

Cloudera Runtime 7.2.11

## Accessing Apache HBase

Date published: 2020-02-29

Date modified: 2023-05-04

# CLOUDERA

<https://docs.cloudera.com/>

# Legal Notice

© Cloudera Inc. 2024. All rights reserved.

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

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

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

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

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

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

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

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

# Contents

|                                                                                |           |
|--------------------------------------------------------------------------------|-----------|
| <b>Use the HBase shell.....</b>                                                | <b>4</b>  |
| Virtual machine options for HBase Shell.....                                   | 4         |
| Script with HBase Shell.....                                                   | 4         |
| <b>Use the HBase command-line utilities.....</b>                               | <b>5</b>  |
| <b>Use the HBase APIs for Java.....</b>                                        | <b>11</b> |
| <b>Use the HBase REST server.....</b>                                          | <b>12</b> |
| Installing the REST Server using Cloudera Manager.....                         | 12        |
| Using the REST API.....                                                        | 12        |
| Using the REST proxy API.....                                                  | 18        |
| <b>Using the Apache Thrift Proxy API.....</b>                                  | <b>19</b> |
| Preparing a thrift server and client.....                                      | 19        |
| List of Thrift API and HBase configurations.....                               | 20        |
| Example for using THttpClient API in secure cluster.....                       | 21        |
| Example for using THttpClient API in unsecure cluster.....                     | 23        |
| Example for using TSaslClientTransport API in secure cluster without HTTP..... | 24        |
| <b>Using Apache HBase Hive integration.....</b>                                | <b>25</b> |
| Configure Hive to use with HBase.....                                          | 25        |
| Using HBase Hive integration.....                                              | 25        |
| <b>Using the HBase-Spark connector.....</b>                                    | <b>27</b> |
| Configure HBase-Spark connector using Cloudera Manager.....                    | 27        |
| Example: Using the HBase-Spark connector.....                                  | 30        |
| <b>Use the Hue HBase app.....</b>                                              | <b>34</b> |
| Configure the HBase thrift server role.....                                    | 34        |

## Use the HBase shell

You can use the HBase Shell from the command line interface to communicate with HBase. In CDP, you can create a namespace and manage it using the HBase shell. Namespaces contain collections of tables and permissions, replication settings, and resource isolation.

In CDP, you need to SSH into an HBase node before you can use the HBase Shell. For example, to SSH into an HBase node with the IP address 10.10.10.10, you must use the command:

```
ssh <username>@10.10.10.10
```



**Note:** You must use your IPA password for authentication.

After you have started HBase, you can access the database in an interactive way by using the HBase Shell, which is a command interpreter for HBase which is written in Ruby. Always run HBase administrative commands such as the HBase Shell, hbck, or bulk-load commands as the HBase user (typically hbase).

```
hbase shell
```

You can use the following commands to get started with the HBase shell:

- To get help and to see all available commands, use the help command.
- To get help on a specific command, use help "command". For example:

```
hbase> help "create"
```

- To remove an attribute from a table or column family or reset it to its default value, set its value to nil. For example, use the following command to remove the KEEP\_DELETED\_CELLS attribute from the f1 column of the users table:

```
hbase> alter 'users', { NAME => 'f1', KEEP_DELETED_CELLS => nil }
```

- To exit the HBase Shell, type quit.

## Virtual machine options for HBase Shell

You can set variables for the virtual machine running HBase Shell, by using the HBASE\_SHELL\_OPTS environment variable. This example sets several options in the virtual machine.

This example sets several options in the virtual machine.

```
$ HBASE_SHELL_OPTS="-verbose:gc -XX:+PrintGCApplicationStoppedTime -XX:+PrintGCDateStamps  
-XX:+PrintGCDetails -Xloggc:$HBASE_HOME/logs/gc-hbase.log" ./bin/hbase  
shell
```

## Script with HBase Shell

You can use HBase shell in your scripts. You can also write Ruby scripts for use with HBase Shell. Example Ruby scripts are included in the hbase-examples/src/main/ruby/ directory.

The non-interactive mode allows you to use HBase Shell in scripts, and allow the script to access the exit status of the HBase Shell commands. To invoke non-interactive mode, use the `-n` or `--non-interactive` switch. This small example script shows how to use HBase Shell in a Bash script.

```
#!/bin/bash
echo 'list' | hbase shell -n
status=$?
if [ $status -ne 0 ]; then
    echo "The command may have failed."
fi
```

Successful HBase Shell commands return an exit status of 0. However, an exit status other than 0 does not necessarily indicate a failure, but should be interpreted as unknown. For example, a command may succeed, but while waiting for the response, the client may lose connectivity. In that case, the client has no way to know the outcome of the command. In the case of a non-zero exit status, your script should check to be sure the command actually failed before taking further action.

You can use the `get_splits` command, which returns the split points for a given table:

```
hbase> get_splits 't2'
Total number of splits = 5

=> [ "", "10", "20", "30", "40" ]
```

## Use the HBase command-line utilities

Besides the HBase Shell, HBase includes several other command-line utilities, which are available in the `hbase/bin/` directory of each HBase host. This topic provides basic usage instructions for the most commonly used utilities.

