Sharding and MongoDB

Release 3.2.3

MongoDB, Inc.

February 17, 2016

Contents

Sharding is the process of storing data records across multiple machines and is MongoDB's approach to meeting the demands of data growth. As the size of the data increases, a single machine may not be sufficient to store the data nor provide an acceptable read and write throughput. Sharding solves the problem with horizontal scaling. With sharding, you add more machines to support data growth and the demands of read and write operations.

CHAPTER 1

Sharding Introduction

On this page

Sharding is a method for storing data across multiple machines. MongoDB uses sharding to support deployments with very large data sets and high throughput operations.

1.1 Purpose of Sharding

Database systems with large data sets and high throughput applications can challenge the capacity of a single server. High query rates can exhaust the CPU capacity of the server. Larger data sets exceed the storage capacity of a single machine. Finally, working set sizes larger than the system's RAM stress the I/O capacity of disk drives.

To address these issues of scales, database systems have two basic approaches: **vertical scaling** and **sharding**.

Vertical scaling adds more CPU and storage resources to increase capacity. Scaling by adding capacity has limitations: high performance systems with large numbers of CPUs and large amount of RAM are disproportionately *more expensive* than smaller systems. Additionally, cloud-based providers may only allow users to provision smaller instances. As a result there is a *practical maximum* capability for vertical scaling.

Sharding, or *horizontal scaling*, by contrast, divides the data set and distributes the data over multiple servers, or **shards**. Each shard is an independent database, and collectively, the shards make up a single logical database.

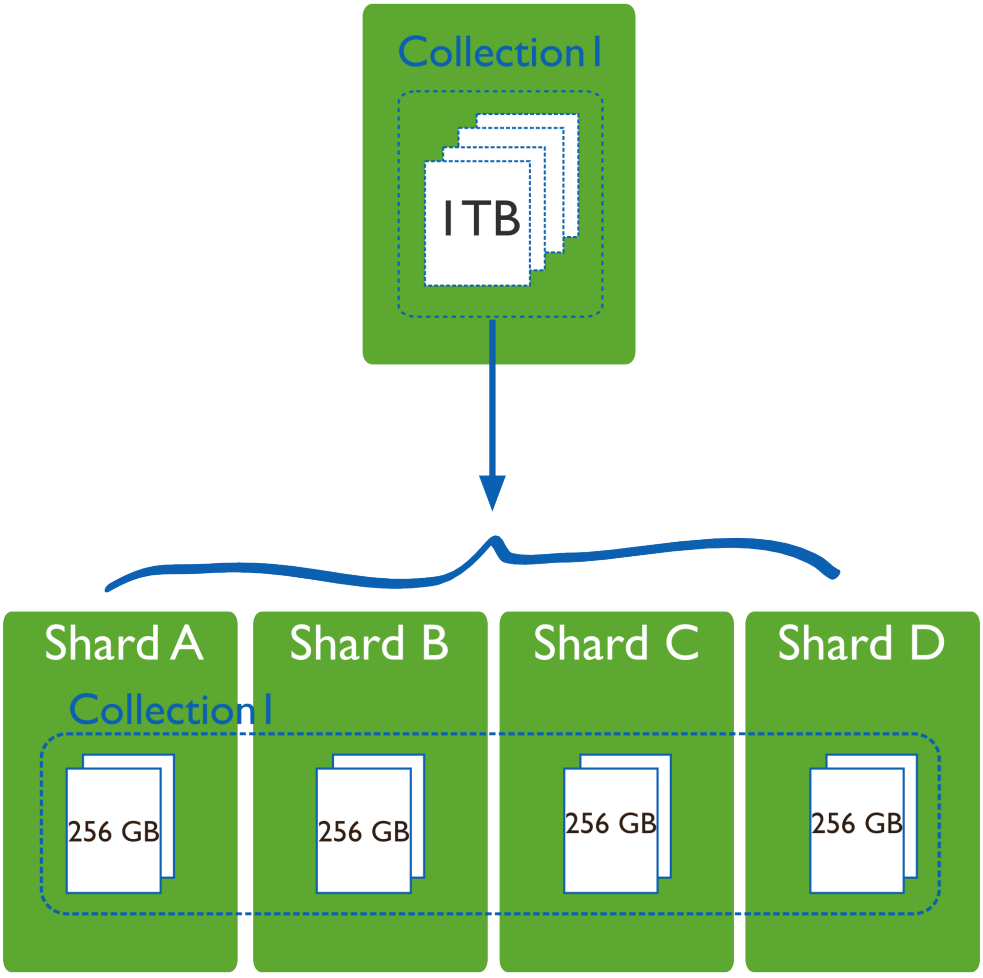
Sharding addresses the challenge of scaling to support high throughput and large data sets:

- Sharding reduces the number of operations each shard handles. Each shard processes fewer operations as the cluster grows. As a result, a cluster can increase capacity and throughput *horizontally*.

  For example, to insert data, the application only needs to access the shard responsible for that record.

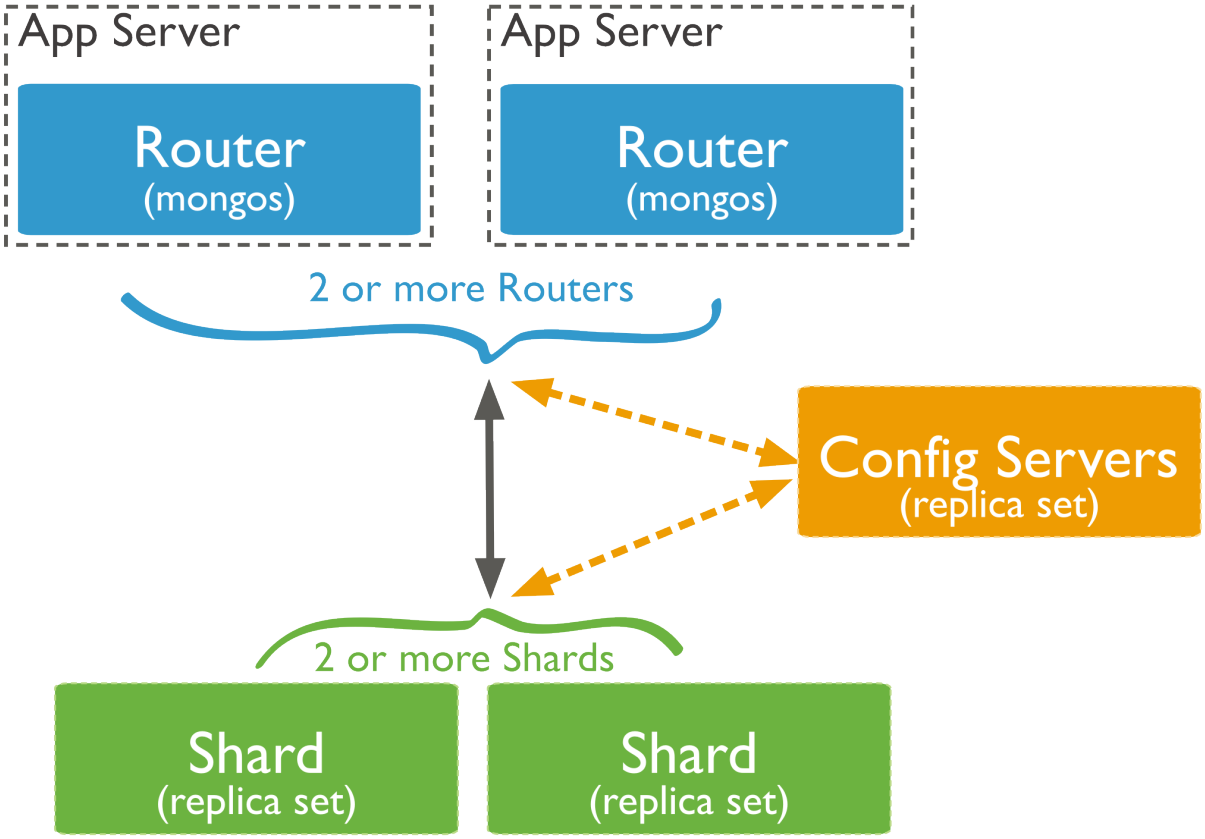
- Sharding reduces the amount of data that each server needs to store. Each shard stores less data as the cluster grows.

  For example, if a database has a 1 terabyte data set, and there are 4 shards, then each shard might hold only 256 GB of data. If there are 40 shards, then each shard might hold only 25 GB of data.


Collection I
1 TB
Shard A
Collection I
256 GB
Shard B
256 GB
Shard C
256 GB
Shard D
256 GB

1.2 Sharding in MongoDB

MongoDB supports sharding through the configuration of a *sharded clusters*.



Sharded cluster has the following components: *shards*, *query routers* and *config servers*.

Shards store the data. To provide high availability and data consistency, in a production sharded cluster, each shard is a *replica set* [1]. For more information on replica sets, see `Replica Sets`.

Query Routers, or `mongos` instances, interface with client applications and direct operations to the appropriate shard or shards. A client sends requests to a `mongos`, which then routes the operations to the shards and returns the results to the clients. A sharded cluster can contain more than one `mongos` to divide the client request load, and most sharded clusters have more than one `mongos` for this reason.

Config servers store the cluster's metadata. This data contains a mapping of the cluster's data set to the shards. The query router uses this metadata to target operations to specific shards.

Changed in version 3.2: Starting in MongoDB 3.2, config servers for sharded clusters can be deployed as a `replica set`. The replica set config servers must run the `WiredTiger storage engine`. MongoDB 3.2 deprecates the use of three mirrored `mongod` instances for config servers.

[1] For development and testing purposes only, each **shard** can be a single `mongod` instead of a replica set.

1.3 Data Partitioning

MongoDB distributes data, or shards, at the collection level. Sharding partitions a collection's data by the **shard key**.

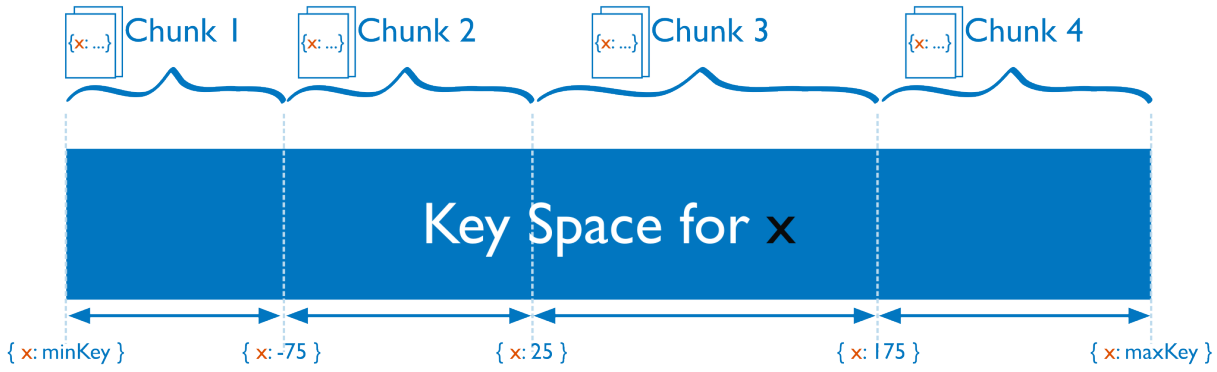
1.3.1 Shard Keys

To shard a collection, you need to select a **shard key**. A *shard key* is either an indexed field or an indexed compound field that exists in every document in the collection. MongoDB divides the shard key values into **chunks** and distributes the *chunks* evenly across the shards. To divide the shard key values into chunks, MongoDB uses either **range based partitioning** or **hash based partitioning**. See the *Shard Key* (page 19) documentation for more information.

1.3.2 Range Based Sharding

For *range-based sharding*, MongoDB divides the data set into ranges determined by the shard key values to provide **range based partitioning**. Consider a numeric shard key: If you visualize a number line that goes from negative infinity to positive infinity, each value of the shard key falls at some point on that line. MongoDB partitions this line into smaller, non-overlapping ranges called **chunks** where a chunk is range of values from some minimum value to some maximum value.

Given a range based partitioning system, documents with "close" shard key values are likely to be in the same chunk, and therefore on the same shard.



1.3.3 Hash Based Sharding

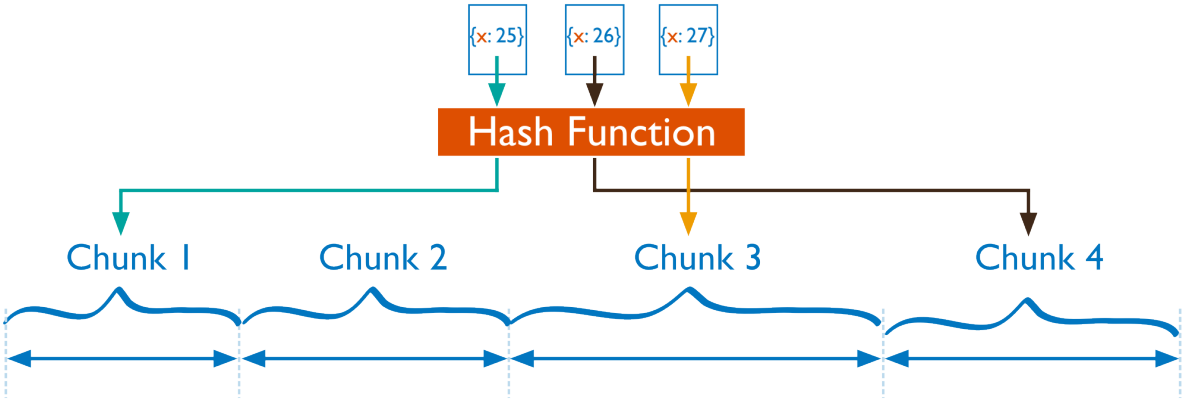
For *hash based partitioning*, MongoDB computes a hash of a field's value, and then uses these hashes to create chunks.

With hash based partitioning, two documents with "close" shard key values are *unlikely* to be part of the same chunk. This ensures a more random distribution of a collection in the cluster.

1.3.4 Performance Distinctions between Range and Hash Based Partitioning

Range based partitioning supports more efficient range queries. Given a range query on the shard key, the query router can easily determine which chunks overlap that range and route the query to only those shards that contain these chunks.

However, range based partitioning can result in an uneven distribution of data, which may negate some of the benefits of sharding. For example, if the shard key is a linearly increasing field, such as time, then all requests for a given time



range will map to the same chunk, and thus the same shard. In this situation, a small set of shards may receive the majority of requests and the system would not scale very well.

Hash based partitioning, by contrast, ensures an even distribution of data at the expense of efficient range queries. Hashed key values results in random distribution of data across chunks and therefore shards. But random distribution makes it more likely that a range query on the shard key will not be able to target a few shards but would more likely query every shard in order to return a result.

1.3.5 Customized Data Distribution with Tag Aware Sharding

MongoDB allows administrators to direct the balancing policy using **tag aware sharding**. Administrators create and associate tags with ranges of the shard key, and then assign those tags to the shards. Then, the balancer migrates tagged data to the appropriate shards and ensures that the cluster always enforces the distribution of data that the tags describe.

Tags are the primary mechanism to control the behavior of the balancer and the distribution of chunks in a cluster. Most commonly, tag aware sharding serves to improve the locality of data for sharded clusters that span multiple data centers.

See *Tag Aware Sharding* (page 27) for more information.

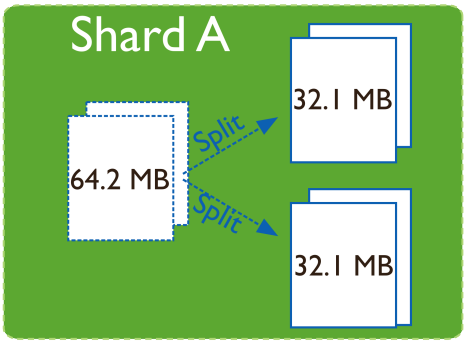
1.4 Maintaining a Balanced Data Distribution

The addition of new data or the addition of new servers can result in data distribution imbalances within the cluster, such as a particular shard contains significantly more chunks than another shard or a size of a chunk is significantly greater than other chunk sizes.

MongoDB ensures a balanced cluster using two background process: splitting and the balancer.

1.4.1 Splitting

Splitting is a background process that keeps chunks from growing too large. When a chunk grows beyond a *specified chunk size* (page 33), MongoDB splits the chunk in half. Inserts and updates triggers splits. Splits are an efficient meta-data change. To create splits, MongoDB does *not* migrate any data or affect the shards.



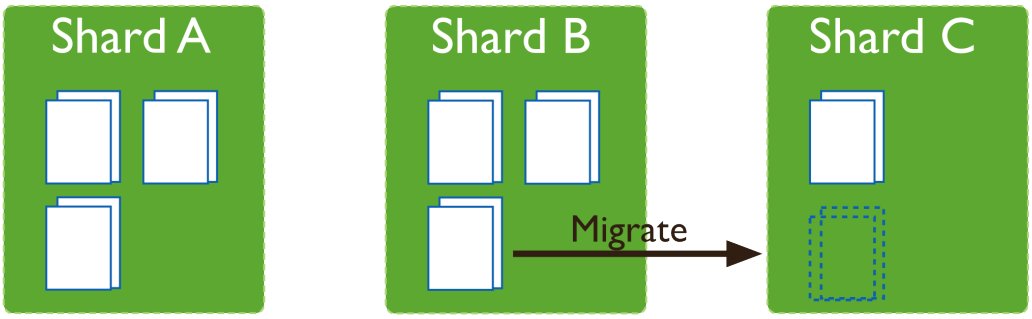
1.4.2 Balancing

The *balancer* (page 29) is a background process that manages chunk migrations. The balancer can run from any of the `mongos` instances in a cluster.

When the distribution of a sharded collection in a cluster is uneven, the balancer process migrates chunks from the shard that has the largest number of chunks to the shard with the least number of chunks until the collection balances. For example: if collection `users` has 100 chunks on *shard 1* and 50 chunks on *shard 2*, the balancer will migrate chunks from *shard 1* to *shard 2* until the collection achieves balance.

The shards manage *chunk migrations* as a background operation between an *origin shard* and a *destination shard*. During a chunk migration, the *destination shard* is sent all the current documents in the chunk from the *origin shard*. Next, the destination shard captures and applies all changes made to the data during the migration process. Finally, the metadata regarding the location of the chunk on *config server* is updated.

If there's an error during the migration, the balancer aborts the process leaving the chunk unchanged on the origin shard. MongoDB removes the chunk's data from the origin shard **after** the migration completes successfully.



1.4.3 Adding and Removing Shards from the Cluster

Adding a shard to a cluster creates an imbalance since the new shard has no chunks. While MongoDB begins migrating data to the new shard immediately, it can take some time before the cluster balances.

When removing a shard, the balancer migrates all chunks from a shard to other shards. After migrating all data and updating the meta data, you can safely remove the shard.

1.5 Additional Resources

- Sharding Methods for MongoDB (Presentation)[2]
- Everything You Need to Know About Sharding (Presentation)[3]
- MongoDB for Time Series Data: Sharding[4]
- MongoDB Operations Best Practices White Paper[5]
- Talk to a MongoDB Expert About Scaling[6]
- MongoDB Consulting Package[7]
- Quick Reference Cards[8]

[2] http://www.mongodb.com/presentations/webinar-sharding-methods-mongodb?jmp=docs
[3] http://www.mongodb.com/presentations/webinar-everything-you-need-know-about-sharding?jmp=docs
[4] http://www.mongodb.com/presentations/mongodb-time-series-data-part-3-sharding?jmp=docs
[5] http://www.mongodb.com/lp/white-paper/ops-best-practices?jmp=docs
[6] http://www.mongodb.com/lp/contact/planning-for-scale?jmp=docs
[7] https://www.mongodb.com/products/consulting?jmp=docs
[8] https://www.mongodb.com/lp/misc/quick-reference-cards?jmp=docs

CHAPTER 2

Sharding Concepts

These documents present the details of sharding in MongoDB. These include the components, the architectures, and the behaviors of MongoDB sharded clusters. For an overview of sharding and sharded clusters, see *Sharding Introduction* (page 3).

Sharded Cluster Components **(page 12)** A sharded cluster consists of shards, config servers, and `mongos` instances.

- ***Shards*** **(page 13)** A shard is a single server or replica set that holds a part of the sharded collection.
- ***Config Servers*** **(page 14)** Config servers hold the metadata about the cluster, such as the shard location of the data.

Sharded Cluster Architectures **(page 15)** Outlines the requirements for sharded clusters, and provides examples of several possible architectures for sharded clusters.

- ***Sharded Cluster Requirements*** **(page 15)** Discusses the requirements for sharded clusters in MongoDB.
- ***Production Cluster Architecture*** **(page 16)** Outlines the components required to deploy a redundant and highly available sharded cluster.

Continue reading from *Sharded Cluster Architectures* (page 15) for additional descriptions of sharded cluster deployments.

Sharded Cluster Behavior **(page 18)** Discusses the operations of sharded clusters with regards to the automatic balancing of data in a cluster and other related availability and security considerations.

- ***Shard Keys*** **(page 19)** MongoDB uses the shard key to divide a collection's data across the cluster's shards.
- ***Sharded Cluster High Availability*** **(page 21)** Sharded clusters provide ways to address some availability concerns.
- ***Sharded Cluster Query Routing*** **(page 23)** The cluster's routers, or `mongos` instances, send reads and writes to the relevant shard or shards.

Sharding Mechanics **(page 29)** Discusses the internal operation and behavior of sharded clusters, including chunk migration, balancing, and the cluster metadata.

- ***Sharded Collection Balancing*** **(page 29)** Balancing distributes a sharded collection's data cluster to all of the shards.
- ***Sharded Cluster Metadata*** **(page 35)** The cluster maintains internal metadata that reflects the location of data within the cluster.

Continue reading from *Sharding Mechanics* (page 29) for more documentation of the behavior and operation of sharded clusters.

2.1 Sharded Cluster Components

Sharded clusters implement *sharding*. A sharded cluster consists of the following components:

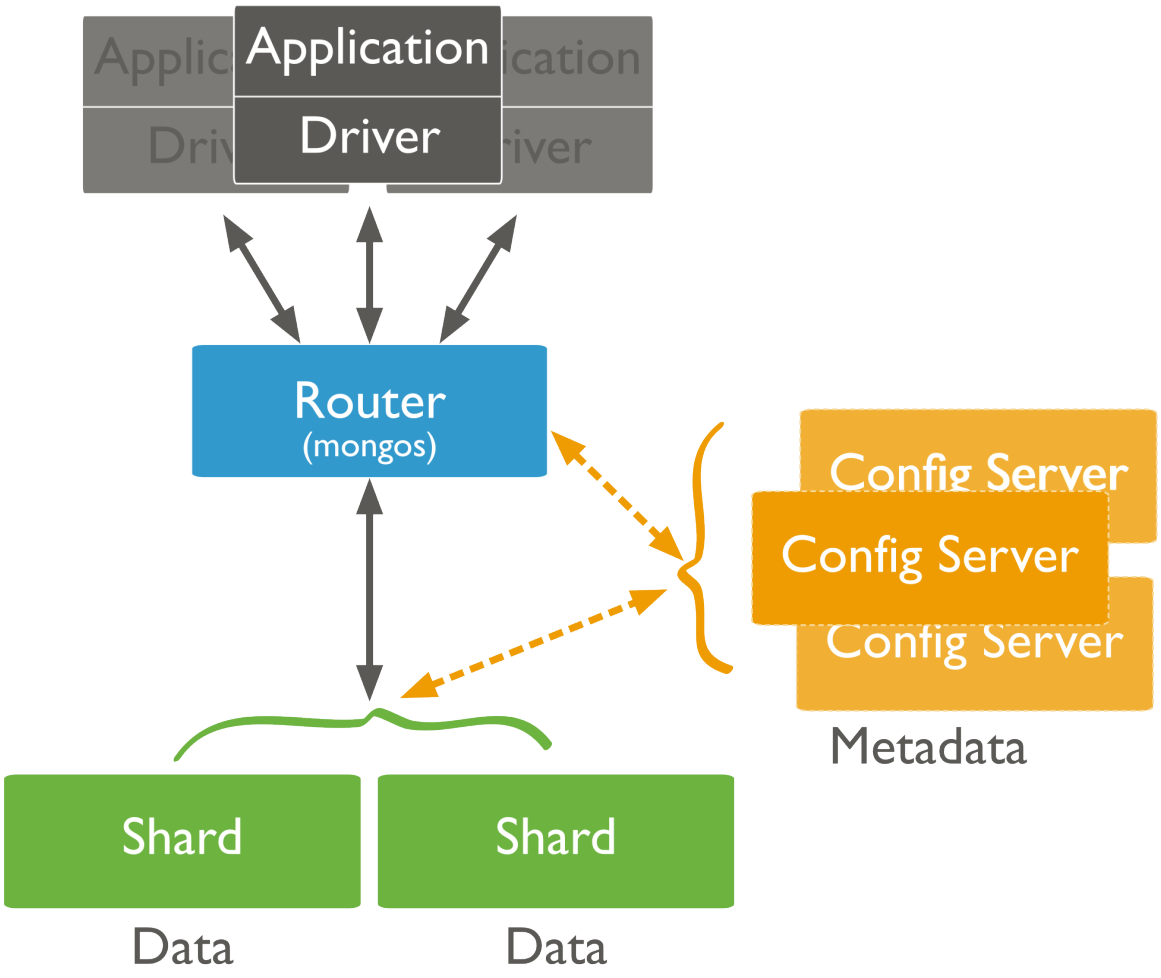
Shards A shard is a MongoDB instance that holds a subset of a collection's data. Each shard is either a single `mongod` instance or a *replica set*. In production, all shards are replica sets. For more information see *Shards* (page 13).

