CPU capacity and how much network traffic the compression could save.

For more on techniques and tradeoffs involving backup and restore performance, see [Chapter 11, Performance Considerations for MySQL Enterprise Backup](#).

1.3 Files that Are Backed Up

This section explains the various types of files contained in a backup.

1.3.1 Types of Files Contained in a Backup

The following table shows the different types of files that are included in a single-file backup image or a directory backup. In the case of a single-file backup, unpack the file into a [backup directory](#) structure using the [extract](#) or the [image-to-backup-dir](#) command to view the files.

Table 1.1 Types of Files in a Backup

File Name, Pattern, or Extension	Relation to Original Data Files	Notes
<code>ibdata*</code>	The InnoDB system tablespace, containing multiple InnoDB tables and associated indexes.	Because the original files might change while the backup is in progress, the apply-log step applies the same changes to the corresponding backup files.
<code>*.ibd</code>	An InnoDB tablespace, which can be (a) a file-per-table tablespace, containing a single InnoDB table and associated indexes, or (b) a file-per-table external tablespace located outside of the server's data directory, containing a single InnoDB table	Because the original files might change while the backup is in progress, the apply-log step applies the same changes to the corresponding backup files.

File Name, Pattern, or Extension	Relation to Original Data Files	Notes
	and associated indexes, or (c) a general tablespace , containing one or more tables and their indexes.	
.ibz	Compressed form of InnoDB data files from the MySQL data directory.	Produced instead of .ibd files in a compressed backup. The ibdata files representing the InnoDB system tablespace also receive this extension in a compressed backup. The .ibz files are uncompressed during the apply-log , copy-back , or copy-back-and-apply-log step.
*.frm	Hold metadata about all MySQL tables.	The database is put into a read-only state while these files are copied. These files are copied unmodified.
*.MYD	MyISAM table data.	The database is put into a read-only state while these files are copied. These files are copied unmodified.
*.MYI	MyISAM index data.	The database is put into a read-only state while these files are copied. These files are copied unmodified.
*.CSM	Metadata for CSV tables.	These files are copied unmodified. The backup_history and backup_progress tables created by mysqlbackup use the CSV format, so the backup always includes some files with this extension.
*.CSV	Data for CSV tables.	These files are copied unmodified. The backup_history and backup_progress tables created by mysqlbackup use the CSV format, so the backup always includes some files with this extension.
*.MRG	MERGE storage engine references to other tables.	The database is put into a read-only state while these files are copied. These files are copied unmodified.
*.TRG	Trigger parameters.	The database is put into a read-only state while these files are copied. These files are copied unmodified.

File Name, Pattern, or Extension	Relation to Original Data Files	Notes
*.TRN	Trigger namespace information.	The database is put into a read-only state while these files are copied. These files are copied unmodified.
*.opt	Database configuration information.	The database is put into a read-only state while these files are copied. These files are copied unmodified.
*.par	Definitions for partitioned tables.	The database is put into a read-only state while these files are copied. These files are copied unmodified.
*.ARM	ARCHIVE storage engine table metadata.	The database is put into a read-only state while these files are copied. These files are copied unmodified.
*.ARZ	ARCHIVE storage engine table data.	The database is put into a read-only state while these files are copied. These files are copied unmodified.
backup-my.cnf	Records the configuration parameters that specify the layout and other important information about the MySQL data files.	The file is created during a backup, and it contains crucial parameters describing the backed-up data like <code>innodb_data_file_path</code> , <code>innodb_log_file_size</code> , <code>innodb_log_files_in_group</code> , and so on. It might also contain other InnoDB parameters like <code>innodb_data_home_dir</code> and <code>innodb_undo_directory</code> if some of the backup repository options were used during the backup. <code>mysqlbackup</code> uses the parameters stored in this file to understand the structure of the backup and to perform various operations. You might need to supply some of these parameters to <code>mysqlbackup</code> during a restore and to <code>mysqld</code> when you start the target server if the target server and the backup are configured differently. See the discussion in Section 4.2.4, “Restoring a Database” for details.
ibbackup_ibd_files	Records names of the <code>.ibd</code> files and their space IDs during an incremental backup.	This file is created during an incremental backup. During a restore, the information in the file is used to delete the tables

File Name, Pattern, or Extension	Relation to Original Data Files	Notes
		from the full backup that has been removed between the time of the full backup and the time of the incremental backup.
<code>ibbackup_logfile</code>	A condensed version of the <code>ib_logfile*</code> files from the MySQL data directory.	The InnoDB log files (<code>ib_logfile*</code>) are fixed-size files that are continuously updated during the database's operation. For backup purposes, only the changes that are committed while the backup is in progress are needed. These changes are recorded in <code>ibbackup_logfile</code> , and used to re-create the <code>ib_logfile*</code> files during the apply-log phase.
<code>ibbackup_redo_log_only</code>	Created instead of the <code>ibbackup_logfile</code> for incremental backups taken with the <code>--incremental-with-redo-log-only</code> option.	
<code>ib_logfile*</code>	Created in the backup directory by <code>mysqlbackup</code> during the <code>apply-log</code> phase after the initial backup.	These files are not copied from the original data directory, but rather re-created in the backup directory during the <code>apply-log</code> phase after the initial backup, using the changes recorded in the <code>ibbackup_logfile</code> file.
<code>*.bl</code>	Renamed version of each <code>.isl</code> file from the backed-up server.	A <code>.isl</code> file is created when you specify the location of an InnoDB table using the syntax <code>CREATE TABLE ... DATA DIRECTORY = ...</code> (see Creating Tables Externally for details) or when a table is put into a general tablespace (only for MySQL 5.7 and after; see general tablespace for details). The <code>.isl</code> file acts like a symbolic link pointing to the tablespace file. The <code>.bl</code> files might or might not be turned back into <code>.isl</code> files during the <code>copy-back</code> or <code>copy-back-and-apply-log</code> operation. If the specified directory does not exist on the server where the backup is restored, <code>mysqlbackup</code> attempts to create it. If the directory cannot be created, the restore operation fails. Thus, if you would like to use the <code>DATA DIRECTORY</code> clause to


File Name, Pattern, or Extension	Relation to Original Data Files	Notes
		<p>put tables at different locations or to restore to a server with a different file structure where the corresponding directories cannot be created, edit the <code>.bl</code> files before restoring to point to directories that do exist on the destination server.</p> <p>When restoring a backup created with transportable tablespaces (TTS), if the directory on the target server pointed to by a <code>.bl</code> file already contains <code>.ibd</code> files, the <code>--force</code> option is required when you restore the backup.</p>
Timestamped directory, such as <code>2011-05-26_13-42-02</code>	Created by the <code>--with-timestamp</code> option. All the backup files go inside this subdirectory.	Use the <code>--with-timestamp</code> option to easily keep more than one set of backup data under the same main backup directory.
<code>datadir</code> directory	A subdirectory that stores the data files and database subdirectories from the original MySQL instance.	Created under the backup directory by <code>mysqlbackup</code> .
binary log files	Binary log files from the server, which are included in a backup by default (except when the backup is created with the <code>--use-tts</code> option). They allow a snapshot of the server to be taken, so a server can be cloned to its exact state. Using a full backup as a basis, the binary log files that are included with an incremental backup can be used for a point-in-time recovery (PITR), which restores a database to its state at a certain point in time after the last full backup. See Section 5.2, "Point-in-Time Recovery" for details.	<p>Saved under the <code>datadir</code> directory inside the backup. A copy of the index file on the MySQL server that lists all the used binary log files, with the locations of the binary log files properly updated to point to the files' locations in the backup, is included into the backup as well also under the <code>datadir</code> directory. Use the <code>--skip-binlog</code> option to exclude the binary log from the backup.</p> <p>For offline backups, use the <code>--log-bin-index</code> option to specify the absolute path of the index file on the MySQL server that lists all the used binary log files, if it is different from the default value of the option, for <code>mysqlbackup</code> to find the binary log files and include them in the backups.</p> <p><i>For release 4.1.2 and later:</i> By default, the binary log files and the index file are restored to the same locations they were</p>


File Name, Pattern, or Extension	Relation to Original Data Files	Notes
		<p>found on the backed-up server. Use the <code>--log-bin</code> option to specify a different target location for the binary log. Use the <code>--skip-binlog</code> option to skip the restoring of the binary log.</p> <p><i>For release 4.1.1 and earlier:</i> The binary log files and the index file are restored to the data directory of the restored server. Use the <code>--skip-binlog</code> option to skip the restoring of the binary log.</p> <p>The binary log files are compressed and saved with the <code>.bz</code> extension when being included in a compressed backup.</p> <div data-bbox="1078 835 1146 911"> </div> <div data-bbox="1289 825 1365 846"> Notes </div> <ul style="list-style-type: none"> • If any binary log files are missing on the server you are backing up, you should use the <code>--skip-binlog</code> option to avoid <code>mysqlbackup</code> throwing an error for the missing files. • No binary log files are copied into the incremental backup


File Name, Pattern, or Extension	Relation to Original Data Files	Notes
		<p>if the <code>--use-tts</code> option or the <code>--start-lsn</code> option is used. To include binary log files for the period covered by the incremental backup, do not use the <code>--use-tts</code> option and, instead of <code>--start-lsn</code>, use the <code>--incremental-base</code> option, which provides the necessary information for <code>mysqlbackup</code> to ensure that no gap exists between binary log data included in the previous backup and the</p>

File Name, Pattern, or Extension	Relation to Original Data Files	Notes
		current incremental backup.
relay log files	Relay log files from a replica server, which are included in a backup of a replica server by default (except when the backup is created with the <code>--use-tts</code> option). Their inclusion saves the time and resources required for fetching the relay logs from the source when the replica is being restored.	<p>Saved under the <code>datadir</code> directory under the backup directory. A copy of the index file on the replica server that lists all the used relay log files, with the locations of the relay log files properly updated to point to the files' locations in the backup directory, is included into the backup as well, under the <code>datadir</code> directory. Use the <code>--skip-relaylog</code> option to exclude the relay log from the backup.</p> <p>For offline backup, use the <code>--relay-log-index</code> option to specify the absolute path of the index file on the MySQL server that lists all the used relay log files, if it is different from the default value of the option, for <code>mysqlbackup</code> to find the relay log files and include them in the backups.</p> <p><i>For release 4.1.2 and later:</i> By default, the relay log files and the index file are restored to the same locations they were found on the backed-up replica server. Use the <code>--relay-log</code> option to specify a different target location for the relay log. Use the <code>--skip-relaylog</code> option to skip the restoring of the relay log.</p> <p><i>For release 4.1.1 and earlier:</i> The relay log files and the index file are restored to the data directory of the restored server. Use the <code>--skip-relaylog</code> option to skip the restoring of the relay log.</p> <p>The relay log files are compressed and saved with the <code>.bz</code> extension when being included in a compressed backup.</p>

File Name, Pattern, or Extension	Relation to Original Data Files	Notes
*.bz	Compressed binary log or relay log files.	The binary log and relay log files are compressed and saved with the <code>.bz</code> extension when being included in a compressed backup. They are decompressed during a restore.
*.bkt (for release 4.1.0, or release 4.1.1 and later working with MySQL 5.7.20 and earlier)	Transfer file created for an encrypted InnoDB table during backup .	It contains the reencrypted tablespace key and other information related to the encryption. See Chapter 6, Working with Encrypted InnoDB Tables for detail.
encrypted keyring data file (for release 4.1.1 and later working with MySQL 5.7.21 and later)	For a server using the <code>keyring_encrypted_file</code> plugin, the file specified by the <code>keyring_encrypted_file_data</code> option on the server is copied over into the backup with its original name under the <code>meta</code> folder. For a server using the a keyring plugin other than <code>keyring_encrypted_file</code> , the file is named <code>keyring_kef</code> , saved under the <code>meta</code> folder.	An encrypted file containing the master key for InnoDB table encryption . See Chapter 6, Working with Encrypted InnoDB Tables for detail.
replication metadata repository files	Usually named <code>master.info</code> and <code>relay-log.info</code> , they are included by default in a backup of a replica database in a replication setup. See Replication Metadata Repositories , for details.	Saved under the <code>datadir</code> directory under the backup directory. For an offline backup, use the <code>--master-info-file</code> and <code>--relaylog-info-file</code> options to specify the absolute paths of the information files, if they are different from the default values of the options, for <code>mysqlbackup</code> to find those files and include them in the backups. The copying of these files are skipped during a backup or a restore when the <code>--skip-relay-log</code> option is used.
Backup image file	A single-file backup produced by the <code>backup-to-image</code> option, with a name specified by the <code>--backup-image</code> option.	You can move the image file without losing or damaging the contents inside it, then unpack it with <code>mysqlbackup</code> using the <code>extract</code> command and specifying the same image name with the <code>--backup-image</code> option. Although some extra files such as <code>backup-my.cnf</code> and the <code>meta</code> subdirectory are present in

File Name, Pattern, or Extension	Relation to Original Data Files	Notes
		the backup directory, these files are also included in the image file and do not need to be moved along with it.
Any other files in subdirectories under the <code>datadir</code> directory (that is, under <code>backup-dir/datadir/subdir</code>)	Copied from the database subdirectories under the MySQL data directory.	<p>By default, any unrecognized files in subdirectories under the MySQL data directory are copied to the backup. To omit such files, specify the <code>--only-known-file-types</code> option.</p> <div>  <div> Note <p>Some limitations apply to this behavior. See the discussion here in Appendix B, Limitations of MySQL Enterprise Backup.</p> </div> </div>
<code>meta</code> directory	A subdirectory that stores files with metadata about the backup.	Created under the backup directory by <code>mysqlbackup</code> . All files listed below go inside the <code>meta</code> subdirectory.
<code>backup_variables.txt</code>	Holds important information about the backup. For use by <code>mysqlbackup</code> only.	<code>mysqlbackup</code> consults and possibly updates this file during operations after the initial backup, such as the apply-log phase or the restore phase.
<code>image_files.xml</code>	Contains the list of all the files (except itself) that are present in the single-file backup produced by the <code>backup-to-image</code> or <code>backup-dir-to-image</code> options. For details about this file, see Section 13.4, “Using the MySQL Enterprise Backup Manifest” .	This file is not modified at any stage once generated.
<code>backup_create.xml</code>	Lists the command line arguments and environment in which the backup was created. For details about this file, see Section 13.4, “Using the MySQL Enterprise Backup Manifest” .	This file is not modified once it is created. You can prevent this file from being generated by specifying the <code>--disable-manifest</code> option.

File Name, Pattern, or Extension	Relation to Original Data Files	Notes
<code>backup_content.xml</code>	Essential metadata for the files and database definitions of the backup data. It also contains details of all the plugins defined on the backed-up server, by which users should make sure the same plugins are defined in the same manner on the target server for restoration. For details about this file, see Section 13.4, “Using the MySQL Enterprise Backup Manifest” .	This file is not modified once created. You can prevent this file from being generated by specifying the <code>--disable-manifest</code> option.
<code>comments.txt</code>	Produced by the <code>--comments</code> or <code>--comments-file</code> option.	The comments are specified by you to document the purpose or special considerations for this backup job.
<code>backup_gtid_executed.sql</code>	Signifies the backup came from a server with GTIDs enabled.	GTIDs are a replication feature in MySQL 5.6 and higher. See Replication with Global Transaction Identifiers for details. When you back up a server with GTIDs enabled using <code>mysqlbackup</code> , the file named <code>backup_gtid_executed.sql</code> is created in the <code>meta</code> folder under the backup directory. Edit and execute this file after restoring the backup data on a replica server; see Section 7.1, “Setting Up a New Replica” for details.
<code>server-my.cnf</code>	Contains values of the backed-up server's global variables that are set to non-default values. Use this file or <code>server-all.cnf</code> to start the target server for restoration.	<p>During a <code>copy-back</code> or <code>copy-back-and-apply-log</code> operation, the server repository options values (e.g., <code>--datadir</code>, <code>--innodb_data_home_dir</code>, etc.) in the file are modified if the command makes changes to them through the command options. However, during an <code>apply-incremental-backup</code> operation, the values already saved in the file take precedence and they are not modified by the option values supplied through the command.</p> <div>  <div> Warning When using the file </div> </div>

File Name, Pattern, or Extension	Relation to Original Data Files	Notes
		<p>to restart the target server, change parameters like <code>--tmpdir</code>, <code>--general-log</code>, etc., and any global variable that uses an absolute filepath to avoid the accidental usage of the wrong file locations by the target server.</p>
<code>server-all.cnf</code>	Contains values of all the global variables of the backed-up server. Use this file or <code>server-my.cnf</code> to start the target server for restoration.	<p>During a <code>copy-back</code> or <code>copy-back-and-apply-log</code> operation, the <code>server repository options</code> values (e.g., <code>--datadir</code>, <code>--innodb_data_home_dir</code>, etc.) in the file are modified if the command makes changes to them through the command options. However, during an <code>apply-incremental-backup</code> operation, the values already saved in the file take precedence and they are not modified by the option values supplied through the command.</p> <div>  <div> Warning <p>When using the file to restart the target server, change parameters</p> </div> </div>

File Name, Pattern, or Extension	Relation to Original Data Files	Notes
		like <code>--tmpdir</code> , <code>--general-log</code> , etc., and any global variable that uses an absolute filepath to avoid the accidental usage of the wrong file locations by the target server.
<code>ib_buffer_pool</code>	<p>The file produced on the server when <code>innodb_buffer_pool_dump_at_shutdown</code> (enabled by default on MySQL 5.7.7 and after) or <code>innodb_buffer_pool_dump_now</code> is enabled. It holds the list of tablespace IDs and page IDs of the server's buffer pool.</p> <p>The actual file name might be different, as it can be configured by the server's system variable <code>innodb_buffer_pool_filename</code>.</p>	<p>With the default setting on MySQL server 5.7.7 and after <code>innodb_buffer_pool_load_at_start</code> the target server, during start up, is going to restore the buffer pool state of the backed up server using this file. See Saving and Restoring the Buffer Pool State for details.</p>

1.3.2 Files Backed up for InnoDB Data

The InnoDB-related data files that are backed up include the `ibdata*` files (which represent the [system tablespace](#) and possibly the data for some user tables), any `.ibd` files (which contains data from user tables created with the `file-per-table` setting enabled), and the data extracted from the `ib_logfile*` files (the [redo log](#) information representing changes that occur while the backup is running), which is stored in a new backup file `ibbackup_logfile`.

If you use the compressed backup feature, the `.ibd` files are renamed in their compressed form to `.ibz` files.

The files, as they are originally copied, form a [raw backup](#) that requires further processing before it is ready to be restored. You then run the [apply](#) step (either as part of a `copy-back-and-apply-log` command or a `backup-and-apply-log` command, or as a separate `apply-log` command), which updates the backup files based on the changes recorded in the `ibbackup_logfile` file, producing a [prepared backup](#). At this point, the backup data corresponds to a single point in time. The files are now ready to be restored, or for some other uses such as testing, reporting, or deployment as a replica.

To restore InnoDB tables to their original state, you must also have the corresponding [.frm files](#) along with the backup data. Otherwise, the table definitions could be missing or outdated if someone has run [ALTER TABLE](#) or [DROP TABLE](#) statements since the backup. By default, [mysqlbackup](#) automatically copies the [.frm](#) files during a backup operation and restores the files during a restore operation.

**Note**

To avoid concurrency issues during backups of busy databases, you can use the [--only-innodb](#) or [--only-innodb-with-frm](#) option to back up only InnoDB tables and the associated data.

1.3.3 Files Backed up for Data Stored with MyISAM and Other Storage Engines

[mysqlbackup](#) also backs up the [.MYD files](#), [.MYI files](#), and the [.frm](#) files associated with the MyISAM tables. Files with other extensions that are backed up are shown in [Table 1.1, “Types of Files in a Backup”](#).

**Note**

While MySQL Enterprise Backup can back up non-InnoDB data (like MYISAM tables), the MySQL server to be backed up must support InnoDB (i.e., the backup process will fail if the server was started up with the [--innodb=OFF](#) or [--skip-innodb](#) option), and the server must contain at least one InnoDB table.

MyISAM tables and these other types of files cannot be backed up in the same non-blocking way as InnoDB tables can be. They can be backed up using the [warm backup](#) technique: changes to these tables are prevented while they are being backed up, possibly making the database unresponsive for a time, but no shutdown is required during the backup.

1.3.4 Files Generated by [mysqlbackup](#)

Inside the image backup file created by the [backup-to-image](#) command of [mysqlbackup](#) are some new files that are produced during the backup process. These files are used to control later tasks such as verifying and restoring the backup data. The files generated during the backup process include:

- [meta/backup_create.xml](#): Lists the command line arguments and environment in which the backup was created.
- [meta/backup_content.xml](#): Essential metadata for the files and database definitions of the backup data.
- [backup-my.cnf](#): Records the crucial configuration parameters that apply to the backup. These configuration parameters are read by [mysqlbackup](#) during operations like [apply-log](#) to determine how the backup data is structured. These parameters are also checked during a restore operation for their compatibility with your target server's configuration.
- [server-my.cnf](#): Contains values of the backed-up server's global variables that are set to non-default values.
- [server-all.cnf](#): Contains values of all the global variables of the backed-up server.
- [*.bkt](#): Transfer file created for an encrypted InnoDB table during backup. It contains the reencrypted tablespace key and other information related to the encryption. See [Chapter 6, Working with Encrypted InnoDB Tables](#) for detail.

For details about these and other files contained in the backup, see [Table 1.1, “Types of Files in a Backup”](#).

Chapter 2 Installing MySQL Enterprise Backup

Install MySQL Enterprise Backup on each database server whose contents you intend to back up. Typically, you perform all backup and restore operations locally, by running `mysqlbackup` on the same server as the MySQL instance.

MySQL Enterprise Backup is packaged as either an archive file (`.tgz`, archived with `tar` and compressed with `gzip`) or as a platform-specific installer.

Installing on Unix and Linux Systems

For all Linux and Unix systems, the product is available as a `.tgz` file. Unpack this file as follows:

```
tar xvzf package.tgz
```

`mysqlbackup` is unpacked into a subdirectory. You can either copy them into a system directory (preserving their execute permission bits), or add to your `$PATH` setting the directory where you unpacked it.

For certain Linux distributions, the product is also available as an RPM archive. When you install the RPM using the command `sudo rpm -i package_name.rpm`, the `mysqlbackup` client is installed in the directory `/opt/mysql/meb-4.1`. You must add this directory to your `$PATH` setting.

Installation packages for Debian and Ubuntu platforms are also available. Install the package with the following command `sudo dpkg -i package_name.deb`.

Installing on Windows Systems

The product can be installed together with other MySQL products with the MySQL Installer for Windows. It can also be installed separately with either an individual `.msi` installer or `.zip` file.

When installing with a `.msi` installer, specify the installation location, preferably under the same directory where other MySQL products have been installed. Choose the option **Include directory in Windows PATH**, so that you can run `mysqlbackup` from any directory.

When installing with a `.zip` file, simply unzip the file and put `mysqlbackup.exe` at the desired installation location. You can add that location to the `%PATH%` variable, so that you can run the `mysqlbackup` client from any directory.

Verify the installation by selecting the menu item **Start > Programs > MySQL Enterprise Backup 4.1 > MySQL Enterprise Backup Command Line**. The menu item displays version information and opens a command prompt for running the `mysqlbackup` command.

Chapter 3 What's New in MySQL Enterprise Backup 4.1?

This chapter highlights the new features in MySQL Enterprise Backup 4.1, as well as any significant changes made to MySQL Enterprise Backup with the release of this series.

- MySQL Enterprise Backup now supports [optimistic incremental backup](#), in which `mysqlbackup` scans only those InnoDB data files that have been modified since the last backup for changed pages and then saves them into the incremental backup. It potentially makes incremental backups faster. See [Full-scan versus Optimistic Incremental Backup](#) for details.
- A full set of exit codes have now been implemented for MySQL Enterprise Backup. Also, a new `mysqlbackup` command, `print-message`, returns an exit message for any given exit code supplied with the new option `--error-code`. See [Section 13.1, “Exit codes of MySQL Enterprise Backup”](#) for details.
- Apply-log operations can now be performed with multiple worker threads in parallel, which can improve performance for the operations. The number of threads to be used can be specified with the `--process-threads` option.
- MySQL Enterprise Backup now supports the `--ssl-mode` option, which enables you to specify the security state of the connection to the server. It replaces the client side `--ssl` and `--ssl-verify-server-cert` options, which are now deprecated. See the description of the `--ssl-mode` option in [MySQL 5.7 Reference Manual](#) for details.
- A number of measures have been implemented to increase the performance for hot backups by decreasing the duration of the final phase of hot backups in which the server is locked. See the [MySQL Enterprise Backup 4.1 Release Notes](#) for details.
- A new option, `--skip-final-rescan`, makes `mysqlbackup` skip the final rescan for InnoDB tables that are modified by DDL operations after the database has been locked near the end of a backup operation. See the description for `--skip-final-rescan` for details.
- The output by `mysqlbackup`, which goes to the `stderr` stream and the message log, has now been improved to include the timestamps and thread IDs for all steps taken by `mysqlbackup`, in order to provide more information for debugging purposes.
- The `backup_history` table now includes the following new columns:
 - `start_time_utc`
 - `end_time_utc`
 - `consistency_time_utc`
 - `meb_version`
 - `server_uuid` (for release 4.1.2 and later)
- *For MySQL Enterprise Backup 4.1.1 and later working with MySQL Server 5.7.21 and later:* Servers' use of the [keyring_encrypted_file](#) and [keyring_aws](#) plugins is now supported by MySQL Enterprise Backup. See [Chapter 6, Working with Encrypted InnoDB Tables](#) for details.
- *For MySQL Enterprise Backup 4.1.1 and later:* HTTP Basic Authentication and non-chunked transfer are now supported for backup and restore using OpenStack Swift-compatible object storage services. See [Section 16.15, “Cloud Storage Options”](#) for details.

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- *For MySQL Enterprise Backup 4.1.2 and later:* OAuth is now supported for Oracle Cloud Infrastructure Object Storage client authentication. Two new options, `--cloud-storage-url` and `--cloud-oauth-token`, have been introduced for the purpose. See [Section 16.15, “Cloud Storage Options”](#) for details.
 - *For MySQL Enterprise Backup 4.1.2 and later:* The binary log for a backed-up server, instead of being restored always to the data directory on the target server, is now restored by default to the same location it was found on the backed-up server. It can also be restored to a different location specified with the new `--log-bin` option.
 - *For MySQL Enterprise Backup 4.1.2 and later:* The relay log for a backed-up replica server, instead of being restored always to the data directory on the target replica server, is now restored by default to the same location it was found on the backed-up replica server. It can also be restored to a different location specified with the new `--relay-log` option.
 - *For MySQL Enterprise Backup 4.1.2 and later:* When working with a [Group Replication](#) setup, `mysqlbackup` now makes the backup history available to all members of the server group by making sure that the `backup_history` table is updated on a primary node after each `mysqlbackup` operation. See [Chapter 8, Using MySQL Enterprise Backup with Group Replication](#) for details, including the resulting new user privilege requirement for `mysqlbackup` to connect to a server, regardless of whether the server belongs to a Group Replication setup.
 - *For MySQL Enterprise Backup 4.1.2 and later:* The storage engine of the `mysql.backup_history` table on a backed-up server has switched from CSV to InnoDB. See [here](#) for the special user privileges required by `mysqlbackup` for the mandatory table migration to take place.
 - *For MySQL Enterprise Backup 4.1.3 and later:* In addition to the requirement that the target data directory for a restore specified by `--datadir` must be non-existent or empty, `mysqlbackup` now enforces the same rule for the `--innodb_data_home_dir`, `--innodb_log_group_home_dir`, and `--innodb_undo_directory` options (the `--force` option cannot be used to override the requirement on the three options).
 - *For MySQL Enterprise Backup 4.1.4 and later:*
 - A new option, `--lock-wait-retry-count`, can now be used to specify the maximum number of retries to be attempted by `mysqlbackup` after the `FLUSH TABLES WITH READ LOCK` statement, issued during the final stage of a backup to temporarily put the database into a read-only state, fails due to a timeout. See the description of the option for details.
 - The `--uncompress` option is now supported for the `extract` operation, so that files from a compressed single-file backup can now be extracted and uncompressed with a single command.

-
- For *MySQL Enterprise Backup 4.1.5 and later*:
 - For `copy-back-and-apply-log` and other [single-file operations](#) except `backup-to-image`, when a relative path is specified for the `--backup-image` option, `mysqlbackup` takes the path as relative to the current working directory in which the `mysqlbackup` command is run.
 - The `--rename` option now works with both full and partial restores:
 - If the `--include-tables` and `--exclude-tables` options are not used, all tables in the backup are restored, with the table selected by the `--rename` option renamed as specified.
 - If the `--include-tables` and `--exclude-tables` options are used, all tables selected by the two options together are restored, with the table selected by the `--rename` option renamed as specified.
 - When a server using the `keyring_file`, `keyring_encrypted_file`, or `keyring_aws` was backed up, if it did not contain any encrypted InnoDB tables, the keyring file was not included in the backup. That created a problem when, for example, `mysqlbackup` was used for a server upgrade, in which case the keyring file was not preserved in the process. `mysqlbackup` now always looks for the keyring data file and copies it when the above-mentioned keyring plugins are active on the server.
 - Encrypted InnoDB tables can now be included in partial backups and restores using [transportable tablespaces \(TTS\)](#).
 - The file `backup_gtid_executed.sql` was not included in a TTS backup for a replica server using GTIDs. The file is now included in a TTS backup as long as the `--slave-info` option is used.
 - `mysqlbackup` now skips copying the binary log for an incremental backup when the backup it is based on does not include the binary log. Also, when restoring onto a server an incremental backup that does not contain the binary log, `mysqlbackup` now renames any binary log files that have already been restored onto the server by adding to them the `.old` extension; the same thing happens when an incremental backup is restored with the `--skip-binlog` option.
 - A backup now fails when a binary or relay log file is purged while the backup is going on; it also fails when `mysqlbackup` finds a binary log file missing on the server (however, if a relay log file is missing, the backup continues).
 - The `--incremental-base` option now accepts a new value, `history:last_full_backup`, which makes it easy to create a [differential backup](#). See the description of `--incremental-base` for details.

Part II Using MySQL Enterprise Backup

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This section explains the preparations you need for creating backups with MySQL Enterprise Backup, the typical backup-verify-restore cycle, and the different backup scenarios for using MySQL Enterprise Backup. It also includes sample commands and outputs, showing you how to use the [mysqlbackup](#) client in different situations.

4.1 Before the First Backup

This section outlines some of the preparations needed before you can start working with MySQL Enterprise Backup.

4.1.1 Collect Database Information

Before backing up a particular database server for the first time, gather some information and use it to make some planning decisions, as outlined in the following table.

Table 4.1 Information Needed to Back Up a Database

Information to Gather	Where to Find It	How to Use It
Path to MySQL configuration file	Default system locations, hardcoded application default locations, or from the <code>--defaults-file</code> option in the <code>mysqld</code> startup script.	The preferred way to convey database configuration information to mysqlbackup is to use the <code>--defaults-file</code> option. When connection and data layout information is available from the configuration file, you no longer need to supply separately most of the information listed below.

Information to Gather	Where to Find It	How to Use It
MySQL port	MySQL configuration file or mysqld startup script.	Used to connect to the database instance during backup operations. Specified via the <code>--port</code> option of mysqlbackup . The specification is not needed if the information is available from the MySQL configuration file. Also not needed when doing a cold (offline) backup, which works directly on the files using OS-level file operations.
Path to MySQL data directory	MySQL configuration file or mysqld startup script.	Used to retrieve files from the database instance during backup operations, and to copy files back to the database instance during restore operations. Automatically retrieved from database connection for hot and warm backups, and taken from the MySQL configuration file for cold backups.
ID and password of privileged MySQL user	You record this during installation of your own databases, or get it from the DBA when backing up databases you do not own. Not needed when doing an offline (cold) backup, which works directly on the files using OS-level file permissions. For cold backups, you log in as an administrative user.	Specified via the <code>--password</code> option of the mysqlbackup . Prompted at the terminal if the <code>--password</code> option is present without the password argument.
Path under which to store backup data or metadata, temporarily or permanently	You choose this. See Section 4.1.3, “Designate a Location for the Backup Directory” for details.	In general, this directory must be empty for mysqlbackup to write data into it.
Owner and permission information for backed-up files (for Linux, Unix, and OS X systems)	In the MySQL data directory.	If you perform the backup and restore using a different OS user than the one who runs the server, this information might become important. See Section 4.2.1, “OS User for Running mysqlbackup” for details.
Size of InnoDB redo log files	Calculated from the values of the innodb_log_file_size and innodb_log_files_in_group configuration variables. Use the technique explained for the <code>--incremental-with-redo-log-only</code> option.	Only needed if you perform incremental backups using the <code>--incremental-with-redo-log-only</code> option rather than the <code>--incremental</code> option. The size of the InnoDB redo log and the rate of generation for redo data dictate how often you must perform incremental backups.

Information to Gather	Where to Find It	How to Use It
Rate at which redo data is generated	Calculated from the values of the InnoDB logical sequence number at different points in time. Use the technique explained for the --incremental-with-redo-log-only option.	Only needed if you perform incremental backups using the --incremental-with-redo-log-only option rather than the --incremental option. The size of the InnoDB redo log and the rate of generation for redo data dictate how often you must perform incremental backups.

4.1.2 Grant MySQL Privileges to Backup Administrator

For most backup operations, the [mysqlbackup](#) command connects to the MySQL server using the credentials supplied with the [--user](#) and [--password](#) options. The specified [user](#) needs certain privileges. You can either create a new user with a minimal set of privileges, or use an administrative account such as root. Here are the privileges required by [mysqlbackup](#):

- The minimum privileges for the MySQL user with which [mysqlbackup](#) connects to the server are:
 - [RELOAD](#) on all databases and tables.
 - [CREATE](#), [INSERT](#), [DROP](#), and [UPDATE](#) on the tables [mysql.backup_progress](#) and [mysql.backup_history](#), and also [SELECT](#) and [ALTER](#) on [mysql.backup_history](#).
 - [SUPER](#), to enable and disable logging, and to optimize locking in order to minimize disruption to database processing.
 - [REPLICATION CLIENT](#), to retrieve the [binary log](#) position, which is stored with the backup.
 - [PROCESS](#), to process DDL statements with the [ALGORITHM = INPLACE](#) clause.
 - [SELECT](#) on [performance_schema.replication_group_members](#), to know whether the server instance is part of a Group Replication setup and, if so, to gather information on the group members (required by release 4.1.2 and later).

To create a MySQL user ([mysqlbackup](#) in this example) and set the above-mentioned privileges for the user to connect from localhost, issue statements like the following from the [mysql](#) client program:

```
CREATE USER 'mysqlbackup'@'localhost' IDENTIFIED BY 'password';
GRANT RELOAD, SUPER, PROCESS ON *.* TO 'mysqlbackup'@'localhost';
GRANT CREATE, INSERT, DROP, UPDATE ON mysql.backup_progress TO 'mysqlbackup'@'localhost';
GRANT CREATE, INSERT, SELECT, DROP, UPDATE, ALTER ON mysql.backup_history
  TO 'mysqlbackup'@'localhost';
GRANT REPLICATION CLIENT ON *.* TO 'mysqlbackup'@'localhost';
GRANT SELECT ON performance_schema.replication_group_members TO 'mysqlbackup'@'localhost';
```

- The following additional privileges are required when **using MySQL Enterprise Backup 4.1.2 or later for the first time on a MySQL Server that has been upgraded from 5.7.22 or earlier and has been backed up by MySQL Enterprise Backup before**:
 - [CREATE](#), [INSERT](#), and [DROP](#) on [mysql.backup_history_old](#).
 - [CREATE](#), [INSERT](#), [DROP](#), and [ALTER](#) on [mysql.backup_history_new](#).

Grant these privileges by issuing these sample statements at the [mysql](#) client:

```
GRANT CREATE, INSERT, DROP ON mysql.backup_history_old TO 'mysqlbackup'@'localhost';
GRANT CREATE, INSERT, DROP, ALTER ON mysql.backup_history_new TO 'mysqlbackup'@'localhost';
```

**Note**

If you are working with a multiprimary Group Replication setting, make sure these privileges are granted on all primary nodes; see also [Chapter 8, Using MySQL Enterprise Backup with Group Replication](#).

These privileges are for the attempt to migrate the `mysql.backup_history` table to a newer format (see [Appendix D, Backup History Table Update](#) for details), and they are no longer needed after the first backup operation by MySQL Enterprise Backup 4.1.2 or later has taken place on the server, by which point they can be revoked.

- The following additional privileges are required for using specific features of MySQL Enterprise Backup:
 - For using [transportable tablespaces \(TTS\)](#) to back up and restore InnoDB tables:
 - `LOCK TABLES` and `SELECT` for backing up tables. `CREATE` for restoring tables.
 - `DROP` for dropping tables if the restore fails for some reasons.
 - `FILE` for restoring tables in external tablespaces outside of the server's data directory.
 - For [creating tape backups using the System Backup to Tape \(SBT\) API](#) :
 - `CREATE`, `INSERT`, `DROP`, and `UPDATE` on the `mysql.backup_sbt_history` table

Set those additional privileges if you are using the features that require them. To set all of them, issue a statement like the following from the `mysql` client program:

```
GRANT LOCK TABLES, SELECT, CREATE, DROP, FILE ON *.* TO 'mysqlbackup'@'localhost';
GRANT CREATE, INSERT, DROP, UPDATE ON mysql.backup_sbt_history TO 'mysqlbackup'@'localhost';
```

- For privileges required for using MySQL Enterprise Backup with a Group Replication setting, see [Chapter 8, Using MySQL Enterprise Backup with Group Replication](#).

4.1.3 Designate a Location for the Backup Directory

Most `mysqlbackup` operations, including those on single-file backups, write data or metadata to a designated directory referred to as the “[backup directory](#)” in this manual. See the description for `--backup-dir` for details on its usage for different operations.

Choose in advance for this directory a location on a file system with sufficient storage; it could even be remotely mounted from a different server. You specify the path to this directory with the `--backup-dir` option for many `mysqlbackup` commands.

If you use the backup directory as a location to store your backups, it is preferable to keep each backup within a timestamped subdirectory underneath the main backup directory. To make `mysqlbackup` create these subdirectories automatically, specify the `--with-timestamp` option each time you run `mysqlbackup`.

4.2 The Typical Backup / Verify / Restore Cycle

To illustrate the basic steps in creating and making use of a backup, the following example shows how to perform a full backup, verify it, and then restore it to a server.

4.2.1 OS User for Running mysqlbackup

For Linux and other Unix-like platforms: `mysqlbackup` does not record file ownership or permissions of the files that are backed up. To ensure no file permission issues prevent a server to be backed up, restored, and restarted successfully, *it is highly recommended that you run `mysqlbackup` with the same OS user who runs the MySQL server (typically `mysql`)*. If that is not possible, pay attention to the following guidelines:

- For backups, `mysqlbackup` should be run by a user that can read all the server files and directories and can execute all server directories. To satisfy that requirement, the OS user that runs `mysqlbackup` should, for example, have the group owner of the server files and directories (typically `mysql`) as its primary group or secondary group.
- For restores, unless `mysqlbackup` is run by the same user that runs the server, it can be very hard to ensure that the server has access to all the restored server files and folders, especially in the case of an online restore, where the server must be able to access the files immediately after they are restored. For an offline restore, you might need to, for example, set a `umask` to the user before the restore and adjust the permissions of the restored files and folders using a series of `chmod` and `chown` commands, so that the original permissions for the backed-up files and folders are reproduced.

4.2.2 Backing Up an Entire MySQL Instance

In the following example, we back up an entire MySQL instance to a single file using the `backup-to-image` command, which appears at the end of the sample command. We specify some of the connection information for the database using the `--user` and `--host` options (and, with the `--password` option, tell the MySQL server to prompt for a user password). The location and filename for the single-file backup is specified using the `--backup-image` option, and the location for an empty folder to store temporary files is supplied with the `--backup-dir` option.

The output echoes all the parameters used by the backup operation, including several that are retrieved automatically using the database connection. The unique ID for this backup job is recorded in special tables that `mysqlbackup` creates inside the MySQL instance, allowing you to monitor long-running backups and view information on previous backups. The final output section repeats the location of the backup data and provides the LSN values that you might use when you perform an `incremental backup` next time over the `full backup` that has just been made.

```
$ ./mysqlbackup --user=root --password --host=127.0.0.1 --backup-image=/home/admin/backups/my.mbi \
--backup-dir=/home/admin/backup-tmp backup-to-image
MySQL Enterprise Backup version 4.1.0 Linux-2.6.39-400.215.10.el5uek-x86_64 [2017/02/13]
Copyright (c) 2003, 2017, Oracle and/or its affiliates. All Rights Reserved.

170214 17:38:59 MAIN      INFO: A thread created with Id '140286817412928'
170214 17:38:59 MAIN      INFO: Starting with following command line ...
./mysqlbackup --user=root --password --host=127.0.0.1
--backup-image=/home/admin/backups/my.mbi
--backup-dir=/home/admin/backup-tmp backup-to-image

170214 17:38:59 MAIN      INFO:
Enter password:
170214 17:39:07 MAIN      INFO: MySQL server version is '5.7.17'
170214 17:39:07 MAIN      INFO: MySQL server compile os version is 'Linux'
170214 17:39:07 MAIN      INFO: Got some server configuration information from running server.

170214 17:39:07 MAIN      INFO: Server system variable 'old_alter_table' was set to '0'. Setting it to '1'.
IMPORTANT: Please check that mysqlbackup run completes successfully.
At the end of a successful 'backup-to-image' run mysqlbackup
prints "mysqlbackup completed OK!".

170214 17:39:07 MAIN      INFO: MEB logfile created at /home/admin/backup-tmp/meta/MEB_2017-02-14.17-39-07_i
```

```

-----
Server Repository Options:
-----
datadir                      = /var/lib/mysql/
innodb_data_home_dir        =
innodb_data_file_path        = ibdata1:12M:autoextend
innodb_log_group_home_dir    = /var/lib/mysql/
innodb_log_files_in_group    = 2
innodb_log_file_size         = 50331648
innodb_undo_directory        = /var/lib/mysql/
innodb_undo_tablespace       = 0
innodb_undo_logs             = 128
innodb_buffer_pool_filename  = ib_buffer_pool
innodb_page_size             = 16384
innodb_checksum_algorithm    = crc32
-----

Backup Config Options:
-----
datadir                      = /home/admin/backup-tmp/datadir
innodb_data_home_dir        = /home/admin/backup-tmp/datadir
innodb_data_file_path        = ibdata1:12M:autoextend
innodb_log_group_home_dir    = /home/admin/backup-tmp/datadir
innodb_log_files_in_group    = 2
innodb_log_file_size         = 50331648
innodb_undo_directory        = /home/admin/backup-tmp/datadir
innodb_undo_tablespace       = 0
innodb_undo_logs             = 128
innodb_buffer_pool_filename  = ib_buffer_pool
innodb_page_size             = 16384
innodb_checksum_algorithm    = crc32

Backup Image Path = /home/admin/backups/my.mbi
170214 17:39:07 MAIN      INFO: Unique generated backup id for this is 14871119474450201

170214 17:39:07 MAIN      INFO: Creating 14 buffers each of size 16777216.
170214 17:39:07 MAIN      INFO: Full Image Backup operation starts with following threads
      1 read-threads      6 process-threads      1 write-threads
170214 17:39:07 MAIN      INFO: Found checkpoint at lsn 2543123.
170214 17:39:07 MAIN      INFO: Starting log scan from lsn = 2543104 at offset = 2536448 and checkpoint = 254312
170214 17:39:07 RDR1      INFO: A thread created with Id '140286535427840'
170214 17:39:07 RDR1      INFO: Copying meta file /home/admin/backup-tmp/backup-my.cnf.
170214 17:39:07 PCR1      INFO: A thread created with Id '140286527035136'
170214 17:39:07 PCR2      INFO: A thread created with Id '140286518642432'
170214 17:39:07 RDR1      INFO: Copying meta file /home/admin/backup-tmp/meta/backup_create.xml.
170214 17:39:07 RDR1      INFO: System tablespace file format is Antelope.
170214 17:39:07 RDR1      INFO: Starting to copy all innodb files...
170214 17:39:07 PCR3      INFO: A thread created with Id '140286510249728'
170214 17:39:07 PCR4      INFO: A thread created with Id '140286382569216'
170214 17:39:07 PCR5      INFO: A thread created with Id '140286501857024'
170214 17:39:07 PCR6      INFO: A thread created with Id '140286493464320'
170214 17:39:07 WTR1      INFO: A thread created with Id '140286485071616'
170214 17:39:07 RLR1      INFO: A thread created with Id '140286476678912'
170214 17:39:07 RLW1      INFO: A thread created with Id '140286468286208'
170214 17:39:07 RLP1      INFO: A thread created with Id '140286459893504'
170214 17:39:07 RDR1      INFO: Copying /var/lib/mysql/ibdata1 (Barracuda file format).
170214 17:39:08 RDR1      INFO: Copying /var/lib/mysql/mysql/engine_cost.ibd (Barracuda file format).
170214 17:39:08 RDR1      INFO: Copying /var/lib/mysql/mysql/gtid_executed.ibd (Barracuda file format).
170214 17:39:08 RDR1      INFO: Copying /var/lib/mysql/mysql/help_category.ibd (Barracuda file format).
170214 17:39:08 RDR1      INFO: Copying /var/lib/mysql/mysql/help_keyword.ibd (Barracuda file format).
170214 17:39:08 RDR1      INFO: Copying /var/lib/mysql/mysql/help_relation.ibd (Barracuda file format).
170214 17:39:08 RDR1      INFO: Copying /var/lib/mysql/mysql/help_topic.ibd (Barracuda file format).
170214 17:39:09 RDR1      INFO: Copying /var/lib/mysql/mysql/innodb_index_stats.ibd (Barracuda file format).
170214 17:39:10 RDR1      INFO: Copying /var/lib/mysql/mysql/innodb_table_stats.ibd (Barracuda file format).
170214 17:39:10 RDR1      INFO: Copying /var/lib/mysql/mysql/plugin.ibd (Barracuda file format).
170214 17:39:10 RDR1      INFO: Copying /var/lib/mysql/mysql/server_cost.ibd (Barracuda file format).
170214 17:39:10 RDR1      INFO: Copying /var/lib/mysql/mysql/servers.ibd (Barracuda file format).

