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ApsaraDB for MongoDB

Best Practices

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Document conventions

Style	Description	Example
Danger	A danger notice indicates a situation that will cause major system changes, faults, physical injuries, and other adverse results.	Danger: Resetting will result in the loss of user configuration data.
Warning	A warning notice indicates a situation that may cause major system changes, faults, physical injuries, and other adverse results.	Warning: Restarting will cause business interruption. About 10 minutes are required to restart an instance.
Notice	A caution notice indicates warning information, supplementary instructions, and other content that the user must understand.	Notice: If the weight is set to 0, the server no longer receives new requests.
Note	A note indicates supplemental instructions, best practices, tips, and other content.	Note: You can use Ctrl + A to select all files.
>	Closing angle brackets are used to indicate a multi-level menu cascade.	Click **Settings**> **Network**> **Set network type**.
Bold	Bold formatting is used for buttons , menus, page names, and other UI elements.	Click **OK**.
`Courier font`	Courier font is used for commands	Run the `cd /d C:/window` command to enter the Windows system folder.
Italic	Italic formatting is used for parameters and variables.	`bae log list --instanceid` *Instance_ID*
[] or [a|b]	This format is used for an optional value, where only one item can be selected.	`ipconfig [-all|-t]`
{} or {a|b}	This format is used for a required value, where only one item can be selected.	`switch {active|stand}`

Table of Contents

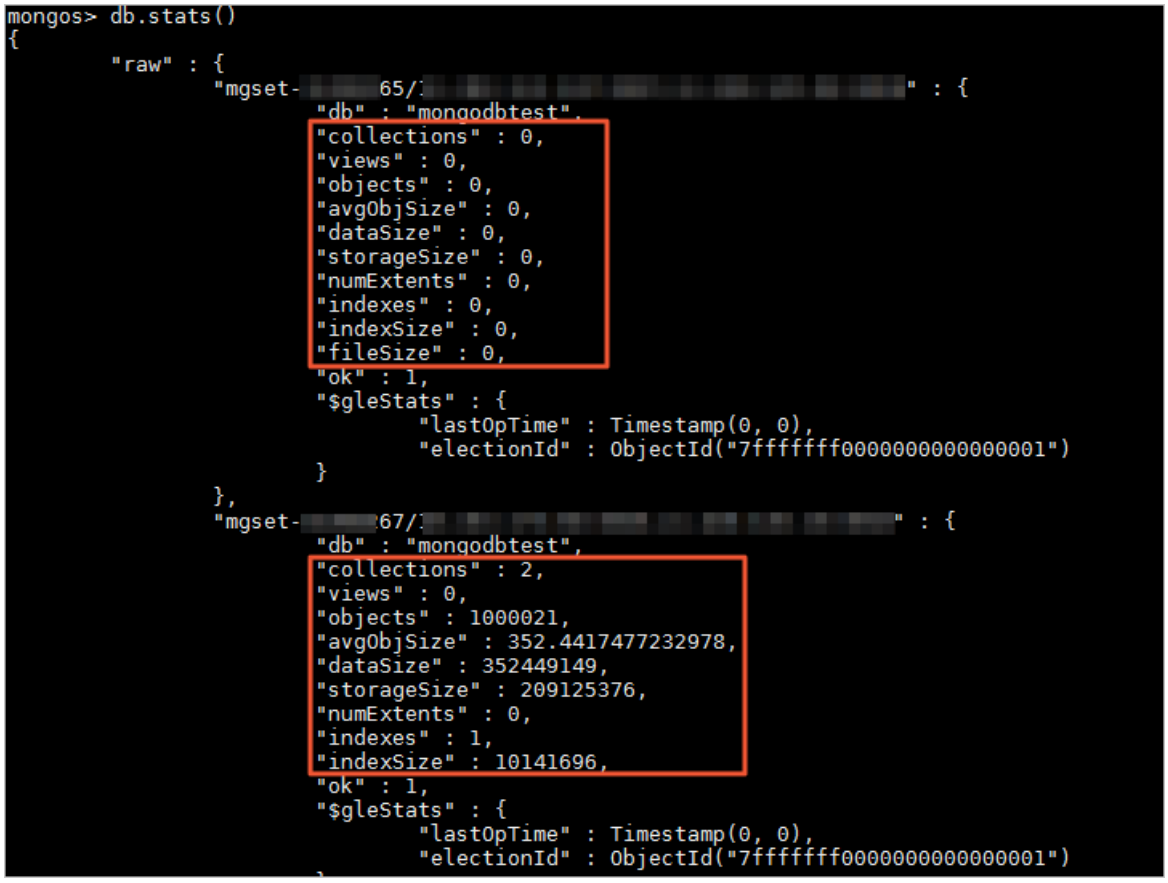
1.Performance

1.1. Configure sharding to maximize the performance of shards

You can configure sharding for each collection in a sharded cluster instance to make full use of the storage space and maximize the computing performance of shards in the sharded cluster.

Background

If a collection is not sharded, all its data is stored on the same shard. In this case, you cannot make full use of the storage space and maximize the computing performance of other shards in the sharded cluster.



Prerequisites

A sharded cluster instance is used.

Precautions

- You cannot change or delete the configured shard key after sharding.
- After you configure sharding, the balancer shards existing data that meets the specified criteria, which consumes the resources of an instance. We recommend that you perform this operation during off-peak hours.

> **Note** Before configuring sharding, you can set an active time window to limit the effective period of the balancer to off-peak hours. For more information, see Set an active time window for the balancer.

- The choice of a shard key affects the performance of a sharded cluster instance. For more information about how to choose a shard key, see Shard key selection.

Sharding strategies

Sharding strategy	Description	Scenario
Ranged sharding	MongoDB divides data into contiguous ranges determined by the shard key values. Each chunk represents a contiguous range of data. • Advantage: The mongos can quickly locate the data being requested and forward the requests to the target shard. • Disadvantage: Data may be distributed unevenly among shards, causing hot shards for reads and writes and an uneven spread of writes.	The shard key value is not monotonically increasing or decreasing. The shard key has large cardinality and low frequency. Range-based queries are required.
Hashed sharding	MongoDB computes the hash value of a single field as the index value and divides data into chunks based on the range of hash values. • Advantage: Data can be distributed evenly among shards, guaranteeing an even spread of writes. • Disadvantage: This strategy is inapplicable to range-based queries because read requests must be distributed across all shards during the queries.	The shard key value is monotonically increasing or decreasing. The shard key has large cardinality and low frequency. Data writes are randomly distributed to shards. Data is read with high randomness.

In addition to the preceding two sharding strategies, you can also configure a compound shard key. For example, configure both a key with low cardinality and a monotonically increasing key. For more information, see .

Procedure

The following procedure uses the database named mongodbtest and the collection named customer as an example.

1. Connect to a sharded cluster instance by using the mongo shell.
2. Enable sharding for the database where the collection to be sharded resides.

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

> **Note** <database>: the name of the database.

Example:

```
sh.enableSharding("mongodbtest")
```

Note You can run the `sh.status()` command to check whether sharding is enabled.

3. Create an index on the shard key field.

```
db.<collection>.createIndex(<keyPatterns>,<options>)
```

Note

- <collection>: the name of the collection.
- <keyPatterns>: the field used for indexing and the index type.

  Common index types are as follows:

  - 1: an ascending index
  - -1: a descending index
  - "hashed": a hashed index
- <options>: the optional parameters. For more information, see db.collection.createIndex(). This field is not used in this example.

Sample command for creating an ascending index:

```
db.customer.createIndex({name:1})
```

Sample command for creating a hashed index:

```
db.customer.createIndex({id:"hashed"})
```

4. Configure sharding for the collection.

```
sh.shardCollection("<database>.<collection>",{ "<key>":<value> } )
```

Note

- <database>: the name of the database.
- <collection>: the name of the collection.
- <key>: the shard key that MongoDB uses to shard data.
- <value>
  - 1: ranged sharding. This strategy supports efficient range-based queries based on the shard key.
  - "hashed": hashed sharding. This strategy distributes data evenly among shards.

Sample command for configuring ranged sharding:

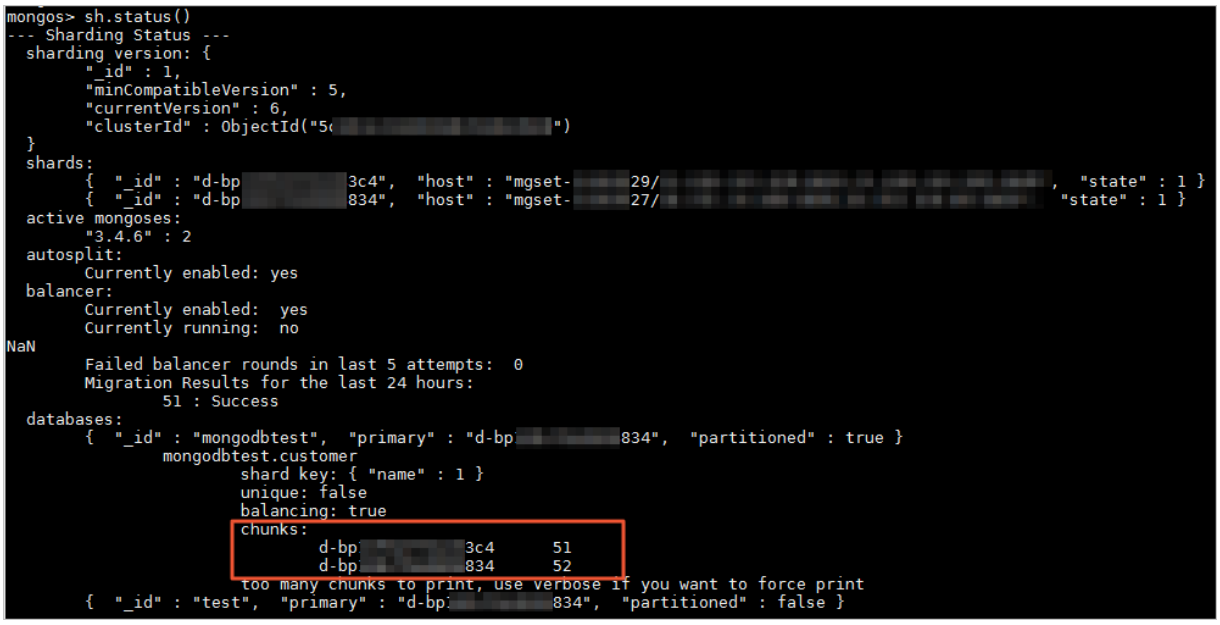
```
sh.shardCollection("mongodbtest.customer",{"name":1})
```

Sample command for configuring hashed sharding:

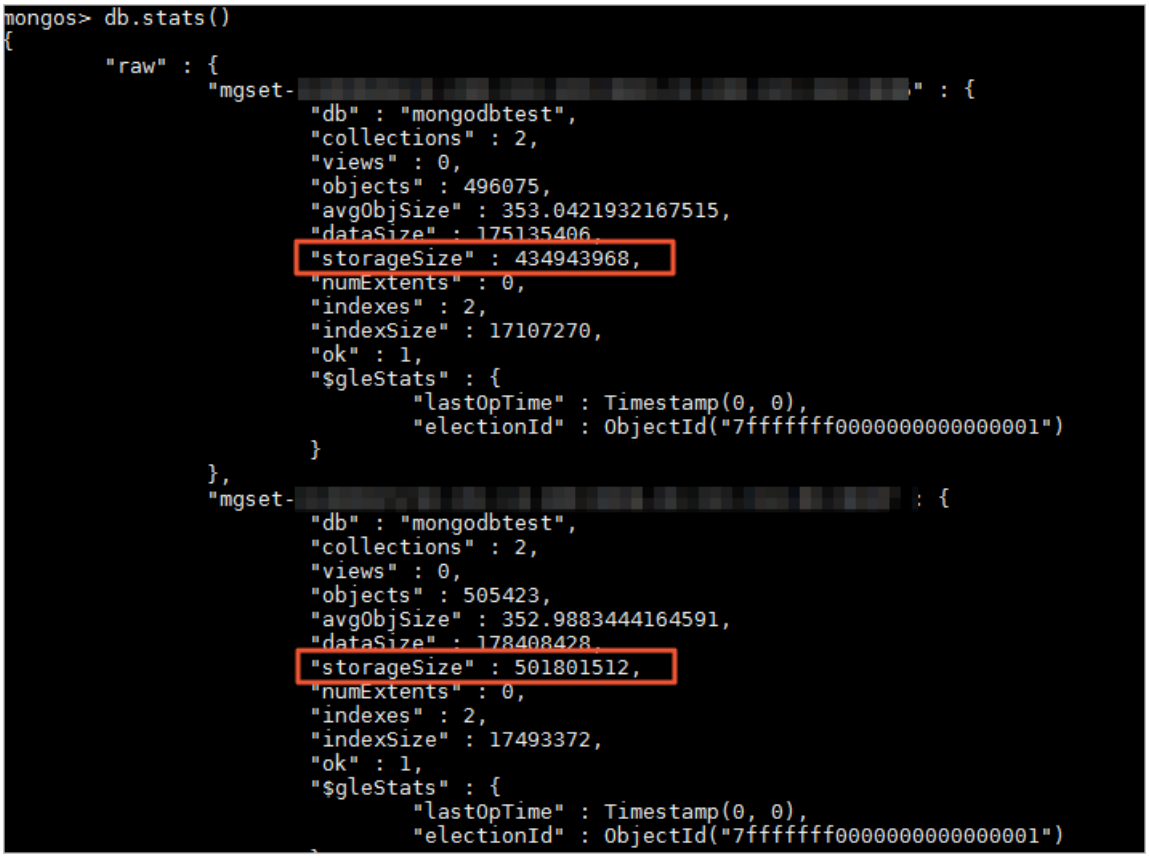
```
sh.shardCollection("mongodbtest.customer",{"id":"hashed"})
```

What to do next

After the database has been running and data has been written for a while, you can run the `sh.status()` command in the mongo shell to check the chunk information on shards.