Config Servers *Config servers* (page 14) hold metadata about the sharded cluster. The metadata maps *chunks* to shards.

Changed in version 3.2: Starting in MongoDB 3.2, config servers for sharded clusters can be deployed as a `replica set`. The replica set config servers must run the `WiredTiger storage engine`. MongoDB 3.2 deprecates the use of three mirrored `mongod` instances for config servers.

For more information, see *Config Servers* (page 14).

`mongos` Instances `mongos` instances route the reads and writes from applications to the shards. Applications do not access the shards directly. For more information see *Sharded Cluster Query Routing* (page 23).



To deploy a sharded cluster, see *Deploy a Sharded Cluster* (page 38).

2.1.1 Shards

On this page

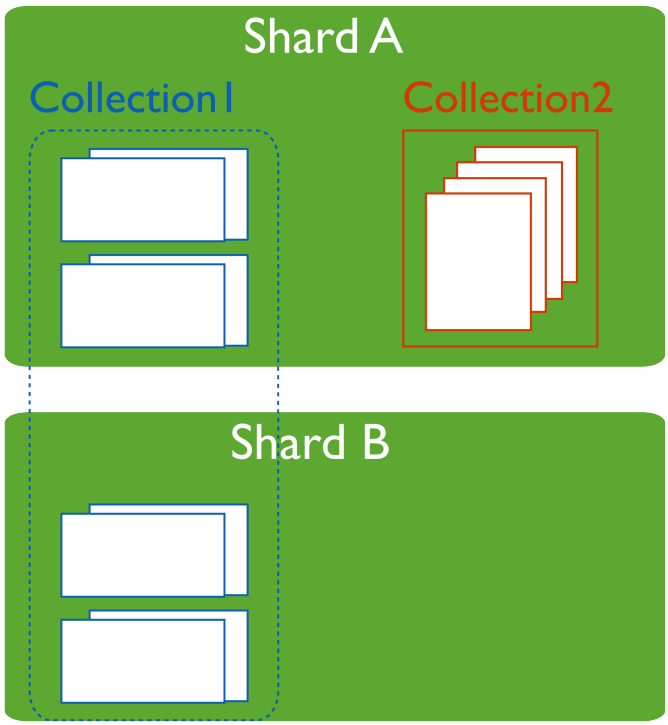
A shard is a *replica set* or a single `mongod` that contains a subset of the data for the sharded cluster. Together, the cluster's shards hold the entire data set for the cluster.

Typically each shard is a replica set. The replica set provides redundancy and high availability for the data in each shard.

Important: MongoDB shards data on a *per collection* basis. You *must* access all data in a sharded cluster via the `mongos` instances. If you connect directly to a shard, you will see only its fraction of the cluster's data. There is no particular order to the data set on a specific shard. MongoDB does not guarantee that any two contiguous chunks will reside on a single shard.

Primary Shard

Every database has a "primary" [1] shard that holds all the un-sharded collections in that database.



To change the primary shard for a database, use the `movePrimary` command. The process of migrating the primary shard may take significant time to complete, and you should not access the collections until it completes.

[1] The term "primary" shard has nothing to do with the term *primary* in the context of *replica sets*.

When you deploy a new *sharded cluster* with shards that were previously used as replica sets, all existing databases continue to reside on their original shard. Databases created subsequently may reside on any shard in the cluster.

Shard Status

Use the `sh.status()` method in the `mongo` shell to see an overview of the cluster. This reports includes which shard is primary for the database and the *chunk* distribution across the shards. See `sh.status()` method for more details.

2.1.2 Config Servers

On this page

Config servers store the *metadata* (page 35) for a sharded cluster.

Warning: If the config servers become inaccessible, the cluster is not accessible. If you cannot recover the data on a config server, the cluster will be inoperable.

MongoDB also uses the config servers to manage distributed locks.

Replica Set Config Servers

Changed in version 3.2.

Starting in MongoDB 3.2, config servers for new sharded clusters can be deployed as a `replica set`. This change improves consistency across the config servers, since MongoDB can take advantage of the standard replica set read and write protocols to replicate the data across the config servers. In addition, using a replica set for config servers allows a sharded cluster to have more than 3 config servers since a replica set can have up to 50 members.

The following restrictions apply to a replica set configuration when used for config servers:

- Must have zero `arbiters`.
- Must have no `delayed members`.
- Must build indexes (i.e. no member should have `buildIndexes` setting set to false).

Earlier versions of MongoDB required *exactly three* mirrored `mongod` instances to act as the config servers. MongoDB 3.2 deprecates the use of three mirrored `mongod` instances for config servers.

Each sharded cluster must have its own config servers. Do not use the same config servers for different sharded clusters.

Read and Write Operations on Config Servers

Config servers store the cluster's metadata in the *config database* (page 95). The `mongos` instances cache this data and use it to route reads and writes to shards.

MongoDB only writes data to the config servers when the metadata changes, such as

- after a *chunk migration* (page 30), or
- after a *chunk split* (page 33).

When writing to the replica set config servers, MongoDB uses a *write concern* of `"majority"`.

MongoDB reads data from the config server in the following cases:

- A new `mongos` starts for the first time, or an existing `mongos` restarts.
- After change in the cluster metadata, such as after a chunk migration.

When reading from the replica set config servers, MongoDB uses a `https://docs.mongodb.org/manual/reference/read` level of `"majority"`.

Config Server Availability

If the config server replica set loses its primary and cannot elect a primary, the cluster's metadata becomes *read only*. You can still read and write data from the shards, but no chunk migration or chunk splits will occur until the replica set can elect a primary. If all config databases become unavailable, the cluster can become inoperable.

The `mongos` instances cache the metadata from the config servers. As such, if all config server members become unavailable, you can still use the cluster if you do not restart the `mongos` instances until after the config servers are accessible again. If you restart the `mongos` instances before the config servers are available, the `mongos` will be unable to route reads and writes.

Clusters become inoperable without the cluster metadata. To ensure that the config servers remain available and intact, backups of config servers are critical. The data on the config server is small compared to the data stored in a cluster, and the config server has a relatively low activity load.

See *A Config Server Replica Set Member Become Unavailable* (page 22) for more information.

2.2 Sharded Cluster Architectures

The following documents introduce deployment patterns for sharded clusters.

Sharded Cluster Requirements **(page 15)** Discusses the requirements for sharded clusters in MongoDB.

Production Cluster Architecture **(page 16)** Outlines the components required to deploy a redundant and highly available sharded cluster.

Sharded Cluster Test Architecture **(page 18)** Sharded clusters for testing and development can include fewer components.

2.2.1 Sharded Cluster Requirements

On this page

While sharding is a powerful and compelling feature, sharded clusters have significant infrastructure requirements and increases the overall complexity of a deployment. As a result, only deploy sharded clusters when indicated by application and operational requirements

Sharding is the *only* solution for some classes of deployments. Use *sharded clusters* if:

- your data set approaches or exceeds the storage capacity of a single MongoDB instance.

- the size of your system's active *working set will soon* exceed the capacity of your system's *maximum* RAM.
- a single MongoDB instance cannot meet the demands of your write operations, and all other approaches have not reduced contention.

If these attributes are not present in your system, sharding will only add complexity to your system without adding much benefit.

Important: It takes time and resources to deploy sharding. If your system has *already* reached or exceeded its capacity, it will be difficult to deploy sharding without impacting your application.

As a result, if you think you will need to partition your database in the future, **do not** wait until your system is over capacity to enable sharding.

When designing your data model, take into consideration your sharding needs.

Data Quantity Requirements

Your cluster should manage a large quantity of data if sharding is to have an effect. The default *chunk* size is 64 megabytes. And the *balancer* (page 29) will not begin moving data across shards until the imbalance of chunks among the shards exceeds the *migration threshold* (page 30). In practical terms, unless your cluster has many hundreds of megabytes of data, your data will remain on a single shard.

In some situations, you may need to shard a small collection of data. But most of the time, sharding a small collection is not worth the added complexity and overhead unless you need additional write capacity. If you have a small data set, a properly configured single MongoDB instance or a replica set will usually be enough for your persistence layer needs.

Chunk size is `user configurable`. For most deployments, the default value is of 64 megabytes is ideal. See *Chunk Size* (page 33) for more information.

2.2.2 Production Cluster Architecture

In a production cluster, you must ensure that data is redundant and that your systems are highly available. To that end, a production cluster must have the following components:

- **Config Servers** Changed in version 3.2: Starting in MongoDB 3.2, config servers for sharded clusters can be deployed as a `replica set`. The replica set config servers must run the `WiredTiger storage engine`. MongoDB 3.2 deprecates the use of three mirrored `mongod` instances for config servers.

  A single *sharded cluster* must have exclusive use of its *config servers* (page 14). If you have multiple sharded clusters, each cluster must have its own replica set config servers.

- **Two or More Replica Sets As Shards** These replica sets are the *shards*. For information on replica sets, see `https://docs.mongodb.org/manual/replication`.

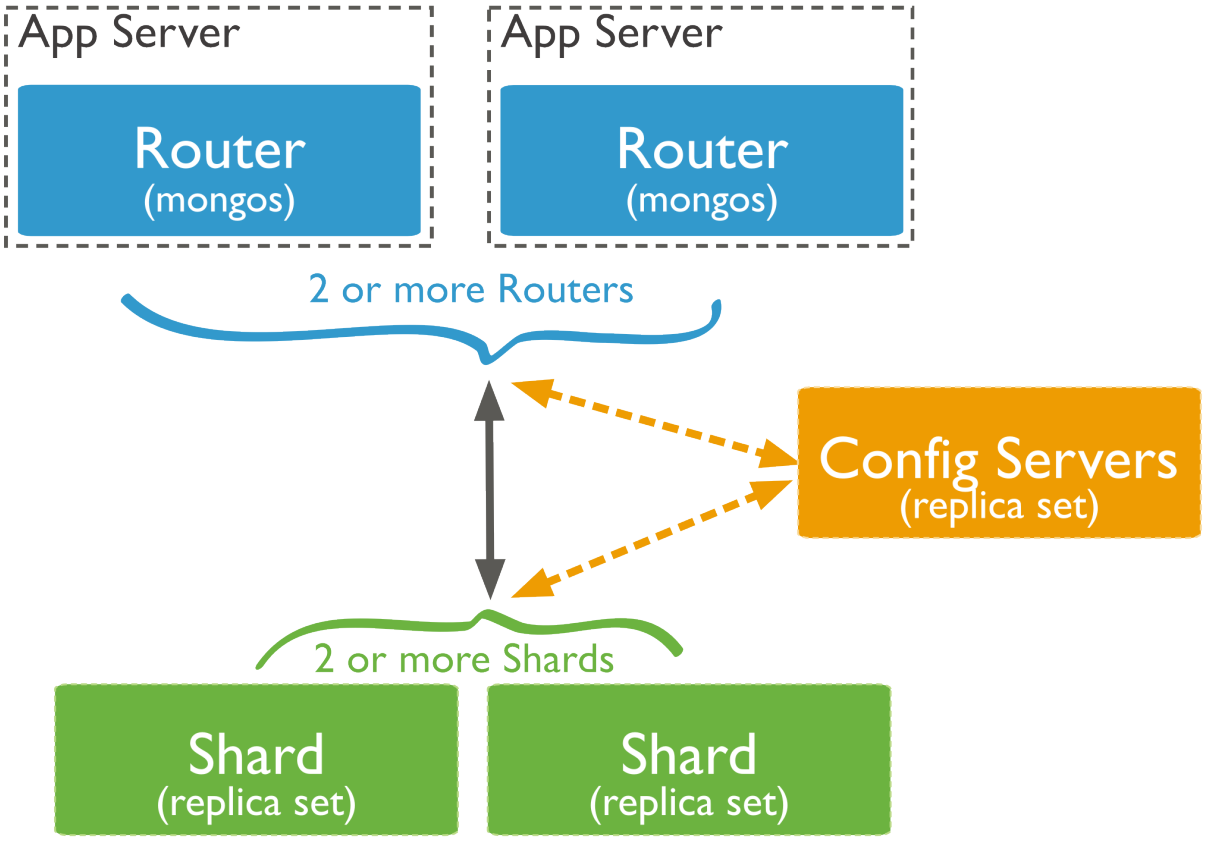
- **One or More Query Routers (`mongos`)** The `mongos` instances are the routers for the cluster. Typically, deployments have one `mongos` instance on each application server.

  You may also deploy a group of `mongos` instances and use a proxy/load balancer between the application and the `mongos`. In these deployments, you *must* configure the load balancer for *client affinity* so that every connection from a single client reaches the same `mongos`.

  Because cursors and other resources are specific to an single `mongos` instance, each client must interact with only one `mongos` instance.

See also:

Deploy a Sharded Cluster (page 38)


App Server
Router
(mongos)
App Server
Router
(mongos)
2 or more Routers
Config Servers
(replica set)
2 or more Shards
Shard
(replica set)
Shard
(replica set)

2.2.3 Sharded Cluster Test Architecture

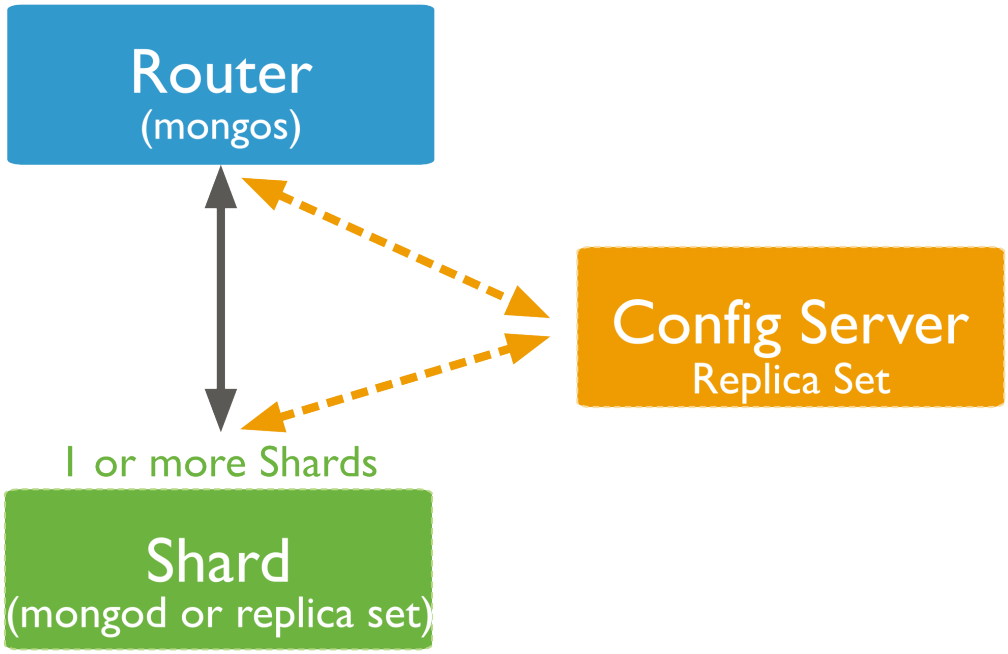
Warning: Use the test cluster architecture for testing and development only.

For testing and development, you can deploy a sharded cluster with a minimum number of components. These **non-production** clusters have the following components:

- A replica set *config server* (page 14) with one member.

  Changed in version 3.2: Starting in MongoDB 3.2, config servers for sharded clusters can be deployed as a `replica set`. The replica set config servers must run the `WiredTiger storage engine`. MongoDB 3.2 deprecates the use of three mirrored `mongod` instances for config servers.

- At least one shard. Shards are either *replica sets* or a standalone `mongod` instances.
- One `mongos` instance.



See

Production Cluster Architecture (page 16)

2.3 Sharded Cluster Behavior

These documents address the distribution of data and queries to a sharded cluster as well as specific security and availability considerations for sharded clusters.

Shard Keys **(page 19)** MongoDB uses the shard key to divide a collection's data across the cluster's shards.

Sharded Cluster High Availability **(page 21)** Sharded clusters provide ways to address some availability concerns.

Sharded Cluster Query Routing **(page 23)** The cluster's routers, or `mongos` instances, send reads and writes to the relevant shard or shards.

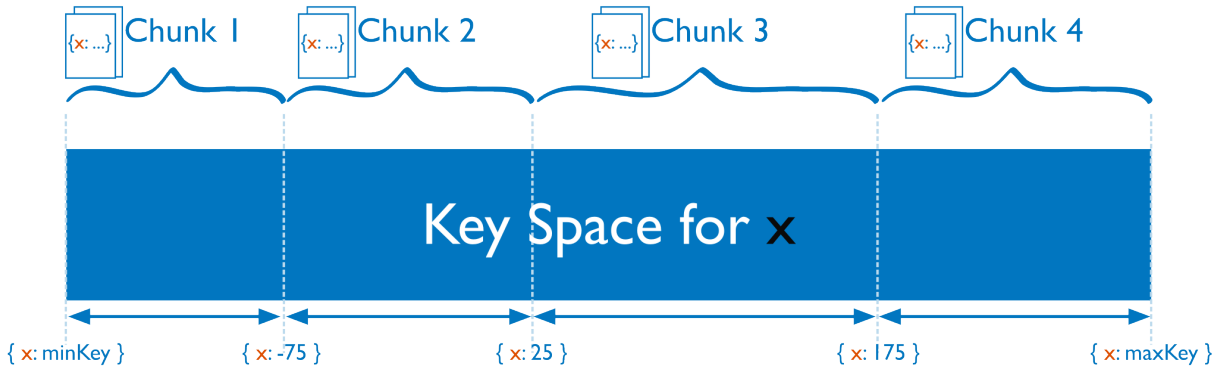
Tag Aware Sharding **(page 27)** Tags associate specific ranges of *shard key* values with specific shards for use in managing deployment patterns.

2.3.1 Shard Keys

On this page

The shard key determines the distribution of the collection's *documents* among the cluster's *shards*. The shard key is either an indexed *field* or an indexed compound field that exists in every document in the collection.

MongoDB partitions data in the collection using ranges of shard key values. Each range, or *chunk*, defines a non-overlapping range of shard key values. MongoDB distributes the chunks, and their documents, among the shards in the cluster.



When a chunk grows beyond the *chunk size* (page 33), MongoDB attempts to *split* the chunk into smaller chunks, always based on ranges in the shard key.

Considerations

Shard keys are immutable and cannot be changed after insertion. See the *system limits for sharded cluster* for more information.

The index on the shard key **cannot** be a *multikey index*.

Hashed Shard Keys

New in version 2.4.

Hashed shard keys use a *hashed index* of a single field as the *shard key* to partition data across your sharded cluster.

The field you choose as your hashed shard key should have a good cardinality, or large number of different values. Hashed keys work well with fields that increase monotonically like *ObjectId* values or timestamps.

If you shard an empty collection using a hashed shard key, MongoDB will automatically create and migrate chunks so that each shard has two chunks. You can control how many chunks MongoDB will create with the `numInitialChunks` parameter to `shardCollection` or by manually creating chunks on the empty collection using the `split` command.

To shard a collection using a hashed shard key, see *Shard a Collection Using a Hashed Shard Key* (page 45).

Tip

MongoDB automatically computes the hashes when resolving queries using hashed indexes. Applications do **not** need to compute hashes.

Impacts of Shard Keys on Cluster Operations

The shard key affects write and query performance by determining how the MongoDB partitions data in the cluster and how effectively the `mongos` instances can direct operations to the cluster. Consider the following operational impacts of shard key selection:

Write Scaling

Some possible shard keys will allow your application to take advantage of the increased write capacity that the cluster can provide, while others do not. Consider the following example where you shard by the values of the default *_id* field, which is *ObjectId*.

MongoDB generates `ObjectId` values upon document creation to produce a unique identifier for the object. However, the most significant bits of data in this value represent a time stamp, which means that they increment in a regular and predictable pattern. Even though this value has *high cardinality* (page 45), when using this, *any date, or other monotonically increasing number* as the shard key, all insert operations will be storing data into a single chunk, and therefore, a single shard. As a result, the write capacity of this shard will define the effective write capacity of the cluster.

A shard key that increases monotonically will not hinder performance if you have a very low insert rate, or if most of your write operations are `update()` operations distributed through your entire data set. Generally, choose shard keys that have *both* high cardinality and will distribute write operations across the *entire cluster*.

Typically, a computed shard key that has some amount of "randomness," such as ones that include a cryptographic hash (i.e. MD5 or SHA1) of other content in the document, will allow the cluster to scale write operations. However, random shard keys do not typically provide *query isolation* (page 21), which is another important characteristic of shard keys.

New in version 2.4: MongoDB makes it possible to shard a collection on a hashed index. This can greatly improve write scaling. See *Shard a Collection Using a Hashed Shard Key* (page 45).

Querying

The `mongos` provides an interface for applications to interact with sharded clusters that hides the complexity of *data partitioning*. A `mongos` receives queries from applications, and uses metadata from the *config server* (page 14), to route queries to the `mongod` instances with the appropriate data. While the `mongos` succeeds in making all querying operational in sharded environments, the *shard key* you select can have a profound affect on query performance.

See also:

The *Sharded Cluster Query Routing* (page 23) and *config server* (page 14) sections for a more general overview of querying in sharded environments.

Query Isolation Generally, the fastest queries in a sharded environment are those that `mongos` will route to a single shard, using the *shard key* and the cluster meta data from the *config server* (page 14). For queries that don't include the shard key, `mongos` must query all shards, wait for their responses and then return the result to the application. These "scatter/gather" queries can be long running operations.

If your query includes the first component of a compound shard key [2], the `mongos` can route the query directly to a single shard, or a small number of shards, which provides better performance. Even if you query values of the shard key that reside in different chunks, the `mongos` will route queries directly to specific shards.

To select a shard key for a collection:

- determine the most commonly included fields in queries for a given application
- find which of these operations are most performance dependent.

If this field has low cardinality (i.e not sufficiently selective) you should add a second field to the shard key making a compound shard key. The data may become more splittable with a compound shard key.

See

Sharded Cluster Query Routing (page 23) for more information on query operations in the context of sharded clusters.

Sorting In sharded systems, the `mongos` performs a merge-sort of all sorted query results from the shards. See *Sharded Cluster Query Routing* (page 23) and *index-sort* for more information.

Indivisible Chunks

An insufficiently granular shard key can result in chunks that are "unsplittable". See *Create a Shard Key that is Easily Divisible* (page 44) for more information.

Additional Information

- *Considerations for Selecting Shard Keys* (page 43)
- *Shard a Collection Using a Hashed Shard Key* (page 45).

2.3.2 Sharded Cluster High Availability

On this page

A *production* (page 16) *cluster* has no single point of failure. This section introduces the availability concerns for MongoDB deployments in general and highlights potential failure scenarios and available resolutions.

[2] In many ways, you can think of the shard key a cluster-wide index. However, be aware that sharded systems cannot enforce cluster-wide unique indexes *unless* the unique field is in the shard key. Consider the `https://docs.mongodb.org/manual/core/indexes` page for more information on indexes and compound indexes.

Application Servers or mongos Instances Become Unavailable

If each application server has its own mongos instance, other application servers can continue to access the database. Furthermore, mongos instances do not maintain persistent state, and they can restart and become unavailable without losing any state or data. When a mongos instance starts, it retrieves a copy of the *config database* and can begin routing queries.

A Single mongod Becomes Unavailable in a Shard

Replica sets provide high availability for shards. If the unavailable mongod is a *primary*, then the replica set will *elect* a new primary. If the unavailable mongod is a *secondary*, and it disconnects the primary and secondary will continue to hold all data. In a three member replica set, even if a single member of the set experiences catastrophic failure, two other members have full copies of the data. [3]

Always investigate availability interruptions and failures. If a system is unrecoverable, replace it and create a new member of the replica set as soon as possible to replace the lost redundancy.

All Members of a Shard Become Unavailable

If all members of a replica set shard are unavailable, all data held in that shard is unavailable. However, the data on all other shards will remain available, and it is possible to read and write data to the other shards. However, your application must be able to deal with partial results, and you should investigate the cause of the interruption and attempt to recover the shard as soon as possible.

A Config Server Replica Set Member Become Unavailable

Changed in version 3.2: Starting in MongoDB 3.2, config servers for sharded clusters can be deployed as a replica set. The replica set config servers must run the WiredTiger storage engine. MongoDB 3.2 deprecates the use of three mirrored mongod instances for config servers.

Replica sets provide high availability for the config servers. If an unavailable config server is a *primary*, then the replica set will *elect* a new primary.

If the replica set config server loses its primary and cannot elect a primary, the cluster's metadata becomes *read only*. You can still read and write data from the shards, but no *chunk migration* (page 29) or *chunk splits* (page 78) will occur until a primary is available. If all config databases become unavailable, the cluster can become inoperable.

Note: All config servers must be running and available when you first initiate a *sharded cluster*.