```

Backing Up an Entire MySQL Instance

```
170214 17:39:10 RDR1 INFO: Copying /var/lib/mysql/mysql/slave_master_info.ibd (Barracuda file format).
170214 17:39:10 RDR1 INFO: Copying /var/lib/mysql/mysql/slave_relay_log_info.ibd (Barracuda file format).
170214 17:39:10 RDR1 INFO: Copying /var/lib/mysql/mysql/slave_worker_info.ibd (Barracuda file format).
170214 17:39:10 RDR1 INFO: Copying /var/lib/mysql/mysql/time_zone.ibd (Barracuda file format).
170214 17:39:10 RDR1 INFO: Copying /var/lib/mysql/mysql/time_zone_leap_second.ibd (Barracuda file format).
170214 17:39:10 RDR1 INFO: Copying /var/lib/mysql/mysql/time_zone_name.ibd (Barracuda file format).
170214 17:39:10 RDR1 INFO: Copying /var/lib/mysql/mysql/time_zone_transition.ibd (Barracuda file format).
170214 17:39:10 RDR1 INFO: Copying /var/lib/mysql/mysql/time_zone_transition_type.ibd (Barracuda file format).
170214 17:39:10 RDR1 INFO: Copying /var/lib/mysql/pets/cats.ibd (Barracuda file format).
170214 17:39:10 RDR1 INFO: Copying /var/lib/mysql/sys/sys_config.ibd (Barracuda file format).
170214 17:39:10 RDR1 INFO: Completing the copy of innodb files.
170214 17:39:10 RDR1 INFO: Requesting a dump of the InnoDB buffer pool
170214 17:39:10 RDR1 INFO: Waiting for the dump of the InnoDB buffer pool to complete
170214 17:39:11 RDR1 INFO: The dump of the InnoDB buffer pool completed
170214 17:39:11 RDR1 INFO: Could not find binlog index file. binlogs will not be copied for this backup
Point-In-Time-Recovery will not be possible.
If this is online backup then server may not have started with --log-bin.
You may specify its location with --log-bin-index option.
170214 17:39:11 RDR1 INFO: Preparing to lock tables: Connected to mysqld server.
170214 17:39:11 RDR1 INFO: Starting to lock all the tables...
170214 17:39:11 RDR1 INFO: Flushing the default MyISAM key cache.
170214 17:39:11 RDR1 INFO: All tables are locked and flushed to disk
170214 17:39:11 RDR1 INFO: Completed the copy of binlog files...
170214 17:39:11 RDR1 INFO: Opening backup source directory '/var/lib/mysql'
170214 17:39:11 RDR1 INFO: Starting to backup all non-innodb files in
subdirectories of '/var/lib/mysql'
170214 17:39:11 WTR1 INFO: Adding database directory: datadir
170214 17:39:11 WTR1 INFO: Adding database directory: datadir
170214 17:39:11 WTR1 INFO: Adding database directory: datadir
170214 17:39:11 WTR1 INFO: Adding database directory: datadir
170214 17:39:11 RDR1 INFO: Completing the copy of all non-innodb files.
170214 17:39:11 RDR1 INFO: Requesting completion of redo log copy. Rapid: 0
170214 17:39:11 RLR1 INFO: Signaled '1' to complete log copy.
170214 17:39:11 RLR1 INFO: Signaled '1' to complete log copy.
170214 17:39:11 RLR1 INFO: Signaled '1' to complete log copy.
170214 17:39:11 RLR1 INFO: Redo log reader waited = 1270.00 ms for logs to generate.
170214 17:39:11 RLW1 INFO: A copied database page was modified at 2543123.
(This is the highest lsn found on page)
Scanned log up to lsn 2543132.
Was able to parse the log up to lsn 2543132.
170214 17:39:13 RDR1 INFO: All tables unlocked
170214 17:39:13 RDR1 INFO: All MySQL tables were locked for 1.367 seconds.
170214 17:39:13 RDR1 INFO: Setting server system variable 'old_alter_table' back to '0'.
170214 17:39:13 RDR1 INFO: Reading all global variables from the server.
170214 17:39:13 RDR1 INFO: Completed reading of all global variables from the server.
170214 17:39:13 RDR1 INFO: Writing config file for server '5.7.17'.
170214 17:39:13 RDR1 INFO: Creating server config files server-my.cnf and server-all.cnf in /home/admin
170214 17:39:13 RDR1 INFO: Copying meta file /home/admin/backup-tmp/meta/backup_variables.txt.
170214 17:39:13 RDR1 INFO: Copying meta file /home/admin/backup-tmp/datadir/ibbackup_logfile.
170214 17:39:13 RDR1 INFO: Copying meta file /home/admin/backup-tmp/server-all.cnf.
170214 17:39:13 RDR1 INFO: Copying meta file /home/admin/backup-tmp/server-my.cnf.
170214 17:39:13 RDR1 INFO: Copying meta file /home/admin/backup-tmp/meta/backup_content.xml.
170214 17:39:13 RDR1 INFO: Copying meta file /home/admin/backup-tmp/meta/image_files.xml.
170214 17:39:13 MAIN INFO: Full Image Backup operation completed successfully.
170214 17:39:13 MAIN INFO: Backup image created successfully.
170214 17:39:13 MAIN INFO: Image Path = /home/admin/backups/my.mbi
```

Parameters Summary

```
Start LSN      : 2543104
End LSN        : 2543132
```

mysqlbackup completed OK!

4.2.3 Verifying a Backup

You can check the integrity of your backup using the `validate` command. The following is a sample command for validating a backup image and the output for the successful validation:

```
$ ./mysqlbackup --backup-image=/home/admin/backups/my.mbi validate
MySQL Enterprise Backup version 4.1.0 Linux-2.6.39-400.215.10.el5uek-x86_64 [2017/02/13]
Copyright (c) 2003, 2017, Oracle and/or its affiliates. All Rights Reserved.

170214 17:46:09 MAIN      INFO: A thread created with Id '139996701841216'
170214 17:46:09 MAIN      INFO: Starting with following command line ...
      ./mysqlbackup --backup-image=/home/admin/backups/my.mbi validate

170214 17:46:09 MAIN      INFO:
IMPORTANT: Please check that mysqlbackup run completes successfully.
          At the end of a successful 'validate' run mysqlbackup
          prints "mysqlbackup completed OK!".

170214 17:46:09 MAIN      INFO: Backup Image MEB version string: 4.1.0 [2017/02/13]
170214 17:46:09 MAIN      INFO: MySQL server version is '5.7.17'
170214 17:46:09 MAIN      INFO: Creating 14 buffers each of size 16777216.
170214 17:46:09 MAIN      INFO: Validate operation starts with following threads
      1 read-threads      6 process-threads
170214 17:46:09 MAIN      INFO: Validating image ... /home/admin/backups/my.mbi
170214 17:46:09 PCR1      INFO: A thread created with Id '139996431771392'
170214 17:46:09 PCR2      INFO: A thread created with Id '139996423378688'
170214 17:46:09 PCR3      INFO: A thread created with Id '139996414985984'
170214 17:46:09 PCR4      INFO: A thread created with Id '139996406593280'
170214 17:46:09 PCR5      INFO: A thread created with Id '139996263982848'
170214 17:46:09 PCR6      INFO: A thread created with Id '139996398200576'
170214 17:46:09 RDR1      INFO: A thread created with Id '139996440164096'
170214 17:46:09 PCR1      INFO: Validate: [Dir]: meta
170214 17:46:10 PCR4      INFO: Validate: [Dir]: datadir/mysql
170214 17:46:10 PCR2      INFO: Validate: [Dir]: datadir/performance_schema
170214 17:46:10 PCR2      INFO: Validate: [Dir]: datadir/pets
170214 17:46:10 PCR2      INFO: Validate: [Dir]: datadir/sys
170214 17:46:10 PCR2      INFO: Validate: [Dir]: datadir/mysql
170214 17:46:10 PCR2      INFO: Validate: [Dir]: datadir/performance_schema
170214 17:46:10 PCR2      INFO: Validate: [Dir]: datadir/pets
170214 17:46:10 PCR2      INFO: Validate: [Dir]: datadir/sys
170214 17:46:10 MAIN      INFO: Total files as specified in image: 297
170214 17:46:10 MAIN      INFO: datadir/ibdata1 validated.
170214 17:46:10 MAIN      INFO: datadir/mysql/engine_cost.ibd validated.
170214 17:46:10 MAIN      INFO: datadir/mysql/gtid_executed.ibd validated.
170214 17:46:10 MAIN      INFO: datadir/mysql/help_category.ibd validated.
170214 17:46:10 MAIN      INFO: datadir/mysql/help_keyword.ibd validated.
170214 17:46:10 MAIN      INFO: datadir/mysql/help_relation.ibd validated.
170214 17:46:10 MAIN      INFO: datadir/mysql/help_topic.ibd validated.
170214 17:46:10 MAIN      INFO: datadir/mysql/innodb_index_stats.ibd validated.
170214 17:46:10 MAIN      INFO: datadir/mysql/innodb_table_stats.ibd validated.
170214 17:46:10 MAIN      INFO: datadir/mysql/plugin.ibd validated.
170214 17:46:10 MAIN      INFO: datadir/mysql/server_cost.ibd validated.
170214 17:46:10 MAIN      INFO: datadir/mysql/servers.ibd validated.
170214 17:46:10 MAIN      INFO: datadir/mysql/slave_master_info.ibd validated.
170214 17:46:10 MAIN      INFO: datadir/mysql/slave_relay_log_info.ibd validated.
170214 17:46:10 MAIN      INFO: datadir/mysql/slave_worker_info.ibd validated.
170214 17:46:10 MAIN      INFO: datadir/mysql/time_zone.ibd validated.
170214 17:46:10 MAIN      INFO: datadir/mysql/time_zone_leap_second.ibd validated.
170214 17:46:10 MAIN      INFO: datadir/mysql/time_zone_name.ibd validated.
170214 17:46:10 MAIN      INFO: datadir/mysql/time_zone_transition.ibd validated.
170214 17:46:10 MAIN      INFO: datadir/mysql/time_zone_transition_type.ibd validated.
170214 17:46:10 MAIN      INFO: datadir/pets/cats.ibd validated.
170214 17:46:10 MAIN      INFO: datadir/sys/sys_config.ibd validated.
170214 17:46:10 MAIN      INFO: Validate operation completed successfully.
170214 17:46:10 MAIN      INFO: Backup Image validation successful.
170214 17:46:10 MAIN      INFO: Source Image Path = /home/admin/backups/my.mbi
```



```
mysqlbackup completed OK!
```

Furthermore, you can also verify that your backup has been successful by restoring the backup data on a different server and run the MySQL daemon (`mysqld`) on the new data directory. You can then execute `SHOW` statements to verify the database and table structures, and execute queries to verify further details of the database. See [Section 4.2.4, “Restoring a Database”](#) for the basic steps for restoring a backup, and see [Chapter 5, *Recovering or Restoring a Database*](#) for more detailed instructions.



Warning

Do not try to verify a backup by using the [backup directory](#) as a data directory to start a MySQL server. This will crash the server, and might also corrupt your backup. See [Appendix A, *Frequently Asked Questions for MySQL Enterprise Backup*](#) for details.

4.2.4 Restoring a Database

To restore a MySQL instance from a backup to a database server:

- Shut down the database server.
- Delete all files inside the server's data directory. Also delete all files inside the directories specified by the `--innodb_data_home_dir`, `--innodb_log_group_home_dir`, and `--innodb_undo_directory` options for restore, if the directories are different from the data directory.
- Use, for example, the `copy-back-and-apply-log` command, which converts the raw backup into a prepared backup by updating it to a consistent state, and then copies the tables, indexes, metadata, and any other required files onto a target server. For the various options that you can specify for this operation, see [Section 15.3, “Restore Operations”](#).

In the example below, the single-file backup created in the example given in [Section 4.2.2, “Backing Up an Entire MySQL Instance”](#) is restored using the `copy-back-and-apply-log` command. Besides the usual connection parameters, the following options are used:

- `--defaults-file` supplies the configuration for restoring the data. It must be the first option to appear in a `mysqlbackup` command, if ever used. In most cases, you can supply to `mysqlbackup` with this option the configuration file for the target server to which you are restoring the data. However, when the following InnoDB settings for the backup are different from those on the target server, it is important to supply the values for the backup to `mysqlbackup` during restore and to `mysqld` when you start the restored server (otherwise, the restore might fail, and you might have problem starting the restored server):
 - `innodb_data_file_path`
 - `innodb_log_file_size`
 - `innodb_log_files_in_group`
 - `innodb_page_size`
 - `innodb_checksum_algorithm`
 - `innodb_undo_tablespaces`
 - `innodb_buffer_pool_filename`

If you are not sure about those settings for your backup, they are stored in the `backup-my.cnf` file during the backup—you can find the file either in the temporary directory you specified with `--backup-dir` when you created the single-image backup, or in a backup directory you can create by unpacking the backup image using the `extract` command. If the values of these options differ from those on the target server, add them to the configuration file you are supplying to `mysqlbackup` and also to the configuration file you are going to use to start the server afterwards; alternatively, you can also supply them as command line options to `mysqlbackup` and `mysqld`.

For some of the options listed above (namely, `innodb_data_file_path`, `innodb_log_file_size`, `innodb_log_files_in_group`, and `innodb_undo_tablespace`), `mysqlbackup` checks the values you supply for them to ensure that you will be able to start the target server afterwards with those values: it throws an error if any of them does not match with the actual values for the backup. Warnings are given if those values are not specified for `mysqlbackup` in either the configuration file or on the command line (which is the case in the example below).

- `--datadir` supplies the location of the data directory for restoring the data. You must specify this option for any restore operation.
- `--backup-image` provides the path of the single-file backup.
- `--backup-dir` provides the location of an empty folder to store some temporary files created during the restore procedure.

```
$ ./mysqlbackup --defaults-file=/etc/mysql/my.cnf --datadir=/var/lib/mysql \
--backup-image=/home/admin/backups/my.mbi --backup-dir=/home/admin/restore-tmp copy-back-and-apply-log
MySQL Enterprise Backup version 4.1.0 Linux-2.6.39-400.215.10.el5uek-x86_64 [2017/02/13]
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170214 22:11:38 MAIN      INFO: A thread created with Id '140027243398976'
170214 22:11:38 MAIN      INFO: Starting with following command line ...
./mysqlbackup --defaults-file=/etc/mysql/my.cnf --datadir=/var/lib/mysql
--backup-image=/home/admin/backups/my.mbi
--backup-dir=/home/admin/restore-tmp copy-back-and-apply-log

170214 22:11:38 MAIN      INFO:
IMPORTANT: Please check that mysqlbackup run completes successfully.
          At the end of a successful 'copy-back-and-apply-log' run mysqlbackup
          prints "mysqlbackup completed OK!".

170214 22:11:38 MAIN      INFO: Backup Image MEB version string: 4.1.0 [2017/02/13]
170214 22:11:38 MAIN      INFO: MySQL server version is '5.7.17'
170214 22:11:38 MAIN      WARNING: If you restore to a server of a different version, the innodb_data_file_path par
that case you need to add 'innodb_data_file_path=ibdata1:12M:autoextend' to the target server configuration.
170214 22:11:38 MAIN      WARNING: If you restore to a server of a different version, the innodb_log_files_in_group
In that case you need to add 'innodb_log_files_in_group=2' to the target server configuration.
170214 22:11:38 MAIN      WARNING: If you restore to a server of a different version, the innodb_log_file_size para
at case you need to add 'innodb_log_file_size=50331648' to the target server configuration.
170214 22:11:38 MAIN      INFO: Keyring service not initialized. MEB cannot validate the encryption keys.
170214 22:11:38 MAIN      INFO: Valid keyring to be specified on server start to access the encrypted tables.
170214 22:11:38 MAIN      INFO: MEB logfile created at /home/admin/restore-tmp/meta/MEB_2017-02-14.22-11-38_copy

-----
Server Repository Options:
-----
datadir                = /var/lib/mysql
innodb_data_home_dir    = /var/lib/mysql
innodb_data_file_path   = ibdata1:12M:autoextend
innodb_log_group_home_dir = /var/lib/mysql
innodb_log_files_in_group = 2
innodb_log_file_size    = 50331648
innodb_buffer_pool_filename = ib_buffer_pool
```

```

innodb_page_size           = Null
innodb_checksum_algorithm  = crc32

-----
Backup Config Options:
-----

datadir                    = /home/admin/restore-tmp/datadir
innodb_data_home_dir       = /home/admin/restore-tmp/datadir
innodb_data_file_path      = ibdata1:12M:autoextend
innodb_log_group_home_dir  = /home/admin/restore-tmp/datadir
innodb_log_files_in_group  = 2
innodb_log_file_size       = 50331648
innodb_buffer_pool_filename = ib_buffer_pool
innodb_page_size           = 16384
innodb_checksum_algorithm  = crc32

170214 22:11:38 MAIN      INFO: Creating 14 buffers each of size 16777216.
170214 22:11:38 MAIN      INFO: Copy-back-and-apply-log operation starts with following threads
      1 read-threads      6 process-threads      1 write-threads
170214 22:11:38 RDR1      INFO: A thread created with Id '140026981721856'
170214 22:11:38 PCR1      INFO: A thread created with Id '140026973329152'
170214 22:11:38 PCR1      INFO: Copying database directory: meta
170214 22:11:38 PCR2      INFO: A thread created with Id '140026964936448'
170214 22:11:38 PCR3      INFO: A thread created with Id '140026956543744'
170214 22:11:38 PCR4      INFO: A thread created with Id '140026948151040'
170214 22:11:38 PCR5      INFO: A thread created with Id '140026939758336'
170214 22:11:38 PCR6      INFO: A thread created with Id '140026931365632'
170214 22:11:38 WTR1      INFO: A thread created with Id '140026922972928'
170214 22:11:38 RDR1      INFO: Copying ibdata1.
170214 22:11:38 RDR1      INFO: Copying mysql/engine_cost.ibd.
170214 22:11:38 RDR1      INFO: Copying mysql/gtid_executed.ibd.
170214 22:11:38 RDR1      INFO: Copying mysql/help_category.ibd.
170214 22:11:38 RDR1      INFO: Copying mysql/help_keyword.ibd.
170214 22:11:38 RDR1      INFO: Copying mysql/help_relation.ibd.
170214 22:11:38 RDR1      INFO: Copying mysql/help_topic.ibd.
170214 22:11:38 PCR2      INFO: Copying database directory: mysql
170214 22:11:39 RDR1      INFO: Copying mysql/innodb_index_stats.ibd.
170214 22:11:39 RDR1      INFO: Copying mysql/innodb_table_stats.ibd.
170214 22:11:39 RDR1      INFO: Copying mysql/plugin.ibd.
170214 22:11:39 RDR1      INFO: Copying mysql/server_cost.ibd.
170214 22:11:39 RDR1      INFO: Copying mysql/servers.ibd.
170214 22:11:39 RDR1      INFO: Copying mysql/slave_master_info.ibd.
170214 22:11:39 RDR1      INFO: Copying mysql/slave_relay_log_info.ibd.
170214 22:11:39 RDR1      INFO: Copying mysql/slave_worker_info.ibd.
170214 22:11:39 RDR1      INFO: Copying mysql/time_zone.ibd.
170214 22:11:39 RDR1      INFO: Copying mysql/time_zone_leap_second.ibd.
170214 22:11:39 RDR1      INFO: Copying mysql/time_zone_name.ibd.
170214 22:11:39 RDR1      INFO: Copying mysql/time_zone_transition.ibd.
170214 22:11:39 RDR1      INFO: Copying mysql/time_zone_transition_type.ibd.
170214 22:11:40 PCR5      INFO: Copying database directory: performance_schema
170214 22:11:40 PCR5      INFO: Copying database directory: pets
170214 22:11:40 RDR1      INFO: Copying pets/cats.ibd.
170214 22:11:40 PCR5      INFO: Copying database directory: sys
170214 22:11:40 RDR1      INFO: Copying sys/sys_config.ibd.
170214 22:11:40 PCR5      INFO: Copying database directory: mysql
170214 22:11:40 PCR5      INFO: Copying database directory: performance_schema
170214 22:11:40 PCR5      INFO: Copying database directory: pets
170214 22:11:40 PCR5      INFO: Copying database directory: sys
170214 22:11:40 MAIN      INFO: Total files as specified in image: 297
170214 22:11:40 MAIN      INFO: MySQL server version is '5.7.17'
170214 22:11:40 MAIN      INFO: MySQL server compile os version is 'Linux'
170214 22:11:40 MAIN      INFO: Writing config file for server '5.7.17'.
170214 22:11:40 MAIN      INFO: Creating server config files server-my.cnf and server-all.cnf in /var/lib/mysql

[Some lines of output not shown]

170214 22:11:40 MAIN      INFO: Copy-back operation completed successfully.

```

```

170214 22:11:40 MAIN      INFO: Source Image Path = /home/admin/backups/my.mbi

170214 22:11:40 MAIN      INFO: MySQL server version is '5.7.17'
170214 22:11:40 MAIN      INFO: Restoring ...5.7.17 version
170214 22:11:40 MAIN      INFO: Creating 14 buffers each of size 65536.
170214 22:11:40 MAIN      INFO: Apply-log operation starts with following threads
      1 read-threads      1 process-threads      6 apply-threads
170214 22:11:40 MAIN      INFO: Using up to 100 MB of memory.
170214 22:11:40 MAIN      INFO: ibbackup_logfile's creation parameters:
      start lsn 2543104, end lsn 2543132,
      start checkpoint 2543123.
170214 22:11:40 ALW1      INFO: A thread created with Id '140026922972928'
170214 22:11:40 ALW6      INFO: A thread created with Id '140027204466432'
170214 22:11:40 ALW5      INFO: A thread created with Id '140027212859136'
170214 22:11:40 ALW4      INFO: A thread created with Id '140026948151040'
170214 22:11:40 ALW3      INFO: A thread created with Id '140026939758336'
170214 22:11:40 ALW2      INFO: A thread created with Id '140026931365632'
170214 22:11:40 RDR1      INFO: A thread created with Id '140027196073728'
170214 22:11:40 PCR1      INFO: A thread created with Id '140027187681024'
170214 22:11:40 PCR1      INFO: InnoDB: Doing recovery: scanned up to log sequence number 2543132.
170214 22:11:40 PCR1      INFO: InnoDB: Starting an apply batch of log records to the database...
.
InnoDB: Progress in percent: 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80
 94 95 96 97 98 99
170214 22:11:40 PCR1      INFO: InnoDB: Setting log file size to 50331648.
170214 22:11:45 PCR1      INFO: InnoDB: Setting log file size to 50331648.
170214 22:11:50 PCR1      INFO: We were able to parse ibbackup_logfile up to
      lsn 2543132.
170214 22:11:50 PCR1      INFO: The first data file is '/var/lib/mysql/ibdata1'
      and the new created log files are at '/var/lib/mysql'
170214 22:11:50 MAIN      INFO: MySQL server version is '5.7.17'
170214 22:11:50 MAIN      INFO: Restoring ...5.7.17 version
170214 22:11:50 MAIN      INFO: Apply-log operation completed successfully.
170214 22:11:50 MAIN      INFO: Full Backup has been restored successfully.

mysqlbackup completed OK! with 3 warnings

```

Now the original database directory is restored from the backup. Depending on how you are going to start the restored server, you might need to adjust the ownership of the restored data directory. For example, if the server is going to be started by the user `mysql`, use the following command to change the owner attribute of the data directory and the files under it to the `mysql` user, and the group attribute to the `mysql` group.

```
$ chown -R mysql:mysql /path/to/datadir
```

You are now ready to start the restored database server. For more discussions on how to perform different kinds of restores, see [Section 5.1, “Performing a Restore Operation”](#).

4.3 Backup Scenarios and Examples

4.3.1 Making a Single-File Backup

To avoid having a large number of backup files to keep track, store, and transport, `mysqlbackup` conveniently creates backups in a single-file format. It can also pack an existing backup directory into a single file, unpack the single file back to a backup directory, list the contents of a single-file backup, verify the contents of a single-file backup against embedded checksums, or extract a single file into a directory tree. For the syntax of the relevant `mysqlbackup` options, see [Section 16.9, “Single-File Backup Options”](#).

Advanced: While `mysqlbackup` can also create a directory backup (see description for the `backup` command for details) instead of a single-file backup, the single-file format is preferable in most cases: a

single-file backup is easier to handle and store, and certain functions of `mysqlbackup` are not supported for directory backups—for example, backup to cloud and backup to tape using the System Backup to Tape (SBT) API. Throughout the manual, directory backup is mostly treated as an advanced topic, and information and examples for directory backups are marked with the *Advanced* tag, like this paragraph.

Because the single-file backup can be streamed or piped to another process such as a tape backup or a command, you can use the technique to put the backup onto another storage device or server and avoid significant storage overhead on the original database server.

To create a single-file backup, use the `backup-to-image` command. The following examples illustrate how to perform a single-file backup and other related operations.

Example 4.1 Single-File Backup to Absolute Path

This command creates a single backup image on the given absolute path. It still requires `--backup-dir`, which is used to hold temporary output, status, and metadata files.

```
mysqlbackup --backup-image=/backups/sales.mbi --backup-dir=/backup-tmp backup-to-image
```

Example 4.2 Single-File Backup to Relative Path

When a relative path instead of an absolute path was supplied with the `--backup-image` option, the path is taken to be relative to the backup directory. Therefore, in this example, the resulting single-file backup is created as `/backups/sales.mbi`.

```
mysqlbackup --backup-image=sales.mbi --backup-dir=/backups backup-to-image
```

Example 4.3 Single-File Backup to Standard Output

The following command dumps the backup output to standard output. Again, the folder specified with the `--backup-dir` option is used as a temporary directory.

```
mysqlbackup --backup-dir=/backups --backup-image=- backup-to-image > /backup/mybackup.mbi
```

Example 4.4 Convert Existing Backup Directory to Single Image

The `backup-dir` directory is bundled into the `/backup/my.mbi` file.

```
mysqlbackup --backup-image=/backup/my.mbi --backup-dir=/var/mysql/backup backup-dir-to-image
```

Example 4.5 Extract Existing Image to Backup Directory

The image contents are unpacked into `backup-dir`.

```
mysqlbackup --backup-dir=/var/backup --backup-image=/backup/my.mbi image-to-backup-dir
```

Example 4.6 List Single-File Backup Contents

The image contents are listed, with each line indicating a file or directory entry.

```
mysqlbackup --backup-image=/backup/my.mbi list-image
```

Example 4.7 Validate a Single-File Backup

The following command verifies that the single-file backup is not corrupted, truncated, or damaged by validating the checksum value for each data page in the backup.

```
mysqlbackup --backup-image=/logs/fullimage.mi validate
```

Example 4.8 Extract Single-File Backup into Current Directory

The following command extracts all contents from a single-file backup into the current working directory.

```
mysqlbackup --backup-image=/var/my.mbi extract
```

Example 4.9 Extract Single-File Backup into a Backup Directory

This command behaves like the `image-to-backup-dir` option by extracting all contents of a single-file backup into the directory specified with the `--backup-dir` option.

```
mysqlbackup --backup-image=/var/my.mbi --backup-dir=/var/backup extract
```

Example 4.10 Selective Extract of Single File

The following command extracts the single file `meta/comments.txt` from the backup image `my.mbi` into the local path `./meta/comments.txt`.

```
mysqlbackup --backup-image=/var/my.mbi \  
--src-entry=meta/comments.txt extract
```

The following command extracts the `meta/comments.txt` file from the backup image `my.mbi` into a specified path `/tmp/mycomments.txt` by using the `--dst-entry` option.

```
mysqlbackup --backup-image=/var/my.mbi \  
--src-entry=meta/comments.txt \  
--dst-entry=/tmp/mycomments.txt extract
```

The following command dumps the contents of `meta/comments.txt` (which is inside the single-file backup `my.mbi`) to standard output.

```
mysqlbackup --backup-image=/var/my.mbi --src-entry=meta/comments.txt --dst-entry=- extract
```

Example 4.11 Selective Extract of Single Directory

The following command extracts a single directory `meta` from the backup image `my.mbi` into a local file system path `./meta`. All contents in the `meta` directory are extracted, including any subdirectories.

```
mysqlbackup --backup-image=/backup/my.mbi --src-entry=meta extract
```

The following command extracts all contents of the `meta` directory, including all its files and subdirectories, into the directory `/tmp/my-meta`.

```
mysqlbackup --backup-image=/backup/my.mbi --src-entry=meta \  
--dst-entry=/tmp/my-meta extract
```

Example 4.12 Dealing with Absolute Path Names

Since absolute pathnames are extracted to the same paths in local system, it could be a problem if you do not have write permission for that path. You can remap absolute paths as follows:

```
mysqlbackup --backup-image=/backup/my.mbi --src-entry=/ --dst-entry=/myroot extract  
mysqlbackup --backup-image=/backup/my.mbi --src-entry=. extract
```

The first command extracts all absolute paths to `/myroot` directory in the local system. The second command extracts all relative paths to the current directory.

4.3.1.1 Streaming the Backup Data to Another Device or Server

To limit the storage overhead on the database server, you can transfer the backup data to a different server without ever storing it locally. You can achieve that with a single-file backup. To send the single-file backup to standard output, use the `mysqlbackup` command `backup-to-image` without specifying the `--backup-image` option. (You can also specify `--backup-image=-` to make it obvious that the data is sent to stdout.) To stream the data, you use the single-file backup in combination with operating system features such as pipes, `ssh`, and so on, which take the input from standard output and create an equivalent file on a remote system. You can either store the single-file backup directly on the remote system, or invoke `mysqlbackup` with the `copy-back-and-apply-log` command on the other end to restore the backup to a remote MySQL server.

Example 4.13 Single-File Backup to a Remote Host

The following command streams the backup as a single-file output to a remote host to be saved under the file name `my_backup.img` (`--backup-dir=/tmp` designates the directory for storing temporary files rather than the final output file):

```
mysqlbackup --defaults-file=~/.my_backup.cnf --backup-image=- --backup-dir=/tmp backup-to-image | \
ssh <user name>@<remote host name> 'cat > ~/backups/my_backup.img'
```

For simplicity, all the connection and other necessary options are assumed to be specified in the default configuration file. `ssh` can be substituted with another communication protocol like `ftp`, and `cat` can be substituted with another command (for example, `dd` or `tar` for normal archiving).

Example 4.14 Single-file Backup to a Remote MySQL Server

The following command streams the backup as a single backup file to be restored on a remote MySQL server:

```
mysqlbackup --backup-dir=backup --backup-image=- --compress backup-to-image | \
ssh <user name>@<remote host name> 'mysqlbackup --backup-dir=backup_tmp --datadir=/data \
--innodb_log_group_home_dir=. \
--innodb_log_files_in_group=<innodb_log_files_in_group_of_backedup_server> \
--innodb_log_file_size=<innodb_log_file_size_of_backedup_server> \
--innodb_data_file_path=<innodb_data_file_path_of_backedup_server> \
--uncompress --backup-image=- copy-back-and-apply-log'
```

Example 4.15 Stream a Backup Directory to a Remote MySQL Server

The following command streams a backup directory as a single backup file to be restored on a remote MySQL server:

```
mysqlbackup --backup-image=- --backup-dir=/path/to/my/backup backup-dir-to-image | \
ssh <user name>@<remote host name> 'mysqlbackup --backup-dir=backup_tmp --datadir=/data --backup-image=- c
```

4.3.1.2 Backing Up to Tape

Tape drives are affordable, high-capacity storage devices for backup data. MySQL Enterprise Backup can interface with media management software (MMS) such as Oracle Secure Backup (OSB) to drive MySQL backup and restore jobs. The media management software must support Version 2 or higher of the System Backup to Tape (SBT) interface.

For information about doing tape backups in combination with MMS products such as Oracle Secure Backup, see [Chapter 10, Using MySQL Enterprise Backup with Media Management Software \(MMS\) Products](#).

4.3.1.3 Backing Up to Cloud Storage

MySQL Enterprise Backup supports cloud backups. Only single-file backups can be created on and restored from a cloud storage. All `mysqlbackup` options compatible with single-file operations (including, for example, the `incremental`, `compression`, `partial`, and `encryption` options) can be used with cloud backups or restores.



Note

See [Appendix B, *Limitations of MySQL Enterprise Backup*](#) for some limitations regarding the support for cloud storage by `mysqlbackup`.

Currently, MySQL Enterprise Backup supports two types of cloud storage services: OpenStack Swift or compatible object storage services (for example, Oracle Cloud Infrastructure Object Storage and Oracle Cloud Infrastructure Object Storage Classic) and Amazon S3.

MySQL Enterprise Backup 4.1 supports the Swift v1.0 API, and also the OpenStack Identity (Keystone) API v2.0 for authentication. It also supports authentication using Swift's TempAuth system or HTTP Basic Authentication.

A cloud backup is created using the cloud options for `mysqlbackup`, which are described in details in [Section 16.15, “Cloud Storage Options”](#). Here are some sample commands for creating a cloud backup:

Example 4.16 Creating a Cloud Backup on Oracle Cloud Infrastructure Object Storage Classic

This example creates a cloud backup in an Oracle Cloud Infrastructure (OCI) Object Storage Classic container, using the TempAuth system for authenticating the user's credentials.

```
mysqlbackup \
--cloud-service=openstack --cloud-container=<OCI Object Storage Classic container> \
--cloud-user-id=<serviceInstanceName>:<identityDomainName>:<userName> --cloud-password='<password>' \
--cloud-tempauth-url=https://<dataCenterCode>.storage.oraclecloud.com \
--cloud-trace=1 --cloud-object=image_900.mbi \
--backup-dir=/home/user/dba/orbackuptmpdir \
--backup-image=- \
backup-to-image
```

Example 4.17 Creating a Cloud Backup on Oracle Cloud Infrastructure Object Storage

This example creates a cloud backup in an Oracle Cloud Infrastructure (OCI) Object Storage bucket, using HTTP basic authentication.

```
mysqlbackup \
--cloud-service=openstack --cloud-container=<OCI Object Storage bucket> \
--cloud-user-id=<OCI userName> --cloud-password='<OCI auth token>' \
--cloud-ca-info=/etc/ssl/certs/ca-certificates.crt \
--cloud-basicauth-url=https://swiftobjectstorage.<region>.oraclecloud.com/v1/<OCI Object Storage namespace> \
--cloud-trace=1 --cloud-object=backup_image_900.mbi \
--backup-dir=/home/user/dba/orbackuptmpdir \
--backup-image=- \
backup-to-image
```

Example 4.18 Creating a Cloud Incremental Backup on Oracle Cloud Infrastructure Object Storage

This example creates an incremental cloud backup in an Oracle Cloud Infrastructure (OCI) Object Storage bucket, using HTTP basic authentication.

```
mysqlbackup \
```



```
--cloud-service=openstack --cloud-container=<OCI Object Storage bucket> \  
--cloud-user-id=<OCI userName> --cloud-password='<OCI auth token>' \  
--cloud-ca-info=/etc/ssl/certs/ca-certificates.crt \  
--cloud-basicauth-url=https://swiftobjectstorage.<region>.oraclecloud.com/v1/<OCI Object Storage namespace> \  
--cloud-object=backup_incr_image_900.mbi \  
--backup-dir=/home/user/dba/orincrbackuptmpdir \  
--incremental --incremental-base=history:last_backup \  
--backup-image=- \  
backup-to-image
```

Example 4.19 Creating a Cloud Backup on an OpenStack Object Storage

This example creates a cloud backup on an OpenStack object storage, using the Keystone identity service to authenticate the user's credentials.

```
mysqlbackup \  
--include-tables=testdb.tl --use-tts=with-full-locking \  
--cloud-service=openstack --cloud-container=<swift container> \  
--cloud-user-id=<keystone user> --cloud-password=<keystone password> \  
--cloud-region=<keystone region> --cloud-tenant=<keystone tenant> \  
--cloud-identity-url=<keystone url> \  
--cloud-trace=1 --cloud-object=image_800.mbi \  
--backup-dir=/home/user/dba/opbackuptmpdir \  
--backup-image=- \  
backup-to-image
```

Example 4.20 Creating a Cloud Backup on Amazon S3

```
mysqlbackup\  
--cloud-service=s3 --cloud-aws-region=<aws region> \  
--cloud-access-key-id=<aws access key id> --cloud-secret-access-key=< aws secret access key> \  
--cloud-bucket=<s3 bucket name> --cloud-object-key=<aws object key> \  
--backup-dir=/home/user/dba/s3backuptmpdir \  
--backup-image=- \  
backup-to-image
```

A cloud backup always uses one write thread.

Besides `backup-to-image`, all other `mysqlbackup` operations for single-file backups (`backup-dir-to-image`, `list-image`, `validate`, `image-to-backup-dir`, `extract`, `copy-back`, and `copy-back-and-apply-log`) can also be performed with cloud storage. For example:

Example 4.21 Extract an Existing Image from an Oracle Cloud Infrastructure Object Storage Classic Container to a Backup Directory

Extract a backup image from an Oracle Cloud Infrastructure Object Storage Classic container, using the `--backup-dir` option to specify the directory into which the image will be extracted:

```
mysqlbackup \  
--cloud-service=openstack --cloud-container=<OCI Object Storage Classic container> \  
--cloud-user-id=<serviceName>:<identityDomainName>:<userName> --cloud-password=<password> \  
--cloud-tempauth-url=https://<dataCenterCode>.storage.oraclecloud.com \  
--cloud-object=image_930.mbi \  
--backup-dir=/home/user/dba/orbackupdir \  
--backup-image=- \  
image-to-backup-dir
```

Example 4.22 Extract an Existing Image from Amazon S3 Cloud Storage to a Backup Directory

Extract a backup image from Amazon S3, using the `--backup-dir` option to specify the directory into which the image will be extracted:

```
mysqlbackup\
--cloud-service=s3 --cloud-aws-region=<aws region> \
--cloud-access-key-id=<aws access key id> --cloud-secret-access-key=< aws secret access key> \
--cloud-bucket=<s3 bucket name> --cloud-object-key=<aws object key> \
--backup-dir=/home/user/dba/s3backupdir \
--backup-image=- \
image-to-backup-dir
```

See [Section 5.1.5, “Restoring a Backup from Cloud Storage to a MySQL Server”](#) on how to restore a backup image from a cloud storage.

4.3.2 Making a Full Backup

Most backup strategies start with a complete backup of the MySQL server, from which you can restore all databases and tables. After you have created a [full backup](#), you might perform [incremental backups](#) (which are smaller and faster) for the next several backup tasks. You then make a full backup periodically to begin the cycle again.

For sample commands for making a full backup, see [Section 4.2.2, “Backing Up an Entire MySQL Instance”](#).

This section outlines some of the things to consider when deciding on a strategy for creating full backups. As we shall see, factors like speed, capacity, and convenience are all relevant for your decisions.

Options on Command Line or in Configuration File?

For clarity, the examples in this manual often show some of the command-line options that are used with the `mysqlbackup` commands. For convenience and consistency, you can include those options that remain unchanged for most backup jobs into the `[mysqlbackup]` section of the MySQL configuration file that you supply to `mysqlbackup`. `mysqlbackup` also picks up the options from the `[mysqld]` section if they are present there. Putting the options into a configuration file can simplify backup administration for you: for example, putting port information into a configuration file, you can avoid the need to edit your backup scripts each time the database instance switches to a different port. See [Chapter 17, Configuration Files and Parameters](#) for details about the use of configuration files.

Using a Single Backup Directory or Timestamped Subdirectories?

For convenience, the `--with-timestamp` option creates uniquely named subdirectories under the [backup directory](#) to hold the backup data (permanent or temporary) and metadata. The timestamped subdirectories make it simpler to establish retention periods, allowing easy removal and archiving of backup data that has passed a certain age.

If you do use a single backup directory (that is, if you omit the `--with-timestamp` option), specify a new, unique directory name for each backup job.

For incremental backups that uses the `--incremental-base` option to specify the directory containing the previous backup, in order to make the directory names predictable, you might prefer to not use the `--with-timestamp` option and generate a sequence of directory names with your backup script instead .

Always Full Backup, or Full Backup plus Incremental Backups?

If your InnoDB data volume is small, or if your database is so busy that a high percentage of data changes between backups, you might want to run a full backup each time. However, you can usually save time and storage space by running periodic full backups and then several incremental backups in between them, as described in [Section 4.3.3, “Making a Differential or Incremental Backup”](#).

Use Compression or Not?

Creating a compressed backup can save you considerable storage space and reduce I/O usage significantly. And with the LZ4 compression method, the overhead for processing compression is quite low. In cases where database backups are moving from a faster disk system where the active database files sit to a possibly slower storage, compression will often significantly lower the overall backup time. It can result in reduced restoration time as well. In general, we recommend LZ4 compression over no compression for most users, as LZ4-based backups often finish in a shorter time period. However, test out MySQL Enterprise Backup within your environment to determine what is the most efficient approach. For more discussions on compressed backups, see [Section 4.3.4, “Making a Compressed Backup”](#).

4.3.3 Making a Differential or Incremental Backup

Assuming a good portion of the data on your MySQL server remains unchanged over time, you can increase the speed and reduce the required storage space for your regular backups by backing up not all the data on the server each time, but only the changes to the data which have taken place over time. In order to that, after making first a full backup that contains all data, you can do one of the following:

- **Performing a series of differential backups.** Each [differential backups](#) includes all the changes made to the data since the last full backup was performed. To restore data up to, for example, time *t*, you simply restore first the full backup, and then, on top of it, the differential backup taken for time *t*.
- **Perform a series of incremental backup.** Each [incremental backup](#) only includes the changes since the previous backup, which can itself be a full or incremental backup. The first backup in an incremental series is always then a differential backup; but after that, each incremental backup only contains the changes made since that last incremental backup. Each subsequent incremental backup is thus usually smaller in size than a differential backup, and is faster to make; that allows you to make very frequent incremental backups, and then enables you to restore the database to a more precise point in time when necessary. However, restoring data with incremental backups might take longer and more work: in general, to restore data up to, for example, time *t*, you start with restoring the full backup, and then restore the incremental backups one by one, until you are finished with the incremental backup taken for time *t*.

MySQL Enterprise Backup supports both incremental and differential backups. You should decide on which backup strategy to adopt by looking at such factors like how much storage space you have, how quickly you have to be able to restore data, and so on.

MySQL Enterprise Backup treats differential backup as a special case of incremental backup that has a full backup as its base. To create a differential backup, simply follow the instructions below for performing incremental backups, and make sure you specify a full backup as the base of your incremental backup using the methods we describe below; you should also ignore any instructions that only apply to the handling of multiple incremental backups.



Note

For MySQL Enterprise Backup 4.1.5 and later, you can create a differential backup easily using the option `--incremental-base=history:last_full_backup`.

See [Section 16.7, “Incremental Backup Options”](#), for descriptions of the `mysqlbackup` options used for incremental backups. An Incremental backup is enabled with one of the two options: `--incremental` and `--incremental-with-redo-log-only` option. See [Creating Incremental Backups Using Only the Redo Log](#) for their differences.

When creating an incremental backup, you have to indicate to `mysqlbackup` the point in time of the previous full or incremental backup. For convenience, you can use the `--incremental-base` option to

automatically derive the necessary [log sequence number](#) (LSN) from the metadata stored in a previous backup directory or on the server. Or, you can specify an explicit LSN value using the `--start-lsn` option, providing to `mysqlbackup` the ending LSN from a previous full or incremental backup (see [Other Considerations for Incremental Backups](#) on some limitation that applies when using the `--start-lsn` option).

To prepare the backup data to be restored, you combine all incremental backups with an original full backup. Typically, you perform a new full backup after a designated period of time, after which you can discard the older incremental backup data.

Creating Incremental Backups Using Only the Redo Log

The `--incremental-with-redo-log-only` might offer some benefits over the `--incremental` option for creating an incremental backup:

- The changes to InnoDB tables are determined based on the contents of the [InnoDB redo log](#). Since the redo log files have a fixed size that you know in advance, it can require less I/O to read the changes from them than to scan the InnoDB tablespace files to locate the changed pages, depending on the size of your database, amount of DML activity, and size of the redo log files.
- Since the redo log files act as a circular buffer, with records of older changes being overwritten as new [DML](#) operations take place, you must take new incremental backups on a predictable schedule dictated by the size of the log files and the amount of redo data generated for your workload. Otherwise, the redo log might not reach back far enough to record all the changes since the previous incremental backup, in which case `mysqlbackup` will quickly determine that it cannot proceed and will return an error. Your backup script should be able to catch that error and then perform an incremental backup with the `--incremental` option instead.

For example:

- To calculate the size of the redo log, issue the command `SHOW VARIABLES LIKE 'innodb_log_file%'` and, based on the output, multiply the `innodb_log_file_size` setting by the value of `innodb_log_files_in_group`. To compute the redo log size at the physical level, look into the `datadir` directory of the MySQL instance and sum up the sizes of the files matching the pattern `ib_logfile*`.
- The InnoDB [LSN](#) value corresponds to the number of bytes written to the redo log. To check the LSN at some point in time, issue the command `SHOW ENGINE INNODB STATUS` and look under the `LOG` heading. While planning your backup strategy, record the LSN values periodically and subtract the earlier value from the current one to calculate how much redo data is generated each hour, day, and so on.
- This type of incremental backup is not so forgiving of too-low `--start-lsn` values as the standard `--incremental` option is. For example, you cannot make a full backup and then make a series of `--incremental-with-redo-log-only` backups all using the same `--start-lsn` value. Make sure to specify the precise end LSN of the previous backup as the start LSN of the next incremental backup; do not use arbitrary values.



Note

To ensure the LSN values match up exactly between successive incremental backups, it is recommended that you always use the `--incremental-base` option when you use the `--incremental-with-redo-log-only` option.

- To judge whether this type of incremental backup is practical and efficient for a particular MySQL instance:

- Measure how fast the data changes within the InnoDB redo log files. Check the [LSN](#) periodically to decide how much redo data accumulates over the course of some number of hours or days.
- Compare the rate of redo log accumulation with the size of the redo log files. Use this ratio to see how often to take an incremental backup, in order to avoid the likelihood of the backup failing because the historical data are not available in the redo log. For example, if you are producing 1GB of redo log data per day, and the combined size of your redo log files is 7GB, you would schedule incremental backups more frequently than once a week. You might perform incremental backups every day or two, to avoid a potential issue when a sudden flurry of updates produced more redo log data than usual.
- Benchmark incremental backup times using both the `--incremental` and `--incremental-with-redo-log-only` options, to confirm if the redo log backup technique performs faster and with less overhead than the traditional incremental backup method. The result could depend on the size of your data, the amount of DML activity, and the size of your redo log files. Do your testing on a server with a realistic data volume and a realistic workload. For example, if you have huge redo log files, reading them in the course of an incremental backup could take as long as reading the InnoDB data files using the traditional incremental technique. Conversely, if your data volume is large, reading all the data files to find the few changed pages could be less efficient than processing the much smaller redo log files.

Other Considerations for Incremental Backups

The incremental backup feature is primarily intended for InnoDB tables, or non-InnoDB tables that are read-only or rarely updated. Incremental backups detect changes at the level of [pages](#) in the InnoDB [data files](#), as opposed to table rows; each page that has changed is backed up. Thus, the space and time savings are not exactly proportional to the percentage of changed InnoDB rows or columns.

For non-InnoDB files, the entire file is always included in an incremental backup, which means the savings for backup resources are less significant when comparing with the case with InnoDB tables.

You cannot perform incremental backups with the `--compress` option.

No binary log files are copied into the incremental backup if the `--start-lsn` option is used. To include binary log files for the period covered by the incremental backup, use the `--incremental-base` option instead, which provides the necessary information for [mysqlbackup](#) to ensure that no gap exists between binary log data included in the previous backup and the current incremental backup.

Full-scan versus Optimistic Incremental Backup

By default, when the `--incremental` option is used for a backup without any value specified, [mysqlbackup](#) scans all InnoDB data files in the server's data directory to find pages that have been changed since the last backup was made and then saves those pages. This is called a full-scan incremental backup, which might not be very efficient when not many tables have been modified since the last backup. An optimistic incremental backup, on the other hand, only scans for changed pages in InnoDB data files that have been modified since the last backup, thus saving some unnecessary scan time.

An optimistic incremental backup can be performed by specifying `--incremental=optimistic`. While an optimistic incremental backup might shorten the backup time, it has the following limitations:

- Since this feature makes use of the modification times of the files in the server's data directory, two things must have remained unchanged since the previous backup: (1) the system time on the server, and (2) the location of the data directory. Otherwise, the backup might fail, or an inconsistent incremental backup might be produced.
- Optimistic incremental backups cannot be performed with the `--incremental-with-redo-log-only`, for which [mysqlbackup](#) reads the redo log files instead of scanning the files in the data directory.

- If the `--start-lsn` option is used, a full scan is performed even if `--incremental=optimistic` is specified since, in that case, `mysqlbackup` cannot determine the point in time for which the previous backup is consistent, and thus has no time frame to determine which files have been modified recently.

For these and other cases in which an optimistic backup is not desirable, perform a full-scan incremental backup by using the `--incremental` option without specifying a value, or use `--incremental=full-scan`, which has the same effect.

See [Section 4.1.2, “Grant MySQL Privileges to Backup Administrator”](#) on the privileges required for `mysqlbackup` to perform an optimistic incremental backup. Also see [Using Optimistic Backups and Optimistic Incremental Backups Together](#) on how to utilize the two features together in a backup schedule.

Examples of Incremental Backups

These examples use `mysqlbackup` to make an incremental backup of a MySQL server, including all databases and tables. We show two alternatives, one using the `--incremental-base` option and the other using the `--start-lsn` option.