### PerformanceEvaluation

The PerformanceEvaluation utility allows you to run several preconfigured tests on your cluster and reports its performance. To run the PerformanceEvaluation tool, use the `bin/hbase pecommand`.

```
$ hbase pe

Usage: java org.apache.hadoop.hbase.PerformanceEvaluation \
  <OPTIONS> [-D<property=value>]* <command> <nclients>

Options:
  nomapred          Run multiple clients using threads (rather than use mapred
  use)
  rows              Rows each client runs. Default: One million
  size              Total size in GiB. Mutually exclusive with --rows. Default:
  1.0.
  sampleRate       Execute test on a sample of total rows. Only supported by r
  andomRead.
                   Default: 1.0
  traceRate        Enable HTrace spans. Initiate tracing every N rows. Defaul
  t: 0
  table             Alternate table name. Default: 'TestTable'
  multiGet          If >0, when doing RandomRead, perform multiple gets instea
  of single
                   gets.
                   Default: 0
  compress          Compression type to use (GZ, LZ0, ...). Default: 'NONE'
  flushCommits     Used to determine if the test should flush the table. Defau
  lt: false
  writeToWAL       Set writeToWAL on puts. Default: True
```

```

autoFlush          Set autoFlush on htable. Default: False
oneCon            all the threads share the same connection. Default: False
presplit          Create presplit table. Recommended for accurate perf analy
sis (see         guide). Default: disabled
inmemory         Tries to keep the HFiles of the CF inmemory as far as possi
ble. Not        guaranteed that reads are always served from memory. Defa
ult: false
usetags          Writes tags along with KVs. Use with HFile V3. Default:
false
numoftags        Specify the no of tags that would be needed. This works o
nly if usetags  is true.
filterAll        Helps to filter out all the rows on the server side there
by not returnin anything back to the client. Helps to check the server si
de performance. Uses FilterAllFilter internally.
latency          Set to report operation latencies. Default: False
bloomFilter      Bloom filter type, one of [NONE, ROW, ROWCOL]
valueSize        Pass value size to use: Default: 1024
valueRandom      Set if we should vary value size between 0 and 'valueSiz
e'; set on read  for stats on size: Default: Not set.
valueZipf        Set if we should vary value size between 0 and 'valueSize'
in zipf form:    Default: Not set.
period          Report every 'period' rows: Default: opts.perClientRunRo
ws / 10
multiGet        Batch gets together into groups of N. Only supported by ran
domRead.        Default: disabled
addColumnns     Adds columns to scans/gets explicitly. Default: true
replicas        Enable region replica testing. Defaults: 1.
splitPolicy     Specify a custom RegionSplitPolicy for the table.
randomSleep     Do a random sleep before each get between 0 and entered v
alue. Defaults: 0
columns         Columns to write per row. Default: 1
caching         Scan caching to use. Default: 30

Note: -D properties will be applied to the conf used.
For example:
-Dmapreduce.output.fileoutputformat.compress=true
-Dmapreduce.task.timeout=60000
Command:
append          Append on each row; clients overlap on keyspace so some c
oncurrent      operations
checkAndDelete CheckAndDelete on each row; clients overlap on keyspace so
some concurrent operations
checkAndMutate  CheckAndMutate on each row; clients overlap on keyspace so
some concurrent operations
checkAndPut     CheckAndPut on each row; clients overlap on keyspace so s
ome concurrent operations
filterScan     Run scan test using a filter to find a specific row based
on it's value  (make sure to use --rows=20)
increment      Increment on each row; clients overlap on keyspace so some
concurrent     operations

```

```

randomRead      Run random read test
randomSeekScan Run random seek and scan 100 test
randomWrite     Run random write test
scan            Run scan test (read every row)
scanRange10    Run random seek scan with both start and stop row (max 10
rows)
scanRange100   Run random seek scan with both start and stop row (max 100
rows)
scanRange1000  Run random seek scan with both start and stop row (max 1000
rows)
scanRange10000 Run random seek scan with both start and stop row (max 1
0000 rows)
sequentialRead Run sequential read test
sequentialWrite Run sequential write test
Args:
nclients       Integer. Required. Total number of clients (and HRegionS
ervers)
               running: 1 <= value <= 500
Examples:
To run a single client doing the default 1M sequentialWrites:
$ bin/hbase org.apache.hadoop.hbase.PerformanceEvaluation sequentialWrite 1
To run 10 clients doing increments over ten rows:
$ bin/hbase org.apache.hadoop.hbase.PerformanceEvaluation --rows=10 --noma
pred increment 10

```

## LoadTestTool

The LoadTestTool utility load-tests your cluster by performing writes, updates, or reads on it. To run the LoadTest Tool, use the `bin/hbase ltt` command. To print general usage information, use the `-h` option.

```

$ bin/hbase ltt -h

Options:
-batchupdate           Whether to use batch as opposed to separate
updates for every column in a row
-bloom <arg>          Bloom filter type, one of [NONE, ROW, ROWC
OL]
-compression <arg>    Compression type, one of [LZO, GZ, NONE, SN
APPY, LZ4]
-data_block_encoding <arg> Encoding algorithm (e.g. prefix compress
ion) to use for data blocks in the test column family, one of
[NONE, PREFIX, DIFF, FAST_DIFF, PREFIX_T
REE].
-deferredlogflush     Enable deferred log flush.
-encryption <arg>    Enables transparent encryption on the test
table, one of [AES]
-families <arg>      The name of the column families to use se
parated by comma
-generator <arg>     The class which generates load for the too
l. Any args for this class can be passed as colon separated after c
lass name
-h, --help            Show usage
-in_memory            Tries to keep the HFiles of the CF inmemory
as far as possible. Not guaranteed that reads are always served fro
m inmemory
-init_only           Initialize the test table only, don't do
any loading

```

```

-key_window <arg>           The 'key window' to maintain between reads
and writes for concurrent write/read workload. The default is 0.

-max_read_errors <arg>     The maximum number of read errors to tol
erate before terminating all reader threads. The default is 10.

-mob_threshold <arg>      Desired cell size to exceed in bytes that
will use the MOB write path

-multiget_batchsize <arg> Whether to use multi-gets as opposed to sep
arate gets for every column in a row

-multiput                  Whether to use multi-puts as opposed to s
eparate puts for every column in a row

-num_keys <arg>           The number of keys to read/write
-num_regions_per_server <arg> Desired number of regions per region serv
er. Defaults to 5.
-num_tables <arg>        A positive integer number. When a number n
is specified, load test tool will load n table parallely. -tn parameter
value becomes table name prefix. Each table name is in format <tn>_1...<tn>
_n

-read <arg>              <verify_percent>[:<#threads=20>]
-reader <arg>            The class for executing the read requests
-region_replica_id <arg> Region replica id to do the reads from
-region_replication <arg> Desired number of replicas per region
-regions_per_server <arg> A positive integer number. When a number n
is specified, load test tool will create the test table with n regions p
er server

-skip_init                Skip the initialization; assume test table
already exists

-start_key <arg>         The first key to read/write (a 0-based ind
ex). The default value is 0.

-tn <arg>                The name of the table to read or write
-update <arg>           <update_percent>[:<#threads=20>][:<#whether
to ignore nonce collisions=0>]

-updater <arg>          The class for executing the update requests
-write <arg>            <avg_cols_per_key>:<avg_data_size>[:<#thr
eads=20>]

-writer <arg>           The class for executing the write requests
-zk <arg>               ZK quorum as comma-separated host names w
ithout port numbers

-zk_root <arg>          name of parent znode in zookeeper