Renaming Mirrored Config Servers and Cluster Availability

If the sharded cluster is using *mirrored* config servers instead of a replica set and the name or address that a sharded cluster uses to connect to a config server changes, you must restart **every** mongod and mongos instance in the sharded cluster. Avoid downtime by using CNAMEs to identify config servers within the MongoDB deployment.

To avoid downtime when renaming config servers, use DNS names unrelated to physical or virtual hostnames to refer to your *config servers* (page 14).

Generally, refer to each config server using the DNS alias (e.g. a CNAME record). When specifying the config server connection string to mongos, use these names. These records make it possible to change the IP address or rename config servers without changing the connection string and without having to restart the entire cluster.

[3] If an unavailable secondary becomes available while it still has current oplog entries, it can catch up to the latest state of the set using the normal *replication process*; otherwise, it must perform an *initial sync*.

Shard Keys and Cluster Availability

The most important consideration when choosing a *shard key* are:

- to ensure that MongoDB will be able to distribute data evenly among shards, and
- to scale writes across the cluster, and
- to ensure that `mongos` can isolate most queries to a specific `mongod`.

Furthermore:

- Each shard should be a *replica set*, if a specific `mongod` instance fails, the replica set members will elect another to be *primary* and continue operation. However, if an entire shard is unreachable or fails for some reason, that data will be unavailable.
- If the shard key allows the `mongos` to isolate most operations to a single shard, then the failure of a single shard will only render *some* data unavailable.
- If your shard key distributes data required for every operation throughout the cluster, then the failure of the entire shard will render the entire cluster unavailable.

In essence, this concern for reliability simply underscores the importance of choosing a shard key that isolates query operations to a single shard.

2.3.3 Sharded Cluster Query Routing

On this page

MongoDB `mongos` instances route queries and write operations to *shards* in a sharded cluster. `mongos` provide the only interface to a sharded cluster from the perspective of applications. Applications never connect or communicate directly with the shards.

The `mongos` tracks what data is on which shard by caching the metadata from the *config servers* (page 14). The `mongos` uses the metadata to route operations from applications and clients to the `mongod` instances. A `mongos` has no *persistent* state and consumes minimal system resources.

The most common practice is to run `mongos` instances on the same systems as your application servers, but you can maintain `mongos` instances on the shards or on other dedicated resources.

Changed in version 3.2: For `aggregation operations` that run on multiple shards, if the operations do not require running on the database's primary shard, these operations can route the results to any shard to merge the results and avoid overloading the primary shard for that database.

Routing Process

A `mongos` instance uses the following processes to route queries and return results.

How `mongos` Determines which Shards Receive a Query

A `mongos` instance routes a query to a *cluster* by:

1. Determining the list of *shards* that must receive the query.
2. Establishing a cursor on all targeted shards.

In some cases, when the *shard key* or a prefix of the shard key is a part of the query, the `mongos` can route the query to a subset of the shards. Otherwise, the `mongos` must direct the query to *all* shards that hold documents for that collection.

Example

Given the following shard key:

```
{ zipcode: 1, u_id: 1, c_date: 1 }
```

Depending on the distribution of chunks in the cluster, the `mongos` may be able to target the query at a subset of shards, if the query contains the following fields:

```
{ zipcode: 1 }
{ zipcode: 1, u_id: 1 }
{ zipcode: 1, u_id: 1, c_date: 1 }
```

How `mongos` Handles Query Modifiers

If the result of the query is not sorted, the `mongos` instance opens a result cursor that "round robins" results from all cursors on the shards.

If the query specifies sorted results using the `sort()` cursor method, the `mongos` instance passes the `$orderby` option to the shards. The primary shard for the database receives and performs a merge sort for all results before returning the data to the client via the `mongos`.

If the query limits the size of the result set using the `limit()` cursor method, the `mongos` instance passes that limit to the shards and then re-applies the limit to the result before returning the result to the client.

If the query specifies a number of records to *skip* using the `skip()` cursor method, the `mongos` *cannot* pass the skip to the shards, but rather retrieves unskipped results from the shards and skips the appropriate number of documents when assembling the complete result. However, when used in conjunction with a `limit()`, the `mongos` will pass the *limit* plus the value of the `skip()` to the shards to improve the efficiency of these operations.

Detect Connections to `mongos` Instances

To detect if the MongoDB instance that your client is connected to is `mongos`, use the `isMaster` command. When a client connects to a `mongos`, `isMaster` returns a document with a `msg` field that holds the string `isdbgrid`. For example:

```
{
   "ismaster" : true,
   "msg" : "isdbgrid",
   "maxBsonObjectSize" : 16777216,
   "ok" : 1
}
```

If the application is instead connected to a `mongod`, the returned document does not include the `isdbgrid` string.

Broadcast Operations and Targeted Operations

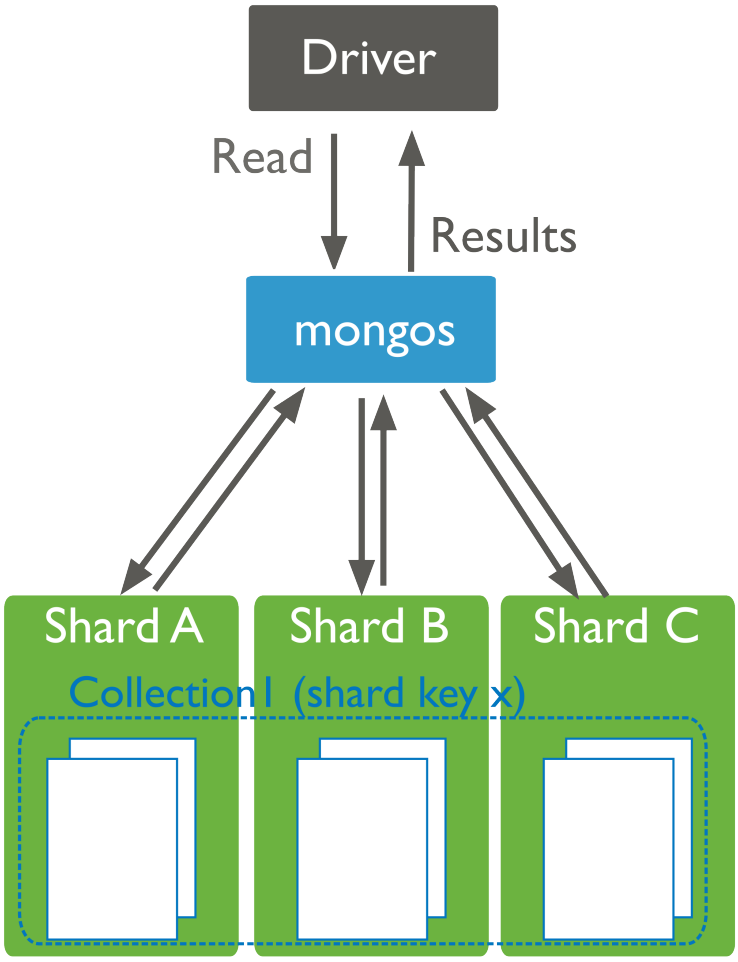
In general, operations in a sharded environment are either:

- Broadcast to all shards in the cluster that hold documents in a collection
- Targeted at a single shard or a limited group of shards, based on the shard key

For best performance, use targeted operations whenever possible. While some operations must broadcast to all shards, you can ensure MongoDB uses targeted operations whenever possible by always including the shard key.

Broadcast Operations

`mongos` instances broadcast queries to all shards for the collection **unless** the `mongos` can determine which shard or subset of shards stores this data.



Multi-update operations are always broadcast operations.

The `remove()` operation is always a broadcast operation, unless the operation specifies the shard key in full.

Targeted Operations

All `insert()` operations target to one shard.

All single `update()` (including *upsert* operations) and `remove()` operations must target to one shard.

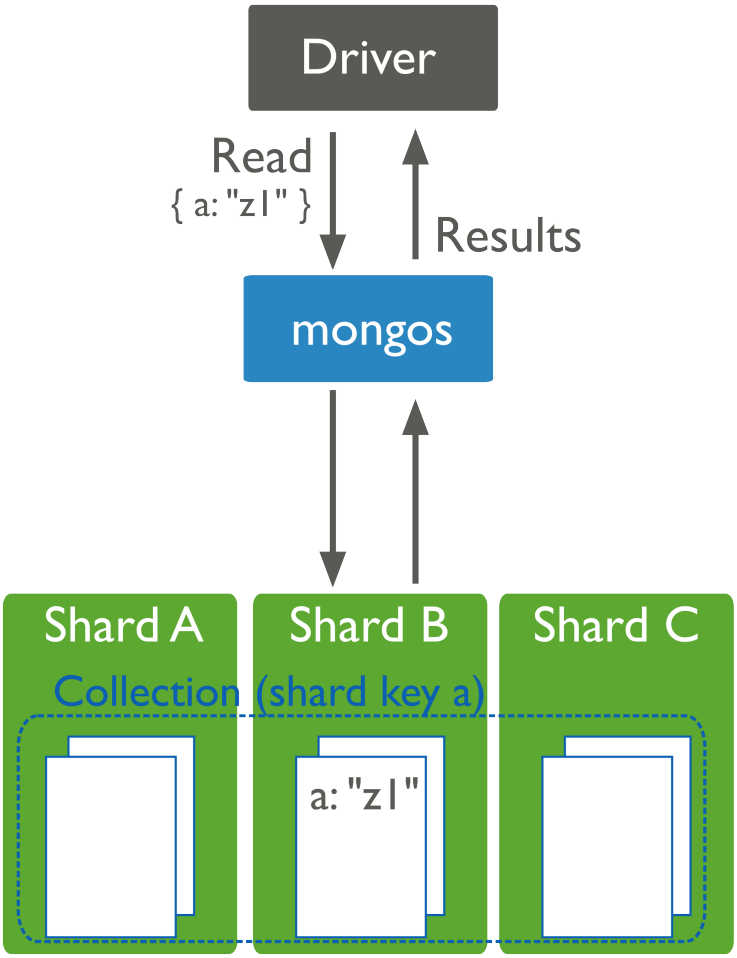
Important: All `update()` and `remove()` operations for a sharded collection that specify the `justOne` or `multi: false` option must include the *shard key or* the `_id` field in the query specification. `update()` and `remove()` operations specifying `justOne` or `multi: false` in a sharded collection without the *shard key or* the `_id` field return an error.

For queries that include the shard key or portion of the shard key, `mongos` can target the query at a specific shard or set of shards. This is the case only if the portion of the shard key included in the query is a *prefix* of the shard key. For example, if the shard key is:

```
{ a: 1, b: 1, c: 1 }
```

The `mongos` program *can* route queries that include the full shard key or either of the following shard key prefixes at a specific shard or set of shards:

```
{ a: 1 }
{ a: 1, b: 1 }
```

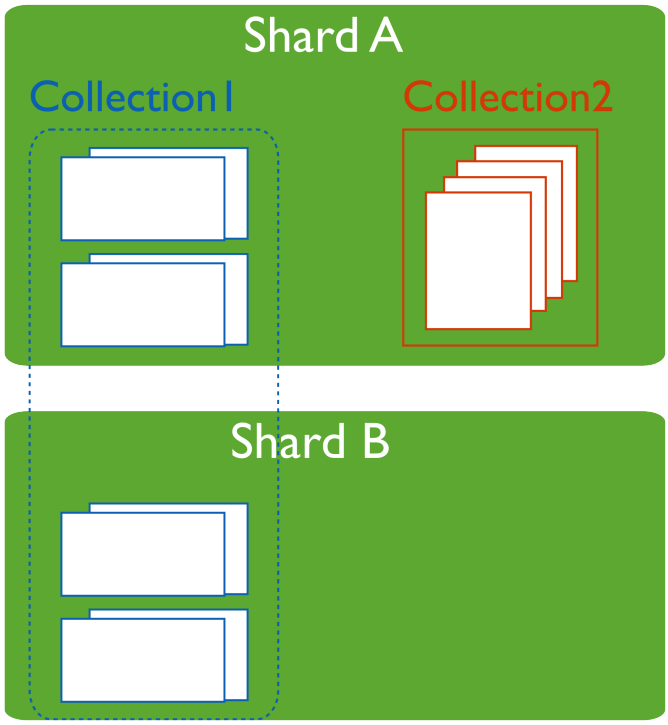


Depending on the distribution of data in the cluster and the selectivity of the query, `mongos` may still have to contact multiple shards [4] to fulfill these queries.

[4] `mongos` will route some queries, even some that include the shard key, to all shards, if needed.

Sharded and Non-Sharded Data

Sharding operates on the collection level. You can shard multiple collections within a database or have multiple databases with sharding enabled. [5] However, in production deployments, some databases and collections will use sharding, while other databases and collections will only reside on a single shard.



Regardless of the data architecture of your *sharded cluster*, ensure that all queries and operations use the *mongos* router to access the data cluster. Use the `mongos` even for operations that do not impact the sharded data.

2.3.4 Tag Aware Sharding

On this page

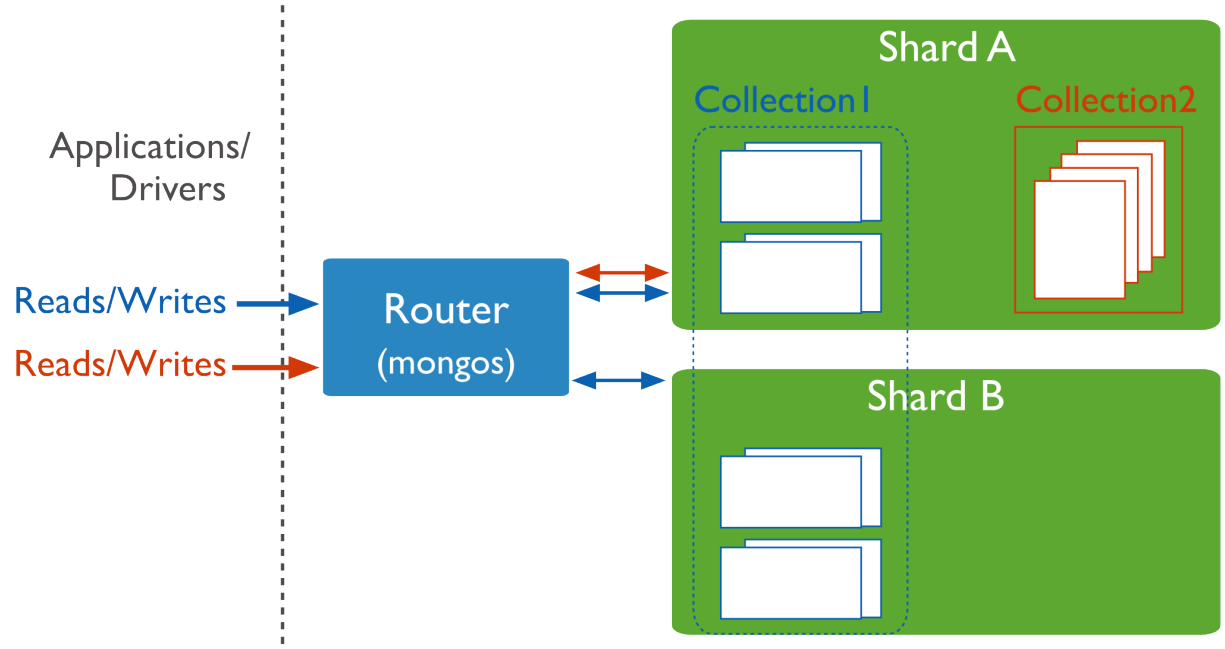
MongoDB supports tagging a range of *shard key* values to associate that range with a shard or group of shards. Those shards receive all inserts within the tagged range.

The balancer obeys tagged range associations, which enables the following deployment patterns:

- isolate a specific subset of data on a specific set of shards.
- ensure that the most relevant data reside on shards that are geographically closest to the application servers.

This document describes the behavior, operation, and use of tag aware sharding in MongoDB deployments.

[5] As you configure sharding, you will use the `enableSharding` command to enable sharding for a database. This simply makes it possible to use the `shardCollection` command on a collection within that database.



Considerations

- *Shard key* range tags are distinct from *replica set member tags*.
- *Hash-based sharding* only supports tag-aware sharding on an entire collection.
- Shard ranges are always inclusive of the lower value and exclusive of the upper boundary.

Behavior and Operations

The balancer migrates chunks of documents in a sharded collection to the shards associated with a tag that has a *shard key* range with an *upper* bound *greater* than the chunk's *lower* bound.

During balancing rounds, if the balancer detects that any chunks violate configured tags, the balancer migrates those chunks to shards associated with those tags.

After configuring a tag with a shard key range and associating it with a shard or shards, the cluster may take some time to balance the data among the shards. This depends on the division of chunks and the current distribution of data in the cluster.

Once configured, the balancer respects tag ranges during future *balancing rounds* (page 29).

See also:

Manage Shard Tags (page 86)

Additional Resource

- Whitepaper: MongoDB Multi-Data Center Deployments[6]
- Webinar: Multi-Data Center Deployment[7]

[6] http://www.mongodb.com/lp/white-paper/multi-dc?jmp=docs
[7] https://www.mongodb.com/presentations/webinar-multi-data-center-deployment?jmp=docs

2.4 Sharding Mechanics

The following documents describe sharded cluster processes.

Sharded Collection Balancing **(page 29)** Balancing distributes a sharded collection's data cluster to all of the shards.

Chunk Migration Across Shards **(page 30)** MongoDB migrates chunks to shards as part of the balancing process.

Chunk Splits in a Sharded Cluster **(page 33)** When a chunk grows beyond the configured size, MongoDB splits the chunk in half.

Shard Key Indexes **(page 34)** Sharded collections must keep an index that starts with the shard key.

Sharded Cluster Metadata **(page 35)** The cluster maintains internal metadata that reflects the location of data within the cluster.

2.4.1 Sharded Collection Balancing

On this page

Balancing is the process MongoDB uses to distribute data of a sharded collection evenly across a *sharded cluster*. When a *shard* has too many of a sharded collection's *chunks* compared to other shards, MongoDB automatically balances the chunks across the shards. The balancing procedure for *sharded clusters* is entirely transparent to the user and application layer.

Cluster Balancer

The *balancer* process is responsible for redistributing the chunks of a sharded collection evenly among the shards for every sharded collection. By default, the balancer process is always enabled.

Any `mongos` instance in the cluster can start a balancing round. When a balancer process is active, the responsible `mongos` acquires a "lock" by modifying a document in the `lock` collection in the *Config Database* (page 95).

Changed in version 3.2: With replica set config servers, clock skew does not affect distributed lock management. If you are using *mirrored* config servers, large differences in timekeeping can lead to failed distributed locks. With *mirrored* config servers, minimize clock skew by running the network time protocol (NTP) `ntpd` on your servers.

To address uneven chunk distribution for a sharded collection, the balancer *migrates chunks* (page 30) from shards with more chunks to shards with a fewer number of chunks. The balancer migrates the chunks, one at a time, until there is an even distribution of chunks for the collection across the shards. For details about chunk migration, see *Chunk Migration Procedure* (page 31).

Changed in version 2.6: Chunk migrations can have an impact on disk space. Starting in MongoDB 2.6, the source shard automatically archives the migrated documents by default. For details, see *moveChunk directory* (page 32).

Chunk migrations carry some overhead in terms of bandwidth and workload, both of which can impact database performance. The *balancer* attempts to minimize the impact by:

- Moving only one chunk at a time. See also *Chunk Migration Queuing* (page 32).
- Starting a balancing round **only** when the difference in the number of chunks between the shard with the greatest number of chunks for a sharded collection and the shard with the lowest number of chunks for that collection reaches the *migration threshold* (page 30).

You may disable the balancer temporarily for maintenance. See *Disable the Balancer* (page 72) for details.

You can also limit the window during which the balancer runs to prevent it from impacting production traffic. See *Schedule the Balancing Window* (page 71) for details.

Note: The specification of the balancing window is relative to the local time zone of all individual `mongos` instances in the cluster.

See also:

Manage Sharded Cluster Balancer (page 69).

Migration Thresholds

To minimize the impact of balancing on the cluster, the *balancer* will not begin balancing until the distribution of chunks for a sharded collection has reached certain thresholds. The thresholds apply to the difference in number of *chunks* between the shard with the most chunks for the collection and the shard with the fewest chunks for that collection. The balancer has the following thresholds:

Number of Chunks	Migration Threshold
Fewer than 20	2
20-79	4
80 and greater	8

Once a balancing round starts, the balancer will not stop until, for the collection, the difference between the number of chunks on any two shards for that collection is *less than two* or a chunk migration fails.

Shard Size

By default, MongoDB will attempt to fill all available disk space with data on every shard as the data set grows. To ensure that the cluster always has the capacity to handle data growth, monitor disk usage as well as other performance metrics.

When adding a shard, you may set a "maximum size" for that shard. This prevents the *balancer* from migrating chunks to the shard when the value of `mem.mapped` exceeds the "maximum size". Use the `maxSize` parameter of the `addShard` command to set the "maximum size" for the shard.

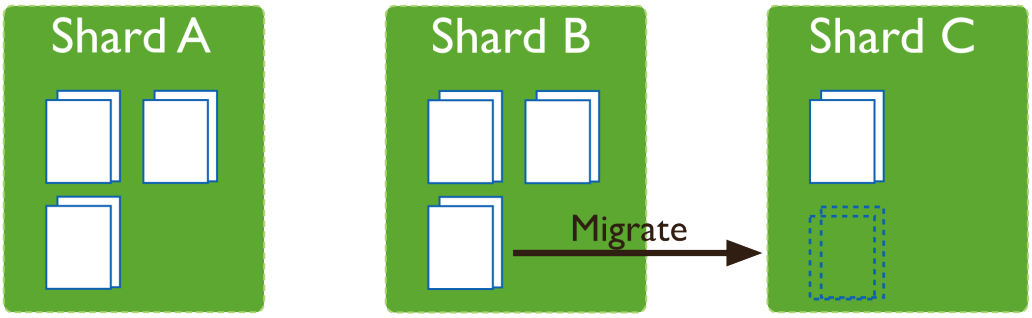
See also:

Change the Maximum Storage Size for a Given Shard (page 68) and `https://docs.mongodb.org/manual/administration/monitoring`.

2.4.2 Chunk Migration Across Shards

On this page

Chunk migration moves the chunks of a sharded collection from one shard to another and is part of the *balancer* (page 29) process.



Chunk Migration

MongoDB migrates chunks in a *sharded cluster* to distribute the chunks of a sharded collection evenly among shards. Migrations may be either:

- Manual. Only use manual migration in limited cases, such as to distribute data during bulk inserts. See *Migrating Chunks Manually* (page 79) for more details.
- Automatic. The *balancer* (page 29) process automatically migrates chunks when there is an uneven distribution of a sharded collection's chunks across the shards. See *Migration Thresholds* (page 30) for more details.

Chunk Migration Procedure

All chunk migrations use the following procedure:

1. The balancer process sends the `moveChunk` command to the source shard.
2. The source starts the move with an internal `moveChunk` command. During the migration process, operations to the chunk route to the source shard. The source shard is responsible for incoming write operations for the chunk.
3. The destination shard builds any indexes required by the source that do not exist on the destination.
4. The destination shard begins requesting documents in the chunk and starts receiving copies of the data.
5. After receiving the final document in the chunk, the destination shard starts a synchronization process to ensure that it has the changes to the migrated documents that occurred during the migration.
6. When fully synchronized, the destination shard connects to the *config database* and updates the cluster metadata with the new location for the chunk.
7. After the destination shard completes the update of the metadata, and once there are no open cursors on the chunk, the source shard deletes its copy of the documents.

Note: If the balancer needs to perform additional chunk migrations from the source shard, the balancer can start the next chunk migration without waiting for the current migration process to finish this deletion step. See *Chunk Migration Queuing* (page 32).

Changed in version 2.6: The source shard automatically archives the migrated documents by default. For more information, see *moveChunk directory* (page 32).

The migration process ensures consistency and maximizes the availability of chunks during balancing.

Chunk Migration Queuing

To migrate multiple chunks from a shard, the balancer migrates the chunks one at a time. However, the balancer does not wait for the current migration's delete phase to complete before starting the next chunk migration. See *Chunk Migration* (page 31) for the chunk migration process and the delete phase.

This queuing behavior allows shards to unload chunks more quickly in cases of heavily imbalanced cluster, such as when performing initial data loads without pre-splitting and when adding new shards.

This behavior also affect the `moveChunk` command, and migration scripts that use the `moveChunk` command may proceed more quickly.

In some cases, the delete phases may persist longer. If multiple delete phases are queued but not yet complete, a crash of the replica set's primary can orphan data from multiple migrations.

The `_waitForDelete`, available as a setting for the balancer as well as the `moveChunk` command, can alter the behavior so that the delete phase of the current migration blocks the start of the next chunk migration. The `_waitForDelete` is generally for internal testing purposes. For more information, see *Wait for Delete* (page 69).

Chunk Migration and Replication

Changed in version 3.0: The default value `secondaryThrottle` became `true` for all chunk migrations.

The new `writeConcern` field in the balancer configuration document allows you to specify a `write concern` semantics with the `_secondaryThrottle` option.

By default, each document operation during chunk migration propagates to at least one secondary before the balancer proceeds with the next document, which is equivalent to a write concern of `{ w: 2 }`. You can set the `writeConcern` option on the balancer configuration to set different write concern semantics.