With the `--incremental-base` option, you do not have to keep track of LSN values between one backup and the next. Instead, you can do one of the following:

- Tell `mysqlbackup` to query the `end_lsn` value from the last successful [non-TTS backup](#) as recorded in the `backup_history` table on the server using `--incremental-base=history:last_backup` or `history:last_full_backup` (for release 4.1.5 and later).
- *Advanced:* For directory backups, specify the directory of the previous backup (either full or incremental) with `--incremental-base=dir:directory_path`, and `mysqlbackup` will figure out the starting point for this backup based on the metadata of the earlier one. Because you need a known set of directory names, you might want to use hardcoded names or generate a sequence of names in your own backup script, rather than using the `--with-timestamp` option. If your last backup was a single-file, you can still use `--incremental-base=dir:directory_path` to provide the location of the temporary directory you supplied with the `--backup-dir` option during the last backup

In the following example, the `--incremental-base=history:last_backup` option is used, given which `mysqlbackup` fetches the LSN of the last successful (non-TTS) full or partial backup from the `mysql.backup_history` table and performs an incremental backup basing on that.

```
mysqlbackup --defaults-file=/home/dbadmin/my.cnf \
--incremental --incremental-base=history:last_backup \
--backup-dir=/home/dbadmin/temp_dir \
--backup-image=incremental_image1.bi \
backup-to-image
```

In the following example, an incremental backup similar to the one in the last example but [optimistic](#) in nature is performed.

```
mysqlbackup --defaults-file=/home/dbadmin/my.cnf \
--incremental=optimistic --incremental-base=history:last_backup \
--backup-dir=/home/dbadmin/temp_dir \
--backup-image=incremental_image1.bi \
backup-to-image
```

Advanced: Use the following command to create an incremental directory backup using the `--incremental-base=dir:directory_path` option; the backup is saved at the location specified by `--incremental-backup-dir`:

```
mysqlbackup --defaults-file=/home/dbadmin/my.cnf --incremental \
--incremental-base=dir:/incr-backup/wednesday \
```



```
--incremental-backup-dir=/incr-backup/thursday \
backup
```

You can also use the `--start-lsn` option to specify where the incremental backup should start. You have to record the LSN of the previous backup reported by `mysqlbackup` at the end of the backup:

```
mysqlbackup: Was able to parse the log up to lsn 2654255716
```

The number is also recorded in the `meta/backup_variables.txt` file in the folder specified by `--backup-dir` during the backup. Supply then that number to `mysqlbackup` using the `--start-lsn` option. The incremental backup then includes all changes that came *after* the specified LSN.

To create an incremental backup image with the `--start-lsn` option, use the following command, specifying with `--backup-dir` the backup directory, which, in this case, is a directory for storing the metadata for the backup and some temporary files:

```
mysqlbackup --defaults-file=/home/dbadmin/my.cnf --incremental \
--start-lsn=2654255716 \
--with-timestamp \
--backup-dir=/incr-tmp \
--backup-image=/incr-backup/incremental_image.bi \
backup-to-image
```

In the following example though, because `--backup-image` does not provide a full path to the image file to be created, the incremental backup image is created under the folder specified by `--backup-dir`:

```
mysqlbackup --defaults-file=/home/dbadmin/my.cnf --incremental \
--start-lsn=2654255716 \
--with-timestamp \
--backup-dir=/incr-images \
--backup-image=incremental_image1.bi \
backup-to-image
```

Maintaining a backup schedule:

- On a regular schedule determined by date or amount of database activity, take more incremental or differential backups.
- Optionally, periodically start the cycle over again by taking a [full](#), [uncompressed](#) or [compressed](#) backup. Typically, this milestone happens when you can archive and clear out your oldest backup data.

On how to restore your database using the incremental backups, see [Section 5.1.3, “Restoring an Incremental Backup”](#)

4.3.4 Making a Compressed Backup

To save disk space, you can compress InnoDB backup data files by using the `--compress` option of `mysqlbackup`. Compression lets you keep more sets of backup data on hand or save transmission time when sending the backup data to another server. Also, compression often results in faster backups because of reduced IO.

The backup compression feature works only for InnoDB tables. After the InnoDB tablespace files are compressed during backup, they receive the `.ibz` extension. To avoid wasting CPU cycles without saving additional disk space, `--compress` does not attempt to compress tables that were already-compressed on the server (see [Creating Compressed Tables](#)); nevertheless, such tablespace files are also saved with the `.ibz` extension inside the backup.



Note

When there is unused space within an InnoDB tablespace file, the entire file is copied during an uncompressed backup. Perform a compressed backup to avoid the storage overhead for the unused space.

The binary log and relay log files are compressed and saved with the `.bz` extension when being included in a compressed backup.

You can only use the `--compress` option for [full backups](#), not for [incremental backups](#).

You can also select the compression algorithm to use by the `--compress-method` option and, when using the ZLIB or LZMA compression algorithm, the level of compression by the `--compress-level` option. See [Section 16.6, “Compression Options”](#) for details.

This is a sample command for making a compressed single-file backup:

```
mysqlbackup --defaults-file=/etc/my.cnf --compress --backup-image=backup.img backup-to-image
```

Advanced: This is a sample command for making a compressed directory backup:

```
mysqlbackup --defaults-file=/etc/my.cnf --compress-method=zlib --compress-level=5 backup
```

This is a sample command for making a compressed and [prepared](#) directory backup (only supported for MySQL Enterprise Backup 4.0.1 and later):

```
mysqlbackup --defaults-file=/etc/my.cnf --compress-method=zlib --compress-level=5 backup-and-apply-log
```



Warning

Compression ratio is low for encrypted InnoDB tables. Creating a compressed backup with a database containing many encrypted InnoDB tables is not recommended.



Note

See the [limitation](#) that applies to compressed backups in [Appendix B, Limitations of MySQL Enterprise Backup](#).

4.3.5 Making a Partial Backup



Note

To facilitate the creation of partial backups, MySQL Enterprise Backup has introduced two new options for partial backup since version 3.10: `--include-tables` and `--exclude-tables`. The new options are intended for replacing the older options of `--include`, `--databases`, `--databases-list-file`, and `--only-innodb-with-frm`, which are incompatible with the new options and will be deprecated in the upcoming releases. In the discussions below we assume the new options are used for partial backups. For reference purpose, we have included information on the older options at the end of this section in [Making a Partial Backup with Legacy Options](#).

By default, all the files under the database subdirectories in the data directory are included in the backup, so that the backup includes data from all MySQL storage engines, any third-party storage engines, and even any non-database files in that directory. This section explains options you can use to selectively back up or exclude data.

There are various ways to create different kinds of partial backup with MySQL Enterprise Backup:

- Including or excluding specific tables by their names. This uses the `--include-tables` or `--exclude-tables` option.

Each table is checked against the regular expression specified with the `--include-tables` or `--exclude-tables` option. If the regular expression matches the fully qualified name of the table (in the form of `db_name.table_name`), the table is included or excluded for the backup. The regular expression syntax used is the extended form specified in the POSIX 1003.2 standard. The options have been implemented with the RE2 regular expression library.

- Including some or all InnoDB tables, but not other table types. This uses the `--only-innodb` option.
- Leaving out files that are present in the MySQL data directory but not actually part of the MySQL instance. This uses the `--only-known-file-types` option.
- Achieving a multiple of selection effects by using a combination of the above mentioned options.
- Backing up a selection of InnoDB tables using [transportable tablespaces \(TTS\)](#). This uses the `--use-tts` and the `--include-tables` or `--exclude-tables` (or both) options.

For syntax details on all the options involved, see [Section 16.8, “Partial Backup and Restore Options”](#).



Important

Typically, a partial backup is more difficult to restore than a full backup, because the backup data might not include the necessary interrelated pieces to constitute a complete MySQL instance. In particular, InnoDB tables have internal IDs and other data values that can only be restored to the same instance, not a different MySQL server. Always fully test the recovery procedure for any partial backups to understand the relevant procedures and restrictions.



Important

Because the InnoDB system tablespace holds metadata about InnoDB tables from all databases in an instance, restoring a partial backup on a server that includes other databases could cause the system to lose track of those InnoDB tables in the other databases. Always restore partial backups on a fresh MySQL server instance without any other InnoDB tables that you want to preserve.

The following are some command samples for partial backups.

Including all tables with names starting with “emp” into the backup:

```
mysqlbackup \
--host=localhost --user=mysqluser --protocol=TCP --port=3306 \
--backup-dir=$MEB_TEMP_BACKUP_DIR --backup-image=$MEB_BACKUPS_DIR/my.mbi \
--include-tables=".emp" \
backup-to-image
```

Taking a backup of all tables except tables from the “mysql” and “performance_schema” databases:

```
mysqlbackup \
--host=localhost --user=mysqluser --protocol=TCP --port=3306 \
--backup-dir=$MEB_TEMP_BACKUP_DIR --backup-image=$MEB_BACKUPS_DIR/my.mbi \
--exclude-tables="^(mysql|performance_schema)\." \
backup-to-image
```

Taking a backup of all tables in the “sales” database, but excludes the table with the name “hardware”

```
mysqlbackup \
--host=localhost --user=mysqluser --protocol=TCP --port=3306 \
--backup-dir=$MEB_TEMP_BACKUP_DIR --backup-image=$MEB_BACKUPS_DIR/my.mbi \
--include-tables="^sales\." --exclude-tables="^sales\.hardware$" \
backup-to-image
```

Taking a backup of all tables in the “sales reps” database, but excludes the table with the name “euro-asia” (special characters like spaces or dashes are supported by the partial backup options since release 3.12.1):

```
mysqlbackup \
--host=localhost --user=mysqluser --protocol=TCP --port=3306 \
--backup-dir=$MEB_TEMP_BACKUP_DIR --backup-image=$MEB_BACKUPS_DIR/my.mbi \
--include-tables="^sales reps\." --exclude-tables="^sales reps\.euro-asia" \
backup-to-image
```

Backing up all InnoDB tables, but not `.frm` files:

```
mysqlbackup --defaults-file=/home/dbadmin/my.cnf --only-innodb backup-to-image
```

You can also make [compressed](#) and other kinds of selective backups by using the appropriate command options.

Making a Partial Backup with the Legacy Options



Important

Information in this subsection is only for using the legacy options of `--include`, `--databases`, `--databases-list-file`, and `--only-innodb-with-frm`, which will be deprecated in the upcoming issues. For creating partial backups, it is strongly recommended that the new options of `--include-tables` and `--exclude-tables` be used instead. Note that you cannot combine the legacy and the new partial-backup options in a single command.

MySQL Enterprise Backup can make different kinds of partial backup using the legacy partial-backup options:

- Including certain InnoDB tables but not others. This operation involves the `--include`, `--only-innodb`, and `--only-innodb-with-frm` options.
- Including certain non-InnoDB tables from selected databases but not others. This operation involves the `--databases` and `--databases-list-file` options.

For syntax details on all these options, see [Legacy Partial Backup Options](#).



Note

Typically, a partial backup is more difficult to restore than a full backup, because the backup data might not include the necessary interrelated pieces to constitute a complete MySQL instance. In particular, InnoDB tables have internal IDs and other data values that can only be restored to the same instance, not a different MySQL server. Always fully test the recovery procedure for any partial backups to understand the relevant procedures and restrictions.

With its `--include` option, `mysqlbackup` can make a backup that includes some InnoDB tables but not others:

- A partial backup with the `--include` option always contains the InnoDB system tablespace and all the tables inside it.

- For the InnoDB tables stored outside the system tablespace, the partial backup includes only those tables whose names match the regular expression specified with the `--include` option.

This operation requires the tables being left out to be stored in separate `table_name.ibd` files. To put an InnoDB table outside the system tablespace, create it while the `innodb_file_per_table` MySQL configuration option is enabled. Each `.ibd` file holds the data and indexes of one table only.

Those InnoDB tables created with `innodb_file_per_table` turned off are stored as usual in the InnoDB `system tablespace`, and cannot be left out of the backup.

For each table with a per-table data file a string of the form `db_name.table_name` is checked against the regular expression specified with the `--include` option. If the regular expression matches the complete string `db_name.table_name`, the table is included in the backup. The regular expression syntax used is the extended form specified in the POSIX 1003.2 standard. On Unix-like systems, quote the regular expression appropriately to prevent interpretation of shell meta-characters. This feature has been implemented with the RE2 regular expression library.

The backup directory produced contains a backup log file and copies of InnoDB data files.

IMPORTANT: Although `mysqlbackup` supports taking partial backups, be careful when restoring a database from a partial backup. `mysqlbackup` copies also the `.frm` files of those tables that are not included in the backup, except when you do partial backups using, for example, the `--databases` option. If you use `mysqlbackup` with the `--include` option, before restoring the database, delete from the backup data the `.frm` files for any tables that are not included in the backup.

IMPORTANT: Because the InnoDB system tablespace holds metadata about InnoDB tables from all databases in an instance, restoring a partial backup on a server that includes other databases could cause the system to lose track of those InnoDB tables in other databases. Always restore partial backups on a fresh MySQL server instance without any other InnoDB tables that you want to preserve.

The `--only-innodb` and `--only-innodb-with-frm` options back up InnoDB tables only, skipping those of other storage engines. You might also use them together with the `--include` option to make selective backup of InnoDB tables while excluding all other files created by other storage engines.

Example 4.23 Making an Uncompressed Partial Backup of InnoDB Tables

In this example, we have configured MySQL so that some InnoDB tables have their own tablespaces. We make a partial backup including only those InnoDB tables in `test` database whose name starts with `ib`. The contents of the database directory for `test` database are shown below. The directory contains a MySQL description file (`.frm` file) for each of the tables (`alex1`, `alex2`, `alex3`, `blobt3`, `ibstest0`, `ibstest09`, `ibtest11a`, `ibtest11b`, `ibtest11c`, and `ibtest11d`) in the database. Of these 10 tables six (`alex1`, `alex2`, `alex3`, `blobt3`, `ibstest0`, `ibstest09`) are stored in per-table data files (`.ibd` files).

```
$ ls /sqldata/mts/test
alex1.frm  alex2.ibd  blobt3.frm  ibstest0.ibd  ibtest11a.frm  ibtest11d.frm
alex1.ibd  alex3.frm  blobt3.ibd  ibtest09.frm  ibtest11b.frm
alex2.frm  alex3.ibd  ibstest0.frm  ibtest09.ibd  ibtest11c.frm
```

We run the `mysqlbackup` with the `--include` option:

```
# Back up some InnoDB tables but not any .frm files.
$ mysqlbackup --defaults-file=/home/dbadmin/my.cnf --include="^test\.ib.*" --only-innodb backup

# Contents in the backup directory's subdirectory for the test database:
$ ls /sqldata-backup/test
ibstest0.ibd  ibtest09.ibd
```

```
# Back up some InnoDB tables and the .frm files for the backed-up tables only.
$ mysqlbackup --defaults-file=/home/dbadmin/my.cnf --include="^test\.ib.*" \
  --only-innodb-with-frm=related backup

# Contents in the backup directory's subdirectory for the test database:
$ ls /sqldata-backup/test
ibstest0.frm  ibtest09.frm
ibstest0.ibd  ibtest09.ibd
```

The backup directory's subdirectory for the `test` database contains only backups of `ibstest0` and `ibtest09` tables, because other InnoDB tables do not match the include pattern `^test\.ib.*`. The related `.frm` files are included in the second case. Notice that, however, the tables `ibtest11a`, `ibtest11b`, `ibtest11c`, `ibtest11d` are in the backup even though they are not visible in the directory shown below, because they are stored in the system tablespace (`ibdata1` file) which is always included in the backup.

Example 4.24 Making a Compressed Partial Backup

We have configured MySQL so that every InnoDB table has its own tablespace. We make a partial backup including only those InnoDB tables whose name starts with `alex` or `blob`. The contents of the database directory for `test` database is shown below.

```
$ ls /sqldata/mts/test
alex1.frm  alex2.ibd  blobt3.frm  ibstest0.ibd  ibtest11a.frm  ibtest11d.frm
alex1.ibd  alex3.frm  blobt3.ibd  ibtest09.frm  ibtest11b.frm
alex2.frm  alex3.ibd  ibstest0.frm  ibtest09.ibd  ibtest11c.frm
```

We run `mysqlbackup` with the `--compress` and `--include` options:

```
$ mysqlbackup --defaults-file=/home/dbadmin/my.cnf --compress \
  --include=".*\.(alex|blob).*" --only-innodb backup
```

The backup directory for the database `test` is shown below. The `.ibz` files are compressed per-table data files.

```
$ ls /sqldata-backup/test
alex1.ibz  alex2.ibz  alex3.ibz  blobt3.ibz
```

The `--databases` and `--databases-list-file` options of `mysqlbackup` let you back up non-InnoDB tables only from selected databases, rather than across the entire MySQL instance. (To filter InnoDB tables, use the `--include` option instead.) With `--databases`, you specify a space-separated list of database names, with the entire list enclosed in double quotation marks. With `--databases-list-file`, you specify the path of a file containing the list of database names, one per line.

Some or all of the database names can be qualified with table names, to only back up selected non-InnoDB tables from those databases.

If you specify this option, make sure you include the same set of databases for every backup (especially incremental backups), so that you do not restore out-of-date versions of any databases.

4.3.6 Making an Optimistic Backup

Optimistic backup is a feature for improving performance for backing up and restoring huge databases in which only a small number of tables are modified frequently.

During a hot backup of a huge database (say, in the order of terabytes), huge redo log files could be generated on the server when the backup is in progress. As the redo log files grow faster than they can be

processed by `mysqlbackup`, the backup operation can actually fail when `mysqlbackup` cannot catch up with the redo log cycles and LSNs get overwritten by the server before they are read by `mysqlbackup`. Moreover, the `apply-log` step for [preparing a backup for restoration](#) can take a very long time as `mysqlbackup` has huge `ibbackup_logfile` files (created from the big redo log files) to apply to the backup. The problems are intensified when the I/O resources available for reading and writing the redo logs are scarce during the backup and restoration processes.

Optimistic backup relieves the problems by dividing the backup process into two internal phases, which are transparent to the users:

1. Optimistic phase: In this first phase, tables that are unlikely to be modified during the backup process (referred to as the “inactive tables” below, identified by the user with the `optimistic-time` option or, by exclusion, with the `optimistic-busy-tables` option) are backed up without locking the MySQL instance. And because those tables are not expected to be changed before the backup is finished, redo logs, undo logs, and system table spaces are not backed up by `mysqlbackup` in this phase.
2. Normal phase: In this second phase, tables that are not backed up in the first phase (referred to as the “busy tables” below) are being backed up in a manner similar to how they are processed in an ordinary backup: the InnoDB files are copied first, and then other relevant files and copied or processed with the MySQL instance locked. The redo logs, undo logs, and the system tablespace are also backed up in this phase.

An optimistic backup occurs whenever the `optimistic-time` or `optimistic-busy-tables` option is used. For how to use the options, see detailed descriptions for them in [Section 16.10, “Performance / Scalability / Capacity Options”](#). If, as expected, the list of inactive tables identified by the optimistic options do not change during the backup (or, even if it changes by a small percentage), most users will find that the overall backup time is reduced significantly compared to an ordinary backup, as the size of the redo log data to be backed up will be far smaller. Additionally, restore time for the backup will also be reduced, as the `apply-log` operation will be much faster because of the smaller redo log. However, if it turns out that the list of inactive tables identified changed by a significant portion during the backup process, benefits of performing an optimistic back up will become limited and, in the worst case, an optimistic backup might actually take longer to perform and, for a single-file backup, the size of the backup will be larger when comparing with an ordinary backup. Therefore, users should be careful in identifying which tables are “inactive” and which are “busy” when trying to perform an optimistic backup.



Note

An optimistic backup cannot be performed for an incremental backup or a backup using [transportable tablespaces \(TTS\)](#).

The following examples illustrate how to make an optimistic backup.

Example 4.25 Optimistic Backup Using the Option `optimistic-time=YYMMDDHHMMSS`

In this example, tables that have been modified since the noon of May 16, 2011 are treated as busy tables and backed up in the normal phase of an optimistic backup, and all other tables are backed up in the optimistic phase:

```
mysqlbackup --defaults-file=/etc/my.cnf --optimistic-time=110516120000 backup-to-image
```

Example 4.26 Optimistic Backup Using the Option `optimistic-time=now`

In this example, all tables are treated as inactive tables and backed up in the optimistic phase of an optimistic backup:

```
mysqlbackup --defaults-file=/etc/my.cnf --optimistic-time=now backup-to-image
```

Example 4.27 Optimistic Backup Using the `optimistic-busy-tables` Option

In this example, tables in `mydatabase` that are prefixed by `mytables-` in their names are treated as busy tables and backed up in the normal phase of an optimistic backup, and all other tables are backed up in the optimistic phase:

```
mysqlbackup --defaults-file=/etc/my.cnf --optimistic-busy-tables="^mydatabase\.mytables-.*" backup
```

When you use both the `optimistic-time` and `optimistic-busy-tables` options and they come into conflict on determining which tables are to be busy tables, `optimistic-busy-tables` takes precedence over `optimistic-time`. For example:

Example 4.28 Optimistic and Partial Backup Using both the `optimistic-busy-tables` and `optimistic-time` Options

In this example, tables in `mydatabase` that are prefixed by `mytables-` in their names are treated as busy tables and backed up in the normal phase, even if they have not been modified since May 16, 2010, the time specified by `optimistic-time`:

```
mysqlbackup --defaults-file=/etc/my.cnf --optimistic-busy-tables="^mydatabase\.mytables-.*" \
--optimistic-time=100516 backup
```

Using Optimistic Backups and Optimistic Incremental Backups Together

By utilizing `optimistic backup` and `optimistic incremental backup` together in your backup schedule, you can speed up backups for huge databases, especially when only a relatively small number of tables have been modified since a certain time and not many tables are being modified on a frequent basis. Below is a sample sequence of commands illustrating a weekly backup schedule that makes use of the two features; it also includes the steps for restoring the data to a certain day.

```
# A full optimistic backup performed on 2017/02/04, Sat, at 1130 PM.
# The --optimistic-time option is used to specify an optimistic time of 2016/08/16, 0800 PM

mysqlbackup --defaults-file=/home/admin/my.cnf --optimistic-time=160816200000 \
--backup-dir=/home/admin/temp_dir --backup-image=/home/admin/backups/mydb_full_201702042330.bi \
--with-timestamp \
backup-to-image

# A sequence of optimistic incremental backups are then performed on each the following six days at 1130 PM
# On Sunday, 2017/02/05
mysqlbackup --defaults-file=/home/admin/my.cnf \
--incremental=optimistic --incremental-base=history:last_backup \
--backup-dir=/home/admin/temp_dir \
--backup-image=/home/admin/backups/mydb_incremental__201702052330.bi \
--with-timestamp \
backup-to-image

# On Monday, 2017/02/06
mysqlbackup --defaults-file=/home/admin/my.cnf \
--incremental=optimistic --incremental-base=history:last_backup \
--backup-dir=/home/admin/temp_dir \
--backup-image=/home/admin/backups/mydb_incremental__201702062330.bi \
--with-timestamp \
backup-to-image

# On Tuesday, 2017/02/07
mysqlbackup --defaults-file=/home/admin/my.cnf \
--incremental=optimistic --incremental-base=history:last_backup \
--backup-dir=/home/admin/temp_dir \
--backup-image=/home/admin/backups/mydb_incremental__201702072330.bi \
--with-timestamp \
backup-to-image

# On Wednesday, 2017/02/08
mysqlbackup --defaults-file=/home/admin/my.cnf \
--incremental=optimistic --incremental-base=history:last_backup \
```

```
--backup-dir=/home/admin/temp_dir \
--backup-image=/home/admin/backups/mydb_incremental__201702082330.bi \
--with-timestamp backup-to-image
# On Thursday, 2017/02/09
mysqlbackup --defaults-file=/home/admin/my.cnf \
--incremental=optimistic --incremental-base=history:last_backup \
--backup-dir=/home/admin/temp_dir \
--backup-image=/home/admin/backups/mydb_incremental__201702092330.bi \
--with-timestamp \
backup-to-image
# On Friday, 2017/02/10
mysqlbackup --defaults-file=/home/admin/my.cnf \
--incremental=optimistic --incremental-base=history:last_backup \
--backup-dir=/home/admin/temp_dir \
--backup-image=/home/admin/backups/mydb_incremental__201702102330.bi \
--with-timestamp \
backup-to-image

# Another full optimistic backup is performed on Saturday, 2017/02/11
mysqlbackup --defaults-file=/etc/my.cnf --optimistic-time=110516200000 \
--backup-dir=/home/admin/temp_dir --backup-image=/home/admin/backups/mydb_full_201702112330.bi \
--with-timestamp \
backup-to-image

# Restore the database to its state at Tuesday, 2017/02/07, at 11:30 PM
# First, restore the full optimistic backup taken on the Saturday before, which was 2017/02/04:
mysqlbackup --defaults-file=/etc/my.cnf --backup-image=/home/admin/backups/mydb_full_201702042330.bi \
--backup-dir=/home/admin/temp_dir --datadir=/var/lib/mysql \
--with-timestamp \
copy-back-and-apply-log
# Next, restore the optimistic incremental taken on the Sunday, Monday, and Tuesday that follow:
mysqlbackup --defaults-file=/etc/my.cnf --backup-image=/home/admin/backups/mydb_incremental__201702052330.bi \
--backup-dir=/home/admin/temp_dir --datadir=/var/lib/mysql --incremental \
--with-timestamp \
copy-back-and-apply-log
mysqlbackup --defaults-file=/etc/my.cnf --backup-image=/home/admin/backups/mydb_incremental__201702062330.bi \
--backup-dir=/home/admin/temp_dir --datadir=/var/lib/mysql --incremental \
--with-timestamp \
copy-back-and-apply-log
mysqlbackup --defaults-file=/etc/my.cnf --backup-image=/home/admin/backups/mydb_incremental__201702072330.bi \
--backup-dir=/home/admin/temp_dir --datadir=/var/lib/mysql --incremental \
--with-timestamp \
copy-back-and-apply-log
```

4.3.7 Making a Back Up of In-Memory Database Data

The `--exec-when-locked` option of `mysqlbackup` lets you specify a command (together with the desired command arguments) to run near the end of the backup while the database is still locked. This command can copy or create additional files in the backup directory. For example, you can use this option to back up `MEMORY` tables with the `mysqldump` command, storing the output in the backup directory. To delay any redirection or variable substitution until the command is executed, enclose the entire option value within single quotes.

4.3.8 Making Scheduled Backups

Maintaining a regular backup schedule is an important measure for preventing data loss for you MySQL server. This section discusses some simple means for setting up a schedule for running MySQL Enterprise Backup.

For Linux and other Unix-like platforms: you can set up a cron job on your system for scheduled backups. There are two types of cron jobs. To set up a user cron job, which is owned and run by a particular user, do the following:

- Log on as the user who runs MySQL Enterprise Backup and use the following command to invoke an editor for creating (or modifying) a crontab:

```
$> crontab -e
```

- In the editor, add an entry similar to the following one to the crontab, and then save your changes (make sure contents in both lines below appear in a single line in the crontab):

```
@daily /path-to-mysqldbckup/mysqlbackup -uroot --backup-dir=/path-to-backup-folder/cronbackups \
--with-timestamp --backup-image=my.mib backup-to-image &>/dev/null
```

This crontab entry invokes `mysqlbackup` to create a backup under the `cronbackups` directory at `00:00:00` everyday. Outputs from the `stderr` and `stdout` streams are redirected to `/dev/null`, so they will not invoke other actions on the part of the Cron server (for example, email notifications to the user).

To set up a system cron job, which is owned and run by `root`, create a file under the `/etc/cron.d` folder and put into it a similar crontab entry as the one above, adding the user (`root` in the following example) before the `mysqlbackup` command:

```
@daily root /path-to-mysqldbckup/mysqlbackup -uroot --backup-dir=/path-to-backup-folder/cronbackups \
--with-timestamp --backup-image=my.mib backup-to-image &>/dev/null
```

Check your platform's documentation for further details on the different ways to set up cron jobs for various types of schedules.

For Windows platforms: Use the Task Scheduler for the purpose. Check the documentation for your Windows platform for instructions.

4.4 Making Backups with a Distributed File System (DFS) or Storage Access Network (SAN)

When system administrators attempt to set up MySQL and MySQL Enterprise Backup in an environment that uses a distributed file system (DFS) or a storage access network (SAN), the MySQL server, the server's data directory, MySQL Enterprise Backup, and the backup directory may end up existing on different physical servers. When that happens, the operations of `mysqlbackup` might be impacted. The operation most likely to be adversely affected is hot backup, the success of which depends on:

1. Each page of a data file is copied consistently, that is, all the bytes in the page correspond to the same LSN.
2. No copied page is older than the time that marks the beginning of the temporal duration the backup is supposed to cover.
3. The redo log is copied consistently, meaning a continuous segment of redo log is copied, and it includes all the changes from the beginning of the temporal period that the backup is to cover until the end of the backup operation. Each block of the copied redo log has to be consistent.

Condition 1 is easily achievable with most DFSs or SANs of reasonable performance. Condition 2 though can remain unfulfilled even when condition 1 has been satisfied: for example, `mysqlbackup` could copy all the pages of a tablespace correctly except for one page for which `mysqlbackup` has included an old version into the copy. If the LSN of that old version of the page is smaller than the LSN first seen by `mysqlbackup` at the beginning of the backup process, the resulting backup will be defective. This example shows that `mysqlbackup` may have problem performing a hot backup unless it can see the writes to the file system being executed in the correct order, that is, the order in which the server executed them.

Regarding condition 3, unlike data file pages, redo log blocks are written sequentially, which means condition 3 is easier to fulfill than conditions 1 and 2. However, if `mysqlbackup` reaches the highest LSN

in the copied data file pages before encountering the end of the redo log, the backup fails. A failure occurs also if `mysqlbackup` reads a corrupted log block at any time during the copying of the redo log. Both these failures can occur if `mysqlbackup` does not see the same history of the file system states as the MySQL server does.

Therefore, to use `mysqlbackup` with a DFS or SAN, it is important to make sure that `mysqlbackup` sees all the writes to the file system in the same order as the MySQL server does. The condition is most likely to be satisfied when `mysqlbackup` and the MySQL server are running on the same server node, and it is unlikely to be always fulfilled when it is otherwise.

Chapter 5 Recovering or Restoring a Database

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The ultimate purpose of backup data is to help recover from a database issue or to create a clone of the original database in another location (typically, to run report queries or to create a new replica). This section describes the procedures to handle those scenarios.

After a serious database issue, you might need to perform a recovery under severe time pressure. It is critical to confirm in advance:

- How long the recovery will take, including any steps to transfer, unpack, and otherwise process the data.
- That you have practiced and documented all steps of the recovery process, so that you can do it correctly in one try. If a hardware issue requires restoring the data to a different server, verify all privileges, storage capacity, and so on, on that server ahead of time.
- That you have periodically verified the accuracy and completeness of the backup data, so that the system will be up and running soon after being recovered.

5.1 Performing a Restore Operation

The `mysqlbackup` commands to perform a restore operation are `copy-back-and-apply-log` and `copy-back` (for directory backup only; see [Section 5.1.7, “Advanced: Preparing and Restoring a Directory Backup”](#)). Normally, the restoration process requires the database server to be already shut down (or, at least not operating on the directory you are restoring the data to), except for restorations of backups created with the `--use-tts` option; see [explanations](#) below. The process copies the data files, logs, and other backed-up files from the backup directory back to their original locations, and performs any required post-processing on them.

Example 5.1 Restoring a Database

```
mysqlbackup --defaults-file=<my.cnf> -uroot --backup-image=<image_name> \  
--backup-dir=<backupTmpDir> --datadir=<restoreDir> copy-back-and-apply-log
```

The `copy-back-and-apply-log` command achieves two things:

- Extracts the backup from the image file and copies it to the data directory on the server to be restored.
- Performs an [apply log operation](#) to the restored data to bring them up-to-date.

See [Section 4.2.4, “Restoring a Database”](#) for an explanation of the important options used in a restore operation like `--defaults-file`, `--datadir`, `--backup-image`, and `--backup-dir`.

The restored data includes the `backup_history` table, where MySQL Enterprise Backup records details of each backup. The table allows you to perform future incremental backups using the `--incremental-base=history:{last_backup | last_full_backup}` option.



Important

- When performing a restore, make sure the target directories for restore data are all clean, containing no old or unwanted data files (this might require manual removal of files at the locations specified by the `--datadir`, `--innodb_data_home_dir`, `--innodb_log_group_home_dir`, and `--innodb_undo_directory` options). The same cleanup is not required for restoring backups created with the `--use-tts` option (in which case other requirements described in [Section 5.1.4, “Restoring Backups Created with the --use-tts Option”](#) apply though).
- After a full restore, depending on how you are going to start the restored server, you might need to adjust the ownership of the restored data directory. For example, if the server is going to be started by the user `mysql`, use the following command to change the owner attribute of the data directory and the files under it to the `mysql` user, and the group attribute to the `mysql` group.

```
$ chown -R mysql:mysql /path/to/datadir
```

- Because `mysqlbackup` does not support MySQL server's [online DDL feature](#) feature, a backup might become corrupted if, during the backup process, a DDL operation that took advantage of the feature occurred. To avoid the issue, `mysqlbackup` turns the server's system variable `old_alter_table` to “1” at the beginning of a backup if it is “0,” so that any DDL operations that take place during the backup are handled with the old table copy method. `mysqlbackup` then turns the variable back to “0” near the end of the backup operation.

Notice that in cases where `mysqlbackup` quits unexpectedly and does not turn `old_alter_table` back to its original value, the user will have to turn the value back to “0” manually on the server, in order to return the server to its original configuration. This should be performed if the statement “Server system variable 'old_alter_table' was set to '0'.” Setting it to '1'” appears in the early output of `mysqlbackup`, but the statement “Setting server system variable 'old_alter_table' back to '0'” does not appear before `mysqlbackup` quits.

The following subsections describe a number of different scenarios for restoring a backup.

5.1.1 Restoring a Compressed Backup

Restore a compressed backup image named `<image_name>`, using the `--backup-dir` option to specify the temporary directory into which temporary output, status files, and backup metadata will be saved:

Example 5.2 Restoring a Compressed Backup

```
mysqlbackup --defaults-file=<my.cnf> -uroot --backup-image=<image_name> \
--backup-dir=<backupTmpDir> --datadir=<restoreDir> --uncompress copy-back-and-apply-log
```

Advanced: Do the same for a compressed directory backup at `<backupDir>` to `<restoreDir>` on the server using `copy-back-and-apply-log`:

Example 5.3 Restoring a Compressed Directory Backup

```
mysqlbackup --defaults-file=<my.cnf> -uroot --backup-dir=<backupDir> --datadir=<restoreDir> \
--uncompress copy-back-and-apply-log
```

To restore a compressed and [prepared](#) directory backup created with the [backup-and-apply-log](#) command, use the [copy-back](#) command and the [--uncompress](#) option:

Example 5.4 Restoring a Compressed and Prepared Directory Backup

```
mysqlbackup --defaults-file=<my.cnf> -uroot --backup-dir=<backupDir> --datadir=<restoreDir> \
--uncompress copy-back
```

See [Section 4.3.4, “Making a Compressed Backup”](#) and [Section 16.6, “Compression Options”](#) for more details on compressed backups.

5.1.2 Restoring an Encrypted Backup Image

Restore an encrypted backup image named [<image_name>](#) to [<restoreDir>](#) on the server with [copy-back-and-apply-log](#), using the encryption key contained in a file named [<keyFile>](#) :

Example 5.5 Restoring an Encrypted Backup Image

```
mysqlbackup --defaults-file=<my.cnf> --backup-image=<image_name> \
--backup-dir=<backupTmpDir> --datadir=<restoreDir> --decrypt --key-file=<keyFile> copy-back-and-apply-log
```

See [Section 16.13, “Encryption Options”](#) for more details on backup encryption and decryption.

5.1.3 Restoring an Incremental Backup

There are different ways to use incremental backups to restore a database under different scenarios. The preferred method is to first restore the full backup and make it up-to-date to the time at which the full backup was performed using the [copy-back-and-apply-log](#) command (see [Example 5.1, “Restoring a Database”](#) on how to do it), then use [copy-back-and-apply-log](#) again to restore the incremental backup image on top of the full backup that was just restored:

Example 5.6 Restoring an Incremental Backup Image

```
mysqlbackup --defaults-file=<my.cnf> -uroot --backup-image=<inc_image_name> \
--backup-dir=<incBackupTmpDir> --datadir=<restoreDir> --incremental \
copy-back-and-apply-log
```

In this example, the incremental backup image named [<inc_image_name>](#) is restored to [<restoreDir>](#) on the server (where the full backup that the incremental backup image was based on has already been restored). The [--backup-dir](#) option is used to specify the temporary directory into which temporary output, status files, and backup metadata are saved. Repeat the step with other incremental backup images that you have, until the data has been restored to a desired point in time.

Advanced: Restoring an Incremental Backup Directory

Incremental directory backups can be restored in a series of [copy-back-and-apply-log](#) command, as illustrated above for single-file backups. Alternatively, at anytime after an incremental backup is taken and before the data is restored, you can bring your full backup up-to-date with your incremental backup. First, apply to the full backup any changes that occurred while the backup was running:

```
$ mysqlbackup --backup-dir=/full-backup/2010-12-08_17-14-11 apply-log
..many lines of output...
101208 17:15:10 mysqlbackup: Full backup prepared for recovery successfully!
```

```
101208 17:15:10 mysqlbackup: mysqlbackup completed OK!
```

Then, we apply the changes from the incremental backup using the `apply-incremental-backup` command:

```
$ mysqlbackup --incremental-backup-dir=/incr-backup/2010-12-08_17-14-48
  --backup-dir=/full-backup/2010-12-08_17-14-11 apply-incremental-backup
...many lines of output...
101208 17:15:12 mysqlbackup: mysqlbackup completed OK!
```

Now, the data files in the full backup directory are fully up-to-date, as of the time of the last incremental backup. You can keep updating it with more incremental backups, so it is ready to be restored anytime.

Binary Log and Relay Log Restore

When an incremental backup is being restored using either the `copy-back-and-apply-log` or `apply-incremental-backup` command, the binary log (and also the relay log, in the case of a replica server), if included in the incremental backup, is also restored to the target server by default. This default behavior is overridden when either (1) the `--skip-binlog` option (or the `--skip-relaylog` option for the relay log) is used with the restore command, or (2) if the full backup the incremental backup was based on or any prior incremental backup that came in between the full backup and this incremental backup has the binary log (or relay log) missing (in both cases, *for MySQL Enterprise Backup 4.1.5 and later*, `mysqlbackup` renamed any binary log (but not relay log) files and their index files that have already been restored onto the server by adding the `.old` extension to their file names).

For release 4.1.2 and later: Location of the binary log (or relay log) after an incremental backup is restored is, by default, the same as the log's location on the backed-up server when the incremental backup was taken, or as specified by the `--log-bin` (or `--relay-log`) option during the restore of the incremental backup.

For release 4.1.1 and earlier: Location of the binary log (or relay log) after an incremental backup is restored is the data directory of the restored server.

See [Section 4.3.3, “Making a Differential or Incremental Backup”](#), and [Section 16.7, “Incremental Backup Options”](#), for more details on incremental backups.

5.1.4 Restoring Backups Created with the `--use-tts` Option

There are some special requirements for restoring backups created with [transportable tablespaces \(TTS\)](#) (that is, created with the `--use-tts` option):

- The destination server must be running.
- Make sure that the required parameters for connecting to the server (port number, socket name, etc.) are provided as command-line options for `mysqlbackup`, or are specified in the `[client]` section of a defaults file.
- The destination server must be using the same page size that was used on the server on which the backup was made.
- The `innodb_file_per_table` option must be enabled on the destination server.
- The tables being restored must not exist on the destination server.
- A restore fails if the InnoDB file format of a per-table data file (`.ibd` file) to be restored does not match the value of the `innodb_file_format` system variable on the destination server. In that case, use the

`--force` option with the restore commands to change temporarily the value of `innodb_file_format` on the server, in order to allow restores of per-table data files regardless of their format.

When restoring a single-file backup created with the option setting `--use-tts=with-minimum-locking`, the folder specified with `--backup-dir`, besides holding temporary output, status files, and metadata, is also used for extracting temporarily all the tables in the backup and for performing an `apply-log` operation to make the data up-to-date before restoring them to the server's data directory.

Selected tables can be restored from a backup created with [transportable tablespaces \(TTS\)](#) using the `--include-tables` and `--exclude-tables` options. The following command restores all tables in the "sales" database from the backup, but excludes the table with the name "hardware" :

Example 5.7 Restoring Selected Tables from a TTS Image Backup

```
mysqlbackup --socket=/tmp/restoreserver.sock --datadir=/logs/restoreserverdata --backup-dir=/logs/backup \
--include-tables="^sales\" --exclude-tables="^sales\\.hardware$" copy-back-and-apply-log
```

This following commands rename a table when restoring it from a TTS Backup by using the `--rename` option:

Example 5.8 Restoring and Renaming a Table from a TTS Backup

```
# Using fully qualified table names:
mysqlbackup --socket=/tmp/restoreserver.sock --datadir=/logs/restoreserverdata \
--backup-dir=/BackupDirTemp --backup-image=/home/dbadmin/backups/tts-backup.mbi \
--include-tables="^sales\\.cars" --rename="sales.cars to sales.autos" copy-back-and-apply-log

# It works the same if database names are omitted in the argument for --rename:
mysqlbackup --socket=/tmp/restoreserver.sock --datadir=/logs/restoreserverdata \
--backup-dir=/BackupDirTemp --backup-image=/home/dbadmin/backups/tts-backup.mbi \
--include-tables="^sales\\.cars" --rename="cars to autos" copy-back-and-apply-log
```

5.1.5 Restoring a Backup from Cloud Storage to a MySQL Server

To restore a backup image from cloud storage to `datadir` on the server, use the [cloud storage options](#), and also the `--backup-dir` option to specify the temporary directory into which temporary output, status files, and backup metadata will be saved:

Example 5.9 Restoring a Single-file Backup from an Oracle Cloud Infrastructure (OCI) Object Storage Classic Container to a MySQL Server

```
mysqlbackup \
--defaults-file=<my.cnf> \
--cloud-service=openstack --cloud-container=<OCI Object Storage Classic container> \
--cloud-user-id=<serviceInstanceName>-<identityDomainName>:<userName> --cloud-password=<password> \
--cloud-tempauth-url=https://<dataCenterCode>.storage.oraclecloud.com \
--cloud-object=<backup_image_name> \
--datadir=/home/user/dba/datadir \
--backup-dir=/home/user/dba/orbackuptmpdir \
--backup-image=- \
copy-back-and-apply-log
```

Example 5.10 Restoring a Single-file Backup from an Oracle Cloud Infrastructure (OCI) Object Storage to a MySQL Server

```
mysqlbackup \
--defaults-file=<my.cnf> \
--cloud-service=openstack --cloud-container=<OCI Object Storage bucket> \
```

```
-cloud-user-id=<OCI userName> --cloud-password='<OCI auth token>' \
--cloud-ca-info=/etc/ssl/certs/ca-certificates.crt
--cloud-basicauth-url=https://swiftobjectstorage.<region>.oraclecloud.com/v1/<OCI Object Storage namespace> \
--cloud-object=<backup_image_name> \
--datadir=<server_datadir> \
--backup-dir=/home/user/dba/orbackuptmpdir \
--backup-image=- \
copy-back-and-apply-log
```

Example 5.11 Restoring a Cloud Incremental Backup from an Oracle Cloud Infrastructure (OCI) Object Storage Service to a MySQL Server

```
mysqlbackup \--defaults-file=<my.cnf> \
--cloud-service=openstack --cloud-container=<OCI Object Storage bucket> \
--cloud-user-id=<OCI userName> --cloud-password='<OCI auth token>' \
--cloud-ca-info=/etc/ssl/certs/ca-certificates.crt
--cloud-basicauth-url=https://swiftobjectstorage.<region>.oraclecloud.com/v1/<OCI Object Storage namespace> \
--cloud-object=<backup_image_name> \
--backup-image=- --datadir=<server_datadir> \
--backup-dir=/home/user/dba/orincrbbackuptmpdir \
--incremental
copy-back-and-apply-log
```

Example 5.12 Restoring a Single-file Backup from an OpenStack Object Storage to a MySQL Server

```
mysqlbackup \
--defaults-file=<my.cnf> \
--cloud-service=openstack --cloud-container=<swift container> \
--cloud-user-id=<keystone user> --cloud-password=<keystone password> \
--cloud-region=<keystone region> --cloud-tenant=<keystone tenant> \
--cloud-identity-url=<keystone url> --cloud-object=image_800.mbi \
--backup-dir=/home/user/dba/swiftbackuptmpdir \
--datadir=/home/user/dba/datadir \
--backup-image=- \
copy-back-and-apply-log
```

Example 5.13 Restoring a Single-file Backup from Amazon S3 to a MySQL Server

```
mysqlbackup\
--defaults-file=<my.cnf> \
--cloud-service=s3 --cloud-aws-region=<aws region> \
--cloud-access-key-id=<aws access key id> --cloud-secret-access-key=<aws secret access key> \
--cloud-bucket=<s3 bucket name> --cloud-object-key=<aws object key> \
--backup-dir=/home/user/dba/s3backuptmpdir \
--datadir=/home/user/dba/datadir \
--backup-image=- \
copy-back-and-apply-log
```

5.1.6 Restoring External InnoDB Tablespaces to Different Locations

When a backup contains external InnoDB tablespaces that resided outside of the backed-up server's data directory, you can restore them to locations different from their original ones by updating their path names in the `.bl` file inside the backup; see description of the file in [Table 1.1, “Types of Files in a Backup”](#) for details.

5.1.7 Advanced: Preparing and Restoring a Directory Backup

A directory backup, just like a single-file backup, can be [prepared](#) and restored using the `copy-back-and-apply-log` command as explained at the beginning of [Section 5.1, “Performing a Restore Operation”](#).

Example 5.14 Restoring a Backup Directory using `copy-back-and-apply-log`

```
mysqlbackup --defaults-file=/usr/local/mysql/my.cnf \
--backup-dir=/export/backups/full \
copy-back-and-apply-log
```

However, two alternatives exist for directory backups:

- Perform the [apply log operation](#) on the [raw backup](#) right after the backup, or anytime before restore, using the `apply-log` command. You can run this step on the same database server where you did the backup, or transfer the raw backup files to a different system first, to limit the CPU and storage overhead on the database server. Here are some examples of doing that, on different kinds of directory backups:

Example 5.15 Applying the Log to a Backup

This example runs `mysqlbackup` to roll forward the data files so that the data is ready to be restored:

```
mysqlbackup --backup-dir=/export/backups/2011-06-21__8-36-58 apply-log
```

That command creates InnoDB log files (`ib_logfile*`) within the backup directory and applies log records to the InnoDB data files (`ibdata*` and `*.ibd`).

Example 5.16 Applying the Log to a Compressed Backup

If the backup is compressed, as in [Section 4.3.4, “Making a Compressed Backup”](#), specify the `--uncompress` option to `mysqlbackup` when applying the log to the backup:

```
mysqlbackup --backup-dir=/export/backups/compressed --uncompress apply-log
```

**Note**

Since the [apply log operation](#) does not modify any of the original files in the backup, nothing is lost if the operation fails for some reason (for example, insufficient disk space). After fixing the problem, you can safely retry `apply-log` and by specifying the `--force` option, which allows the data and log files created by the failed [apply log operation](#) to be overwritten.

- For backups that are non-incremental, you can combine the initial backup and the `apply-log` steps using the `backup-and-apply-log` command.

After the backup has been prepared, you can now restore it using the `copy-back` command:

```
mysqlbackup --defaults-file=/usr/local/mysql/my.cnf \
--backup-dir=/export/backups/full \
copy-back
```

5.2 Point-in-Time Recovery

You can restore your database to its state at an arbitrary time using the [binary log](#) files included in the backups. The process assumes that following conditions are met:

- The backed-up MySQL Server has had its binary logging enabled. To check if this condition has been satisfied, perform this query on the server:

```
mysql> SHOW VARIABLES LIKE 'log_bin';
+-----+-----+
| Variable_name | Value |
+-----+-----+
```

```
| log_bin | ON |
+-----+
1 row in set (0.00 sec)
```

If the value of `log_bin` is `OFF`, binary logging has not been enabled. See [The Binary Log](#) on how to enable binary logging for the server.

