

## Managing Apache Kudu Security

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## Kudu security considerations

Kudu includes security features that allow Kudu clusters to be hardened against access from unauthorized users.

Kudu uses strong authentication with Kerberos, and authorization with Ranger. Communication between Kudu clients and servers, and between servers to other servers, can be encrypted with TLS. Kudu also supports HTTPS on the web UI.

These security features should work seamlessly in Impala as well, as long as Impala's user is given permission to access Kudu.

## Kudu security limitations

Here are some limitations related to data encryption and authorization in Kudu.

- Data encryption at rest is not directly built into Kudu. Encryption of Kudu data at rest can be achieved through the use of local block device encryption software such as dmccrypt.
- Row-level authorization is not available.
- Kudu uses an internal PKI system to issue X.509 certificates to servers in the cluster. As a result you cannot run Kudu with public IPs.
- Server certificates generated by Kudu IPKI are incompatible with bouncycastle version 1.52 and earlier.
- When you are creating a new Kudu service using the Ranger web UI, the Test Connection button is displayed. However, the TestConnection tab is not implemented in the Kudu Ranger plugin. As a result if you try to use it with Kudu it will fail, but that does not mean that the service is not working.

## Kudu authentication

Configure Kudu to enforce secure authentication among servers, and between clients and servers.

Authentication prevents untrusted actors from gaining access to Kudu, and securely identifies connecting users or services for authorization checks. Authentication in Kudu is designed to interoperate with other secure Hadoop components by utilizing Kerberos.

### Scalability

Kudu authentication is designed to scale to thousands of nodes, which means it must avoid unnecessary coordination with a central authentication authority (such as the Kerberos KDC) for each connection.

Instead, Kudu servers and clients use Kerberos to establish initial trust with the Kudu master, and then use alternate credentials for subsequent connections. The Kudu master issues internal X.509 certificates to tablet servers on startup, and temporary authentication tokens to clients on first contact.

### Internal private key infrastructure (PKI)

Kudu uses an internal PKI to issue X.509 certificates to servers in the cluster. Connections between peers who have both obtained certificates will use TLS for authentication. In such cases, neither peer needs to contact the Kerberos KDC.

X.509 certificates are only used for internal communication among Kudu servers, and between Kudu clients and servers. These certificates are never presented in a public facing protocol. By using internally-issued certificates, Kudu offers strong authentication which scales to huge clusters, and allows TLS encryption to be used without requiring you to manually deploy certificates on every node.

## Kudu authentication with Kerberos

You can configure authentication on Kudu servers. Authentication in Kudu is designed to interoperate with other secure Hadoop components by utilizing Kerberos.

The `--rpc_authentication` flag is used to configure authentication on Kudu servers. In a Cloudera Manager managed cluster that flag is configured using the Enable Secure Authentication And Encryption property. This property can have the following values:

- Optional: Kudu will attempt to use strong authentication, but will allow unauthenticated connections. The connection between servers will be encrypted. This is the default value which is indicated by a clear checkbox.
- Required: Kudu will reject connections from clients and servers who lack authentication credentials. If you want to secure your cluster you have to set the `--rpc_authentication` flag to this value, meaning that you have to select the Enable Secure Authentication And Encryption property.

## Kudu authentication tokens

After authenticating to a secure cluster, the Kudu client will automatically request an authentication token from the Kudu master. An authentication token encapsulates the identity of the authenticated user and carries the Kudu master's RSA signature so that its authenticity can be verified. This token will be used to authenticate subsequent connections.

By default, authentication tokens are only valid for seven days, so that even if a token were compromised, it cannot be used indefinitely. For the most part, authentication tokens should be completely transparent to users. By using authentication tokens, Kudu is able to take advantage of strong authentication, without paying the scalability cost of communicating with a central authority for every connection.

When used with distributed compute frameworks such as Apache Spark, authentication tokens can simplify configuration and improve security. For example, the Kudu Spark connector will automatically retrieve an authentication token during the planning stage, and distribute the token to tasks. This allows Spark to work against a secure Kudu cluster where only the planner node has Kerberos credentials.

## Client authentication to secure Kudu clusters

Users running client Kudu applications must first run the `kinit` command to obtain a Kerberos ticket-granting ticket.