```

## wal

The wal utility prints information about the contents of a specified WAL file. To get a list of all WAL files, use the HDFS command `hadoop fs -ls -R /hbase/WALs`. To run the wal utility, use the `bin/hbase wal` command. Run it without options to get usage information.

```

hbase wal
usage: WAL <filename...> [-h] [-j] [-p] [-r <arg>] [-s <arg>] [-w <arg>]
-h,--help                Output help message
-j,--json                 Output JSON
-p,--printvals            Print values
-r,--region <arg>       Region to filter by. Pass encoded region name; e.g.
'9192caead6a5a20acb4454ffbc79fa14'
-s,--sequence <arg>     Sequence to filter by. Pass sequence number.
-w,--row <arg>          Row to filter by. Pass row name.

```



## hfile

The hfile utility prints diagnostic information about a specified hfile, such as block headers or statistics. To get a list of all hfiles, use the HDFS command `hadoop fs -ls -R /hbase/data`. To run the hfile utility, use the `bin/hbase hfilecommand`. Run it without options to get usage information.

```
$ hbase hfile

usage: HFile [-a] [-b] [-e] [-f <arg> | -r <arg>] [-h] [-i] [-k] [-m] [-p]
          [-s] [-v] [-w <arg>]
-a,--checkfamily      Enable family check
-b,--printblocks      Print block index meta data
-e,--printkey         Print keys
-f,--file <arg>      File to scan. Pass full-path; e.g.
                    hdfs://a:9000/hbase/hbase:meta/12/34
-h,--printblockheaders Print block headers for each block.
-i,--checkMobIntegrity Print all cells whose mob files are missing
-k,--checkrow         Enable row order check; looks for out-of-order
                    keys
-m,--printmeta        Print meta data of file
-p,--printkv          Print key/value pairs
-r,--region <arg>    Region to scan. Pass region name; e.g.
                    'hbase:meta,,1'
-s,--stats            Print statistics
-v,--verbose          Verbose output; emits file and meta data
                    delimiters
-w,--seekToRow <arg> Seek to this row and print all the kvs for this
                    row only
```

## hbck

The hbck utility checks and optionally repairs errors in HFiles.



**Warning:** Running hbck with any of the `-fix` or `-repair` commands is dangerous and can lead to data loss. Contact Cloudera support before running it.

To run hbck, use the `bin/hbase hbck` command. Run it with the `-h` option to get more usage information.

```
-----
NOTE: As of HBase version 2.0, the hbck tool is significantly changed.
In general, all Read-Only options are supported and can be used
safely. Most -fix/ -repair options are NOT supported. Please see usage
below for details on which options are not supported.
-----
```

```
Usage: fsck [opts] {only tables}
where [opts] are:
  -help Display help options (this)
  -details Display full report of all regions.
  -timelag <timeInSeconds> Process only regions that have not experienced
any metadata updates in the last <timeInSeconds> seconds.
  -sleepBeforeRerun <timeInSeconds> Sleep this many seconds before checking
if the fix worked if run with -fix
  -summary Print only summary of the tables and status.
  -metaonly Only check the state of the hbase:meta table.
  -sidelineDir <hdfs://> HDFS path to backup existing meta.
  -boundaries Verify that regions boundaries are the same between META and
store files.
  -exclusive Abort if another hbck is exclusive or fixing.
```

```
Datafile Repair options: (expert features, use with caution!)
```

```

-checkCorruptHFiles      Check all Hfiles by opening them to make sure the
y are valid
-sidelineCorruptHFiles  Quarantine corrupted HFiles.  implies -checkCorru
ptHFiles

Replication options
-fixReplication         Deletes replication queues for removed peers

Metadata Repair options supported as of version 2.0: (expert features, use
with caution!)
-fixVersionFile        Try to fix missing hbase.version file in hdfs.
-fixReferenceFiles     Try to offline lingering reference store files
-fixHFileLinks         Try to offline lingering HFileLinks
-noHdfsChecking        Don't load/check region info from HDFS. Assumes hbas
e:meta region info is good. Won't check/fix any HDFS issue, e.g. hole, orpha
n, or overlap
-ignorePreCheckPermission ignore filesystem permission pre-check

NOTE: Following options are NOT supported as of HBase version 2.0+.
UNSUPPORTED Metadata Repair options: (expert features, use with caution!)
-fix                    Try to fix region assignments. This is for backwards
compatibility
-fixAssignments        Try to fix region assignments. Replaces the old -fix
-fixMeta               Try to fix meta problems. This assumes HDFS region inf
o is good.
-fixHdfsHoles          Try to fix region holes in hdfs.
-fixHdfsOrphans        Try to fix region dirs with no .regioninfo file in hdfs
-fixTableOrphans       Try to fix table dirs with no .tableinfo file in hdfs
(online mode only)
-fixHdfsOverlaps       Try to fix region overlaps in hdfs.
-maxMerge <n>          When fixing region overlaps, allow at most <n> regions
to merge. (n=5 by default)
-sidelineBigOverlaps   When fixing region overlaps, allow to sideline big
overlaps
-maxOverlapsToSideline <n> When fixing region overlaps, allow at most <
n> regions to sideline per group. (n=2 by default)
-fixSplitParents       Try to force offline split parents to be online.
-removeParents         Try to offline and sideline lingering parents and keep
daughter regions.
-fixEmptyMetaCells     Try to fix hbase:meta entries not referencing any
region (empty REGIONINFO_QUALIFIER rows)

UNSUPPORTED Metadata Repair shortcuts
-repair                Shortcut for -fixAssignments -fixMeta -fixHdfsHoles -
fixHdfsOrphans -fixHdfsOverlaps -fixVersionFile -sidelineBigOverlaps -fixRef
erenceFiles -fixHFileLinks
-repairHoles           Shortcut for -fixAssignments -fixMeta -fixHdfsHoles

```

## clean

After you have finished using a test or proof-of-concept cluster, the `hbase clean` utility can remove all HBase-related data from ZooKeeper and HDFS.