You can also run the `db.stats()` command to check the size of data stored on each shard.



1.2. Defragment the disk space to improve disk usage

Fragmentation may occur in the disk space when you frequently write and delete large amounts of data in ApsaraDB for MongoDB databases. The fragments occupy disk space and reduce disk usage. You can rewrite and defragment all the data and indexes in a collection to release idle space. This improves disk usage and query performance.

Prerequisites

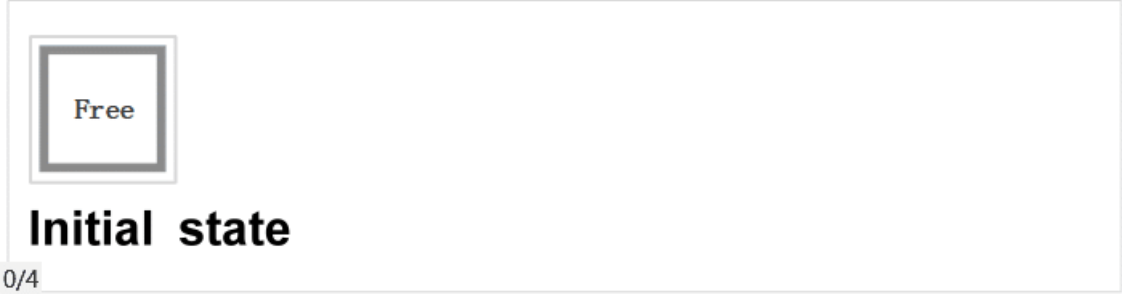
The ApsaraDB for MongoDB instance uses WiredTiger as the storage engine.

Important notes

- We recommend that you back up data in ApsaraDB for MongoDB databases before defragmentation. For more information, see Manually back up an ApsaraDB for MongoDB instance.
- During defragmentation, the database where the collection is stored is locked and read and write operations are not allowed in the database. We recommend that you defragment the disk space during off-peak hours.

> **Note** The time required for defragmenting the disk space through the compact command depends on multiple factors, such as the data volume of the collection and the system load.

Background



Generally, if you run the `db.collection.remove({}, {multi: true})` command to delete a document from the B tree, the disk space occupied by the document is not reclaimed. If you run the remove command to delete a large number of documents, but write little data to the disk later, disk usage is reduced. In this case, you can run the compact command to reclaim the idle disk space.

> **Note**
>
> - The newly written data occupies the disk space that is not reclaimed. Therefore, you do not need to frequently run the compact command for defragmentation in scenarios where data is continuously written.
> - If you run the `db.collection.drop()` command to delete a collection, the files in the collection are deleted and the disk space occupied by the files is reclaimed.

Estimate the disk space to be reclaimed

1. Connect to the ApsaraDB for MongoDB instance by using the mongo shell. For more information, see the following topics:
   - Connect to a standalone ApsaraDB for MongoDB instance through DMS
   - Connect to a replica set instance by using the mongo shell
   - Connect to a sharded cluster instance by using the mongo shell
2. Run the following command to switch to the database where the collection is stored:

   ```
   use <database_name>
   ```

   > **Note** <database_name>: the name of the database.

3. Run the following command to query the disk space that can be reclaimed from the collection:

   ```
   db.<collection_name>.stats().wiredTiger["block-manager"]["file bytes available for reuse"]
   ```

   > **Note** <collection_name>: the name of the collection.

   Sample command:

   ```
   db.customer.stats().wiredTiger["block-manager"]["file bytes available for reuse"]
   ```

Sample result:

```
207806464
```

Defragment a standalone instance or a replica set instance

1. Connect to the primary node of an ApsaraDB for MongoDB instance by using the mongo shell. For more information, see Connect to a replica set instance by using the mongo shell.
2. Run the following command to switch to the database where the collection is stored:

   ```
   use <database_name>
   ```

   > **Note** <database_name>: the name of the database.

3. Run the `db.stats()` command to view the disk space occupied by the database before defragmentation.
4. Run the following command to defragment a collection:

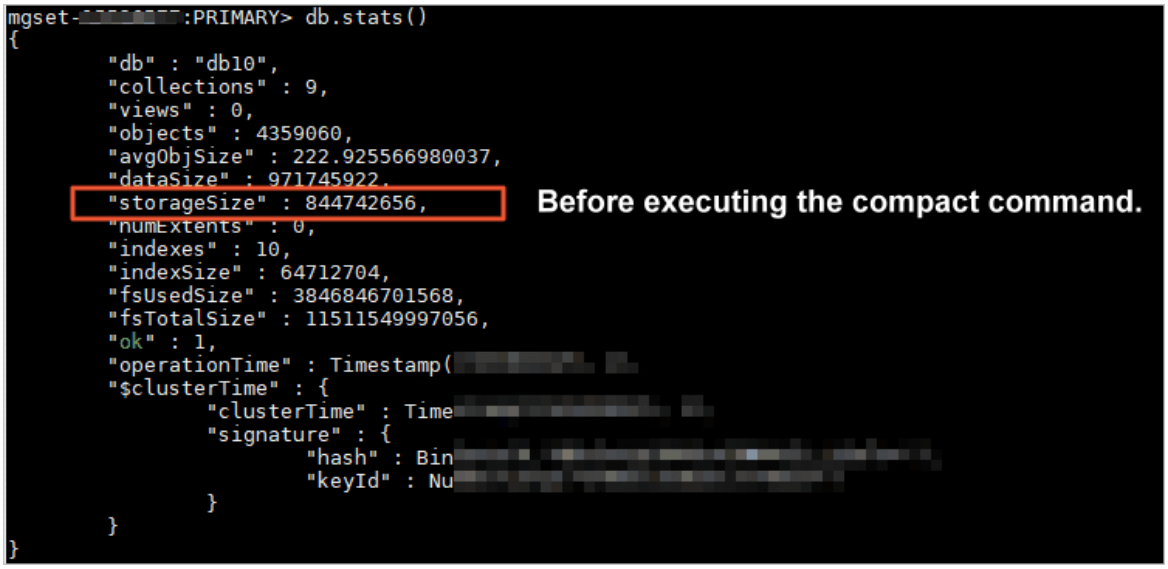
   ```
   db.runCommand({compact:"<collection_name>",force:true})
   ```

   > **Note**
   > - <collection_name>: the name of the collection.
   > - The `force` parameter is optional. To run the compact command on the primary node of a replica set instance, you must set the `force` parameter to *true*.

5. Wait until `{"ok":1}` is returned, indicating that the command is executed.

   > **Note** The compact command executed on the primary node does not affect a secondary node. For a replica set instance, repeat the preceding steps to connect to a secondary node through the mongo shell and run the compact command.

After defragmentation is complete, you can run the `db.stats()` command to view the disk space occupied by the database. The following figure shows the storage size before and after defragmentation.



Defragment a sharded cluster instance

1. Connect to any mongos node in the sharded cluster instance by using the mongo shell. For more information, see Connect to a sharded cluster instance by using the mongo shell.
2. Run the `db.stats()` command to view the disk space occupied by the database before defragmentation.
3. Run the following command to defragment a collection on the primary node of a shard:

   ```
   db.runCommand({runCommandOnShard:"<Shard ID>","command":{compact:"<collection_name>",force:true}})
   ```

   > **Note**
   > - <Shard ID>: the ID of the shard.
   > - <collection_name>: the name of the collection.

4. Run the following command to defragment a collection on a secondary node of a shard:

   ```
   db.runCommand({runCommandOnShard:"<Shard ID>","command":{compact:"<collection_name>"},$queryOptions: {$readPreference: {mode: 'secondary'}}})
   ```

   > **Note**
   > - <Shard ID>: the ID of the shard.
   > - <collection_name>: the name of the collection.

   After defragmentation is complete, you can run the `db.runCommand({dbstats:1})` command to view the disk space occupied by the database.

1.3. Troubleshoot the high CPU usage of ApsaraDB for MongoDB

When you use ApsaraDB for MongoDB, the CPU usage may become excessively high or even approach 100%. The high CPU usage slows down data read /write operations and affects normal business operations. This topic describes how to troubleshoot the high CPU usage of ApsaraDB for MongoDB for your applications.

Analyze running requests in ApsaraDB for MongoDB

1. Connect to an ApsaraDB for MongoDB instance through the mongo shell.

   For more information, see Connect to a standalone instance through the mongo shell, Connect to a replica set instance through the mongo shell, and Connect to a sharded cluster instance through the mongo shell.

2. Run the `db.currentOp()` command to check running operations in ApsaraDB for MongoDB.

   Example of the command output:

```
{
    "desc" : "conn632530",
    "threadId" : "140298196924160",
    "connectionId" : 632530,
    "client" : "11.192.159.236:57052",
    "active" : true,
    "opid" : 1008837885,
    "secs_running" : 0,
    "microsecs_running" : NumberLong(70),
    "op" : "update",
    "ns" : "mygame.players",
    "query" : {
      "uid" : NumberLong(31577677)
    },
    "numYields" : 0,
    "locks" : {
      "Global" : "w",
      "Database" : "w",
      "Collection" : "w"
    },
    ....
  },
```

The following table describes some fields.

Field	Description
client	The client that sent the request.
opid	The unique ID of the operation. **Note** If necessary, you can run the `db.killOp(opid)` command to terminate an operation.
secs_running	The duration that the operation has been running, in seconds. If this field returns a value that exceeds the defined threshold, check whether the request is appropriate.
microsecs_running	The duration that the operation has been running, in microseconds. If this field returns a value that exceeds the defined threshold, check whether the request is appropriate.
ns	The target collection of the operation.
op	The operation type, which is usually query, insert, update, or delete.
locks	The lock-related fields. For more information, see MongoDB official documentation. **Note** For more information about the db.currentOp() command, see db.currentOp.

You can run the `db.currentOp()` command to check in-progress operations and analyze whether ApsaraDB for MongoDB is processing any time-consuming requests. The CPU usage is normal for your routine business. When O&M personnel log on to ApsaraDB for MongoDB to perform some operations that require a collection scan, the CPU usage significantly increases and ApsaraDB for MongoDB responds slowly. In this case, you must check for long-running operations.

Note If you find any abnormal request, you can obtain the operation ID (specified by the opid field) of such a request and run the `db.killOp(opid)` command to terminate this request.

For example, the CPU usage of the relevant ApsaraDB for MongoDB instance immediately increases and remains high after your application starts running. If you cannot find any abnormal requests in the output of the `db.currentOp()` command, you can analyze slow requests in ApsaraDB for MongoDB.

Analyze slow requests in ApsaraDB for MongoDB

ApsaraDB for MongoDB enables slow request profiling by default. ApsaraDB for MongoDB automatically records requested operations that have been running for longer than 100 ms in the system.profile collection of the relevant database.

1. Connect to an ApsaraDB for MongoDB instance through the mongo shell.

For more information, see Connect to a standalone instance through the mongo shell, Connect to a replica set instance through the mongo shell, and Connect to a sharded cluster instance through the mongo shell.