For example: `kinit admin@EXAMPLE.COM`

Once authenticated, you use the same client code to read from and write to Kudu servers with and without the Kerberos configuration.

## Kudu coarse-grained authorization

Kudu supports coarse-grained authorization checks for client requests based on the client's authenticated Kerberos principal (user or service). Access levels are granted based on whitelist-style Access Control Lists (ACLs), one for each level. Each ACL specifies a comma-separated list of users, or may be set to `'*'` to indicate that all authenticated users have access rights at the specified level.

The two levels of access which can be configured are:

- Superuser - Principals authorized as a superuser can perform certain administrative functions such as using the `kudu` command line tool to diagnose and repair cluster issues.
- User - Principals authorized as a user are able to access and modify all data in the Kudu cluster. This includes the ability to create, drop, and alter tables, as well as read, insert, update, and delete data. The default value for the User ACL is `'*'`, which allows all users access to the cluster. However, if authentication is enabled, this will

restrict access to only those users who are able to successfully authenticate using Kerberos. Unauthenticated users on the same network as the Kudu servers will be unable to access the cluster.



**Note:** Internally, Kudu has a third access level for the daemons themselves called Service. This is used to ensure that users cannot connect to the cluster and pose as tablet servers.

## Kudu fine-grained authorization

Kudu can be configured to enforce fine-grained authorization across servers.

Fine-grained authorization ensures that users can see only the data they are explicitly authorized to see. Kudu supports this by leveraging policies defined in Apache Ranger.



**Note:** Fine-grained authorization policies are not enforced when accessing the web UI. User data may appear on various pages of the web UI (for example, in logs, metrics, scans). As such, it is recommended to either limit access to the web UI ports, or redact or disable the web UI entirely, as desired.

## Kudu and Apache Ranger integration

Learn about how Apache Ranger is integrated with Kudu in order to provide fine-grained authorization across servers.

The Ranger models tabular objects are stored in a Kudu cluster in the following hierarchy: Database, Table, Column.



**Note:** Ranger allows you to add separate service repositories to manage privileges for different Kudu clusters. Depending on the value of the `ranger.plugin.kudu.service.name` configuration in the Ranger client, Kudu knows which service repository to connect to. For more details about Ranger service repository, see the [Apache Ranger documentation](#).

**Database:** Kudu does not have the concept of a database. Therefore, a database is indicated as a prefix of table names with the format `<database>.<table>`. Since Kudu's only restriction on table names is that they be valid UTF-8 encoded strings, Kudu considers special characters to be valid parts of database or table names. For example, if a managed Kudu table created from Impala is named `impala:bar.foo`, its database will be `impala:bar`.

**Table:** Is a single Kudu table.

**Column:** Is a column within a Kudu table.

In Ranger, privileges are also associated with specific actions. Access to Kudu tables may rely on privileges on the following actions:

- ALTER
- CREATE
- DELETE
- DROP
- INSERT
- UPDATE
- SELECT

There are two additional access types:

- ALL
- METADATA

If a user has the ALL privilege on a resource, they implicitly have privileges to perform any action on that resource that does not require the users to be a delegated admin.

If a user is granted any privilege, they are able to perform actions requiring METADATA (for example, opening a table) without having to explicitly grant them METADATA privileges.

Ranger supports a delegate admin flag which is independent of the action type. It is not implied by ALL and does not imply METADATA. This is similar to the GRANT OPTION part of the ALL WITH GRANT OPTION in SQL as it is required to modify privileges in Ranger and change the owner of a Kudu table.

Table creation requires CREATE ON DATABASE privilege. If the user creates a table with a different owner, ALL and delegate admin are required.



**Warning:** A user with delegate admin privilege on a resource can grant any privilege to themselves and others.

While the action types are hierarchical, in terms of privilege evaluation, Ranger does not have the concept of hierarchy. For instance, if a user has SELECT privilege on a database, it does not imply that the user has SELECT privilege on every table belonging to that database.

However, Ranger supports privilege wildcard matching. For example, `db=a->table=*` matches all the tables that belong to database a. Therefore, in Ranger users actually need the SELECT privilege granted on `db=a->table=*>column=*` to allow SELECT on every table and every column in database a.