**Warning:** The `hbase clean` command destroys data. Do not run it on production clusters, or unless you are absolutely sure you want to destroy the data.

To run the `hbase clean` utility, use the `bin/hbase clean` command. Run it with no options for usage information.

```

$ bin/hbase clean

Usage: hbase clean (--cleanZk|--cleanHdfs|--cleanAll)
Options:

```

```
--cleanZk    cleans hbase related data from zookeeper.  
--cleanHdfs  cleans hbase related data from hdfs.  
--cleanAll   cleans hbase related data from both zookeeper and hdfs.
```

## Use the HBase APIs for Java

You can use the Apache HBase Java API to communicate with Apache HBase. The Java API is one of the most common ways to communicate with HBase.

The following sample uses Apache HBase APIs to create a table and put a row into that table. The table name, column family name, qualifier (or column) name, and a unique ID for the row are defined. Together, these define a specific cell. Next, the table is created and the text “Hello, World!” is inserted into this cell.

```
import java.io.IOException;  
import org.apache.hadoop.conf.Configuration;  
import org.apache.hadoop.hbase.HBaseConfiguration;  
import org.apache.hadoop.hbase.TableName;  
import org.apache.hadoop.hbase.client.*;  
import org.apache.hadoop.hbase.util.Bytes;  
  
public class CreateAndPut {  
    private static final TableName TABLE_NAME = TableName.valueOf("test_table_example");  
    private static final byte[] CF_NAME = Bytes.toBytes("test_cf");  
    private static final byte[] QUALIFIER = Bytes.toBytes("test_column");  
    private static final byte[] ROW_ID = Bytes.toBytes("row01");  
    public static void createTable(final Admin admin) throws IOException {  
        if(!admin.tableExists(TABLE_NAME)) {  
            TableDescriptor desc = TableDescriptorBuilder.newBuilder(TABLE_NAME)  
                .setColumnFamily(ColumnFamilyDescriptorBuilder.of(CF_NAME))  
                .build();  
            admin.createTable(desc);  
        }  
    }  
  
    public static void putRow(final Table table) throws IOException {  
        table.put(new Put(ROW_ID).addColumn(CF_NAME, QUALIFIER, Bytes.toBytes("Hello, World!")));  
    }  
    public static void main(String[] args) throws IOException {  
        Configuration config = HBaseConfiguration.create();  
  
        try (Connection connection = ConnectionFactory.createConnection(config); Admin admin = connection.getAdmin()) {  
            createTable(admin);  
  
            try(Table table = connection.getTable(TABLE_NAME)) {  
                putRow(table);  
            }  
        }  
    }  
}
```

### Related Information

[HBase API reference documentation](#)

## Use the HBase REST server

You can use the Apache HBase REST server to interact with the Apache HBase. This is a very good alternative if you do not want to use the Java API. Interactions happen using URLs and the REST API. REST uses HTTP to perform various actions, and this makes it easy to interface with the operational database using a wide array of programming languages.

You can use the REST server to create, delete tables, and perform other operations that have the REST end-points. You can configure SSL for encryption between the client and the REST server. This helps you to ensure that your operations are secure during data transmission.

Using the REST server enables you access your data across different network boundaries. For example, if you have an CDP operational database Data Hub cluster running inside a private network and don't want to expose it to your company's public network, the REST server can work as a gateway between the private and public networks.

## Installing the REST Server using Cloudera Manager

You can use the HBase REST API to interact with HBase services, tables, and regions using HTTP endpoints. You must manually install the REST Server only in a CDP Private Cloud Base deployment. The REST Server service is automatically added to the Data Hub cluster in a CDP Public Cloud deployment.

### About this task

Install the REST Server using Cloudera Manager in your CDP Private Cloud Base deployment.

### Procedure

1. Click the Clusters tab.
2. Select Clusters *HBase*.
3. Click the Instances tab.
4. Click Add Role Instance.
5. Under HBase REST Server, click Select Hosts.
6. Select one or more hosts to serve the HBase Rest Server role. Click Continue.
7. Select the HBase Rest Server roles. Click Actions For Selected Start.

## Using the REST API

The HBase REST Server exposes endpoints that provide CRUD (create, read, update, delete) operations for each HBase process, as well as tables, regions, and namespaces.

### Background

For a given endpoint, the HTTP verb controls the following type of operations (create, read, update, or delete).

**Note:** curl Command Examples

The examples in these tables use the curl command, and follow these guidelines:

- The HTTP verb is specified using the `-X` parameter.
- For GET queries, the Accept header is set to `text/xml`, which indicates that the client (curl) expects to receive responses formatted in XML. You can set it to `application/json` to receive JSON responses instead.
- For PUT, POST, and DELETE queries, the Content-Type header should be set only if data is also being sent with the `-d` parameter. If set, it should match the format of the data being sent, to enable the REST server to deserialize the data correctly.
- If you are using a Data Hub cluster, you must provide the basic authentication parameters in your REST query string to access the REST server end-point. For example, `curl -vi -X GET \`  
`-H "Accept: text/xml" -u "<USER>:<MY_WORKLOAD_PASSWORD>" \`

For more details about the curl command, see the documentation for the curl version that ships with your operating system.

In CDP, all REST queries are routed through the Apache Knox gateway. In your REST query, ensure that the hostname points to the gateway node and `cdp-proxy-api` endpoint as shown in these examples.