- A series of backups, consisting typically of a full backup followed by a series of incremental backups, has been created for the server. The last backup in the series covers the targeted point in time for recovery. The example below illustrates such a typical case.
- The last backup in the backup series you have taken include in itself the relevant binary log files. (To ensure this requirement is satisfied, do not use any of the following MySQL Enterprise Backup options when creating the backup: `--skip-binlog`, `--use-tts`, `--no-locking`, or `--start-lsn`.)

These are the steps for a point-in-time recovery:

1. Restore the series of backups to the server, except for the last incremental backup in the series (which covers the targeted point in time for recovery). When finished, note the binary log position to which you have restored the server. The information is available from the `backup_variables.txt` file in the restored data directory of the server: look for the value of the entry `binlog_position` in the file. For example:

```
binlog_position=binlog.000012:426
```

This means after the restore of the backup series, the server is now at log position 426 found in the binary log file `binlog.000012`. You will need the information later.



Note

While the last binary log position recovered is also displayed by InnoDB after the restore, that is not a reliable means for obtaining the ending log position of your restore, as there could be DDL events and non-InnoDB changes that have taken place after the time reflected by the displayed position.

2. Extract the binary log from the last incremental backup in the backup series (that is, the backup that covers the targeted point in time for recovery). You do this by unpacking the incremental backup image into a backup directory using the `image-to-backup-dir` command; for example:

```
mysqlbackup --backup-dir=incr-backup-dir2 --backup-image=incremental_image2.bi image-to-backup-dir
```

Next, go into the resulting backup directory (`incr-backup-dir2` in this example) and, under the data directory inside, find the binary log file[s] (`binlog.000012` in this example):

```
incr-backup-dir2$ ls datadir
binlog.000012      ibbackup_logfile  mysql            pets            undo_002
...
```

3. Roll forward the database to its state at the targeted point in time for recovery, identified as `tR` in this example, using the `binary log` file extracted in the last step. Then, using the `mysqlbinlog` utility, replay to the server the SQL activities recorded in the `binary log` file[s], from the log position the server has been restored to in Step 1 above (which is 426 in our example) all the way to time `tR`. Specify the range of binary log events to replay using the `--start-position` option and the `--stop-position` option (which indicates the corresponding binary log position for `tR`), and pipe the output to the `mysql` client:

```
mysqlbinlog --start-position="binary-log-position-at-the-end-of-backup-restores" \
--stop-position="binary-log-position-corresponding-to-tR" \
```

```
binary-log-filename | mysql -uadmin -p
```



Notes

- Using the `--start-datetime` or `--stop-datetime` option to specify the range of binary log segment to replay is not recommended: there is a higher risk of missing binary log events when using the option. Use `--start-position` and `--stop-position` instead.
- If you have more than one binary log files in your incremental backup and they are all needed for bringing the server up to its state at `tR`, you need to pipe all of them to the server in a single connection; for example:

```
mysqlbinlog --start-position="426" --stop-position="binary-log-position-corresponding-to-tR" \
binlog.000012 binlog.000013 binlog.000014 | mysql -u admin -p
```

You can also dump all the `mysqlbinlog` output to a single file first, and then pipe or play the file to the `mysql` client.

For more explanations on using the binary log for point-in-time recovery, see [Point-in-Time \(Incremental\) Recovery](#).

4. Check that the server has been restored to the desired point in time.

5.3 Restoring a Backup with a Database Upgrade or Downgrade



Important

You may encounter technical challenges during a server upgrade or downgrade, and it is beyond the function of MySQL Enterprise Backup, as a backup tool, to ensure a successful server upgrade or downgrade. Users interested in the topic are advised to consult the MySQL server manual, especially the [Upgrading MySQL](#) and [Downgrading MySQL](#) sections, and pay careful attention to the requirements and restrictions discussed there.

You can facilitate a server upgrade or downgrade by using MySQL Enterprise Backup to make a backup of your data from a *source server*, restore it to a new *target server*, and, after some preparations, start a different version of MySQL Server on the restored data. Here are a number of things that users should pay attention to when restoring a backup with a database upgrade or downgrade:

- *Restoring a database with a server downgrade* should only be performed when the MySQL servers on the source and the target servers are in the same release series. Downgrading to a lower series (for example, from 5.7.21 to 5.6.39) might cause server crashes or data corruption.
- *Restoring a database with a server upgrade* requires the following steps, the skipping of any of which might crash the restored server:
 1. Back up the data on the source server.
 2. Using *the same version of MySQL Enterprise Backup with which the backup was taken*, restore the data to the target server by running a `copy-back-and-apply-log` operation on the backup.
 3. Install on the target server *the same version of MySQL Server that was running on the source server when your backup was created*.
 4. Start the MySQL Server you just installed. Your restored data go through an abbreviated [crash recovery](#) process in preparation for a server upgrade.

5. Perform a slow shutdown of the MySQL Server you just started in the last step by issuing the `SET GLOBAL innodb_fast_shutdown=0` statement and then shutting the server down. This ensures that all dirty pages are flushed, and hence there will be no redo log processing later for the upgraded server.
6. Install the newer MySQL Server version on the target server.
7. Start the newer MySQL Server version you just installed on the data directory you have restored and prepared in the earlier steps.
8. Perform any other additional [upgrade steps](#) that might be required for your platform or distribution as documented in the MySQL reference manual. Make sure the [mysql_upgrade](#) that comes with your newer server version is applied.

After performing these steps, check your data to make sure that your restore has been successful.

Chapter 6 Working with Encrypted InnoDB Tables

MySQL Enterprise Backup supports encrypted InnoDB tablespaces. For details on how the MySQL server encrypts and decrypts InnoDB tables, see [InnoDB Data-at-Rest Encryption](#)—it explains concepts like master key and tablespace keys, which are important for understanding how MySQL Enterprise Backup works with encrypted InnoDB tablespaces.

When InnoDB tablespace encryption uses a centralized key management solution, the feature is referred to as “MySQL Enterprise Transparent Data Encryption (TDE).”

The following is a brief description on how encrypted InnoDB tables are handled by MySQL Enterprise Backup in backup, restore, and apply-log operations.

Backing up a database with encrypted InnoDB tables. The following is a typical command for backing up a database containing encrypted InnoDB tables:

```
$ mysqlbackup --user=root --password --backup-image=/home/admin/backups/my.mbi --backup-dir=/home/admin/ba
--encrypt-password="password" backup-to-image
```

During the backup operation, `mysqlbackup` copies the encrypted InnoDB tablespace files into the backup, and also performs the following actions:

- For MySQL Enterprise Backup 4.1.0, MySQL Enterprise Backup 4.1.1 and later working with MySQL Enterprise Server 5.7.20 and earlier, or MySQL Enterprise Backup 4.1.1 and later working with MySQL Community Server 5.7:
 - For online backups, `mysqlbackup` contacts the MySQL server to determine the keyring plugin the server is using, which, currently, is either one of `keyring_file` or `keyring_okv` (for offline backups, the `--keyring` option must be used to convey the same information to `mysqlbackup`). `mysqlbackup` also finds out from the server where to access the keyring (for offline backup, the `--keyring_file_data` or `--keyring_okv_conf_dir` option must be used to supply the same information). Once `mysqlbackup` has access to the keyring, it obtains the master key and uses it to decrypt the encrypted tablespace keys, which were used to encrypt the InnoDB tables on the server.
 - Using the user password supplied with the option `--encrypt-password`, `mysqlbackup` reencrypts the tablespace keys. For each encrypted table, the reencrypted tablespace key, together with other information, is stored into a transfer file (with the `.bkt` extension), which is saved into the backup.
- For MySQL Enterprise Backup 4.1.1 and later working with MySQL Enterprise Server 5.7.21 and later:
 - MySQL Enterprise Backup always stores the master key for encryption in an encrypted file inside the backup, irrespective of the kind of keyring plugin the server uses.
 - `mysqlbackup` contacts the MySQL server to determine the keyring plugin the server is using, which, currently, is one of `keyring_encrypted_file`, `keyring_file`, `keyring_okv`, or `keyring_aws`.
 - If the server is using the `keyring_encrypted_file` plugin, the user must use the option `--encrypt-password` to supply to `mysqlbackup` the keyring file encryption password that has been set on the server with the `keyring_encrypted_file_password` option. `mysqlbackup` then copies over from the server the encrypted keyring data file, which contains the master key used to encrypt all the tablespace keys, into the `meta` folder in the backup. The encrypted tablespace files are also copied into the backup.
 - If the server uses a keyring plugin other than `keyring_encrypted_file`, `mysqlbackup` accesses the keyring to obtain the master key and uses it to decrypt the encrypted tablespace keys, which were used to encrypt the InnoDB tables on the server. The master key is then put into a keyring data file

encrypted with the user password supplied with the option `--encrypt-password` and saves the file, named `keyring_kef`, into the `meta` folder in the backup.



Note

Users who do not want to supply the password on the command line or in a defaults file may use the `--encrypt-password` option without specifying any value; `mysqlbackup` then asks the user to type in the password before the operation starts. This applies to all commands that use the `--encrypt-password` option.

An `extract` or `image-to-backup-dir` command for an image backup containing encrypted InnoDB tables does not require the `--encrypt-password` option.

Restoring a backup with encrypted InnoDB tables. The following is a typical command for restoring a single-file back up containing encrypted InnoDB tables:

```
$ mysqlbackup --defaults-file=/usr/local/mysql/my.cnf --backup-image=/home/admin/backups/my.mbi \
--backup-dir=/home/admin/restore-tmp --encrypt-password="password" copy-back-and-apply-log
```

For MySQL Enterprise Backup 4.1.0, or MySQL Enterprise Backup 4.1.1 and later working with MySQL 5.7.20 and earlier: During the restore operation, `mysqlbackup` copies the encrypted InnoDB tablespace files onto the server. `mysqlbackup` also performs the following actions:

- Using the user password supplied with the option `--encrypt-password`, which should be the same password used for backing up the database, `mysqlbackup` decrypts the tablespace keys, which were encrypted using the password when the backup was performed earlier.
- If the `--generate-new-master-key` option is used, `mysqlbackup` generates a new master key and uses it to reencrypt the tablespace keys. To use the `--generate-new-master-key` option, the `--keyring` option, as well as the `--keyring_file_data` option (when `--keyring=keyring_file`) or `--keyring_okv_conf_dir` option (when `--keyring=keyring_okv`) must be specified, so `mysqlbackup` can access the keyring and add the new master key to it.

```
$ mysqlbackup --defaults-file=/usr/local/mysql/my.cnf --backup-image=/home/admin/backups/my.mbi \
--backup-dir=/home/admin/restore-tmp --encrypt-password="password" \
--generate-new-master-key --keyring=keyring_file --keyring-file-data=path-to-keyring-file \
copy-back-and-apply-log
```

The keyring parameters should then be supplied to the restored server.

If the `--generate-new-master-key` is not used, `mysqlbackup` assumes that the same keyring used on the server when it was backed up continues to be valid and is available to the restored server.

For MySQL Enterprise Backup 4.1.1 and later working with MySQL 5.7.21 and later: The same password used for backing up the database must be supplied with the `--encrypt-password` option for a restore operation. During a restore, `mysqlbackup` copies the encrypted InnoDB tablespace files and the encrypted file containing the master keys (`keyring_kef`) onto the server. It also performs the following actions:

- For a MySQL Enterprise Server: `mysqlbackup` restores the encrypted keyring data file to its proper location on the server. The restored server has to be started with `keyring_encrypted_file` plugin and with the options `keyring_encrypted_file_data` and `keyring_encrypted_file_password` (which should supply the server with the same password used with the `--encrypt-password` option during the restore).
- For a MySQL Community Server: The `keyring_file` plugin is the only keyring plugin supported by the MySQL Community Server; therefore `mysqlbackup` uses the password supplied with the `--encrypt-`

`password` option to decrypt keyring data file and then restores it to the proper location on the server for the `keyring_file` plugin to use.

For Incremental Backups. For a series of incremental backups, if a keyring plugin other than `keyring_encrypted_file` is being used on the server, users can provide a different value for `--encrypt-password` for any of the full or incremental backup in the backup sequence. However, the password used to make the specific full or incremental backup must be provided to restore that backup. When starting the server after restoring a series of incremental backups, the password used for the restore of the last incremental backup should be supplied to the server (except for a MySQL Community Server, which will start with the `keyring_file` plugin and does not require the `keyring_encrypted_file_password` option to start).

Advanced: Creating and Restoring a directory backup with encrypted InnoDB tables. The following is a typical command for creating a directory backup containing encrypted InnoDB tables:

```
$ mysqlbackup --user=root --password --backup-dir=/home/admin/backup \  
--encrypt-password="password" backup
```

The following is a typical command for preparing the backup with the `apply-log` command:

```
$ mysqlbackup --backup-dir=/home/admin/backup --encrypt-password="password" apply-log
```

Notice that the user password must be supplied with the `--encrypt-password` option, as the tablespace keys must be decrypted before the log can be applied. The same requirement applies when you try to update a backup with an incremental backup using the `apply-incremental-backup` command:

```
$ mysqlbackup --backup-dir=/home/admin/backup --incremental-backup-dir=/home/admin/backup-in \  
--encrypt-password="password" apply-incremental-backup
```

If you used different values for `--encrypt-password` for the full or incremental backups in the backup sequence, make sure you supply the very password you used to create an individual backup when you perform an `apply-log` or `apply-incremental-backup` operation with it.

Next, a `copy-back` command restores the prepared backup onto the server:

```
$ mysqlbackup --defaults-file=/usr/local/mysql/my.cnf --backup-dir=/home/admin/backup copy-back
```

Notice that the `--encrypt-password` option is not required for this step.

You can combine the two steps of `apply-log` and `copy-back` into one by running the `copy-back-and-apply-log` command, for which the `--encrypt-password` option is required:

```
$ mysqlbackup --defaults-file=/usr/local/mysql/my.cnf --backup-dir=/home/admin/backup \  
--encrypt-password="password" copy-back-and-apply-log
```

For MySQL Enterprise Backup 4.1.0, or MySQL Enterprise Backup 4.1.1 and later working with MySQL 5.7.20 and earlier: You can also use the `--generate-new-master-key` option, just like when you are restoring a single-file backup:

```
$ mysqlbackup --defaults-file=/usr/local/mysql/my.cnf --backup-dir=/home/admin/backup \  
--generate-new-master-key --keyring=keyring_file --keyring-file-data=path-to-keyring-file \  
--encrypt-password="password" copy-back-and-apply-log
```

Limitations. Certain limitations apply when MySQL Enterprise Backup works with encrypted InnoDB tables:

- For MySQL 5.7.11 and earlier, backup for InnoDB tablespaces encrypted with “MySQL Enterprise Transparent Data Encryption (TDE)” is not supported by `mysqlbackup`. To perform a backup for those tables, upgrade the server to the latest MySQL 5.7 release, paying attention to any upgrade

requirements explained in [Changes in MySQL 5.7](#), especially the one regarding the `--early-plugin-load` option, and rotate the master key on the upgraded server using the `ALTER INSTANCE ROTATE INNODB MASTER KEY` statement. Proceed then with the backup process.

- During a `validate` operation, if `mysqlbackup` encounters any encrypted InnoDB tables, it issues a warning and then skips over them.
- For partial backups using transportable table spaces (that is, when the `--use-tts` option is used), encrypted InnoDB tables are never included in a backup. A warning is issued in the log file whenever an encrypted InnoDB table that matches the table selection criteria has been skipped over.
- The `--skip-unused-pages` option has no effect on encrypted InnoDB tables during a backup (that is, empty pages for those tables are not skipped).
- Offline backups of encrypted InnoDB tables are not supported by MySQL Enterprise Backup 4.1.1 and later when working with MySQL Enterprise Server 5.7.21 and later.

Chapter 7 Using MySQL Enterprise Backup with Replication

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Backup and restore operations are especially important in systems that use MySQL replication to synchronize data across a source server and a set of replica servers. In a replication configuration, MySQL Enterprise Backup helps you manage images for the entire system, set up new replica servers, or restore a source server in an efficient way that avoids unnecessary work for the replica servers. On the other hand, having multiple replica servers to choose from gives you more flexibility about where to perform backups. When the binary log is enabled, you have more flexibility about restoring the database to a specific point in time, even a time that is later than that of the last backup.

7.1 Setting Up a New Replica

MySQL Enterprise Backup allows you to set up a replica by backing up the source and restoring the backup on a new replica server, without having to stop the source.

For servers NOT using GTID:

1. Take a full backup of the source and then use, for example, the `copy-back-and-apply-log` command, to restore the backup and the log files to the right directories on the new replica and prepare the data.



Note

Do not use the `--no-locking` option when backing up the server, or you will be unable to get a proper binary log position in Step 4 below for initializing the replica.

2. Edit the `my.cnf` file of the new replica and put `skip-slave-start` and `event_scheduler=off` (if the source uses the `Event Scheduler`) under the `[mysqld]` section.
3. Start the new replica `mysqld`. You see the following in the server's output:

```
...
InnoDB: Last MySQL binlog file position 0 128760007, file name ./hundin-bin.000006
...
```

While a `Last MySQL binlog file position` has been displayed, it is NOT necessarily the latest binary log position on the backed up server, as InnoDB does not store binary log position information for any DDL operations or any changes to non-InnoDB tables. *Do not use this binary log position to initialize the replica.* The next step explains how to find the correct binary log position to use.

4. Look for the file `datadir/meta/backup_variables.txt` where `datadir` is the data directory of the new replica. Look into the file to retrieve the latest binary log position and the corresponding log file number stored inside:

```
binlog_position=hundin-bin.000006:128760128
```

5. Use the `CHANGE MASTER TO` SQL statement and the information you have retrieved in the last step to initialize the replica properly:

```
CHANGE MASTER TO
MASTER_LOG_FILE='hundin-bin.000006',
MASTER_LOG_POS=128760128;
```

6. Set the statuses of any events that were copied from the source to `SLAVESIDE_DISABLED`. For example:

```
mysql> UPDATE mysql.event SET status = 'SLAVESIDE_DISABLED';
```

7. Remove the line `skip-slave-start` and `event_scheduler=off` entries you added to the `my.cnf` file of the replica in step 2. (You can also leave the `skip-slave-start` entry in, but then you will always need to use the `START SLAVE` statement to start replication whenever you restart the replica server.)
8. Restart the replica server. Replication starts.

For servers using GTIDs (see [Setting Up Replication Using GTIDs](#) on how to enable servers to use GTIDs):

1. Take a full backup of the source and then use, for example, the `copy-back-and-apply-log` command, to restore the backup and the log files to the right directories on a new GTID-enabled replica and prepare the data.
2. Edit the `my.cnf` file of the new replica and put `skip-slave-start` and `event_scheduler=off` (if the source uses the [Event Scheduler](#)) under the `[mysqld]` section.
3. Start the new replica server.
4. Connect to the replica server with the `mysql` client. Then, execute the following statement to reset the binary log:

```
mysql> RESET MASTER;
```

And execute the following statement to stop the binary logging:

```
mysql> SET sql_log_bin=0;
```

5. When a server using the GTID feature is backed up, `mysqlbackup` produces a file named `backup_gtid_executed.sql`, which can be found in the restored data directory of the new replica server. The file contains a SQL statement that sets the `GTID_PURGED` configuration option on the replica:

```
# On a new replica, issue the following command if GTIDs are enabled:
SET @@GLOBAL.GTID_PURGED='f65db8e2-0e1a-11e5-a980-080027755380:1-3';
```

It also contains a commented-out `CHANGE MASTER TO` statement for initializing the replica:

```
# Use the following command if you want to use the GTID handshake protocol:
# CHANGE MASTER TO MASTER_AUTO_POSITION = 1;
```

Uncomment the command and add any needed connection and authentication parameters to it (for example, `MASTER_HOST`, `MASTER_USER`, `MASTER_PASSWORD`, and `MASTER_PORT`):

```
# Use the following command if you want to use the GTID handshake protocol:
CHANGE MASTER TO MASTER_HOST='127.0.0.1', MASTER_USER='muser', MASTER_PASSWORD='mpass', MASTER_PORT=18675,
```

Execute the file with the `mysql` client

```
mysql> source /path-to-backup_gtid_executed.sql/backup_gtid_executed.sql
```

- Set the statuses of any events that were copied from the source to `SLAVESIDE_DISABLED`. For example:

```
mysql> UPDATE mysql.event SET status = 'SLAVESIDE_DISABLED';
```

- Remove the `skip-slave-start` and `event_scheduler=off` entries you added to the `my.cnf` file of the replica in step 2. (You can also leave the `skip-slave-start` entry in, but then you will always need to use the `START SLAVE` statement to start replication whenever you restart the replica server.)
- Restart the replica server. Replication starts.

For more information on the GTIDs, see [GTID feature](#).

7.2 Backing up and Restoring a Replica Database

To backup a replica database, add the `--slave-info` option to your backup command.

To restore the backup on a replica server, follow the same steps outlined in [Section 7.1, “Setting Up a New Replica”](#).

Temporary tables on statement-based replication (SBR) replica. MySQL Enterprise Backup does not include temporary tables inside a backup. As a result, for a replica server in a statement-based replication (SBR) or a mixed-based replication setup (see [Replication Formats](#) for details), any temporary tables still open at the end of the backup process will be missing in the restored replica server, making the replication state of the replica inconsistent, and any subsequent replicated statements that refer to the temporary tables will fail. To avoid the issue, after the hot backup phase in which `mysqlbackup` copies all the InnoDB tables, it enters into a loop, in which the following happens:

- `mysqlbackup` waits until all temporary tables have been closed by the replication SQL thread. `mysqlbackup` tells if that is the case by checking if the variable `Slave_open_temp_tables` has a zero value.
- After `Slave_open_temp_tables=0` is detected, `mysqlbackup` stops the replication SQL thread to prevent more changes to the tables on the replica.
- To avoid the unexpected consequence by a race condition, after the replication SQL thread has been stopped, `mysqlbackup` checks once more if `Slave_open_temp_tables=0` is still true:
 - If it is true, `mysqlbackup` exits the loop and finishes the backup by asserting a global read lock and copies all the non-InnoDB tables.
 - If it is not true, new temporary tables have just been created and opened on the replica. `mysqlbackup` then restarts the replication SQL thread, so more updates can be made on the replica servers. `mysqlbackup` then goes back to step 1 of this loop

Besides the exit condition described in step (3) above (which is, there really are no more open temporary tables and `mysqlbackup` is ready to complete the backup), `mysqlbackup` will time out after staying in the above loop for too long to wait for all temporary tables to be closed. The duration `mysqlbackup` waits until it times out is specified by the `--safe-slave-backup-timeout` option.

In addition, `mysqlbackup` also runs an initial check at the beginning of a replica backup to see if `Slave_open_temp_tables=0` becomes true within the duration set by `--safe-slave-backup-timeout`. See description for `--safe-slave-backup-timeout` on details about the check.

Notice that the above-described issue with temporary tables does not exist for a row-based replication (RBR) setup, for which temporary tables are not replicated onto the replica. User who are certain that SBR is not occurring for the replica can set `--safe-slave-backup-timeout=0`, which will prevent `mysqlbackup` from entering the above-mentioned loop.

**Note**

See the [limitation](#) that applies when backing up a replica in [Appendix B, Limitations of MySQL Enterprise Backup](#).

7.3 Restoring a Source Database

To fix a corruption problem in a replication source database, you can restore the backup, taking care not to propagate unnecessary SQL operations to the replica servers:

1. Shut down the source database and then use, for example, the `copy-back-and-apply-log` command, to restore a backup of it and prepare the data.
2. Edit the source `my.cnf` file and comment out `log-bin`, so that the replicas do not receive twice the binary log needed to recover the source.
3. Replication in the replicas must be stopped temporarily while you pipe the binary log to the source. In the replicas, do:

```
mysql> STOP SLAVE;
```

4. Start the source `mysqld` on the restored backup:

```
$ mysqld
...
InnoDB: Doing recovery: scanned up to log sequence number 0 64300044
InnoDB: Last MySQL binlog file position 0 5585832, file name
./omnibook-bin.000002
...
```

InnoDB prints the binary log file (`./omnibook-bin.000002` in this case) and the position (`5585832` in this case) it was able to recover to.

5. Pipe the remaining of the binary log files to the restored server. The number of remaining binary log files varies depending on the length of the timespan between the last backup and the time to which you want to bring the database up to date. The longer the timespan, the more remaining binary log files there may be. All the binary log files, containing all the continuous binary log positions in that timespan, are required for a successful restore.

You also need to supply the starting position in the binary log by which the piping of the events should start. Deduce that information from the `meta/backup_variables.txt` file in the backup you just restored in step 1 above (access `backup_variables.txt` by, for example, going to the temporary backup directory you specified with `--backup-dir` during the restore, and find the file under the `meta` folder): look for the entry `binlog_position=value` in `meta/backup_variables.txt`, and supply `value` to `mysqlbinlog` with the `--start-position` option.

**Note**

While the last binary log position recovered is also displayed by InnoDB after the restore (see step 4 above), that is not a reliable number for deducing the start position for `mysqlbinlog` to use, as there could be DDL events and non-InnoDB changes that have taken place after the time reflected by the displayed position.

For example, if there are two more binary log files, `omnibook-bin.000003` and `omnibook-bin.000004` that come after `omnibook-bin.000002` and the recovery in step 4 above has ended by `5585834` according to the `backup_variables.txt` file, pipe the binary log with a single connection to the server with this command:

```
$ mysqlbinlog --start-position=5585834 /mysqldatadir/omnibook-bin.000002 \  
/mysqldatadir/omnibook-bin.000003 /mysqldatadir/omnibook-bin.000004 | mysql
```

See [Point-in-Time \(Incremental\) Recovery](#) for more instructions on using `mysqlbinlog`.

6. The source database is now recovered. Shut down the source and edit `my.cnf` to uncomment `log-bin`.
7. Start the source again.
8. Start replication in the replicas again:

```
mysql> START SLAVE;
```

Chapter 8 Using MySQL Enterprise Backup with Group Replication

For how to use MySQL Enterprise Backup to back up and subsequently restore a [Group Replication](#) member, see [Using MySQL Enterprise Backup with Group Replication](#).

For MySQL Enterprise Backup 4.1.2 and later: When working with a [Group Replication](#) setup, `mysqlbackup` makes the backup history available to all members of the server group by making sure that the `backup_history` table is updated on a primary node after each `mysqlbackup` operation. The feature requires the following to be true:

- Host names or host addresses contained in the `member_host` column in the `performance_schema.replication_group_members` table must be resolvable by `mysqlbackup`.
- In addition to the `mysqlbackup@localhost` account created on each host as described in [Section 4.1.2, “Grant MySQL Privileges to Backup Administrator”](#), accounts for the user `mysqlbackup` to access *all* hosts in the group have been created on *every* member of the server group. These are sample statements for creating the accounts:

```
CREATE USER 'mysqlbackup'@'host1' IDENTIFIED BY 'password';
CREATE USER 'mysqlbackup'@'host2' IDENTIFIED BY 'password';
CREATE USER 'mysqlbackup'@'host3' IDENTIFIED BY 'password';
...
```

Or, if the host names fall into a pattern, use a wildcard for the host names (if allowed by your environment's security policy) to perform the same task with a single statement; for example:

```
CREATE USER 'mysqlbackup'@'host_' IDENTIFIED BY 'password';
```

- The account `mysqlbackup@localhost` *AND* all other accounts for accessing the hosts (i.e., `mysqlbackup@host1`, `mysqlbackup@host2`, `mysqlbackup@host3`, etc, or simply `mysqlbackup@host_` in our example) use *the same password* for server access. This is needed because, depending on how host names are resolved, `mysqlbackup` will likely be using two accounts to finish a backup job on a Group Replication set up (one for the actual backup operation, the other for updating the history and progress tables on a primary host), but only one password can be specified in the backup command. Therefore, the accounts must use the same password.
- All the privileges granted to `mysqlbackup@localhost` as described in [Section 4.1.2, “Grant MySQL Privileges to Backup Administrator”](#) are also granted to all other accounts with which `mysqlbackup` connects to the hosts:

```
GRANT SELECT ON performance_schema.replication_group_members TO 'mysqlbackup'@'host1';
GRANT SELECT ON performance_schema.replication_group_members TO 'mysqlbackup'@'host2';
GRANT SELECT ON performance_schema.replication_group_members TO 'mysqlbackup'@'host3';
[More grant statements for other privileges for all hosts ...]
```

Or, if the host names fall into a pattern, use a wildcard for the host names (if allowed by your environment's security policy) to perform the same task; for example:

```
GRANT SELECT ON performance_schema.replication_group_members TO 'mysqlbackup'@'host_';
[More grant statements for other privileges...]
```

Chapter 9 Encryption for Backups

In order to enhance security for backed up data, MySQL Enterprise Backup provides encryption for single-file backups. The encryption can also be applied when creating a partial, compressed, or incremental single-file backups, and for [streaming backup data to another device or server](#).

The encryption is performed with Advanced Encryption Standard (AES) block cipher in CBC mode, with a key string of 64 hexadecimal digits supplied by the user. Decryption is performed using the same key. The key can be created manually just by putting together 64 random hexadecimal bytes, or it can be generated by [shasum](#) (or similar programs for hash calculations that work on your platform) by supplying it with a keyphrase:

```
$ echo -n "my secret passphrase" | shasum -a 256
a7e845b0854294da9aa743b807cb67b19647c1195ea8120369f3d12c70468f29 -
```

Note that the “-” at the end is not part of the key and should be ignored. Supply the key to [mysqlbackup](#) with the `--key` option, or paste the key into a key file and supply the file's pathname to [mysqlbackup](#) with the `--key-file` option.

To generate a key randomly, you can use tools like OpenSSL:

```
$ openssl rand -hex 32
8f3ca9b850ec6366f4a54feba99f2dc42fa79577158911fe8cd641ffff1e63d6
```

To put an OpenSSL-generated key into a key file, you can do the following:

```
$ openssl rand -hex 32 >keyfile
$ cat keyfile
6a1d325e6ef0577f3400b7cd624ae574f5186d0da2eeb946895de418297ed75b
```

The encryption function uses MySQL Enterprise Backup's own encryption format, which means decryption is possible only by using MySQL Enterprise Backup. For Unix-like operating systems, different magic numbers are used to identify encrypted and unencrypted backup files. For example, you can add these lines to the `/etc/magic` file of your operating system:

```
0 string MBackupP\n MySQL Enterprise Backup backup image
0 string MebEncR\n MySQL Enterprise Backup encrypted backup
```

The `file` command can then be used to identify the file types:

```
$ file /backups/image1 /backups/image2
/backups/image1: MySQL Enterprise Backup backup image
/backups/image2: MySQL Enterprise Backup encrypted backup
```

The command options used for encryption and decryption are `--encrypt`, `--decrypt`, `--key`, and `--key-file`. These options can be used with various operations on backup images. See [Section 16.13, “Encryption Options”](#) for details.

The following is a sample command for creating an encrypted backup:

```
mysqlbackup --backup-image=/backups/image.enc --encrypt
--key=23D987F3A047B475C900127148F9E0394857983645192874A2B3049570C12A34
--backup-dir=/var/tmp/backup backup-to-image
```

To use a key file for the same task:

```
mysqlbackup --backup-image=/backups/image.enc --encrypt
--key-file=/meb/key --backup-dir=/var/tmp/backup backup-to-image
```

To decrypt a backup when extracting it:

```
mysqlbackup --backup-image=/backups/image.enc --decrypt  
--key-file=/meb/key --backup-dir=/backups/extract-dir extract
```

To validate an encrypted backup image:

```
mysqlbackup --backup-image=/logs/encimage.bi --decrypt --key-file=/meb/enckey validate
```

Chapter 10 Using MySQL Enterprise Backup with Media Management Software (MMS) Products

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This section describes how you can use MySQL Enterprise Backup in combination with media management software (MMS) products for creating backups for your database. Such products are typically used for managing large volumes of backup data, often with high-capacity backup devices such as tape drives.

10.1 Backing Up to Tape with Oracle Secure Backup

Tape drives are affordable, high-capacity storage devices for backup data. MySQL Enterprise Backup can interface with media management software (MMS) such as Oracle Secure Backup (OSB) to drive MySQL backup and restore jobs. The media management software must support Version 2 or higher of the System Backup to Tape (SBT) API.

On the MySQL Enterprise Backup side, you run the backup job as a single-file backup using the `--backup-image` parameter, with the prefix `sbt:` in front of the filename, and optionally pass other `--sbt-*` parameters to `mysqlbackup` to control various aspects of the SBT processing. The `--sbt-*` options are listed in [Section 16.9, “Single-File Backup Options”](#).

On the OSB side, you can schedule MySQL Enterprise Backup jobs by specifying a configurable command that calls `mysqlbackup`. You control OSB features such as encryption by defining a “storage selector” that applies those features to a particular backup, and passing the name of the storage selector to OSB using the MySQL Enterprise Backup parameter `--sbt-database-name=storage_selector`.

To back up MySQL data to tape:

- Specify the `--backup-image=sbt:name` parameter of `mysqlbackup` to uniquely identify the backup data. The `sbt:` prefix sends the backup data to the MMS rather than a local file, and the remainder of the argument value is used as the unique backup name within the MMS.
- Specify the `--sbt-database-name` parameter of `mysqlbackup` to enable the OSB operator to configure a storage selector for backups from this MySQL source. (This parameter refers to a “storage selector” defined by the OSB operator, not to any MySQL database name.) By default, `mysqlbackup` supplies a value of `MySQL` for this MMS parameter. The argument to this option is limited to 8 bytes.
- If you have multiple media management programs installed, to select the specific SBT library to use, specify the `--sbt-lib-path` parameter of the `mysqlbackup` command. If you do not specify the `--sbt-lib-path` parameter, `mysqlbackup` uses the normal operating system paths and environment variables to locate the SBT library, which is named `libobk.so` on Linux and Unix systems and `ORASBT.DLL` on Windows systems. When you specify `--sbt-lib-path`, you can use a different filename for the library in addition to specifying the path.
- Specify any other product-specific settings that are normally controlled by environment variables using the `--sbt-environment` option.

Each time an online backup is made to a tape using the SBT API, besides recording the backup in the `mysql.backup_history` and the `mysql.backup_progress` tables, an entry is also made to the `mysql.backup_sbt_history` table on the backed up MySQL instance. That facilitates the

management of tape backups by allowing easy look-ups for information on them. The definition of the `backup_sbt_history` table is shown below:

```
mysql> DESCRIBE `backup_sbt_history`;
```

Field	Type	Null	Key	Default	Extra
backup_id	bigint(20)	NO		NULL	
backup_file_name	varchar(4096)	NO		NULL	
file_creation_time	timestamp	NO		0000-00-00 00:00:00	
file_expiry_time	timestamp	NO		0000-00-00 00:00:00	
volume_label	varchar(64)	NO		NULL	
sbt_error_msg	varchar(4096)	NO		NULL	
sbt_error_code	int(11)	NO		NULL	

Here are the descriptions for the fields in the table:

- `backup_id`: The backup's ID, which is also recorded in the backup's entries in the `mysql.backup_history` and the `mysql.backup_progress` tables.
- `backup_file_name`: The file name provided by the user through the `--backup-image=sbt:name` option.
- `file_creation_time`: Creation date and time for the tape backup.
- `file_expiry_time`: Expiration date and time for the tape backup.
- `volume_label`: Volume label for the physical medium which contains the tape backup.
- `sbt_error_msg`: Error message, when an error occurs while retrieving information for the tape backup.
- `sbt_error_code`: Error code, when an error occurs while retrieving information for the tape backup.

Multiple entries, one for each volume label, are created in the `mysql.backup_sbt_history` table, if the backup is split across multiple volumes.

Here are some sample entries in the `mysql.backup_sbt_history` table:

```
mysql> select * from mysql.backup_sbt_history;
```

backup_id	backup_file_name	file_creation_time	file_expiry_time	volume_label	sbt_error_
14377247250385175	test1.mbi	2015-07-24 09:59:00	0000-00-00 00:00:00	MySQL-000018	
14377259679196369	test2.mbi	2015-07-24 10:19:43	0000-00-00 00:00:00	MySQL-000018	
14377265350728997	test3.mbi	2015-07-24 10:29:10	0000-00-00 00:00:00	MySQL-000018	
14377265350728997	test3.mbi	2015-07-24 10:29:10	0000-00-00 00:00:00	MySQL-000019	

4 rows in set (0.00 sec)

A backup to tape always uses one write thread.

To restore MySQL data from tape:

- Specify the `--backup-image=sbt:name` parameter of `mysqlbackup` as part of the restore operation. Use the same `name` value which was used during the backup. This single parameter retrieves the appropriate data from the appropriate tape device.
- Optionally use the `--sbt-lib-path` option, using the same value as for the backup operation.
- Specify any other product-specific settings that are normally controlled by environment variables using the `--sbt-environment` option.

For product-specific information about Oracle Secure Backup, see [the Oracle Secure Backup documentation](#).

Example 10.1 Sample `mysqlbackup` Commands Using MySQL Enterprise Backup with Oracle Secure Backup

```
# Uses libobk.so or ORASBT.DLL, at standard locations:
mysqlbackup --port=3306 --protocol=tcp --user=root --password \
  --backup-image=sbt:backup-shoeprod-2011-05-30 \
  --backup-dir=/backup backup-to-image

# Associates this backup with storage selector 'shoeprod':
mysqlbackup --port=3306 --protocol=tcp --user=root --password \
  --backup-image=sbt:backup-shoeprod-2011-05-30 \
  --sbt-database-name=shoeprod \
  --backup-dir=/backup backup-to-image

# Uses an alternative SBT library, /opt/Other-MMS.so:
mysqlbackup --port=3306 --protocol=tcp --user=root --password \
  --backup-image=sbt:backup-shoeprod-2011-05-30 \
  --sbt-lib-path=/opt/Other-MMS.so \
  --backup-dir=/backup backup-to-image
```

Chapter 11 Performance Considerations for MySQL Enterprise Backup

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This chapter describes the performance considerations for backing up and restoring databases using MySQL Enterprise Backup.

11.1 Optimizing Backup Performance

This section describes the performance considerations for backing up a database with MySQL Enterprise Backup. When optimizing and tuning the backup procedure, measure both the raw performance (how long it takes the backup to complete) and the amount of overhead on the database server. When measuring backup performance, consider:

- The limits imposed by your backup procedures. For example, if you take a backup every 8 hours, the backup must take less than 8 hours to finish.
- The limits imposed by your network and storage infrastructure. For example, if you need to fit many backups on a particular storage device, you might use compressed backups, even if that made the backup process slower.
- The tradeoff between backup time and restore time. You might choose a set of options resulting in a slightly slower backup, if those options enable the restore to be much faster. See [Section 11.2, “Optimizing Restore Performance”](#) for performance information for the restore process.

Full or Incremental Backup

After taking a full backup, subsequent backups can be performed more quickly by doing incremental backups, where only the changed data is backed up. For an incremental backup, specify the `--incremental` or `--incremental-with-redo-log-only` option to `mysqlbackup`. See [Section 16.7, “Incremental Backup Options”](#) for information about these options. For usage instructions for the backup and apply stages of incremental backups, see [Section 4.3.3, “Making a Differential or Incremental Backup”](#).

Compressed Backup

Compressing the backup data before transmitting it to another server involves additional CPU overhead on the database server where the backup takes place, but less network traffic and less disk I/O on the server that is the final destination for the backup data. Consider the load on your database server, the bandwidth of your network, and the relative capacities of the database and destination servers when deciding whether or not to use compression. See [Section 4.3.4, “Making a Compressed Backup”](#) and [Section 16.6, “Compression Options”](#) for information about creating compressed backups.

Compression involves a tradeoff between backup performance and restore performance. In an emergency, the time needed to uncompress the backup data before restoring it might be unacceptable. There might also be storage issues if there is not enough free space on the database server to hold both the compressed backup and the uncompressed data. Thus, the more critical the data is, the more likely that

you might choose not to use compression: accepting a slower, larger backup to ensure that the restore process is as fast and reliable as possible.

Single-File Backups

The single-file backup by itself is not necessarily faster than the traditional type of backup that produces a directory tree of output files. Its performance advantage comes from combining different steps that you might otherwise have to perform in sequence, such as combining the backup data into a single output file and transferring it to another server. See [Section 15.5, “Other Single-File Backup Operations”](#) for the options related to single-file backups, and [Section 4.3.1, “Making a Single-File Backup”](#) for usage instructions.

InnoDB Configuration Options Settings

As discussed later, there are a number of reasons why you might prefer to run with the setting `innodb_file_per_table=1`.

Parallel Backup

`mysqlbackup` can take advantage of modern multicore CPUs and operating system threads to perform backup operations in parallel. See [Section 16.10, “Performance / Scalability / Capacity Options”](#) for the options to control how many threads are used for different aspects of the backup process. If you see that there is unused system capacity during backups, consider increasing the values for these options and testing whether doing so increases backup performance:

- When tuning and testing backup performance using a RAID storage configuration, consider the combination of option settings `--read-threads=3 --process-threads=6 --write-threads=3`. Compare against the combination `--read-threads=1 --process-threads=6 --write-threads=1`.
- When tuning and testing backup performance using a non-RAID storage configuration, consider the combination of option settings `--read-threads=1 --process-threads=6 --write-threads=1`.
- When you increase the values for any of the 3 “threads” options, also increase the value of the `--limit-memory` option, to give the extra threads enough memory to do their work.
- If the CPU is not too busy (less than 80% CPU utilization), increase the value of the `--process-threads` option.
- If the storage device that you are backing up from (the source drive) can handle more I/O requests, increase the value of the `--read-threads` option.
- If the storage device that you are backing up to (the destination drive) can handle more I/O requests, increase the value of the `--write-threads` option (not applicable to single-file backups, which always use a single write thread).

Depending on your operating system, you can measure resource utilization using commands such as `top`, `iostat`, `sar`, `dtrace`, or a graphical performance monitor. Do not increase the number of read or write threads once the system `iowait` value reaches approximately 20%.

MyISAM Considerations



Important

- Although `mysqlbackup` backs up InnoDB tables without interrupting database use, the final stage that copies non-InnoDB files (such as MyISAM tables and

`.frm` files) temporarily puts the database into a read-only state, using the statement `FLUSH TABLES WITH READ LOCK`. For best backup performance and minimal impact on database processing:

1. Do not run long `SELECT` queries or other SQL statements at the time of the backup run.
2. Keep your MyISAM tables relatively small and primarily for read-only or read-mostly work.

Then the locked phase at the end of a `mysqldump` run is short (maybe a few seconds), and does not disturb the normal processing of `mysqld` much. If the preceding conditions are not met in your database application, use the `--only-innodb` or `--only-innodb-with-frm` option to back up only InnoDB tables, or use the `--no-locking` option to back up non-InnoDB files. Note that MyISAM, `.frm`, and other files copied under the `--no-locking` setting cannot be guaranteed to be consistent, if they are updated during this final phase of the backup.

- For a large database, a backup run might take a long time. Always check that `mysqldump` has completed successfully, either by verifying that `mysqldump` returned exit code 0, or by observing that `mysqldump` has printed the text “mysqldump completed OK!”.
- Schedule backups during periods when no DDL operations involving tables are running. See [Appendix B, Limitations of MySQL Enterprise Backup](#) for restrictions on backups at the same time as DDL operations.

Network Performance

For data processing operations, you might know the conventional advice that Unix sockets are faster than TCP/IP for communicating with the database. Although the `mysqldump` command supports the options `--protocol=tcp`, `--protocol=socket`, and `--protocol=pipe`, these options do not have a significant effect on backup or restore performance. These processes involve file-copy operations rather than client/server network traffic. The database communication controlled by the `--protocol` option is low-volume. For example, `mysqldump` retrieves information about database parameters through the database connection, but not table or index data.

Data Size

If certain tables or databases contain non-critical information, or are rarely updated, you can leave them out of your most frequent backups and back them up on a less frequent schedule. See [Section 16.8, “Partial Backup and Restore Options”](#) for information about the relevant options, and [Section 4.3.5, “Making a Partial Backup”](#) for instructions about leaving out data from specific tables, databases, or storage engines. Partial backups are faster because they copy, compress, and transmit a smaller volume of data.

To minimize the overall size of InnoDB data files, consider enabling the MySQL configuration option `innodb_file_per_table`. This option can minimize data size for InnoDB tables in several ways:

- It prevents the InnoDB system tablespace from ballooning in size, allocating disk space that can afterwards only be used by MySQL. For example, sometimes huge amounts of data are only needed temporarily, or are loaded by mistake or during experimentation. Without the `innodb_file_per_table` option, the system tablespace expands to hold all this data, and never shrinks afterward.

- It immediately frees the disk space taken up by an [InnoDB](#) table and its indexes when the table is dropped or truncated. Each table and its associated indexes are represented by a [.ibd file](#) that is deleted or emptied by these DDL operations.
- It allows unused space within a [.ibd](#) file to be reclaimed by the [OPTIMIZE TABLE](#) statement, when substantial amounts of data are removed or indexes are dropped.
- It enables partial backups where you back up some [InnoDB](#) tables and not others, as discussed in [Section 4.3.5, “Making a Partial Backup”](#).
- It allows the use of table compression for InnoDB tables.

In general, using table compression by having [ROW_FORMAT=COMPRESSED](#) decreases table sizes and increase backup and restore performance. However, as a trade-off, table compression can potentially increase redo log sizes and thus slow down incremental backups and restores, as well as [apply-log](#) operations. See [How Compression Works for InnoDB Tables](#) for details.

Avoid creating indexes that are not used by queries. Because indexes take up space in the backup data, unnecessary indexes slow down the backup process. (The copying and scanning mechanisms used by [mysqlbackup](#) do not rely on indexes to do their work.) For example, it is typically not helpful to create an index on each column of a table, because only one index is used by any query. Because the primary key columns are included in each [InnoDB](#) secondary index, it wastes space to define primary keys composed of numerous or lengthy columns, or multiple secondary indexes with different permutations of the same columns.

Advanced: Apply-Log Phase (for Directory Backups only)

If you store the backup data on a separate machine, and that machine is not as busy the machine hosting the database server, you can offload some postprocessing work (the [apply-log](#) phase) to that separate machine. [Apply-log Operation](#)

There is always a performance tradeoff between doing the [apply-log](#) phase immediately after the initial backup (makes restore faster), or postponing it until right before the restore (makes backup faster). In an emergency, restore performance is the most important consideration. Thus, the more crucial the data is, the more important it is to run the [apply-log](#) phase immediately after the backup. Either combine the backup and [apply-log](#) phases on the same server by specifying the [backup-and-apply-log](#) option, or perform the fast initial backup, transfer the backup data to another server, and then perform the [apply-log](#) phase using one of the options from [Apply-log Operation](#).

11.2 Optimizing Restore Performance

This section describes the performance considerations for restoring a database with MySQL Enterprise Backup. This subject is important because:

- The restore operation is the phase of the backup-restore cycle that tends to vary substantially between different backup methods. For example, backup performance might be acceptable using [mysqldump](#), but [mysqldump](#) typically takes much longer than MySQL Enterprise Backup for a restore operation.
- The restore operation is often performed during an emergency, where it is critical to minimize the downtime of the application or web site.
- The restore operation is always performed with the database server shut down.
- The restore operation is mainly dependent on low-level considerations, such as I/O and network speed for transferring files, and CPU speed, processor cores, and so on for uncompressing data.

For the combination of options you can specify for a restore job, see [Section 15.3, “Restore Operations”](#).

Restoring Different Classes of Backup Data

Restoring a partial backup takes less time than restoring a full backup, because there is less data to physically copy. See [Section 16.8, “Partial Backup and Restore Options”](#) for information about making partial backups.

Restoring a compressed backup takes more time than restoring an uncompressed backup, because the time needed to uncompress the data is typically greater than any time saved by transferring less data across the network. If you need to rearrange your storage to free up enough space to uncompress the backup before restoring it, include that administration work in your estimate of the total time required. In an emergency, the time needed to uncompress the backup data before restoring it might be unacceptable. on the database server to hold both the compressed backup and the uncompressed data. Thus, the more critical the data is, the more likely that you might choose not to use compression: accepting a slower, larger backup to ensure that the restore process is as fast and reliable as possible. See [Section 16.6, “Compression Options”](#) for information about making compressed backups.