To override this behavior and allow the balancer to continue without waiting for replication to a secondary, set the `_secondaryThrottle` parameter to `false`. See *Change Replication Behavior for Chunk Migration* (page 68) to update the `_secondaryThrottle` parameter for the balancer.

For the `moveChunk` command, the `secondaryThrottle` parameter is independent of the `_secondaryThrottle` parameter for the balancer.

Independent of the `secondaryThrottle` setting, certain phases of the chunk migration have the following replication policy:

- MongoDB briefly pauses all application writes to the source shard before updating the config servers with the new location for the chunk, and resumes the application writes after the update. The chunk move requires all writes to be acknowledged by majority of the members of the replica set both before and after committing the chunk move to config servers.
- When an outgoing chunk migration finishes and cleanup occurs, all writes must be replicated to a majority of servers before further cleanup (from other outgoing migrations) or new incoming migrations can proceed.

`moveChunk` directory

Starting in MongoDB 2.6, `sharding.archiveMovedChunks` is enabled by default. With `sharding.archiveMovedChunks` enabled, the source shard archives the documents in the migrated chunks in a directory named after the collection namespace under the `moveChunk` directory in the `storage.dbPath`.

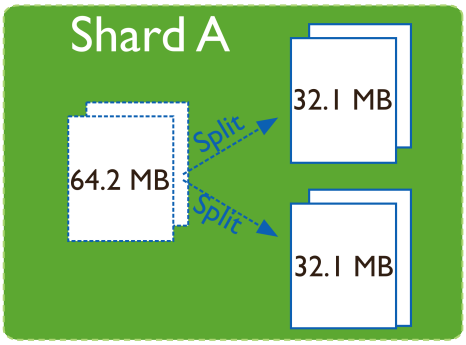
Jumbo Chunks

During chunk migration, if the chunk exceeds the *specified chunk size* (page 33) or if the number of documents in the chunk exceeds `Maximum Number of Documents Per Chunk to Migrate`, MongoDB does not migrate the chunk. Instead, MongoDB attempts to *split* (page 33) the chunk. If the split is unsuccessful, MongoDB labels the chunk as *jumbo* to avoid repeated attempts to migrate the chunk.

2.4.3 Chunk Splits in a Sharded Cluster

On this page

As chunks grow beyond the *specified chunk size* (page 33) a `mongos` instance will attempt to split the chunk in half. Splits may lead to an uneven distribution of the chunks for a collection across the shards. In such cases, the `mongos` instances will initiate a round of migrations to redistribute chunks across shards. See *Sharded Collection Balancing* (page 29) for more details on balancing chunks across shards.



Chunk Size

The default *chunk* size in MongoDB is 64 megabytes. You can *increase or reduce the chunk size* (page 83), mindful of its effect on the cluster's efficiency.

1. Small chunks lead to a more even distribution of data at the expense of more frequent migrations. This creates expense at the query routing (`mongos`) layer.
2. Large chunks lead to fewer migrations. This is more efficient both from the networking perspective *and* in terms of internal overhead at the query routing layer. But, these efficiencies come at the expense of a potentially more uneven distribution of data.
3. Chunk size affects the `Maximum Number of Documents Per Chunk to Migrate`.

For many deployments, it makes sense to avoid frequent and potentially spurious migrations at the expense of a slightly less evenly distributed data set.

Limitations

Changing the chunk size affects when chunks split but there are some limitations to its effects.

- Automatic splitting only occurs during inserts or updates. If you lower the chunk size, it may take time for all chunks to split to the new size.
- Splits cannot be "undone". If you increase the chunk size, existing chunks must grow through inserts or updates until they reach the new size.

Note: Chunk ranges are inclusive of the lower boundary and exclusive of the upper boundary.

Indivisible Chunks

In some cases, chunks can grow beyond the *specified chunk size* (page 33) but cannot undergo a split; e.g. if a chunk represents a single shard key value. See *Considerations for Selecting Shard Keys* (page 43) for considerations for selecting a shard key.

2.4.4 Shard Key Indexes

On this page

All sharded collections **must** have an index that starts with the *shard key*; i.e. the index can be an index on the shard key or a *compound index* where the shard key is a prefix of the index.

If you shard a collection without any documents and *without* such an index, the `shardCollection` command will create the index on the shard key. If the collection already has documents, you must create the index before using `shardCollection`.

Important: The index on the shard key **cannot** be a *multikey index*.

Example

A sharded collection named `people` has for its shard key the field `zipcode`. It currently has the index `{ zipcode: 1 }`. You can replace this index with a compound index `{ zipcode: 1, username: 1 }`, as follows:

1. Create an index on `{ zipcode: 1, username: 1 }`:

   ```
   db.people.createIndex( { zipcode: 1, username: 1 } );
   ```

2. When MongoDB finishes building the index, you can safely drop the existing index on `{ zipcode: 1 }`:

   ```
   db.people.dropIndex( { zipcode: 1 } );
   ```

Since the index on the shard key cannot be a multikey index, the index `{ zipcode: 1, username: 1 }` can only replace the index `{ zipcode: 1 }` if there are no array values for the `username` field.

If you drop the last valid index for the shard key, recover by recreating an index on just the shard key.

For restrictions on shard key indexes, see *limits-shard-keys*.

2.4.5 Sharded Cluster Metadata

Config servers (page 14) store the metadata for a sharded cluster. The metadata reflects state and organization of the sharded data sets and system. The metadata includes the list of chunks on every shard and the ranges that define the chunks. The `mongos` instances cache this data and use it to route read and write operations to shards.

Config servers store the metadata in the *Config Database* (page 95).

Important: Always back up the `config` database before doing any maintenance on the config server.

To access the `config` database, issue the following command from the `mongo` shell:

```
use config
```

In general, you should *never* edit the content of the `config` database directly. The `config` database contains the following collections:

- `changelog` (page 96)
- `chunks` (page 97)
- `collections` (page 98)
- `databases` (page 98)
- `lockpings` (page 98)
- `locks` (page 99)
- `mongos` (page 99)
- `settings` (page 99)
- `shards` (page 100)
- `version` (page 100)

For more information on these collections and their role in sharded clusters, see *Config Database* (page 95). See *Read and Write Operations on Config Servers* (page 14) for more information about reads and updates to the metadata.

CHAPTER 3

Sharded Cluster Tutorials

The following tutorials provide instructions for administering *sharded clusters*. For a higher-level overview, see *Sharding* (page 1).

Sharded Cluster Deployment Tutorials **(page 37)** Instructions for deploying sharded clusters, adding shards, selecting shard keys, and the initial configuration of sharded clusters.

- ***Deploy a Sharded Cluster*** **(page 38)** Set up a sharded cluster by creating the needed data directories, starting the required MongoDB instances, and configuring the cluster settings.
- ***Considerations for Selecting Shard Keys*** **(page 43)** Choose the field that MongoDB uses to parse a collection's documents for distribution over the cluster's shards. Each shard holds documents with values within a certain range.
- ***Shard a Collection Using a Hashed Shard Key*** **(page 45)** Shard a collection based on hashes of a field's values in order to ensure even distribution over the collection's shards.
- ***Add Shards to a Cluster*** **(page 46)** Add a shard to add capacity to a sharded cluster.

Continue reading from *Sharded Cluster Deployment Tutorials* (page 37) for additional tutorials.

Sharded Cluster Maintenance Tutorials **(page 58)** Procedures and tasks for common operations on active sharded clusters.

- ***View Cluster Configuration*** **(page 58)** View status information about the cluster's databases, shards, and chunks.
- ***Remove Shards from an Existing Sharded Cluster*** **(page 74)** Migrate a single shard's data and remove the shard.
- ***Manage Shard Tags*** **(page 86)** Use tags to associate specific ranges of shard key values with specific shards.

Continue reading from *Sharded Cluster Maintenance Tutorials* (page 58) for additional tutorials.

Sharded Cluster Data Management **(page 76)** Practices that address common issues in managing large sharded data sets.

Troubleshoot Sharded Clusters **(page 91)** Presents solutions to common issues and concerns relevant to the administration and use of sharded clusters. Refer to `https://docs.mongodb.org/manual/faq/diagnostics` for general diagnostic information.

3.1 Sharded Cluster Deployment Tutorials

The following tutorials provide information on deploying sharded clusters.

Deploy a Sharded Cluster **(page 38)** Set up a sharded cluster by creating the needed data directories, starting the required MongoDB instances, and configuring the cluster settings.

Considerations for Selecting Shard Keys **(page 43)** Choose the field that MongoDB uses to parse a collection's documents for distribution over the cluster's shards. Each shard holds documents with values within a certain range.

Shard a Collection Using a Hashed Shard Key **(page 45)** Shard a collection based on hashes of a field's values in order to ensure even distribution over the collection's shards.

Add Shards to a Cluster **(page 46)** Add a shard to add capacity to a sharded cluster.

Convert a Replica Set to a Sharded Cluster **(page 48)** Convert a replica set to a sharded cluster in which each shard is its own replica set.

Upgrade Config Servers to Replica Set **(page 53)** Replace your sharded cluster with a single replica set.

Convert Sharded Cluster to Replica Set **(page 57)** Replace your sharded cluster with a single replica set.

3.1.1 Deploy a Sharded Cluster

On this page

Changed in version 3.2.

Starting in MongoDB 3.2, config servers for sharded clusters can be deployed as a `replica set`. The replica set config servers must run the `WiredTiger storage engine`. MongoDB 3.2 deprecates the use of three mirrored `mongod` instances for config servers.

The following tutorial deploys a new sharded cluster for MongoDB 3.2. To deploy a sharded cluster for earlier versions of MongoDB, refer to the corresponding version of the MongoDB Manual.

Considerations

Host Identifier

Warning: Sharding and "localhost" Addresses
If you use either "localhost" or `127.0.0.1` as the hostname portion of any host identifier, for example as the `host` argument to `addShard` or the value to the `--configdb` run time option, then you must use "localhost" or `127.0.0.1` for *all* host settings for any MongoDB instances in the cluster. If you mix localhost addresses and remote host address, MongoDB will error.

Connectivity

All members of a sharded cluster must be able to connect to *all* other members of a sharded cluster, including all shards and all config servers. Ensure that the network and security systems, including all interfaces and firewalls, allow these

connections.

Deploy the Config Server Replica Set

Changed in version 3.2: Starting in MongoDB 3.2, config servers for sharded clusters can be deployed as a `replica set`. The replica set config servers must run the `WiredTiger storage engine`. MongoDB 3.2 deprecates the use of three mirrored `mongod` instances for config servers.

The following restrictions apply to a replica set configuration when used for config servers:

- Must have zero `arbiters`.
- Must have no `delayed members`.
- Must build indexes (i.e. no member should have `buildIndexes` setting set to false).

The config servers store the sharded cluster's metadata. The following steps deploy a three member replica set for the config servers.

1. Start all the config servers with both the *`--configsvr`* and *`--replSet <name>`* options:

   ```
   mongod --configsvr --replSet configReplSet --port <port> --dbpath <path>
   ```

   Or if using a `configuration file`, include the `sharding.clusterRole` and `replication.replSetName` setting:

   ```
   sharding:
      clusterRole: configsvr
   replication:
      replSetName: configReplSet
   net:
      port: <port>
   storage:
      dbpath: <path>
   ```

   For additional options, see `https://docs.mongodb.org/manual/reference/program/mongod` or `https://docs.mongodb.org/manual/reference/configuration-options`.

2. Connect a `mongo` shell to one of the config servers and run `rs.initiate()` to initiate the replica set.

   ```
   rs.initiate( {
      _id: "configReplSet",
      configsvr: true,
      members: [
         { _id: 0, host: "<host1>:<port1>" },
         { _id: 1, host: "<host2>:<port2>" },
         { _id: 2, host: "<host3>:<port3>" }
      ]
   } )
   ```

To use the deprecated mirrored config server deployment topology, see *Start 3 Mirrored Config Servers (Deprecated)* (page 42).

Start the `mongos` Instances

The `mongos` instances are lightweight and do not require data directories. You can run a `mongos` instance on a system that runs other cluster components, such as on an application server or a server running a `mongod` process. By default, a `mongos` instance runs on port `27017`.

When you start the mongos instance, specify the config servers, using either the sharding.configDB setting in the configuration file or the *--configdb* command line option.

Note: All config servers must be running and available when you first initiate a *sharded cluster*.

1. Start one or more mongos instances. For *--configdb*, or sharding.configDB, specify the config server replica set name followed by a slash https://docs.mongodb.org/manual/ and at least one of the config server hostnames and ports:

   ```
   mongos --configdb configReplSet/<cfgsvr1:port1>,<cfgsvr2:port2>,<cfgsvr3:port3>
   ```

If using the deprecated mirrored config server deployment topology, see *Start the mongos Instances (Deprecated)* (page 43).

Add Shards to the Cluster

A *shard* can be a standalone mongod or a *replica set*. In a production environment, each shard should be a replica set. Use the procedure in https://docs.mongodb.org/manual/tutorial/deploy-replica-set to deploy replica sets for each shard.

1. From a mongo shell, connect to the mongos instance. Issue a command using the following syntax:

   ```
   mongo --host <hostname of machine running mongos> --port <port mongos listens on>
   ```

   For example, if a mongos is accessible at mongos0.example.net on port 27017, issue the following command:

   ```
   mongo --host mongos0.example.net --port 27017
   ```

2. Add each shard to the cluster using the sh.addShard() method, as shown in the examples below. Issue sh.addShard() separately for each shard. If the shard is a replica set, specify the name of the replica set and specify a member of the set. In production deployments, all shards should be replica sets.

   Optional

   You can instead use the addShard database command, which lets you specify a name and maximum size for the shard. If you do not specify these, MongoDB automatically assigns a name and maximum size. To use the database command, see addShard.

   The following are examples of adding a shard with sh.addShard():

   - To add a shard for a replica set named rs1 with a member running on port 27017 on mongodb0.example.net, issue the following command:

     ```
     sh.addShard( "rs1/mongodb0.example.net:27017" )
     ```

   - To add a shard for a standalone mongod on port 27017 of mongodb0.example.net, issue the following command:

     ```
     sh.addShard( "mongodb0.example.net:27017" )
     ```

   Note: It might take some time for *chunks* to migrate to the new shard.

Enable Sharding for a Database

Before you can shard a collection, you must enable sharding for the collection's database. Enabling sharding for a database does not redistribute data but make it possible to shard the collections in that database.

Once you enable sharding for a database, MongoDB assigns a *primary shard* for that database where MongoDB stores all data before sharding begins.

1. From a `mongo` shell, connect to the `mongos` instance. Issue a command using the following syntax:

   ```
   mongo --host <hostname of machine running mongos> --port <port mongos listens on>
   ```

2. Issue the `sh.enableSharding()` method, specifying the name of the database for which to enable sharding. Use the following syntax:

   ```
   sh.enableSharding("<database>")
   ```

Optionally, you can enable sharding for a database using the `enableSharding` command, which uses the following syntax:

```
db.runCommand( { enableSharding: <database> } )
```

Shard a Collection

You shard on a per-collection basis.

1. Determine what you will use for the *shard key*. Your selection of the shard key affects the efficiency of sharding. See the selection considerations listed in the *Considerations for Selecting Shard Key* (page 44).
2. If the collection already contains data you must create an index on the *shard key* using `createIndex()`. If the collection is empty then MongoDB will create the index as part of the `sh.shardCollection()` step.
3. Shard a collection by issuing the `sh.shardCollection()` method in the `mongo` shell. The method uses the following syntax:

   ```
   sh.shardCollection("<database>.<collection>", shard-key-pattern)
   ```

   Replace the `<database>.<collection>` string with the full namespace of your database, which consists of the name of your database, a dot (e.g. `.`), and the full name of the collection. The `shard-key-pattern` represents your shard key, which you specify in the same form as you would an `index` key pattern.

   Example

   The following sequence of commands shards four collections:

   ```
   sh.shardCollection("records.people", { "zipcode": 1, "name": 1 } )
   sh.shardCollection("people.addresses", { "state": 1, "_id": 1 } )
   sh.shardCollection("assets.chairs", { "type": 1, "_id": 1 } )
   sh.shardCollection("events.alerts", { "_id": "hashed" } )
   ```

   In order, these operations shard:

   (a) The `people` collection in the `records` database using the shard key `{ "zipcode": 1, "name": 1 }`.

   This shard key distributes documents by the value of the `zipcode` field. If a number of documents have the same value for this field, then that *chunk* will be *splittable* (page 45) by the values of the `name` field.

(b) The `addresses` collection in the `people` database using the shard key `{ "state": 1, "_id": 1 }`.

This shard key distributes documents by the value of the `state` field. If a number of documents have the same value for this field, then that *chunk* will be *splittable* (page 45) by the values of the `_id` field.

(c) The `chairs` collection in the `assets` database using the shard key `{ "type": 1, "_id": 1 }`.

This shard key distributes documents by the value of the `type` field. If a number of documents have the same value for this field, then that *chunk* will be *splittable* (page 45) by the values of the `_id` field.

(d) The `alerts` collection in the `events` database using the shard key `{ "_id": "hashed" }`.

This shard key distributes documents by a hash of the value of the `_id` field. MongoDB computes the hash of the `_id` field for the *hashed index*, which should provide an even distribution of documents across a cluster.

Using 3 Mirrored Config Servers (Deprecated)

Start 3 Mirrored Config Servers (Deprecated)

Changed in version 3.2: Starting in MongoDB 3.2, config servers for sharded clusters can be deployed as a `replica set`. The replica set config servers must run the `WiredTiger storage engine`. MongoDB 3.2 deprecates the use of three mirrored `mongod` instances for config servers.

In production deployments, if using mirrored config servers, you must deploy exactly three config server instances, each running on different servers to assure good uptime and data safety. In test environments, you can run all three instances on a single server.

Important: All members of a sharded cluster must be able to connect to *all* other members of a sharded cluster, including all shards and all config servers. Ensure that the network and security systems including all interfaces and firewalls, allow these connections.

---

1. Create data directories for each of the three config server instances. By default, a config server stores its data files in the */data/configdb* directory. You can choose a different location. To create a data directory, issue a command similar to the following:

   ```
   mkdir /data/configdb
   ```

2. Start the three config server instances. Start each by issuing a command using the following syntax:

   ```
   mongod --configsvr --dbpath <path> --port <port>
   ```

   The default port for config servers is `27019`. You can specify a different port. The following example starts a config server using the default port and default data directory:

   ```
   mongod --configsvr --dbpath /data/configdb --port 27019
   ```

   For additional command options, see `https://docs.mongodb.org/manual/reference/program/mongod` or `https://docs.mongodb.org/manual/reference/configuration-options`.

   Note: All config servers must be running and available when you first initiate a *sharded cluster*.

Start the mongos Instances (Deprecated)

Changed in version 3.2: Starting in MongoDB 3.2, config servers for sharded clusters can be deployed as a replica set. The replica set config servers must run the WiredTiger storage engine. MongoDB 3.2 deprecates the use of three mirrored mongod instances for config servers.

If using 3 mirrored config servers, when you start the mongos instance, specify the hostnames of the three config servers, either in the configuration file or as command line parameters.

Tip

To avoid downtime, give each config server a logical DNS name (unrelated to the server's physical or virtual hostname). Without logical DNS names, moving or renaming a config server requires shutting down every mongod and mongos instance in the sharded cluster.

To start a mongos instance, issue a command using the following syntax:

```
mongos --configdb <config server hostnames>
```

For example, to start a mongos that connects to config server instance running on the following hosts and on the default ports:

- cfg0.example.net
- cfg1.example.net
- cfg2.example.net

You would issue the following command:

```
mongos --configdb cfg0.example.net:27019,cfg1.example.net:27019,cfg2.example.net:27019
```

Each mongos in a sharded cluster must use the same configDB string, with identical host names listed in identical order.

If you start a mongos instance with a string that *does not* exactly match the string used by the other mongos instances in the cluster, the mongos instance returns a *Config Database String Error* (page 91) error and refuses to start.

To add shards, enable sharding and shard a collection, see *Add Shards to the Cluster* (page 40), *Enable Sharding for a Database* (page 41), and *Shard a Collection* (page 41).

3.1.2 Considerations for Selecting Shard Keys

Choosing a Shard Key

For many collections there may be no single, naturally occurring key that possesses all the qualities of a good shard key. The following strategies may help construct a useful shard key from existing data:

1. Compute a more ideal shard key in your application layer, and store this in all of your documents, potentially in the _id field.
2. Use a compound shard key that uses two or three values from all documents that provide the right mix of cardinality with scalable write operations and query isolation.
3. Determine that the impact of using a less than ideal shard key is insignificant in your use case, given:
   - limited write volume,
   - expected data size, or
   - application query patterns.

4. Use a *hashed shard key*. Choose a field that has high cardinality and create a *hashed index* on that field. MongoDB uses these hashed index values as shard key values, which ensures an even distribution of documents across the shards.

Tip

MongoDB automatically computes the hashes when resolving queries using hashed indexes. Applications do **not** need to compute hashes.

Considerations for Selecting Shard Key

Choosing the correct shard key can have a great impact on the performance, capability, and functioning of your database and cluster. Appropriate shard key choice depends on the schema of your data and the way that your applications query and write data.

Create a Shard Key that is Easily Divisible

An easily divisible shard key makes it easy for MongoDB to distribute content among the shards. Shard keys that have a limited number of possible values can result in chunks that are "unsplittable".

For instance, if a chunk represents a single shard key value, then MongoDB cannot split the chunk even when the chunk exceeds the size at which *splits* (page 33) occur.

See also:

Cardinality (page 45)

Create a Shard Key that has High Degree of Randomness

A shard key with high degree of randomness prevents any single shard from becoming a bottleneck and will distribute write operations among the cluster.

See also:

Write Scaling (page 20)

Create a Shard Key that Targets a Single Shard

A shard key that targets a single shard makes it possible for the **mongos** program to return most query operations directly from a single *specific* **mongod** instance. Your shard key should be the primary field used by your queries. Fields with a high degree of "randomness" make it difficult to target operations to specific shards.

See also:

Query Isolation (page 21)

Shard Using a Compound Shard Key

The challenge when selecting a shard key is that there is not always an obvious choice. Often, an existing field in your collection may not be the optimal key. In those situations, computing a special purpose shard key into an additional field or using a compound shard key may help produce one that is more ideal.

Cardinality

Cardinality in the context of MongoDB, refers to the ability of the system to *partition* data into *chunks*. For example, consider a collection of data such as an "address book" that stores address records:

- Consider the use of a `state` field as a shard key:

  The state key's value holds the US state for a given address document. This field has a *low cardinality* as all documents that have the same value in the `state` field *must* reside on the same shard, even if a particular state's chunk exceeds the maximum chunk size.

  Since there are a limited number of possible values for the `state` field, MongoDB may distribute data unevenly among a small number of fixed chunks. This may have a number of effects:

  - If MongoDB cannot split a chunk because all of its documents have the same shard key, migrations involving these un-splittable chunks will take longer than other migrations, and it will be more difficult for your data to stay balanced.
  - If you have a fixed maximum number of chunks, you will never be able to use more than that number of shards for this collection.

- Consider the use of a `zipcode` field as a shard key:

  While this field has a large number of possible values, and thus has potentially higher cardinality, it's possible that a large number of users could have the same value for the shard key, which would make this chunk of users un-splittable.

  In these cases, cardinality depends on the data. If your address book stores records for a geographically distributed contact list (e.g. "Dry cleaning businesses in America,") then a value like zipcode would be sufficient. However, if your address book is more geographically concentrated (e.g "ice cream stores in Boston Massachusetts,") then you may have a much lower cardinality.

- Consider the use of a `phone-number` field as a shard key:

  Phone number has a *high cardinality,* because users will generally have a unique value for this field, MongoDB will be able to split as many chunks as needed.

While "high cardinality," is necessary for ensuring an even distribution of data, having a high cardinality does not guarantee sufficient *query isolation* (page 21) or appropriate *write scaling* (page 20).

If you choose a shard key with low cardinality, some chunks may grow too large for MongoDB to migrate. See *Jumbo Chunks* (page 33) for more information.

Shard Key Selection Strategy

When selecting a shard key, it is difficult to balance the qualities of an ideal shard key, which sometimes dictate opposing strategies. For instance, it's difficult to produce a key that has both a high degree randomness for even data distribution and a shard key that allows your application to target specific shards. For some workloads, it's more important to have an even data distribution, and for others targeted queries are essential.

Therefore, the selection of a shard key is about balancing both your data and the performance characteristics caused by different possible data distributions and system workloads.

3.1.3 Shard a Collection Using a Hashed Shard Key

On this page

New in version 2.4.

Hashed shard keys (page 19) use a *hashed index* of a field as the *shard key* to partition data across your sharded cluster.

For suggestions on choosing the right field as your hashed shard key, see *Hashed Shard Keys* (page 19). For limitations on hashed indexes, see *index-hashed-index*.

Note: If chunk migrations are in progress while creating a hashed shard key collection, the initial chunk distribution may be uneven until the balancer automatically balances the collection.

Shard the Collection

To shard a collection using a hashed shard key, use an operation in the `mongo` that resembles the following:

```
sh.shardCollection( "records.active", { a: "hashed" } )
```

This operation shards the `active` collection in the `records` database, using a hash of the `a` field as the shard key.

