Replication

A *replica set* in MongoDB is a group of `mongod` processes that maintain the same data set. Replica sets provide redundancy and high availability, and are the basis for all production deployments. This section introduces replication in MongoDB as well as the components and architecture of replica sets. The section also provides tutorials for common tasks related to replica sets.

You can deploy a replica set in the UI for deployments hosted in MongoDB Atlas.

Redundancy and Data Availability

Replication provides redundancy and increases data availability. With multiple copies of data on different database servers, replication provides a level of fault tolerance against the loss of a single database server.

In some cases, replication can provide increased read capacity as clients can send read operations to different servers. Maintaining copies of data in different data centers can increase data locality and availability for distributed applications. You can also maintain additional copies for dedicated purposes, such as disaster recovery, reporting, or backup.

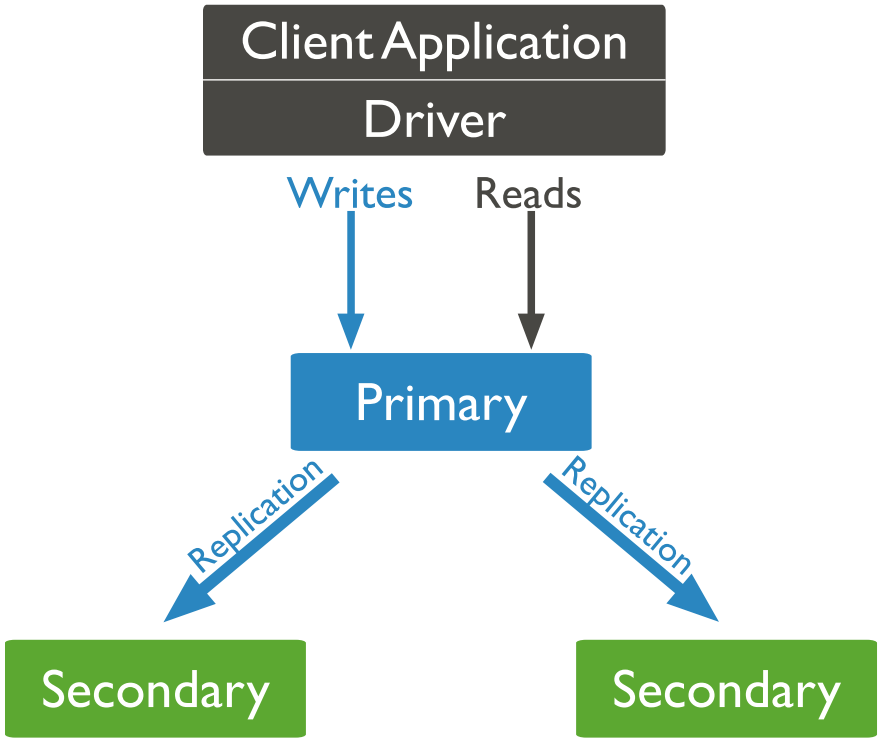
Replication in MongoDB

A replica set is a group of `mongod` instances that maintain the same data set. A replica set contains several data bearing nodes and optionally one arbiter node. Of the data bearing nodes, one and only one member is deemed the primary node, while the other nodes are deemed secondary nodes.