**Table 1: Cluster-Wide Endpoints**

| Endpoint         | HTTP Verb | Description                              | Example                                                                                                                                                                         |
|------------------|-----------|------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| /version/cluster | GET       | Version of HBase running on this cluster | <pre>curl -L -v \ -u "&lt;MY_WORKLOAD_USERNAME:MY_WORKLOAD_PASSWORD&gt;" \ "https://&lt;gateway_node&gt;/cdp-proxy-api/hbase/version/cluster"</pre>                             |
| /status/cluster  | GET       | Cluster status                           | <pre>curl -vi -X GET \ -H "Accept: text/xml" \ -u "&lt;MY_WORKLOAD_USERNAME:MY_WORKLOAD_PASSWORD&gt;" \ "https://&lt;gateway_node&gt;/cdp-proxy-api/hbase/status/cluster"</pre> |
| /                | GET       | List of all nonsystem tables             | <pre>curl -vi -X GET \ -H "Accept: text/xml" \ -u "&lt;MY_WORKLOAD_USERNAME:MY_WORKLOAD_PASSWORD&gt;" \ "https://&lt;gateway_node&gt;/cdp-proxy-api/hbase"</pre>                |

**Table 2: Namespace Endpoints**

| Endpoint                         | HTTP Verb      | Description                                                 | Example                                                                                                                                                                                       |
|----------------------------------|----------------|-------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| /namespaces                      | GET            | List all namespaces.                                        | <pre>curl -vi -X GET \ -H "Accept: text/xml" \ -u "&lt;MY_WORKLOAD_USERNAME:MY_WORKLOAD_PASSWORD&gt;" \ "https://&lt;gateway_node&gt;/cdp-proxy-api/hbase/namespaces/"</pre>                  |
| /namespaces/namespace            | GET            | Describe a specific namespace.                              | <pre>curl -vi -X GET \ -H "Accept: text/xml" \ -u "&lt;MY_WORKLOAD_USERNAME:MY_WORKLOAD_PASSWORD&gt;" \ "https://&lt;gateway_node&gt;/cdp-proxy-api/hbase/namespaces/special_ns"</pre>        |
| /namespaces/namespace            | POST           | Create a new namespace.                                     | <pre>curl -vi -X POST \ -H "Accept: text/xml" \ -u "&lt;MY_WORKLOAD_USERNAME:MY_WORKLOAD_PASSWORD&gt;" \ "https://&lt;gateway_node&gt;/cdp-proxy-api/hbase/namespaces/special_ns"</pre>       |
| /namespaces/namespace/tables     | GET            | List all tables in a specific namespace.                    | <pre>curl -vi -X GET \ -H "Accept: text/xml" \ -u "&lt;MY_WORKLOAD_USERNAME:MY_WORKLOAD_PASSWORD&gt;" \ "https://&lt;gateway_node&gt;/cdp-proxy-api/hbase/namespaces/special_ns/tables"</pre> |
| <del>/namespaces/namespace</del> | <del>PUT</del> | <del>Alter an existing namespace. Currently not used.</del> | <pre>curl -vi -X PUT \ -H "Accept: text/xml" \</pre>                                                                                                                                          |

**Table 3: Table Endpoints**

| Endpoint      | HTTP Verb | Description                                                                         | Example                                                                                                                                                                                                                                                                                                                                                                       |
|---------------|-----------|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| /table/schema | GET       | Describe the schema of the specified table.                                         | <pre>curl -vi -X GET \ -H "Accept: text/xml" \ -u "&lt;MY_WORKLOAD_USERNAME:MY_WORKLOAD_PASSWORD&gt;" \ "https://&lt;gateway_node&gt;/cdp-proxy-api/hbase/users/schema"</pre>                                                                                                                                                                                                 |
| /table/schema | POST      | Create a new table, or replace an existing table's schema with the provided schema. | <pre>curl -vi -X POST \ -H "Accept: text/xml" \ -H "Content-Type: text/xml" \ -d '&lt;?xml version="1.0" encoding="UTF-8"?&gt;&lt;TableSchema name="users"&gt;&lt;ColumnSchema name="cf" /&gt;&lt;/TableSchema&gt;' \ -u "&lt;MY_WORKLOAD_USERNAME:MY_WORKLOAD_PASSWORD&gt;" \ "https://&lt;gateway_node&gt;/cdp-proxy-api/hbase/users/schema"</pre>                          |
| /table/schema | UPDATE    | Update an existing table with the provided schema fragment.                         | <pre>curl -vi -X PUT \ -H "Accept: text/xml" \ -H "Content-Type: text/xml" \ -d '&lt;?xml version="1.0" encoding="UTF-8"?&gt;&lt;TableSchema name="users"&gt;&lt;ColumnSchema name="cf" KEEP_DELETED_CELLS="true" /&gt;&lt;/TableSchema&gt;' \ -u "&lt;MY_WORKLOAD_USERNAME:MY_WORKLOAD_PASSWORD&gt;" \ "https://&lt;gateway_node&gt;/cdp-proxy-api/hbase/users/schema"</pre> |
|               |           | <b>15</b>                                                                           |                                                                                                                                                                                                                                                                                                                                                                               |
| /table/schema | DELETE    | Delete the table. You must use the table/schema endpoint, not just table/           | <pre>curl -vi -X DELETE \</pre>                                                                                                                                                                                                                                                                                                                                               |

**Table 4: Endpoints for Get Operations**

| Endpoint                                          | HTTP Verb | Description                                                                                                                                                                  | Example                                                                                                                                                                                              |
|---------------------------------------------------|-----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| /table/row                                        | GET       | Get all columns of a single row. Values are Base-64 encoded. This requires the Accept request header with a type that can hold multiple columns (like xml, json or protobuf) | <pre>curl -vi -X GET \   -H "Accept: text/xml" \   -u "&lt;MY_WORKLOAD_USERNAME:MY_WORKLOAD_PASSWORD&gt;" \   "https://&lt;gateway_node&gt;/cdp-proxy-api/hbase/users/row1"</pre>                    |
| /table/row/column:qualifier/timestamp             | GET       | Get the value of a single row. Values are Base-64 encoded.                                                                                                                   | <pre>curl -vi -X GET \   -H "Accept: text/xml" \   -u "&lt;MY_WORKLOAD_USERNAME:MY_WORKLOAD_PASSWORD&gt;" \   "https://&lt;gateway_node&gt;/cdp-proxy-api/hbase/users/row1/cf:a/1458586888395"</pre> |
| /table/row/column:qualifier                       | GET       | Get the value of a single column. Values are Base-64 encoded.                                                                                                                | <pre>curl -vi -X GET \   -H "Accept: text/xml" \   -u "&lt;MY_WORKLOAD_USERNAME:MY_WORKLOAD_PASSWORD&gt;" \   "https://&lt;gateway_node&gt;/cdp-proxy-api/hbase/users/row1/cf:a"</pre>               |
| /table/row/column:qualifier/?v=number_of_versions |           | Multi-Get a specified number of versions of a given cell. Values are Base-64 encoded.                                                                                        | <pre>curl -vi -X GET \   -H "Accept: text/xml" \   -u "&lt;MY_WORKLOAD_USERNAME:MY_WORKLOAD_PASSWORD&gt;" \   "https://&lt;gateway_node&gt;/cdp-proxy-api/hbase/users/row1/cf:a/?v=2"</pre>          |