Specify the Initial Number of Chunks

If you shard an empty collection using a hashed shard key, MongoDB automatically creates and migrates empty chunks so that each shard has two chunks. To control how many chunks MongoDB creates when sharding the collection, use `shardCollection` with the `numInitialChunks` parameter.

Important: MongoDB 2.4 adds support for hashed shard keys. After sharding a collection with a hashed shard key, you must use the MongoDB 2.4 or higher `mongos` and `mongod` instances in your sharded cluster.

Warning: MongoDB `hashed` indexes truncate floating point numbers to 64-bit integers before hashing. For example, a `hashed` index would store the same value for a field that held a value of `2.3`, `2.2`, and `2.9`. To prevent collisions, do not use a `hashed` index for floating point numbers that cannot be reliably converted to 64-bit integers (and then back to floating point). MongoDB `hashed` indexes do not support floating point values larger than 2^{53}.

3.1.4 Add Shards to a Cluster

On this page

You add shards to a *sharded cluster* after you create the cluster or any time that you need to add capacity to the cluster. If you have not created a sharded cluster, see *Deploy a Sharded Cluster* (page 38).

In production environments, all shards should be *replica sets*.

Considerations

Balancing

When you add a shard to a sharded cluster, you affect the balance of *chunks* among the shards of a cluster for all existing sharded collections. The balancer will begin migrating chunks so that the cluster will achieve balance. See *Sharded Collection Balancing* (page 29) for more information.

Changed in version 2.6: Chunk migrations can have an impact on disk space. Starting in MongoDB 2.6, the source shard automatically archives the migrated documents by default. For details, see *moveChunk directory* (page 32).

Capacity Planning

When adding a shard to a cluster, always ensure that the cluster has enough capacity to support the migration required for balancing the cluster without affecting legitimate production traffic.

Add a Shard to a Cluster

You interact with a sharded cluster by connecting to a `mongos` instance.

1. From a `mongo` shell, connect to the `mongos` instance. For example, if a `mongos` is accessible at `mongos0.example.net` on port `27017`, issue the following command:

   ```
   mongo --host mongos0.example.net --port 27017
   ```

2. Add a shard to the cluster using the `sh.addShard()` method, as shown in the examples below. Issue `sh.addShard()` separately for each shard. If the shard is a replica set, specify the name of the replica set and specify a member of the set. In production deployments, all shards should be replica sets.

   Optional

   You can instead use the `addShard` database command, which lets you specify a name and maximum size for the shard. If you do not specify these, MongoDB automatically assigns a name and maximum size. To use the database command, see `addShard`.

   The following are examples of adding a shard with `sh.addShard()`:

   - To add a shard for a replica set named `rs1` with a member running on port `27017` on `mongodb0.example.net`, issue the following command:

     ```
     sh.addShard( "rs1/mongodb0.example.net:27017" )
     ```

     Changed in version 2.0.3.

     For MongoDB versions prior to 2.0.3, you must specify all members of the replica set. For example:

     ```
     sh.addShard( "rs1/mongodb0.example.net:27017,mongodb1.example.net:27017,mongodb2.example.net
     ```

   - To add a shard for a standalone `mongod` on port `27017` of `mongodb0.example.net`, issue the following command:

     ```
     sh.addShard( "mongodb0.example.net:27017" )
     ```

   Note: It might take some time for *chunks* to migrate to the new shard.

3.1.5 Convert a Replica Set to a Sharded Cluster

On this page

Overview

This tutorial converts a single three-member replica set to a sharded cluster with two shards. Each shard is an independent three-member replica set. This tutorial is specific to MongoDB 3.2. For other versions of MongoDB, refer to the corresponding version of the MongoDB Manual.

The procedure is as follows:

1. Create the initial three-member replica set and insert data into a collection. See *Set Up Initial Replica Set* (page 48).
2. Start the config servers and a `mongos`. See *Deploy Config Server Replica Set and mongos* (page 49).
3. Add the initial replica set as a shard. See *Add Initial Replica Set as a Shard* (page 50).
4. Create a second shard and add to the cluster. See *Add Second Shard* (page 50).
5. Shard the desired collection. See *Shard a Collection* (page 51).

Prerequisites

This tutorial uses a total of ten servers: one server for the `mongos` and three servers each for the first *replica set*, the second replica set, and the *config server replica set* (page 14).

Each server must have a resolvable domain, hostname, or IP address within your system.

The tutorial uses the default data directories (e.g. `/data/db` and `/data/configdb`). Create the appropriate directories with appropriate permissions. To use different paths, see `https://docs.mongodb.org/manual/reference/configuration-options`.

The tutorial uses the `default ports` (e.g. `27017` and `27019`). To use different ports, see `https://docs.mongodb.org/manual/reference/configuration-options`.

Procedures

Set Up Initial Replica Set

This procedure creates the initial three-member replica set `rs0`. The replica set members are on the following hosts: `mongodb0.example.net`, `mongodb1.example.net`, and `mongodb2.example.net`.

Step 1: Start each member of the replica set with the appropriate options. For each member, start a `mongod`, specifying the replica set name through the `replSet` option. Include any other parameters specific to your deployment. For replication-specific parameters, see *cli-mongod-replica-set*.

```
mongod --replSet "rs0"
```

Repeat this step for the other two members of the `rs0` replica set.

Step 2: Connect a `mongo` shell to a replica set member. Connect a `mongo` shell to *one* member of the replica set (e.g. `mongodb0.example.net`)

```
mongo mongodb0.example.net
```

Step 3: Initiate the replica set. From the `mongo` shell, run `rs.initiate()` to initiate a replica set that consists of the current member.

```
rs.initiate()
```

Step 4: Add the remaining members to the replica set.

```
rs.add("mongodb1.example.net")
rs.add("mongodb2.example.net")
```

Step 5: Create and populate a new collection. The following step adds one million documents to the collection `test_collection` and can take several minutes depending on your system.

Issue the following operations on the primary of the replica set:

```
use test
var bulk = db.test_collection.initializeUnorderedBulkOp();
people = ["Marc", "Bill", "George", "Eliot", "Matt", "Trey", "Tracy", "Greg", "Steve", "Kristina", "
for(var i=0; i<1000000; i++){
   user_id = i;
   name = people[Math.floor(Math.random()*people.length)];
   number = Math.floor(Math.random()*10001);
   bulk.insert( { "user_id":user_id, "name":name, "number":number });
}
bulk.execute();
```

For more information on deploying a replica set, see `https://docs.mongodb.org/manual/tutorial/deploy-replica-`

Deploy Config Server Replica Set and `mongos`

Starting in MongoDB 3.2, config servers for sharded clusters can be deployed as a `replica set`. The replica set config servers must run the `WiredTiger storage engine`. MongoDB 3.2 deprecates the use of three mirrored `mongod` instances for config servers.

This procedure deploys the three-member replica set for the *config servers* (page 14) and the `mongos`.

- The config servers use the following hosts: `mongodb7.example.net`, `mongodb8.example.net`, and `mongodb9.example.net`.
- The `mongos` uses `mongodb6.example.net`.

Step 1: Deploy the config servers as a three-member replica set. Start a config server on `mongodb7.example.net`, `mongodb8.example.net`, and `mongodb9.example.net`. Specify the same replica set name. The config servers use the default data directory `/data/configdb` and the default port `27019`.

```
mongod --configsvr --replSet configReplSet
```

To modify the default settings or to include additional options specific to your deployment, see `https://docs.mongodb.org/manual/reference/program/mongod` or `https://docs.mongodb.org/manual/reference/configuration-options`.

Connect a `mongo` shell to one of the config servers and run `rs.initiate()` to initiate the replica set.

```
rs.initiate( {
   _id: "configReplSet",
   configsvr: true,
   members: [
      { _id: 0, host: "mongodb07.example.net:27019" },
      { _id: 1, host: "mongodb08.example.net:27019" },
      { _id: 2, host: "mongodb09.example.net:27019" }
   ]
} )
```

Step 2: Start a `mongos` instance. On `mongodb6.example.net`, start the `mongos` specifying the config server replica set name followed by a slash `https://docs.mongodb.org/manual/` and at least one of the config server hostnames and ports.

This tutorial specifies a small *`--chunkSize`* of 1 MB to test sharding with the `test_collection` created earlier.

Note: In production environments, do **not** use a small chunkSize size.

```
mongos --configdb configReplSet/mongodb07.example.net:27019,mongodb08.example.net:27019,mongodb09.exa
```

Add Initial Replica Set as a Shard

The following procedure adds the initial replica set `rs0` as a shard.

Step 1: Connect a `mongo` shell to the `mongos`.

```
mongo mongodb6.example.net:27017/admin
```

Step 2: Add the shard. Add a shard to the cluster with the `sh.addShard` method:

```
sh.addShard( "rs0/mongodb0.example.net:27017,mongodb1.example.net:27017,mongodb2.example.net:27017" )
```

Add Second Shard

The following procedure deploys a new replica set `rs1` for the second shard and adds it to the cluster. The replica set members are on the following hosts: `mongodb3.example.net`, `mongodb4.example.net`, and `mongodb5.example.net`.

Step 1: Start each member of the replica set with the appropriate options. For each member, start a `mongod`, specifying the replica set name through the `replSet` option. Include any other parameters specific to your deployment. For replication-specific parameters, see *cli-mongod-replica-set*.

```
mongod --replSet "rs1"
```

Repeat this step for the other two members of the `rs1` replica set.

Step 2: Connect a `mongo` shell to a replica set member. Connect a `mongo` shell to *one* member of the replica set (e.g. `mongodb3.example.net`)

```
mongo mongodb3.example.net
```

Step 3: Initiate the replica set. From the `mongo` shell, run `rs.initiate()` to initiate a replica set that consists of the current member.

```
rs.initiate()
```

Step 4: Add the remaining members to the replica set. Add the remaining members with the `rs.add()` method.

```
rs.add("mongodb4.example.net")
rs.add("mongodb5.example.net")
```

Step 5: Connect a `mongo` shell to the `mongos`.

```
mongo mongodb6.example.net:27017/admin
```

Step 6: Add the shard. In a `mongo` shell connected to the `mongos`, add the shard to the cluster with the `sh.addShard()` method:

```
sh.addShard( "rs1/mongodb3.example.net:27017,mongodb4.example.net:27017,mongodb5.example.net:27017" )
```

Shard a Collection

Step 1: Connect a `mongo` shell to the `mongos`.

```
mongo mongodb6.example.net:27017/admin
```

Step 2: Enable sharding for a database. Before you can shard a collection, you must first enable sharding for the collection's database. Enabling sharding for a database does not redistribute data but makes it possible to shard the collections in that database.

The following operation enables sharding on the `test` database:

```
sh.enableSharding( "test" )
```

The operation returns the status of the operation:

```
{ "ok" : 1 }
```

Step 3: Determine the shard key. For the collection to shard, determine the shard key. The *shard key* (page 19) determines how MongoDB distributes the documents between shards. Good shard keys:

- have values that are evenly distributed among all documents,
- group documents that are often accessed at the same time into contiguous chunks, and
- allow for effective distribution of activity among shards.

Once you shard a collection with the specified shard key, you **cannot** change the shard key. For more information on shard keys, see *Shard Keys* (page 19) and *Considerations for Selecting Shard Keys* (page 43).

This procedure will use the `number` field as the shard key for `test_collection`.

Step 4: Create an index on the shard key. Before sharding a non-empty collection, create an *index on the shard key* (page 34).

```
use test
db.test_collection.createIndex( { number : 1 } )
```

Step 5: Shard the collection. In the `test` database, shard the `test_collection`, specifying `number` as the shard key.

```
use test
sh.shardCollection( "test.test_collection", { "number" : 1 } )
```

The method returns the status of the operation:

```
{ "collectionsharded" : "test.test_collection", "ok" : 1 }
```

The *balancer* (page 29) will redistribute chunks of documents when it next runs. As clients insert additional documents into this collection, the `mongos` will route the documents between the shards.

Step 6: Confirm the shard is balancing. To confirm balancing activity, run `db.stats()` or `db.printShardingStatus()` in the `test` database.

```
use test
db.stats()
db.printShardingStatus()
```

Example output of the `db.stats()`:

```
{
  "raw" : {
      "rs0/mongodb0.example.net:27017,mongodb1.example.net:27017,mongodb2.example.net:27017" : {
         "db" : "test",
         "collections" : 3,
         "objects" : 989316,
         "avgObjSize" : 111.99974123535857,
         "dataSize" : 110803136,
         "storageSize" : 174751744,
         "numExtents" : 14,
         "indexes" : 2,
         "indexSize" : 57370992,
         "fileSize" : 469762048,
         "ok" : 1
      },
      "rs1/mongodb3.example.net:27017,mongodb4.example.net:27017,mongodb5.example.net:27017" : {
         "db" : "test",
         "collections" : 3,
         "objects" : 14697,
         "avgObjSize" : 111.98258147921345,
         "dataSize" : 1645808,
         "storageSize" : 2809856,
         "numExtents" : 7,
         "indexes" : 2,
         "indexSize" : 1169168,
         "fileSize" : 67108864,
         "ok" : 1
      }
  },
  "objects" : 1004013,
```

```
  "avgObjSize" : 111,
  "dataSize" : 112448944,
  "storageSize" : 177561600,
  "numExtents" : 21,
  "indexes" : 4,
  "indexSize" : 58540160,
  "fileSize" : 536870912,
  "extentFreeList" : {
      "num" : 0,
      "totalSize" : 0
  },
  "ok" : 1
}
```

Example output of the `db.printShardingStatus()`:

```
--- Sharding Status ---
sharding version: {
   "_id" : 1,
   "minCompatibleVersion" : 5,
   "currentVersion" : 6,
   "clusterId" : ObjectId("5446970c04ad5132c271597c")
}
shards:
   {  "_id" : "rs0",  "host" : "rs0/mongodb0.example.net:27017,mongodb1.example.net:27017,mongodb2.ex
   {  "_id" : "rs1",  "host" : "rs1/mongodb3.example.net:27017,mongodb4.example.net:27017,mongodb5.ex
active mongoses:
   "3.2.0" : 2
balancer:
   Currently enabled:  yes
   Currently running:  no
Failed balancer rounds in last 5 attempts:  0
Migration Results for the last 24 hours:
   1 : Success
databases:
   {  "_id" : "test", "primary" : "rs0", "partitioned" : true }
      test.test_collection
            shard key: { "number" : 1 }
            unique: false
            balancing: true
            chunks:
               rs1    5
               rs0    186
            too many chunks to print, use verbose if you want to force print
```

Run these commands for a second time to demonstrate that *chunks* are migrating from `rs0` to `rs1`.

3.1.6 Upgrade Config Servers to Replica Set

On this page

New in version 3.2: Starting in 3.2, config servers for a sharded cluster can be deployed as a replica set. The following procedure upgrades three mirrored config servers to a *config server replica set* (page 14). Using a replica set for the

config servers improves consistency across the config servers, since MongoDB can take advantage of the standard replica set read and write protocols for the config data. In addition, this allows a sharded cluster to have more than 3 config servers since a replica set can have up to 50 members.

Prerequisites

- All binaries in the sharded clusters must be at least version 3.2. See *3.2-upgrade-cluster* for instructions to upgrade the sharded cluster.
- The existing config servers must be in sync.

Procedure

Important: The procedure outlined in this tutorial requires downtime.

1. **Disable the balancer** as described in *Disable the Balancer* (page 72).
2. Connect a `mongo` shell to the *first* config server listed in the `configDB` setting of the `mongos` and run `rs.initiate()` to initiate the single member replica set.

   ```
   rs.initiate( {
      _id: "csReplSet",
      version: 1,
      configsvr: true,
      members: [ { _id: 0, host: "<host>:<port>" } ]
   } )
   ```

   - `_id` corresponds to the replica set name for the config servers.
   - `version` set to 1, corresponding to the initial version of the replica set configuration.
   - `configsvr` must be set be `true`.
   - `members` array contains a document that specifies:
     - `members._id` which is a numeric identifier for the member.
     - `members.host` which is a string corresponding to the config server's hostname and port.
3. Restart this config server as a single member replica set with:
   - the *--replSet* option set to the replica set name specified during the `rs.initiate()`,
   - the *--configsvrMode* option set to the legacy config server mode Sync Cluster Connection Config (`sccc`),
   - the *--configsvr* option, and
   - the *--storageEngine* option set to the storage engine used by this config server. For this upgrade procedure, the existing config server can be using either MMAPv1 or WiredTiger.

   Include additional options as specific to your deployment.

   ```
   mongod --configsvr --replSet csReplSet --configsvrMode=sccc --storageEngine <storageEngine> --pc
   ```

   Or if using a `configuration file`, specify the `replication.replSetName:`, `sharding.clusterRole`, `sharding.configsvrMode` and `net.port`.

```
sharding:
   clusterRole: configsvr
   configsvrMode: sccc
replication:
   replSetName: csReplSet
net:
   port: <port>
storage:
   dbpath: <path>
   engine: <storageEngine>
```

4. Start the new `mongod` instances to add to the replica set. These instances must use the `WiredTiger` storage engine. Starting in 3.2, the default storage engine is WiredTiger for new `mongod` instances with new data paths.

   Important:

   - Do not add existing config servers to the replica set.
   - Use new dbpaths for the new instances.

   The number of new `mongod` instances to add depends on the config server currently in the single-member replica set:

   - If the config server is using MMAPv1, start 3 new `mongod` instances.
   - If the config server is using WiredTiger, start 2 new `mongod` instances.

   Note: The example in this procedure assumes that the existing config servers use MMAPv1.

   For each new `mongod` instance to add, include the `--configsvr` and the `--replSet` options:

   ```
   mongod --configsvr --replSet csReplSet --port <port> --dbpath <path>
   ```

   Or if using a `configuration file`:

   ```
   sharding:
      clusterRole: configsvr
   replication:
      replSetName: csReplSet
   net:
      port: <port>
   storage:
      dbpath: <path>
   ```

5. Using the `mongo` shell connected the replica set config server, add the new `mongod` instances as *non-voting*, `priority 0` members:

   ```
   rs.add( { host: <host:port>, priority: 0, votes: 0 } )
   ```

6. Once all the new members have been added as *non-voting*, `priority 0` members, ensure that the new nodes have completed the *initial sync* and have reached `SECONDARY` state. To check the state of the replica set members, run `rs.status()` in the `mongo` shell:

   ```
   rs.status()
   ```

7. Shut down one of the other non-replica set config servers; i.e. either the second and third config server listed in the `configDB` setting of the `mongos`.

8. Reconfigure the replica set to allow all members to vote and have default priority of `1`.

```
var cfg = rs.conf();

cfg.members[0].priority = 1;
cfg.members[1].priority = 1;
cfg.members[2].priority = 1;
cfg.members[3].priority = 1;
cfg.members[0].votes = 1;
cfg.members[1].votes = 1;
cfg.members[2].votes = 1;
cfg.members[3].votes = 1;

rs.reconfig(cfg);
```

9. Step down the first config server, i.e. the server started with `--configsvrMode=sccc`.

   ```
   rs.stepDown()
   ```

10. Shut down the following members of the sharded cluster:

    - The `mongos` instances.
    - The shards.
    - The remaining non-replica set config servers.

11. Shut down the first config server.

    If the first config server uses the MMAPv1 storage engine, remove the member from the replica set. Connect a `mongo` shell to the current primary and use `rs.remove()`:

    Important: If the first config server uses the WiredTiger storage engine, do not remove.

    ```
    rs.remove("<hostname>:<port>")
    ```

12. If the first config server uses `WiredTiger`, restart the first config server in config server replica set (`CSRS`) mode; i.e. restart **without** the `--configsvrMode=sccc` option:

    Important: If the first config server uses the MMAPv1 storage engine, do not restart.

    ```
    mongod --configsvr --replSet csReplSet --storageEngine wiredTiger --port <port> --dbpath <path>
    ```

    Or if using a `configuration file`, omit the `sharding.configsvrMode` setting:

    ```
    sharding:
       clusterRole: configsvr
    replication:
       replSetName: csReplSet
    net:
       port: <port>
    storage:
       dbpath: <path>
       engine: <storageEngine>
    ```

13. Restart the shards.

14. Restart `mongos` instances with updated *`--configdb`* or `configDB` setting.

    For the updated *`--configdb`* or `configDB` setting, specify the replica set name for the config servers and the members in the replica set.

```
mongos --configdb csReplSet/<rsconfigsver1:port1>,<rsconfigsver2:port2>,<rsconfigsver3:port3>
```

15. **Re-enable the balancer** as described in *Enable the Balancer* (page 72).

3.1.7 Convert Sharded Cluster to Replica Set

On this page

This tutorial describes the process for converting a *sharded cluster* to a non-sharded *replica set*. To convert a replica set into a sharded cluster *Convert a Replica Set to a Sharded Cluster* (page 48). See the *Sharding* (page 1) documentation for more information on sharded clusters.

Convert a Cluster with a Single Shard into a Replica Set

In the case of a *sharded cluster* with only one shard, that shard contains the full data set. Use the following procedure to convert that cluster into a non-sharded *replica set*:

1. Reconfigure the application to connect to the primary member of the replica set hosting the single shard that system will be the new replica set.
2. Optionally remove the `--shardsrv` option, if your `mongod` started with this option.

   Tip

   Changing the `--shardsrv` option will change the port that `mongod` listens for incoming connections on.

The single-shard cluster is now a non-sharded *replica set* that will accept read and write operations on the data set.

You may now decommission the remaining sharding infrastructure.

Convert a Sharded Cluster into a Replica Set

Use the following procedure to transition from a *sharded cluster* with more than one shard to an entirely new *replica set*.

1. With the *sharded cluster* running, `deploy a new replica set` in addition to your sharded cluster. The replica set must have sufficient capacity to hold all of the data files from all of the current shards combined. Do not configure the application to connect to the new replica set until the data transfer is complete.
2. Stop all writes to the *sharded cluster*. You may reconfigure your application or stop all `mongos` instances. If you stop all `mongos` instances, the applications will not be able to read from the database. If you stop all `mongos` instances, start a temporary `mongos` instance on that applications cannot access for the data migration procedure.
3. Use `mongodump and mongorestore` to migrate the data from the `mongos` instance to the new *replica set*.

   Note: Not all collections on all databases are necessarily sharded. Do not solely migrate the sharded collections. Ensure that all databases and all collections migrate correctly.

4. Reconfigure the application to use the non-sharded *replica set* instead of the `mongos` instance.

The application will now use the un-sharded *replica set* for reads and writes. You may now decommission the remaining unused sharded cluster infrastructure.

3.2 Sharded Cluster Maintenance Tutorials

The following tutorials provide information in maintaining sharded clusters.

View Cluster Configuration **(page 58)** View status information about the cluster's databases, shards, and chunks.

Replace a Config Server **(page 60)** Replace a config server in a config server replica set.

Migrate Config Servers with the Same Hostname **(page 61)** For a sharded cluster with three mirrored config servers, migrate a config server to a new system while keeping the same hostname. This procedure requires changing the DNS entry to point to the new system.

Migrate Config Servers with Different Hostnames **(page 62)** For a sharded cluster with three mirrored config servers, migrate a config server to a new system that uses a new hostname. If possible, avoid changing the hostname and instead use the *Migrate Config Servers with the Same Hostname* (page 61) procedure.

Migrate a Sharded Cluster to Different Hardware **(page 63)** Migrate a sharded cluster to a different hardware system, for example, when moving a pre-production environment to production.

Backup Cluster Metadata **(page 66)** Create a backup of a sharded cluster's metadata while keeping the cluster operational.

Configure Behavior of Balancer Process in Sharded Clusters **(page 67)** Manage the balancer's behavior by scheduling a balancing window, changing size settings, or requiring replication before migration.

Manage Sharded Cluster Balancer **(page 69)** View balancer status and manage balancer behavior.

Remove Shards from an Existing Sharded Cluster **(page 74)** Migrate a single shard's data and remove the shard.

3.2.1 View Cluster Configuration

On this page

List Databases with Sharding Enabled

To list the databases that have sharding enabled, query the `databases` collection in the *Config Database* (page 95). A database has sharding enabled if the value of the `partitioned` field is `true`. Connect to a `mongos` instance with a `mongo` shell, and run the following operation to get a full list of databases with sharding enabled:

```
use config
db.databases.find( { "partitioned": true } )
```

Example

You can use the following sequence of commands when to return a list of all databases in the cluster:

```
use config
db.databases.find()
```

If this returns the following result set:

```
{ "_id" : "admin", "partitioned" : false, "primary" : "config" }
{ "_id" : "animals", "partitioned" : true, "primary" : "m0.example.net:30001" }
{ "_id" : "farms", "partitioned" : false, "primary" : "m1.example2.net:27017" }
```

Then sharding is only enabled for the `animals` database.

List Shards

To list the current set of configured shards, use the `listShards` command, as follows:

```
use admin
db.runCommand( { listShards : 1 } )
```

View Cluster Details

To view cluster details, issue `db.printShardingStatus()` or `sh.status()`. Both methods return the same output.