WARNING

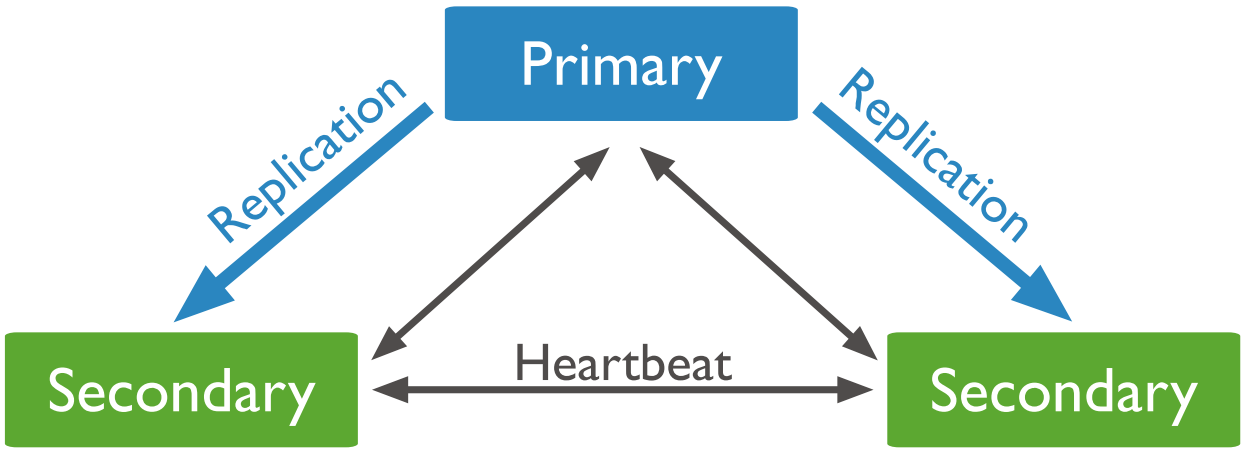
Each replica set node must belong to one, and only one, replica set. Replica set nodes cannot belong to more than one replica set.

The primary node receives all write operations. A replica set can have only one primary capable of confirming writes with `{ w: "majority" }` write concern; although in some circumstances, another mongod instance may transiently believe itself to also be primary. [1] The primary records all changes to its data sets in its operation log, i.e. oplog. For more information on primary node operation, see Replica Set Primary.

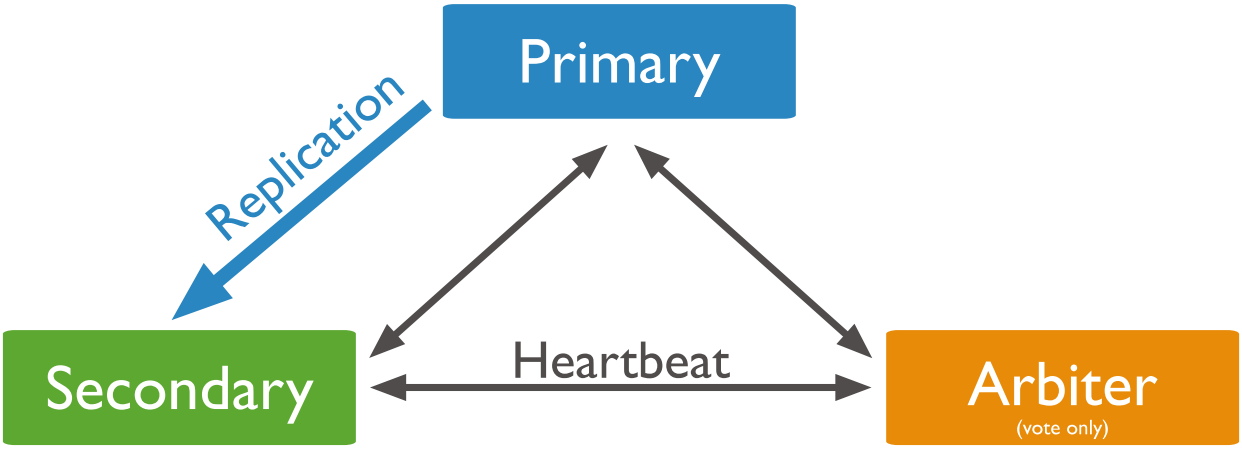


click to enlarge

The secondaries replicate the primary's oplog and apply the operations to their data sets such that the secondaries' data sets reflect the primary's data set. If the primary is unavailable, an eligible secondary will hold an election to elect itself the new primary. For more information on secondary members, see Replica Set Secondary Members.



In some circumstances (such as you have a primary and a secondary but cost constraints prohibit adding another secondary), you may choose to add a `mongod` instance to a replica set as an arbiter. An arbiter participates in elections but does not hold data (i.e. does not provide data redundancy). For more information on arbiters, see Replica Set Arbiter.



An arbiter will always be an arbiter whereas a primary may step down and become a secondary and a secondary may become the primary during an election.

Asynchronous Replication

Secondaries replicate the primary's oplog and apply the operations to their data sets asynchronously. By having the secondaries' data sets reflect the primary's data set, the replica set can continue to function despite the failure of one or more members.

