

# Apache Kudu Background Operations

Date published:

Date modified:

The Cloudera logo, featuring the word "CLOUDERA" in a bold, orange, sans-serif font. The letter "E" is stylized with a horizontal bar through its center.

# Legal Notice

© Cloudera Inc. 2024. All rights reserved.

The documentation is and contains Cloudera proprietary information protected by copyright and other intellectual property rights. No license under copyright or any other intellectual property right is granted herein.

Unless otherwise noted, scripts and sample code are licensed under the Apache License, Version 2.0.

Copyright information for Cloudera software may be found within the documentation accompanying each component in a particular release.

Cloudera software includes software from various open source or other third party projects, and may be released under the Apache Software License 2.0 (“ASLv2”), the Affero General Public License version 3 (AGPLv3), or other license terms. Other software included may be released under the terms of alternative open source licenses. Please review the license and notice files accompanying the software for additional licensing information.

Please visit the Cloudera software product page for more information on Cloudera software. For more information on Cloudera support services, please visit either the Support or Sales page. Feel free to contact us directly to discuss your specific needs.

Cloudera reserves the right to change any products at any time, and without notice. Cloudera assumes no responsibility nor liability arising from the use of products, except as expressly agreed to in writing by Cloudera.

Cloudera, Cloudera Altus, HUE, Impala, Cloudera Impala, and other Cloudera marks are registered or unregistered trademarks in the United States and other countries. All other trademarks are the property of their respective owners.

Disclaimer: EXCEPT AS EXPRESSLY PROVIDED IN A WRITTEN AGREEMENT WITH CLOUDERA, CLOUDERA DOES NOT MAKE NOR GIVE ANY REPRESENTATION, WARRANTY, NOR COVENANT OF ANY KIND, WHETHER EXPRESS OR IMPLIED, IN CONNECTION WITH CLOUDERA TECHNOLOGY OR RELATED SUPPORT PROVIDED IN CONNECTION THEREWITH. CLOUDERA DOES NOT WARRANT THAT CLOUDERA PRODUCTS NOR SOFTWARE WILL OPERATE UNINTERRUPTED NOR THAT IT WILL BE FREE FROM DEFECTS NOR ERRORS, THAT IT WILL PROTECT YOUR DATA FROM LOSS, CORRUPTION NOR UNAVAILABILITY, NOR THAT IT WILL MEET ALL OF CUSTOMER’S BUSINESS REQUIREMENTS. WITHOUT LIMITING THE FOREGOING, AND TO THE MAXIMUM EXTENT PERMITTED BY APPLICABLE LAW, CLOUDERA EXPRESSLY DISCLAIMS ANY AND ALL IMPLIED WARRANTIES, INCLUDING, BUT NOT LIMITED TO IMPLIED WARRANTIES OF MERCHANTABILITY, QUALITY, NON-INFRINGEMENT, TITLE, AND FITNESS FOR A PARTICULAR PURPOSE AND ANY REPRESENTATION, WARRANTY, OR COVENANT BASED ON COURSE OF DEALING OR USAGE IN TRADE.

# Contents

**Maintenance manager..... 4**

**Flushing data to disk.....4**

**Compacting on-disk data.....4**

**Write-ahead log garbage collection..... 4**

**Tablet history garbage collection and the ancient history mark..... 5**

## Maintenance manager

The maintenance manager schedules and runs background tasks. At any given point in time, the maintenance manager is prioritizing the next task based on improvements needed at that moment, such as relieving memory pressure, improving read performance, or freeing up disk space.

The number of worker threads dedicated to running background tasks can be controlled by setting `--maintenance_manager_num_threads`.

With Kudu 1.4, the maintenance manager features improved utilization of the configured maintenance threads. Previously, maintenance work would only be scheduled a maximum of 4 times per second, but now maintenance work will be scheduled immediately whenever any configured thread is available. Make sure that the `--maintenance_manager_num_threads` property is set to at most a 1:3 ratio for Maintenance Manager threads to the number of data directories (for spinning disks). This will improve the throughput of write-heavy workloads.

## Flushing data to disk

Flushing data from memory to disk relieves memory pressure and can improve read performance by switching from a write-optimized, row-oriented in-memory format in the `MemRowSet`, to a read-optimized, column-oriented format on disk.

Background tasks that flush data include `FlushMRSOp` and `FlushDeltaMemStoresOp`. The metrics associated with these operations have the prefix `flush_mrs` and `flush_dms`, respectively.

With Kudu 1.4, the maintenance manager aggressively schedules flushes of in-memory data when memory consumption crosses 60 percent of the configured process-wide memory limit. The backpressure mechanism which begins to throttle client writes was also adjusted to not begin throttling until memory consumption reaches 80 percent of the configured limit. These two changes together result in improved write throughput, more consistent latency, and fewer timeouts due to memory exhaustion.

## Compacting on-disk data

Kudu constantly performs several compaction tasks in order to maintain consistent read and write performance over time.

- A merging compaction, which combines multiple `DiskRowSets` together into a single `DiskRowSet`, is run by `CompactRowSetsOp`.
- Kudu also runs two types of delta store compaction operations: `MinorDeltaCompactionOp` and `MajorDeltaCompactionOp`.

For more information on what these compaction operations do, see the [Kudu Tablet design document](#).

The metrics associated with these tasks have the prefix `compact_rs`, `delta_minor_compact_rs`, and `delta_major_compact_rs`, respectively.

## Write-ahead log garbage collection

Kudu maintains a write-ahead log (WAL) per tablet that is split into discrete fixed-size segments. A tablet periodically rolls the WAL to a new log segment when the active segment reaches a size threshold (configured by the `--log_segment_size_mb` property).

In order to save disk space and decrease startup time, a background task called LogGCOp attempts to garbage-collect (GC) old WAL segments by deleting them from disk once it is determined that they are no longer needed by the local node for durability.

The metrics associated with this background task have the prefix `log_gc`.

## Tablet history garbage collection and the ancient history mark

Kudu uses a multiversion concurrency control (MVCC) mechanism to ensure that snapshot scans can proceed isolated from new changes to a table. Therefore, periodically, old historical data should be garbage-collected (removed) to free up disk space. While Kudu never removes rows or data that are visible in the latest version of the data, Kudu does remove records of old changes that are no longer visible.

The specific threshold in time (in the past) beyond which historical MVCC data becomes inaccessible and is free to be deleted is called the ancient history mark (AHM). The AHM can be configured by setting the `--tablet_history_max_age_sec` property.

There are two background tasks that remove historical MVCC data older than the AHM:

- The one that runs the merging compaction, called `CompactRowSetsOp` (see above).
- A separate background task deletes old undo delta blocks, called `UndoDeltaBlockGCOp`. Running `UndoDeltaBlockGCOp` reduces disk space usage in all workloads, but particularly in those with a higher volume of updates or upserts. The metrics associated with this background task have the prefix `undo_delta_block`.