Example

In the following example output from `sh.status()`

- `sharding version` displays the version number of the shard metadata.
- `shards` displays a list of the `mongod` instances used as shards in the cluster.
- `databases` displays all databases in the cluster, including database that do not have sharding enabled.
- The `chunks` information for the `foo` database displays how many chunks are on each shard and displays the range of each chunk.

```
--- Sharding Status ---
  sharding version: { "_id" : 1, "version" : 3 }
  shards:
    {  "_id" : "shard0000",  "host" : "m0.example.net:30001" }
    {  "_id" : "shard0001",  "host" : "m3.example2.net:50000" }
  databases:
    {  "_id" : "admin",  "partitioned" : false,  "primary" : "config" }
    {  "_id" : "contacts",  "partitioned" : true,  "primary" : "shard0000" }
        foo.contacts
            shard key: { "zip" : 1 }
            chunks:
                shard0001    2
                shard0002    3
                shard0000    2
            { "zip" : { "$minKey" : 1 } } -->> { "zip" : "56000" } on : shard0001 { "t" : 2, "i" : 0
            { "zip" : 56000 } -->> { "zip" : "56800" } on : shard0002 { "t" : 3, "i" : 4 }
            { "zip" : 56800 } -->> { "zip" : "57088" } on : shard0002 { "t" : 4, "i" : 2 }
            { "zip" : 57088 } -->> { "zip" : "57500" } on : shard0002 { "t" : 4, "i" : 3 }
            { "zip" : 57500 } -->> { "zip" : "58140" } on : shard0001 { "t" : 4, "i" : 0 }
            { "zip" : 58140 } -->> { "zip" : "59000" } on : shard0000 { "t" : 4, "i" : 1 }
            { "zip" : 59000 } -->> { "zip" : { "$maxKey" : 1 } } on : shard0000 { "t" : 3, "i" : 3 }
    {  "_id" : "test",  "partitioned" : false,  "primary" : "shard0000" }
```

3.2.2 Replace a Config Server

On this page

Changed in version 3.2: Starting in MongoDB 3.2, config servers for sharded clusters can be deployed as a `replica set`. The replica set config servers must run the `WiredTiger storage engine`. MongoDB 3.2 deprecates the use of three mirrored `mongod` instances for config servers.

For replacing config servers deployed as three mirrored `mongod` instances, see *Migrate Config Servers with the Same Hostname* (page 61) and *Migrate Config Servers with Different Hostnames* (page 62).

Overview

If the config server replica set becomes read only, i.e. does not have a primary, the sharded cluster cannot support operations that change the cluster metadata, such as chunk splits and migrations. Although no chunks can be split or migrated, applications will be able to write data to the sharded cluster.

If one of the config servers is unavailable or inoperable, repair or replace it as soon as possible. The following procedure replaces a member of a *config server replica set* (page 14) with a new member.

The tutorial is specific to MongoDB 3.2. For earlier versions of MongoDB, refer to the corresponding version of the MongoDB Manual.

Considerations

The following restrictions apply to a replica set configuration when used for config servers:

- Must have zero `arbiters`.
- Must have no `delayed members`.
- Must build indexes (i.e. no member should have `buildIndexes` setting set to false).

Procedure

Step 1: Start the replacement config server.

Start a `mongod` instance, specifying both the `--configsvr` and `--replSet` options.

```
mongod --configsvr --replSet <replicaSetName>
```

Step 2: Add the new config server to the replica set.

Connect a `mongo` shell to the primary of the config server replica set and use `rs.add()` to add the new member.

```
rs.add("<hostnameNew>:<portNew>")
```

The initial sync process copies all the data from one member of the config server replica set to the new member without restarting.

`mongos` instances automatically recognize the change in the config server replica set members without restarting.

Step 3: Shut down the member to replace.

If replacing the primary member, step down the primary first before shutting down.

Step 4: Remove the member to replace from the config server replica set.

Upon completion of initial sync of the replacement config server, from a `mongo` shell connected to the primary, use `rs.remove()` to remove the old member.

```
rs.remove("<hostnameOld>:<portOld>")
```

`mongos` instances automatically recognize the change in the config server replica set members without restarting.

Step 5: If necessary, update `mongos` configuration or DNS entry.

With replica set config servers, the `mongos` instances specify in the *`--configdb`* or `sharding.configDB` setting the config server replica set name and at least one of the replica set members.

As such, if the `mongos` instance does not specify the removed replica set member in the *`--configdb`* or `sharding.configDB` setting, no further action is necessary.

If, however, a `mongos` instance specified the removed member in the `--configdb` or `configDB` setting, either:

- Update the setting for the next time you restart the `mongos`, or
- Modify the DNS entry that points to the system that provided the old config server, so that the *same* hostname points to the new config server.

3.2.3 Migrate Config Servers with the Same Hostname

Important: This procedure applies to migrating config servers when using three mirrored `mongod` instances as config servers.

Starting in MongoDB 3.2, config servers can be deployed as `replica set`. MongoDB 3.2 deprecates the use of three mirrored `mongod` instances for config servers.

For replacing config servers deployed as members of a replica set, see *Replace a Config Server* (page 60).

For a *sharded cluster* (page 11) that uses 3 mirrored config servers, use the following procedure migrates a *config server* (page 14) to a new system that uses *the same* hostname.

To migrate all three mirrored config servers, perform this procedure for each config server separately and migrate the config servers in reverse order from how they are listed in the `mongos` instances' `configDB` string. Start with the last config server listed in the `configDB` string.

1. Shut down the config server.

   This renders all config data for the sharded cluster "read only."

2. Change the DNS entry that points to the system that provided the old config server, so that the *same* hostname points to the new system. How you do this depends on how you organize your DNS and hostname resolution services.
3. Copy the contents of `dbPath` from the old config server to the new config server.

   For example, to copy the contents of `dbPath` to a machine named `mongodb.config2.example.net`, you might issue a command similar to the following:

   ```
   rsync -az /data/configdb/ mongodb.config2.example.net:/data/configdb
   ```

4. Start the config server instance on the new system. The default invocation is:

   ```
   mongod --configsvr
   ```

When you start the third config server, your cluster will become writable and it will be able to create new splits and migrate chunks as needed.

3.2.4 Migrate Config Servers with Different Hostnames

On this page

Important: This procedure applies to migrating config servers when using three mirrored `mongod` instances as config servers.

Changed in version 3.2: Starting in MongoDB 3.2, config servers can be deployed as `replica set`. MongoDB 3.2 deprecates the use of three mirrored `mongod` instances for config servers.

For replacing config servers deployed as members of a replica set, see *Replace a Config Server* (page 60).

Overview

For a *sharded cluster* (page 11) that uses three mirrored config servers, all three config servers must be available in order to support operations that result in cluster metadata changes, e.g. chunk splits and migrations. If one of the config servers is unavailable or inoperable, you must replace it as soon as possible.

For a *sharded cluster* (page 11) that uses three mirrored config servers, this procedure migrates a *config server* (page 14) to a new server that uses a different hostname. Use this procedure only if the config server *will not* be accessible via the same hostname. If possible, avoid changing the hostname so that you can instead use the procedure to *migrate a config server and use the same hostname* (page 61).

Considerations

With three mirrored config servers, changing a *config server's* (page 14) hostname **requires downtime** and requires restarting every process in the sharded cluster.

While migrating config servers, always make sure that all `mongos` instances have three config servers specified in the `configDB` setting at all times. Also ensure that you specify the config servers in the same order for each `mongos` instance's `configDB` setting.

Procedure

Important: This procedure applies to migrating config servers when using three mirrored `mongod` instances as config servers. For replacing config servers deployed as members of a replica set, see *Replace a Config Server* (page 60).

1. Disable the cluster balancer process temporarily. See *Disable the Balancer* (page 72) for more information.
2. Shut down the config server to migrate.

   This renders all config data for the sharded cluster "read only."
3. Copy the contents of `dbPath` from the old config server to the new config server. For example, to copy the contents of `dbPath` to a machine named `mongodb.config2.example.net`, use a command that resembles the following:

   ```
   rsync -az /data/configdb mongodb.config2.example.net:/data/configdb
   ```
4. Start the config server instance on the new system. The default invocation is:

   ```
   mongod --configsvr
   ```
5. Shut down all existing MongoDB processes. This includes:
   - the `mongod` instances for the shards.
   - the `mongod` instances for the existing *config databases* (page 95).
   - the `mongos` instances.
6. Restart all shard `mongod` instances.
7. Restart the `mongod` instances for the two existing non-migrated config servers.
8. Update the `configDB` setting for each `mongos` instances.
9. Restart the `mongos` instances.
10. Re-enable the balancer to allow the cluster to resume normal balancing operations. See the *Disable the Balancer* (page 72) section for more information on managing the balancer process.

3.2.5 Migrate a Sharded Cluster to Different Hardware

On this page

The tutorial is specific to MongoDB 3.2. For earlier versions of MongoDB, refer to the corresponding version of the MongoDB Manual.

Changed in version 3.2.

Starting in MongoDB 3.2, config servers for sharded clusters can be deployed as a `replica set`. The replica set config servers must run the `WiredTiger storage engine`. MongoDB 3.2 deprecates the use of three mirrored `mongod` instances for config servers.

This procedure moves the components of the *sharded cluster* to a new hardware system without downtime for reads and writes.

Important: While the migration is in progress, do not attempt to change to the *cluster metadata* (page 35). Do not use any operation that modifies the cluster metadata *in any way*. For example, do not create or drop databases, create or drop collections, or use any sharding commands.

If your cluster includes a shard backed by a *standalone* `mongod` instance, consider `converting the standalone to a replica set` to simplify migration and to let you keep the cluster online during future maintenance. Migrating a shard as standalone is a multi-step process that may require downtime.

Disable the Balancer

Disable the balancer to stop *chunk migration* (page 30) and do not perform any metadata write operations until the process finishes. If a migration is in progress, the balancer will complete the in-progress migration before stopping.

To disable the balancer, connect to one of the cluster's `mongos` instances and issue the following method:

```
sh.stopBalancer()
```

To check the balancer state, issue the `sh.getBalancerState()` method.

For more information, see *Disable the Balancer* (page 72).

Migrate Each Config Server Separately

Changed in version 3.2.

Starting in MongoDB 3.2, config servers for sharded clusters can be deployed as a `replica set`. The replica set config servers must run the `WiredTiger storage engine`. MongoDB 3.2 deprecates the use of three mirrored `mongod` instances for config servers.

The following restrictions apply to a replica set configuration when used for config servers:

- Must have zero `arbiters`.
- Must have no `delayed members`.
- Must build indexes (i.e. no member should have `buildIndexes` setting set to false).

For each member of the config server replica set:

Important: Replace the secondary members before replacing the primary.

Step 1: Start the replacement config server.

Start a `mongod` instance, specifying both the `--configsvr` and `--replSet` options.

```
mongod --configsvr --replSet <replicaSetName>
```

Step 2: Add the new config server to the replica set.

Connect a `mongo` shell to the primary of the config server replica set and use `rs.add()` to add the new member.

```
rs.add("<hostnameNew>:<portNew>")
```

The initial sync process copies all the data from one member of the config server replica set to the new member without restarting.

`mongos` instances automatically recognize the change in the config server replica set members without restarting.

Step 3: Shut down the member to replace.

If replacing the primary member, step down the primary first before shutting down.

Restart the `mongos` Instances

Changed in version 3.2: With replica set config servers, the `mongos` instances specify in the *`--configdb`* or `sharding.configDB` setting the config server replica set name and at least one of the replica set members. The `mongos` instances for the sharded cluster must specify the same config server replica set name but can specify different members of the replica set.

If a `mongos` instance specifies a migrated replica set member in the *`--configdb`* or `sharding.configDB` setting, update the config server setting for the next time you restart the `mongos` instance.

For more information, see *Start the mongos Instances* (page 39).

Migrate the Shards

Migrate the shards one at a time. For each shard, follow the appropriate procedure in this section.

Migrate a Replica Set Shard

To migrate a sharded cluster, migrate each member separately. First migrate the non-primary members, and then migrate the *primary* last.

If the replica set has two voting members, add an `arbiter` to the replica set to ensure the set keeps a majority of its votes available during the migration. You can remove the arbiter after completing the migration.

Migrate a Member of a Replica Set Shard

1. Shut down the `mongod` process. To ensure a clean shutdown, use the `shutdown` command.
2. Move the data directory (i.e., the `dbPath`) to the new machine.
3. Restart the `mongod` process at the new location.
4. Connect to the replica set's current primary.
5. If the hostname of the member has changed, use `rs.reconfig()` to update the `replica set configuration document` with the new hostname.

   For example, the following sequence of commands updates the hostname for the instance at position `2` in the `members` array:

   ```
   cfg = rs.conf()
   cfg.members[2].host = "pocatello.example.net:27017"
   rs.reconfig(cfg)
   ```

   For more information on updating the configuration document, see *replica-set-reconfiguration-usage*.

6. To confirm the new configuration, issue `rs.conf()`.
7. Wait for the member to recover. To check the member's state, issue `rs.status()`.

Migrate the Primary in a Replica Set Shard While migrating the replica set's primary, the set must elect a new primary. This failover process which renders the replica set unavailable to perform reads or accept writes for the duration of the election, which typically completes quickly. If possible, plan the migration during a maintenance window.

1. Step down the primary to allow the normal *failover* process. To step down the primary, connect to the primary and issue the either the `replSetStepDown` command or the `rs.stepDown()` method. The following example shows the `rs.stepDown()` method:

   ```
   rs.stepDown()
   ```

2. Once the primary has stepped down and another member has become `PRIMARY` state. To migrate the stepped-down primary, follow the *Migrate a Member of a Replica Set Shard* (page 65) procedure

   You can check the output of `rs.status()` to confirm the change in status.

Migrate a Standalone Shard

The ideal procedure for migrating a standalone shard is to `convert the standalone to a replica set` and then use the procedure for *migrating a replica set shard* (page 65). In production clusters, all shards should be replica sets, which provides continued availability during maintenance windows.

Migrating a shard as standalone is a multi-step process during which part of the shard may be unavailable. If the shard is the *primary shard* for a database,the process includes the `movePrimary` command. While the `movePrimary` runs, you should stop modifying data in that database. To migrate the standalone shard, use the *Remove Shards from an Existing Sharded Cluster* (page 74) procedure.

Re-Enable the Balancer

To complete the migration, re-enable the balancer to resume *chunk migrations* (page 30).

Connect to one of the cluster's `mongos` instances and pass `true` to the `sh.setBalancerState()` method:

```
sh.setBalancerState(true)
```

To check the balancer state, issue the `sh.getBalancerState()` method.

For more information, see *Enable the Balancer* (page 72).

3.2.6 Backup Cluster Metadata

This procedure shuts down the `mongod` instance of a *config server* (page 14) in order to create a backup of a *sharded cluster's* (page 3) metadata. The cluster's config servers store all of the cluster's metadata, most importantly the mapping from *chunks* to *shards*.

When you perform this procedure, the cluster remains operational [1].

1. Disable the cluster balancer process temporarily. See *Disable the Balancer* (page 72) for more information.
2. Shut down one of the config databases.

[1] While one of the three config servers is unavailable, the cluster cannot split any chunks nor can it migrate chunks between shards. Your application will be able to write data to the cluster. See *Config Servers* (page 14) for more information.

3. Create a full copy of the data files (i.e. the path specified by the `dbPath` option for the config instance.)
4. Restart the original configuration server.
5. Re-enable the balancer to allow the cluster to resume normal balancing operations. See the *Disable the Balancer* (page 72) section for more information on managing the balancer process.

See also:

`https://docs.mongodb.org/manual/core/backups`.

3.2.7 Configure Behavior of Balancer Process in Sharded Clusters

On this page

The balancer is a process that runs on *one* of the `mongos` instances in a cluster and ensures that *chunks* are evenly distributed throughout a sharded cluster. In most deployments, the default balancer configuration is sufficient for normal operation. However, administrators might need to modify balancer behavior depending on application or operational requirements. If you encounter a situation where you need to modify the behavior of the balancer, use the procedures described in this document.

For conceptual information about the balancer, see *Sharded Collection Balancing* (page 29) and *Cluster Balancer* (page 29).

Schedule a Window of Time for Balancing to Occur

You can schedule a window of time during which the balancer can migrate chunks, as described in the following procedures:

- *Schedule the Balancing Window* (page 71)
- *Remove a Balancing Window Schedule* (page 72).

The `mongos` instances use their own local timezones when respecting balancer window.

Configure Default Chunk Size

The default chunk size for a sharded cluster is 64 megabytes. In most situations, the default size is appropriate for splitting and migrating chunks. For information on how chunk size affects deployments, see details, see *Chunk Size* (page 33).

Changing the default chunk size affects chunks that are processes during migrations and auto-splits but does not retroactively affect all chunks.

To configure default chunk size, see *Modify Chunk Size in a Sharded Cluster* (page 83).

Change the Maximum Storage Size for a Given Shard

The `maxSize` field in the `shards` (page 100) collection in the *config database* (page 95) sets the maximum size for a shard, allowing you to control whether the balancer will migrate chunks to a shard. If `mem.mapped` size [2] is above a shard's `maxSize`, the balancer will not move chunks to the shard. Also, the balancer will not move chunks off an overloaded shard. This must happen manually. The `maxSize` value only affects the balancer's selection of destination shards.

By default, `maxSize` is not specified, allowing shards to consume the total amount of available space on their machines if necessary.

You can set `maxSize` both when adding a shard and once a shard is running.

To set `maxSize` when adding a shard, set the `addShard` command's `maxSize` parameter to the maximum size in megabytes. For example, the following command run in the `mongo` shell adds a shard with a maximum size of 125 megabytes:

```
db.runCommand( { addshard : "example.net:34008", maxSize : 125 } )
```

To set `maxSize` on an existing shard, insert or update the `maxSize` field in the `shards` (page 100) collection in the *config database* (page 95). Set the `maxSize` in megabytes.

Example

Assume you have the following shard without a `maxSize` field:

```
{ "_id" : "shard0000", "host" : "example.net:34001" }
```

Run the following sequence of commands in the `mongo` shell to insert a `maxSize` of 125 megabytes:

```
use config
db.shards.update( { _id : "shard0000" }, { $set : { maxSize : 125 } } )
```

To later increase the `maxSize` setting to 250 megabytes, run the following:

```
use config
db.shards.update( { _id : "shard0000" }, { $set : { maxSize : 250 } } )
```

Change Replication Behavior for Chunk Migration

Secondary Throttle

Changed in version 3.0.0: The balancer configuration document added configurable `writeConcern` to control the semantics of the `_secondaryThrottle` option.

The `_secondaryThrottle` parameter of the balancer and the `moveChunk` command affects the replication behavior during *chunk migration* (page 32). By default, `_secondaryThrottle` is `true`, which means each document move during chunk migration propagates to at least one secondary before the balancer proceeds with the next document: this is equivalent to a write concern of `{ w: 2 }`.

You can also configure the `writeConcern` for the `_secondaryThrottle` operation, to configure how migrations will wait for replication to complete. For more information on the replication behavior during various steps of chunk migration, see *Chunk Migration and Replication* (page 32).

To change the balancer's `_secondaryThrottle` and `writeConcern` values, connect to a `mongos` instance and directly update the `_secondaryThrottle` value in the `settings` (page 99) collection of the *config database* (page 95). For example, from a `mongo` shell connected to a `mongos`, issue the following command:

[2] This value includes the mapped size of all data files including the‘‘local‘‘ and `admin` databases. Account for this when setting `maxSize`.

```
use config
db.settings.update(
   { "_id" : "balancer" },
   { $set : { "_secondaryThrottle" : false ,
              "writeConcern": { "w": "majority" } } },
   { upsert : true }
)
```

The effects of changing the `_secondaryThrottle` and `writeConcern` value may not be immediate. To ensure an immediate effect, stop and restart the balancer to enable the selected value of `_secondaryThrottle`. See *Manage Sharded Cluster Balancer* (page 69) for details.

Wait for Delete

The `_waitForDelete` setting of the balancer and the `moveChunk` command affects how the balancer migrates multiple chunks from a shard. By default, the balancer does not wait for the on-going migration's delete phase to complete before starting the next chunk migration. To have the delete phase **block** the start of the next chunk migration, you can set the `_waitForDelete` to true.

For details on chunk migration, see *Chunk Migration* (page 31). For details on the chunk migration queuing behavior, see *Chunk Migration Queuing* (page 32).

The `_waitForDelete` is generally for internal testing purposes. To change the balancer's `_waitForDelete` value:

1. Connect to a `mongos` instance.
2. Update the `_waitForDelete` value in the `settings` (page 99) collection of the *config database* (page 95). For example:

   ```
   use config
   db.settings.update(
      { "_id" : "balancer" },
      { $set : { "_waitForDelete" : true } },
      { upsert : true }
   )
   ```

Once set to `true`, to revert to the default behavior:

1. Connect to a `mongos` instance.
2. Update or unset the `_waitForDelete` field in the `settings` (page 99) collection of the *config database* (page 95):

   ```
   use config
   db.settings.update(
      { "_id" : "balancer", "_waitForDelete": true },
      { $unset : { "_waitForDelete" : "" } }
   )
   ```

3.2.8 Manage Sharded Cluster Balancer

On this page

This page describes common administrative procedures related to balancing. For an introduction to balancing, see *Sharded Collection Balancing* (page 29). For lower level information on balancing, see *Cluster Balancer* (page 29).

See also:

Configure Behavior of Balancer Process in Sharded Clusters (page 67)

Check the Balancer State

`sh.getBalancerState()` checks if the balancer is enabled (i.e. that the balancer is permitted to run). `sh.getBalancerState()` does not check if the balancer is actively balancing chunks.

To see if the balancer is enabled in your *sharded cluster*, issue the following command, which returns a boolean:

```
sh.getBalancerState()
```

New in version 3.0.0: You can also see if the balancer is enabled using `sh.status()`. The `currently-enabled` field indicates whether the balancer is enabled, while the `currently-running` field indicates if the balancer is currently running.

Check the Balancer Lock

To see if the balancer process is active in your *cluster*, do the following:

1. Connect to any `mongos` in the cluster using the `mongo` shell.
2. Issue the following command to switch to the *Config Database* (page 95):

   ```
   use config
   ```

3. Use the following query to return the balancer lock:

   ```
   db.locks.find( { _id : "balancer" } ).pretty()
   ```

   When this command returns, you will see output like the following:

   ```
   {   "_id" : "balancer",
   "process" : "mongos0.example.net:1292810611:1804289383",
     "state" : 2,
        "ts" : ObjectId("4d0f872630c42d1978be8a2e"),
     "when" : "Mon Dec 20 2010 11:41:10 GMT-0500 (EST)",
      "who" : "mongos0.example.net:1292810611:1804289383:Balancer:846930886",
      "why" : "doing balance round" }
   ```

   This output confirms that:

- The balancer originates from the `mongos` running on the system with the hostname `mongos0.example.net`.
- The value in the `state` field indicates that a `mongos` has the lock. For version 2.0 and later, the value of an active lock is `2`; for earlier versions the value is `1`.

Schedule the Balancing Window

In some situations, particularly when your data set grows slowly and a migration can impact performance, it is useful to ensure that the balancer is active only at certain times. The following procedure specifies the `activeWindow`, which is the timeframe during which the *balancer* will be able to migrate chunks:

Step 1: Connect to `mongos` using the `mongo` shell.

You can connect to any `mongos` in the cluster.

Step 2: Switch to the *Config Database*.

Issue the following command to switch to the config database.

```
use config
```

Step 3: Ensure that the balancer is not `stopped`.

The balancer will not activate in the `stopped` state. To ensure that the balancer is not `stopped`, use `sh.setBalancerState()`, as in the following:

```
sh.setBalancerState( true )
```

The balancer will not start if you are outside of the `activeWindow` timeframe.

Step 4: Modify the balancer's window.

Set the `activeWindow` using `update()`, as in the following:

```
db.settings.update(
   { _id: "balancer" },
   { $set: { activeWindow : { start : "<start-time>", stop : "<stop-time>" } } },
   { upsert: true }
)
```

Replace `<start-time>` and `<end-time>` with time values using two digit hour and minute values (i.e. `HH:MM`) that specify the beginning and end boundaries of the balancing window.

- For `HH` values, use hour values ranging from `00` - `23`.
- For `MM` value, use minute values ranging from `00` - `59`.

MongoDB evaluates the start and stop times relative to the time zone of each individual `mongos` instance in the sharded cluster. If your `mongos` instances are physically located in different time zones, set the time zone on each server to UTC+-00:00 so that the balancer window is uniformly interpreted.

Note: The balancer window must be sufficient to *complete* the migration of all data inserted during the day.

As data insert rates can change based on activity and usage patterns, it is important to ensure that the balancing window you select will be sufficient to support the needs of your deployment.

Do not use the `sh.startBalancer()` method when you have set an `activeWindow`.