Table 5: Endpoints for Scan Operations

| Endpoint                  | HTTP Verb | Description                                                                                                                                                                                                                                                                                                                                                                                                                          | Example                                                                                                                                                                                                                                         |
|---------------------------|-----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| /table/scanner/           | PUT       | Get a Scanner object. Required by all other Scan operations. Adjust the batch parameter to the number of rows the scan should return in a batch. See the next example for adding filters to your Scanner. The scanner endpoint URL is returned as the Location in the HTTP response. The other examples in this table assume that the Scanner endpoint is <code>http://example.com:20550/users/scanner/14586907282437552207</code> . | <pre>curl -vi -X PUT \ -H "Accept: text/xml" \ -H "Content-Type: text/xml" \ -d '&lt;Scanner batch="1"/&gt;' \ -u "&lt;MY_WORKLOAD_USERNAME:MY_WORKLOAD_PASSWORD&gt;" \ "https://&lt;gateway_node&gt;/cdp-proxy-api/hbase/users/scanner/"</pre> |
| /table/scanner/           | PUT       | To supply filters to the Scanner object or configure the Scanner in any other way, you can create a text file and add your filter to the file. For example, to return only rows for which keys start with <code>u123</code> and use a batch size of 100: <pre>&lt;Scanner batch="100"&gt;   &lt;filter&gt;     {       "type":         "PrefixFilter",       "value":         "u123"     }   &lt;/filter&gt; &lt;/Scanner&gt;</pre>  | <pre>curl -vi -X PUT \ -H "Accept: text/xml" \ -H "Content-Type: text/xml" \ -d @filter.txt \ -u "&lt;MY_WORKLOAD_USERNAME:MY_WORKLOAD_PASSWORD&gt;" \ "https://&lt;gateway_node&gt;/cdp-proxy-api/hbase/users/scanner/"</pre>                  |
| /table/scanner/scanner_id | GET       | Get the next batch from the scanner. Cell values are byte-encoded. If the scanner is exhausted, HTTP status 204 is returned.                                                                                                                                                                                                                                                                                                         | <pre>curl -vi -X GET \ -H "Accept: text/xml" \ -u "&lt;MY_WORKLOAD_USERNAME:MY_WORKLOAD_PASSWORD&gt;" \ "https://&lt;gateway_node&gt;/cdp-proxy-api/hbase/users/scanner/14586907282437552207"</pre>                                             |
| /table/scanner/scanner_id | DELETE    | Deletes the scanner and frees the resources it was using.                                                                                                                                                                                                                                                                                                                                                                            | <pre>curl -vi -X DELETE \ -H "Accept: text/xml" \ -u "&lt;MY_WORKLOAD_USERNAME:MY_WORKLOAD_PASSWORD&gt;" \</pre>                                                                                                                                |

**Table 6: Endpoints for Put Operations**

| Endpoint        | HTTP Verb | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Example                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|-----------------|-----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| /table/row_key/ | PUT       | Write a row to a table. The row, column qualifier, and value must each be Base-64 encoded. To encode a string, you can use the base64 command-line utility. To decode the string, use base 64 -d. The payload is in the --data argument, so the /users/fakerow value is a placeholder. Insert multiple rows by adding them to the <CellSet> element. You can also save the data to be inserted to a file and pass it to the -d parameter with the syntax -d @filename.txt. | <p>XML:</p> <pre>curl -vi -X PUT \ -H "Accept: text/xml" \ -H "Content-Type: text/xml" \ -d '&lt;?xml version="1.0" encoding="UTF-8" standalone="yes"?&gt;&lt;CellSet&gt;&lt;Row key="cm93NQo="&gt;&lt;Cell column="Y2Y6ZQo="&gt;dmFsdWU1Cg==&lt;/Cell&gt;&lt;/Row&gt;&lt;/CellSet&gt;' \ -u "&lt;MY_WORKLOAD_USERNAME:MY_WORKLOAD_PASSWORD&gt;" \ "https://&lt;gateway_node&gt;/cdp-proxy-api/hbase/users/fakerow"</pre> <p>JSON:</p> <pre>curl -vi -X PUT \ -H "Accept: application/json" \ -H "Content-Type: application/json" \ -d '{"Row":[{"key":"cm93NQo=", "Cell":[{"column":"Y2Y6ZQo=", "\$":"dmFsdWU1Cg==" }]}]}' \</pre> |

## Using the REST proxy API

After configuring and starting HBase on your cluster, you can use the HBase REST Proxy API to stream data into HBase, from within another application or shell script, or by using an HTTP client such as wget or curl.

The REST Proxy API is slower than the Java API and may have fewer features. This approach is simple and does not require advanced development experience to implement. However, like the Java and Thrift Proxy APIs, it uses the full write path and can cause compactions and region splits.

Specified addresses without existing data create new values. Specified addresses with existing data create new versions, overwriting an existing version if the row, column:qualifier, and timestamp all match that of the existing value.

```
curl -H "Content-Type: text/xml" http://localhost:8000/test/testrow/test:tes
tcolumn
```

The REST Proxy API does not support writing to HBase clusters that are secured using Kerberos.

For full documentation and more examples, see the [REST Proxy API documentation](#).

## Using the Apache Thrift Proxy API

The Apache Thrift library provides cross-language client-server remote procedure calls (RPCs), using Thrift bindings.