2. Run the `use <database>` command to access a database.

```
use mongodbtest
```

3. Run the following command to check the slow request logs of the database:

```
db.system.profile.find().pretty()
```

4. Analyze the slow request logs to discover the cause of high CPU usage in ApsaraDB for MongoDB.

   The following is an example of a slow request log. For this request, ApsaraDB for MongoDB did not query data based on an index, but has run a collection scan and scanned 11,000,000 documents.

```
{
    "op" : "query",
    "ns" : "123.testCollection",
    "command" : {
        "find" : "testCollection",
        "filter" : {
            "name" : "zhangsan"
        },
        "$db" : "123"
    },
    "keysExamined" : 0,
    "docsExamined" : 11000000,
    "cursorExhausted" : true,
    "numYield" : 85977,
    "nreturned" : 0,
    "locks" : {
        "Global" : {
            "acquireCount" : {
                "r" : NumberLong(85978)
            }
        },
        "Database" : {
            "acquireCount" : {
                "r" : NumberLong(85978)
            }
        },
        "Collection" : {
```

```
                "acquireCount" : {
                    "r" : NumberLong(85978)
                }
            }
        },
        "responseLength" : 232,
        "protocol" : "op_command",
        "millis" : 19428,
        "planSummary" : "COLLSCAN",
        "execStats" : {
            "stage" : "COLLSCAN",
            "filter" : {
                "name" : {
                    "$eq" : "zhangsan"
                }
            },
            "nReturned" : 0,
            "executionTimeMillisEstimate" : 18233,
            "works" : 11000002,
            "advanced" : 0,
            "needTime" : 11000001,
            "needYield" : 0,
            "saveState" : 85977,
            "restoreState" : 85977,
            "isEOF" : 1,
            "invalidates" : 0,
            "direction" : "forward",
....in"
            }
        ],
        "user" : "root@admin"
}
```


For slow request logs, you must notice the following points:

- Collection scan (keywords: COLLSCAN and docsExamined)

- COLLSCAN indicates a collection scan.

  A collection scan for a request (such as a query, update, or delete operation) can cause a high CPU usage. If you find a COLLSCAN keyword in slow request logs, your CPU resources may have been occupied by these slow requests.

  > Note If such slow requests are frequently submitted, we recommend that you create an index on queried fields to optimize query performance.

- The docsExamined field indicates the number of documents that ApsaraDB for MongoDB has scanned for a request. A larger value of this field indicates higher CPU overhead occupied by this request.

- Inappropriate indexes (keywords: IXSCAN and keysExamined)

  > Note
  > - If you have too many indexes, the write and update performance is affected.
  > - If your application contains to many write operations, inappropriate indexes may affect the application performance.

  The keysExamined field indicates the number of index keys that ApsaraDB for MongoDB has scanned for a request that uses an index. A larger value of this field indicates higher CPU overhead occupied by this request.

  If you create an index that is inappropriate or matches a large amount of data, the index cannot reduce CPU overhead or accelerate the execution of a request.

  For example, for the data in a collection, the x field can be set only to 1 or 2, whereas the y field has a wider value range.

  ```
  { x: 1, y: 1 }
  { x: 1, y: 2 }
  { x: 1, y: 3 }
  ......
  { x: 1, y: 100000}
  { x: 2, y: 1 }
  { x: 2, y: 2 }
  { x: 2, y: 3 }
  ......
  { x: 1, y: 100000}
  ```

  To query data { x: 1, y: 2 }, you can create an index.

```
db.createIndex( {x: 1} ) // This index is inappropriate because a large amount of data has the same value of the x field.
db.createIndex( {x: 1, y: 1} ) // This index is inappropriate because a large amount of data has the same value of the x field.
db.createIndex( {y: 1 } ) // This index is appropriate because a small amount of data has the same value of the y field.
db.createIndex( {y: 1, x: 1 } ) // This index is appropriate because a small amount of data has the same value of the y field.
```

For the difference between indexes {y: 1} and {y: 1, x: 1}, see Design Principles of MongoDB Indexes and Compound Indexes.

- Sorting of a large amount of data (keywords: SORT and hasSortStage)

  The value of the hasSortStage field is true in the system.profile collection when a query cannot use the sort order in the index to return the requested sorted results. In this case, ApsaraDB for MongoDB must sort the query results. Considering that a sort operation will cause a high CPU usage, you can create an index on frequently sorted fields to optimize sorting performance.

  > **Note** If you find the SORT keyword in the system.profile collection, you can use an index to optimize sorting performance.

Other operations such as index creation and aggregation (a combination of traverse, query, update, sort, and other operations) may also cause a high CPU usage. You can also use the preceding troubleshooting methods. For more information about profiling, see Database Profiler.

Assess service capabilities

After you analyze and optimize running requests and slow requests in ApsaraDB for MongoDB, all requests efficiently use indexes and the query performance of ApsaraDB for MongoDB is optimized.

If CPU resources are still fully occupied during business operations, the maximum capabilities of your instances may have reached. In this case, you can view the monitoring information to analyze the resource usage of instances. You can also check whether current instances satisfy the performance and capability requirements in your business scenarios.

To upgrade instances, you can follow the instructions in Change the configuration of an instance or Change the number of nodes for a replica set instance.

1.4. Connect to a replica set instance and implement read /write splitting and high availability

An ApsaraDB for MongoDB replica set instance provides multiple copies of data to ensure the high reliability of data. It also provides an automatic failover mechanism to guarantee the high availability of ApsaraDB for MongoDB. You must use a correct method to connect to a replica set instance to implement high availability. You can also configure the connection for read /write splitting.

Notes

- The primary node of a replica set instance may change. A failover between the primary and secondary nodes may be triggered when nodes of the replica set instance are upgraded in turn, the primary node is faulty, or the network is partitioned. In these scenarios, the replica set can elect a new primary node and downgrade the original primary node to a secondary node.
- If the primary node of a replica set instance is directly connected through the connection string of the primary node, the primary node will bear heavy load to process all read and write operations. If a failover is triggered in the replica set instance and the connected primary node is downgraded to a secondary node, you can no longer perform write operations and your business is seriously affected.

Connection string URIs

To correctly connect to a replica set instance, you must understand the format of connection string URIs of MongoDB. All official MongoDB drivers allow you to use a connection string URI to connect to MongoDB.

```
mongodb://[username:password@]host1[:port1][,host2[:port2],...[,hostN[:portN]]][/[database][?options]]
```

Parameter description:

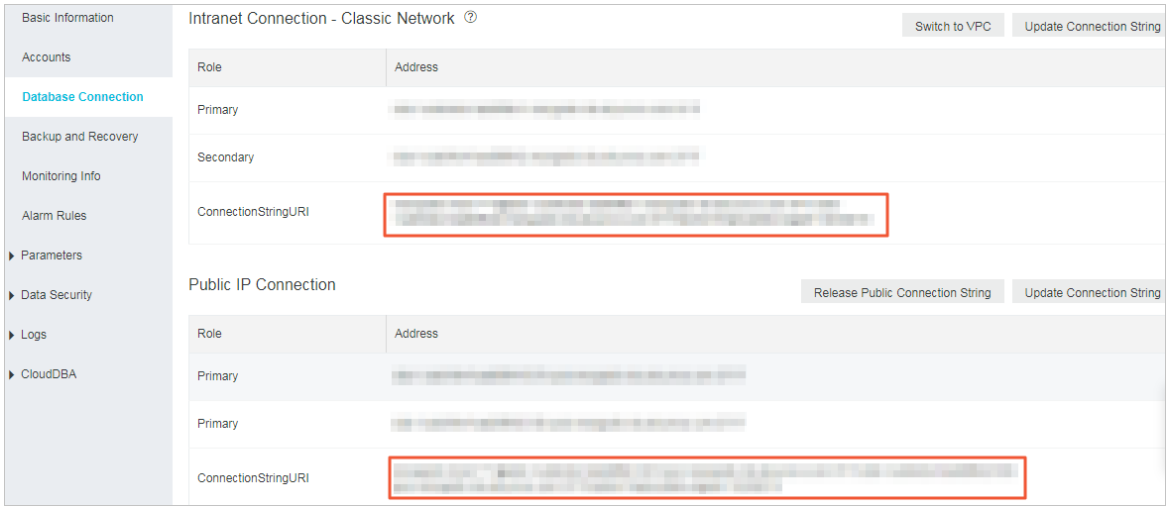
- `mongodb://` : the prefix, indicating a connection string URI.
- `username:password@` : the username and password used to log on to the database. If authentication is enabled, a password is required.
- `hostX:portX` : the list of connection strings used to connect to nodes in the replica set instance. Each connection string consists of an IP address and a port number. Separate multiple connection strings with commas (,).
- `/database` : the database corresponding to the username and password if authentication is enabled.
- `?options` : additional connection options.

> **Note** For more information about connection string URIs, see connection String URI Format.

Use a connection string URI to connect to a replica set instance

You can use a connection string URI to connect to a replica set instance.

1. Obtain the connection string URI of a replica set instance. For more information, see Overview of replica set instance connections.



2. Use the obtained connection string URI to connect your applications to the instance. For more information, see Connection sample code for MongoDB drivers.

> **Note**
>
> For read /write splitting, you must add `readPreference=secondaryPreferred` in the options parameter to set read preference to secondary nodes.
>
> For more information about read preference options, see Read Preference.

Example:

```
mongodb://root:xxxxxxxx@dds-xxxxxxxxxxxx:3717,xxxxxxxxxxxx:3717/admin? replicaSet=mgset-xxxxxx&readPreference=secondaryPreferred
```

After you use the preceding method to connect to a replica set instance, a client can preferentially send read requests to secondary nodes to implement read/write splitting. The client also automatically detects the relationship between the primary and secondary nodes. If the primary node changes, the client automatically switches over write operations to the new primary node to ensure the high availability of ApsaraDB for MongoDB.

1.5. Import and export MongoDB data through Data Integration

Data Integration is a stable, efficient, and scalable data synchronization platform provided by DataWorks. It supports batch transmission of data for Alibaba Cloud services such as MaxCompute, AnalyticDB, and OSS. This topic describes how to import and export MongoDB data through Data Integration.

For more information about how to import and export MongoDB data through Data Integration, see Configure a MongoDB reader and Configure a MongoDB writer.

2.Best practices for data security of ApsaraDB for MongoDB

ApsaraDB for MongoDB provides comprehensive security protection to eliminate your data security concerns. You can guarantee database data security by using zone-disaster recovery, RAM authorization, audit logs, network isolation, whitelists, or password authentication.

Zone-disaster recovery

ApsaraDB for MongoDB provides a zone-disaster recovery solution to further meet HA and data security requirements. In this solution, the nodes in a replica set instance or the components in a sharded cluster instance are deployed across three zones of a region. If a zone is disconnected due to force majeure factors such as power or network failures, the HA system automatically triggers a failover to ensure availability and data security of the instance.

You can select multiple zones when creating an instance. For more information, see Create a multi-zone replica set instance or Create a multi-zone sharded cluster instance. You can also migrate a replica set instance to multiple zones. For more information, see Migrate an ApsaraDB for MongoDB instance across zones in the same region.

Access control

- Authorize a RAM user to manage ApsaraDB for MongoDB instances

  Resource Access Management (RAM) allows you to create and manage RAM users and control their permissions on resources of your Alibaba Cloud account. If multiple users in your enterprise need to use the resource at the same time, you can use RAM to assign least permissions to them and avoid the need to share the key of your Alibaba Cloud account. This reduces information security risks for your enterprise.

  For more information, see How to configure RAM user permissions on ApsaraDB for MongoDB.

- Create and authorize a database user

  Do not connect to a database as the root user in the production environment. You can create database users and grant permissions to them as needed.

  For more information, see Manage MongoDB users though DMS.

Network isolation

- Use VPCs

  ApsaraDB for MongoDB supports multiple network types. We recommend that you use VPCs.

  A VPC is an isolated virtual network with higher security and better performance than a classic network. You must create the VPC in advance. For more information, see Create a default VPC and VSwitch.

  If an ApsaraDB for MongoDB instance is deployed in a classic network, you can switch the network type of the instance to VPC. For more information, see Switch the network type of an ApsaraDB for MongoDB instance. If your ApsaraDB for MongoDB instance is deployed in a VPC, no further action is required.

> **Note** ApsaraDB for MongoDB supports password-free access over a VPC. VPCs provide a convenient and secure way to connect to databases. For more information, see Enable or disable password-free access for an ApsaraDB for MongoDB instance.

- Set the whitelist

  By default, after an ApsaraDB for MongoDB instance is created, the IP address in its whitelist is `127.0.0.1`. You must manually set the IP address in the whitelist before connecting to MongoDB databases.