Remove a Balancing Window Schedule

If you have *set the balancing window* (page 71) and wish to remove the schedule so that the balancer is always running, use `$unset` to clear the `activeWindow`, as in the following:

```
use config
db.settings.update({ _id : "balancer" }, { $unset : { activeWindow : true } })
```

Disable the Balancer

By default, the balancer may run at any time and only moves chunks as needed. To disable the balancer for a short period of time and prevent all migration, use the following procedure:

1. Connect to any `mongos` in the cluster using the `mongo` shell.
2. Issue the following operation to disable the balancer:

   ```
   sh.stopBalancer()
   ```

   If a migration is in progress, the system will complete the in-progress migration before stopping.
3. To verify that the balancer will not start, issue the following command, which returns `false` if the balancer is disabled:

   ```
   sh.getBalancerState()
   ```

   Optionally, to verify no migrations are in progress after disabling, issue the following operation in the `mongo` shell:

   ```
   use config
   while( sh.isBalancerRunning() ) {
             print("waiting...");
             sleep(1000);
   }
   ```

Note: To disable the balancer from a driver that does not have the `sh.stopBalancer()` or `sh.setBalancerState()` helpers, issue the following command from the `config` database:

```
db.settings.update( { _id: "balancer" }, { $set : { stopped: true } } ,  { upsert: true } )
```

Enable the Balancer

Use this procedure if you have disabled the balancer and are ready to re-enable it:

1. Connect to any `mongos` in the cluster using the `mongo` shell.
2. Issue one of the following operations to enable the balancer:

   From the `mongo` shell, issue:

```
sh.setBalancerState(true)
```

From a driver that does not have the `sh.startBalancer()` helper, issue the following from the `config` database:

```
db.settings.update( { _id: "balancer" }, { $set : { stopped: false } } , { upsert: true } )
```

Disable Balancing During Backups

If MongoDB migrates a *chunk* during a `backup`, you can end with an inconsistent snapshot of your *sharded cluster*. Never run a backup while the balancer is active. To ensure that the balancer is inactive during your backup operation:

- Set the *balancing window* (page 71) so that the balancer is inactive during the backup. Ensure that the backup can complete while you have the balancer disabled.
- *manually disable the balancer* (page 72) for the duration of the backup procedure.

If you turn the balancer off while it is in the middle of a balancing round, the shut down is not instantaneous. The balancer completes the chunk move in-progress and then ceases all further balancing rounds.

Before starting a backup operation, confirm that the balancer is not active. You can use the following command to determine if the balancer is active:

```
!sh.getBalancerState() && !sh.isBalancerRunning()
```

When the backup procedure is complete you can reactivate the balancer process.

Disable Balancing on a Collection

You can disable balancing for a specific collection with the `sh.disableBalancing()` method. You may want to disable the balancer for a specific collection to support maintenance operations or atypical workloads, for example, during data ingestions or data exports.

When you disable balancing on a collection, MongoDB will not interrupt in progress migrations.

To disable balancing on a collection, connect to a `mongos` with the `mongo` shell and call the `sh.disableBalancing()` method.

For example:

```
sh.disableBalancing("students.grades")
```

The `sh.disableBalancing()` method accepts as its parameter the full *namespace* of the collection.

Enable Balancing on a Collection

You can enable balancing for a specific collection with the `sh.enableBalancing()` method.

When you enable balancing for a collection, MongoDB will not *immediately* begin balancing data. However, if the data in your sharded collection is not balanced, MongoDB will be able to begin distributing the data more evenly.

To enable balancing on a collection, connect to a `mongos` with the `mongo` shell and call the `sh.enableBalancing()` method.

For example:

```
sh.enableBalancing("students.grades")
```

The `sh.enableBalancing()` method accepts as its parameter the full *namespace* of the collection.

Confirm Balancing is Enabled or Disabled

To confirm whether balancing for a collection is enabled or disabled, query the `collections` collection in the `config` database for the collection *namespace* and check the `noBalance` field. For example:

```
db.getSiblingDB("config").collections.findOne({_id : "students.grades"}).noBalance;
```

This operation will return a null error, `true`, `false`, or no output:

- A null error indicates the collection namespace is incorrect.
- If the result is `true`, balancing is disabled.
- If the result is `false`, balancing is enabled currently but has been disabled in the past for the collection. Balancing of this collection will begin the next time the balancer runs.
- If the operation returns no output, balancing is enabled currently and has never been disabled in the past for this collection. Balancing of this collection will begin the next time the balancer runs.

New in version 3.0.0: You can also see if the balancer is enabled using `sh.status()`. The `currently-enabled` field indicates if the balancer is enabled.

3.2.9 Remove Shards from an Existing Sharded Cluster

On this page

To remove a *shard* you must ensure the shard's data is migrated to the remaining shards in the cluster. This procedure describes how to safely migrate data and how to remove a shard.

This procedure describes how to safely remove a *single* shard. *Do not* use this procedure to migrate an entire cluster to new hardware. To migrate an entire shard to new hardware, migrate individual shards as if they were independent replica sets.

To remove a shard, first connect to one of the cluster's `mongos` instances using `mongo` shell. Then use the sequence of tasks in this document to remove a shard from the cluster.

Ensure the Balancer Process is Enabled

To successfully migrate data from a shard, the *balancer* process **must** be enabled. Check the balancer state using the `sh.getBalancerState()` helper in the `mongo` shell. For more information, see the section on *balancer operations* (page 72).

Determine the Name of the Shard to Remove

To determine the name of the shard, connect to a `mongos` instance with the `mongo` shell and either:

- Use the `listShards` command, as in the following:

```
db.adminCommand( { listShards: 1 } )
```

- Run either the `sh.status()` or the `db.printShardingStatus()` method.

The `shards._id` field lists the name of each shard.

Remove Chunks from the Shard

From the `admin` database, run the `removeShard` command. This begins "draining" chunks from the shard you are removing to other shards in the cluster. For example, for a shard named `mongodb0`, run:

```
use admin
db.runCommand( { removeShard: "mongodb0" } )
```

This operation returns immediately, with the following response:

```
{
    "msg" : "draining started successfully",
    "state" : "started",
    "shard" : "mongodb0",
    "ok" : 1
}
```

Depending on your network capacity and the amount of data, this operation can take from a few minutes to several days to complete.

Check the Status of the Migration

To check the progress of the migration at any stage in the process, run `removeShard` from the `admin` database again. For example, for a shard named `mongodb0`, run:

```
use admin
db.runCommand( { removeShard: "mongodb0" } )
```

The command returns output similar to the following:

```
{
     "msg" : "draining ongoing",
    "state" : "ongoing",
    "remaining" : {
        "chunks" : 42,
        "dbs" : 1
    },
    "ok" : 1
}
```

In the output, the `remaining` document displays the remaining number of chunks that MongoDB must migrate to other shards and the number of MongoDB databases that have "primary" status on this shard.

Continue checking the status of the *removeShard* command until the number of chunks remaining is `0`. Always run the command on the `admin` database. If you are on a database other than `admin`, you can use `sh._adminCommand` to run the command on `admin`.

Move Unsharded Data

If the shard is the *primary shard* for one or more databases in the cluster, then the shard will have unsharded data. If the shard is not the primary shard for any databases, skip to the next task, *Finalize the Migration* (page 76).

In a cluster, a database with unsharded collections stores those collections only on a single shard. That shard becomes the primary shard for that database. (Different databases in a cluster can have different primary shards.)

Warning: Do not perform this procedure until you have finished draining the shard.

1. To determine if the shard you are removing is the primary shard for any of the cluster's databases, issue one of the following methods:

   - `sh.status()`
   - `db.printShardingStatus()`

   In the resulting document, the `databases` field lists each database and its primary shard. For example, the following `database` field shows that the `products` database uses `mongodb0` as the primary shard:

   ```
   {  "_id" : "products",  "partitioned" : true,  "primary" : "mongodb0" }
   ```

2. To move a database to another shard, use the `movePrimary` command. For example, to migrate all remaining unsharded data from `mongodb0` to `mongodb1`, issue the following command:

   ```
   db.runCommand( { movePrimary: "products", to: "mongodb1" })
   ```

   This command does not return until MongoDB completes moving all data, which may take a long time. The response from this command will resemble the following:

   ```
   { "primary" : "mongodb1", "ok" : 1 }
   ```

Finalize the Migration

To clean up all metadata information and finalize the removal, run `removeShard` again. For example, for a shard named `mongodb0`, run:

```
use admin
db.runCommand( { removeShard: "mongodb0" } )
```

A success message appears at completion:

```
{
    "msg" : "removeshard completed successfully",
    "state" : "completed",
    "shard" : "mongodb0",
    "ok" : 1
}
```

Once the value of the `state` field is "completed", you may safely stop the processes comprising the `mongodb0` shard.

See also:

`https://docs.mongodb.org/manual/administration/backup-sharded-clusters`

3.3 Sharded Cluster Data Management

The following documents provide information in managing data in sharded clusters.

Create Chunks in a Sharded Cluster **(page 77)** Create chunks, or *pre-split* empty collection to ensure an even distribution of chunks during data ingestion.

Split Chunks in a Sharded Cluster **(page 78)** Manually create chunks in a sharded collection.

Migrate Chunks in a Sharded Cluster **(page 79)** Manually migrate chunks without using the automatic balance process.

Merge Chunks in a Sharded Cluster **(page 80)** Use the `mergeChunks` to manually combine chunk ranges.

Modify Chunk Size in a Sharded Cluster **(page 83)** Modify the default chunk size in a sharded collection

Clear jumbo Flag **(page 83)** Clear *jumbo* flag from a shard.

Manage Shard Tags **(page 86)** Use tags to associate specific ranges of shard key values with specific shards.

Enforce Unique Keys for Sharded Collections **(page 87)** Ensure that a field is always unique in all collections in a sharded cluster.

Shard GridFS Data Store **(page 90)** Choose whether to shard GridFS data in a sharded collection.

3.3.1 Create Chunks in a Sharded Cluster

Pre-splitting the chunk ranges in an empty sharded collection allows clients to insert data into an already partitioned collection. In most situations a *sharded cluster* will create and distribute chunks automatically without user intervention. However, in a limited number of cases, MongoDB cannot create enough chunks or distribute data fast enough to support required throughput. For example:

- If you want to partition an existing data collection that resides on a single shard.
- If you want to ingest a large volume of data into a cluster that isn't balanced, or where the ingestion of data will lead to data imbalance. For example, monotonically increasing or decreasing shard keys insert all data into a single chunk.

These operations are resource intensive for several reasons:

- Chunk migration requires copying all the data in the chunk from one shard to another.
- MongoDB can migrate only a single chunk at a time.
- MongoDB creates splits only after an insert operation.

Warning: Only pre-split an empty collection. If a collection already has data, MongoDB automatically splits the collection's data when you enable sharding for the collection. Subsequent attempts to manually create splits can lead to unpredictable chunk ranges and sizes as well as inefficient or ineffective balancing behavior.

To create chunks manually, use the following procedure:

1. Split empty chunks in your collection by manually performing the `split` command on chunks.

   Example

   To create chunks for documents in the `myapp.users` collection using the `email` field as the *shard key*, use the following operation in the `mongo` shell:

   ```
   for ( var x=97; x<97+26; x++ ){
     for( var y=97; y<97+26; y+=6 ) {
       var prefix = String.fromCharCode(x) + String.fromCharCode(y);
       db.runCommand( { split : "myapp.users" , middle : { email : prefix } } );
     }
   }
   ```

   This assumes a collection size of 100 million documents.

For information on the balancer and automatic distribution of chunks across shards, see *Cluster Balancer* (page 29) and *Chunk Migration* (page 31). For information on manually migrating chunks, see *Migrate Chunks in a Sharded Cluster* (page 79).

3.3.2 Split Chunks in a Sharded Cluster

Normally, MongoDB splits a *chunk* after an insert if the chunk exceeds the maximum *chunk size* (page 33). However, you may want to split chunks manually if:

- you have a large amount of data in your cluster and very few *chunks*, as is the case after deploying a cluster using existing data.
- you expect to add a large amount of data that would initially reside in a single chunk or shard. For example, you plan to insert a large amount of data with *shard key* values between `300` and `400`, *but* all values of your shard keys are between `250` and `500` are in a single chunk.

Note: New in version 2.6: MongoDB provides the `mergeChunks` command to combine contiguous chunk ranges into a single chunk. See *Merge Chunks in a Sharded Cluster* (page 80) for more information.

The *balancer* may migrate recently split chunks to a new shard immediately if `mongos` predicts future insertions will benefit from the move. The balancer does not distinguish between chunks split manually and those split automatically by the system.

Warning: Be careful when splitting data in a sharded collection to create new chunks. When you shard a collection that has existing data, MongoDB automatically creates chunks to evenly distribute the collection. To split data effectively in a sharded cluster you must consider the number of documents in a chunk and the average document size to create a uniform chunk size. When chunks have irregular sizes, shards may have an equal number of chunks but have very different data sizes. Avoid creating splits that lead to a collection with differently sized chunks.

Use `sh.status()` to determine the current chunk ranges across the cluster.

To split chunks manually, use the `split` command with either fields `middle` or `find`. The `mongo` shell provides the helper methods `sh.splitFind()` and `sh.splitAt()`.

`splitFind()` splits the chunk that contains the *first* document returned that matches this query into two equally sized chunks. You must specify the full namespace (i.e. "`<database>.<collection>`") of the sharded collection to `splitFind()`. The query in `splitFind()` does not need to use the shard key, though it nearly always makes sense to do so.

Example

The following command splits the chunk that contains the value of `63109` for the `zipcode` field in the `people` collection of the `records` database:

```
sh.splitFind( "records.people", { "zipcode": "63109" } )
```

Use `splitAt()` to split a chunk in two, using the queried document as the lower bound in the new chunk:

Example

The following command splits the chunk that contains the value of `63109` for the `zipcode` field in the `people` collection of the `records` database.

```
sh.splitAt( "records.people", { "zipcode": "63109" } )
```

Note: `splitAt()` does not necessarily split the chunk into two equally sized chunks. The split occurs at the location of the document matching the query, regardless of where that document is in the chunk.

3.3.3 Migrate Chunks in a Sharded Cluster

In most circumstances, you should let the automatic *balancer* migrate *chunks* between *shards*. However, you may want to migrate chunks manually in a few cases:

- When *pre-splitting* an empty collection, migrate chunks manually to distribute them evenly across the shards. Use pre-splitting in limited situations to support bulk data ingestion.
- If the balancer in an active cluster cannot distribute chunks within the *balancing window* (page 71), then you will have to migrate chunks manually.

To manually migrate chunks, use the `moveChunk` command. For more information on how the automatic balancer moves chunks between shards, see *Cluster Balancer* (page 29) and *Chunk Migration* (page 31).

Example

Migrate a single chunk

The following example assumes that the field `username` is the *shard key* for a collection named `users` in the `myapp` database, and that the value `smith` exists within the *chunk* to migrate. Migrate the chunk using the following command in the `mongo` shell.

```
db.adminCommand( { moveChunk : "myapp.users",
                   find : {username : "smith"},
                   to : "mongodb-shard3.example.net" } )
```

This command moves the chunk that includes the shard key value "smith" to the *shard* named `mongodb-shard3.example.net`. The command will block until the migration is complete.

Tip

To return a list of shards, use the `listShards` command.

Example

Evenly migrate chunks

To evenly migrate chunks for the `myapp.users` collection, put each prefix chunk on the next shard from the other and run the following commands in the mongo shell:

```
var shServer = [ "sh0.example.net", "sh1.example.net", "sh2.example.net", "sh3.example.net", "sh4.exa
for ( var x=97; x<97+26; x++ ){
  for( var y=97; y<97+26; y+=6 ) {
    var prefix = String.fromCharCode(x) + String.fromCharCode(y);
    db.adminCommand({moveChunk : "myapp.users", find : {email : prefix}, to : shServer[(y-97)/6]})
  }
}
```

See *Create Chunks in a Sharded Cluster* (page 77) for an introduction to pre-splitting.

New in version 2.2: The `moveChunk` command has the: `_secondaryThrottle` parameter. When set to `true`, MongoDB ensures that changes to shards as part of chunk migrations replicate to *secondaries* throughout the migration

operation. For more information, see *Change Replication Behavior for Chunk Migration* (page 68).

Changed in version 2.4: In 2.4, `_secondaryThrottle` is `true` by default.

Warning: The `moveChunk` command may produce the following error message:

```
The collection's metadata lock is already taken.
```

This occurs when clients have too many open *cursors* that access the migrating chunk. You may either wait until the cursors complete their operations or close the cursors manually.

3.3.4 Merge Chunks in a Sharded Cluster

On this page

Overview

The `mergeChunks` command allows you to collapse empty chunks into neighboring chunks on the same shard. A *chunk* is empty if it has no documents associated with its shard key range.

Important: Empty *chunks* can make the *balancer* assess the cluster as properly balanced when it is not.

Empty chunks can occur under various circumstances, including:

- If a *pre-split* (page 77) creates too many chunks, the distribution of data to chunks may be uneven.
- If you delete many documents from a sharded collection, some chunks may no longer contain data.

This tutorial explains how to identify chunks available to merge, and how to merge those chunks with neighboring chunks.

Procedure

Note: Examples in this procedure use a `users` *collection* in the `test` *database*, using the `username` filed as a *shard key*.

Identify Chunk Ranges

In the `mongo` shell, identify the *chunk* ranges with the following operation:

```
sh.status()
```

The output of the `sh.status()` will resemble the following:

```
--- Sharding Status ---
sharding version: {
     "_id" : 1,
     "version" : 4,
```

```
    "minCompatibleVersion" : 4,
    "currentVersion" : 5,
    "clusterId" : ObjectId("5260032c901f6712dcd8f400")
}
shards:
    {  "_id" : "shard0000",  "host" : "localhost:30000" }
    {  "_id" : "shard0001",  "host" : "localhost:30001" }
  databases:
    {  "_id" : "admin",  "partitioned" : false,  "primary" : "config" }
    {  "_id" : "test",  "partitioned" : true,  "primary" : "shard0001" }
            test.users
                    shard key: { "username" : 1 }
                    chunks:
                            shard0000       7
                            shard0001       7
                    { "username" : { "$minKey" : 1 } } -->> { "username" : "user16643" } on : shard0
                    { "username" : "user16643" } -->> { "username" : "user2329" } on : shard0000 Tim
                    { "username" : "user2329" } -->> { "username" : "user29937" } on : shard0000 Tim
                    { "username" : "user29937" } -->> { "username" : "user36583" } on : shard0000 Ti
                    { "username" : "user36583" } -->> { "username" : "user43229" } on : shard0000 Ti
                    { "username" : "user43229" } -->> { "username" : "user49877" } on : shard0000 Ti
                    { "username" : "user49877" } -->> { "username" : "user56522" } on : shard0000 Ti
                    { "username" : "user56522" } -->> { "username" : "user63169" } on : shard0001 Ti
                    { "username" : "user63169" } -->> { "username" : "user69816" } on : shard0001 Ti
                    { "username" : "user69816" } -->> { "username" : "user76462" } on : shard0001 Ti
                    { "username" : "user76462" } -->> { "username" : "user83108" } on : shard0001 Ti
                    { "username" : "user83108" } -->> { "username" : "user89756" } on : shard0001 Ti
                    { "username" : "user89756" } -->> { "username" : "user96401" } on : shard0001 Ti
                    { "username" : "user96401" } -->> { "username" : { "$maxKey" : 1 } } on : shard0
```

The chunk ranges appear after the chunk counts for each sharded collection, as in the following excerpts:

Chunk counts:

```
    chunks:
            shard0000       7
            shard0001       7
```

Chunk range:

```
    { "username" : "user36583" } -->> { "username" : "user43229" } on : shard0000 Timestamp(6, 0)
```

Verify a Chunk is Empty

The `mergeChunks` command requires at least one empty input chunk. To check the size of a chunk, use the `dataSize` command in the sharded collection's database. For example, the following checks the amount of data in the chunk for the `users` collection in the `test` database:

Important: You must use the `use <db>` helper to switch to the database containing the sharded collection before running the `dataSize` command.

```
use test
db.runCommand({
   "dataSize": "test.users",
   "keyPattern": { username: 1 },
   "min": { "username": "user36583" },
```

```
   "max": { "username": "user43229" }
})
```

If the input chunk to `dataSize` is empty, `dataSize` produces output similar to:

```
{ "size" : 0, "numObjects" : 0, "millis" : 0, "ok" : 1 }
```

Merge Chunks

Merge two contiguous *chunks* on the same *shard*, where at least one of the contains no data, with an operation that resembles the following:

```
db.runCommand( { mergeChunks: "test.users",
                 bounds: [ { "username": "user68982" },
                           { "username": "user95197" } ]
             } )
```

On success, `mergeChunks` produces the following output:

```
{ "ok" : 1 }
```

On any failure condition, `mergeChunks` returns a document where the value of the `ok` field is `0`.

View Merged Chunks Ranges

After merging all empty chunks, confirm the new chunk, as follows:

```
sh.status()
```

The output of `sh.status()` should resemble:

```
--- Sharding Status ---
sharding version: {
     "_id" : 1,
     "version" : 4,
     "minCompatibleVersion" : 4,
     "currentVersion" : 5,
     "clusterId" : ObjectId("5260032c901f6712dcd8f400")
}
shards:
     {  "_id" : "shard0000",  "host" : "localhost:30000" }
     {  "_id" : "shard0001",  "host" : "localhost:30001" }
  databases:
     {  "_id" : "admin",  "partitioned" : false,  "primary" : "config" }
     {  "_id" : "test",  "partitioned" : true,  "primary" : "shard0001" }
             test.users
                     shard key: { "username" : 1 }
                     chunks:
                             shard0000       2
                             shard0001       2
                     { "username" : { "$minKey" : 1 } } -->> { "username" : "user16643" } on : shard0
                     { "username" : "user16643" } -->> { "username" : "user56522" } on : shard0000 T
                     { "username" : "user56522" } -->> { "username" : "user96401" } on : shard0001 T
                     { "username" : "user96401" } -->> { "username" : { "$maxKey" : 1 } } on : shard0
```

3.3.5 Modify Chunk Size in a Sharded Cluster

When the first `mongos` connects to a set of *config servers*, it initializes the sharded cluster with a default chunk size of 64 megabytes. This default chunk size works well for most deployments; however, if you notice that automatic migrations have more I/O than your hardware can handle, you may want to reduce the chunk size. For automatic splits and migrations, a small chunk size leads to more rapid and frequent migrations. The allowed range of the chunk size is between 1 and 1024 megabytes, inclusive.

To modify the chunk size, use the following procedure:

1. Connect to any `mongos` in the cluster using the `mongo` shell.
2. Issue the following command to switch to the *Config Database* (page 95):

   ```
   use config
   ```

3. Issue the following `save()` operation to store the global chunk size configuration value:

   ```
   db.settings.save( { _id:"chunksize", value: <sizeInMB> } )
   ```

Note: The `chunkSize` and *`--chunkSize`* options, passed at startup to the `mongos`, **do not** affect the chunk size after you have initialized the cluster.

To avoid confusion, *always* set the chunk size using the above procedure instead of the startup options.

Modifying the chunk size has several limitations:

- Automatic splitting only occurs on insert or update.
- If you lower the chunk size, it may take time for all chunks to split to the new size.
- Splits cannot be undone.
- If you increase the chunk size, existing chunks grow only through insertion or updates until they reach the new size.
- The allowed range of the chunk size is between 1 and 1024 megabytes, inclusive.

3.3.6 Clear `jumbo` Flag

On this page

If MongoDB cannot split a chunk that exceeds the *specified chunk size* (page 33) or contains a number of documents that exceeds the `max`, MongoDB labels the chunk as *jumbo* (page 33).

If the chunk size no longer hits the limits, MongoDB clears the `jumbo` flag for the chunk when the `mongos` reloads or rewrites the chunk metadata.

In cases where you need to clear the flag manually, the following procedures outline the steps to manually clear the `jumbo` flag.

Procedures

Divisible Chunks

The preferred way to clear the `jumbo` flag from a chunk is to attempt to split the chunk. If the chunk is divisible, MongoDB removes the flag upon successful split of the chunk.

Step 1: Connect to `mongos`. Connect a `mongo` shell to a `mongos`.

Step 2: Find the `jumbo` Chunk. Run `sh.status(true)` to find the chunk labeled `jumbo`.

```
sh.status(true)
```

For example, the following output from sh.status(true) shows that chunk with shard key range `{ "x" : 2 } -->> { "x" : 4 }` is `jumbo`.

```
--- Sharding Status ---
  sharding version: {
     ...
  }
  shards:
     ...
  databases:
     ...
        test.foo
           shard key: { "x" : 1 }
        chunks:
             shard-b  2
             shard-a  2
        { "x" : { "$minKey" : 1 } } -->> { "x" : 1 } on : shard-b Timestamp(2, 0)
        { "x" : 1 } -->> { "x" : 2 } on : shard-a Timestamp(3, 1)
        { "x" : 2 } -->> { "x" : 4 } on : shard-a Timestamp(2, 2) jumbo
        { "x" : 4 } -->> { "x" : { "$maxKey" : 1 } } on : shard-b Timestamp(3, 0)
```

Step 3: Split the `jumbo` Chunk. Use either `sh.splitAt()` or `sh.splitFind()` to split the `jumbo` chunk.

```
sh.splitAt( "test.foo", { x: 3 })
```

MongoDB removes the `jumbo` flag upon successful split of the chunk.

Indivisible Chunks

In some instances, MongoDB cannot split the no-longer `jumbo` chunk, such as a chunk with a range of single shard key value, and the preferred method to clear the flag is not applicable. In such cases, you can clear the flag using the following steps.

Important: Only use this method if the *preferred method* (page 84) is *not* applicable.

Before modifying the *config database* (page 95), *always* back up the config database.

If you clear the `jumbo` flag for a chunk that still exceeds the chunk size and/or the document number limit, MongoDB will re-label the chunk as `jumbo` when MongoDB tries to move the chunk.