A *Thrift binding* that uses the Apache Thrift Proxy API, is a client code generated by the Apache Thrift compiler for a target language (such as Python) that allows communication between the Thrift server and clients using that client code. HBase includes an Apache Thrift Proxy API, which allows you to write HBase applications in Python, C, C++, or another language that Thrift supports. The Thrift Proxy API is slower than the Java API and may have fewer features. To use the Thrift Proxy API, you need to configure and run the HBase Thrift server on your cluster. You also need to install the [Apache Thrift compiler](#) on your development system.

## Preparing a thrift server and client

Learn how to prepare a Thrift server and client before using a Thrift Proxy API.

### Before you begin

Ensure that the thrift server is configured and running.

### Procedure

1. Generate *Thrift bindings* for the language of your choice, using an HBase IDL file, named HBase.thrift that is included as part of HBase.
2. Copy the Thrift libraries for your language into the same directory as the generated bindings.
3. Verify that the Thrift compiler version is newer than 0.9.0 by running the `thrift -version` command. You need to find the Hbase.thrift file from the HBase node or copy it to co-locate with the Thrift compiler. In the following Python example, these libraries provide the `thrift.transport` and `thrift.protocol` libraries. These commands show how you might generate the *Thrift bindings* for Python and copy the libraries on a Linux system.

```
mkdir HBaseThrift
cd HBaseThrift/
thrift -gen py /path/to/Hbase.thrift
mv gen-py/* .
rm -rf gen-py/
mkdir thrift
cp -rp ~/Downloads/thrift/lib/py/src/* ./thrift/
```

### Results

As a result, the HBase thrift Python bindings appears as follows:

```
HbaseThrift/
|-- hbased
|   |-- constants.py
|   |-- Hbase.py
```

```

|-- Hbase-remote
|-- __init__.py
|-- ttypes.py
|-- __init__.py
|-- thrift
|-- compat.py
|-- ext
|-- binary.cpp
|-- binary.h
|-- compact.cpp
|-- compact.h
|-- endian.h
|-- module.cpp
|-- protocol.h
|-- protocol.tcc
|-- types.cpp
|-- types.h
|-- __init__.py
|-- protocol
|-- __init__.py
|-- TBase.py
|-- TBinaryProtocol.py
|-- TCompactProtocol.py
|-- THeaderProtocol.py
|-- TJSONProtocol.py
|-- TMultiplexedProtocol.py
|-- TProtocolDecorator.py
|-- TProtocol.py
|-- server
|-- __init__.py
|-- THttpServer.py
|-- TNonblockingServer.py
|-- TProcessPoolServer.py
|-- TServer.py
|-- Thrift.py
|-- TMultiplexedProcessor.py
|-- transport
|-- __init__.py
|-- sslcompat.py
|-- THeaderTransport.py
|-- THttpClient.py
|-- TSocket.py
|-- TSSLSocket.py
|-- TTransport.py
|-- TTwisted.py
|-- TZlibTransport.py
|-- TRecursive.py
|-- TCons.py
|-- TSerialization.py
|-- TTornado.py

```

### What to do next

## List of Thrift API and HBase configurations

References for the right classes and functions along with the right configurations for HBase.

### Classes and functions

#### Transport level

TBufferedTransport, TFrameTransport, TSaslTransport, and THttpClient

**Protocol level**

TBinaryProtocol and TCompactProtocol

**HBase Thrift configurations**

HBase thrift configurations

| Property                          | Default value (secured) | Default value (unsecured) | Description                                                                                                                                                                        |
|-----------------------------------|-------------------------|---------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| hbase.thrift.support.proxyuser    | true                    | true                      | Use this to allow proxy users on the thrift gateway, which is mainly needed for doAs functionality.                                                                                |
| hbase.regionserver.thrift.framed  | true                    | true                      | Use framed transport. When using the THttpServer or TNonblockingServer, framed transport is always used irrespective of this configuration value.                                  |
| hbase.regionserver.thrift.compact | true                    | true                      | Use the TCompactProtocol instead of the default TBinaryProtocol. TCompactProtocol is a binary protocol that is more compact than the default and typically more efficient.         |
| hbase.regionserver.thrift.http    | true                    | true                      | Use this to enable HTTP server usage on thrift, which is mainly needed for doAs functionality.                                                                                     |
| hbase.thrift.security.qop         | auth_conf               | none                      | If this is set, HBase Thrift Server authenticates its clients. HBase Proxy User Hosts and Groups must be configured to allow specific users to access HBase through Thrift Server. |
| hbase.thrift.ssl.enabled          | true                    | false                     | Encrypt communication between clients and HBase Thrift Server over HTTP using Transport Layer Security (TLS) (formerly known as Secure Socket Layer (SSL)).                        |

**Related Information**[Example for using THttpClient API in secure cluster](#)[Example for using THttpClient API in unsecure cluster](#)[Example for using TSaslClientTransport API in secure cluster without HTTP](#)**Example for using THttpClient API in secure cluster**

Refer to this example of using the THttpClient API in secure cluster.

**THttpClient API in secure cluster**Let us consider that the cluster is secured with the configuration properties mentioned in the *HBase thrift configurations* table under the *Default value (secured)* column.

Before proceeding, ensure that the following applications are installed on your system.

- python 3.6.8 and python 3-devel
- pip 21.3.1
- virtualenv 20.17.1

Perform the following steps:

1. Install virtualenv using pip3.

```
pip3 install virtualenv
```

2. Create a new virtual environment named *py3env*.

```
virtualenv py3env
```

3. Activate the virtual environment.

```
source py3env/bin/activate
```

4. Install the required Python packages and their specific versions. Consider you are inside the python3 virtual environment.

```
pip3 install kerberos==1.3.1 pure-sasl==0.6.2 setuptools==59.6.0 six==1.16.0 wheel==0.37.1
```