  For more information, see 设置白名单及安全组.

  > **Note**
  > - Do not set the IP address to `0.0.0.0/0`, which indicates that the database can be accessed from any IP address.
  > - We recommend that you set the whitelist based on your business needs and regularly remove IP addresses that are no longer needed from the whitelist.

Log audit

Audit logs of ApsaraDB for MongoDB record all operations that you have performed on databases. With audit logs, you can obtain data execution information by performing fault analysis, behavior analysis, and security audit on databases.

For more information, see Configure audit logging for an ApsaraDB for MongoDB instance.

Data encryption

- SSL encryption

  If you connect to a database over the Internet, you can enable Secure Sockets Layer (SSL) encryption to improve the security of data links. SSL encryption can encrypt network connections at the transport layer. This improves data security and ensures data integrity. For more information, see Use the mongo shell to connect to an ApsaraDB for MongoDB database in SSL encryption mode.

- TDE

  Transparent Data Encryption (TDE) implements real-time I/O encryption and decryption for data files. TDE encrypts data before data is written to a disk and decrypts data before data is read from the disk. TDE does not increase the size of data files. You can use TDE without modifying your application that uses ApsaraDB for MongoDB. For information, see Configure TDE for an ApsaraDB for MongoDB instance.

  > **Note** Currently, you can only enable TDE for an instance and disable encryption for a collection, For field level encryption, see Explicit (Manual) Client-Side Field Level Encryption(Only supports MongoDB 4.2 version instances).

3.Set common alert rules for ApsaraDB for MongoDB

ApsaraDB for MongoDB provides the instance monitoring and alerting feature. This topic describes how to configure common metrics such as disk usage, input/output operations per second (IOPS), connections, and CPU usage.

Background information

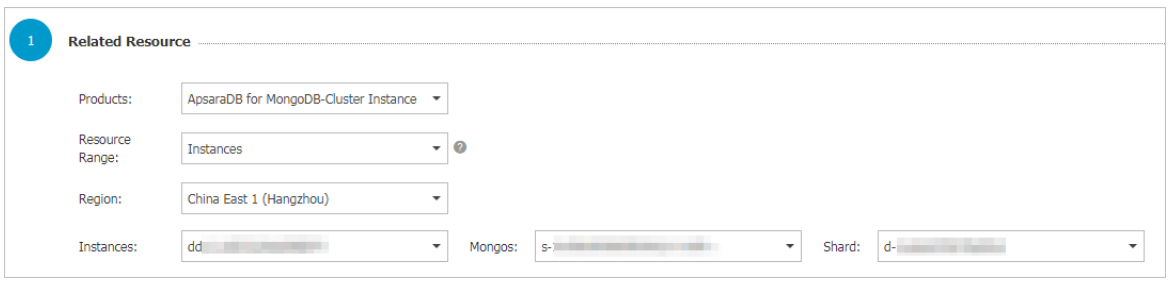
- With the growth of business data, more performance resources of ApsaraDB for MongoDB instances are consumed. Sometimes performance resources may even be used up.
- For example, when a great number of slow queries occur, writing a large amount of data causes performance resources of ApsaraDB for MongoDB instances exceptionally consumed.

> **Note** Instances with insufficient disk space may be locked. In this case, you can submit a ticket to unlock instances. After that, you can increase disk space with the configuration change feature.

You can set alert rules for key performance metrics of instances to help you detect abnormal data and troubleshoot errors.

Procedure

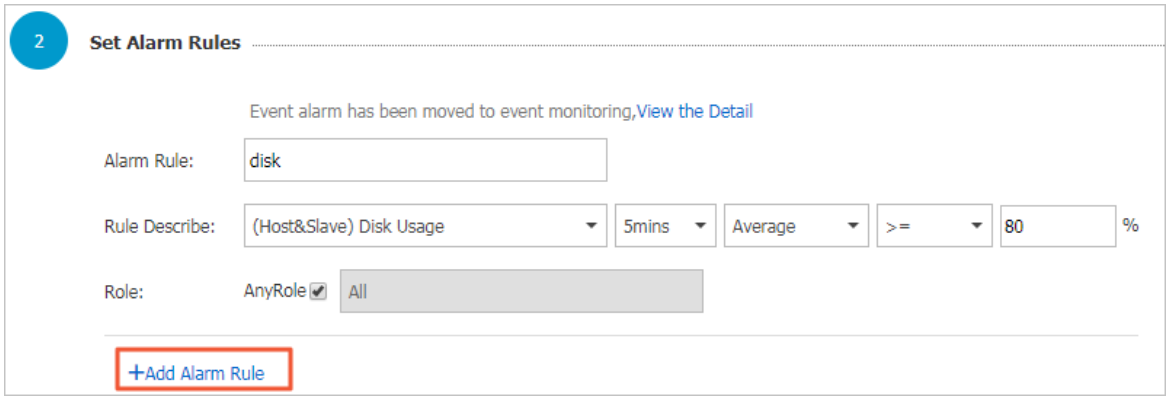
1. Log on to the ApsaraDB for MongoDB console.
2. In the upper-left corner of the page, select the resource group and the region of the target instance.
3. In the left-side navigation pane, click **Replica Set Instances**, or **Sharded Cluster Instances** based on the instance type.
4. Find the target instance and click its ID.
5. In the left-side navigation pane, click **Alert Rules**.
6. Click **Set Alert Rule**. You are redirected to the **Cloud Monitor console**.
7. On the Alarm Rules tab of the **Cloud Monitor console**, click **Create Alarm Rule** in the upper-right corner.
8. On the **Create Alarm Rule** page, configure the parameters.



Parameter	Description

Parameter	Description
Products	The architecture of the instance. Valid values: ○ ApsaraDB for MongoDB-Instance Copy ○ ApsaraDB for MongoDB-Cluster Instance ○ ApsaraDB for MongoDB-Single Node Instance Note If you select ApsaraDB for MongoDB-Cluster Instance, you must specify the mongos and shard nodes to be monitored.
Resource Range	○ **All Resources**: The alert rule is applicable to all ApsaraDB for MongoDB instances. ○ **Instances**: The alert rule is applicable to the specified ApsaraDB for MongoDB instances.
Region	The region where the instance is deployed.
Instances	The ID of the instance. You can select multiple instance IDs.

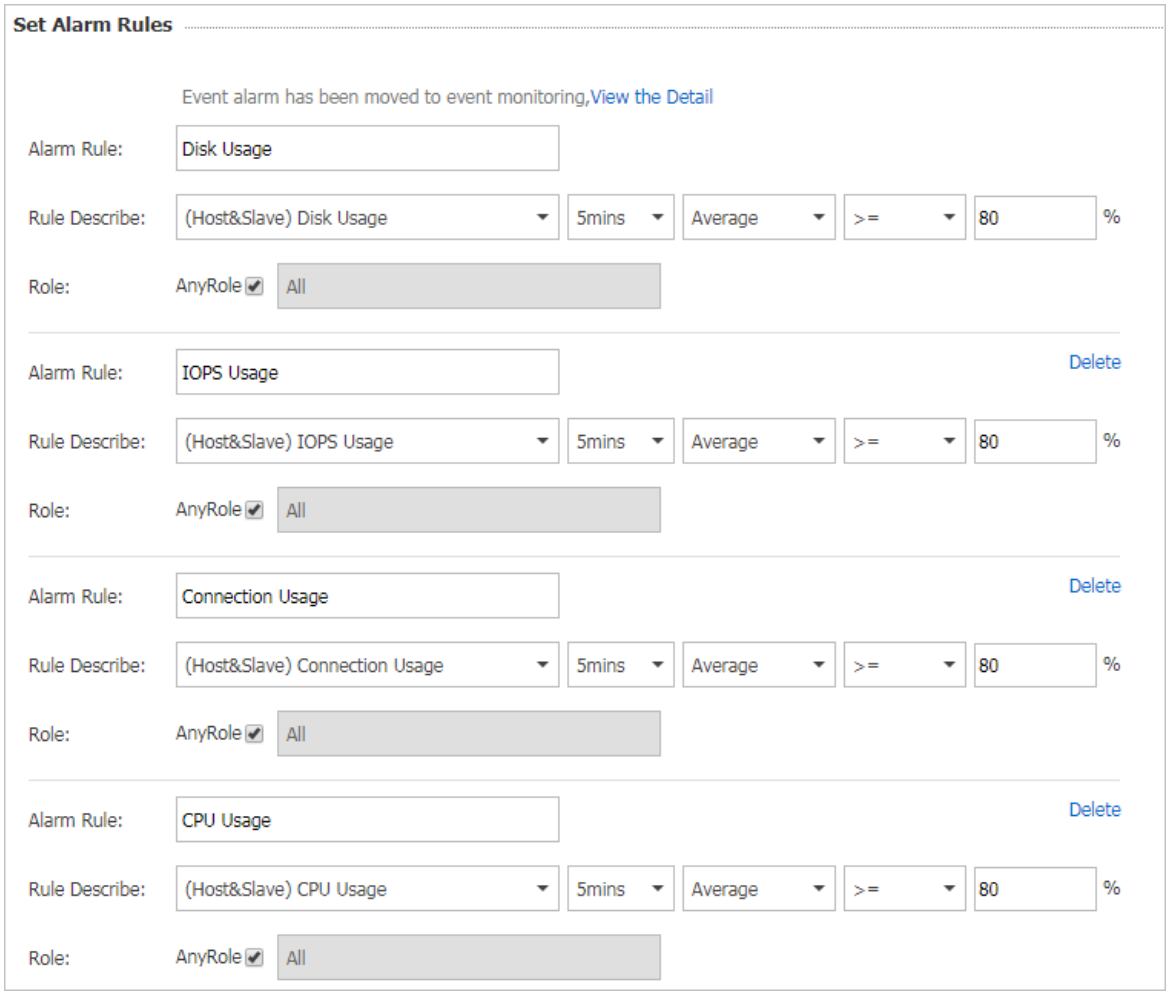
9. Set alert rules. You can set the disk usage first, and then click **Add Alarm Rule**.



Note

- If you set Rule Description to Disk Usage 5mins Average >= 80%, the alerting module checks the disk usage every 5 minutes to detect whether the average disk usage in the last 5 minutes is greater than or equal to 80%. You can adjust each alert threshold based on your business scenarios.
- If you select AnyRole for the Role parameter, the primary and secondary nodes for each instance are monitored.

10. Set alert rules for IOPS, connections, and CPU utilization in the similar way to disk usage.



11. Set other parameters for alert rules.

Parameter	Description
Mute for	Specifies the mute period. If the alert is not cleared within the mute period, a new alert notification is sent when the mute period ends.
Effective Period	The period when the alert rule takes effect.

12. Set the notification method.

Parameter	Description
Notification Contact	The contacts or contact group to which an alert notification is sent. For more information, see Manage alert contacts and alert contact groups.
Notification Methods	The notification methods corresponding to an alert severity, which can be Critical, Warning, or Info. ○ Critical: phone calls, SMS messages, emails, and DingTalk ChatBot. ○ Warning: SMS messages, emails, and DingTalk ChatBot. ○ Info: emails and DingTalk ChatBot.

Parameter	Description
Email Subject	The subject of the alert notification email. The default email subject is in the format of service name + metric name + instance ID.
Email Remark	The custom additional information in the alert notification email. Remarks will be included in the alert notification email if you specify this parameter.
HTTP CallBack	For more information, see Use alert callback.

13. Click **Confirm**. Alert rules automatically take effect.

4.Migrate Azure Cosmos DB's API for MongoDB to ApsaraDB for MongoDB

MongoDB provides native backup utilities that you can use to migrate Azure Cosmos DB's API for MongoDB to ApsaraDB for MongoDB.

Precautions

- This is a full migration. To ensure data consistency we recommend that you stop all write operations to the database before migration.
- If you have used mongodump commands to back up the database, move the files in the dump folder to other directories. Make sure that the default dump folder is empty before data migration. Otherwise, existing backup files in this folder will be overwritten.
- Run mongodump and mongorestore commands on servers on which MongoDB is installed. Do not run these commands in the mongo shell.

Required database account permissions

Instance	Account permission
Azure Cosmos DB	Read
Destination MongoDB instance	Read and write

Environment configuration

1. Create an ApsaraDB for MongoDB instance. For more information, see Create an instance.

   > Note
   > - The instance storage capacity must be larger than Azure Cosmos DB.
   > - Select MongoDB version 3.4.

2. Set a password for the ApsaraDB for MongoDB instance. For more information, see Set a password.
3. Install MongoDB on a server. For more information, see Install MongoDB.