The unpacking process to restore a single-file backup is typically not expensive either in terms of raw speed or extra storage. Each file is unpacked directly to its final destination, the same as if it was copied individually. Thus, if you can speed up the backup substantially or decrease its storage requirements by using single-file backups, that typically does not involve a tradeoff with restore time. See [Section 15.5, “Other Single-File Backup Operations”](#) for information about making single-file backups.

The Apply-Log Phase (for Directory Backups only)

See [Advanced: Apply-Log Phase \(for Directory Backups only\)](#) for performance considerations regarding the apply-log phase.

Network Performance

For data processing operations, you might know the conventional advice that Unix sockets are faster than TCP/IP for communicating with the database. Although the `mysqlbackup` command supports the options `--protocol=tcp`, `--protocol=socket`, and `--protocol=pipe`, these options do not have a significant effect on backup or restore performance. These processes involve file-copy operations rather than client/server network traffic. The database communication controlled by the `--protocol` option is low-volume. For example, `mysqlbackup` retrieves information about database parameters through the database connection, but not table or index data.

Parallel Restore

`mysqlbackup` can take advantage of modern multicore CPUs and operating system threads to perform backup operations in parallel. See [Section 16.10, “Performance / Scalability / Capacity Options”](#) for the options to control how many threads are used for different aspects of the restore process. If you see that there is unused system capacity during a restore, consider increasing the values for these options and testing whether doing so increases restore performance:

- When tuning and testing backup performance using a RAID storage configuration, consider the combination of option settings `--read-threads=3` `--process-threads=6` `--write-threads=3`. Compare against the combination `--read-threads=1` `--process-threads=6` `--write-threads=1`.
- When tuning and testing backup performance using a non-RAID storage configuration, consider the combination of option settings `--read-threads=1` `--process-threads=6` `--write-threads=1`.

- When you increase the values for any of the 3 “threads” options, also increase the value of the `--limit-memory` option, to give the extra threads enough memory to do their work.
- If the CPU is not too busy (less than 80% CPU utilization), increase the value of the `--process-threads` option.
- If the storage device that you are restoring from (the source drive) can handle more I/O requests, increase the value of the `--read-threads` option (not applicable to restores of single-file backups, which always use a single read thread).
- If the storage device that you are restoring to (the destination drive) can handle more I/O requests, increase the value of the `--write-threads` option.

For an apply-log operation, the `--process-threads` option controls the number of threads that read and write modified datafile pages in parallel; those threads are usually I/O bound, even though they also perform some in-memory processing.

Depending on your operating system, you can measure resource utilization using commands such as `top`, `iostat`, `sar`, `dtrace`, or a graphical performance monitor. Do not increase the number of read or write threads `iowait` once the system `iowait` value reaches approximately 20%.

Chapter 12 Monitoring Backups with MySQL Enterprise Monitor

The MySQL Enterprise Monitor is a companion product to the MySQL Server that enables monitoring of MySQL instances and their hosts, notification of potential issues and problems, and advice on how to correct issues. Among its other functions, it can be used to monitor the progress and history of backup jobs. Check the [MySQL Enterprise Monitor User's Guide](#) for detail.

Chapter 13 Troubleshooting for MySQL Enterprise Backup

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To troubleshoot issues regarding backup and restore with the MySQL Enterprise Backup product, consider the following aspects:

- Before troubleshooting any problem, familiarize yourself with the known limits and restrictions on the product, in [Appendix B, *Limitations of MySQL Enterprise Backup*](#).
- If `mysqlbackup` encounters problems during operating system calls, it returns the corresponding OS error codes. You might need to consult your operating system's documentation for the meaning of those error codes and how to handle them.
- The output from `mysqlbackup` is sent to `stderr` rather than `stdout`. By default, the same output is also saved to a log file in the `backup_dir` for use in error diagnosis. See [Section 16.11, “Message Logging Options”](#) for details on how to configure this logging feature.
- Incremental backups, when performed using the `--start-lsn` option, require care to specify a sequence of time periods. You must record the final LSN value at the end of each backup, and specify that value in the next incremental backup. You must also make sure that the full backup you restore is prepared correctly first, so that it contains all the changes from the sequence of incremental backups.
- As `mysqlbackup` proceeds, it writes progress information into the `mysql.backup_progress` table. When the command finishes the backup operation, it records status information in the `mysql.backup_history` table. You can query those tables to monitor ongoing backup jobs, see how much time has been used for various stages, and check if any errors have occurred.

13.1 Exit codes of MySQL Enterprise Backup

MySQL Enterprise Backup returns one of the following exit codes as it exits an operation. The meaning of each code is explained in [Table 13.1, “MySQL Enterprise Backup Exit Codes and Messages”](#) by its associated exit message.

Table 13.1 MySQL Enterprise Backup Exit Codes and Messages

Exit Code	Exit Message
0	No error
1	Unknown Error
2	Internal Error
3	One of the required files is corrupt
4	One of the required files not found
5	Corrupt page or header encountered
6	Mismatch in config and the value obtained

Exit Code	Exit Message
7	Illegal Argument
8	One or more of the arguments are unknown
9	IO operation failed
10	Error allocating memory
11	Connection to server failed
12	Ongoing operation interrupted by user
13	User doesn't have sufficient privileges
14	No space left on device
15	Image version is not supported by this version of meb
16	The value is out of range
17	Innodb Error
18	Timedout while waiting for resource
19	Server returned error while executing sql

The `mysqlbackup` command `print-message` takes an exit code supplied with the `--error-code` option and returns the corresponding exit message in the `stdout` stream. Users can, for example, use a script to catch the exit code returned by `mysqlbackup`, and then pass it onto the `print-message` command to obtain an exit message. See the description for `print-message` for details.

13.2 Working Around Corruption Problems

Sometimes the operating system or the hardware can corrupt a data file page at a location that does not cause a database error, but prevents `mysqlbackup` from completing:

```
170225 10:46:18 PCR1 INFO: Re-reading page at offset 0 in D:/temp/5.7_master/test/emp2.ibd
170225 10:46:18 PCR1 INFO: Re-reading page at offset 0 in D:/temp/5.7_master/test/emp2.ibd
...
170225 10:46:26 PCR1 ERROR: Page at offset 0 in D:/temp/5.7_master/test/emp2.ibd seems corrupt!
```

A corruption problem can have different causes. Here are some suggestions for dealing with it:

- The problem can occur if the MySQL server is too busy. Before trying other solutions, you might want to perform the backup again using some non-default settings for the following `mysqlbackup` options:
 - `--page-reread-time=MS`. Try set the value to, for example, "0.05", for faster rereads during checksum failures.
 - `--page-reread-count=retry_limit`. Try set the value to, for example, "1000", to allow more rereads during checksum failures before MySQL Enterprise Backup gives up and throws an error.
- Scrambled data in memory can cause the problem even though the data on disk is actually uncorrupted. Reboot the database server and the storage device to see if the problem persists.
- If the problem persists after the database server and the storage device have been restarted, you might really have a corruption on your disk. You might consider restoring data from an earlier backup and "roll forward" the recent changes to bring the database back to its current state.
- If you want to make MySQL Enterprise Backup finish a backup anyway before you go and investigate the root cause of the issue, you can rewrite the checksum values on the disk by running the `innochecksum` utility on the server:


```
innochecksum --no-checksum --write=crc32
```

The option `--no-checksum` disables the verification function of the tool, and the option `--write=crc32` makes `innochecksum` rewrite the checksum values on the disk.

IMPORTANT: Do not treat corruption problems as a minor annoyance. Find out what is wrong with the system that causes the corruption—however, such troubleshooting is beyond the scope of this manual.

13.3 Using the MySQL Enterprise Backup Logs

Besides the message output of MySQL Enterprise Backup to the `stderr` stream and the log file, progress and history of each backup are also logged into the `mysql.backup_progress` and `mysql.backup_history` tables on the backed-up servers (to skip updating the two tables, use the `--no-history-logging` option with the backup command).

backup_progress Table

Each row in the `backup_progress` table records a state change or message from a running backup job. The `backup_progress` table has the following columns:

```
mysql> DESCRIBE mysql.backup_progress;
```

Field	Type	Null	Key	Default	Extra
backup_id	bigint(20)	NO		NULL	
tool_name	varchar(4096)	NO		NULL	
error_code	int(11)	NO		NULL	
error_message	varchar(4096)	NO		NULL	
current_time	timestamp	NO		CURRENT_TIMESTAMP	DEFAULT_GENERATED on update CURRENT_TIMESTAMP
current_state	varchar(200)	NO		NULL	

6 rows in set (0.00 sec)

The `backup_progress` table is in CSV format. You can query the table with the `mysql` client, or parse the corresponding `.CSV` file with an application or script.

Here are some ways to make use of the information in the `backup_progress` table:

- Use the `backup_id` value to query all the information for different stages of a single backup operation, and to find the corresponding row in the `backup_history` table for the same backup (the row is written to the `backup_history` table only after the backup is finished).
- Use the `error_code` and `error_message` values to track any errors that have occurred, and to see if the backup operation should be terminated because of any serious errors.
- Use the `current_time` and `current_state` values to track the progress of the operation. They also allow you to measure how long each stage of the backup takes, which helps you plan for your future backups.

backup_history Table

Each row in the `backup_history` table records the details of one completed backup produced by a `mysqlbackup` command. The `backup_history` table has the following columns:

```
mysql> DESC backup_history;
```

Field	Type	Null	Key	Default	Extra
backup_id	bigint(20)	NO	PRI	NULL	

tool_name	varchar(4096)	NO	NULL
start_time	timestamp	NO	0000-00-00 00:00:00
end_time	timestamp	NO	0000-00-00 00:00:00
binlog_pos	bigint(20)	NO	NULL
binlog_file	varchar(255)	NO	NULL
compression_level	int(11)	NO	NULL
engines	varchar(100)	NO	NULL
innodb_data_file_path	varchar(2048)	NO	NULL
innodb_file_format	varchar(100)	NO	NULL
start_lsn	bigint(20)	NO	NULL
end_lsn	bigint(20)	NO	NULL
incremental_base_lsn	bigint(20)	NO	NULL
backup_type	varchar(50)	NO	NULL
backup_format	varchar(50)	NO	NULL
mysql_data_dir	varchar(2048)	NO	NULL
innodb_data_home_dir	varchar(2048)	NO	NULL
innodb_log_group_home_dir	varchar(2048)	NO	NULL
innodb_log_files_in_group	varchar(100)	NO	NULL
innodb_log_file_size	varchar(100)	NO	NULL
backup_destination	varchar(4096)	NO	NULL
lock_time	double(7,3)	NO	NULL
exit_state	varchar(10)	NO	NULL
last_error	varchar(4096)	NO	NULL
last_error_code	int(11)	NO	NULL
start_time_utc	bigint(20)	NO	NULL
end_time_utc	bigint(20)	NO	NULL
consistency_time_utc	bigint(20)	NO	NULL
meb_version	varchar(20)	NO	0.0.0
server_uuid	varchar(36)	NO	NULL

+-----+-----+-----+-----+
30 rows in set (0.00 sec)



Warning

Because a successful backup is always recorded as such in the `backup_history` table, a failure in the `apply-log` phase of a `backup-and-apply-log` command is not reflected in the `backup_history` table. It is always important to check the output of `mysqlbackup` to see if an operation is completed fully without an error.

Here is information on some columns of the `backup_history` table, and some ways to make use of the information:

- The `tool_name` column records the full `mysqlbackup` command that triggers the backup, including all the options used.
- You can use the `end_lsn` value of the latest backup as the starting LSN value for the next incremental backup by specifying it with the `--start-lsn` option. (An alternative to specifying the start LSN value for an incremental backup is to use the `--incremental-base` option).
- The `binlog_pos` column gives the position of the binary log up to where log events have been covered by the backup. Because the `backup_history` table used to be in the CSV format, which cannot register `NULL` values directly, if binary logging is not enabled, a value of `-1` is entered into the column; the same applies to other columns for the logging of `NULL` values.
- The value for `backup_type` is one of `FULL`, `PARTIAL`, `INCREMENTAL`, or `TTS`.
- The value for `backup_format` is one of `IMAGE` (for single-file backups) or `DIRECTORY` (for directory backups).
- Use the values that show the backup's settings such as `mysql_data_dir`, `innodb_data_home_dir`, and `backup_destination` to confirm that the backups are using the right source and destination directories.

- The value for `exit_state` is either `SUCCESS` or `FAILURE`. If the `exit_state` is `SUCCESS` and `last_error` is `'NO_ERROR'`, the backup operation has been successful; when it is not the case, see `last_error` and `last_error_code` for the latest error of the operation. To retrieve the full list of errors for that backup operation, go to the `backup_progress` table.

13.4 Using the MySQL Enterprise Backup Manifest

Each backup directory includes some files in the `meta` subdirectory that detail how the backup was produced, and what files it contains. The files containing this information are known collectively as the `manifest`.

`mysqlbackup` produces these files for use by database management tools; it does not consult or modify the manifest files after creating them. Management tools can use the manifest during diagnosis and troubleshooting procedures, for example where the original MySQL instance has been lost entirely and the recovery process is more involved than copying files back to a working MySQL server.

The files in the manifest include:

- `backup_create.xml`: information about the backup operation.
- `backup_content.xml`: information about the files in the backup. This information is only complete and consistent when the backup operation succeeds. A management tool might use this information to confirm which tables are part of a backup. A management tool might compare the checksum recorded in the manifest for a single-file backup against the checksum for the file after the single-file backup is unpacked. The file also contains details of all the plugins defined on the backed-up server, by which users should make sure the same plugins are defined in the same manner on the target server for restoration.
- `image_files.xml`: information about the files in a single-file backup. (Only produced for backups taken with the `backup-to-image` and `backup-dir-to-image` commands.) A management tool might use the paths recorded in this file to plan or automate the unpacking of a single-file backup using the `image-to-backup-dir` or `extract` commands, or to remap the paths of extracted files with the `--src-entry` and `--dst-entry` options.

Part III `mysqlbackup` Command Reference

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Chapter 14 `mysqlbackup`

The `mysqlbackup` client is an easy-to-use tool for all backup and restore operations. During backup operations, `mysqlbackup` backs up:

- All InnoDB tables and indexes, including:
 - The InnoDB `system tablespace`, which, by default contains all the InnoDB tables.
 - Any separate data files produced with the InnoDB `file-per-table` setting. Each one contains one table and its associated indexes. Each data file can use either the original `Antelope` or the new `Barracuda` file format.
- All MyISAM tables and indexes.
- Tables managed by other storage engines.
- Other files underneath the MySQL data directory, such as the `.frm` files that record the structure of each table.
- Any other files in the database subdirectories under the server's data directory.

In addition to creating backups, `mysqlbackup` can pack and unpack backup data, apply to the backup data any changes to InnoDB tables that occurred during the backup operation, and restore data, index, and log files back to their original locations, or to other places.

Here are some sample commands to start a backup operation with `mysqlbackup` are:

```
# Information about data files can be retrieved through the database connection.
# Specify connection options on the command line.
mysqlbackup --user=dba --password --port=3306 \
  --with-timestamp --backup-dir=/export/backups \
  backup

# Or we can include the above options in the configuration file
# under the [mysqlbackup] section, and just specify the configuration file
# and the 'backup' operation.
mysqlbackup --defaults-file=/usr/local/mysql/my.cnf backup

# Or we can specify the configuration file as above, but
# override some of those options on the command line.
mysqlbackup --defaults-file=/usr/local/mysql/my.cnf \
  --compress --user=backupadmin --password --port=18080 \
  backup
```

The `--user` and the `--password` you specify are used to connect to the MySQL server. This MySQL user must have certain privileges in the MySQL server, as described in [Section 4.1.2, “Grant MySQL Privileges to Backup Administrator”](#).

The `--with-timestamp` option places the backup in a subdirectory created under the directory you specified above. The name of the backup subdirectory is formed from the date and the clock time of the backup run.

For the meanings of other command-line options, see [Chapter 16, `mysqlbackup` Command-Line Options](#). For information about configuration files, see [Chapter 17, *Configuration Files and Parameters*](#).

Make sure that the user or the cron job running `mysqlbackup` has the rights to copy files from the MySQL database directories to the backup directory.

Make sure that your connection timeouts are long enough so that the `mysqlbackup` command can keep the connection to the server open for the duration of the backup run. `mysqlbackup` pings the server after copying each database to keep the connection alive.



Important

- Although `mysqlbackup` backs up InnoDB tables without interrupting database use, the final stage that copies non-InnoDB files (such as MyISAM tables and `.frm` files) temporarily puts the database into a read-only state, using the statement `FLUSH TABLES WITH READ LOCK`. For best backup performance and minimal impact on database processing:
 1. Do not run long `SELECT` queries or other SQL statements at the time of the backup run.
 2. Keep your MyISAM tables relatively small and primarily for read-only or read-mostly work.
- Then the locked phase at the end of a `mysqlbackup` run is short (maybe a few seconds), and does not disturb the normal processing of `mysqld` much. If the preceding conditions are not met in your database application, use the `--only-innodb` option to back up only InnoDB tables, or use the `--no-locking` option to back up non-InnoDB files. Note that MyISAM, `.frm`, and other files copied under the `--no-locking` setting cannot be guaranteed to be consistent, if they are updated during this final phase of the backup.
- For a large database, a backup run might take a long time. Always check that the `mysqlbackup` command has been completed successfully by verifying that `mysqlbackup` has returned the exit code 0, or by observing that `mysqlbackup` has printed the text “mysqlbackup completed OK!”.
- `mysqlbackup` is not the same as the former “MySQL Backup” open source project from the MySQL 6.0 source tree. The MySQL Enterprise Backup product supersedes the MySQL Backup initiative.
- Schedule backups during periods when no DDL operations involving tables are running. See [Appendix B, Limitations of MySQL Enterprise Backup](#) for restrictions on creating backups in parallel with the DDL operations.

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These are commands for the major operations for `mysqlbackup`. Only one of them can be specified for each `mysqlbackup` invocation, and, unlike the command options, the name of a command is not preceded by any dashes.

Each of these commands has its own set of required or allowed command options. For example, the `backup` command typically requires connection information to the database server. The `apply-log` and other commands that operate on the backup data after it is produced require the options that specify where the backup data is located.

The major groups of commands are:

- Backup operations: `backup`, `backup-and-apply-log`, `backup-to-image`
- Update operations: `apply-log`, `apply-incremental-backup`
- Restore operations: `copy-back`, `copy-back-and-apply-log`
- Validation operation: `validate`
- Single-file backup operations: `image-to-backup-dir`, `backup-dir-to-image`, `list-image`, `extract`

15.1 Backup Operations

The backup operations are the most frequently performed tasks by MySQL Enterprise Backup. Various kinds of backups can be performed by adding different options, like using `--compress` or `--incremental` for compressed or incremental backups. Here is the syntax for the `mysqlbackup` commands for performing a backup operation:

```
mysqlbackup [STD-OPTIONS]
            [CONNECTION-OPTIONS]
            [SERVER-REPOSITORY-OPTIONS]
            [BACKUP-REPOSITORY-OPTIONS]
            [METADATA-OPTIONS]
            [COMPRESSION-OPTIONS]
            [SPECIAL-BACKUP-TYPES-OPTIONS]
            [INCREMENTAL-BACKUP-OPTIONS]
            [PARTIAL-BACKUP-RESTORE-OPTIONS]
            [SINGLE-FILE-BACKUP-OPTIONS]
            [PERFORMANCE-SCALABILITY-CAPACITY-OPTIONS]
            [MESSAGE-LOGGING-OPTIONS]
            [PROGRESS-REPORT-OPTIONS]
            [ENCRYPTION-OPTIONS]
            [CLOUD-STORAGE-OPTIONS]
            [ENCRYPTED-INNOODB-OPTIONS]
            backup-to-image
```

```
mysqlbackup [ STD-OPTIONS ]
            [ CONNECTION-OPTIONS ]
            [ SERVER-REPOSITORY-OPTIONS ]
            [ BACKUP-REPOSITORY-OPTIONS ]
            [ METADATA-OPTIONS ]
            [ COMPRESSION-OPTIONS ]
            [ SPECIAL-BACKUP-TYPES-OPTIONS ]
            [ INCREMENTAL-BACKUP-OPTIONS ]
            [ PARTIAL-BACKUP-RESTORE-OPTIONS ]
            [ PERFORMANCE-SCALABILITY-CAPACITY-OPTIONS ]
            [ MESSAGE-LOGGING-OPTIONS ]
            [ PROGRESS-REPORT-OPTIONS ]
            [ ENCRYPTED-INNOODB-OPTIONS ]
            backup | backup-and-apply-log
```

- `backup-to-image`

Produces a single-file backup holding the backup data. In most cases, single-file backups are preferred over directory backups, which are created using the `backup` command.

The command requires the `--backup-image` option to specify the destination file. Can be used to stream the backup to a storage device or another system without ever storing the data on the database server. You can specify `--backup-image=-`, representing standard output, allowing the output to be piped to another command. To avoid mixing normal informational messages with backup output, the `--help` message, errors, alerts, and normal informational messages are always printed to standard error stream.

The command also requires the use of the `--backup-dir` option to supply a temporary folder to save the backup metadata (including the `mysqlbackup` message log, the start and end LSN, and so on) and some temporary output. Note that, however, except when streaming the backup image with `--backup-image=-`, if `--backup-image` does not give a full path name, `mysqlbackup` will actually take the value of `--backup-image` as a path relative to the directory specified by `--backup-dir`, and thus store the single-file backup under `--backup-dir` (or, if the `--with-timestamp` option is used, under a subdirectory created under `--backup-dir` that bears the timestamp in its name).

- `backup`

Backs up data to a directory. In most cases, single-file backups, which are created using the `backup-to-image` command, are preferred over directory backups.

The command only performs the initial phase of a complete backup process. The second phase is performed later by running `mysqlbackup` again with the `apply-log` command, which makes the backup consistent.

- `backup-and-apply-log`

A combination of `backup` and `apply-log`. It cannot be used for an incremental backup.

15.2 Update Operations

There are two types of operations to bring your backup data up-to-date:

Apply-log Operation

After a backup job was first completed, the backup data might not be in a consistent state, because data could have been inserted, updated, or deleted while the backup was running. This initial backup file is known as the `raw backup`. During a backup, `mysqlbackup` also copies the accumulated InnoDB log to a file called `ibbackup_logfile`. In an apply-log operation, the `ibbackup_logfile` file is used to “roll

forward” the raw data files, so that every page in the data files corresponds to the same log sequence number of the InnoDB log. This is similar to the operation that takes place during a [crash recovery](#).

For single-file backups, the apply-log operation is usually performed as part of the [copy-back-and-apply-log](#) command. For directory backups, the [copy-back-and-apply-log](#) command can also be used, but you also have the two alternatives of

- Performing the apply-log operation together with the back up using the [backup-and-apply-log](#) command (not applicable for incremental or compressed directory backups)
- Performing the apply-log operation separately with the [apply-log](#) command on the raw backup, before running the [copy-back](#) command.

```
mysqlbackup [STD-OPTIONS]
             [--limit-memory=MB] [--uncompress] [--backup-dir=PATH]
             [MESSAGE-LOGGING-OPTIONS]
             [PROGRESS-REPORT-OPTIONS]
             [ENCRYPTED-INNOODB-OPTIONS]
             apply-log
```

- [apply-log](#)

Advanced: Brings the InnoDB tables in the directory backup up-to-date, including any changes made to the data while the backup was running.

Example 15.1 Apply Log to Full Backup

```
mysqlbackup --backup-dir=/path/to/backup apply-log
```

It reads the [backup-my.cnf](#) file inside [backup-dir](#) to understand the backup. The [my.cnf](#) defaults files have no effect other than supplying the [limit-memory=MB](#) value, which limits usage of memory while doing the [apply-log](#) operation.

Apply-incremental-backup Operation

Advanced: Use the [apply-incremental-backup](#) to update a backup directory with data in an incremental backup directory:

```
mysqlbackup [STD-OPTIONS]
             [--incremental-backup-dir=PATH] [--backup-dir=PATH]
             [--limit-memory=MB] [--uncompress]
             [MESSAGE-LOGGING-OPTIONS]
             [PROGRESS-REPORT-OPTIONS]
             [ENCRYPTED-INNOODB-OPTIONS]
             apply-incremental-backup
```

- [apply-incremental-backup](#)

Advanced: Brings up-to-date a directory backup, specified by the [--backup-dir](#) option, using the data from an incremental backup directory, specified with the [--incremental-backup-dir](#) option. See [Section 5.1.3, “Restoring an Incremental Backup”](#) for instructions on restoring incremental backups.

For a single-file incremental backup, you typically use the [copy-back-and-apply-log](#) command with the [--incremental](#) option to apply the data in the incremental image backup to the full backup that has already been restored to the data directory of the target server.

15.3 Restore Operations

The restore operations restores the data files from a backup to their original locations on the database server, or to other desired locations. Normally, the restoration process requires the database server

to be already shut down (or, at least not operating on the directory you are restoring the data to), except for restorations of backups created with the `--use-tts` option. The options `datadir`, `innodb_log_files_in_group`, and `innodb_log_file_size` must be specified either in the target server's configuration file, in the file specified by the `--defaults-file` option, or as command-line options. For usage examples, see [Chapter 5, Recovering or Restoring a Database](#).

```
mysqlbackup [STD-OPTIONS]
            [SERVER-REPOSITORY-OPTIONS]
            [--backup-image=IMAGE]
            [--backup-dir=PATH]
            [--uncompress]
            [MESSAGE-LOGGING-OPTIONS]
            [PARTIAL-BACKUP-RESTORE-OPTIONS]
            [PROGRESS-REPORT-OPTIONS]
            [ENCRYPTION-OPTIONS]
            [CLOUD-STORAGE-OPTIONS]
            [ENCRYPTED-INNODB-OPTIONS]
            copy-back-and-apply-log
mysqlbackup [STD-OPTIONS]
            [SERVER-REPOSITORY-OPTIONS]
            [--backup-dir=PATH]
            [--uncompress]
            [MESSAGE-LOGGING-OPTIONS]
            [PARTIAL-BACKUP-RESTORE-OPTIONS]
            [PROGRESS-REPORT-OPTIONS]
            [CLOUD-STORAGE-OPTIONS]
            [ENCRYPTED-INNODB-OPTIONS]
            copy-back
```

- `copy-back-and-apply-log`

In a single step, restores a [single-file backup](#) specified by the `--backup-image` option or a backup from the directory specified by the `--backup-dir` option to a server's data directory and performs an `apply-log` operation to the restored data to bring them up-to-date. Comparing with a multi-step approach for restoring a [single-file backup](#) (which typically consists of performing the successive steps of [extract](#), [uncompress](#), [apply-log](#), and [copy-back](#) for restoring compressed image, or [extract](#), [apply-log](#), and [copy-back](#) for uncompressed image), the command makes the restoration process simpler and faster, and also saves the disk space required.

The following are some special requirements for different kinds of backup restoration using `copy-back-and-apply-log`:

- To restore a compressed directory or image, include the `--uncompress` option in the command line.
- To restore a single-file backup, besides specifying the location of the backup image with the `--backup-image` option, also supply with the `--backup-dir` option the location of a folder that will be used for storing temporary files produced during the restoration process.
- To restore a single-file incremental backup, assuming the full backup (on which the incremental backup was based) has already been restored:
 - Include the `--incremental` option in the command line.
 - Specifies the location of the incremental backup image with the `--backup-image` option
 - Supplies with the `--backup-dir` option the location of a folder that will be used for storing temporary files produced during the restoration process.
- *Advanced:* To restore an incremental backup directory, assuming the full backup (on which the incremental backup was based) has already been restored:

- Include the `--incremental` option in the command line.
- Use either the `--backup-dir` or `--incremental-backup-dir` option to specify the incremental backup directory.
- To restore a backup created with the `--use-tts` option:
 - See the general requirements described in [Section 5.1.4, “Restoring Backups Created with the `--use-tts` Option”](#).
 - When restoring a single-file backup created with the option setting `--use-tts=with-minimum-locking`, the folder specified with `--backup-dir` is also used for extracting temporarily all the tables in the backup and for performing an `apply-log` operation to make the data up-to-date before restoring them to the server's data directory.
 - *Advanced:* When restoring a backup directory created with the option `--use-tts=with-minimum-locking`, an `apply-log` operation will be performed on the backup directory. That means the backup taken will be altered during the process, and users might want to make an extra copy of the backup directory before proceeding with the restoration, in order to prevent the loss of backup data in case something goes wrong.

Also note that:

- Backups created with the `--skip-unused-pages` option cannot be restored using `copy-back-and-apply-log`.
- For image backups taken with MySQL Enterprise Backup 3.8.2 or earlier, per-table `.ibd` files pointed to by `.isl` files in a backup are restored by `copy-back-and-apply-log` to the server's data directory rather than the locations pointed to by the `.isl` files.
- Due to a known issue, when restoring a compressed backup created with MySQL Enterprise Backup 3.9 or earlier and containing any InnoDB tables that were created on the server as compressed tables (by using the `ROW_FORMAT=COMPRESSED` option, the `KEY_BLOCK_SIZE=` option, or both), do not use `copy-back-and-apply-log`; instead, perform an `apply-log` first, and then a `copy-back`. See entry for Bug# 17992297 in the [MySQL Enterprise Backup 3.10.0 changelog](#) for details.

At the end of the `copy-back-and-apply-log` operation, the file `backup_variables.txt` is being created or updated in the data directory. This file contains metadata about the restored contents and is being used by successive single-step restores of incremental backups; it should not be deleted or modified by users.

For some sample commands for restoring different kinds of backups with the `copy-back-and-apply-log` command, see [Section 5.1, “Performing a Restore Operation”](#).

- `copy-back`

Restores files from a directory backup to their original locations within the MySQL server.

Before restoring a [hot backup](#) using the `copy-back` command, the backup has to be [prepared](#) and made consistent using the `apply-log` command. See [Section 5.1.7, “Advanced: Preparing and](#)

[Restoring a Directory Backup](#)” for details. You can also perform `apply-log` and `copy-back` together with a single `copy-back-and-apply-log` command.

Some clean-up efforts on the target directory for restoration might be needed before performing a full restore (for example, when the backup data is used to set up a new MySQL server or to replace all data of an existing MySQL server). See the discussions [here](#) for details.

There are some special requirements when restoring backups created with the `--use-tts` option; see [Section 5.1.4, “Restoring Backups Created with the `--use-tts` Option”](#) for details.



Warning

When restoring a server for [replication](#) purpose, if the backed-up server has used the `innodb_undo_directory` option to put the undo logs outside of the data directory, when using the file `server-my.cnf` or `server-all.cnf` for the `--defaults-file` option with `copy-back` or `copy-back-and-apply-log`, care should be taken to configure correctly the `innodb_undo_directory` option in the file. Otherwise, the data or log files on the original server might be overwritten by accident.

15.4 Validation Operations

To ensure the integrity of the backup data, MySQL Enterprise Backup provides a `validate` command for validating a backup by the checksum values of its data pages after the backup is created or transferred to another system.

```
mysqlbackup [STD-OPTIONS]
             [--backup-dir=PATH][--backup-image=IMAGE]
             [MESSAGE-LOGGING-OPTIONS]
             [PROGRESS-REPORT-OPTIONS]
             [CLOUD-STORAGE-OPTIONS]
             validate
```

- `validate`

Verifies that a backup is not corrupted, truncated, or damaged. This operation validates the checksum value for each data page in a backup.

To avoid spending excessive time and resources on files that are too heavily corrupted, `mysqlbackup` stops validating a `.ibd` file after more than twenty corrupted pages are found in it, and proceeds to the next file instead. In that case, the operation's summary will not give a full count of corrupted pages, but only says “at least 20 pages are corrupted.”

The operation also has the following limitations:

- If any `.ibd` or `.frm` files are missing from the data directory during a backup or have been deleted from a backup after the backup was made, the `validate` operation will not be able to detect the problem.
- If a backup has been corrupted by removing or truncating pages from any of the `.ibd` files inside, the `validate` operation will not be able to detect the problem.
- For any backup directory, the operation can only validate the InnoDB data files (`ibdata*` and `*.ibd` files) in it. Problems with other file types within a backup directory (for example, `.frm` file corruptions) are not detected.

Here is a sample command for validating a backup image:


```
mysqlbackup -uroot --backup-image=/logs/fullimage.mi validate
```

Advanced: Here is a sample command for validating a backup directory:

```
mysqlbackup -uroot --backup-dir=/logs/backupext validate
```

For more usage examples for the `validate` command, see [Section 4.2.3, “Verifying a Backup”](#)

15.5 Other Single-File Backup Operations

Besides the commands for creating and restoring single-file backups (namely, `backup-to-image` and `copy-back-and-apply-log`), `mysqlbackup` provides a number of other commands for you to work with single-file backups. They are explained below.

```
mysqlbackup [STD-OPTIONS]
             [--backup-image=IMAGE] [--backup-dir=PATH]
             [MESSAGE-LOGGING-OPTIONS]
             [PROGRESS-REPORT-OPTIONS]
             [ENCRYPTION-OPTIONS]
             [CLOUD-STORAGE-OPTIONS]
             image-to-backup-dir

mysqlbackup [STD-OPTIONS]
             [--backup-dir=PATH] [--backup-image=IMAGE]
             [MESSAGE-LOGGING-OPTIONS]
             [PROGRESS-REPORT-OPTIONS]
             [ENCRYPTION-OPTIONS]
             [CLOUD-STORAGE-OPTIONS]
             backup-dir-to-image

mysqlbackup [STD-OPTIONS]
             [--backup-image=IMAGE]
             [MESSAGE-LOGGING-OPTIONS]
             [ENCRYPTION-OPTIONS]
             [CLOUD-STORAGE-OPTIONS]
             list-image

mysqlbackup [STD-OPTIONS]
             [--backup-image=IMAGE]
             [--backup-dir=PATH]
             [--src-entry=PATH] [--dst-entry=PATH]
             [--uncompress]
             [MESSAGE-LOGGING-OPTIONS]
             [PROGRESS-REPORT-OPTIONS]
             [ENCRYPTION-OPTIONS]
             [CLOUD-STORAGE-OPTIONS]
             extract
```

- `image-to-backup-dir`

Unpacks a single-file backup to a full backup directory structure. You specify the paths to both the image file and the destination directory for the unpacking. For usage examples, see [Section 4.3.1, “Making a Single-File Backup”](#).



Note

`image-to-backup-dir` only creates a `raw backup` directory, which is NOT ready to be restored by the `copy-back` command. To become a `prepared backup`, the backup directory has to go through an `apply-log operation`, executed either by a stand-alone `apply-log` command or as a part of a `copy-back-and-apply-log` command.

- `backup-dir-to-image`

Packs an existing backup directory into a single file. The value for the `--backup-image` parameter should either be “-”(stands for standard output) or an absolute path outside of the `backup-dir` directory. Specify a `--backup-image` value of - (standard output) to stream an existing backup directory structure to a tape device or a command that transfers the backup to another server. For usage examples, see [Section 4.3.1, “Making a Single-File Backup”](#).

- `list-image`

Display the contents of a single-file backup. Lists all files and directories in the image. For usage examples, see [Section 4.3.1, “Making a Single-File Backup”](#).



Note

The `list-image` operation can be performed on a cloud backup only if the cloud proxy supports HTTP range headers.

- `extract`

Unpacks individual files or directories from a single-file backup. It is useful for troubleshooting, or for restorations that do not require the full set of backup data. The resulting file or directory goes into the current directory, or into the `backup directory`, if specified with `--backup-dir`; in either case, the destination directory must be empty. For usage examples, see [Section 4.3.1, “Making a Single-File Backup”](#).

The `--src-entry=string` option can be used for selective extraction of files or directories whose path names in the image contain the `string` specified with the option.



Notes

- Some items are always extracted from the backup; see the descriptions of `--src-entry` for details.
- The option is currently not supported for the extraction of cloud backups, which can only be extracted in full.

The `--dst-entry=path` option, along with `--src-entry=path` option, can be used to extract files or directories into user-specified locations; see the description for the option for details.

For MySQL Enterprise Backup 4.1.4 and later: Use the `--uncompress` option to extract files from a compressed single-file backup.

The default destination for the `extract` is the current working directory. All the files with relative pathnames in the image are extracted to pathnames relative to the destination directory. If the image contains some entries with absolute pathnames, those entries are extracted to the same absolute pathnames on the local system even if the `--backup-dir` option is specified. The `--dst-entry` option must be used to relocate an absolute pathname; see [Example 4.12, “Dealing with Absolute Path Names”](#).



Important

Even with all files extracted from the backup image, `extract` only creates a `raw backup` directory, which is NOT ready to be restored by the `copy-back` command. To become a `prepared backup`, the backup directory has to go through an `apply-log operation`, executed either by a stand-alone `apply-log` command or as a part of a `copy-back-and-apply-log` command.

15.6 Other Operations

This group of operations consists of any `mysqlbackup` commands not covered in other sections of this chapter.

```
mysqlbackup --error-code=CODE print-message
```

- `print-message`

Prints the associated exit message for a `mysqlbackup` exit code to the `stdout` stream.

Use the `--error-code` option to supply the exit code for which you want to receive the associated exit message:

```
$ mysqlbackup print-message --error-code=4 2> /dev/null
```

```
One of the required files not found
```

For a list of `mysqlbackup` exit codes and messages, see [Section 13.1, “Exit codes of MySQL Enterprise Backup”](#).

Chapter 16 `mysqlbackup` Command-Line Options

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The following sections describe the command-line options for the different modes of operation of `mysqlbackup`.

The table below list all the command options for `mysqlbackup`. Use the hyperlinks at the option names to jump to the detailed descriptions for the options.



Note

The command options can also be specified in configuration files; see explanations in [Chapter 17, Configuration Files and Parameters](#). `mysqlbackup` follows the MySQL standard practice for handling duplicate options, whether specified in a configuration file, on the command line, or both. Options are processed first from configuration files, then from the command line. If an option is specified more than once, the last instance takes precedence.

Table 16.1 List of All Options

Option Name	Description	Introduced	Deprecated
--backup-dir	The directory to store the backup data.		
--backup-image	Specifies the path name of the backup image.		
--backup_innodb_checksum_algorithm	The name of the checksum algorithm used for validating InnoDB tablespaces.		
--backup_innodb_data_file_path	Specifies InnoDB system tablespace files' path and size in backup.		

Option Name	Description	Introduced	Deprecated
-- backup_innodb_data_home_dir	Backup base directory for all InnoDB data files in the system tablespace.		
-- backup_innodb_log_file_size	The size in bytes of each InnoDB backup log file.		
-- backup_innodb_log_files_in_group	Number of InnoDB log files in backup.		
-- backup_innodb_log_group_home_dir	Backup directory for InnoDB log files.		
-- backup_innodb_page_size	The page size for all InnoDB tablespaces in a MySQL instance.		
-- backup_innodb_undo_directory	The relative or absolute directory path where InnoDB creates separate tablespaces for the undo logs.		
-- backup_innodb_undo_logs	Number of rollback segments in the system tablespace that InnoDB uses within a transaction.		
-- backup_innodb_undo_tablespaces	The number of tablespace files that the undo logs are divided between when a non-zero innodb_undo_logs setting is used.		
--character-sets-dir	Directory for character set files.		
--cloud-access-key-id	AWS access key ID for logging onto Amazon S3.		
--cloud-aws-region	Region for Amazon Web Services that mysqlbackup access for S3.		
--cloud-basicauth-url	The URL for HTTP Basic Authentication for accessing Swift.	4.1.1	
--cloud-bucket	The storage bucket for the backup image.		
--cloud-buffer-size	Size of buffer for cloud operations.	4.1.1	
--cloud-ca-info	Absolute path to the CA bundle file for host authentication for SSL connections.		

Option Name	Description	Introduced	Deprecated
<code>--cloud-ca-path</code>	CA certificate directory, in addition to the system's default folder.		
<code>--cloud-chunked-transfer</code>	Use chunked transfer with cloud storage service.	4.1.1	
<code>--cloud-container</code>	The Swift container for the backup image.		
<code>--cloud-identity-url</code>	The URL of the Keystone identity service.		
<code>--cloud-object</code>	The storage object for the backup image.		
<code>--cloud-object-key</code>	The Amazon S3 object key for the backup image.		
<code>--cloud-password</code>	Password for user specified by <code>--cloud-user-id</code> .		
<code>--cloud-proxy</code>	Proxy address and port number for overriding the environment's default proxy settings for accessing cloud service.		
<code>--cloud-region</code>	The Keystone region for the user specified by <code>--cloud-user-id</code> .		
<code>--cloud-secret-access-key</code>	AWS secret access key.		
<code>--cloud-service</code>	Cloud service for data backup or restoration.		
<code>--cloud-tempauth-url</code>	The URL of the identity service for authenticating user credentials with Swift's TempAuth authentication system.		
<code>--cloud-tenant</code>	The Keystone tenant for the user specified by <code>--cloud-user-id</code> .		
<code>--cloud-trace</code>	Print trace information for cloud operations.		
<code>--cloud-user-id</code>	User ID for accessing Swift.		
<code>--comments</code>	Specifies comments string.		
<code>--comments-file</code>	Specifies path to comments file.		

Option Name	Description	Introduced	Deprecated
<code>--compress</code>	Create backup in compressed format.		
<code>--compress-level</code>	Specifies the level of compression.		
<code>--compress-method</code>	Specifies the compression algorithm.		
<code>--connect-if-online</code>	Use connection only if available.		
<code>--connect_timeout</code>	Connection timeout in seconds.		
<code>--databases</code>	[Legacy] Specifies the list of non-InnoDB tables to back up.		
<code>--databases-list-file</code>	[Legacy] Specifies the pathname of a file that lists the non-InnoDB tables to be backed up.		
<code>--datadir</code>	Path to mysql server data directory.		
<code>--debug</code>	Print debug information.		
<code>--decrypt</code>	Decrypt backup image written in an MEB Secure File.		
<code>--default-character-set</code>	Set the default character set.		
<code>--defaults-extra-file</code>	Read this file after the global files are read.		
<code>--defaults-file</code>	Only read default options from the given file.		
<code>--defaults-group-suffix</code>	Also read option groups with the usual names and a suffix of str.		
<code>--disable-manifest</code>	Disable generation of manifest files for a backup operation.		
<code>--dst-entry</code>	Used with single-file backups to extract a single file or directory to a user-specified path.		
<code>--encrypt</code>	Encrypt backup image and write it in an MEB Secure File.		
<code>--encrypt-password</code>	The user-supplied password by which mysqlbackup encrypts the encryption keys		

Option Name	Description	Introduced	Deprecated
	for encrypted InnoDB tablespaces.		
<code>--error-code</code>	The exit code for which the print-message command prints the corresponding exit message.		
<code>--exclude-tables</code>	Exclude in a backup or restore tables whose names match the regular expression REGEXP.		
<code>--exec-when-locked</code>	Execute the specified utility in the lock phase near the end of the backup operation.		
<code>--force</code>	Force overwriting of data, log, or image files, depending on the operation.		
<code>--free-os-buffers</code>	Free filesystem cache by syncing the buffers		
<code>--generate-new-master-key</code>	Generate new master key for encrypted InnoDB tablespaces.		
<code>--help</code>	Display help.		
<code>--host</code>	Host name to connect.		
<code>--include</code>	[Legacy] Backup only those per-table innodb data files which match the regular expression REGEXP.		
<code>--include-tables</code>	Include in a backup or a restore tables whose names match the regular expression REGEXP.		
<code>--incremental</code>	Specifies that the associated backup or backup-to-image operation is incremental.		
<code>--incremental-backup-dir</code>	Specifies the location for an incremental directory backup.		
<code>--incremental-base</code>	The specification of base backup for --incremental option.		
<code>--incremental-with-redo-log-only</code>	Specifies the incremental backup of InnoDB tables		

Option Name	Description	Introduced	Deprecated
	to be based on copying redo log to the backup, without including any InnoDB data files in the backup.		
-- innodb_checksum_algorithm	The name of the checksum algorithm used for validating InnoDB tablespaces.		
-- innodb_data_file_path	Specifies InnoDB system tablespace files' path and size.		
-- innodb_data_home_dir	Specifies base directory for all InnoDB data files in the shared system tablespace.		
-- innodb_log_file_size	The size in bytes of each InnoDB log file in the log group.		
-- innodb_log_files_in_group	The number of InnoDB log files.		
-- innodb_log_group_home_dir	The directory path to InnoDB log files.		
-- innodb_page_size	The page size for all InnoDB tablespaces in a MySQL instance.		
-- innodb_undo_directory	The directory path to InnoDB undo tablespaces.		
-- key	The symmetric key used for encryption and decryption.		
-- key-file	The pathname of a file that contains the symmetric key used for encryption and decryption.		
-- keyring	The kind of keyring plugin used for master encryption key management.		
-- keyring_file_data	Path to the keyring file.		
-- keyring_okv_conf_dir	Path to the Oracle Key Vault (OKV) endpoint directory.		

Option Name	Description	Introduced	Deprecated
<code>--limit-memory</code>	The memory in MB available for the MEB operation.		
<code>--lock-wait-retry-count</code>	Specify the maximum number of retries to be attempted by mysqlbackup after the FLUSH TABLES WITH READ LOCK statement fails due to a timeout.	4.1.4	
<code>--lock-wait-timeout</code>	Specify the timeout in seconds for the FLUSH TABLES WITH READ LOCK statement that mysqlbackup issues during the final stage of a backup.		
<code>--log-bin</code>	Specify the location for the binary log to be restored.	4.1.2	
<code>--log-bin-index</code>	Specifies the absolute path of the index file that lists all the binary log files.		
<code>--login-path</code>	Read options from the named login path in the .mylogin.cnf login file.		
<code>--master-info-file</code>	Specifies the absolute path of the information file in which a replica records information about its source (for offline backups of replica servers only).		
<code>--messages-logdir</code>	Specifies the path name of an existing directory for storing the message log.		
<code>--no-connection</code>	Do not connect to server.		
<code>--no-defaults</code>	Do not read default options from any given file.		
<code>--no-history-logging</code>	Disable history logging even if connection is available.		
<code>--no-locking</code>	Disable all locking of tables during backups.		

Option Name	Description	Introduced	Deprecated
<code>--number-of-buffers</code>	Specifies the exact number of memory buffers to be used for the backup operation.		
<code>--on-disk-full</code>	Specifies the behavior when a backup process encounters a disk-full condition.		
<code>--only-innodb</code>	Back up only InnoDB data and log files.		
<code>--only-innodb-with-frm</code>	[Legacy] Back up only InnoDB data, log files, and the .frm files associated with the InnoDB tables.		
<code>--only-known-file-types</code>	Includes only files of a list of known types in the backup.		
<code>--optimistic-busy-tables</code>	Perform an optimistic backup, using the regular expression specified with the option to select tables that will be skipped in the first phase of an optimistic backup.		
<code>--optimistic-time</code>	Perform an optimistic backup with the value specified with the option as the optimistic time —a time after which tables that have not been modified are believed to be inactive tables.		
<code>--page-reread-count</code>	Maximum number of page re-reads.		
<code>--page-reread-time</code>	Wait time before a page re-read.		
<code>--password</code>	Connection password.		
<code>--pipe</code>	alias for <code>--protocol=pipe</code> .		
<code>--port</code>	TCP portnumber to connect to.		
<code>--print-defaults</code>	Print a list of option values supplied by defaults files and exit.		
<code>--process-threads</code>	Specifies the number of process-threads for the backup operation.		

Option Name	Description	Introduced	Deprecated
<code>--progress-interval</code>	Interval between progress reports in seconds.		
<code>--protocol</code>	Connection protocol.		
<code>--read-threads</code>	Specifies the number of read-threads for the backup operation.		
<code>--relay-log</code>	Specify the location for the relay log to be restored on a replica server.	4.1.2	
<code>--relay-log-index</code>	Specifies the absolute path of the index file that lists all the relay log files.		
<code>--relaylog-info-file</code>	Specifies the absolute path of the information file in which a replica records information about the relay logs (for offline backups of replica servers only).		
<code>--rename</code>	Rename a single table when it is selected by the <code>--include-tables</code> option to be restored		
<code>--safe-slave-backup-timeout</code>	When backing up a replica server, the timeout value for waiting for the replication SQL thread to drop its temporary tables.		
<code>--sbt-database-name</code>	Used as a hint to the Media Management Software (MMS) for the selection of media and policies for tape backup.		
<code>--sbt-environment</code>	Comma separated list of environment variable assignments to be given to the SBT library.		
<code>--sbt-lib-path</code>	Path name of the SBT library used by software that manages tape backups.		
<code>--secure-auth</code>	Refuse client connecting to server if it uses old (pre-4.1.1) protocol.		