For more information on replication mechanics, see Replica Set Oplog and Replica Set Data Synchronization.

Slow Operations

Starting in version 4.2, secondary members of a replica set now log oplog entries that take longer than the slow operation threshold to apply. These slow oplog messages:

- Are logged for the secondaries in the `diagnostic log`.
- Are logged under the `REPL` component with the text `applied op: <oplog entry> took <num>ms`.
- Do not depend on the log levels (either at the system or component level)
- Do not depend on the profiling level.
- Are affected by `slowOpSampleRate`.

The profiler does not capture slow oplog entries.

Replication Lag and Flow Control

Replication lag is a delay between an operation on the primary and the application of that operation from the oplog to the secondary. Some small delay period may be acceptable, but significant problems emerge as replication lag grows, including building cache pressure on the primary.

Starting in MongoDB 4.2, administrators can limit the rate at which the primary applies its writes with the goal of keeping the `majority committed` lag under a configurable maximum value `flowControlTargetLagSeconds`.

By default, flow control is `enabled`.

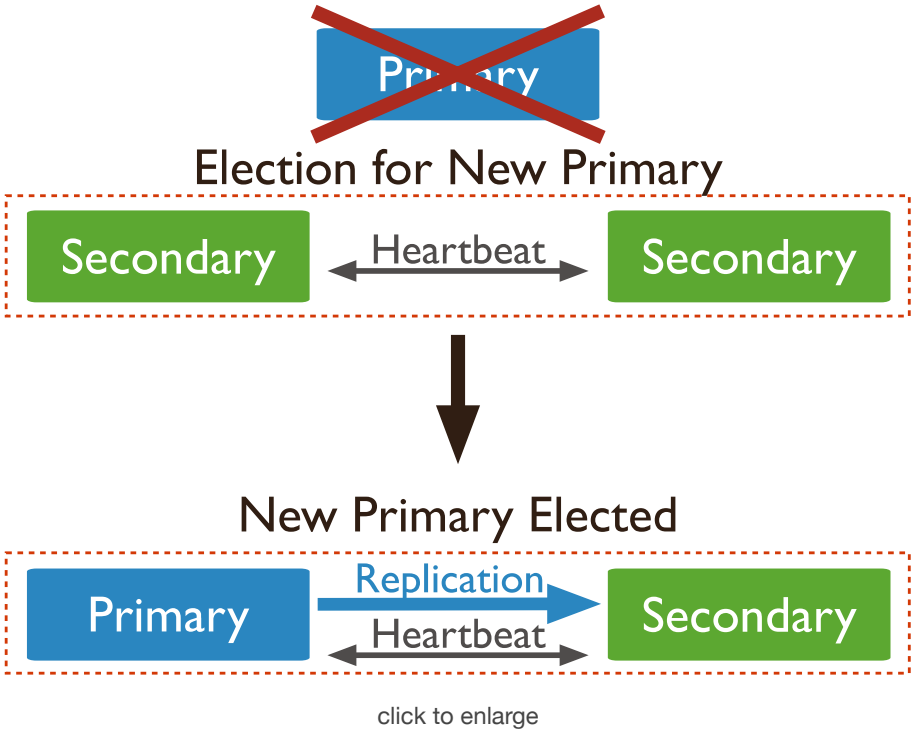
> **NOTE**
>
> For flow control to engage, the replica set/sharded cluster must have: featureCompatibilityVersion (fCV) of `4.2` and read concern `majority enabled`. That is, enabled flow control has no effect if fCV is not `4.2` or if read concern majority is disabled.

With flow control enabled, as the lag grows close to the `flowControlTargetLagSeconds`, writes on the primary must obtain tickets before taking locks to apply writes. By limiting the number of tickets issued per second, the flow control mechanism attempts to keep the lag under the target.

For more information, see Check the Replication Lag and Flow Control.

Automatic Failover

When a primary does not communicate with the other members of the set for more than the configured `electionTimeoutMillis` period (10 seconds by default), an eligible secondary calls for an election to nominate itself as the new primary. The cluster attempts to complete the election of a new primary and resume normal operations.



click to enlarge

The replica set cannot process write operations until the election completes successfully. The replica set can continue to serve read queries if such queries are configured to run on secondaries while the primary is offline.