Nevertheless, with Ranger integration, when a Kudu master receives a request, it consults Ranger to determine what privileges a user has. And the required policies documented in the <<security.adoc#policy-for-kudu-masters, policy section>> are enforced to determine whether the user is authorized to perform the requested action or not.



**Note:** Even though Kudu table names remain case sensitive with Ranger integration, policies authorization is considered case-insensitive.

In addition to granting privileges to a user by username, privileges can also be granted to table owners using the special {OWNER} username. These policies are evaluated only when a user tries to perform an action on a table that they own. For example, a policy can be defined for the {OWNER} user and `db=*>table=*` resource, and it will automatically be applied when any table is accessed by its owner. This way administrators do not need to choose between creating policies one by one for each table, and granting access to a wide range of users.



**Warning:** If a user has ALL and delegate admin privileges on a table only by ownership and no privileges by username, they can effectively lock themselves out by giving away the ownership.

### Related Information

[Ranger User Guide](#)

## Kudu authorization tokens

Learn about authorization tokens which are used by Ranger to propagate and check privileges.

Rather than having every tablet server communicate directly with the underlying authorization service (Ranger), privileges are propagated and checked via authorization tokens. These tokens encapsulate what privileges a user has on a given table. Tokens are generated by the master and returned to Kudu clients upon opening a Kudu table. Kudu clients automatically attach authorization tokens when sending requests to tablet servers.

Authorization tokens are a means to limit the number of nodes directly accessing the authorization service to retrieve privileges. As such, since the expected number of tablet servers in a cluster is much higher than the number of Kudu masters, they are only used to authorize requests sent to tablet servers. Kudu masters fetch privileges directly from the authorization service or cache.

Similar to the validity interval for authentication tokens, to limit the window of potential unwanted access if a token becomes compromised, authorization tokens are valid for five minutes by default. The acquisition and renewal of a token is hidden from the user, as Kudu clients automatically retrieve new tokens when existing tokens expire.

When a tablet server that has been configured to enforce fine-grained access control receives a request, it checks the privileges in the attached token, rejecting it if the privileges are not sufficient to perform the requested operation, or if it is invalid (e.g. expired).

## Specifying trusted users

You can specify which users can view and modify data stored in Kudu. Additionally, some services that interact with Kudu may authorize requests on behalf of their end users.

### About this task

It may be desirable to allow certain users to view and modify any data stored in Kudu. Such users can be specified via the `--trusted_user_acl` master configuration. Trusted users can perform any operation that would otherwise require fine-grained privileges, without Kudu consulting the authorization service.

Furthermore, some services that interact with Kudu can authorize requests on behalf of their end users. For example, Apache Impala authorizes queries on behalf of its users, and sends requests to Kudu as the Impala service user, commonly "impala". Since Impala authorizes requests on its own, to avoid extraneous communication between the authorization service and Kudu, the Impala service user should be listed as a trusted user.



**Note:** When accessing Kudu through Impala, Impala enforces its own fine-grained authorization policy. This policy is similar to Kudu's and can be found in the [Impala authorization documentation](#).

### Procedure

1. In Cloudera Manager, navigate to Kudu Configuration .
2. Find the Master Advanced Configuration Snippet (Safety Valve) for gflagfile propertz.
3. Click View as XML and add the following configuration:

```
--trusted_user_acl=impala,hive,kudu,rangeradmin,[***TRUSTED USER***]
```

4. Click Save Changes.
5. Restart the Kudu service.

## Kudu authorization policies

Review the authorization policies that are enforced by Kudu masters and Kudu tablet servers.

### Policy for Kudu masters

The following authorization policy is enforced by Kudu masters:

**Table 1: Authorization Policy for Masters**

| Operation   | Required Privilege   |
|---|--|
| CreateTable   | CREATE ON DATABASE   |
| CreateTable with a different owner specified than the requesting user | ALL ON DATABASE with the Sentry GRANT OPTION.                  |
| DeleteTable   | DROP ON TABLE  |
| AlterTable (with no rename)   | ALTER ON TABLE   |
| AlterTable (with rename)  | ALL ON TABLE <old-table> and CREATE ON DATABASE <new-database> |
| IsCreateTableDone   | METADATA ON TABLE  |
| IsAlterTableDone  | METADATA ON TABLE  |
| ListTables  | METADATA ON TABLE  |
| GetTableLocations   | METADATA ON TABLE  |
| GetTableSchema  | METADATA ON TABLE  |

| Operation         | Required Privilege |
|-------------------|--------------------|
| GetTableLocations | METADATA ON TABLE  |