Option Name	Description	Introduced	Deprecated
<code>--shared-memory-base-name</code>	It designates the shared-memory name used by a Windows server to permit clients to connect using shared memory (Windows only).		
<code>--show-progress</code>	Instructs mysqlbackup to periodically output short progress reports known as progress indicators on its operation.		
<code>--skip-binlog</code>	Do not include binary log files during backup, or do not restore binary log files during restore.		
<code>--skip-final-rescan</code>	Skip the final rescan for InnoDB tables that are modified by DDL operations.		
<code>--skip-messages-logdir</code>	Disable logging to teelog file.		
<code>--skip-relaylog</code>	Do not include relay log files during backup, or do not restore relay log files during a restore.		
<code>--skip-unused-pages</code>	Skip unused pages in tablespaces when backing up InnoDB tables.		
<code>--slave-info</code>	Capture information needed to set up an identical replica server.		
<code>--sleep</code>	Time to sleep in milliseconds after copying each 1MB of data.		
<code>--socket</code>	Socket file to use to connect.		
<code>--src-entry</code>	Identifies a file or directory to extract from a single-file backup.		
<code>--ssl</code>	Enable SSL for connection (automatically enabled with other --ssl-flags).		Yes
<code>--ssl-ca</code>	CA file in PEM format (implies --ssl).		

Option Name	Description	Introduced	Deprecated
--ssl-capath	CA directory (check OpenSSL docs, implies --ssl).		
--ssl-cert	X509 cert in PEM format (implies --ssl).		
--ssl-cipher	SSL cipher to use (implies --ssl).		
--ssl-key	X509 key in PEM format (implies --ssl).		
--ssl-mode	Security state of connection to server.		
--ssl-verify-server-cert	Verify server's "Common Name" in its cert against hostname used when connecting.		Yes
--start-lsn	Specifies the highest LSN value included in a previous backup.		
--suspend-at-end	Pauses the mysqlbackup command when the backup procedure is close to ending.		
--trace	Trace level of messages by mysqlbackup.		
--uncompress	Uncompress a backup during an operation.		
--use-tts	Enable selective backup of InnoDB tables using transportable tablespaces (TTS).		
--user	Database server user name to connect.		
--verbose	Print more verbose information.		
--version	Display version information.		
--with-timestamp	Create a subdirectory underneath the backup directory with a name formed from the timestamp of the backup operation.		
--write-threads	Specifies the number of write-threads for the backup operation.		

16.1 Standard Options

The standard options are options of a general nature, or options that are not classified under any other specific option group:

- The following standard options also exist for the `mysql` command. Full descriptions for these options can be found in the MySQL reference manual, accessible through, e.g., [Server Option, System Variable, and Status Variable Reference](#). These options must be specified ahead of any other `mysqlbackup` options, including the rest of the standard options:

```
--print-defaults      Print the program argument list and exit.
--no-defaults         Don't read default options from any option file.
--defaults-file=PATH  Only read default options from the given file. It has to be the first option to
--defaults-extra-file=PATH Read this file after the global files are read.
--defaults-group-suffix=str Also read option groups with the usual names and a suffix of str.
```

- The following options are also common between `mysqlbackup` and `mysql`, and full descriptions for them can be found in the MySQL reference manual, accessible through, e.g., [Server Option, System Variable, and Status Variable Reference](#). However, `mysqlbackup` does not accept any short forms for these options as `mysql` does (for example, you must use `--help` instead of `-h` for `mysqlbackup`):

```
--help      Display help.
--version   Display version information.
```

- More standard options are available for `mysqlbackup`:

`--verbose`: Print more verbose information.

`--debug=STRING`: Print additional debug information. The option accepts the following arguments:

- `all`: Print additional debug information for all operations
- `sbt`: Print additional debug information for [operations using the System Backup to Tape \(SBT\) interface](#)
- `null`: When a null string or no argument at all is specified for the option, `mysqlbackup` behaves as if the `--verbose` option is used.

`--force`: By default, some of the operations halt rather than overwrite any user data or log files when told to write to existing files. `--force` allows the following:



Warning

For any restore operations, do NOT attempt to restore data to a non-empty data directory using the `--force` option; doing so may cause data corruption and other unexpected behaviors. Do not use the `--force` option with a `copy-back` or a `copy-back-and-apply-log` operation, except for the special cases described below.

- Overwriting of InnoDB data and log files during the `apply-log` and `apply-incremental-backup` operations.
- When restoring a TTS backup, changing temporarily the value of `innodb_file_format` on the server, in order to allow restores of per-table InnoDB data files regardless of their format.
- Replacing of an image file during an `backup-to-image` or `backup-dir-to-image` operation.

- Restoring a partial image backup created with MySQL Enterprise Backup 3.11 or earlier; the `--force` option is required, due to a known issue (Bug# 20485910).
- Restoring a backup onto a server where the directory pointed to by the `.bl` file in the backup (a copy of the `.isl` file from the backed-up server) already contains `.ibd` data files.

`--trace=level`

Command-Line Format	<code>--trace=LEVEL</code>
Type	Enumeration
Default Value	0
Valid Values	0 1 2 3

Trace level of `mysqlbackup` messages. The permissible levels, in the order of increasing fineness, are:

- 0 - INFO (information, warnings, errors)
- 1 - FINE (more information given than at trace level 0)
- 2 - FINER (finer level of information given than at trace level 1)
- 3 - FINEST (finest level of information that can be given)

16.2 Connection Options

When `mysqlbackup` creates a backup, it sends SQL commands to MySQL server using a database connection. The general connection details are the same as described in [Connecting to the MySQL Server Using Command Options](#) in the MySQL Reference Manual.

As part of the `mysqlbackup` invocation, specify the appropriate `--user`, `--password`, `--port`, and/or `--socket` options that are necessary to connect to the MySQL server.

You can specify the following connection-specific options in the `[mysqlbackup]` or `[client]` sections of a MySQL configuration file, or through `mysqlbackup` command-line options. `mysqlbackup` reads your default configuration files and then the `my.cnf` file specified on the command line.



Note

- `mysqlbackup` reads only `--user`, `--password`, `--port`, and `--socket` options from the `[client]` group, and ignores any other connection options.
- If you do not provide a value for the `--password`, the command prompts for one from the keyboard.
- The `--host` option is allowed in the configuration file for compatibility, but currently it has no effect. `mysqlbackup` always connects to the local server's IP address.

Options Common to `mysqld`

```

=====
--login-path=name
--port=port-num
--protocol=tcp|socket|pipe|memory
--pipe [ alias for --protocol=pipe ]
--user=name [ short option: -u ]
--host=hostname
--socket=name
--shared-memory-base-name=value [Windows only]
--character-sets-dir=PATH
--default-character-set=VALUE
--secure-auth [ Don't connect to pre-4.1.1 server ]
--password[=value] [ short option: -p ]
--connect-timeout
--ssl [ Enable SSL for connection. Deprecated. ]
--ssl-mode=mode
--ssl-key=file_name
--ssl-cert=file_name
--ssl-ca=file_name
--ssl-capath=directory_name
--ssl-cipher=cipher_list
--ssl-verify-server-cert [ Deprecated. ]

Connection Options Specific to mysqlbackup
=====

--no-connection
--connect-if-online

```

Most other connection parameters used by the `mysql` command are recognized, but silently ignored. Unknown connection parameters cause `mysqlbackup` to stop.

The following connections options are specific to `mysqlbackup`:

- `--no-connection`

The `--no-connection` option supersedes the other connection options and uses file-level operations to perform the backup. When you use this option, you must specify in the configuration file or on the command line many options whose values are normally retrieved automatically through the database connection.



Warning

This option also turns on the `--no-history-logging` and `--no-locking` options, which might result in inconsistencies in non-InnoDB data if the tables are modified during the backup operation. It might also affect subsequent incremental backups; see the description for the `--incremental-base` option for details.

- `--connect-if-online`

By default, a database connection is used for backup operations both during the initial stage to retrieve source repository configuration, and to lock tables while copying non-InnoDB data. This option allows `mysqlbackup` to make connection attempts in both phases, but continues even if the connection cannot be established. If a connection cannot be established, the processing is the same as with the `--no-connection` option. This option can be useful in emergency situations: for example, when the database server goes down during the backup operation.

16.3 Server Repository Options

These repository options specify various parameters related to the database server, from which the data is backed up or to which a backup is restored.

These options are used only with the following operations:

- Backup creation operations: [backup](#), [backup-and-apply-log](#), [backup-to-image](#).
- Restore operations: [copy-back](#), [copy-back-and-apply-log](#).

When a database connection is available during a backup, the parameters describing the source repository are ignored, overridden by the corresponding values retrieved from the database connection.

For information about how these options are specified for the MySQL server, click the option names to see the descriptions in the MySQL Reference Manual.

- [datadir=PATH](#)

This is the [datadir](#) value used by the MySQL instance. The [.frm](#) files reside here inside subdirectories named after the databases inside the instance.

When a database connection exists, the value is retrieved automatically and overrides any value you specify. This is a crucial parameter for both the MySQL server and MySQL Enterprise Backup.

- [log-bin\[=basename\]](#)

For MySQL Enterprise Backup 4.1.2 and later: Specify the location for the binary log to be restored. By default, during a restore, the binary log is restored to the same location it was found on the backed-up server. Use this option to specify a different target location for the binary log. The option works similarly as the [--log-bin](#) option of the MySQL server in determining the location and the name of the binary log files—see [description of the server --log-bin option](#) for details. As a summary:

- Using this option without supplying a [basename](#) puts the binary log in the target server's data directory with the default basename [host_name-bin](#).
- Using this option while supplying a [basename](#) puts the binary log in the target server's data directory with the specified basename.
- Using this option while supplying a [basename](#) containing a full file path (for example, [/home/admin/db/binlogdir/binlog](#)) puts the binary log on the target server in the specified folder ([/home/admin/db/binlogdir/](#)) using the supplied basename ([binlog](#)).

The option is only for the [copy-back-and-apply-log](#) and [copy-back](#) operations. Using it with any other operations makes the command fail.

- [relay-log\[=basename\]](#)

For MySQL Enterprise Backup 4.1.2 and later: Specify the location for the relay log to be restored on a replica server. By default, during a restore for a replica server, the relay log is restored to the same location it was found on the backed-up replica server. Use this option to specify a different target location for the relay log. The option works similarly as the [--log-bin](#) option for [mysqlbackup](#) in determining the location and the name of the relay log—see [description of the --log-bin option](#) for details.

The option is only for the [copy-back-and-apply-log](#) and [copy-back](#) operations. Using it with any other operations makes the command fail.

- [innodb_data_home_dir=PATH](#)

Specifies the directory where InnoDB data files reside. Usually the same as `datadir`, but can be different.

This parameter, together with `innodb_data_file_path=SIZE`, determines where the InnoDB data files such as `ibdata1`, `ibdata2`, and so on, are situated within the MySQL server.

For backups: Typically, you do not need to specify this option, because its value is retrieved automatically using the database connection. Specifies the option for an offline backup if the InnoDB data files do not reside under the server's data directory.

For restores: The directory where InnoDB data files are to be restored. Specify the option only if the InnoDB data files are to be restored outside of the server's data directory. *For release 4.1.3 and later:* the specified directory must be non-existent or empty, or the restore operation will fail, even if the `--force` option is used.

Its value is derived as follows:

- If `innodb_data_home_dir` is not specified, it inherits the value of `datadir`.
- If `innodb_data_home_dir` is a relative path, the path is located relative to (that is, underneath) the `datadir` value.
- An `innodb_data_home_dir` of `"` refers to the `/` root directory.
- If `innodb_data_home_dir` is an absolute path, its value is used as-is.
- `innodb_data_file_path=VALUE`

Specifies InnoDB data file names and sizes. Examples:

```
ibdata1:32M:ibdata2:32M:autoextend
/abs/path/ibdata1:32M:autoextend
innodb-dir/ibdata1:32M:autoextend
```

When a database connection exists, the value is retrieved automatically and overrides any value you specify.

This parameter together with `innodb_data_home_dir` determines where the InnoDB data files (such as `ibdata1`, `ibdata2`, and so on) reside in server repository.

Typically, you do not need to specify this option, because its value is retrieved automatically using the database connection. If no database connection is available, you must specify it.

Whether the initial file name begins with a `/` character or not, the files are located relative to the `innodb_data_home_dir` value.

- `innodb_log_group_home_dir=PATH`

Specifies where the InnoDB redo log reside within the server repository. Usually the same as `datadir`, but can be different.

For backups: Typically, you do not need to specify this option, because its value is retrieved automatically using the database connection. Specifies the option for an offline backup if the InnoDB redo log files do not reside under the server's data directory.

For restores: The directory where InnoDB redo log files are to be restored. Specify the option only if the InnoDB redo log files are to be restored outside of the server's data directory. *For release 4.1.3 and later:*

the specified directory must be non-existent or empty, or the restore operation will fail, even if the `--force` option is used.

Its value is derived as follows:

- If `innodb_log_group_home_dir` is not specified, it inherits the value of `datadir`.
- If `innodb_log_group_home_dir` is a relative path, the path is taken to be relative to (that is, underneath) the `datadir` value.
- If `innodb_log_group_home_dir` is an absolute path, its value is used as-is.
- `innodb_log_files_in_group=N`

Specifies the number of InnoDB log files before being rotated.

Typically, you do not need to specify this option, because its value is retrieved automatically using the database connection. If no database connection is available, you must specify it.

When a database connection exists, the value is retrieved automatically and overrides any value you specify.

- `innodb_log_file_size=SIZE`

Specifies maximum single InnoDB log file size before switching to next log file. Example: 20M.

Typically, you do not need to specify this option, because its value is retrieved automatically using the database connection. If no database connection is available, you must specify it.

When a database connection exists, the value is retrieved automatically and overrides any value you specify.

- `innodb_page_size=SIZE`

Specifies the page size for all InnoDB tablespaces.

Typically, you do not need to specify this option, because its value is retrieved automatically using the database connection. If no database connection is available, you must specify it.

When a database connection exists, the value is retrieved automatically and overrides any value you specify.

- `innodb_undo_directory=PATH`

Specifies where the InnoDB undo log reside within the server repository. Usually the same as `datadir`, but can be different.

For backups: Typically, you do not need to specify this option, because its value is retrieved automatically using the database connection. Specifies the option for an offline backup if the InnoDB undo log files do not reside under the server's data directory.

For restores: The directory where InnoDB undo log files are to be restored. Specify the option only if the undo log files are to be restored outside of the server's data directory. *For release 4.1.3 and later:* the

specified directory must be non-existent or empty, or the restore operation will fail, even if the `--force` option is used.

Its value is derived as follows:

- If `innodb_undo_directory` is not specified, it inherits the value of `datadir`.
- If `innodb_undo_directory` is a relative path, the path is taken to be relative to (that is, underneath) the `datadir` value.
- If `innodb_undo_directory` is an absolute path, its value is used as-is.



Warning

When using this option, make sure the undo log location does not change between successive restores of a full and an incremental backups, or of two incremental backups. Otherwise, the restore is going to fail.

- `innodb_checksum_algorithm=NAME`

Specifies the name of the checksum algorithm used for validating InnoDB tablespaces. Default is `innodb`.

Typically, you do not need to specify this option, because its value is retrieved automatically using the database connection. If no database connection is available, you must specify it.

When a database connection exists, the value is retrieved automatically and overrides any value you specify.

- `innodb_buffer_pool_filename=FILENAME`

The file produced on the server when `innodb_buffer_pool_dump_at_shutdown` (enabled by default on MySQL 5.7.7 and after) or `innodb_buffer_pool_dump_now` is enabled. It holds the list of tablespace IDs and page IDs of the server's [buffer pool](#).

Typically, you do not need to specify this option, because its value is retrieved automatically using the database connection. If no database connection is available during backup, you must specify it.

When a database connection exists, the value is retrieved automatically and overrides any value you specify.

16.4 Backup Repository Options

These options specify various parameters related to the backup image or directory, or to how the backup will be restored. Typically, `--backup-image` and `--backup-dir` are the only options from the group that you need to specify when using `mysqlbackup`.

The backup repository options are used with the following operations:

- Backup operations: `backup`, `backup-and-apply-log`, `backup-to-image`.
- Restore operations: `copy-back`, `copy-back-and-apply-log`.

The backup repository options are divided into two groups: the first one determines the structure of the backup, and the second one provides information on the original structure of the data on the backed-up server for future operations on the backup.

The following options determine the structure of the backup:

- `--backup-image=IMAGE`

Command-Line Format	<code>--backup-image=IMAGE</code>
Type	File name

Specify the path name of the file used for a single-file backup, restore, or another [single-file operation](#).

Except when streaming the backup image with `--backup-image=-`, if `--backup-image` does not give a full path name, this is how `mysqlbackup` interprets the value of the option:

- For `backup-to-image` operations, `mysqlbackup` takes the value of `--backup-image` as a path relative to the location specified by `--backup-dir`. If the `--with-timestamp` option is also used, the backup image is then saved in a subdirectory that bears the timestamp in its name under the [backup directory](#).
- For `copy-back-and-apply-log` and other [single-file operations](#) other than `backup-to-image` AND for release 4.1.5 and later, `mysqlbackup` takes the value of `--backup-image` as a path relative to the current working directory in which the `mysqlbackup` command is run.



Note

For release 4.1.4 and earlier: A relative path specified for `--backup-image` is taken to be relative to the [backup directory](#) for the above-mentioned operations.

By default, the single-file backup is streamed to standard output, so that you can pipe it directly to other commands such as a tape backup or an [ssh](#)-related network command.

You can optionally prefix the image name with `file:` to signify a file I/O (the default). For tape backups, prefix the image name with `sbt:`. See [Section 4.3.1.2, “Backing Up to Tape”](#) for details about tape backups.

- `--backup_dir=PATH`

Same as `--backup-dir`. The [backup directory](#) under which the backup data and metadata are stored, permanently or temporarily. It is a crucial parameter required for most kinds of backup and restore operations.

The option is used differently for different operations and under different situations:

- For backup to a single file (including incremental, compressed, encrypted, and cloud backups): Use `--backup-dir` to supply a temporary folder to save the backup metadata (including the `mysqlbackup` message log, the start and end [LSN](#), and so on) and some temporary output. The backup data, together with a copy of the metadata, will be stored in a single file whose name is specified with the `--backup-image` option. Note that, however, if `--backup-image` does not give a full path name, `mysqlbackup` will actually take the value of `--backup-image` as a path relative to the directory specified by `--backup-dir`, and thus store the single-file backup under `--backup-dir` (or, if the `--with-timestamp` option is used, under a subdirectory created under `--backup-dir`, which bears the timestamp in its name).

- *For backup to a directory:* Use `--backup-dir` to specify the directory to store the backup data and metadata (including the `mysqlbackup` message log, the start and end `LSN`, and so on). The directory specified by `--backup-dir` cannot be a subdirectory of the directory specified by `--datadir`.

When the `--with-timestamp` option is also specified, an additional level of subdirectory, with the timestamp in its name, is created under `--backup-dir` (see description for the `--with-timestamp` option for details). Unless the `--with-timestamp` option is used, the directory specified by `--backup-dir` must be empty, or the backup operation will fail with an error.

- *For restoring a single-file backup (including incremental, compressed, encrypted, and cloud backups):* When using `copy-back-and-apply-log` to restore a single-file backup, use `--backup-dir` to supply a temporary folder to store the temporary data of the restore operation. The directory specified by `--backup-dir` should be empty—if a non-empty directory is used, the restore operation will still be carried out, but the restore data might be corrupted.

When restoring a single-file backup created with the option setting `use-tts=with-minimum-locking`, the folder specified with `--backup-dir` is also used for extracting temporarily all the tables in the backup and for performing an `apply-log` operation to make the data up-to-date before restoring them to the server's data directory.

- *For restoring a backup directory:* Use `--backup-dir` to specify the location of the backup directory, from which data will be restored to the server.

- `backup_innodb_data_home_dir=PATH`

The directory under which the backup's InnoDB data files are to be stored. Specify the option if you want to put the data files at somewhere other than the default location (which is `backup-dir/datadir`). If the value of the parameter is different from `backup-dir/datadir`, it is stored into the `backup-my.cnf` file as `innodb_data_home_dir` for information, so that `mysqlbackup` can understand the structure of the backup when it performs various operations on the backup. Together with `backup_innodb_data_file_path` option, it determines the actual file paths of the InnoDB data files inside the backup.

The value for the parameter is derived as follows:

- If `backup_innodb_data_home_dir` is not specified, its value will be `backup-dir/datadir`.
- If `backup_innodb_data_home_dir` is an absolute path, its value is used as-is.
- If `backup_innodb_data_home_dir` is a relative path, the path is taken to be relative to (that is, underneath) `backup-dir`.
- An empty string ("") for `backup_innodb_data_home_dir` means the value of `innodb_data_file_path` is to be taken as an absolute path..

This parameter is applicable only for backup operations; during a restore, the InnoDB data files are restored under the data directory specified by `--datadir`, unless another location is specified using the `--innodb_data_home_dir` option during restore.

- `backup_innodb_data_file_path=VALUE`

The InnoDB data file names and sizes. Examples:

```
ibdata1:32M;ibdata2:32M:autoextend
/abs/path/ibdata1:32M:autoextend
```



```
innodb-dir/ibdata1:32M:autoextend
```

This parameter, together with `backup_innodb_data_home_dir`, determines where the InnoDB data files are stored within the backup repository. Any file path specified with this option is taken to be relative to the value of the `backup_innodb_data_home_dir` option (that is true even if the file path is specified in the form of an absolute path, like `/abs/path/ibdata1:32M:autoextend`). To specify truly absolute paths for InnoDB data files in the backup with this option, you must set the `backup_innodb_data_home` option to `" "` [empty string], in addition to using an absolute path for this option.

When the parameter is not specified, it inherits the value from the value of the `innodb_data_file_path` option on the backed-up server. If both the source and destination of the backup attempt to use the same absolute paths that resolves to the same files, the backup is cancelled.

The value of the parameter is stored into the `backup-my.cnf` file as `innodb_data_file_path` for information, so that `mysqlbackup` can understand the structure of the backup when it performs various operations on the backup.

- `backup_innodb_log_group_home_dir=PATH`

The directory under which the backup's InnoDB logs will be stored. Specify this option only if you want to put the logs at somewhere other than the default location (which is `backup-dir/datadir`). If the value of the parameter is different from `backup-dir/datadir`, it is stored in the `backup-my.cnf` file as `innodb_log_group_home_dir` for information, so that `mysqlbackup` can understand the structure of the backup when it performs various operations on the backup. Note that while you can specify a directory for saving the logs, the names of the log files are fixed and not reconfigurable.

This parameter is applicable only for backup operations; during a restore, the InnoDB log files are restored under the data directory specified by `--datadir`, unless another location is specified using the `--innodb_log_group_home_dir` option during restore. The value of the parameter is derived as follows:

- If `backup_innodb_log_group_home_dir` is not specified, its value will be `backup-dir/datadir`.
- If `backup_innodb_log_group_home_dir` is an absolute path, its value is used as-is.
- If `backup_innodb_log_group_home_dir` is a relative path, the path is taken to be relative to (that is, underneath) `backup-dir`.
- An empty string (`""`) for the option produces an error.
- `backup_innodb_undo_directory=PATH`

The relative or absolute directory path where separate tablespaces are created for the InnoDB undo logs during the backup. When unspecified, the option takes up the same value as `backup_innodb_log_group_home_dir`; specify this option only if you want to put the undo logs at some other location. If the value of the parameter is different from `backup-dir/datadir`, it is stored in the `backup-my.cnf` file as `innodb_undo_directory` for information, so that `mysqlbackup` can understand the structure of the backup when it performs various operations on the backup.

This parameter is applicable only for backup operations; during a restore, the InnoDB undo log tablespaces are restored under the data directory specified by `--datadir`, unless another location is specified by the `--innodb_undo_directory` option during restore.

- `--with-timestamp`

Creates a subdirectory underneath the backup directory, with a name formed with the timestamp of the backup operation. It is useful for maintaining a single backup directory containing many backup snapshots put under different subdirectories.

Default: no timestamped subdirectory is created. To reuse the same backup directory for a new backup without using this option, either remove the previous backup files manually or, for a single-file backup, specify the `--force` option to overwrite the old backup file.

The following parameters provide information on the original structure of the data on the backed-up server for future operations on the backup, but do not affect the structure of the backup itself:

- `backup_innodb_log_files_in_group=N`

The number of InnoDB log files in a log group on the restored server. See the description for `innodb_log_files_in_group` in the MySQL server manual. The value for this parameter, saved as `innodb_log_files_in_group` in the `backup-my.cnf` file, is derived as follows:

- Use the `backup_innodb_log_files_in_group` value from command line or configuration file, if specified.
- Else, use the `innodb_log_files_in_group` value from the backed-up server, if it is an online backup.
- Else, use the `innodb_log_files_in_group` value from the `mysqlbackup` command line or configuration file.

- `backup_innodb_log_file_size=SIZE`

The maximum single InnoDB log file size in backup before switching to next log file, on the restored server. See the description for `innodb_log_file_size` in the MySQL server manual. The value for this parameter, saved as `innodb_log_file_size` in the `backup-my.cnf` file, is derived as follows:

- Use the `backup_innodb_log_file_size` value from command line or configuration file, if specified.
- Else, use the `innodb_log_file_size` value from the backed-up server, if it is an online backup.
- Else, use the specified `innodb_log_file_size` value from the `mysqlbackup` command line or configuration file.

- `backup_innodb_page_size=SIZE`

Specifies, for an offline backup, the page size for all InnoDB tablespaces on the restored server. This option should be specified carefully, because the page size must be the same as that of the backed up MySQL instance, or the backup could become useless. For an online backup, the value is taken from the value of the `innodb_page_size` option on the backed-up server.

Value of this option is saved in the `backup-my.cnf` file, to be used for restoring the database.

- `backup_innodb_undo_logs=NUMBER`

Specifies, for an offline backup, the number of rollback segments in the InnoDB system tablespace on the restored server. This option should be specified carefully, because the value must be the same as that of `innodb_undo_logs` on the backed-up MySQL instance, or the backup could become useless.

For an online backup, the value for the parameter is taken from the value of the `innodb_undo_logs` option on the backed-up server.

- `backup_innodb_undo_tablespaces=NUMBER`

Specifies the number of tablespace files that the undo logs are divided between, when you use a non-zero `backup_innodb_undo_logs` setting. This option should be specified carefully, because the value must be the same as that of `innodb_undo_tablespaces` on the backed-up MySQL instance, or the backup could become useless. For an online backup, the value for the parameter is taken from the value of the `innodb_undo_tablespaces` option on the backed-up server. By default, all the undo logs are part of the system tablespace, and the system tablespace will always contain one undo tablespace in addition to those configured by `innodb_undo_tablespaces`.

- `backup_innodb_checksum_algorithm=NAME`

Specifies, for an offline backup, the name of the checksum algorithm used for validating the InnoDB tablespaces on the restored server. This option should be specified carefully, because the checksum algorithm must be the same use on the backed-up MySQL instance, or the backup could become useless. For an online backup, the value is taken from the value of the `innodb_checksum_algorithm` option on the backed-up server.

Default value of the option is “innodb”.

Value of this option is saved in the `backup-my.cnf` file, to be used for restoring the database.

16.5 Metadata Options

These options control the generation of metadata about backups. Some metadata is stored in the backup directory, other metadata is stored in tables within the `mysql` database of the backed-up instance.

- `--no-history-logging`

Turns off the recording of backup progress and history in logging tables inside the backed-up database. See [Section 13.3, “Using the MySQL Enterprise Backup Logs”](#) for details about these tables.

Default: history logging is enabled. When `--no-connection` is specified, history logging is automatically disabled. When `--connect-if-online` is specified, history logging only works if a database connection is successfully established during the backup.

- `--comments=STRING`

Command-Line Format	<code>--comments=STRING</code>
Type	String

Specifies a comment string that describes or identifies the backup. Surround multi-word comments with appropriate quotation marks. The string is saved in a file `meta/comments.txt` in the backup. For example: `--comments="Backup of HR data on 2010/12/10"`.

- `--comments-file=PATH`

Command-Line Format	<code>--comments-file=PATH</code>
Type	File name

Specifies path to a file containing comments describing the backup. This file is saved as `meta/comments.txt` in the backup. For example: `--comments-file=/path/to/comments.txt`.

This option overrides the `--comments` option if both are specified.

16.6 Compression Options

For an overview on backup compression, see [Section 4.3.4, “Making a Compressed Backup”](#).

- `--compress`

Create backup in compressed format. For a regular backup, among all the storage engines supported by MySQL, only data files of the InnoDB format are compressed, and they bear the `.ibz` extension after the compression. Similarly, for a single-image backup, only data files of the InnoDB format inside the backup image are compressed. The binary log and relay log files are compressed and saved with the `.bz` extension when being included in a compressed backup.

Default: compression is disabled.

- `--compress-method=ALGORITHM`

Command-Line Format	<code>--compress-method=ALGORITHM</code>
Type	Enumeration
Default Value	<code>lz4</code>
Valid Values	<code>zlib</code> <code>lz4</code> <code>lzma</code> <code>punch-hole</code> <code>none</code>

Specifies the compression algorithm. The supported arguments for the option and the algorithms they represent are:

- `lz4`: LZ4 r109. Out of the three algorithms that are supported, this is the most efficient one, typically taking the shortest backup and restore times with the lowest CPU cost. See [lz4—Extremely Fast Compression algorithm](#) for more details, including a comparison with other compression algorithms.
- `lzma`: LZMA 9.20. Out of the three supported algorithms, this typically provides the highest compression ratio; but it is also far more expensive in terms of CPU cost than the other two options. Thus we do not recommend this for active systems, but only for off-hour or inactive databases, or where I/O rates are extremely low.
- `zlib`: ZLIB v1.2.3. This is in between the other two supported algorithms in terms of both speed and compression ratio. ZLIB was the only compression algorithm available for MySQL Enterprise Backup versions prior to 3.10.

Default: `lz4`. Explicitly specifying a value for the option through a configuration file or command line automatically enables the `--compress` option.

- `--compress-level=LEVEL`

Command-Line Format	<code>--compress-level=LEVEL</code>
Type	Numeric

Default Value	1
Minimum Value	0
Maximum Value	9

Specifies the level of compression, ranging from “0” to “9”: “0” disables compression; “1” is fastest compression, and “9” is highest (and slowest) compression. The option is only meaningful for compression using the ZLIB or LZMA algorithm; it is ignored when any other algorithms are selected by the `--compress-method` option.

Default: 1 (lowest and fastest compression). Explicitly specifying a non-zero value through a configuration file or command line automatically enables the `--compress` option.

- `--uncompress`

When used with the `apply-log` or `copy-back-and-apply-log` operation, uncompresses a compressed backup before applying the InnoDB log. When used with the `copy-back` operation, uncompresses a compressed [prepared backup](#) (created by the `backup-and-apply-log` command with the `--compress` option) before restoring it to a server.

For MySQL Enterprise Backup 4.1.4 and later: When used with the `extract` operation, uncompresses files that are extracted from a compressed single-file backup.

16.7 Incremental Backup Options

For an overview of incremental backups and usage examples for these options, see [Section 4.3.3, “Making a Differential or Incremental Backup”](#) and [Section 5.1.3, “Restoring an Incremental Backup”](#).

To take an incremental backup, specify the `--incremental` or `--incremental-with-redo-log-only`, along with the `--backup-dir` option. Depending on whether `--incremental` or `--incremental-with-redo-log-only` is used, other options are required or recommended. All InnoDB data modified after the LSN (specified directly or indirectly by the options you use) is copied into the incremental backup. To restore an incremental backup, specify the `--incremental` and the `--backup-dir` option.

- `--incremental[={full-scan|optimistic}]`

Command-Line Format	<code>--incremental</code>
Type	Enumeration
Default Value	<code>full-scan</code>
Valid Values	<code>page-track</code> <code>full-scan</code> <code>optimistic</code>

Specifies that the associated `backup`, `backup-to-image`, `copy-back-and-apply-log`, or `copy-back` operation is [incremental](#). When performing an incremental backup, there are two possible values for this option:

- `full-scan`: `mysqlbackup` scans all InnoDB data files in the server's data directory to find pages that have been changed since the last backup and saves them.
- `optimistic`: `mysqlbackup` only scans for changed pages in the InnoDB data files that have been modified since the last backup and then saves them. In general, optimistic incremental backups are

faster than full-scan ones when not many tables in the database have been modified; however a few restrictions apply to this feature. See [Full-scan versus Optimistic Incremental Backup](#) for details.

Default: `full-scan`. The value for the option have no meaning when the option is used for restoring an incremental backup.

During a backup, the option also requires the use of either the `--incremental-base` option or the `--start-lsn` option. Only InnoDB tables are backed up incrementally. By default, all non-InnoDB and `.frm` files are included into the incremental backup and in their fullness. To exclude non-InnoDB data in an incremental backup, use the `--only-innodb` option.

- `--incremental-with-redo-log-only`

Specifies that an [incremental](#) backup is to be created using only the redo log. This alternate type of incremental backup has different performance characteristics and operational limitations compared to backups created with the `--incremental` option; see [Creating Incremental Backups Using Only the Redo Log](#) for a discussion on their differences.

To use this option, you also need to specify the `--incremental-base` option or the `--start-lsn` option. Just like with the `--incremental` option, only InnoDB tables are backed up incrementally. By default, all non-InnoDB and `.frm` files are included into the incremental backup and in their fullness. To exclude non-InnoDB data in an incremental backup, use the `--only-innodb` option.

- `--incremental-base=mode:argument`

Command-Line Format	<code>--incremental-base=mode:argument</code>
Type	String

With this option, the `mysqlbackup` retrieves the information needed to perform incremental backups from the metadata inside the backup directory rather than from the `--start-lsn` option. It saves you from having to specify an ever-changing, unpredictable [LSN](#) value when doing a succession of incremental backups. Instead, you specify a way to locate the previous backup directory through the combination of `mode` and `argument` in the option syntax. The alternatives are:

- `dir:directory_path`

You specify the prefix `dir:` followed by a directory path. The path argument points to the directory where the data from the previous backup is stored. With the first incremental backup, you specify the directory holding the full backup; with the second incremental backup, you specify the directory holding the first incremental backup, and so on.

- `history:{last_backup | last_full_backup}`

The prefix `history:` followed by one of the two possible values:

- `last_backup`: This makes `mysqlbackup` query the `end_lsn` value from the last successful **non-TTS backup** as recorded in the `backup_history` table of the server instance that is being backed up.
- `last_full_backup`: (For MySQL Enterprise Backup 4.1.5 and later) This works similarly as the value `last_backup`, except that it makes `mysqlbackup` look for the last **full backup** that was taken and use it as the base backup, thus creating a **differential backup**.



Note

If the last full or partial backup made was a **TTS backup**, `mysqlbackup` skips it, and keeps searching the backup history until it finds the last **non-TTS backup** and then returns its `end_lsn` value.



Warning

Do not use the `history:` mode if the previous backup was a full backup taken with the `--no-connection` option, which always turns off the recording of backup history and might cause errors for a subsequent incremental backup using this mode of the `--incremental-base` option.

- `--start-lsn=LSN`

Command-Line Format	<code>--start-lsn=LSN</code>
Type	Numeric

In an **incremental backup**, specifies the highest **LSN** value included in a previous backup. You can get this value from the output of the previous backup operation, or from the `backup_history` table's `end_lsn` column for the previous backup operation. Always used in combination with the `--incremental` option; not needed when you use the `--incremental-base` option; not recommended when you use the `--incremental-with-redo-log-only` mechanism for incremental backups.



Note

No binary log files are copied into the incremental backup if the `--start-lsn` option is used. To include binary log files for the period covered by the incremental backup, instead of `--start-lsn`, use the `--incremental-base` option, which provides the necessary information for `mysqlbackup` to ensure that no gap exists between binary log data included in the previous backup and the current incremental backup.

- `--incremental-backup-dir=PATH`

Advanced: Specifies the location for data of an incremental directory backup. When creating or restoring an incremental directory backup, the option serves the same function as `--backup-dir` does

for backups and restores in general, and the option can in fact be used interchangeably with `--backup-dir` for directory backups. See the description for `--backup-dir` for details.

For an `apply-incremental-backup` operation, the option specifies the incremental backup directory whose data is used to update a directory backup specified by the `--backup-dir` option.



Note

Do not use this option with any operations for image backups, for which the option has no meaning.

16.8 Partial Backup and Restore Options



Note

Since MySQL Enterprise Backup 3.10, the two options `--include-tables` and `--exclude-tables` have been introduced. These were intended for replacing the older options of `--include`, `--databases`, `--databases-list-file`, and `--only-innodb-with-frm`, which are incompatible with the new options and will be deprecated in future releases. For references purpose, we have included information on the older options at the end of this section in [Legacy Partial Backup Options](#).

To select specific data to be backed up or restored, use the partial backup and restore options described in this section.

For an overview of partial backup and usage examples on the following options, see [Section 4.3.5, “Making a Partial Backup”](#). See also [Section 5.1.4, “Restoring Backups Created with the --use-tts Option”](#), on selective restore of tables from a backup.

- `--include-tables=REGEXP`

Command-Line Format	<code>--include-tables=REGEXP</code>
Type	String

Include for backup or restoration only those tables (both Innodb and non-Innodb) whose fully qualified names (in the form of `db_name.table_name`) match the regular expression `REGEXP`. The regular expression syntax used is the extended form specified in the POSIX 1003.2 standard. For example, `--include-tables=^mydb\.t[12]$` matches the tables `t1` and `t2` in the database `mydb`. On Unix-like systems, quote the regular expression appropriately to prevent interpretation of shell meta-characters. `mysqlbackup` throws an error when the option is used without a regular expression being supplied with it.

While `mysqlbackup` understands the MySQL convention of quoting the database or the table name (or both) by backticks (see [Schema Object Names](#)), there is no need to include the backticks in the regular expression for `--include-tables`.

For a backup operation, `mysqlbackup` throws an error when no table matches the regular expression specified with `--include-tables`.

While the option can be used for different kinds of backups, selective restore is only supported for backups created using [transportable tablespace \(TTS\)](#) (that is, backups created with the `--use-tts` option). The option can also be used with the `backup-dir-to-image` and `image-to-backup-dir` commands to select tables when creating or unpacking a backup image.

The option cannot be used together with the legacy `--include`, `--databases`, `--databases-list-file`, or `--only-innodb-with-frm` option.

When used together with the `--exclude-tables` option, `--include-tables` is applied first, meaning `mysqlbackup` first selects all tables specified by `--include-tables` and then excludes from the set those tables specified by `--exclude-tables`.

- `--exclude-tables=REGEXP`

Command-Line Format	<code>--exclude-tables=REGEXP</code>
Type	String

Exclude for backup or restoration all tables (both InnoDB and non-InnoDB) whose fully qualified names (in the form of `db_name.table_name`) match the regular expression `REGEXP`. The regular expression syntax is the extended form specified in the POSIX 1003.2 standard. For example, `--exclude-tables=^mydb\.t[12]$` matches the tables `t1` and `t2` in the database `mydb`. On Unix-like systems, quote the regular expression appropriately to prevent interpretation of shell meta-characters. `mysqlbackup` throws an error when the option is used without a regular expression being supplied with it.

While `mysqlbackup` understands the MySQL convention of quoting the database or the table name (or both) by backticks (see [Schema Object Names](#)), there is no need to include the backticks in the regular expression for `--exclude-tables`.

While the option can be used for different kinds of backups, selective restore is only supported for backups created using [transportable tablespaces \(TTS\)](#) (that is, backups created with the `--use-tts` option). The option can also be used with the `backup-dir-to-image` and `image-to-backup-dir` commands to select tables when creating or unpacking a backup image.

The option cannot be used together with the `--include`, `--databases`, `--databases-list-file`, or `--only-innodb-with-frm` option.

When used together with the `--include-tables` option, `--include-tables` is applied first, meaning `mysqlbackup` first select all tables specified by `--include-tables`, and then exclude from the set those tables specified by `--exclude-tables`.

- `--only-known-file-types`

For back up only. By default, all files in the database subdirectories under the data directory of the server are included in the backup (see [Table 1.1, “Types of Files in a Backup”](#) for details). If the `--only-known-file-types` option is specified, `mysqlbackup` only backs up those types of files that are data files for MySQL or its built-in storage engines, which, besides the `ibdata*` files, have the following extensions:

- `.ARM`: ARCHIVE table metadata
- `.ARZ`: ARCHIVE table data
- `.CSM`: CSV table metadata
- `.CSV`: CSV table data
- `.frm`: table definitions
- `.ibd`: InnoDB tablespace created using the file-per-table mode

- `.MRG`: Merge storage engine references to other tables
- `.MYD`: MyISAM data
- `.MYI`: MyISAM indexes
- `.opt`: database configuration information
- `.par`: partition definitions
- `.TRG`: trigger parameters
- `.TRN`: trigger namespace information
- `--only-innodb`

For back up only. When this option is used, only InnoDB data and log files are included in the backup, and all files created by other storage engines are excluded. Typically used when no connection to `mysqld` is allowed or when there is no need to copy MyISAM files.

The option is not compatible with the `--slave-info` option.

- `--use-tts[={with-minimum-locking|with-full-locking}]`

Command-Line Format	<code>--use-tts[={with-minimum-locking with-full-locking}]</code>
Type	Enumeration
Default Value	<code>with-minimum-locking</code>
Valid Values	<code>with-minimum-locking</code> <code>with-full-locking</code>

Enable selective backup of InnoDB tables using [transportable tablespaces \(TTS\)](#). This is to be used in conjunction with the `--include-tables` and `--exclude-tables` options for selecting the InnoDB tables to be backed up by regular expressions. Using [TTS](#) for backups offers the following advantages:

- Backups can be restored to a different server
- The [system tablespace](#) is not backed up, saving disk space and I/O resources
- Data consistency of the tables is managed by MySQL Enterprise Backup

However, the option has the following limitations:

- Backing up and restoring of partitioned tables are only supported for MySQL 5.7.4 and later. Also, individual partitions cannot be selectively backed up or restored. Tables selected by the `--include-tables` and `--exclude-tables` options are always backed up or restored in full.
- Can only backup tables that are stored in their own individual tablespaces (i.e., tables created with the [innodb_file_per_table](#) option enabled)
- Non-InnoDB tables are not backed up

- *For MySQL Enterprise Backup 4.1.4 and earlier:* For partial backups, encrypted InnoDB tables are never included (a warning is issued in the log file whenever an encrypted InnoDB table that matches the table selection criteria has been skipped over).
 - Cannot be used for incremental backups
 - Does not include the binary log or the relay log in the backup
- See also [Appendix B, Limitations of MySQL Enterprise Backup](#) for some more minor limitations.

There are two possible values for the option:

- `with-minimum-locking`: Hot copies of the selected tables are backed up, and the tables are then locked in read-only mode while the [redo log](#) (with only the portion containing the relevant changes made after the hot backup) is being included in the backup. Any tables created during the locking phase are ignored.
- `with-full-locking`: The selected tables are locked in read-only mode while they are being backed up. The [redo log](#) is not included in the backup. Any tables created during the locking phase are ignored.



Note

Due to a known issue, when creating a backup using TTS for a server containing tables with a mix of the Antelope and Barracuda file formats, do NOT apply full locking on the tables.

Default: `with-minimum-locking`

To use the `--use-tts` option, extra privileges are required of the user through which `mysqlbackup` connects to the server; see [Section 4.1.2, “Grant MySQL Privileges to Backup Administrator”](#) for details.

There are some special requirements for restoring backups created with the `--use-tts` option; see [Section 5.1.4, “Restoring Backups Created with the `--use-tts` Option”](#) for details.

- `--rename=“old_table_name to new_table_name”`

Rename a single table when it is restored to a database from a backup created using the `--use-tts` option. The table named `old_table_name` is renamed to `new_table_name`. Note that when using the option:

- `old_table_name` and `new_table_name` can be fully qualified (containing the database names, in the format of `db_name.tb_name`) or not. Regular expressions are not accepted for `old_table_name` and `new_table_name`. The restore fails if `old_table_name` does not match any table that is to be restored, or when `new_table_name` already exists in the target database.
- *For MySQL Enterprise Backup 4.1.4 and earlier:* The `--include-tables` or `--exclude-tables` option (or both together) must be used in the restore command for the `--rename` option to work, unless there is only one table in the backup. Also, the `--include-tables` or `--exclude-tables` option (or both together) should specify one and only one table for restore when `--rename` is used, or the restore will fail.
- *For MySQL Enterprise Backup 4.1.4 and earlier:* The restore fails if `old_table_name` does not match with the table specified using the `--include-tables` or `--exclude-tables` option (or both together),

- The requirements listed in [Section 5.1.4, “Restoring Backups Created with the `--use-tts` Option”](#) apply. See [Section 5.1.4, “Restoring Backups Created with the `--use-tts` Option”](#), for more information on selective restores, and for an example of table renaming.

Legacy Partial Backup Options



Important

Information in this subsection is only for using the legacy options of `--include`, `--databases`, `--databases-list-file`, and `--only-innodb-with-frm`, which will be deprecated in the upcoming issues. For creating partial backups, it is strongly recommended that the new options of `--include-tables` and `--exclude-tables` be used instead. Note that you cannot combine the legacy and the new partial-backup options in a single command.

Besides the legacy options, some other options are also discussed below, but the information is only for using the options together with the legacy partial-backup options.

For an overview of partial backups and usage examples for these legacy options, see [Making a Partial Backup with the Legacy Options](#).

- `--include=REGEXP`

This option is for filtering InnoDB tables for backup. The InnoDB tables' fully qualified names are checked against the regular expression specified by the option. If the REGEXP matches `db_name.table_name`, the table is included. The regular expression syntax used is the extended form specified in the POSIX 1003.2 standard. For example, `--include=mydb\.t[12]` matches the tables `t1` and `t2` in the database `mydb`. `mysqlbackup` throws an error when the option is used without a regular expression being supplied with it.

This option only applies to InnoDB tables created with the MySQL option `innodb_file_per_table` enabled (which is the default setting for MySQL 5.6 and after), in which case the tables are in separate files that can be included or excluded from the backup. All tables in the InnoDB system tablespace are always backed up.

When no InnoDB table names match the specified regular expression, an error is thrown with a message indicating there are no matches.

Default: Backs up all InnoDB tables.



Note

This option does not filter non-InnoDB tables, for which options like `--databases` and `--databases-list-file` can be used.



Important

This option does not filter the `.frm` files associated with InnoDB tables, meaning that regardless of the option's value, all the `.frm` files for all InnoDB tables are always backed up unless they are excluded by other options. Those `.frm` files for InnoDB tables that are not backed up should be deleted before the database backup is restored. See [Making a Partial Backup with the Legacy Options](#) for details.

- `--databases=LIST`

Specifies the list of non-InnoDB tables to back up. The argument specifies a space-separated list of database or table names of the following form:

```
"db_name[.table_name] db_name1[.table_name1] ...".
```

If the specified values do not match any database or table, then no non-InnoDB data files are backed up. See [Making a Partial Backup with the Legacy Options](#) for details.

By default, all non-InnoDB tables from all databases are backed up.

**Note**

The option has no filtering effects on the InnoDB data files (`.ibd` files) for the databases or tables it specifies. To filter InnoDB data files, use the `--include` option instead.

- `--databases-list-file=PATH`

Specifies the pathname of a file that lists the non-InnoDB tables to be backed up. The file contains entries for databases or fully qualified table names separated by newline or space. The format of the entries is the same as for the `--databases` option:

```
db_name[.table_name]  
db_name1[.table_name1]  
...
```

Remove any white spaces surrounding the database or table names, as the white spaces are not removed automatically. Begin a line with the `#` character to include a comment. No regular expressions are allowed.

If the specified entries do not match any database or table, then no non-InnoDB data files are backed up.