Step 1: Stop the balancer. Disable the cluster balancer process temporarily, following the steps outlined in *Disable the Balancer* (page 72).

Step 2: Create a backup of `config` database. Use `mongodump` against a config server to create a backup of the `config` database. For example:

```
mongodump --db config --port <config server port> --out <output file>
```

Step 3: Connect to `mongos`. Connect a `mongo` shell to a `mongos`.

Step 4: Find the `jumbo` Chunk. Run `sh.status(true)` to find the chunk labeled `jumbo`.

```
sh.status(true)
```

For example, the following output from sh.status(true) shows that chunk with shard key range `{ "x" : 2 } -->> { "x" : 3 }` is `jumbo`.

```
--- Sharding Status ---
  sharding version: {
     ...
  }
  shards:
     ...
  databases:
     ...
        test.foo
           shard key: { "x" : 1 }
        chunks:
             shard-b  2
             shard-a  2
        { "x" : { "$minKey" : 1 } } -->> { "x" : 1 } on : shard-b Timestamp(2, 0)
        { "x" : 1 } -->> { "x" : 2 } on : shard-a Timestamp(3, 1)
        { "x" : 2 } -->> { "x" : 3 } on : shard-a Timestamp(2, 2) jumbo
        { "x" : 3 } -->> { "x" : { "$maxKey" : 1 } } on : shard-b Timestamp(3, 0)
```

Step 5: Update `chunks` collection. In the `chunks` collection of the `config` database, unset the `jumbo` flag for the chunk. For example,

```
db.getSiblingDB("config").chunks.update(
   { ns: "test.foo", min: { x: 2 }, jumbo: true },
   { $unset: { jumbo: "" } }
)
```

Step 6: Restart the balancer. Restart the balancer, following the steps in *Enable the Balancer* (page 72).

Step 7: Optional. Clear current cluster meta information. To ensure that `mongos` instances update their cluster information cache, run `flushRouterConfig` in the `admin` database.

```
db.adminCommand({ flushRouterConfig: 1 } )
```

3.3.7 Manage Shard Tags

On this page

In a sharded cluster, you can use tags to associate specific ranges of a *shard key* with a specific *shard* or subset of shards.

Tag a Shard

Associate tags with a particular shard using the `sh.addShardTag()` method when connected to a `mongos` instance. A single shard may have multiple tags, and multiple shards may also have the same tag.

Example

The following example adds the tag `NYC` to two shards, and the tags `SFO` and `NRT` to a third shard:

```
sh.addShardTag("shard0000", "NYC")
sh.addShardTag("shard0001", "NYC")
sh.addShardTag("shard0002", "SFO")
sh.addShardTag("shard0002", "NRT")
```

You may remove tags from a particular shard using the `sh.removeShardTag()` method when connected to a `mongos` instance, as in the following example, which removes the `NRT` tag from a shard:

```
sh.removeShardTag("shard0002", "NRT")
```

Tag a Shard Key Range

To assign a tag to a range of shard keys use the `sh.addTagRange()` method when connected to a `mongos` instance. Any given shard key range may only have *one* assigned tag. You cannot overlap defined ranges, or tag the same range more than once.

Example

Given a collection named `users` in the `records` database, sharded by the `zipcode` field. The following operations assign:

- two ranges of zip codes in Manhattan and Brooklyn the `NYC` tag
- one range of zip codes in San Francisco the `SFO` tag

```
sh.addTagRange("records.users", { zipcode: "10001" }, { zipcode: "10281" }, "NYC")
sh.addTagRange("records.users", { zipcode: "11201" }, { zipcode: "11240" }, "NYC")
sh.addTagRange("records.users", { zipcode: "94102" }, { zipcode: "94135" }, "SFO")
```

Note: Shard ranges are always inclusive of the lower value and exclusive of the upper boundary.

Remove a Tag From a Shard Key Range

The `mongod` does not provide a helper for removing a tag range. You may delete tag assignment from a shard key range by removing the corresponding document from the `tags` (page 100) collection of the `config` database.

Each document in the `tags` (page 100) holds the *namespace* of the sharded collection and a minimum shard key value.

Example

The following example removes the `NYC` tag assignment for the range of zip codes within Manhattan:

```
use config
db.tags.remove({ _id: { ns: "records.users", min: { zipcode: "10001" }}, tag: "NYC" })
```

View Existing Shard Tags

The output from `sh.status()` lists tags associated with a shard, if any, for each shard. A shard's tags exist in the shard's document in the `shards` (page 100) collection of the `config` database. To return all shards with a specific tag, use a sequence of operations that resemble the following, which will return only those shards tagged with `NYC`:

```
use config
db.shards.find({ tags: "NYC" })
```

You can find tag ranges for all *namespaces* in the `tags` (page 100) collection of the `config` database. The output of `sh.status()` displays all tag ranges. To return all shard key ranges tagged with `NYC`, use the following sequence of operations:

```
use config
db.tags.find({ tags: "NYC" })
```

Additional Resource

- Whitepaper: MongoDB Multi-Data Center Deployments[3]
- Webinar: Multi-Data Center Deployment[4]

3.3.8 Enforce Unique Keys for Sharded Collections

On this page

Overview

The `unique` constraint on indexes ensures that only one document can have a value for a field in a *collection*. For *sharded collections these unique indexes cannot enforce uniqueness* because insert and indexing operations are local to each shard.

[3] http://www.mongodb.com/lp/white-paper/multi-dc?jmp=docs
[4] https://www.mongodb.com/presentations/webinar-multi-data-center-deployment?jmp=docs

MongoDB does not support creating new unique indexes in sharded collections and will not allow you to shard collections with unique indexes on fields other than the `_id` field.

If you need to ensure that a field is always unique in a sharded collection, there are three options:

1. Enforce uniqueness of the *shard key* (page 19).

   MongoDB *can* enforce uniqueness for the *shard key*. For compound shard keys, MongoDB will enforce uniqueness on the *entire* key combination, and not for a specific component of the shard key.

   You cannot specify a unique constraint on a *hashed index*.

2. Use a secondary collection to enforce uniqueness.

   Create a minimal collection that only contains the unique field and a reference to a document in the main collection. If you always insert into a secondary collection *before* inserting to the main collection, MongoDB will produce an error if you attempt to use a duplicate key.

   If you have a small data set, you may not need to shard this collection and you can create multiple unique indexes. Otherwise you can shard on a single unique key.

3. Use guaranteed unique identifiers.

   Universally unique identifiers (i.e. UUID) like the `ObjectId` are guaranteed to be unique.

Procedures

Unique Constraints on the Shard Key

Process To shard a collection using the `unique` constraint, specify the `shardCollection` command in the following form:

```
db.runCommand( { shardCollection : "test.users" , key : { email : 1 } , unique : true } );
```

Remember that the `_id` field index is always unique. By default, MongoDB inserts an `ObjectId` into the `_id` field. However, you can manually insert your own value into the `_id` field and use this as the shard key. To use the `_id` field as the shard key, use the following operation:

```
db.runCommand( { shardCollection : "test.users" } )
```

Limitations

- You can only enforce uniqueness on one single field in the collection using this method.
- If you use a compound shard key, you can only enforce uniqueness on the *combination* of component keys in the shard key.

In most cases, the best shard keys are compound keys that include elements that permit *write scaling* (page 20) and *query isolation* (page 21), as well as *high cardinality* (page 45). These ideal shard keys are not often the same keys that require uniqueness and enforcing unique values in these collections requires a different approach.

Unique Constraints on Arbitrary Fields

If you cannot use a unique field as the shard key or if you need to enforce uniqueness over multiple fields, you must create another *collection* to act as a "proxy collection". This collection must contain both a reference to the original document (i.e. its `ObjectId`) and the unique key.

If you must shard this "proxy" collection, then shard on the unique key using the *above procedure* (page 88); otherwise, you can simply create multiple unique indexes on the collection.

Process Consider the following for the "proxy collection:"

```
{
  "_id" : ObjectId("...")
  "email" ": "..."
}
```

The `_id` field holds the `ObjectId` of the *document* it reflects, and the `email` field is the field on which you want to ensure uniqueness.

To shard this collection, use the following operation using the `email` field as the *shard key*:

```
db.runCommand( { shardCollection : "records.proxy" ,
                 key : { email : 1 } ,
                 unique : true } );
```

If you do not need to shard the proxy collection, use the following command to create a unique index on the `email` field:

```
db.proxy.createIndex( { "email" : 1 }, { unique : true } )
```

You may create multiple unique indexes on this collection if you do not plan to shard the `proxy` collection.

To insert documents, use the following procedure in the *JavaScript shell*:

```
db = db.getSiblingDB('records');

var primary_id = ObjectId();

db.proxy.insert({
   "_id" : primary_id
   "email" : "example@example.net"
})

// if: the above operation returns successfully,
// then continue:

db.information.insert({
   "_id" : primary_id
   "email": "example@example.net"
   // additional information...
})
```

You must insert a document into the `proxy` collection first. If this operation succeeds, the `email` field is unique, and you may continue by inserting the actual document into the `information` collection.

See

The full documentation of: `createIndex()` and `shardCollection`.

Considerations

- Your application must catch errors when inserting documents into the "proxy" collection and must enforce consistency between the two collections.
- If the proxy collection requires sharding, you must shard on the single field on which you want to enforce uniqueness.

- To enforce uniqueness on more than one field using sharded proxy collections, you must have *one* proxy collection for *every* field for which to enforce uniqueness. If you create multiple unique indexes on a single proxy collection, you will *not* be able to shard proxy collections.

Use Guaranteed Unique Identifier

The best way to ensure a field has unique values is to generate universally unique identifiers (UUID,) such as MongoDB's `ObjectId` values.

This approach is particularly useful for the''_id'' field, which *must* be unique: for collections where you are *not* sharding by the `_id` field the application is responsible for ensuring that the `_id` field is unique.

3.3.9 Shard GridFS Data Store

On this page

When sharding a *GridFS* store, consider the following:

`files` Collection

Most deployments will not need to shard the `files` collection. The `files` collection is typically small, and only contains metadata. None of the required keys for GridFS lend themselves to an even distribution in a sharded situation. If you *must* shard the `files` collection, use the `_id` field possibly in combination with an application field.

Leaving `files` unsharded means that all the file metadata documents live on one shard. For production GridFS stores you *must* store the `files` collection on a replica set.

`chunks` Collection

To shard the `chunks` collection by `{ files_id : 1 , n : 1 }`, issue commands similar to the following:

```
db.fs.chunks.createIndex( { files_id : 1 , n : 1 } )
```

```
db.runCommand( { shardCollection : "test.fs.chunks" , key : { files_id : 1 , n : 1 } } )
```

You may also want to shard using just the `file_id` field, as in the following operation:

```
db.runCommand( { shardCollection : "test.fs.chunks" , key : {  files_id : 1 } } )
```

Important: `{ files_id : 1 , n : 1 }` and `{ files_id : 1 }` are the **only** supported shard keys for the `chunks` collection of a GridFS store.

Note: Changed in version 2.2.

Before 2.2, you had to create an additional index on `files_id` to shard using *only* this field.

The default `files_id` value is an *ObjectId*, as a result the values of `files_id` are always ascending, and applications will insert all new GridFS data to a single chunk and shard. If your write load is too high for a single server to handle, consider a different shard key or use a different value for `_id` in the `files` collection.

3.4 Troubleshoot Sharded Clusters

On this page

This section describes common strategies for troubleshooting *sharded cluster* deployments.

3.4.1 Config Database String Error

Changed in version 3.2: Starting in MongoDB 3.2, config servers are deployed as replica sets by default. The `mongos` instances for the sharded cluster must specify the same config server replica set name but can specify hostname and port of different members of the replica set.

If using the deprecated topology of three mirrored `mongod` instances for config servers, `mongos` instances in a sharded cluster must specify identical `configDB` string.

3.4.2 Cursor Fails Because of Stale Config Data

A query returns the following warning when one or more of the `mongos` instances has not yet updated its cache of the cluster's metadata from the *config database*:

```
could not initialize cursor across all shards because : stale config detected
```

This warning *should* not propagate back to your application. The warning will repeat until all the `mongos` instances refresh their caches. To force an instance to refresh its cache, run the `flushRouterConfig` command.

3.4.3 Avoid Downtime when Moving Config Servers

Use CNAMEs to identify your config servers to the cluster so that you can rename and renumber your config servers without downtime.

CHAPTER 4

Sharding Reference

On this page

4.1 Sharding Methods in the mongo Shell

Name	Description
sh._adminCommand()	Runs a *database command* against the admin database, like db.runCommand(), but can confirm that it is issued against a mongos.
sh.getBalancerLockDetails()	Reports on the active balancer lock, if it exists.
sh._checkFullName()	Tests a namespace to determine if its well formed.
sh._checkMongos()	Tests to see if the mongo shell is connected to a mongos instance.
sh._lastMigration()	Reports on the last *chunk* migration.
sh.addShard()	Adds a *shard* to a sharded cluster.
sh.addShardTag()	Associates a shard with a tag, to support *tag aware sharding* (page 27).
sh.addTagRange()	Associates range of shard keys with a shard tag, to support *tag aware sharding* (page 27).
sh.removeTagRange()	Removes an association between a range shard keys and a shard tag. Use to manage *tag aware sharding* (page 27).
sh.disableBalancing()	Disable balancing on a single collection in a sharded database. Does not affect balancing of other collections in a sharded cluster.
sh.enableBalancing()	Activates the sharded collection balancer process if previously disabled using sh.disableBalancing().
sh.enableSharding()	Enables sharding on a specific database.
sh.getBalancerHost()	Returns the name of a mongos that's responsible for the balancer process.
sh.getBalancerState()	Returns a boolean to report if the *balancer* is currently enabled.
sh.help()	Returns help text for the sh methods.
sh.isBalancerRunning()	Returns a boolean to report if the balancer process is currently migrating chunks.
sh.moveChunk()	Migrates a *chunk* in a *sharded cluster*.
sh.removeShardTag()	Removes the association between a shard and a shard tag.
sh.setBalancerState()	Enables or disables the *balancer* which migrates *chunks* between *shards*.
sh.shardCollection()	Enables sharding for a collection.
sh.splitAt()	Divides an existing *chunk* into two chunks using a specific value of the *shard key* as the dividing point.
sh.splitFind()	Divides an existing *chunk* that contains a document matching a query into two approximately equal chunks.
sh.startBalancer()	Enables the *balancer* and waits for balancing to start.
sh.status()	Reports on the status of a *sharded cluster*, as db.printShardingStatus().
sh.stopBalancer()	Disables the *balancer* and waits for any in progress balancing rounds to complete.
sh.waitForBalancer()	Internal. Waits for the balancer state to change.
sh.waitForBalancerOff()	Internal. Waits until the balancer stops running.
sh.waitForDLock()	Internal. Waits for a specified distributed *sharded cluster* lock.
sh.waitForPingChange()	Internal. Waits for a change in ping state from one of the mongos in the sharded cluster.

4.2 Sharding Database Commands

The following database commands support *sharded clusters*.

Name	Description
flushRouterConfig	Forces an update to the cluster metadata cached by a mongos.
addShard	Adds a *shard* to a *sharded cluster*.
cleanupOrphaned	Removes orphaned data with shard key values outside of the ranges of the chunks owned by a shard.
checkShardingIndex	Internal command that validates index on shard key.
enableSharding	Enables sharding on a specific database.
listShards	Returns a list of configured shards.
removeShard	Starts the process of removing a shard from a sharded cluster.
getShardMap	Internal command that reports on the state of a sharded cluster.
getShardVersion	Internal command that returns the *config server* version.
mergeChunks	Provides the ability to combine chunks on a single shard.
setShardVersion	Internal command to sets the *config server* version.
shardCollection	Enables the sharding functionality for a collection, allowing the collection to be sharded.
shardingState	Reports whether the mongod is a member of a sharded cluster.
unsetSharding	Internal command that affects connections between instances in a MongoDB deployment.
split	Creates a new *chunk*.
splitChunk	Internal command to split chunk. Instead use the methods sh.splitFind() and sh.splitAt().
splitVector	Internal command that determines split points.
medianKey	Deprecated internal command. See splitVector.
moveChunk	Internal command that migrates chunks between shards.
movePrimary	Reassigns the *primary shard* when removing a shard from a sharded cluster.
isdbgrid	Verifies that a process is a mongos.

4.3 Reference Documentation

Config Database **(page 95)** Complete documentation of the content of the local database that MongoDB uses to store sharded cluster metadata.

4.3.1 Config Database

On this page

The config database supports *sharded cluster* operation. See the *Sharding* (page 1) section of this manual for full documentation of sharded clusters.

Important: Consider the schema of the config database *internal* and may change between releases of MongoDB. The config database is not a dependable API, and users should not write data to the config database in the course of normal operation or maintenance.

Warning: Modification of the config database on a functioning system may lead to instability or inconsistent data sets. If you must modify the config database, use mongodump to create a full backup of the config database.

To access the config database, connect to a mongos instance in a sharded cluster, and use the following helper:

```
use config
```

You can return a list of the collections, with the following helper:

```
show collections
```

Collections

config

config.**changelog**

Internal MongoDB Metadata

The config (page 96) database is internal: applications and administrators should not modify or depend upon its content in the course of normal operation.

The changelog (page 96) collection stores a document for each change to the metadata of a sharded collection.

Example

The following example displays a single record of a chunk split from a changelog (page 96) collection:

```
{
 "_id" : "<hostname>-<timestamp>-<increment>",
 "server" : "<hostname><:port>",
 "clientAddr" : "127.0.0.1:63381",
 "time" : ISODate("2012-12-11T14:09:21.039Z"),
 "what" : "split",
 "ns" : "<database>.<collection>",
 "details" : {
    "before" : {
       "min" : {
          "<database>" : { $minKey : 1 }
       },
       "max" : {
          "<database>" : { $maxKey : 1 }
       },
       "lastmod" : Timestamp(1000, 0),
       "lastmodEpoch" : ObjectId("000000000000000000000000")
    },
    "left" : {
       "min" : {
          "<database>" : { $minKey : 1 }
       },
       "max" : {
          "<database>" : "<value>"
       },
       "lastmod" : Timestamp(1000, 1),
       "lastmodEpoch" : ObjectId(<...>)
    },
    "right" : {
       "min" : {
          "<database>" : "<value>"
       },
       "max" : {
          "<database>" : { $maxKey : 1 }
```

```
        },
        "lastmod" : Timestamp(1000, 2),
        "lastmodEpoch" : ObjectId("<...>")
    }
 }
}
```

Each document in the changelog (page 96) collection contains the following fields:

config.changelog.**_id**
The value of changelog._id is: <hostname>-<timestamp>-<increment>.

config.changelog.**server**
The hostname of the server that holds this data.

config.changelog.**clientAddr**
A string that holds the address of the client, a mongos instance that initiates this change.

config.changelog.**time**
A *ISODate* timestamp that reflects when the change occurred.

config.changelog.**what**
Reflects the type of change recorded. Possible values are:

- dropCollection
- dropCollection.start
- dropDatabase
- dropDatabase.start
- moveChunk.start
- moveChunk.commit
- split
- multi-split

config.changelog.**ns**
Namespace where the change occurred.

config.changelog.**details**
A *document* that contains additional details regarding the change. The structure of the details (page 97) document depends on the type of change.

config.**chunks**

Internal MongoDB Metadata

The config (page 96) database is internal: applications and administrators should not modify or depend upon its content in the course of normal operation.

The chunks (page 97) collection stores a document for each chunk in the cluster. Consider the following example of a document for a chunk named records.pets-animal_\"cat\":

```
{
   "_id" : "mydb.foo-a_\"cat\"",
   "lastmod" : Timestamp(1000, 3),
   "lastmodEpoch" : ObjectId("5078407bd58b175c5c225fdc"),
```

```
    "ns" : "mydb.foo",
    "min" : {
          "animal" : "cat"
    },
    "max" : {
          "animal" : "dog"
    },
    "shard" : "shard0004"
}
```

These documents store the range of values for the shard key that describe the chunk in the `min` and `max` fields. Additionally the `shard` field identifies the shard in the cluster that "owns" the chunk.

config.collections

Internal MongoDB Metadata

The `config` (page 96) database is internal: applications and administrators should not modify or depend upon its content in the course of normal operation.

The `collections` (page 98) collection stores a document for each sharded collection in the cluster. Given a collection named `pets` in the `records` database, a document in the `collections` (page 98) collection would resemble the following:

```
{
    "_id" : "records.pets",
    "lastmod" : ISODate("1970-01-16T15:00:58.107Z"),
    "dropped" : false,
    "key" : {
          "a" : 1
    },
    "unique" : false,
    "lastmodEpoch" : ObjectId("5078407bd58b175c5c225fdc")
}
```

config.databases

Internal MongoDB Metadata

The `config` (page 96) database is internal: applications and administrators should not modify or depend upon its content in the course of normal operation.

The `databases` (page 98) collection stores a document for each database in the cluster, and tracks if the database has sharding enabled. `databases` (page 98) represents each database in a distinct document. When a databases have sharding enabled, the `primary` field holds the name of the *primary shard*.

```
{ "_id" : "admin", "partitioned" : false, "primary" : "config" }
{ "_id" : "mydb", "partitioned" : true, "primary" : "shard0000" }
```

config.lockpings

Internal MongoDB Metadata

The `config` (page 96) database is internal: applications and administrators should not modify or depend upon its content in the course of normal operation.

The lockpings (page 98) collection keeps track of the active components in the sharded cluster. Given a cluster with a mongos running on example.com:30000, the document in the lockpings (page 98) collection would resemble:

```
{ "_id" : "example.com:30000:1350047994:16807", "ping" : ISODate("2012-10-12T18:32:54.892Z") }
```

config.locks

Internal MongoDB Metadata

The config (page 96) database is internal: applications and administrators should not modify or depend upon its content in the course of normal operation.

The locks (page 99) collection stores a distributed lock. This ensures that only one mongos instance can perform administrative tasks on the cluster at once. The mongos acting as *balancer* takes a lock by inserting a document resembling the following into the locks collection.

```
{
    "_id" : "balancer",
    "process" : "example.net:40000:1350402818:16807",
    "state" : 2,
    "ts" : ObjectId("507daeedf40e1879df62e5f3"),
    "when" : ISODate("2012-10-16T19:01:01.593Z"),
    "who" : "example.net:40000:1350402818:16807:Balancer:282475249",
    "why" : "doing balance round"
}
```

If a mongos holds the balancer lock, the state field has a value of 2, which means that balancer is active. The when field indicates when the balancer began the current operation.

Changed in version 2.0: The value of the state field was 1 before MongoDB 2.0.

config.mongos

Internal MongoDB Metadata

The config (page 96) database is internal: applications and administrators should not modify or depend upon its content in the course of normal operation.

The mongos (page 99) collection stores a document for each mongos instance affiliated with the cluster. mongos instances send pings to all members of the cluster every 30 seconds so the cluster can verify that the mongos is active. The ping field shows the time of the last ping, while the up field reports the uptime of the mongos as of the last ping. The cluster maintains this collection for reporting purposes.

The following document shows the status of the mongos running on example.com:30000.

```
{ "_id" : "example.com:30000", "ping" : ISODate("2012-10-12T17:08:13.538Z"), "up" : 13699, "wait
```

config.settings

Internal MongoDB Metadata

The config (page 96) database is internal: applications and administrators should not modify or depend upon its content in the course of normal operation.

The settings (page 99) collection holds the following sharding configuration settings:

- Chunk size. To change chunk size, see *Modify Chunk Size in a Sharded Cluster* (page 83).
- Balancer status. To change status, see *Disable the Balancer* (page 72).

The following is an example settings collection:

```
{ "_id" : "chunksize", "value" : 64 }
{ "_id" : "balancer", "stopped" : false }
```

config.shards

Internal MongoDB Metadata

The config (page 96) database is internal: applications and administrators should not modify or depend upon its content in the course of normal operation.

The shards (page 100) collection represents each shard in the cluster in a separate document. If the shard is a replica set, the host field displays the name of the replica set, then a slash, then the hostname, as in the following example:

```
{ "_id" : "shard0000", "host" : "shard1/localhost:30000" }
```

If the shard has *tags* (page 27) assigned, this document has a tags field, that holds an array of the tags, as in the following example:

```
{ "_id" : "shard0001", "host" : "localhost:30001", "tags": [ "NYC" ] }
```

config.tags

Internal MongoDB Metadata

The config (page 96) database is internal: applications and administrators should not modify or depend upon its content in the course of normal operation.

The tags (page 100) collection holds documents for each tagged shard key range in the cluster. The documents in the tags (page 100) collection resemble the following:

```
{
    "_id" : { "ns" : "records.users", "min" : { "zipcode" : "10001" } },
    "ns" : "records.users",
    "min" : { "zipcode" : "10001" },
    "max" : { "zipcode" : "10281" },
    "tag" : "NYC"
}
```

config.version

Internal MongoDB Metadata

The config (page 96) database is internal: applications and administrators should not modify or depend upon its content in the course of normal operation.

The version (page 100) collection holds the current metadata version number. This collection contains only one document:

To access the `version` (page 100) collection you must use the `db.getCollection()` method. For example, to display the collection's document:

```
mongos> db.getCollection("version").find()
{ "_id" : 1, "version" : 3 }
```