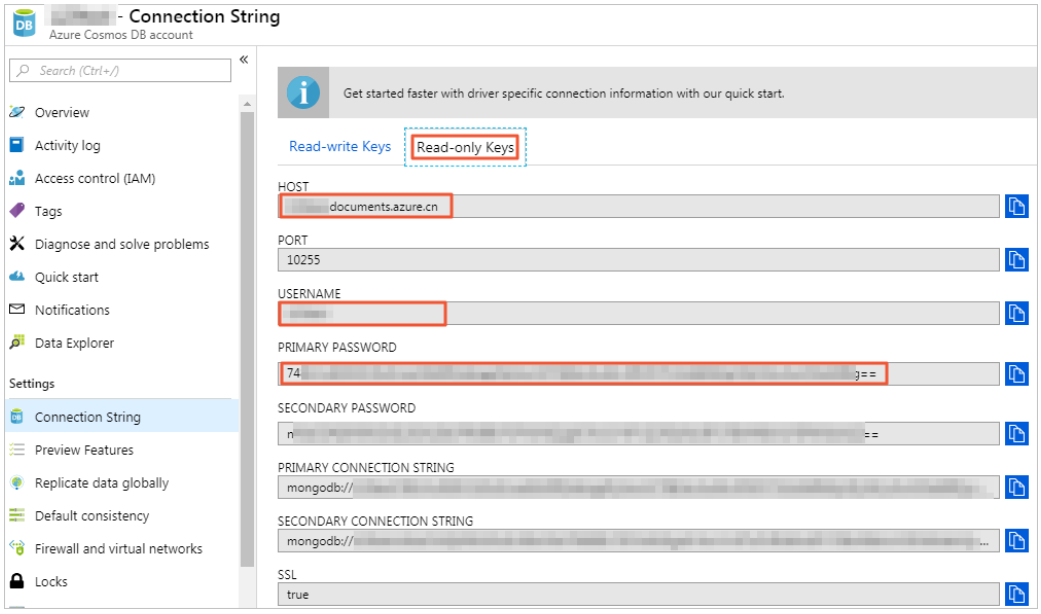
   > Note
   > - Install a MongoDB version later than 3.0.
   > - This server is used to temporarily store data during backup and recovery, and is not needed after the migration is complete.
   > - The capacity of the disk where the backup is stored must be larger than Azure Cosmos DB.

   This example installs MongoDB on a Linux server. You can also use other operating systems, such as Windows.

Procedure

1. Log on to the Azure portal.
2. In the left-side navigation pane, click **Azure Cosmos DB**.
3. On the **Azure Cosmos DB** page, click the account name of the Azure Cosmos DB that you want to migrate.
4. On the account details page, click **Connection String**.
5. Click the **Read-only Keys** tab to view the database connection information.

   Azure connection information



> **Note** To migrate data, you only need a database account that has read-only permissions.

6. Run the following command on the MongoDB server to back up the Azure Cosmos DB to this server.

```
mongodump --host <HOST>:10255 --authenticationDatabase admin -u <USERNAME> -p <PRIMARY PASSWORD> --ssl --sslAllowInvalidCertificates
```

   Note: Replace <HOST>, <USERNAME>, and <SECONDARY PASSWORD> with the actual values shown in the Azure connection information figure.

   After the backup is complete, backups of the Azure Cosmos DB are stored in the dump folder.

7. Obtain the endpoint of the primary node of the ApsaraDB for MongoDB instance. For more information, see Overview of replica set instance connections.
8. Run the following command on the MongoDB server to export the backups to the ApsaraDB for MongoDB instance.

```
mongorestore --host <mongodb_host>:3717 --authenticationDatabase admin -u <username> -p <password> dump
```

Parameter description:

- <mongodb_host>: the endpoint of the primary node of the MongoDB instance.
- <username>: the account used to log on to the ApsaraDB for MongoDB instance.
- <password>: the password used to log on to the ApsaraDB for MongoDB instance.

After the recovery is complete, backups of the Azure Cosmos DB are migrated to the ApsaraDB for MongoDB instance.

5.Manage the ApsaraDB for MongoDB balancer

ApsaraDB for MongoDB allows you to manage the balancer. You can enable or disable the balancer and set an active time window for the balancer to meet specific business needs.

Precautions

- The balancer is a feature of the sharded cluster architecture and applies only to sharded cluster instances.
- Operations related to the balancer may occupy the resources of an instance. Therefore, we recommend that you perform these operations during off-peak hours.

Set an active time window for the balancer

The balancer consumes resources of nodes in an instance to migrate chunks, which may cause imbalanced resource usage on the nodes and affect business operations. To avoid negative impact on your business while the balancer is migrating chunks, you can set an active time window to allow the balancer to migrate chunks only within the specified period of time.

> **Note** Before performing this operation, make sure that the balancer is enabled. For more information about how to enable the balancer, see Enable the balancer.

1. Connect to a sharded cluster instance by using the mongo shell.
2. After connecting to a mongos node, run the following command in the mongo shell to switch to the config database:

```
use config
```

3. Run the following command to set an active time window for the balancer:

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

> **Note**
>
> - <start-time>: the start time in HH:MM format in UTC+8, where the value range of HH is 00 to 23 and that of MM is 00 to 59.
> - <stop-time>: the end time in HH:MM format in UTC+8, where the value range of HH is 00 to 23 and that of MM is 00 to 59.

You can run the `sh.status()` command to check the active time window of the balancer. For example, the following command output shows that the active time window of the balancer is 01:00 to 03:00.

You can also perform other related operations. For example, to ensure that the balancer is always running, you can run the following command to clear the active time window settings:

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

Enable the balancer

If you have configured sharding, the balancer can immediately start a balancing procedure among shards after being enabled. Balancing occupies the resources of an instance. Therefore, we recommend that you perform this operation during off-peak hours.

1. Connect to a sharded cluster instance by using the mongo shell.
2. After connecting to a mongos node, run the following command in the mongo shell to switch to the config database:

   ```
   use config
   ```

3. Run the following command to enable the balancer:

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

Disable the balancer

ApsaraDB for MongoDB enables the balancer by default. To disable the balancer in special business scenarios, follow these steps:

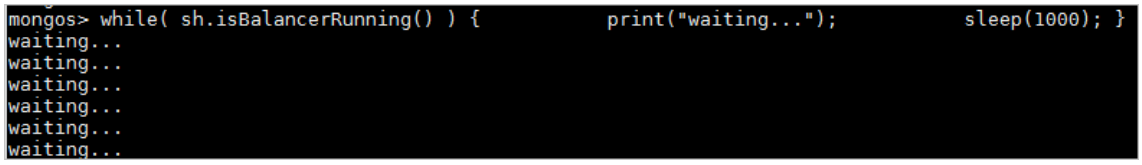
1. Connect to a sharded cluster instance by using the mongo shell.
2. After connecting to a mongos node, run the following command in the mongo shell to switch to the config database:

   ```
   use config
   ```

3. Run the following command to check the running status of the balancer:

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

- If the command does not return any values, the balancer is not running any tasks. You can proceed to disable the balancer.
- If the command returns `waiting`, the balancer is migrating chunks. In this case, you cannot disable the balancer. Otherwise, data may become inconsistent.



4. After confirming that the balancer is not running any tasks, run the following command to disable the balancer:

```
sh.stopBalancer()
```

6.Redirect read requests to data images while data is being updated

ApsaraDB for MongoDB allows you to create read-only data images in a replica set instance or a sharded cluster instance. A data image in a replica set instance can store up to 3 TB of data and that in a sharded cluster instance can store up to 96 TB of data.

How data images work

After you create data images for an instance in which a large amount of data is being updated, all read requests from applications are redirected to read data from the data images. The applications do not read data from the instance until data is completely updated in the instance. The applications read data from the data images as if they were reading data from the instance, without any compromise to the read performance.

> **Note** After data is updated in the instance, you can synchronize the updated data to the data images so that the applications can read the latest data from the data images later. You can use the commands provided by Alibaba Cloud to enable automatic data synchronization within seconds. Data synchronization does not affect normal read operations.

Create data images in a replica set instance

1. Use the mongo shell to connect to the primary node or a secondary node where you want to create a data image. For more information, see Connect to a replica set instance by using the mongo shell.
2. Run the following command to create a data image:

   ```
   db.runCommand({checkpoint:"create"})
   ```

3. Run the following command to delete the data image when you no longer need it:

   ```
   db.runCommand({checkpoint:"drop"})
   ```

Create data images in a sharded cluster instance

1. Use the mongo shell to connect to any mongos node in the sharded cluster instance where you want to create data images. For more information, see Connect to a sharded cluster instance by using the mongo shell.
2. Create data images.
   - To create a data image on the primary node of each shard, run the following command:

     ```
     db.runCommand({runCommandOnShard: "all", "command": {checkpoint:"create"}})
     ```

   - To create a data image on a secondary node of each shard, run the following command:

     ```
     db.runCommand({runCommandOnShard: "all", "command": {checkpoint:"create"}, $queryOptions : {$readPreference: {mode: 'secondary'}}})
     ```

3. Delete the data images when you no longer need them.
   - To delete the data image on the primary node of each shard, run the following command:

     ```
     db.runCommand({runCommandOnShard: "all", "command": {checkpoint:"drop"}})
     ```

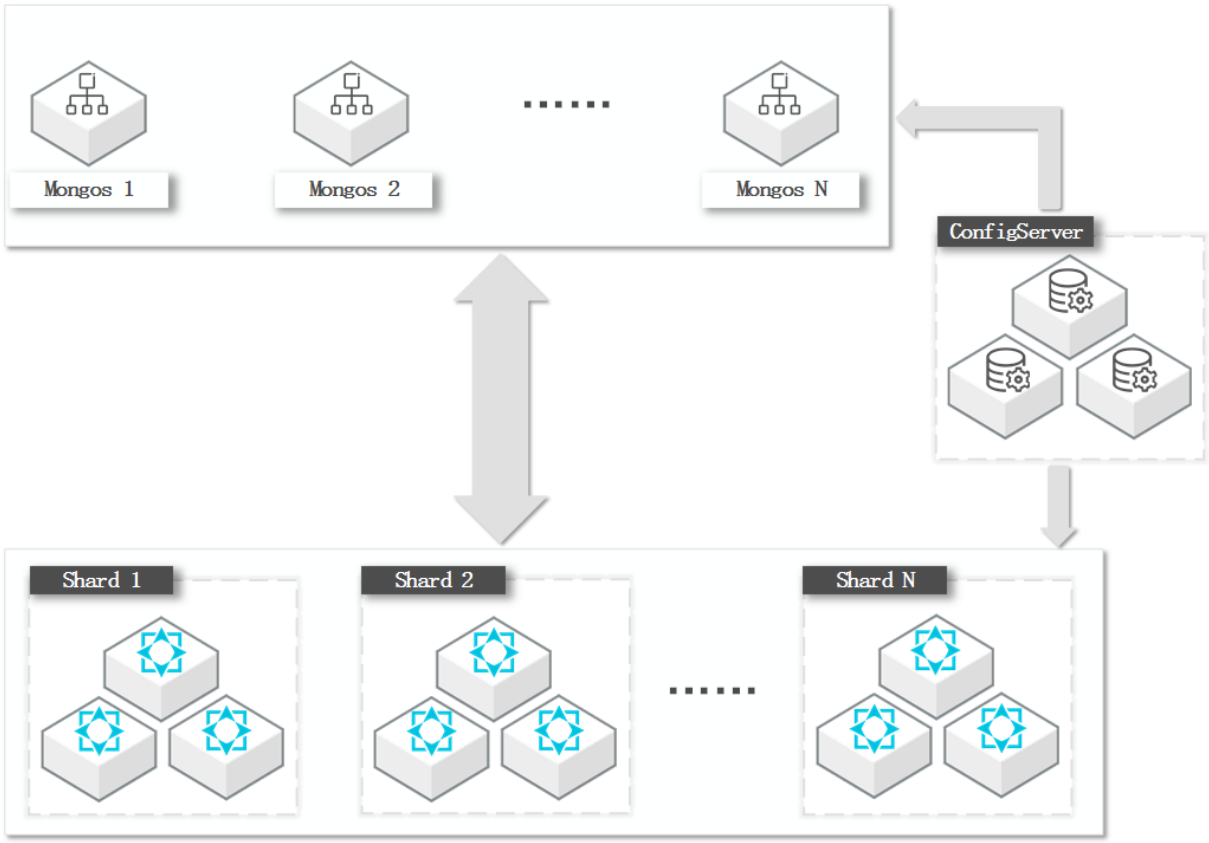
   - To delete the data image on a secondary node of each shard, run the following command:

     ```
     db.runCommand({runCommandOnShard: "all", "command": {checkpoint:"drop"}, $queryOptions: {
     $readPreference: {mode: 'secondary'}}})
     ```

7.Use a connection string URI to connect to a sharded cluster instance

An ApsaraDB for MongoDB sharded cluster instance provides the connection string for each mongos node. You can access the databases of the sharded cluster instance after connecting to a mongos node. However, you must use a correct method to connect to a sharded cluster instance to implement load balancing and high availability.