**Note**

The option has no filtering effects on the InnoDB data files (`.ibd` files) for the databases or tables it specifies. To filter InnoDB data files, use the `--include` option instead.

- `--only-innodb-with-frm[={all|related}]`

Back up only InnoDB data, log files, and the `.frm` files associated with the InnoDB tables.

- `--only-innodb-with-frm=all` includes the `.frm` files for all InnoDB tables in the backup.
- `--only-innodb-with-frm=related`, in combination with the `--include` option, copies only the `.frm` files for the tables that are included in the partial backup.
- `--only-innodb-with-frm` with no argument is the same as `--only-innodb-with-frm=related`.



Note

For incremental backups, even only changed `.ibd` files are backed up, `.frm` files associated with *all* specified InnoDB tables are included.

This option saves you having to script the backup step for InnoDB `.frm` files, which you would normally do while the server is put into a read-only state by a `FLUSH TABLES WITH READ LOCK` statement. The `.frm` files are copied without putting the server into a read-only state, so that the backup operation is a true **hot backup** and does not interrupt database processing. You must ensure that no `ALTER TABLE` or other DDL statements change `.frm` files for InnoDB tables while the backup is in progress. If `mysqlbackup` detects changes to any relevant `.frm` files during the backup operation, it halts with an error. If it is not practical to forbid DDL on InnoDB tables during the backup operation, use the `--only-innodb` option instead and use the traditional method of copying the `.frm` files while the server is locked.

All files created by other storage engines are excluded. Typically used when no connection to `mysqld` is allowed or when there is no need to copy MyISAM files, for example, when you are sure there are no DDL changes during the backup. See [Making a Partial Backup with the Legacy Options](#) for instructions and examples.

The option is not compatible with the `--slave-info` option.

Default: backups include files from all storage engines.

- `--use-tts[={with-minimum-locking|with-full-locking}]`

Enable selective backup of InnoDB tables using **transportable tablespaces (TTS)**. This is to be used in conjunction with the `--include` option, which selects the InnoDB tables to be backed up by a regular expression. Using **TTS** for backups offers the following advantages:

- Backups can be restored to a different server
- The **system tablespace** is not backed up, saving disk space and I/O resources
- Data consistency of the tables is managed by MySQL Enterprise Backup

See important discussions [here](#) on the limitations with using the `--use-tts` option.

There are two possible values for the option:

- `with-minimum-locking`: Hot copies of the selected tables are backed up, and the tables are then locked in read-only mode while the **redo log** (with only the portion containing the relevant changes

made after the hot backup) is being included in the backup. Any tables created during the locking phase are ignored.

- `with-full-locking`: The selected tables are locked in read-only mode while they are being backed up. The `redo log` is not included in the backup. Any tables created during the locking phase are ignored.

Default: back up with minimum locking

There are some special requirements for restoring backups created with the `--use-tts` option; see the [explanations](#) in [Section 5.1, “Performing a Restore Operation”](#) for details.

16.9 Single-File Backup Options

These options are associated with single-file backups. You use them in combination with the `mysqlbackup` commands `backup-to-image`, `image-to-backup-dir`, `backup-dir-to-image`, `copy-back-and-apply-log`, `list-image`, and `extract`. For usage examples, see [Section 4.3.1, “Making a Single-File Backup”](#).

- `--backup-image=IMAGE`

See description of the option in [Section 16.4, “Backup Repository Options”](#)

- `--src-entry=STRING`

Command-Line Format	<code>--src-entry=STRING</code>
Type	Path name

Identifies files or directories whose pathnames contain the `STRING` to be extracted from a single-file backup. This option is used with the `extract` command. Optionally, you can also specify the `--dst-entry` option to extract a file or directory to a location different from its original path name.

For example: `src-entry=d1/f2` extracts only one file, `f1`, while `src-entry=d1/` extracts the entire directory tree for the `d1` folder (notice the slash (/) at the end of the argument, without which all files or folders containing the string `d1` in their pathnames will be extracted).

Default: All entries are extracted.



Notes

- The following items are always extracted from the backup, irrespective of the value of `--src-entry` (and the locations of their extraction are unaffected by the `--dst-entry` option):
 - The file `backup-my.cnf`.
 - A `datadir` folder (which only contains items matched by the `--src-entry` option).
 - A `meta` folder, which contains the file `backup_variables.txt`, a log file for the extract operation, and also items matched by the `--src-entry` option.
- The option is currently not supported for the `extract` command for cloud backups, which can only be extracted in full.

- `--dst-entry=PATH`

Command-Line Format	<code>--dst-entry=PATH</code>
Type	Path name

Used with single-file backups to extract a single file or directory to a user-specified path. Use of this option requires specifying the `--src-entry` option. This option specifies the destination path for the entry selected from the backup image by `--src-entry`. The entry could point to a single file or single directory. For example, to retrieve the comments file from a backup image and store it as `/tmp/my-comments.txt`, use a command like the following:

```
mysqlbackup --src-entry=meta/comments.txt \
--dst-entry=/tmp/my-comments.txt \
--backup-image=/var/myimage.bki extract
```

Similarly, to extract all the contents of the `datadir/pets/` directory in a single-file backup as `/pets-extracted/`, use a command like the following:

```
mysqlbackup --src-entry=datadir/pets/ \
--dst-entry=/pets-extracted/ \
--backup-image=/var/myimage.bki extract
```

The specified path is a simple path name without any wildcard expansion or regular expressions.

In case the argument for `--src-entry` matches multiple files or folders, they are all extracted into a folder whose pathname, relative to the destination folder, is given by the argument of `--dst-entry` (unless the argument specifies an absolute path).

Default: Original pathnames are used to create files under the destination folder.

- `--sbt-database-name=NAME`

Command-Line Format	<code>--sbt-database-name=NAME</code>
Type	String
Default Value	MySQL

For tape backups, this option can be used as a hint to the Media Management Software (MMS) for the selection of media and policies. This name has nothing to do with MySQL database names. It is a term used by the MMS. See [Section 4.3.1.2, “Backing Up to Tape”](#) for usage details.

- `--sbt-lib-path=PATH`

Command-Line Format	<code>--sbt-lib-path=PATH</code>
Type	File name

Path name of the SBT library used by the software that manages tape backups. If this is not specified, operating system-specific search methods are used to locate `libobk.so` (UNIX) or `orasbt.dll` (Windows). See [Section 4.3.1.2, “Backing Up to Tape”](#) for usage details.

- `--sbt-environment=VAR=value,...`

Command-Line Format	<code>--sbt-environment=VAR1=value1[,VAR2=value2[,...]]</code> SBT API provider)
---------------------	---

Type	String
------	--------

Passes product-specific environment variables to Oracle Secure Backup or another SBT-compliant backup management product, as an alternative to setting and unsetting environment variables before and after each `mysqlbackup` invocation.

The parameter to this option is a comma-separated list of key-value pairs, using syntax similar to that of the RMAN tool for the Oracle Database. For example, `--sbt-environment=VAR1=val1,VAR2=val2,VAR3=val3`.

Consult the documentation for your backup management product to see which of its features can be controlled through environment variables. For example, the Oracle Secure Backup product [defines environment variables](#) such as `OB_MEDIA_FAMILY`, `OB_DEVICE`, and `OB_RESOURCE_WAIT_TIME`. You might set such variables with the `mysqlbackup` by specifying an option such as `--sbt-environment="OB_MEDIA_FAMILY=my_mf,OB_DEVICE=my_tape"`.

If the argument string contains any whitespace or special characters recognized by the command shell, enclose the entire argument string in quotation marks. To escape an equal sign or comma, use the `\` character. For example, `--sbt-environment="VAR1=multiple words,VAR2=<angle_brackets>,VAR3=2+2\=4"`.

- `--disable-manifest`

Disable generation of [manifest](#) files for a backup operation, which are `backup_create.xml` and `backup_content.xml` present in the `meta` subdirectory.

16.10 Performance / Scalability / Capacity Options

These options limit the resources used by the backup process, in order to minimize backup overhead for busy or huge databases, or specify behaviors of the process when encountering resource issues.

- `--number-of-buffers=num_buffers`

Command-Line Format	<code>--number-of-buffers=NUMBER</code>
Type	Numeric
Default Value	14
Minimum Value	1

Specifies the number of buffers, each 16MB in size, to use during multithreaded options.

Use a high number for CPU-intensive processing such as backup, particularly when using compression. Use a low number for disk-intensive processing such as restoring a backup. This value should be at least as high as the number of read threads or write threads, depending on the type of operation.

Default: currently 14.

For compression or incremental backup operations, the buffer size is slightly more than 16MB to accommodate the headers.

One additional buffer is used for single-file incremental backup and single-file compressed backup.

Compressed backup, compressed single-file backup, and uncompress apply-log operations require one additional buffer for each process thread.

If you change the number of read, write, and processing threads, you can experiment with changing this value so that it is slightly larger than the total number of threads specified by those other options. See [Section 11.1, “Optimizing Backup Performance”](#) and [Section 11.2, “Optimizing Restore Performance”](#) for additional advice about recommended combinations of values for this and other performance-related options for various hardware configurations, such as RAID or non-RAID storage devices.

- `--read-threads=num_threads`

Command-Line Format	<code>--read-threads=NUMBER</code>
Type	Numeric
Default Value	1
Minimum Value	1
Maximum Value	15

Specifies the number of threads to use for reading data from disk. This option applies to these kinds of operations: `copy-back`, `copy-back-and-apply-log` (for directory backups only), `extract`, `backup`, and `backup-and-apply-log`. If you specify a value of 0, it is silently adjusted to 1. The maximum is 15. If you supply a negative value, it is silently adjusted to 15. For the following operations, the number of read threads is always 1 regardless of this option's setting:

- Restores of single-file backups
- `apply-log` operations and the apply-log phase of a `copy-back-and-apply-log`, `backup-and-apply-log`, or `apply-incremental-backup` operation.

See [Section 11.1, “Optimizing Backup Performance”](#) and [Section 11.2, “Optimizing Restore Performance”](#) for advice about recommended combinations of values for `--read-threads`, `--process-threads`, and `--write-threads` for various hardware configurations, such as RAID or non-RAID storage devices.

Default: 1.

- `--process-threads=num_threads`

Command-Line Format	<code>--process-threads=NUMBER</code>
Type	Numeric
Default Value	6
Minimum Value	1
Maximum Value	15

Specifies the number of threads to use for processing data, including compression and uncompression, encryption and decryption, apply-log operations, and packing and extracting of backup images. For `backup-and-apply-log`, `copy-back-and-apply-log`, and `apply-incremental-backup`, `--process-threads` sets the worker threads number for the apply-log phase of the operation. The option is ignored for those operations that do not involve data processing like `copy-back` (unless decryption

or uncompression is involved), `backup-dir-to-image` , or a backup operation that uses the `--incremental-with-redo-log-only` option.

Default: 6 for all operations to which the option is applicable.

If you specify a value of 0, it is silently adjusted to 1. The maximum is 15. If you supply a negative value, it is silently adjusted to 15. See [Section 11.1, “Optimizing Backup Performance”](#) and [Section 11.2, “Optimizing Restore Performance”](#) for advice about recommended combinations of values for `--read-threads`, `--process-threads`, and `--write-threads` for various hardware configurations, such as RAID or non-RAID storage devices.

- `--write-threads=num_threads`

Command-Line Format	<code>--write-threads=NUMBER</code>
Type	Numeric
Default Value	1
Minimum Value	1
Maximum Value	15

Specifies the number of threads to use for writing data to disk. This option applies to these kinds of operations: `copy-back`, `copy-back-and-apply-log`, `extract`, `backup`, and `backup-and-apply-log` (when applied to directory backups). For the supported operations, multiple write threads are supported for any write target that is seekable; `--write-threads` is forced to be 1 only when the write target is non-seekable. The option is ignored for other operations like single-file backups (uses 1 write thread always), `list-image` (uses no write threads), and `validate` (uses no write threads).

If you specify a value of 0, it is silently adjusted to 1 (for operations that uses write threads). The maximum is 15. If you supply a negative value, it is silently adjusted to 15. For `apply-log` operations and the apply-log phase of `copy-back-and-apply-log`, `backup-and-apply-log`, or `apply-incremental-backup`, the number of write threads is always 0 regardless of this option's setting. See [Section 11.1, “Optimizing Backup Performance”](#) and [Section 11.2, “Optimizing Restore Performance”](#) for advice about recommended combinations of values for `--read-threads`, `--process-threads`, and `--write-threads` for various hardware configurations, such as RAID or non-RAID storage devices.

Default: 1.

- `--limit-memory=MB`

Command-Line Format	<code>--limit-memory=MB</code>
Type	Numeric
Default Value	100 for <code>apply-log</code> (without uncompression), 400 for other operations
Minimum Value	0
Maximum Value	999999
Unit	megabyte

Specify maximum memory in megabytes that can be used by `mysqlbackup`. Formerly applied only to `apply-log` operation, but in MySQL Enterprise Backup 3.8 and higher it applies to all operations. Do not include any suffixes such as `mb` or `kb` in the option value.

Default: 100 for `apply-log` not used with `--uncompress`, 400 for all operations (in megabytes).

The memory limit specified by this option also caps the number of 16MB buffers available for multithreaded processing. For example, with a 400 MB limit, the maximum number of buffers is 25 (except for a cloud backup, for which extra memory is needed, and the maximum number of buffers is 18). If additional buffers are required because you increased the values for `--read-threads`, `--process-threads`, `--write-threads`, and/or `--number-of-buffers`, increase the `--limit-memory` value proportionally.

- `--sleep=MS`

Command-Line Format	<code>--sleep=MS</code>
Type	Numeric
Default Value	0
Unit	millisecond

Specify the number in milliseconds to sleep after copying a certain amount of data from InnoDB tables. Each block of data is 1024 InnoDB data pages, typically totalling 16MB. This is to limit the CPU and I/O overhead on the database server.

Default: 0 (no voluntary sleeps).

- `--no-locking`

Disables locking during backup of non-InnoDB files, even if a connection is available. Can be used to copy non-InnoDB data with less disruption to normal database processing. There could be inconsistencies in non-InnoDB data if any changes are made while those files are being backed up.

- `--lock-wait-timeout`

Command-Line Format	<code>--lock-wait-timeout=S</code>
Type	Numeric
Default Value	60
Minimum Value	1
Unit	second

Specify the timeout in seconds for the `FLUSH TABLES WITH READ LOCK` statement, which `mysqlbackup` issues during the final stage of a backup to temporarily put the database into a read-only state. If the timeout is exceeded, the statement is failed and the lock on the tables is released, so that queries held up by the lock can then be executed. `mysqlbackup` then retries the statement and continues with the backup. The timeout prevents the case in which a long query running on the server prevents the `FLUSH TABLES WITH READ LOCK` statement from finishing, holding up further queries and eventually bringing down the server. Default is 60. Minimum value is 1.

- `--lock-wait-retry-count`

Command-Line Format	<code>--lock-wait-retry-count</code>
Introduced	4.1.4
Type	Integer
Default Value	2147483647

Minimum Value	0
Maximum Value	2147483647

Specify the maximum number of retries to be attempted by `mysqlbackup` after the `FLUSH TABLES WITH READ LOCK` statement, issued during the final stage of a backup to temporarily put the database into a read-only state, fails due to a timeout. The timeout is specified by the `mysqlbackup` option `--lock-wait-timeout`, or by the system variable `--innodb_lock_wait_timeout` on the server. This option prevents an excessive number of retries of the lock statement, during which all transactions are blocked on the server. Default and maximum value is 2147483647. Minimum value is 0 (no retry).

- `--page-reread-time=MS`

Command-Line Format	<code>--page-reread-time=MS</code>
Type	Numeric
Default Value	100
Unit	millisecond

Interval in milliseconds that `mysqlbackup` waits before re-reading a [page](#) that fails a checksum test. A busy server could be writing a page at the same moment that `mysqlbackup` is reading it. Can be a floating-point number, such as 0.05 meaning 50 microseconds. Best possible resolution is 1 microsecond, but it could be worse on some platforms. Default is 100 milliseconds (0.1 second).

- `--page-reread-count=retry_limit`

Command-Line Format	<code>--page-reread-count=number</code>
Type	Numeric
Default Value	500

Maximum number of re-read attempts, when a [page](#) fails a checksum test. A busy server could be writing a page at the same moment that `mysqlbackup` is reading it. If the same page fails this many checksum tests consecutively, with a pause based on the `--page-reread-time` option between each attempt, the backup fails. Default is 500.

- `--on-disk-full={abort|abort_and_remove|warn}`

Command-Line Format	<code>--on-disk-full=option</code>
Type	Enumeration
Default Value	<code>abort</code>
Valid Values	<code>abort</code> <code>warn</code> <code>abort_and_remove</code>

Specifies the behavior when a backup process encounters a disk-full condition. This option is only for backup operations (`backup`, `backup-and-apply-log`, and `backup-to-image`).

- `abort`: Abort backup, without removing the backup directory. The disk remains full.
- `abort_and_remove`: Abort backup and remove the backup directory.

- `warn`: Write a warning message every 30 seconds and retry backup until disk space becomes available.

Default: `abort`.

- `--skip-unused-pages`

Skip unused pages in tablespaces when backing up InnoDB tables. This option is applicable to the `backup` and `backup-to-image` operations, but not to `incremental` backups. The option is ignored by the `backup-and-apply-log` operation.

Note that backups created with the `--skip-unused-pages` option cannot be restored using `copy-back-and-apply-log`.

Unused pages are free pages often caused by bulk delete of data. By skipping the unused pages during backups, this option can reduce the backup sizes and thus the required disk space and I/O resources for the operations. However, subsequent `apply-log` operations on the backups will take more time to complete, as the unused pages are inserted back into the tables during the operations.

- `--skip-binlog`

Skip including the binary log files in the backup during a backup operation, or skip copying the binary log files onto a server during a restore operation.

Binary log files, together with the binary log index file, are included by default for all kinds of online backups (full, incremental, compressed, partial, single-file, etc.). See Table 1.1, “Types of Files in a Backup”, for details. Use this option to skip backing up binary logs for the following situations:

- If resource or performance issues arise.
- If any binary log files are missing on the server you are backing up, in order to avoid `mysqlbackup` throwing an error for the missing files.
- If you are making an incremental backup that is based on a backup (full or incremental) created using the `--no-locking` option, as binary log information will then be unavailable to `mysqlbackup` in that situation.

- `--skip-relaylog`

When working with a replica server, skip including the relay log files in the backup during a backup operation, or skip copying the relay log files onto a server during a restore operation.

Relay log files, together with the relay log index file and the `master.info` and the `slave.info` files, are included by default for all kinds of online backups (full, incremental, compressed, partial, single-file, etc.) of a replica server. See Table 1.1, “Types of Files in a Backup”, for details. Use this option to skip backing up relay logs if resource, performance, or other issues arise.



Note

If a user runs a `FLUSH LOGS` statement while backup is in progress for a replica, the backup process will fail. Use the `--skip-relaylog` option if you expect a `FLUSH LOGS` statement will be run during the backup and it is not necessary to include the relay logs in the backup.

The relay log files and the files backed up together with them, when included in a backup, are always copied into the restored server's data directory during a restore operation; if that is not the behavior you desire, use this option to skip the restoring of the relay log.

- `--skip-final-rescan`

Skip the final rescan for InnoDB tables that are modified by DDL operations after the database has been read-locked near the end of a backup operation. This potentially shortens the duration for the lock and reduces the backup's impact on the server's normal operation, especially when many tables are being backed up.



Warning

This option can cause an incomplete or inconsistent backup if, during the backup operation, DDL operations are executed on any InnoDB tables whose [file-per-table](#) tablespaces are outside the MySQL data directory (i.e., any [InnoDB tables created using the DATA DIRECTORY table option](#)).

The option is ignored for backups using the `--incremental-with-redo-log-only` option and for non-backup operations.

- `--log-bin-index[=PATH]`

Command-Line Format	<code>--log-bin-index=FILENAME</code>
Type	File name
Default Value	<code>data_dir/host_name-bin.index</code>

For all offline backups: specify the absolute path (including file name and extension) of the index file on the MySQL server that lists all the used binary log files, if it is different from the default path given below, in order to include the binary log files in the backup.

Default: `data_dir/host_name-bin.index`.

- `--relay-log-index[=PATH]`

Command-Line Format	<code>--relay-log-index=FILENAME</code>
Type	File name
Default Value	<code>data_dir/host_name-relay-bin.index</code>

For offline backups of replica servers only: specify the absolute path (including file name and extension) of the index file on the MySQL server that lists all the used relay log files, if it is different from the default path given below, in order to include the relay log files in the backup.

Default: `data_dir/host_name-relay-bin.index`.

- `--master-info-file[=PATH]`

Command-Line Format	<code>--master-info-file=FILENAME</code>
Type	File name
Default Value	<code>data_dir/master.info</code>

For offline backups of replica servers only: specify the absolute path (including file name and extension) of the information file in which a replica records information about its source, if it is different from the default path given below, in order to include the information file in the backup.

Default: `data_dir/master.info`.

- `--relaylog-info-file[=PATH]`

Command-Line Format	<code>--relaylog-info-file=FILENAME</code>
Type	File name
Default Value	<code>data_dir/relay-log.info</code>

For offline backups of replica servers only: specify the absolute path (including file name and extension) of the information file in which a replica records information about the relay logs, if it is different from the default path given below, in order to include the information file in the backup.

Default: `data_dir/relay-log.info`.

- `--optimistic-time[=DATE-TIME]`

Command-Line Format	<code>--optimistic-time=DATE-TIME</code>
Type	String
Default Value	<code>now</code>

Perform an optimistic backup with the value specified with the option as the “optimistic time”—a time after which the tables that have not been modified are taken as “inactive tables.” The “inactive tables” are believed to be unlikely to change during the backup process. The inactive tables are backed up in the optimistic phase of the backup, and all other tables are backed up in the normal phase. See [Section 4.3.6, “Making an Optimistic Backup”](#) for details on the concept, use cases, and command samples for an optimistic backup.

Accepted formats for specifying the option include:

- `now`: This includes all tables into the optimistic phase of the backup process. It is the default value for the option when no value is specified.
- `{Number}{Unit}`: Indicates the optimistic time as a time at a certain duration into the past. `{Unit}` can be any one of `years`, `months`, `hours`, and `minutes`. Some examples for option strings in this format include: `5years`, `2days`, `13months`, `23hours`, and `35minutes`.
- A date-time format in any of the following forms: `YYMMDD`, `YYYYMMDD`, `YYMMDDHHMMSS`, `YYYYMMDDHHMMSS`, `YY-MM-DD`, `YYYY-MM-DD`, `YY-MM-DD HH.MM.SS`, or `YYYYMMDDTHHMMSS` (where `T` is the character `T`).

When both the `optimistic-time` and the `optimistic-busy-tables` options are used and they come into conflict on determining which tables are to be backed up in the optimistic phase, `optimistic-busy-tables` takes precedence over `optimistic-time`.

- `--optimistic-busy-tables=REGEXP`

Command-Line Format	<code>--optimistic-busy-tables=REGEXP</code>
Type	String

Perform an optimistic backup, using the regular expression specified with the option to select tables that will be skipped in the first phase of an optimistic backup, because they are likely to be modified during the backup process. Tables whose fully qualified names (in the form of `database_name.table_name`) are matched by the regular expression are taken as “busy tables”, which will be backed up in the second or the “normal” phase of the backup. Tables whose fully qualified names are NOT matched by the regular expression are taken as “inactive tables”, which will be backed

up in the first or the “optimistic” phase of the backup. See [Section 4.3.6, “Making an Optimistic Backup”](#) for details on the concept, use cases, and command samples for an optimistic backup.

MySQL Enterprise Backup will throw an error if the option is used but no regular expression is supplied with it.

When both the `optimistic-time` and the `optimistic-busy-tables` options are used and they come into conflict on determining which tables are to be “optimistic”, `optimistic-busy-tables` takes precedence over `optimistic-time`.

- `--free-os-buffers`

Free the system buffer cache at the end of a backup operation by syncing all data from the buffer cache to the hard disk. Using the option might increase the backup time significantly for systems with slow storage devices and databases with many tables.

Default: Automatic syncing disabled.

16.11 Message Logging Options

`mysqlbackup` writes important progress and error information to the `stderr` stream. The information is often very valuable for tracking down problems that occur during an operation. Starting from MySQL Enterprise Backup 3.9, the output to the `stderr` stream is also saved to a log file by default (for most `mysqlbackup` operations), so that the error information can be easily accessed in any debug process.

The message logging works like a `tee` process on a Unix-like system, in which the output of a program is split to be both displayed and saved to a file. The log file thus produced is named in the following format: `MEB_timestamp_operation.log`, where `operation` is the `mysqlbackup` operation that was run (e.g., `backup`, `apply-log`, etc.), and `timestamp` is the date and time at which the operation was run. Here are some examples of names for the log files:

```
MEB_2013-06-24.16-32-43_backup.log
MEB_2013-06-28.11-07-18_apply_log.log
MEB_2013-06-29.10-08-06_list_image.log
```

The following options control the message logging function:

- `--skip-messages-logdir`

Skip message logging. Logging is turned on by default (except for the `list-image` and `validate` operations; see the description for the `--messages-logdir` option for details), and it is turned off by this option.

- `--messages-logdir=path`

Command-Line Format	<code>--messages-logdir=PATH</code>
Type	Directory name
Default Value	<code>backup_dir/meta</code>

Specifies the path name of an existing directory for storing the message log. If the specified directory does not exist, message logging fails and returns an error message. When this option is omitted, the default directory of `backup_dir/meta` is used, where `backup_dir` is the directory specified with the `--backup-dir` option.

**Note**

Use this option to turn on message logging for the `list-image` and `validate` operations. Message logging is turned off by default for the two operations, because they do not modify any files and a message log is usually not required for debugging them. And because the default path name of `backup_dir/meta` is not meaningful for the two operations, this option is required for both turning on message logging and for supplying the path name of a directory in which to save the log file. However, if the `--skip-messages-logdir` option is also specified, it takes precedence and message logging is skipped.

The following are some examples showing how the message logging is controlled.

This creates a log file for the `backup` operation in the directory `/home/backup_dir/meta` due to the default settings:

```
mysqlbackup -uroot --port=3306 --backup-dir=/home/backup_dir backup
```

This skips message logging for the `backup` operation:

```
mysqlbackup -uroot --port=3306 --backup-dir=/home/backup_dir \
  --skip-messages-logdir backup
```

This creates a log file for the `apply-log` operation in an existing directory named `/home/teelog_dir`, rather than the default location:

```
mysqlbackup -uroot --port=3306 --backup-dir=/home/backup_dir \
  --messages-logdir=/home/teelog_dir apply-log
```

This creates a log file for the `list-image` operation in an existing directory named `/home/teelog_dir`:

```
mysqlbackup -uroot --port=3306 --backup-image=/backup/my.mbi \
  --messages-logdir=/home/teelog_dir list-image
```

16.12 Progress Report Options

There are two options for controlling the progress reporting function of `mysqlbackup`: `--show-progress` and `--progress-interval`:

- `--show-progress[={stderr|stdout|file:FILENAME|fifo:FIFONAME|table|variable}]`

Command-Line Format	<code>--show-progress[=destinations]</code>
Type	Enumeration
Valid Values	<code>stderr</code> <code>stdout</code> <code>file:FILENAME</code> <code>fifo:FIFONAME</code> <code>table</code> <code>variable</code>

The option instructs `mysqlbackup` to periodically output short progress reports known as progress indicators on its operation.

The argument of the option controls the destination to which the progress indicators are sent:

- **stderr**: Progress indicators are sent to the standard error stream. The report is embedded in a time-stamped `mysqlbackup` INFO message. For example:

```
130607 12:22:38 mysqlbackup: INFO: Progress: 191 of 191 MB; state: Completed
```

- **stdout**: Progress indicators are sent to the standard output stream. A single newline character is printed after each progress indicator.
- **file:FILENAME**: Progress indicators are sent to a file. Each new progress report overwrites the file, and the file contains the most recent progress indicator followed by a single newline character.
- **fifo:FIFONAME**: Progress indicators are sent to a file system FIFO. A single newline character is printed after each progress indicator.



Warning

If there is no process reading the FIFO, the `mysqlbackup` process hangs at the end of the execution.

- **table**: Progress indicators are sent to the `mysql.backup_progress` table. This requires a connection to the MySQL server, and therefore, only works when backing up a running MySQL instance. `mysqlbackup` first adds one row of the progress report to the `mysql.backup_progress` table, and then updates the row afterwards with the latest progress indicator. The progress indicator is stored in the `current_status` column of the table.

If the backup locks the MySQL instance (for example, by issuing a `FLUSH TABLES WITH READ LOCK` statement), the progress reports are not delivered to the `mysql.backup_progress` table until the MySQL instance is unlocked.

- **variable**: Progress indicators are sent to the system variable `backup_progress`.



Warning

The system variable `backup_progress` is not yet defined for the MySQL Server. Users need to create their own plugin to define the variable. See [The MySQL Plugin API](#) for more information on user plugins.

When there is no argument specified for `--show-progress`, progress indicators are sent to `stderr`.

Progress can be reported to multiple destinations by specifying the `--show-progress` option several times on the command line. For example the following command line reports progress of the backup command to `stderr` and to a file called `meb_output`:

```
mysqlbackup --show-progress --show-progress=file:meb_output --backup-dir=/full-backup
```

backup

The progress indicators are short strings that indicate how far the execution of a `mysqlbackup` operation has progressed. A progress indicator consists of one or more meters that measure the progress of the operation. For example:

```
Progress: 100 of 1450 MB; state: Copying .ibd files
```

This shows that 100 megabytes of a total of 1450 megabytes have been copied or processed so far, and `mysqlbackup` is currently copying InnoDB data files (`.ibd` files).

The progress indicator string begins with `Progress:`, followed by one or more meters measuring the progress. If multiple meters are present, they are separated by semicolons. The different types of meters include:

- Total data meter: It is always the first meter in the progress indicator. It is in the format of:

```
DATA of TOTAL UNIT
```

`DATA` and `TOTAL` are unsigned decimal integers, and `UNIT` is either MB (megabytes), KB (kilobytes), or bytes (1MB=1024KB and 1KB=1024 bytes).

The total data meter has two slightly different meanings depending on the `mysqlbackup` operation:

- The amount of data copied or processed and the total amount of data to be copied or processed by the `mysqlbackup` operation. For example:

```
Progress: 200 of 1450 MB
```

When the operation is for, e.g., `backup`, the indicator means 200MB is copied of 1450MB. But when the operation is for, e.g., `validate` or `incremental`, it means 200MB is processed out of 1450MB.

- Total amount of data copied or processed and an estimate for the total that will be copied by the end of the operation. The estimated total is updated as per the data on the server, as the execution of the command progresses.

For some operations such as `backup`, it is not possible to know exactly at the start of the execution how much data will be copied or processed. Therefore, the total data meter shows the estimated

amount of the total data for a backup. The estimate is updated during the execution of the command. For example:

```
Progress: 200 of 1450 MB
```

is followed by:

```
Progress: 200 of 1550 MB
```

when 100MB of data is added on the server.

If the operation is successful, the final progress indicator shows the actual amount of data copied at the end of the operation.

- **Compression meter:** It indicates the sliding average of the compression ratio, which is defined for each block of data that is compressed as $(\text{orig_size} - \text{compressed_size}) / \text{orig_size}$. For example:

```
compression: 40%
```

This means that after compression, the data takes 40% less space (calculated as an average over the last 10 data blocks).

The compression meter is included in the progress indicator if the `--compress` option is enabled for the `mysqlbackup` operation. The value of the compression meter is undefined until at least 10 data blocks have been compressed. The undefined meter value is denoted by the '-' in the meter:

```
compression: -
```

- **State meter:** It is a short description of the major step the command is currently executing. For example:

```
state: Copying InnoDB data
```

```
state: Waiting for locks
```

```
state: Copying system tablespace
```

```
state: Copying .ibd files
```

```
state: Copying non-InnoDB data
```

```
state: Completed
```

Here are some examples of progress indicators with different meters:

```
Progress: 300 of 1540 MB; state: Waiting for locks
```

```
Progress: 400 of 1450 MB; state: Copying InnoDB data; compression: 30%
```

The exact set of meters included in the progress indicator depends on the command and the options used for it.

- `--progress-interval=SECONDS`

Command-Line Format	<code>--progress-interval=SECONDS</code>
Type	Numeric
Default Value	2
Minimum Value	1

Maximum Value	100000
Unit	second

Interval between progress reports in seconds. Default value is two seconds. The shortest interval is 1 second and the longest allowed interval is 100000 seconds.

16.13 Encryption Options

These options are for creating encrypted single-file backups and for decrypting them. See [Chapter 9, Encryption for Backups](#) for more details and usage examples for the encryption and decryption functions of MySQL Enterprise Backup.

- `--encrypt`

Encrypt the data when creating a backup image by a `backup-to-image` operation, or when packing a backup directory into a single file with the `backup-dir-to-image` command. It cannot be used with the `backup` or `backup-and-apply-log` command.

- `--decrypt`

Decrypt an encrypted backup image when performing an `extract`, `image-to-backup-dir`, or `copy-back-and-apply-log` operation. It is also used for performing a `validate` or `list-image` operation on an encrypted backup image.

The option cannot be used in a `apply-log`, `backup-and-apply-log`, or `copy-back` operation. For restoration using the `copy-back` command, the encrypted backup image has to be unpacked and decrypted first using the `image-to-backup-dir` or `extract` command, together with the `--decrypt` option.

- `--key=STRING`

Command-Line Format	<code>--key=KEY</code>
Type	String

The symmetric key for encryption and decryption of a backup image. It should be a 256-bit key, encoded as a string of 64 hexadecimal digits. See [Chapter 9, Encryption for Backups](#) on how to create a key. The option is incompatible with the `--key-file` option.

- `--key-file=PATH`

Command-Line Format	<code>--key-file=FILE</code>
Type	File name

The pathname to file that contains a 256-bit key, encoded as a string of 64 hexadecimal digits, for encryption and decryption of a backup image. The option is incompatible with the `--key` option.

16.14 Options for Working with Encrypted InnoDB Tablespaces

Starting with release 4.0.2, MySQL Enterprise Backup supports encrypted InnoDB tablespaces. For details on how the MySQL server encrypts and decrypts InnoDB tables, see [InnoDB Data-at-Rest Encryption](#). See [Chapter 6, Working with Encrypted InnoDB Tables](#) on how `mysqlbackup` commands handle encrypted InnoDB tables.

When InnoDB tablespace encryption uses Oracle Key Vault (OKV) for encryption key management, the feature is referred to as “MySQL Enterprise Transparent Data Encryption (TDE).”

The following are the command-line options for working with encrypted InnoDB tables:

- `--keyring=VALUE`

Command-Line Format	<code>--keyring=VALUE</code>
Type	String

(Only for MySQL Enterprise Backup 4.1.0, or MySQL Enterprise Backup 4.1.1 working with MySQL 5.7.20 and earlier) The kind of keyring plugin used for master encryption key management. Currently, there are two possible values:

- `keyring_file`: The `keyring_file` plugin is used, which means the master encryption key is stored in a keyring file, the location of which is specified by the `--keyring_file_data` option.
- `keyring_okv`: The `keyring_okv` plugin is used, which means the master keys are managed by an Oracle Key Vault (OKV); the location of the key vault's endpoint directory is specified by the `--keyring_okv_conf_dir` option.

The option must be specified for copy-back-and-apply-log operations, copy-back operations that use the `--generate-new-master-key` option, and offline backups. For online backups, the keyring plugin setting on the server overrides the value set by this option.

- `--keyring_file_data=PATH`

Command-Line Format	<code>--keyring_file_data=PATH</code>
Type	File name

(Only for MySQL Enterprise Backup 4.1.0, or MySQL Enterprise Backup 4.1.1 working with MySQL 5.7.20 and earlier) Path to the keyring file. The option is required when the option `--keyring` has the value `keyring_file`. For online backups, the `--keyring_file_data` setting on the server overrides the value set by this option.

- `--keyring_okv_conf_dir=PATH`

Command-Line Format	<code>--keyring_okv_conf_dir=PATH</code>
Type	Directory name

(Only for MySQL Enterprise Backup 4.1.0, or MySQL Enterprise Backup 4.1.1 working with MySQL 5.7.20 and earlier) Path to the Oracle Key Vault (OKV) endpoint directory. The option is required when the option `--keyring` has the value `keyring_okv`. For online backups, the `--keyring_okv_conf_dir` setting on the server overrides the value set by this option.

- `--encrypt-password[=STRING]`

Command-Line Format	<code>--encrypt-password=STRING</code>
Type	String

For MySQL Enterprise Backup 4.1.0, or MySQL Enterprise Backup 4.1.1 working with MySQL 5.7.20 and earlier: The user-supplied password by which `mysqlbackup` encrypts the encryption keys for the tablespaces.

For MySQL Enterprise Backup 4.1.1 working with MySQL 5.7.21 and later: The user-supplied password by which `mysqlbackup` encrypts the master encryption key, which is used to encrypt the encryption keys for the InnoDB tablespaces. If the server is using the `keyring_encrypted_file` plugin, the password supplied with the option must match the value of the system variable `keyring_encrypted_file_password` on the server. If different passwords were used for different backups in a sequence of full and incremental backups, make sure the very password used to create an individual backup is supplied when performing an `apply-log`, `apply-incremental-backup`, or `copy-back-and-apply-log` operation with it.

The option must be used when backing up a server that has a keyring plugin enabled for InnoDB table encryption and for restoring a backup containing encrypted InnoDB tables. The same password supplied during backup must be supplied again during a `copy-back-and-apply-log`, `apply-log`, or an `apply-incremental-backup` operation for the backup, or `mysqlbackup` will error out when it encounters encrypted InnoDB tables during the operation.

Users who do not want to supply the password on the command line or in a defaults file may use the option without specifying any value; `mysqlbackup` then asks the user to type in the password before the operation starts.

- `--generate-new-master-key`

Command-Line Format	<code>--generate-new-master-key</code>
---------------------	--

(Only for MySQL Enterprise Backup 4.1.0, or MySQL Enterprise Backup 4.1.1 working with MySQL 5.7.20 and earlier) Generate new master key. During a restore, when the option is used, `mysqlbackup` generates a new master key and uses it to reencrypt all the tablespace keys. To use the `--generate-new-master-key` option, the `--keyring` option, as well as the `--keyring_file_data` option (when `--keyring=keyring_file`) or `--keyring_okv_conf_dir` option (when `--keyring=keyring_okv`) must be specified, so that `mysqlbackup` can access the keyring.

16.15 Cloud Storage Options

These options are for using cloud storage for single-file operations. See [Section 4.3.1.3, “Backing Up to Cloud Storage”](#), and [Section 5.1.5, “Restoring a Backup from Cloud Storage to a MySQL Server”](#), for more information and instructions on using cloud storage with MySQL Enterprise Backup.

- `--cloud-service=SERVICE`

Cloud service for data backup or restoration. Currently, there are two types of cloud storage services supported by `mysqlbackup`, represented by the following values for the options:

- `openstack`: OpenStack Swift or compatible object storage services (for example, Oracle Cloud Infrastructure Object Storage and Oracle Cloud Infrastructure Object Storage Classic).
- `s3`: Amazon Simple Storage Service (S3).

- `--cloud-trace`

Print trace information for cloud operations. It works independently of `--trace`, which specifies the trace level for the non-cloud operations of `mysqlbackup`. Any non-zero value for the option enables the trace function.

Default value is “0.”

- `--cloud-proxy=proxy-url:port`

Proxy address and port number for overriding the environment's default proxy settings for accessing a cloud storage service.



Note

The `list-image` operation can be performed on a cloud backup only if the cloud proxy supports HTTP range headers.

- `--cloud-ca-info=PATH`

Absolute path to the CA bundle file for host authentication for SSL connections. When the option is specified, the usage of the CA bundle file is preferred over the usage of individual `.pem` files for host authentication.

- `--cloud-ca-path=PATH`

CA certificate directory, in addition to the system's default folder.

- `--cloud-buffer-size=MB`

(For release 4.1.1 and later) Size of the buffer for cloud operations in megabytes. `mysqlbackup` accumulates data up to the size specified by this option before initiating a cloud transfer. The value has to be between 16 to 4096.

Default: 64

- Options used only for OpenStack Swift or compatible object storage services (using them when the argument for `--cloud-service` is anything other than `openstack` will cause `mysqlbackup` to throw an error):

- `--cloud-container=SWIFT_CONTAINER`

The Swift container for the backup image. For Oracle Cloud Infrastructure (OCI) Object Storage, this is the object storage bucket.

- `--cloud-object=SWIFT_OBJECT`

The Swift object for the backup image. Note that names of objects within the same container (or bucket, for OCI Object Storage) have to be unique.

- `--cloud-user-id=SWIFT_USER_ID`

User ID for accessing Swift. The user credentials are authenticated by the Swift TempAuth identity system when the `--cloud-tempauth-url` option is used, by the OpenStack Keystone identity service when the `--cloud-identity-url` option is used, and by HTTP Basic Authentication when the `--cloud-basicauth-url` option is used.

- `--cloud-password=SWIFT_PASSWORD`

Password for accessing Swift for the user specified by the `--cloud-user-id` option. The user credentials are authenticated by the Swift TempAuth identity system when the `--cloud-tempauth-url` option is used, by the OpenStack Keystone identity service when the `--cloud-identity-url`

option is used, and by HTTP Basic Authentication when the `--cloud-basicauth-url` option is used.

- `--cloud-tempauth-url=SWIFT_TEMPAUTH-URL`

The TempAuth URL for authenticating user credentials.

- `--cloud-basicauth-url=SWIFT_BASICAUTH-URL`

(For release 4.1.1 and later) The URL for HTTP Basic Authentication.

- `--cloud-storage-url=SWIFT_STORAGE-URL`

(For release 4.1.2 and later) The URL for Oracle Cloud Infrastructure Object Storage when using OAuth for client authentication.

- `--cloud-oauth-token=SWIFT_OAUTH-TOKEN`

(For release 4.1.2 and later) The OAuth token for Oracle Cloud Infrastructure Object Storage access. The option value must be in one of the following formats:

- `--cloud-oauth-token=oauth_token`, where `oauth_token` is the OAuth token itself
- `--cloud-oauth-token=file:oauth_filepath`, where `oauth_filepath` points to a file containing only the OAuth token.
- `--cloud-identity-url=SWIFT_KEystone-URL`

The URL of the Keystone identity service, when it is used for authenticating user credentials.

- `--cloud-tenant=SWIFT_KEystone-TENANT`

The Keystone tenant for the user specified by `--cloud-user-id`, when the Keystone identity service is used for authenticating user credentials.

- `--cloud-region=SWIFT_KEystone-REGION`

The Keystone region for the user specified by `--cloud-user-id`, when the Keystone identity service is used for authenticating user credentials.

- `--cloud-chunked-transfer=VALUE`

(For release 4.1.1 and later) Use chunked transfer with Swift service.

If the option is set to `true`, backups are transferred and stored as Dynamic Large Objects (DLOs), for which multiple file segments are considered as a single file. Each backup larger than 5GB is split

into multiple parts with names in the form of `<object_name>_part_<number>`. See [the OpenStack documentation](#) for details.

If the option is set to false, `mysqlbackup` uploads the backup in segments in the size of the buffer, and the maximum number of segments a backup can have is determined by the Swift service.

Default: true



Warning

Set the option to false if chunked transfer is not supported by your cloud storage; otherwise, the `mysqlbackup` operation may fail.

One and only one of `--cloud-tempauth-url`, `--cloud-identity-url`, `--cloud-basicauth-url`, or `--cloud-storage-url` should be used when accessing a Swift service, or `mysqlbackup` will throw an error.

- Options used only for Amazon S3 (using them when the argument for `--cloud-service` is anything other than `s3` will cause `mysqlbackup` to throw an error):

- `--cloud-bucket=S3_BUCKET`

The storage bucket on Amazon S3 for the backup image.

In order to perform cloud backups and restores with the bucket, the user identified by the `--cloud-access-key-id` option must have at least the following permissions on the bucket:

- `s3:ListBucket`: For listing information on items in the bucket.
- `s3:ListBucketMultipartUploads`: For listing multipart uploads in progress to the bucket.
- `s3:GetObject`: For retrieving objects from the bucket.
- `s3:PutObject`: For adding objects to the bucket.
- `--cloud-object-key=S3_OBJECT_KEY`

The Amazon S3 object key for the backup image.

- `--cloud-access-key-id=S3_KEY-ID`

AWS access key ID for logging onto Amazon S3.

- `--cloud-secret-access-key=S3_ACCESS-KEY`

AWS secret access key for the AWS access key id specified with `--cloud-access-key-id`.

- `--cloud-aws-region=S3_REGION`

Region for Amazon Web Services that `mysqlbackup` accesses for S3.

16.16 Options for Special Backup Types

These options are for backing up database servers that play specific roles in replication, or contain certain kinds of data that require special care in backing up.

- `--slave-info`

When backing up a replica server, this option captures information needed to set up an identical replica server. It creates a file `meta/ibbackup_slave_info` inside the backup directory, containing a `CHANGE MASTER` statement with the binary log position and name of the binary log file of the source server. This information is also printed in the `mysqlbackup` output. To set up a new replica for this source, restore the backup data on another server, start a replica server on the backup data, and issue a `CHANGE MASTER` command with the binary log position saved in the `ibbackup_slave_info` file. See [Section 7.1, “Setting Up a New Replica”](#) for instructions.



Note

Only use this option when backing up a replica server. Its behavior is undefined when used on a source or non-replication server.

This option is not compatible with the `--no-locking` option; using both options together will make `mysqlbackup` throw an error.

This option is not compatible with the `--only-innodb` or `--only-innodb-with-frm` options.

- `--safe-slave-backup-timeout=SECONDS`

For a statement-based replication (SBR) or a mixed-based replication setup, the option specifies the time (in seconds) `mysqlbackup` will wait for `Slave_open_temp_tables` to become “0” (which is true when no temporary tables are open) to complete the backup for a replica server by asserting a global read lock and copies all the non-InnoDB tables. If the duration of the wait exceeds that specified with the option, `mysqlbackup` times out and throws an error. The wait is for preventing `mysqlbackup` from finishing a replica backup when there are temporary tables still open. See descriptions in [Temporary tables on statement-based replication \(SBR\) replica](#) for details on how `mysqlbackup` deals with temporary tables on a replica server.

In addition, `mysqlbackup` also runs an initial check at the beginning of a replica backup to see if `Slave_open_temp_tables=0` becomes true within the duration set by `--safe-slave-backup-timeout`. If it does not, `mysqlbackup` takes it as an early sign that before the backup is completed, some temporary tables are likely to remain open after the timeout limit is exceeded; `mysqlbackup` then throws an error, instead of continuing with the backup. When that happens, you can either restart the backup with a higher value for `--safe-slave-backup-timeout`, or retry at a time when fewer temporary tables are being used.

Default: 300



Warning

Proper setting of this value depends on the use case, and it can vary a lot according to the situation. Setting the value for this option either too high or too low will affect adversely the performance of the backup operation:

- *Too high:* If you need to wait for a long time for there to be no more temporary tables, the chance is that the change rate for your database is quite high, which means the amount of redo log data to be included in the backup will be large and the restore time for the backup will be long. In such a case, it would have been better to have let `mysqlbackup` timeout and then restart the backup operation, so the tables are copied in their final states. It is therefore not helpful to set a high timeout value for the option. As a very general rule of thumb: even for busy databases that use many contemporary tables, do not set the value to more than an a few hours.

- *Too low:* Setting the wait time value too low would make the backup process time out very easily and when that happens, the process has to be restarted. With a repeating cycle of restarts, the backup might then take a long time to complete, and resources used on the failed backups will be wasted. As a very general rule of thumb, do not set the timeout to below the default value of 300s.

For a row-based replication (RBR) setup, temporary tables are not replicated onto the replica. Users who are certain that SBR is not occurring for the replica can set `--safe-slave-backup-timeout=0`, with which `mysqlbackup` will not check for any open temporary tables before finishing the backup.

- `--suspend-at-end`

This option pauses the `mysqlbackup` command when the backup procedure is close to ending. It creates a file called `ibbackup_suspended` in the backup log group home directory and waits until you delete that file before proceeding. This option is useful to customize locking behavior and backup of non-InnoDB files through custom scripting.