The median time before a cluster elects a new primary should not typically exceed 12 seconds, assuming default `replica configuration settings`. This includes time required to mark the primary as unavailable and call and complete an election. You can tune this time period by modifying the `settings.electionTimeoutMillis` replication configuration option. Factors such as network latency may extend the time required for replica set elections to complete, which in turn affects the amount of time your cluster may operate without a primary. These factors are dependent on your particular cluster architecture.

Lowering the `electionTimeoutMillis` replication configuration option from the default `10000` (10 seconds) can result in faster detection of primary failure. However, the cluster may call elections more frequently due to factors such as temporary network latency even if the primary is otherwise healthy. This can result in increased rollbacks for w : 1 write operations.

Your application connection logic should include tolerance for automatic failovers and the subsequent elections. MongoDB drivers can detect the loss of the primary and automatically retry certain write operations a single time, providing additional built-in handling of automatic failovers and elections:

Compatible drivers enable retryable writes by default

MongoDB provides mirrored reads to pre-warm electable secondary members' cache with the most recently accessed data. Pre-warming the cache of a secondary can help restore performance more quickly after an election.

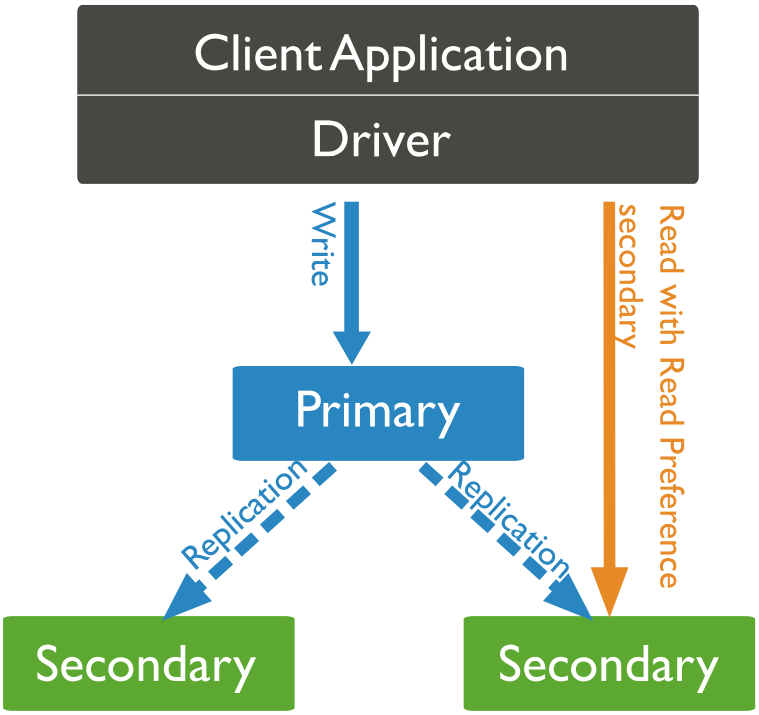
To learn more about MongoDB's failover process, see:

- Replica Set Elections
- Retryable Writes
- Rollbacks During Replica Set Failover

Read Operations

Read Preference

By default, clients read from the primary [1]; however, clients can specify a read preference to send read operations to secondaries.



click to enlarge

Asynchronous replication to secondaries means that reads from secondaries may return data that does not reflect the state of the data on the primary.

Distributed transactions that contain read operations must use read preference `primary`. All operations in a given transaction must route to the same member.

For information on reading from replica sets, see Read Preference.

Data Visibility

Depending on the read concern, clients can see the results of writes before the writes are durable:

- Regardless of a write's write concern, other clients using `"local"` or `"available"` read concern can see the result of a write operation before the write operation is acknowledged to the issuing client.
- Clients using `"local"` or `"available"` read concern can read data which may be subsequently rolled back during replica set failovers.

For operations in a multi-document transaction, when a transaction commits, all data changes made in the transaction are saved and visible outside the transaction. That is, a transaction will not commit some of its changes while rolling back others.