### Policy for Kudu tablet servers

The following authorization policy is enforced by Kudu tablet servers:

**Table 2: Authorization Policy for Tablet Servers**

| Operation   | Required Privilege  |
|---|---|
| Scan  | SELECT ON TABLE, or<br>METADATA ON TABLE and SELECT ON COLUMN for each projected column and each predicate column |
| Scan (no projected columns, equivalent to COUNT(*)) | SELECT ON TABLE, or<br>SELECT ON COLUMN for each column in the table  |
| Scan (with virtual columns)                         | SELECT ON TABLE, or<br>SELECT ON COLUMN for each column in the table  |
| Scan (in ORDERED mode)                              | <privileges required for a Scan> and SELECT ON COLUMN for each primary key column                                 |
| Insert  | INSERT ON TABLE   |
| Update  | UPDATE ON TABLE   |
| Upsert  | INSERT ON TABLE and UPDATE ON TABLE   |
| Delete  | DELETE ON TABLE   |
| SplitKeyRange                                       | SELECT ON COLUMN for each primary key column and SELECT ON COLUMN for each projected column                       |
| Checksum  | User must be configured in --superuser_acl  |
| ListTablets   | User must be configured in --superuser_acl  |



**Note:** Unlike Impala, Kudu only supports all-or-nothing access to a table's schema, rather than showing only authorized columns.

## Ranger policies for Kudu

There are two Kudu related Ranger policies which are applied based on how you are accessing Kudu.

There are two resource-based services in Ranger that are used in relation to Kudu: cm\_kudu and Hadoop SQL.

The Kudu service and its connected clients, such as Spark, native C++, and Java clients, use the cm\_kudu resource-based service.

The Hadoop SQL resource-based service is used by Hive and Impala when Kudu is accessed through them.

When Kudu is accessed by Impala, the Impala service performs actions as the impala user in Kudu. The impala user is set as a trusted user in Kudu, meaning that privilege checks are completely bypassed and the impala user is granted full access. As a result, the cm\_kudu resource-based service is not applied, only the Hadoop SQL resource-based service is used to check for permission and privileges.

As a result, when you are accessing Kudu through Hive or Impala, you must ensure that all applicable permission and privileges are configured in the Hadoop SQL resource-based service.



**Note:** Ranger provides a client side cache that uses privileges and can periodically poll the privilege store for any changes. When a change is detected, the cache is automatically updated.

## Disabling redaction

Data redaction is used to prevent sensitive data from being included in Kudu server logs or in the web UI. Data redaction is enabled by default but you can disable it using the `--redact` or the `--webserver_enabled` flag.

### Log redaction

To prevent sensitive data from being included in Kudu server logs, all row data is redacted. You can turn off log redaction using the `--redact` flag.

### Web UI redaction

To prevent sensitive data from being included in the web UI, all row data is redacted. Table metadata, such as table names, column names, and partitioning information is not redacted. Alternatively, you can choose to completely disable the web UI by setting the `--webserver_enabled` flag to false on the Kudu servers.



**Note:** Disabling the web UI will also disable REST endpoints such as `/metrics`. Monitoring systems rely on these endpoints to gather metrics data.

### Procedure

1. In Cloudera Manager, navigate to **Kudu Configuration**.
2. Find the Kudu Service Advanced Configuration Snippet (Safety Valve) for `gflagfile` property.
3. If you want to disable log redaction, add the following configuration:

```
--redact=false
```

4. If you want to Web UI disable redaction, add the following configuration:

```
--webserver_enabled=false
```

5. Click **Save Changes**.
6. Restart the Kudu service.

## Configuring a secure Kudu cluster using Cloudera Manager

You can configure a secure Kudu cluster using Cloudera Manager. For that you need enabled Kerberos authentication and RPC encryption, configure coarse-grained authorization, and configure HTTPS encryption. Optionally you can configure custom Kerberos principal, TLS/SSL encryption or fine-grained authorization using Ranger.

### Enabling Kerberos authentication and RPC encryption

You must already have a secure Cloudera Manager cluster with Kerberos authentication enabled.