All tables are locked before suspending, putting the database into a read-only state, unless you turn off locking with the `--no-locking` or `--no-connection` option. The `--only-innodb` and `--only-innodb-with-frm` options also prevent the locking step. Because locking all tables could be problematic on a busy server, you might use a combination of `--only-innodb` and `--suspend-at-end` to back up only certain InnoDB tables.

- `--exec-when-locked="utility arg1 arg2 ..."`

Command-Line Format	<code>--exec-when-locked="utility arg1 arg2 ..."</code>
Type	String

You can use this option to run a script that backs up any information that is not included as part of the usual backup. For example, with `--exec-when-locked`, you can use `mysqldump` to back up tables from the MEMORY storage engine, which are not on disk.

Set any variable you want to use within your script before you run `mysqlbackup`. In the following example, the `BACKUP_DIR` environment variable is set to point to the current backup directory (quotes are used for the argument of `--exec-when-locked`, to prevent premature expansion of the variable `BACKUP_DIR`):

On Unix or Linux systems:

```
export BACKUP_DIR=path_to_backupdir
mysqlbackup --exec-when-locked="mysqldump mydb t1 > $BACKUP_DIR/t1.sql" other_options mysqlbackup_command
```

Or on Windows systems:

```
set BACKUP_DIR=path_to_backupdir
mysqlbackup --exec-when-locked="mysqldump mydb t1 > %BACKUP_DIR%/t1.sql" other_options mysqlbackup_command
```

If the utility cannot be executed or returns a non-zero exit status, the whole backup process is cancelled. If you also use the `--suspend-at-end` option, the utility specified by `--exec-when-locked` is executed after the suspension is lifted.

16.17 Other Options

This section explains any options that are not covered by other sections in this chapter.

- `--error-code=CODE`

Command-Line Format	<code>--error-code</code>
Type	Numeric
Minimum Value	0
Maximum Value	19

Specifies the exit code for which the `print-message` command prints the corresponding exit message. See [Section 13.1, “Exit codes of MySQL Enterprise Backup”](#) for details.

Chapter 17 Configuration Files and Parameters

You can specify `mysqlbackup` options either on the command line or as configuration parameters inside a configuration file. This section describes the use of configuration files.

In general, `mysqlbackup` follows the `mysql` style of processing configuration options: `[mysqlbackup]` and `[client]` group options are passed as command-line options. Any command-line options that you specify when you run `mysqlbackup` override the values from the configuration file, and in the case of duplicate options, the last instance takes precedence.

`mysqlbackup` also reads the following options in the `[mysqld]` group in the configuration file to detect parameters related to the source repository when it is not connected to `mysqld`:

- `datadir`
- `innodb_data_home_dir`
- `innodb_log_group_home_dir`
- `innodb_undo_directory`
- `innodb_data_file_path`
- `innodb_log_files_in_group`
- `innodb_log_file_size`
- `innodb_page_size`
- `innodb_checksum_algorithm`
- `innodb_undo_tablespaces`
- `innodb_undo_logs`
- `innodb_buffer_pool_filename`

Options other than the ones listed above should be specified under the `[mysqlbackup]` or `[client]` section in the configuration file.

Within `mysqlbackup` option names, dashes (-) and underscores (_) may be used interchangeably, similar to `mysqld` parameters that use this same convention (see [Using Options on the Command Line](#) in the MySQL Reference Manual for details). The MySQL server's reference manual typically lists the parameter names with underscores, to match the output of the `SHOW VARIABLES` statement.

Options Files

`mysqlbackup` reads the location of the MySQL data to be backed up from the following sources (listed in order of priority):

- The connection information from the running database, whenever possible. Thus, in most cases, you can avoid specifying most options on the command line or in a configuration file.
- Parameters you specify on the `mysqlbackup` command line. You can specify certain options for individual backup jobs this way.
- The MySQL configuration file (by default, `my.cnf` on Unix and `my.ini` on Windows). The parameters are searched for first under the `[mysqlbackup]` group, then under the `[client]` group. You can put common parameters that apply to most of your backup jobs into the configuration file.

Configuration Files Stored with the Backup Data

Each set of backup data includes a configuration file, `backup-my.cnf`, containing a minimal set of configuration parameters. The `mysqlbackup` command generates this file to record the settings that apply to this backup data. Subsequent operations, such as the `apply-log` process, read options from this file to determine how the backup data is structured.

Example 17.1 Example `backup-my.cnf` file

Here is an example `backup-my.cnf` file generated by `mysqlbackup`:

```
#
# Generated backup-my.cnf file.
# Auto generated by mysqlbackup program.
#
[mysqld]
innodb_data_file_path=ibdata1:12M:autoextend
innodb_log_file_size=50331648
innodb_log_files_in_group=2
innodb_page_size=16384
innodb_checksum_algorithm=crc32
innodb_buffer_pool_filename=ib_buffer_pool
```

All paths in the generated `backup-my.cnf` file point to a single backup directory. For ease of verification and maintenance, you typically store all data for a backup inside a single directory rather than scattered among different directories.

During a backup, the configuration parameters that are required for later stages (such as the restore operation) are recorded in the `backup-my.cnf` file that is generated in the backup directory. Only the minimally required parameters are stored in `backup-my.cnf`, to allow you to restore the backup to a different environment without having to make extensive changes to that file. For example, the `innodb_data_home_dir` and `innodb_log_group_home_dir` options are omitted from the `backup-my.cnf` file when their values are the same as the value for `backup-dir`.

Part IV Appendixes

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Appendix A Frequently Asked Questions for MySQL Enterprise Backup

This section lists some common questions about MySQL Enterprise Backup, with answers and pointers to further information.

Questions

- [A.1:](#) What versions of the MySQL server does MySQL Enterprise Backup 4.1 support?
- [A.2:](#) What is the big `ibdata` file that is in all the backups?
- [A.3:](#) Can I back up non-InnoDB data with MySQL Enterprise Backup?
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- [A.5:](#) Why is the option `--defaults-file` not recognized?
- [A.6:](#) Can I back up a database on one OS platform and restore it on another one using MySQL Enterprise Backup?
- [A.7:](#) What if I have included the binary log or relay log in my backup but do not want to restore it?
- [A.8:](#) What would happen if I start a server directly using a raw directory backup, without running either the copy-back or the apply-log operation?

Questions and Answers

A.1: What versions of the MySQL server does MySQL Enterprise Backup 4.1 support?

See [Section C.3, “Compatibility with MySQL Versions”](#) for details of compatibility between different releases of MySQL Enterprise Backup and MySQL Server.

A.2: What is the big `ibdata` file that is in all the backups?

You might find your backup data taking more space than expected because of a large file with a name such as `ibdata1`. This file represents the InnoDB [system tablespace](#), which grows but never shrinks as a database operates, and is included in every full and incremental backup. To reduce the space taken up by this file in your backup data:

- After doing a [full backup](#), do a succession of [incremental backups](#), which take up less space. The `ibdata1` file in the incremental backups is typically much smaller, containing only the portions of the system tablespace that changed since the full backup.
- Set the configuration option `innodb_file_per_table=1` before creating your biggest or most active InnoDB tables. Those tables are split off from the system tablespaces into separate `.ibd` files; the tables can then be individually included or excluded from backups, and disk space is freed when the tables are dropped or truncated.
- If your system tablespace is very large because you created a high volume of InnoDB data before turning on the `innodb_file_per_table` setting, you might use `mysqldump` to create a dump of your entire server instance, then turn on `innodb_file_per_table` before re-creating the database, so that all the table data is kept outside the system tablespace.

A.3: Can I back up non-InnoDB data with MySQL Enterprise Backup?

While MySQL Enterprise Backup can back up non-InnoDB data (like MYISAM tables), the MySQL server to be backed up must support InnoDB (i.e., the backup process will fail if the server was started up with the `--innodb=OFF` or `--skip-innodb` option), and the server must contain at least one InnoDB table.

A.4: What happens if the `apply-log` or `apply-incremental-backup` step is interrupted?

If `mysqlbackup` is interrupted during the `apply-log` or `apply-incremental-backup` stage, the backup data is OK. The file operations performed by those options can be performed multiple times without harming the consistency of the backup data. Just run the same `mysqlbackup` command again, and when it completes successfully, all the necessary changes are present in the backup data.

A.5: Why is the option `--defaults-file` not recognized?

When you specify the `--defaults-file` option, it must be the first option going after `mysqlbackup`. Otherwise, the error message makes it look as if the option name is not recognized.

A.6: Can I back up a database on one OS platform and restore it on another one using MySQL Enterprise Backup?

See [Section C.2, “Cross-Platform Compatibility”](#) for details.

A.7: What if I have included the binary log or relay log in my backup but do not want to restore it?

If you want to skip the restore of the binary log, relay log, or both during a restore, use the `--skip-binlog` option, the `--skip-relaylog` option, or both with your `copy-back` or `copy-back-and-apply-log` command.

A.8: What would happen if I start a server directly using a raw directory backup, without running either the `copy-back` or the `apply-log` operation?

This should never be attempted. Not only would the server crash, but the backup would likely get corrupted and become unusable. This is because the directory backup contains metadata created by `mysqlbackup` that the MySQL server would not understand; also, the raw backup might be inconsistent and need to be brought up-to-date by an `apply-log operation`, so that changes made to the database during the backup process can be applied.

Appendix B Limitations of MySQL Enterprise Backup

Please refer to the [MySQL Enterprise Backup 4.1 Release Notes](#) for a list of fixed bugs for `mysqlbackup`. Here is a list of limitations of MySQL Enterprise Backup:

- In some cases, backups of non-transactional tables such as [MyISAM](#) tables could contain additional uncommitted data. If [autocommit](#) is turned off, and both [InnoDB](#) tables and non-transactional tables are modified within the same transaction, data can be written to the non-transactional table before the binary log position is updated. The binary log position is updated when the transaction is committed, but the non-transactional data is written immediately. If the backup occurs while such a transaction is open, the backup data contains the updates made to the non-transactional table.
- If the `mysqlbackup` process is interrupted by, for example, a Unix `kill -9` command, a `FLUSH TABLES WITH READ LOCK` operation might remain running. In this case, use the `KILL QUERY` statement from the `mysql` command line to kill the `FLUSH TABLES WITH READ LOCK` statement. This issue is more likely to occur if the `FLUSH TABLES` operation is stalled by a long-running query or transaction. Refer to [Section 11.1, “Optimizing Backup Performance”](#) for guidelines about backup timing and performance.
- Do not run the DDL operations (for example, `ALTER TABLE`, `TRUNCATE TABLE`, `OPTIMIZE TABLE`, `REPAIR TABLE`, `RESTORE TABLE` or `CREATE INDEX`) while a backup operation is going on. The resulting backup might become corrupted.
- The `engines` column in the `mysql.backup_history` table does not correctly reflect the storage engines of the backed-up databases.
- Hot backups for large databases with heavy writing workloads (say, in the order of gigabytes per minute) can take a very long time to complete due to the huge redo log files that are generated on the server while the backup is running. However, when it is a relatively small subset of tables in the database that are being modified frequently, the Optimistic Backup feature can be used to improve performance and reduce backup size, as well as backup and recovery times. See [Section 4.3.6, “Making an Optimistic Backup”](#) for details.
- While it is possible to backup to or restore from a Network Attached Storage (NAS) device using MySQL Enterprise Backup, due to networking issues that might arise, the consistency of the backups and the performance of the backup or restore operations might be compromised.
- When creating a backup using [transportable tablespace \(TTS\)](#) for a server containing tables with a mix of the Antelope and Barracuda file formats, do not apply full locking on the tables (that is, do not specify `--use-tts=with-full-locking`). Instead, just specify `--use-tts` or `--use-tts=with-minimum-locking`, both of which will apply minimum locking to the tables.
- Backup of a partitioned table using [transportable tablespace \(TTS\)](#) would fail when any (or all) of its partitions were created in a shared tablespace.
- Restoring a partitioned table backed up using [transportable tablespace \(TTS\)](#), even when the `--force` option is used, would fail if any of the partitions was created outside of the backed-up server's data directory.
- If Data Definition Language (DDL) statements are executed on the server when a backup is being created using [transportable tablespace \(TTS\)](#), the backup might fail. It is because tables not being backed up are not locked during the backup process, but `mysqlbackup` still checks the status of those tables at the end of the process, and an error might occur if definitions of those tables have been changed. To avoid the problem, do not perform any DDL operation, especially `DROP TABLE`, when a TTS backup is going on.

-
- If a table containing full-text search (FTS) index is backed up using [transportable tablespace \(TTS\)](#), after it is restored, the FTS index will be corrupted. Users will need to recreate the index with the following command:

```
mysql> ALTER TABLE mytable ENGINE = INNODB;
```

Then, check that there are no more errors with the table:

```
mysql> CHECK TABLE mytable;
```

- Tables created on the MySQL server with the [ANSI_QUOTES](#) SQL mode cannot be backed up using [transportable tablespace \(TTS\)](#).
- MySQL Enterprise Backup does not include the `.pem` files from the server into the backup. The files are part of the server instance when SSL connections are enabled.
- When backing up an instance of MySQL 5.7, if a `CREATE INDEX` statement with `ALGORITHM = INPLACE` is issued when the backup process is going on, because the statement will not go into the redo log of the MySQL 5.7 server (see [Sorted Index Builds](#) for details), it cannot be recorded in the backup, and the index will not be recreated by `mysqlbackup` when the backup is restored.
- When a file of an unrecognized file type exists under a subdirectory in the server's data directory, it will be backed up by `mysqlbackup` unless the `--only-known-file-types` option is used. However, if the name of the file does not have an extension, it will cause `mysqlbackup` to throw an error when it tries to restore the backup to a server.
- Cloud operations by MySQL Enterprise Backup are not supported on macOS and Windows platforms, and also on Linux platforms when generic Linux builds are used for both the server and MySQL Enterprise Backup (i.e., when both the server and MySQL Enterprise Backup have been installed using generic Linux tarballs).
- Using the `--src-entry` option with the `extract` command on cloud backups will cause the command to fail. Cloud backups can only be extracted in full.
- Some limitations apply when `mysqlbackup` works with [encrypted InnoDB tables](#). See [the discussion here](#) for details.
- Backup operations may fail if checksums for redo log pages are disabled (i.e., if `--innodb_log_checksums` is `OFF` or `FALSE` or `0`) on the server.
- A compressed directory backup fails when a general tablespace bears the same basename as the database's system tablespace (usually `ibdata1`) and exists in the same directory with it (usually the server's data directory). A compressed single-file backup created under the same situation will be corrupted, and cannot be restored. To avoid the problem, the server administrator should not put into the same directory the system tablespace and a general tablespace of the same basename; if that is unavoidable, do not perform a compressed backup for the database.
- When working with a replication set up whose source server also belongs to a separate Group Replication setup, over time, create backups consistently either from the source or the replica, but not from both. Otherwise, there will be conflicts between the `id` values generated by the source and the replica, causing backups to fail.
- A backup fails if the name of any database is the same as the name of any undo tablespace. For backups to be successful, the database administrator should avoid giving any database and undo tablespace the same name (for example, using the default undo tablespace name `undo_001` to name a database), or the database should be renamed before a backup.

-
- A database that contains any tables and was deleted right before a backup started appears as an empty database when the backup is restored. The dropped database has to be deleted again manually from the restored server.

Appendix C Compatibility Information for MySQL Enterprise Backup

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This section describes information related to compatibility issues for MySQL Enterprise Backup releases.

C.1 Supported Platforms

See [Supported Platforms: MySQL Database](#) (MySQL platform support evolves over time; please refer to the page for the latest updates).

C.2 Cross-Platform Compatibility

MySQL Enterprise Backup is cross-platform compatible when running on the Linux and Windows operating systems: backups on a Linux machine can be restored on a Windows machine, and vice versa. However, to avoid data transfer problems arising from letter cases of database or table names, the variable `lower_case_table_names` must be properly configured on the MySQL servers. For details, see [Identifier Case Sensitivity](#).

C.3 Compatibility with MySQL Versions

MySQL Enterprise Backup 4.1 only supports MySQL 5.7. For MySQL 5.6 and earlier, use MySQL Enterprise Backup 3.12.

For MySQL 5.7.11 and earlier, backup for InnoDB tablespaces encrypted with “MySQL Enterprise Transparent Data Encryption (TDE)” is not supported by MySQL Enterprise Backup 4.1. See [the discussion here](#) for details.

C.4 Compatibility with Older MySQL Enterprise Backup

Currently, MySQL Enterprise Backup 4.1 is incompatible with earlier MySQL Enterprise Backup versions.

Appendix D Backup History Table Update

The `mysql.backup_history` table has been updated with the release of MySQL Enterprise Backup 4.1.2 in the following ways:

- Changed the storage engine from CSV to InnoDB
- Added a new column for server UUIDs

When MySQL Enterprise Backup 4.1.2 tries to perform its first full backup on a database, it attempts to perform a format update on the table automatically with the following steps:

- Create in the new format a table named `mysql.backup_history_new` and copy into it data from the original `mysql.backup_history` table.
- Rename the original `mysql.backup_history` table to `mysql.backup_history_old`, and the `mysql.backup_history_new` table to `mysql.backup_history`.

For the migration to the new table format to succeed, before performing the first backup task with MySQL Enterprise Backup 4.1.2, grant the required privileges to the `mysqlbackup` user on the server by issuing these statements at the `mysql` client:

```
GRANT CREATE, INSERT, DROP ON mysql.backup_history_old TO 'mysqlbackup'@'localhost';
GRANT CREATE, INSERT, DROP, ALTER ON mysql.backup_history_new TO 'mysqlbackup'@'localhost';
```

If these privileges are not granted, the first full backup on the upgraded server will fail with an error message similar to the following:

```
180612 08:40:45 MAIN ERROR: MySQL query 'DROP TABLE IF EXISTS mysql.backup_history_old': 1142, DROP command
mysqlbackup failed with errors!
```

These privileges are no longer needed after the first full backup has been performed by MySQL Enterprise Backup 4.1.2, by which point they can be revoked.



Note

If you are working with a multiprimary Group Replication setting, make sure these privileges are granted on all primary nodes; see also [Chapter 8, Using MySQL Enterprise Backup with Group Replication](#).

MySQL Enterprise Backup Glossary

These terms are commonly used in information about the MySQL Enterprise Backup product.

A

.ARM file

Metadata for ARCHIVE tables. Contrast with **.ARZ file**. Files with this extension are always included in backups produced by the `mysqlbackup` command of the **MySQL Enterprise Backup** product.
See Also [.ARZ file](#).

.ARZ file

Data for ARCHIVE tables. Contrast with **.ARM file**. Files with this extension are always included in backups produced by the `mysqlbackup` command of the **MySQL Enterprise Backup** product.
See Also [.ARM file](#).

Antelope

The code name for the original InnoDB **file format**. It supports the **redundant** and **compact** row formats, but not the newer **dynamic** and **compressed** row formats available in the **Barracuda** file format.

If your application could benefit from InnoDB table **compression**, or uses BLOBs or large text columns that could benefit from the dynamic row format, you might switch some tables to Barracuda format. You select the file format to use by setting the `innodb_file_format` option before creating the table.

See Also [Barracuda](#), [compression](#), [file format](#).

apply

The operation that transforms a **raw backup** into a **prepared backup** by incorporating changes that occurred while the backup was running, using data from the **log**.

See Also [log](#), [prepared backup](#), [raw backup](#).

B

.bz file

When `mysqlbackup` performs a compressed backup for a server that has binary logging enabled, it transforms each binary log file and relay log file (for a **replica** server in a **replication** setting) to a *binary-or-relay-log-file-name.bz* file. The **.bz** files are uncompressed at the time of restore.

See Also [binary log](#), [.bz file](#), [compression](#), [compression level](#), [.ibz file](#), [relay log](#).

backup

The process of copying some or all table data and metadata from a MySQL instance, for safekeeping. Can also refer to the set of copied files. This is a crucial task for DBAs. The reverse of this process is the **restore** operation.

With MySQL, **physical backups** are performed by the **MySQL Enterprise Backup** product, and **logical backups** are performed by the `mysqldump` command. These techniques have different characteristics in terms of size and representation of the backup data, and speed (especially speed of the restore operation).

Backups are further classified as **hot**, **warm**, or **cold** depending on how much they interfere with normal database server operation. (Hot backups have the least interference, cold backups the most.)

See Also [cold backup](#), [hot backup](#), [logical backup](#), [mysqldump](#), [physical backup](#), [warm backup](#).

backup directory

The directory under which the backup data and metadata are stored, permanently or temporarily. It is used in most kinds of backup and restore operations, including single-file backups and restores. See the description of the `--backup-dir` option on how the backup directory is used for different purposes and for different operations.

backup repository

Contrast with **server repository**.

See Also [repository](#), [server repository](#).

backup-my.cnf

A small **configuration file** generated by **MySQL Enterprise Backup**, containing a minimal set of configuration parameters. This file records the settings that apply to this backup data. Subsequent operations, such as the **apply** process, read options from this file to determine how the backup data is structured. This file always has the extension `.cnf`, rather than `.cnf` on Unix-like systems and `.ini` on Windows systems.

See Also [apply](#), [configuration file](#).

Barracuda

The code name for an InnoDB **file format** that supports compression for table data. This file format was first introduced in the InnoDB Plugin. It supports the **compressed** row format that enables InnoDB table compression, and the **dynamic** row format that improves the storage layout for BLOB and large text columns. You can select it through the `innodb_file_format` option.

Because the InnoDB **system tablespace** is stored in the original **Antelope** file format, to use the Barracuda file format you must also enable the **file-per-table** setting, which puts newly created tables in their own tablespaces separate from the system tablespace.

The **MySQL Enterprise Backup** product version 3.5 and above supports backing up tablespaces that use the Barracuda file format.

See Also [Antelope](#), [file format](#), [MySQL Enterprise Backup](#), [row format](#), [system tablespace](#).

binary log

A file containing a record of all statements that attempt to change table data. These statements can be replayed to bring replica servers up to date in a **replication** scenario, or to bring a database up to date after restoring table data from a backup. The binary logging feature can be turned on and off, although Oracle recommends always enabling it if you use replication or perform backups.

You can examine the contents of the binary log, or replay those statements during replication or recovery, by using the `mysqlbinlog` command. For full information about the binary log, see [The Binary Log](#). For MySQL configuration options related to the binary log, see [Binary Logging Options and Variables](#).

For the **MySQL Enterprise Backup** product, the file name of the binary log and the current position within the file are important details. To record this information for the source server when taking a backup in a replication context, you can specify the `--slave-info` option.

The binary log, if enabled on the server, is backed up by default.

See Also [binlog](#), [relay log](#), [replication](#).

binlog

An informal name for the **binary log** file. For example, you might see this abbreviation used in e-mail messages or forum discussions.

See Also [binary log](#).

C

cold backup

A **backup** taken while the database is shut down. For busy applications and websites, this might not be practical, and you might prefer a **warm backup** or a **hot backup**.

See Also [backup](#), [connection](#), [hot backup](#), [warm backup](#).

compression

A technique that produces smaller **backup** files, with size reduction influenced by the **compression level** setting. Suitable for keeping multiple sets of non-critical backup files. (For recent backups of critical data, you might leave the data uncompressed, to allow fast restore speed in case of emergency.)

MySQL Enterprise Backup can apply compression to the contents of **InnoDB** tables during the backup process, turning the **.ibd** files into **.ibz** files.

Compression adds CPU overhead to the backup process, and requires additional time and disk space during the **restore** process.

See Also [backup](#), [compression level](#), [.ibd file](#), [.ibz file](#), [InnoDB](#), [restore](#).

compression level

A setting that determines how much **compression** to apply to a compressed backup. This setting ranges from 0 (none), 1 (default level when compression is enabled) to 9 (maximum). The amount of compression for a given compression level depends on the nature of your data values. Higher compression levels do impose additional CPU overhead, so ideally you use the lowest value that produces a good balance of compression with low CPU overhead.

See Also [compression](#).

configuration file

The file that holds the startup options of the MySQL server and related products and components. Often referred to by its default file name, **my.cnf** on Linux, Unix, and macOS systems, and **my.ini** on Windows systems. The **MySQL Enterprise Backup** stores its default configuration settings in this file, under a [\[mysqlbackup\]](#) section. For convenience, MySQL Enterprise Backup can also read settings from the [\[client\]](#) section, for configuration options that are common between MySQL Enterprise Backup and other programs that connect to the MySQL server.

See Also [my.cnf](#), [my.ini](#).

connection

The mechanism used by certain backup operations to communicate with a running MySQL **server**. For example, the [mysqlbackup](#) command can log into the server being backed up to insert and update data in the **progress table** and the **history table**. A **hot backup** typically uses a database connection for convenience, but can proceed anyway if the connection is not available. A **warm backup** always uses a database connection, because it must put the server into a read-only state. A **cold backup** is taken while the MySQL server is shut down, and so cannot use any features that require a connection.

See Also [cold backup](#), [history table](#), [hot backup](#), [progress table](#), [server](#), [warm backup](#).

crash recovery

The cleanup activities for InnoDB tables that occur when MySQL is started again after a crash. Changes that were committed before the crash, but not yet written to the tablespace files, are reconstructed from the **doublewrite buffer**. When the database is shut down normally, this type of activity is performed during shutdown by the **purge** operation.

D

data dictionary

A set of tables, controlled by the InnoDB storage engine, that keeps track of InnoDB-related objects such as tables, indexes, and table columns. These tables are part of the InnoDB **system tablespace**.

Because the **MySQL Enterprise Backup** product always backs up the system tablespace, all backups include the contents of the data dictionary.

See Also [hot backup](#), [MySQL Enterprise Backup](#), [system tablespace](#).

database

A set of tables and related objects owned by a MySQL user. Equivalent to “schema” in Oracle Database terminology. **MySQL Enterprise Backup** can perform a **partial backup** that includes some databases and not others. The full set of databases controlled by a MySQL server is known as an **instance**.

See Also [instance](#), [partial backup](#).

differential backup

A backup that captures only the data changed since the last full backup. It has the potential to be smaller and faster than a **full backup**, but is usually bigger and takes longer to create than an **incremental backup**.

See [Section 4.3.3, “Making a Differential or Incremental Backup”](#) for usage details. Related `mysqlbackup` options are `--incremental`, `--incremental-with-redo-log-only`, `--incremental-backup-dir`, `--incremental-base`, and `--start-lsn`.

See Also [full backup](#), [incremental backup](#).

downtime

A period when the database is unresponsive. The database might be entirely shut down, or in a read-only state when applications are attempting to insert, update, or delete data. The goal for your backup strategy is to minimize downtime, using techniques such as **hot backup** for InnoDB tables, **cold backup** using **replica** servers in a **replication** configuration, and minimizing the duration of the **suspend** stage where you run customized backup logic while the MySQL server is **locked**.

See Also [cold backup](#), [hot backup](#), [InnoDB](#), [locking](#), [replica](#), [replication](#), [suspend](#).

E

exclude

In a **partial backup**, to select a set of tables, databases, or a combination of both to be omitted from the backup. Contrast with **include**.

See Also [partial backup](#).

extract

The operation that retrieves some content from an **image** file produced by a **single-file backup**. It can apply to a single file (unpacked to an arbitrary location) or to the entire backup (reproducing the original directory structure of the backup data). These two kinds of extraction are performed by the `mysqlbackup` options `extract` and `image-to-backup-dir`, respectively.

See Also [image](#), [single-file backup](#).

F

.frm file

A file containing the metadata, such as the table definition, of a MySQL table.

For backups, you must always keep the full set of `.frm` files along with the backup data to be able to restore tables that are altered or dropped after the backup.

Although each InnoDB table has an `.frm` file, InnoDB maintains its own table metadata in the system tablespace; the `.frm` files are not needed for InnoDB to operate on InnoDB tables.

These files are backed up by the **MySQL Enterprise Backup** product. These files must not be modified by an `ALTER TABLE` operation while the backup is taking place, which is why backups that include non-InnoDB tables perform a `FLUSH TABLES WITH READ LOCK` operation to freeze such activity while backing up the `.frm` files. Restoring a backup can result in `.frm` files being created, changed, or removed to match the state of the database at the time of the backup.

file format

The format used by InnoDB for its data files named `ibdata1`, `ibdata2`, and so on. Each file format supports one or more row formats.

See Also [Antelope](#), [Barracuda](#), [ibdata file](#), [row format](#).

full backup

A **backup** that includes all the **tables** in each MySQL database, and all the databases in a MySQL instance. Contrast with **partial backup** and **incremental backup**. Full backups take the longest, but also require the least amount of followup work and administration complexity. Thus, even when you primarily do partial or incremental backups, you might periodically do a full backup.

See Also [backup](#), [incremental backup](#), [partial backup](#), [table](#).

H

history table

The table `mysql.backup_history` that holds details of completed **backup** operations. While a backup job is running, the details (especially the changing status value) are recorded in the **progress table**.

See Also [backup](#), [progress table](#).

hot backup

A backup taken while the MySQL **instance** and is running and applications are reading and writing to it. Contrast with **warm backup** and **cold backup**.

A hot backup involves more than simply copying data files: it must include any data that was inserted or updated while the backup was in process; it must exclude any data that was deleted while the backup was in process; and it must ignore any changes started by **transactions** but not committed.

The Oracle product that performs hot backups, of **InnoDB** tables especially but also tables from MyISAM and other storage engines, is **MySQL Enterprise Backup**.

The hot backup process consists of two stages. The initial copying of the InnoDB data files produces a **raw backup**. The **apply** step incorporates any changes to the databases that happened while the backup was running. Applying the changes produces a **prepared backup**; these files are ready to be restored whenever necessary.

A **full backup** consists of a hot backup phase that copies the InnoDB data, followed by a **warm backup** phase that copies any non-InnoDB data such as MyISAM tables and **.frm** files.

See Also [apply](#), [cold backup](#), [.frm file](#), [full backup](#), [InnoDB](#), [instance](#), [prepared backup](#), [raw backup](#), [warm backup](#).

I

.ibd file

Each InnoDB **tablespace** created using the **file-per-table** setting has a filename with a **.ibd** extension. This extension does not apply to the **system tablespace**, which is made up of files named `ibdata1`, `ibdata2`, and so on.

See Also [.ibz file](#), [system tablespace](#), [tablespace](#).

.ibz file

When the **MySQL Enterprise Backup** product performs a **compressed backup**, it transforms each **tablespace** file that is created using the **file-per-table** setting from a **.ibd** extension to a **.ibz** extension.

The compression applied during backup is distinct from the **compressed row format** that keeps table data compressed during normal operation. An InnoDB tablespace that is already in compressed row format is not compressed a second time, but is, nevertheless, still saved as an **.ibz** file in the compressed backup.

See Also [.bz file](#), [compression](#), [compression level](#), [.ibd file](#), [.ibz file](#), [MySQL Enterprise Backup](#), [tablespace](#).

ibdata file

A set of files with names such as `ibdata1`, `ibdata2`, and so on, that make up the InnoDB **system tablespace**. These files contain metadata about InnoDB tables, and can contain some or all of the table and index data also (depending on whether the **file-per-table option** is in effect when each table is created). For backward compatibility these files always use the **Antelope** file format.
See Also [Antelope](#), [system tablespace](#).

image

The file produced as part of a **single-file backup** operation. It can be a real file that you store locally, or standard output (specified as `-`) when the backup data is **streamed** directly to another command or remote server. This term is referenced in several `mysqlbackup` options such as `backup-dir-to-image` and `image-to-backup-dir`.
See Also [single-file backup](#), [streaming](#).

include

In a **partial backup**, to select a set of tables, databases, or a combination of both to be backed up. Contrast with **exclude**.
See Also [partial backup](#).

incremental backup

A backup that captures only data changed since the previous backup. It has the potential to be smaller and faster than a **full backup**. The incremental backup data must be merged with the contents of the previous backup before it can be restored. See [Section 4.3.3, “Making a Differential or Incremental Backup”](#) for usage details. Related `mysqlbackup` options are `--incremental`, `--incremental-with-redo-log-only`, `--incremental-backup-dir`, `--incremental-base`, and `--start-lsn`.
See Also [full backup](#).

InnoDB

The type of MySQL **table** that works best with **MySQL Enterprise Backup**. These tables can be backed up using the **hot backup** technique that avoids interruptions in database processing. For this reason, and because of the higher reliability and concurrency possible with InnoDB tables, most deployments should use InnoDB for the bulk of their data and their most important data. In MySQL 5.5 and higher, the `CREATE TABLE` statement creates InnoDB tables by default.
See Also [hot backup](#), [table](#).

instance

The full contents of a MySQL server, possibly including multiple **databases**. A **backup** operation can back up an entire instance, or a **partial backup** can include selected databases and tables.
See Also [database](#), [partial backup](#).

L

locking

See Also [suspend](#), [warm backup](#).

log

Several types of log files are used within the MySQL Enterprise Backup product. The most common is the InnoDB **redo log** that is consulted during **incremental backups**.
See Also [incremental backup](#), [redo log](#).

log sequence number

See [LSN](#).

logical backup

A **backup** that reproduces table structure and data, without copying the actual data files. For example, the `mysqldump` command produces a logical backup, because its output contains statements such as `CREATE TABLE` and `INSERT` that can re-create the data. Contrast with **physical backup**.

See Also [backup](#), [physical backup](#).

LSN

Acronym for **log sequence number**. This arbitrary, ever-increasing value represents a point in time corresponding to operations recorded in the **redo log**. (This point in time is regardless of transaction boundaries; it can fall in the middle of one or more transactions.) It is used internally by InnoDB during **crash recovery** and for managing the buffer pool.

In the **MySQL Enterprise Backup** product, you can specify an LSN to represent the point in time from which to take an **incremental backup**. The relevant LSN is displayed by the output of the `mysqlbackup` command. Once you have the LSN corresponding to the time of a full backup, you can specify that value to take a subsequent incremental backup, whose output contains another LSN for the next incremental backup.

See Also [crash recovery](#), [hot backup](#), [incremental backup](#), [redo log](#).

M

.MRG file

A file containing references to other tables, used by the `MERGE` storage engine. Files with this extension are always included in backups produced by the `mysqlbackup` command of the **MySQL Enterprise Backup** product.

.MYD file

A file that MySQL uses to store data for a MyISAM table.

See Also [.MYI file](#).

.MYI file

A file that MySQL uses to store indexes for a MyISAM table.

See Also [.MYD file](#).

manifest

The record of the environment (for example, command-line arguments) and data files involved in a backup, stored in the files `meta/backup_create.xml` and `meta/backup_content.xml`, respectively. This data can be used by management tools during diagnosis and troubleshooting procedures.

master

See [source](#).

media management software

A class of software programs for managing backup media, such as libraries of tape backups. One example is **Oracle Secure Backup**. Abbreviated **MMS**.

See Also [Oracle Secure Backup](#).

my.cnf

The typical name for the MySQL **configuration file** on Linux, Unix, and macOS systems.

See Also [configuration file](#), [my.ini](#).

my.ini

The typical name for the MySQL **configuration file** on Windows systems.

See Also [configuration file](#), [my.cnf](#).

MyISAM

A MySQL storage engine, formerly the default for new tables. In MySQL 5.5 and higher, **InnoDB** becomes the default storage engine. MySQL Enterprise Backup can back up both types of tables, and tables from other

storage engines also. The backup process for InnoDB tables (**hot backup**) is less disruptive to database operations than for MyISAM tables (**warm backup**).
See Also [hot backup](#), [InnoDB](#), [warm backup](#).

MySQL Enterprise Backup

A licensed products that performs **hot backups** of MySQL database servers. It offers the most efficiency and flexibility when backing up **InnoDB** tables; it can also back up MyISAM and other kinds of tables. It is included as part of the MySQL Enterprise Edition subscription.
See Also [Barracuda](#), [hot backup](#), [InnoDB](#).

mysqlbackup

The primary command of the **MySQL Enterprise Backup** product. Different options perform **backup** and **restore** operations.
See Also [backup](#), [restore](#).

mysqldump

A MySQL command that performs **logical backups**, producing a set of SQL commands to recreate tables and data. Suitable for smaller backups or less critical data, because the **restore** operation takes longer than with a **physical backup** produced by **MySQL Enterprise Backup**.
See Also [logical backup](#), [physical backup](#), [restore](#).

N

non-TTS backup

A backup that is NOT created using [transportable tablespace \(TTS\)](#), that is, not with the `--use-tts` option.
See Also [transportable tablespace](#), [TTS backup](#).

O

.opt file

A file containing database server configuration information. Files with this extension are always included in backups produced by the backup operations of the **MySQL Enterprise Backup** product.

offline

A type of operation performed while the database server is stopped. With the **MySQL Enterprise Backup** product, the main offline operation is the **restore** step. You can optionally perform a **cold backup**, which is another offline operation. Contrast with **online**.
See Also [cold backup](#), [online](#), [restore](#).

online

A type of operation performed while the database server is running. A **hot backup** is the ideal example, because the database server continues to run and no read or write operations are blocked. For that reason, sometimes “hot backup” and “online backup” are used as synonyms. A **cold backup** is the opposite of an online operation; by definition, the database server is shut down while the backup happens. A **warm backup** is also a kind of online operation, because the database server continues to run, although some write operations could be blocked while a warm backup is in progress. Contrast with **offline**.
See Also [cold backup](#), [hot backup](#), [offline](#), [warm backup](#).

optimistic backup

Optimistic backup is a feature for improving performance for backing up and restoring huge databases in which only a small number of tables are modified frequently. An optimistic backup consists of two phases: (1) the optimistic phase in which tables that are unlikely to be modified during the backup process (identified by the user with the `optimistic-time` option or, by exclusion, with the `optimistic-busy-tables` option) are backed up without any locks on the MySQL instance; (2) a normal phase, in which tables that are not backed up in the first

phase are being backed up in a manner similar to how they are processed in an ordinary backup: the InnoDB files are copied first, and then other relevant files and copied or processed with various locks applied to the database server. The redo logs, undo logs, and the system tablespace are also backed up in this phase. See [Section 4.3.6, “Making an Optimistic Backup”](#) for details.

optimistic Incremental Backup

In an optimistic incremental backup `mysqlbackup` scans InnoDB data files that have been modified since the last backup for changed pages and then saves them into the incremental backup. It is performed by specifying `--incremental=optimistic`. See [Full-scan versus Optimistic Incremental Backup](#) for details.

Oracle Secure Backup

An Oracle product for managing **backup** media, and so classified as **media management software (MMS)**. Abbreviated **OSB**. For **MySQL Enterprise Backup**, OSB is typically used to manage tape backups. See Also [backup](#), [media management software](#), [OSB](#).

OSB

Abbreviation for **Oracle Secure Backup**, a **media management software** product (**MMS**). See Also [Oracle Secure Backup](#).

P

.par file

A file containing partition definitions. Files with this extension are always included in backups produced by the `mysqlbackup` command of the **MySQL Enterprise Backup** product.

parallel backup

The default processing mode in MySQL Enterprise Backup 3.8 and higher, employing multiple threads for different classes of internal operations (read, process, and write). See [Section 1.2, “Overview of Backup Types”](#) for an overview, [Section 16.10, “Performance / Scalability / Capacity Options”](#) for the relevant `mysqlbackup` options, and [Chapter 11, *Performance Considerations for MySQL Enterprise Backup*](#) for performance guidelines and tips.

partial backup

A **backup** that contains some of the **tables** in a MySQL database, or some of the databases in a MySQL instance. Contrast with **full backup**. Related `mysqlbackup` options are `--include-tables`, `--exclude-tables`, `--use-tts`, `--only-known-file-types`, and `--only-innodb`. See Also [backup](#), [database](#), [full backup](#), [partial restore](#), [table](#).

partial restore

A **restore** operation that applies to one or more **tables** or **databases**, but not the entire contents of a MySQL server. The data being restored could come from either a **partial backup** or a **full backup**. Related `mysqlbackup` options are `--include-tables`, `--exclude-tables`, and `--rename`. See Also [database](#), [full backup](#), [partial backup](#), [restore](#), [table](#).

physical backup

A **backup** that copies the actual data files. For example, the **MySQL Enterprise Backup** command produces a physical backup, because its output contains data files that can be used directly by the `mysqld` server. Contrast with **logical backup**. See Also [backup](#), [logical backup](#).

point in time

The time corresponding to the end of a **backup** operation. A **prepared backup** includes all the changes that occurred while the backup operation was running. **Restoring** the backup brings the data back to the state at the moment when the backup operation completed. See Also [backup](#), [prepared backup](#), [restore](#).

prepared backup

The set of backup data that is entirely consistent and ready to be restored. It is produced by performing the **apply** operation on the **raw backup**.

See Also [apply](#), [raw backup](#).

progress table

The table `mysql.backup_progress` that holds details of running **backup** operations. When a backup job finishes, the details are recorded in the **history table**.

See Also [backup](#), [history table](#).

R

raw backup

The initial set of backup data, not yet ready to be restored because it does not incorporate changes that occurred while the backup was running. The **apply** operation transforms the backup files into a **prepared backup** that is ready to be restored.

See Also [apply](#), [prepared backup](#).

redo log

A set of files, typically named `ib_logfile0` and `ib_logfile1`, that record statements that attempt to change data in InnoDB tables. These statements are replayed automatically to correct data written by incomplete transactions, on startup following a crash. The passage of data through the redo logs is represented by the ever-increasing **LSN** value. The 4GB limit on maximum size for the redo log is raised in MySQL 5.6.

See Also [LSN](#).

regular expression

Some MySQL Enterprise Backup features use POSIX-style regular expressions, for example to specify tables, databases, or both to **include** or **exclude** from a **partial backup**. Regular expressions require escaping for dots in filenames, because the dot is the single-character wildcard; no escaping is needed for forward slashes in path names. When specifying regular expressions on the command line, surround them with quotation marks as appropriate for the shell environment, to prevent expansion of characters such as asterisks by the shell wildcard mechanism.

See Also [exclude](#), [include](#), [partial backup](#).

relay log

A record on a **replica** server for the events read from the **binary log** of the source server and written by the replication I/O thread. The relay log, like the **binary log**, consists of a set of numbered files containing events that describe database changes, and an index file that contains the names of all used relay log files. For more information on relay log, see [The Relay Log](#). The relay log on a server is backed up by default.

See Also [binary log](#), [replication](#).

replica

In a **replication** configuration, a database server that receives updates from a **source** server. Typically used to service user queries, to minimize the query load on the source server. With **MySQL Enterprise Backup**, you might take a backup on one server, and restore on a different system to create a new replica server with the data already in place. You might also back up data from a replica server rather than the source, to minimize any slowdown of the overall system.

See Also [replication](#), [source](#).

replication

A common configuration for MySQL deployments, with data and DML operations from a **source** server synchronized with a set of **replica** servers. With **MySQL Enterprise Backup**, you might take a backup on one server, and restore on a different system to create a new replica server with the data already in place. You might also back up data from a replica server rather than the source, to minimize any slowdown of the overall system.

See Also [replica](#), [source](#).

repository

We distinguish between the **server repository** and the **backup repository**.
See Also [backup repository](#), [server repository](#).

restore

The converse of the **backup** operation. The data files from a **prepared backup** are put back into place to repair a data issue or bring the system back to an earlier state.
See Also [backup](#), [prepared backup](#).

row format

The disk storage format for a row from an InnoDB table. As InnoDB gains new capabilities such as compression, new row formats are introduced to support the resulting improvements in storage efficiency and performance.

Each table has its own row format, specified through the [ROW_FORMAT](#) option. To see the row format for each InnoDB table, issue the command [SHOW TABLE STATUS](#). Because all the tables in the system tablespace share the same row format, to take advantage of other row formats typically requires setting the [innodb_file_per_table](#) option, so that each table is stored in a separate tablespace.

S

SBT

Acronym for **system backup to tape**.
See Also [system backup to tape](#).

selective backup

Another name for **partial backup**.
See Also [partial backup](#), [selective restore](#).

selective restore

Another name for **partial restore**.
See Also [partial restore](#), [selective backup](#).

server

A MySQL **instance** controlled by a [mysqld](#) daemon. A physical machine can host multiple MySQL servers, each requiring its own **backup** operations and schedule. Some backup operations communicate with the server through a **connection**.
See Also [connection](#), [instance](#).

server repository

Contrast with **backup repository**.
See Also [backup repository](#), [repository](#).

single-file backup

A backup technique that packs all the backup data into one file (the backup **image**), for ease of storage and transfer. The **streaming** backup technique requires using a single-file backup.
See Also [image](#), [streaming](#).

slave

See [replica](#).

source

In a **replication** configuration, a database server that sends updates to a set of **replica** servers. It typically dedicates most of its resources to write operations, leaving user queries to the replicas. With **MySQL Enterprise Backup**, typically you perform backups on the replica servers rather than the source, to minimize any slowdown of the overall system.

See Also [replica](#), [replication](#).

streaming

A backup technique that transfers the data immediately to another server, rather than saving a local copy. Uses mechanisms such as Unix pipes. Requires a **single-file backup**, with the destination file specified as `-` (standard output).

See Also [single-file backup](#).

suspend

An optional stage within the backup where the MySQL Enterprise Backup processing stops, to allow for user-specific operations to be run. The `mysqlbackup` command has options that let you specify commands to be run while the backup is suspended. Most often used in conjunction with backups of **InnoDB** tables only, where you might do your own scripting for handling **.frm files**.

See Also [.frm file](#), [InnoDB](#).

system backup to tape

An API for **media management software**. Abbreviated **SBT**. Several `mysqlbackup` options (with **sbt** in their names) pass information to **media management software** products such as **Oracle Secure Backup**.

See Also [Oracle Secure Backup](#), [SBT](#).

system tablespace

By default, this single data file stores all the table data for a database server, as well as all the metadata for InnoDB-related objects (the **data dictionary**).

Turning on the **innodb_file_per_table** option causes each newly created table to be stored in its own **tablespace**, reducing the size of, and dependencies on, the system tablespace.

Keeping all table data in the system tablespace has implications for the **MySQL Enterprise Backup** product (backing up one large file rather than several smaller files), and prevents you from using certain InnoDB features that require the newer **Barracuda** file format. on the

See Also [Barracuda](#), [data dictionary](#), [file format](#), [ibdata file](#), [tablespace](#).

T

.TRG file

A file containing **trigger** parameters. Files with this extension are always included in backups produced by the `mysqlbackup` command of the **MySQL Enterprise Backup** product.

table

Although a table is a distinct, addressable object in the context of SQL, for **backup** purposes we are often concerned with whether the table is part of the **system tablespace**, or was created under the **file-per-table** setting and so resides in its own **tablespace**.

See Also [backup](#), [system tablespace](#), [tablespace](#).

tablespace

For **InnoDB** tables, the file that holds the data and indexes for a table. Can be either the **system tablespace** containing multiple tables, or a table created with the **file-per-table** setting that resides in its own tablespace file.

See Also [InnoDB](#), [system tablespace](#).

transportable tablespace

A feature that allows a **tablespace** to be moved from one instance to another. Traditionally, this has not been possible for InnoDB tablespaces because all table data was part of the **system tablespace**. In MySQL 5.6 and higher, the `FLUSH TABLES ... FOR EXPORT` syntax prepares an InnoDB table for copying to another server; running `ALTER TABLE ... DISCARD TABLESPACE` and `ALTER TABLE ... IMPORT TABLESPACE` on the other server brings the copied data file into the other instance. A separate `.cfg` file, copied along with the

.ibd file, is used to update the table metadata (for example the **space ID**) as the tablespace is imported. See [Importing InnoDB Tables](#) for usage information.

Use the `--use-tts` option to create a backup with transportable tablespace. See also [Section 5.1.4, “Restoring Backups Created with the `--use-tts` Option”](#).

See Also [partial backup](#).

TTS

Short form for **transportable tablespace**.

See Also [partial backup](#), [transportable tablespace](#).

TTS backup

A backup that is created using [transportable tablespace \(TTS\)](#), that is, with the `--use-tts` option.

See Also [non-TTS backup](#), [partial backup](#), [transportable tablespace](#).

W

warm backup

A **backup** taken while the database server is running, but that restricts some database operations during the backup process. For example, tables might become read-only. For busy applications and websites, you might prefer a **hot backup**.

See Also [backup](#), [cold backup](#), [hot backup](#).

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