Until a transaction commits, the data changes made in the transaction are not visible outside the transaction.

However, when a transaction writes to multiple shards, not all outside read operations need to wait for the result of the committed transaction to be visible across the shards. For example, if a transaction is committed and write 1 is visible on shard A but write 2 is not yet visible on shard B, an outside read at read concern `"local"` can read the results of write 1 without seeing write 2.

For more information on read isolations, consistency and recency for MongoDB, see Read Isolation, Consistency, and Recency.

Mirrored Reads

Mirrored reads reduce the impact of primary elections following an outage or planned maintenance. After a failover in a replica set, the secondary that takes over as the new primary updates its cache as new queries come in. While the cache is warming up performance can be impacted.

Mirrored reads pre-warm the caches of `electable` secondary replica set members. To pre-warm the caches of electable secondaries, the primary mirrors a sample of the supported operations it receives to electable secondaries.

The size of the subset of `electable` secondary replica set members that receive mirrored reads can be configured with the `mirrorReads` parameter. See Enable/Disable Support for Mirrored Reads for further details.

> **NOTE**
>
> Mirrored reads do not affect the primary's response to the client. The reads that the primary mirrors to secondaries are "fire-and-forget" operations. The primary doesn't await responses.

Supported Operations

Mirrored reads support the following operations:

- `count`
- `distinct`
- `find`
- `findAndModify` (Specifically, the filter is sent as a mirrored read)
- `update` (Specifically, the filter is sent as a mirrored read)

Enable/Disable Support for Mirrored Reads

Mirrored reads are enabled by default and use a default `sampling rate` of `0.01`. To disable mirrored reads, set the `mirrorReads` parameter to `{ samplingRate: 0.0 }`:

```
db.adminCommand( {
```

```
setParameter: 1,
mirrorReads: { samplingRate: 0.0 }
} )
```

With a sampling rate greater than `0.0`, the primary mirrors supported reads to a subset of `electable` secondaries. With a sampling rate of `0.01`, the primary mirrors one percent of the supported reads it receives to a selection of electable secondaries.

For example, consider a replica set that consists of one primary and two electable secondaries. If the primary receives `1000` operations that can be mirrored and the sampling rate is `0.01`, the primary mirrors about `10` supported reads to electable secondaries. Each electable secondary receives only a fraction of the 10 reads. The primary sends each mirrored read to a randomly chosen, non-empty selection of electable secondaries.

Change the Sampling Rate for Mirrored Reads

To change the sampling rate for mirrored reads, set the `mirrorReads` parameter to a number between `0.0` and `1.0`:

- A sampling rate of `0.0` disables mirrored reads.
- A sampling rate of a number between `0.0` and `1.0` results in the primary forwarding a random sample of the supported reads at the specified sample rate to electable secondaries.
- A sampling rate of `1.0` results in the primary forwarding all supported reads to electable secondaries.

For details, see `mirrorReads`.

Mirrored Reads Metrics

The `serverStatus` command and the `db.serverStatus()` shell method return `mirroredReads` metrics if you specify the field in the operation:

```
db.serverStatus( { mirroredReads: 1
} )
```

Transactions

Starting in MongoDB 4.0, multi-document transactions are available for replica sets.

Distributed transactions that contain read operations must use read preference `primary`. All operations in a given transaction must route to the same member.

Until a transaction commits, the data changes made in the transaction are not visible outside the transaction.

However, when a transaction writes to multiple shards, not all outside read operations need to wait for the result of the committed transaction to be visible across the shards. For example, if a transaction is committed and write 1 is visible on shard A but write 2 is not yet visible on shard B, an outside read at read concern `"local"` can read the results of write 1 without seeing write 2.

Change Streams

Starting in MongoDB 3.6, change streams are available for replica sets and sharded clusters. Change streams allow applications to access real-time data changes without the complexity and risk of tailing the oplog. Applications can use change streams to subscribe to all data changes on a collection or collections.

Additional Features

Replica sets provide a number of options to support application needs. For example, you may deploy a replica set with members in multiple data centers, or control the outcome of elections by adjusting the `members[n].priority` of some members. Replica sets also support dedicated members for reporting, disaster recovery, or backup functions.