### Procedure

1. In Cloudera Manager, navigate to **Kudu Configuration**.
2. In the Search field, type Kerberos to show the relevant properties.

- Find and edit the following properties according to your cluster configuration:

| Field                                       | Usage Notes  |
|---|--|
| Kerberos Principal                          | Set to the default principal, kudu. Currently, Kudu does not support configuring a custom service principal for Kudu processes.  |
| Enable Secure Authentication And Encryption | <p>Select this checkbox to enable authentication and RPC encryption between all Kudu clients and servers, as well as between individual servers. Only enable this property after you have configured Kerberos.</p> <p>If this is not selected, security is not enforced but secured clients are not rejected either and the connection will be encrypted if both sides support it.</p> |

- Click Save Changes.  
An error message displayed that tells you the Kudu keytab is missing.
- Navigate to Administration Security .
- Select the Kerberos Credentials tab.  
  
On this page you will see a list of the existing Kerberos principals for services running on the cluster.
- Click Generate Missing Credentials  
Once the Generate Missing Credentials command has finished running, you will see the Kudu principal added to the list.

## Configuring custom Kerberos principal for Kudu

You can configure a custom Kerberos principal for Kudu using Cloudera Manager.

### About this task



**Important:** Cloudera Manager configures CDP services to use the default Kerberos principal names. Cloudera recommends that you do not change the default Kerberos principal names. If it is unavoidable to do so, contact Cloudera Professional Services because it requires extensive additional custom configuration.

### Procedure

- In Cloudera Manager, navigate to Kudu Configuration .
- Search for kerberos.
- Find the Kerberos principal property and set it to the required name.
- Click Save changes.  
Custom Kerberos principal for Kudu is applied for not just the Kudu server but also for the Hive and Impala clients.
- For components that are not controlled by Cloudera Manager, configure the SASL protocol name.  
You must add the SASL protocol name configuration wherever the Kudu client properties, such as master addresses, are configured.  
  
For example, if the principal name is kudu/\_HOST set the protocol to kudu.

## Configuring coarse-grained authorization with ACLs

The coarse-grained authorization can be configured with the following two ACLs: the Superuser Access Control List and the User Access Control List. The Superuser ACL is the list of all the superusers that can access the cluster. User-level access can be controlled by using the User ACL. By default, all the users can access the clusters. But when you enable authentication using Kerberos, only the users who are able to authenticate successfully can access the cluster.

### Procedure

- Go to the Kudu service.

- Click the Configuration tab.
- Select Category Security .
- In the Search field, type ACL to show the relevant properties.
- Edit the following properties according to your cluster configuration:

| Field                         | Usage Notes  |
|-------------------------------|--|
| Superuser Access Control List | <p>Add a comma-separated list of superusers who can access the cluster. By default, this property is left blank.</p> <p>'*' indicates that all authenticated users will be given superuser access.</p>   |
| User Access Control List      | <p>Add a comma-separated list of users who can access the cluster. By default, this property is set to '*'.</p> <p>The default value of '*' allows all users access to the cluster. However, if authentication is enabled, this will restrict access to only those users who are able to successfully authenticate using Kerberos. Unauthenticated users on the same network as the Kudu servers will be unable to access the cluster.</p> <p>Add the impala user to this list to allow Impala to query data in Kudu. You might choose to add any other relevant usernames if you want to give access to Spark Streaming jobs.</p> |

- Click Save Changes.

## Configuring TLS/SSL encryption for Kudu using Cloudera Manager

TLS/SSL encryption is enabled between Kudu servers and clients by default. You can enable TLS/SSL encryption for Kudu web UIs or configure the encryption using Cloudera Manager.