Background information



A sharded cluster instance distributes and stores data on multiple shards to facilitate high scalability. When creating a sharded cluster instance, ApsaraDB for MongoDB uses a Configserver to store the metadata of the cluster and uses one or more mongos nodes to provide the entrance to the cluster for applications. The mongos nodes read routing information from the Configserver to route requests to corresponding shards at the backend.

- When you connect to a mongos node, the mongos node can function as a mongod process.
- All mongos nodes are equal. You can connect to one or more mongos nodes to access a sharded cluster instance.
- Mongos nodes are stateless and can be scaled out as required. The service capability of a sharded cluster instance is subject to the smaller one between the total service capability of shards and that of mongos nodes.
- When you access a sharded cluster instance, we recommend that you share the load of applications evenly among multiple mongos nodes.

Connection string URIs

To correctly connect to a sharded cluster instance, you must understand the format of connection string URIs of MongoDB. All official MongoDB drivers allow you to use a connection string URI to connect to MongoDB.

Example:

```
mongodb://[username:password@]host1[:port1][,host2[:port2],...[,hostN[:portN]]][/[database][?options]]
```

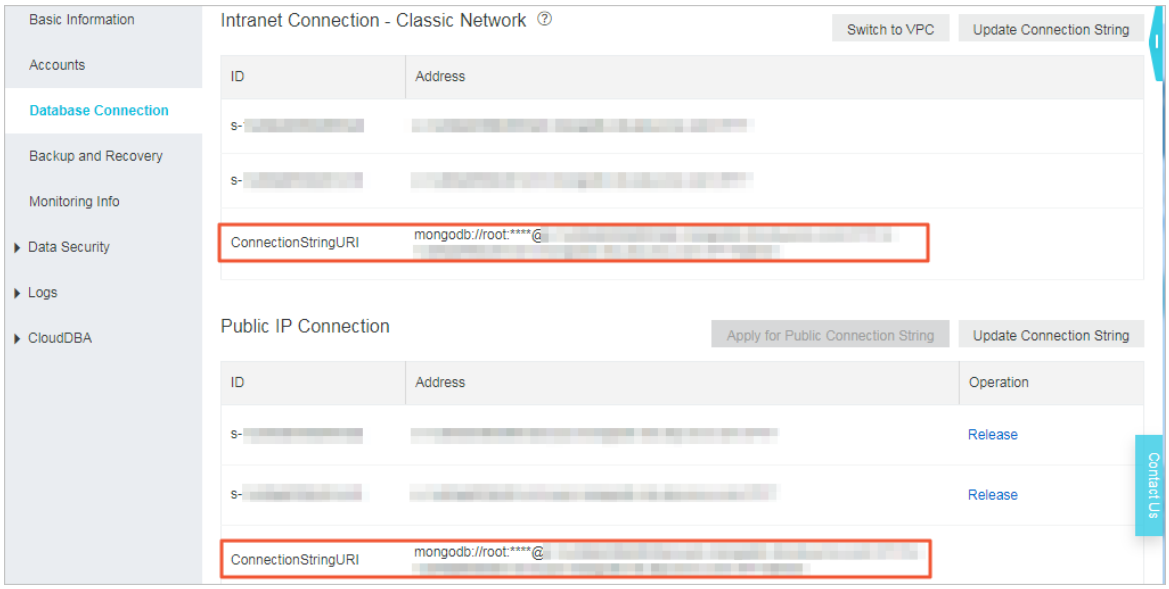
Note

- `mongodb://` : the prefix, indicating a connection string URI.
- `username:password@` : the username and password used to log on to the database.
- `hostX:portX` : the list of connection string used to connect to mongos nodes.
- `/database` : the database corresponding to the username and password if authentication is enabled.
- `?options` : additional connection options.

Use a connection string URI to connect to a sharded cluster instance

You can use a connection string URI to connect to a sharded cluster instance to implement load balancing and high availability.

1. Obtain the connection string URI of a sharded cluster instance. For more information, see Overview of sharded cluster instance connections.



2. Use the obtained connection string URI to connect your applications to the instance. For more information, see Connect to an ApsaraDB for MongoDB instance through the program code.

   Example of the Java code:

```
MongoClientURI connectionString = new MongoClientURI("mongodb://:****@s-xxxxxxxx.mongodb.rds.aliyuncs.com:3717,s-xxxxxxxx.mongodb.rds.aliyuncs.com:3717/admin"); //Replace **** with the password of the root user.
MongoClient client = new MongoClient(connectionString);
MongoDatabase database = client.getDatabase("mydb");
MongoCollection<Document> collection = database.getCollection("mycoll");
```

> **Note**
>
> After you use the preceding method to connect to a sharded cluster instance, a client can automatically distribute requests to multiple mongos nodes to balance the load. If you have used a connection string URI to connect to two or more mongos nodes and a mongos node is faulty, the client can automatically skip this faulty node and distribute requests to the other normal mongos nodes.

If a large number of mongos nodes are used, you can group them by application. For example, you have application A, application B, and four mongos nodes. You can specify only the connection strings of mongos 1 and mongos 2 in the URI for application A, and specify only the connection strings of mongos 3 and mongos 4 in the URI for application B. In this way, you can isolate mongos nodes to provide separate entrance for different applications.

> **Note** Although applications are connected to mutually isolated mongos nodes, they share shards at the backend.

Common connection options

- Implement read/write splitting

  Add `readPreference=secondaryPreferred` in the options parameter to set read preference to secondary nodes.

  Example:

  ```
  mongodb://root:xxxxxxxx@dds-xxxxxxxxxxxx:3717,xxxxxxxxxxxx:3717/admin? replicaSet=mgset-xxxxxx&readPreference=secondaryPreferred
  ```

- Limit connections

  Add `maxPoolSize=xx` in the options parameter to limit the maximum number of connections in the connection pool of a client to xx.

- Send an acknowledgment after data has been written to the majority of nodes

  Add `w= majority` in the options parameter to ensure that ApsaraDB for MongoDB sends an acknowledgment to a client after writing data to the majority of nodes for a write request.

8.Use MongoDB to store logs

An online service generates a large number of operational logs and access logs, which contain information about errors that occurred, triggered alerts, and user behaviors. Generally, such logs are stored in text files, which are readable and can be used to quickly locate issues in routine O&M. However, after a service generates a large number of logs, it is necessary to store and analyze the logs in a more advanced way to explore the value of the log data.

This topic takes the access logs of a web service as an example to describe how to use MongoDB to store and analyze logs to make full use of the log data. The methods and operations described in this topic also apply to other types of log storage services.

Access logs of a web server

The following example shows an access log of a web server. Typically, an access log contains information about the IP address used for the access, the user who accessed the target resource, the operating system and browser that the user used for the access, the endpoint of the target resource, and the result of the access.

```
127.0.0.1 - frank [10/Oct/2000:13:55:36 -0700] "GET /apache_pb.gif HTTP/1.0" 200 2326 "[http://www.example.com/start.html](http://www.example.com/start.html)" "Mozilla/4.08 [en] (Win98; I ;Nav)"
```

You can use MongoDB to store each access log in a single document in the following format:

```
{
        _id: ObjectId('4f442120eb03305789000000'),
        line: '127.0.0.1 - frank [10/Oct/2000:13:55:36 -0700] "GET /apache_pb.gif HTTP/1.0" 200 2326 "[http://www.example.com/start.html](http://www.example.com/start.html)" "Mozilla/4.08 [en] (Win98; I ;Nav)"'
        }
```

The preceding method is easy to configure. However, it may bring inconvenience to the analysis of log data. As MongoDB is not a service targeted at text analysis, we recommend that you convert the format of a log to extract each field and its value from the log before you store it in MongoDB as a document. As shown in the following document, the preceding log is converted to separate fields and values:

```
{
        _id: ObjectId('4f442120eb03305789000000'),
        host: "127.0.0.1",
        logname: null,
        user: 'frank',
        time: ISODate("2000-10-10T20:55:36Z"),
        path: "/apache_pb.gif",
        request: "GET /apache_pb.gif HTTP/1.0",
        status: 200,
        response_size: 2326,
        referrer: "[http://www.example.com/start.html](http://www.example.com/start.html)",
        user_agent: "Mozilla/4.08 [en] (Win98; I ;Nav)"
        }
```

When you convert the format of a log, you can also remove the fields that you regard as useless to the data analysis to save storage space. Several irrelevant fields in the preceding document need to be removed, including the user, request, and status fields. You can also remove the time field because the _id field contains the information about the time when the access was performed. However, you can retain the time field for later analysis because it demonstrates the information in a more clear way and a query statement that uses the time field is more user-friendly. In addition, compared with the _id field, the data type of the time field requires less storage space. Based on the preceding reasons, the following updated content may be eventually stored in the document:

```
{
        _id: ObjectId('4f442120eb03305789000000'),
        host: "127.0.0.1",
        time: ISODate("2000-10-10T20:55:36Z"),
        path: "/apache_pb.gif",
        referer: "[http://www.example.com/start.html](http://www.example.com/start.html)",
        user_agent: "Mozilla/4.08 [en] (Win98; I ;Nav)"
        }
```

Write logs to MongoDB

A log storage service is required to collect a large number of logs at a time. To meet such a requirement, you can specify a write concern for MongoDB to manage the write operation. For example, you can specify the following write concern:

```
db.events.insert({
        host: "127.0.0.1",
        time: ISODate("2000-10-10T20:55:36Z"),
        path: "/apache_pb.gif",
        referer: "[http://www.example.com/start.html](http://www.example.com/start.html)",
        user_agent: "Mozilla/4.08 [en] (Win98; I ;Nav)"
        }
        )
```

> **Note**
>
> - If you require the highest write throughput, you can set the w option of the write concern to {w: 0}.
> - If the target log data is of great importance, for example, the log data is used as the credentials of service billing, you can set the w option to {w: 1} or {w: "majority"}, which is more secure compared with {w: 0}.

To improve the efficiency of the write operation, you can write multiple logs to MongoDB with a single request. The request is in the following format:

```
db.events.insert([doc1, doc2, ...])
```

Query logs in MongoDB

After logs are stored in MongoDB by using the preceding method, you can query logs in MongoDB based on different query requirements.

- Query the logs of all requests to access /apache_pb.gif.

  ```
  q_events = db.events.find({'path': '/apache_pb.gif'})
  ```

  > **Note** If you need to frequently query such access logs, you can create an index on the path field to improve query efficiency, for example, `db.events.createIndex({path: 1})`.

- Query the logs of all requests within a day.

  ```
  q_events = db.events.find({'time': { '$gte': ISODate("2016-12-19T00:00:00.00Z"),'$lt': ISODate("2016-12-20T00:00:00.00Z")}})
  ```

  > **Note** You can create an index on the time field to improve query efficiency, for example, `db.events.createIndex({time: 1})`.

- Query the logs of all requests that are sent to a server over a period of time.

```
q_events = db.events.find({
            'host': '127.0.0.1',
            'time': {'$gte': ISODate("2016-12-19T00:00:00.00Z"),'$lt': ISODate("2016-12-20T00:00:00.00Z"
}
            })
```

Similarly, you can use the aggregation pipeline or perform map-reduce operations provided by MongoDB to initiate more complex queries for data analysis. We recommend that you create indexes on fields properly to improve query efficiency.

Data sharding

When the number of service nodes that generate logs increases, the requirements for the write and storage capabilities of a log storage service also increase. In this case, you can use the sharding feature provided by MongoDB to distribute the log data across multiple shards. When you use the sharding feature, you need to focus on choosing shard keys.

- Use a field that indicates the timestamp as the shard key: For example, use the _id field that contains ObjectId values or the time field as the shard key. However, the following issues may occur in this type of sharding:
  - As the timestamp grows in sequence, newly collected log data will be distributed to the same shard. Hence, the write capability of MongoDB is not enhanced.
  - Many log queries target at the latest log data, which is distributed to only a few shards. Hence, only statistics related to these shards are returned for these queries.
- Use the hashed sharding method: The default shard key of hashed sharding is set to the _id field. This sharding method evenly distributes log data to each shard. Therefore, the write capability of MongoDB grows with shards in a linear manner. However, hashed sharding distributes data randomly. This leads to the issue where MongoDB cannot efficiently process the requests of given ranged queries, which are often used in data analysis. To process such a request, MongoDB needs to traverse all the shards and merge the queried data to return the final result.
- Use the ranged sharding method: Assume that values of the path field in the preceding example are evenly distributed and many queries are based on the path field. Then, you can specify the path field as the shard key to divide data into contiguous ranges. This method has the following benefits:
  - Write requests are evenly distributed to each shard.
  - Query requests based on the path field are densely distributed to one or more shards, which improves the query efficiency.

  In addition, the following issues may occur:
  - If a value of the path field is frequently accessed, logs with the same shard key value are likely to be in the same chunk or shard. The value is at high frequency and the size of the chunk may be large.
  - If the path field has few values, access logs cannot be properly distributed to each shard.

To fix these issues, you can pass an additional field to the shard key. Assume that the original shard key value is {path: 1}. Then, you can add the ssk field to the shard key, for example, `{path: 1, ssk: 1}`.

You can assign a random value to the `ssk` field, such as the hash value of the _id field. You can also assign a timestamp to the ssk field so that the shard key values with the same path value are sorted by time.

In this way, the shard key has multiple values with even frequency. No shard key value is at an extremely high frequency. Each of the preceding sharding methods has its own advantages and disadvantages. You can select a method based on your business requirements.

Solutions to data growth

MongoDB provides the sharding feature for you to store massive data. However, the storage costs increase with the growth of data volume. Typically, the value of log data decreases over time. Data generated one year ago or even three months ago, which is valueless to the analysis, needs to be cleared to reduce storage costs. MongoDB allows you to use the following solutions to meet such a requirement.

- Use TTL indexes: Time to live (TTL) indexes are special single-field indexes that MongoDB can use to automatically remove documents from a collection after a certain amount of time. In the preceding example, the time field indicates the time when the request was sent. You can run the following command to create a TTL index on the time field and specify that MongoDB removes the document after 30 hours: `db.events.createIndex( { time: 1 }, { expireAfterSeconds: 108000 } )`.

  > **Note** With a TTL index created, the background task that removes expired documents written in single-threading mode runs every 60 seconds by default. If a large amount of log data is written to MongoDB, many documents in MongoDB are about to expire over time. The expired documents that are not removed occupy large storage space.

- Use capped collections: If you do not have strict limits on the storage period, whereas you want to limit the storage space, you can use capped collections to store log data. Capped collections work in the following way: After you specify a maximum storage space or a maximum number of stored documents for a capped collection, once one of the limits is reached, MongoDB automatically removes the oldest documents in the collection. For example, you can run the following command to create and configure a capped collection: `db.createCollection("event", {capped: true, size: 104857600000}`.
- Archive documents by collection or database periodically: At the end of a month, you can rename the collection that stores the documents of that month and create another collection to store documents of the next month. We recommend that you append the information about the year and month to the collection name. The following example describes how the 12 collections that store the documents written in each month of 2016 are named:

```
events-201601
        events-201602
        events-201603
        events-201604
        ....
        events-201612
```

If you need to clear the documents of a specific month, you can run the following command to directly delete the corresponding collection:

```
db["events-201601"].drop()
        db["events-201602"].drop()
```

The query statements may be complex if you need to query the documents of multiple months as MongoDB needs to merge the queried data of multiple collections to return the final result.

9.MongoDB sharding

This topic describes knowledge about MongoDB sharding.

Scenarios of sharded clusters

You can use a sharded cluster in the following scenarios:

- The storage capacity of a single machine is restricted.
- The read and write capabilities of a single machine are restricted because of the CPU, memory, or network interface controller (NIC) performance bottleneck.

Number of required shards and mongos nodes

If you use a sharded cluster, you can determine the number of required shards and mongos nodes based on your business needs.

- You may want to use MongoDB sharding to store a large amount of data that is less frequently accessed. Assume that the storage capacity of each shard is M, the storage threshold of each shard is 75%, and the total storage capacity required is N. If the data is less frequently accessed, two or more mongos nodes are enough for high availability. You can calculate the number of required shards and mongos nodes as follows:
  - Number of shards = N/M/0.75
  - Number of mongos nodes = 2 or more
- You may want to use MongoDB sharding to write or read a small amount of data with high concurrency. The number of shards and mongos nodes to be deployed must meet the requirements for the read and write performance. The storage capacity is not an important factor. Assume that the maximum queries per second (QPS) of each shard is M, the maximum QPS of each mongos node is Ms, the total QPS required is Q, and the load threshold of each shard or mongos node is 75%. You can calculate the number of required shards and mongos nodes as follows:
  - Number of shards = Q/M/0.75
  - Number of mongos nodes = Q/Ms/0.75

> **Note** The required performance of the mongos and mongod nodes depends on whether data is frequently accessed in actual scenarios.

If you want to use MongoDB sharding to meet the preceding requirements at the same time, calculate the number of shards and mongos nodes based on more accurate metrics. In this topic, the number of shards and mongos nodes is calculated based on the ideal scenario where the data and requests are distributed evenly. However, the system load may be distributed unevenly in actual scenarios. To resolve this problem, you need to select a proper shard key.

Shard key selection

MongoDB provides the following sharding strategies:

- Ranged sharding: distributes data into ranges based on the shard key values.
- Hashed sharding: distributes data evenly to each shard.

The two sharding strategies cannot resolve the following problems:

- The shard key has a small range of values. That is, the shard key has low cardinality. Assume that you deploy data across several data centers and use a data center as a shard key. The sharding effect, however, is generally not as expected because the number of data centers is limited.
- A shard key value is contained by a large number of documents. Therefore, too many documents are stored in a chunk. If the size of the documents exceeds the upper limit of the chunk, the chunk is labeled as jumbo and the balancer cannot migrate the jumbo chunk.
- If you query and update data based on a synthetic shard key, all queries will become scatter-gather queries. This lower the query and update efficiency.

A proper shard key has the following features:

- Sufficient cardinality
- Evenly distributed write operations
- Targeted read operations

For example, an Internet of Things (IoT) application uses a MongoDB sharded cluster to store the logs of a large number of devices. Assume that millions of devices send logs to the MongoDB sharded cluster every 10s and the logs contain information such as the device IDs and timestamps. The most common query request of an application is to query the logs of a device within a specific time range. Four solutions are listed in this topic for comparison. We recommend that you do not use the first three of these solutions. The fourth solution is optimal.

- Solution 1: Use the timestamp as the shard key and use the ranged sharding strategy.
  - The shard key is improper.
  - The timestamps of newly written data are always increasing in value. All write operations are distributed to the same shard. The write distribution is uneven.
  - The queries based on the device ID are spread across all shards. This lowers the query efficiency.
- Solution 2: Use the timestamp as the shard key and use the hashed sharding strategy.
  - The shard key is improper.
  - All write operations are evenly distributed to shards.
  - The queries based on the device ID are spread across all shards. This lowers the query efficiency.
- Solution 3: Use the device ID as the shard key and use the hashed sharding strategy. If the device IDs are random values, the ranged sharding strategy has the same effect.
  - The shard key is improper.
  - All write operations are evenly distributed to shards.
  - The data of a device cannot be further split but can only be distributed to the same chunk. As a result, the chunk may become a jumbo chunk and the queries based on the device ID can only be distributed to a single shard. In this case, you must scan and sort the entire table if you query data based on the timestamp range.
- Solution 4: Recommended. Use the combination of the device ID and timestamp as the shard key and use the ranged sharding strategy.
  - The shard key is proper.
  - All write operations are evenly distributed to shards.

- The data of a device can be further split and distributed to multiple chunks based on the timestamps.
- You can use a combination of the device ID and timestamp to query the data of a device within a specific time range.

Jumbo chunk and chunk size

The default size of a chunk in a MongoDB sharded cluster is 64 MB. If the size of a chunk exceeds 64 MB and the chunk cannot be split, the chunk is labeled as jumbo. For example, if all documents use the same shard key, the chunk cannot be split. The balancer cannot migrate jumbo chunks, which may cause load imbalance. Try your best to avoid jumbo chunks.

If load balancing is not a demanding requirement, jumbo chunks do not affect the read or write operations. To deal with a chunk labeled as jumbo, use the following methods:

- Split the jumbo chunk. If the jumbo chunk is split, the mongos node automatically removes the jumbo label.
- If the chunk cannot be split and is not a jumbo chunk, you can manually remove the jumbo label. Before you remove the label, back up the config database in case of misoperation.
- Increase the value of the chunk size parameter. If the size of the chunk does not exceed the upper limit, the jumbo label is removed. However, the chunk will be labeled as jumbo again when new data is written to the chunk and the size of the chunk exceeds the upper limit. The best solution is to select a proper shard key.

The default chunk size can be used in most scenarios. In the following scenarios, you may need to change the chunk size to a proper value ranging from 1 to 1024:

- If the input and output (I/O) load is too high during chunk migration, you can reduce the chunk size.
- During testing, you can reduce the chunk size to verify the performance.
- The default chunk size is so small that a large number of chunks are labeled as jumbo and the load is imbalanced. In this case, you can try to increase the chunk size.
- If you want to shard a collection that stores TBs of data, you must increase the chunk size. For more information, see Sharding Existing Collection Data Size.

Tag aware sharding

Tag aware sharding is a useful feature of sharded clusters, allowing you to customize chunk distribution rules. You can use the tag aware sharding feature by following these steps:

1. Use the sh.addShardTag() method to associate a shard with tag A.
2. Use the sh.addTagRange() method to associates a specific range of chunks with tag A. In this way, the chunks with tag A are distributed to the shard with tag A.

Scenarios of tag aware sharding

- Associate shards in different data centers with tags based on data centers and distribute data in different chunks to specified data centers.
- Associate the shards with tags based on their service capabilities and distribute more chunks to the shards with better performance.

Note:

The chunks cannot be distributed to shards with the specified tags in a timely manner. Instead, the distribution is gradually completed after chunk split and migration are triggered by the write and update operations. Make sure that the balancer is enabled during distribution. A period of time after chunks are associated with tags, newly written data may not be distributed to shards with the same tag.

Sharded cluster balancer

Currently, automatic load balancing for MongoDB sharded clusters is implemented by the background threads of mongos. Only one migration task can be run for each collection at the same time. The load balancing is triggered based on the number of chunks on each shard. When the number of chunks on a shard reaches the specific migration threshold, chunks are migrated between shards. The migration threshold depends on the total number of chunks.

By default, the balancer is enabled. To prevent the chunk migration from affecting online services, you can set the balancing window. For example, you can enable the balancer to migrate chunks only from 02:00 to 06:00.

```
use config
        db.settings.update(
        { _id: "balancer" },
        { $set: { activeWindow : { start : "02:00", stop : "06:00" } } },
        { upsert: true }
        )
```

Note: Disable the balancer when you back up a sharded cluster through mongos or back up data on the config server or all shards separately. Otherwise, the status of the data is inconsistent after backup.

```
sh.stopBalancer()
```

Data archiving during chunk migration

When you use a sharded cluster of MongoDB 3.0 or earlier, you may find that the disk usage in the directory keeps increasing after you stop writing data.

The problem is caused by the sharding.archiveMovedChunks parameter. In MongoDB 3.0 or earlier, the sharding.archiveMovedChunks parameter is set to true by default. During chunk migration, the source shard archives the data of the migrated chunks in a directory so that the archived data can be used for recovery if any problem arises. That is, the occupied space on the source shard is not released, whereas the space on the target shard is occupied.