### Procedure

- In Cloudera Manager, navigate to Kudu Configuration .
- In the Search field, type TLS/SSL to show the relevant properties.
- Edit the following properties according to your cluster configuration:

**Table 3: TLS/SSL Kudu properties**

| Property   | Description  |
|--|--|
| Master TLS/SSL Server Private Key File (PEM Format)        | Set to the path containing the Kudu master host's private key (Privacy Enhanced Mail (PEM)-format). This is used to enable TLS/SSL encryption (over HTTPS) for browser-based connections to the Kudu master web UI.  |
| Tablet Server TLS/SSL Server Private Key File (PEM Format) | Set to the path containing the Kudu tablet server host's private key (PEM-format). This is used to enable TLS/SSL encryption (over HTTPS) for browser-based connections to Kudu tablet server web UIs.   |
| Master TLS/SSL Server Certificate File (PEM Format)        | Set to the path containing the signed certificate (PEM-format) for the Kudu master host's private key (set in Master TLS/SSL Server Private Key File). The certificate file can be created by concatenating all the appropriate root and intermediate certificates required to verify trust.               |
| Tablet Server TLS/SSL Server Certificate File (PEM Format) | Set to the path containing the signed certificate (PEM-format) for the Kudu tablet server host's private key (set in Tablet Server TLS/SSL Server Private Key File). The certificate file can be created by concatenating all the appropriate root and intermediate certificates required to verify trust. |
| Enable TLS/SSL for Master Server                           | Enables HTTPS encryption on the Kudu master web UI.  |
| Enable TLS/SSL for Tablet Server                           | Enables HTTPS encryption on the Kudu tablet server web UIs.  |

| Property   | Description  |
|--|--|
| Enable Secure Authentication, Encryption, and Web UI | Enables Kerberos for Kudu servers, clients and web servers, and enables encryption for Kudu servers and clients. |

- Click Save Changes.

## Enabling Ranger authorization

You can configure fine-grained authorization using Apache Ranger. This topic provides the steps to enable Kudu's integration with Ranger from Cloudera Manager.

### Procedure

- From Cloudera Manager, go to Clusters Kudu Configurations .
- Select the Ranger Service with which Kudu should authorize requests.
- If Ranger high-availability is enabled for the cluster, add a Kudu service repository with the following configurations through the Ranger Admin web UI is required:

```
# This example setup configures the Kudu service user as a privileged user
# to be
# able to retrieve authorization policies stored in Ranger.

<property>
  <name>policy.download.auth.users</name>
  <value>kudu</value>
</property>
```

The name of the added Kudu service repository needs to match the one specified in `ranger.plugin.kudu.service.name` of the Ranger client `ranger-kudu-security.xml` configuration file.



**Note:** When a Kudu client opens a table, the Kudu Master will authorize all possible actions the user may want to perform on the given table (ALL, and if it's not allowed, then INSERT, SELECT, UPDATE, DELETE). This results in auditing these requests when a client opens a table, even if they'll never do any of these operations.

## Configuring HTTPS encryption

Lastly, you enable TLS/SSL encryption (over HTTPS) for browser-based connections to both the Kudu master and tablet server web UIs.

### Procedure

- Go to the Kudu service.
- Click the Configuration tab.
- Select Category Security .
- In the Search field, type TLS/SSL to show the relevant properties.
- Edit the following properties according to your cluster configuration:

| Field  | Usage Notes  |
|--|--|
| Master TLS/SSL Server Private Key File (PEM Format)        | Set to the path containing the Kudu master host's private key (PEM-format). This is used to enable TLS/SSL encryption (over HTTPS) for browser-based connections to the Kudu master web UI.            |
| Tablet Server TLS/SSL Server Private Key File (PEM Format) | Set to the path containing the Kudu tablet server host's private key (PEM-format). This is used to enable TLS/SSL encryption (over HTTPS) for browser-based connections to Kudu tablet server web UIs. |

| Field  | Usage Notes  |
|--|--|
| Master TLS/SSL Server Certificate File (PEM Format)        | Set to the path containing the signed certificate (PEM-format) for the Kudu master host's private key (set in Master TLS/SSL Server Private Key File). The certificate file can be created by concatenating all the appropriate root and intermediate certificates required to verify trust.               |
| Tablet Server TLS/SSL Server Certificate File (PEM Format) | Set to the path containing the signed certificate (PEM-format) for the Kudu tablet server host's private key (set in Tablet Server TLS/SSL Server Private Key File). The certificate file can be created by concatenating all the appropriate root and intermediate certificates required to verify trust. |
| Enable TLS/SSL for Master Server                           | Enables HTTPS encryption on the Kudu master web UI.  |
| Enable TLS/SSL for Tablet Server                           | Enables HTTPS encryption on the Kudu tablet server Web UIs.  |

6. Click Save Changes.