> **Note** In MongoDB 3.2, the parameter defaults to false, indicating that the data of the migrated chunks is not archived on the source shard.

recoverShardingState parameter

When you use a MongoDB sharded cluster, the following problem may occur:

The shard does not work after it is started. The ismaster parameter is set to false on the primary node of the shard and other commands cannot be run on the shard. The following result of running the db.isMaster() command shows the status of the shard.

```
mongo-9003:PRIMARY> db.isMaster()
        {
        "hosts" : [
        "host1:9003",
        "host2:9003",
        "host3:9003"
        ],
        "setName" : "mongo-9003",
        "setVersion" : 9,
        "ismaster" : false,  // Indicates that the current node is not a primary node.
        "secondary" : true,
        "primary" : "host1:9003",
        "me" : "host1:9003",
        "electionId" : ObjectId("57c7e62d218e9216c70aa3cf"),
        "maxBsonObjectSize" : 16777216,
        "maxMessageSizeBytes" : 48000000,
        "maxWriteBatchSize" : 1000,
        "localTime" : ISODate("2016-09-01T12:29:27.113Z"),
        "maxWireVersion" : 4,
        "minWireVersion" : 0,
        "ok" : 1
        }
```

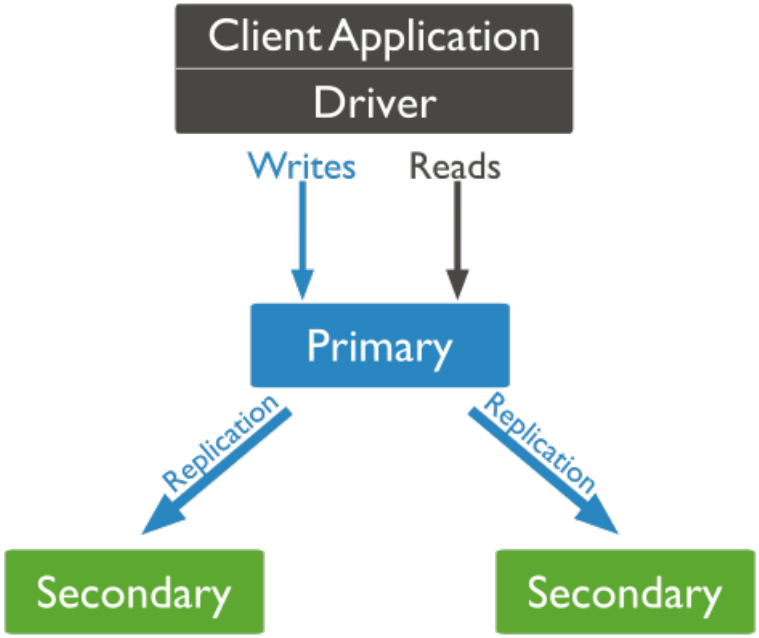
The error log indicates that the shard cannot connect to the config server because the sharding.recoverShardingState parameter is set to true. When the shard is started, it connects to the config server to initialize the sharding. If the shard cannot connect to the config server, initialization fails. In this case, the status of the shard is abnormal.

This problem may arise when you migrate all shards of a sharded cluster to a new host. The information used to connect to the config server is changed whereas the started shard still tries to connect to the config server based on the original information. To resolve this problem, add `setParameter recoverShardingState=false` in the commands used to start the shard.

10.How a replica set in MongoDB works

A replica set in ApsaraDB for MongoDB is a group of mongod processes and contains a primary node and multiple secondary nodes. MongoDB drivers write data to the primary node only. Then, data is synchronized from the primary node to secondary nodes. This ensures data consistency across all nodes in the replica set. Therefore, replica sets provide high availability.

The following figure is extracted from the official documentation of MongoDB. It shows a typical MongoDB replica set that contains one primary node and two secondary nodes.



Primary node election (1)

A replica set is initialized by running the `replSetInitiate` command or running the `rs.initiate()` command in the mongo shell. After the replica set is initialized, the members send heartbeat messages to each other and initiate the primary node election. The node that receives votes from a majority of the members becomes the primary node and the other nodes become secondary nodes.

Initialize the replica set

```
config = {
   _id : "my_replica_set",
   members : [
       {_id : 0, host : "rs1.example.net:27017"},
       {_id : 1, host : "rs2.example.net:27017"},
       {_id : 2, host : "rs3.example.net:27017"},
  ]
}
rs.initiate(config)
```

Definition of majority

A group of voting members is considered a majority only if it contains members of more than the average of the total number of members. If the number of members in a replica set is equal to or less than the average number of all voting members, the election cannot be implemented. In this case, you cannot write data to the replica set.

Number of voting members	Majority	Maximum number of failed nodes
1	1	0
2	2	0
3	2	1
4	3	1
5	3	2
6	4	2
7	4	3

We recommend that you set the number of members in a replica set to an odd number. The preceding table shows that both a replica set with three nodes and a replica set with four nodes tolerate the failure of one node. The two replica sets provide the same service availability. However, the replica set with four nodes provides more reliable data storage.

Special secondary nodes

Secondary nodes of a replica set participate in the primary node election. A secondary node may also be elected as the primary node. The latest data written to the primary node is synchronized to secondary nodes to ensure data consistency across all nodes.

You can read data from secondary nodes. Therefore, you can add secondary nodes to a replica set to improve the read performance and service availability of the replica set. ApsaraDB for MongoDB allows you to configure secondary nodes of a replica set to meet the requirements of different scenarios.

- Arbiter

An arbiter node participates in the election as a voter only. It cannot be elected as the primary node or synchronize data from the primary node.

Assume that you deploy a replica set that contains one primary node and one secondary node. If one node fails, the primary node election cannot be implemented. As a result, the replica set becomes unavailable. In this case, you can add an arbiter node to the replica set to enable primary node election.

An arbiter node is a lightweight node that does not store data. If the number of members in a replica set is an even number, we recommend that you add an arbiter node to increase the availability of the replica set.

- Priority0

  A node that has priority 0 in the primary node election cannot be elected as the primary node.

  Assume that you deploy a replica set that contains nodes in both Data center A and Data center B. To ensure that the elected primary node is deployed in Data center A, set the priorities of the replica set members in Data center B to 0.

  > **Note** If you set the priorities of the members in Data center B to 0, we recommend that you deploy a majority of replica set nodes in Data center A. Otherwise, the primary node election may fail during network partitioning.

- Vote0

  In MongoDB 3.0, a replica set contains a maximum of 50 members, and up to seven members can vote in a primary node election. You must set the members[n].votes attribute to 0 for members that are not expected to vote.

- Hidden

  A hidden member in a replica set cannot be elected as the primary node because its priority is 0. Hidden nodes are invisible to MongoDB drivers.

  You can use hidden nodes to back up data or perform offline computation tasks. This does not affect the services of the replica set because hidden nodes do not process requests from MongoDB drivers.

- Delayed

  A delayed node must be a hidden node. Data on a delayed node reflects an earlier state of the data on the primary node. If you configure a one-hour delay, data on the delayed node is the same as the data on the primary node an hour ago.

  Therefore, if you write incorrect or invalid data to the primary node, you can use the data on the delayed node to restore the data on the primary node to an earlier state.

Primary node election (2)

A primary node election is triggered not only after replica set initialization but also in the following scenarios:

- Replica set reconfiguration

  A primary node election is triggered if the primary node fails or voluntarily steps down and becomes a secondary node. A primary node election is affected by various factors, such as heartbeat messages among nodes, priorities of nodes, and the time when the last oplog entry was generated.

- Node priorities

  All nodes tend to vote for the node that has the highest priority. A priority 0 node cannot trigger primary node elections. If a secondary node has a higher priority than the primary node and the time difference between the latest log entry of the secondary node and that of the primary node is within 10 seconds, the primary node steps down. In this case, this secondary node becomes a candidate for the primary node.

- Optime

  Only secondary nodes that have the latest oplog entry are eligible to be elected as the primary node.

- Network partitioning

  Only nodes that are connected to a majority of voting nodes can be elected as the primary node. If the primary node is disconnected from a majority of the other nodes in the replica set, the primary node voluntarily steps down and becomes a secondary node. A replica set may have multiple primary nodes for a short period of time during network partitioning. When MongoDB drivers write data, we recommend that you set a policy that allows data synchronization from only the primary node that is connected to a majority of nodes.

Data synchronization

Data is synchronized from the primary node to secondary nodes based on the oplog. After a write operation on the primary node is complete, an oplog entry is written to the special local.oplog.rs collection. Secondary nodes constantly import new oplog entries from the primary node and apply the operations.

To prevent unlimited growth in the size of the oplog, local.oplog.rs is configured as a capped collection. When the amount of oplog data reaches the specified threshold, the earliest entries are deleted. All operations in the oplog must be idempotent. This ensures that an operation produces the same results regardless of whether it is repeatedly applied to secondary nodes.

The following code block is a sample oplog entry, which contains fields such as ts, h, op, ns, and o:

```
{
  "ts" : Timestamp(1446011584, 2),
  "h" : NumberLong("1687359108795812092"),
  "v" : 2,
  "op" : "i",
  "ns" : "test.nosql",
  "o" : { "_id" : ObjectId("563062c0b085733f34ab4129"), "name" : "mongodb", "score" : "100" }
}
```

- ts: the time when the operation was performed. The value contains two numbers. The first number is a UNIX timestamp. The second number is a counter that indicates the serial number of each operation that occurs within a second. The counter is reset every second.
- h: the unique identifier of the operation
- v: the version of the oplog
- op: the type of the operation

- i: insert
- u: update
- d: delete
- c: run commands such as createDatabase and dropDatabase
- n: null. This value is used for special purposes.
- ns: the collection on which the operation is performed
- o: the operation details. This field is valid for update operations only.
- o2: the conditions of an update operation. This field is valid for update operations only.

During the initial synchronization, a secondary node runs the `init sync` command to synchronize all data from the primary node or another secondary node that stores the latest data. Then, the secondary node continuously uses the `tailable cursor` feature to query the latest oplog entries in the local.oplog.rs collection of the primary node and applies the operations in these oplog entries.

The initial synchronization process includes the following steps:

1. Before the time of T1, the data synchronization tool runs the `listDatabases`, `listCollections`, and `cloneCollection` commands. At the time of T1, all data in the cloud databases (except the local.oplog.rs database) starts to be synchronized from the primary node to the secondary node. Assume that the synchronization is completed at the time of T2.
2. All the operations in oplog entries generated from T1 to T2 are applied to the secondary node. Operations in oplog entries are idempotent. Therefore, operations that have been applied in Step 1 can be reapplied.
3. Based on the index for each collection on the primary node, indexes for the corresponding collections are created on the secondary node. The index for each collection on the primary node was created in Step 1.

> **Note** You must configure the oplog size based on the database size and the volume of data to be written by the application. If the oplog is oversized, the storage space may be wasted. If the oplog size is too small, the secondary node may fail to complete initial synchronization. For example, in Step 1, if the database stores a large amount of data and the oplog is not large enough, the oplog may fail to store all the oplog entries generated from T1 to T2. As a result, the secondary node cannot synchronize all the data sets from the primary node.

Modify a replica set

You can modify a replica set by running the `replSetReconfig` command or running the `rs.reconfig()` command in the mongo shell. For example, you can add or delete members, and change the priority, vote, hidden, and delayed attributes of a member.

For example, you can run the following command to set the priority of the second member in the replica set to 2:

```
cfg = rs.conf();
cfg.members[1].priority = 2;
rs.reconfig(cfg);
```

Roll back operations on the primary node

Assume that the primary node of a replica set fails. If write operations have been performed on the new primary node when the former primary node rejoins the replica set, the former primary node must roll back operations that have not been synchronized to other nodes. This ensures data consistency between the former primary node and the new primary node.

The former primary node writes the rollback data to a dedicated directory. This allows the database administrator to run the `mongorestore` command to restore operations as needed.

Replica set read/write settings

- Read Preference

  By default, all the read requests for a replica set are routed to the primary node. However, you can modify the read preference modes on the drivers to route read requests to other nodes.

  - primary: This is the default mode. All read requests are routed to the primary node.
  - primaryPreferred: Read requests are routed to the primary node preferentially. If the primary node is unavailable, read requests are routed to secondary nodes.
  - secondary: All read requests are routed to secondary nodes.
  - secondaryPreferred: Read requests are routed to secondary nodes preferentially. If all secondary nodes are unavailable, read requests are routed to the primary node.
  - nearest: Read requests are routed to the nearest reachable node, which can be detected by running the `ping` command.

- Write Concern

  By default, the primary node returns a message that indicates a successful write operation after data is written to the primary node. You can set the write concern on drivers to specify the rule for a successful write operation. For more information, see Write concern.

  The following write concern indicates that a write operation is successful only after the data is written to a majority of nodes before the request times out. The timeout period is five seconds.

  ```
  db.products.insert(
   { item: "envelopes", qty : 100, type: "Clasp" },
   { writeConcern: { w: majority, wtimeout: 5000 } }
  )
  ```

  The preceding settings apply to individual requests. You can also modify the default write concern of a replica set. The write concern of a replica set applies to all the requests for the replica set.

```
cfg = rs.conf()
cfg.settings = {}
cfg.settings.getLastErrorDefaults = { w: "majority", wtimeout: 5000 }
rs.reconfig(cfg)
```