This ensures that you have all the necessary dependencies and packages installed to proceed with your project.

```
from thrift.transport import THttpClient
from thrift.protocol import TBinaryProtocol
from hbase.Hbase import Client
from subprocess import call
import ssl
import kerberos
import os

# Get the env parameters
def get_env_params():
    # Replace with your own parameters
    hostname='your_hbase_thrift_hostname'
    cert_file="your_cert_file"
    key_file="your_key_file"
    ca_file="your_ca_file"
    key_pw='your_key_pw'
    keytab_file='your_keytab'
    principal = 'your_principal'
    return hostname,cert_file,key_file,ca_file,keytab_file,principal,key_pw

#Check if a valid Kerberos ticket is already present in the cache
def check_kerberos_ticket():
    ccache_file = os.getenv('KRB5CCNAME')
    if ccache_file:
        ccache = CCache.load_ccache(ccache_file)
        if ccache.get_principal() and not ccache.get_principal().is_anonymous():
            return True
    return False

# Obtain a Kerberos ticket by running kinit from keytab
def kinit(keytab_file,principal):
    call(['kinit', '-kt', keytab_file, principal])

# Authenticate with Kerberos
def kerberos_auth():
    __, krb_context = kerberos.authGSSClientInit("HTTP")
    kerberos.authGSSClientStep(krb_context, "")
    negotiate_details = kerberos.authGSSClientResponse(krb_context)
    headers = {'Authorization': 'Negotiate ' + negotiate_details, 'Content-Type': 'application/binary'}
    return headers
```

```

# Initialize an SSL context with certificate verification enabled
def get_ssl_context():
    ssl_context = ssl.create_default_context()
    ssl_context.load_cert_chain(certfile=cert_file,keyfile=key_file,password=key_pw)
    ssl_context.load_verify_locations(cafile=ca_file)
    return ssl_context
if __name__ == '__main__':
    hostname,cert_file,key_file,ca_file,keytab_file,principal,key_pw=get_env_params()
    # Check if a valid Kerberos ticket is not in the cache, then kinit.
    if not check_kerberos_ticket():
        kinit(keytab_file,principal)

# create a THttpClient instance with the SSL context and custom headers
httpClient = THttpClient.THttpClient('https://' + hostname + ':9090/', ssl_context=get_ssl_context())
httpClient.setCustomHeaders(headers=kerberos_auth())

# Initialize TBinaryProtocol with THttpClient
protocol = TBinaryProtocol.TBinaryProtocol(httpClient)

# Create HBase client
client = Client(protocol)
# Retrieve list of HBase tables
tables = client.getTableNames()
print(tables)
# Close connection
httpClient.close()

```

### Related Information

[List of Thrift API and HBase configurations](#)

## Example for using THttpClient API in unsecure cluster

Refer to this example of using the THttpClient API in unsecure cluster.

### THttpClient API in unsecure cluster

Let us consider that the cluster is unsecured with the configuration properties mentioned in the *HBase thrift configurations* table under the *Default value (unsecured)* column.

```

from thrift.transport import THttpClient
from thrift.protocol import TBinaryProtocol
from hbase.Hbase import Client
# Replace with your own parameters
hostname = 'your_hbase_thrift_server_hostname'

# Initialize THttpClient
httpClient = THttpClient.THttpClient('http://' + hostname + ':9090/')

# Initialize TBinaryProtocol with THttpClient
protocol = TBinaryProtocol.TBinaryProtocol(httpClient)

# Create HBase client
client = Client(protocol)

# Retrieve list of HBase tables
tables = client.getTableNames()
print(tables)

```

```
# Close connection
httpClient.close()
```

### Related Information

[List of Thrift API and HBase configurations](#)

## Example for using TSaslClientTransport API in secure cluster without HTTP

Refer to this example of using the TSaslClientTransport API in secure cluster without HTTP.

### TSaslClientTransport API in secure cluster without HTTP

If you do not use THttpClient and want to use TSaslClientTransport for legacy compatibility reasons, ensure that you set `hbase.regionserver.thrift.http` property to false. The other settings could be same as the configuration properties mentioned in the *HBase thrift configurations* table under the *Default value (secured)* column.

```
from thrift.transport import TSocket
from thrift.transport import TTransport
from thrift.protocol import TBinaryProtocol
from thrift.protocol import TCompactProtocol
from hbase import Hbase

'''
Assume you already kinit the hbase principal, or you can use the function
in example-1 to kinit.
'''
# Replace with your own parameters
thrift_host = 'your_hbase_thrift_server_hostname'
thrift_port = 9090

# Initialize TSocket and TTransport
socket = TSocket.TSocket(thrift_host, thrift_port)
transport=TTransport.TSaslClientTransport(socket,host=thrift_host,service='
hbase',mechanism='GSSAPI')

# Initialize TCompactProtocol with TTransport
protocol = TCompactProtocol.TCompactProtocol(transport)

# Create HBase client
client = Hbase.Client(protocol)

# Open connection and retrieve list of HBase tables
transport.open()
tables = client.getTableNames()
print(tables)

# Close connection
transport.close()
```

Cloudera recommends you to use the HTTP options (Example-1 and Example-2). You can consider the Example-3 for legacy compatibility issues where some old applications might not rewrite the codes. This is because Hue is using HTTP mode to interact with HBase thrift, and if you disable the HTTP mode, Hue might not work properly with HBase.



### Known bugs while using TSaslClientTransport with Kerberos enabled CDP versions

Upstream JIRA [HBASE-21652](#), where a bug is introduced related to Kerberos principal handling. The affected versions are CDP 7.1.6 and earlier. The versions containing the fix are 7.1.7, 7.2.11, and later.

### Related Information

[List of Thrift API and HBase configurations](#)

## Using Apache HBase Hive integration

You can use the HBase Hive integration to create HBase tables and modify Apache HBase tables from Apache Hive.

HBase Hive integration enables you to READ and WRITE to existing HBase tables. Before you can access your data stored in HBase using Hive, ensure that you have completed the configuration that enables Apache Hive to interact with Apache HBase.

## Configure Hive to use with HBase

To use Hive with HBase, you must add the HBase service as a dependency to the Hive service in Cloudera Manager.

### About this task

The following steps are applicable when both HBase and Hive are in the same cluster.

### Procedure

1. Go to Cloudera Manager.
2. Go to the Hive service.
3. Click the Configuration tab.
4. Select the intended HBase service. For example, HBASE-1 as dependency under HBase Service.
5. Click Save Changes.  
Repeat steps 2 to 5 for the HBase on Tez service.
6. Restart the Hive service.  
Restart the Hive on Tez service, when applicable.

## Using HBase Hive integration

After you have configured HBase Hive integration, you can create an HBase table from Hive, and access that table from HBase.

### About this task

### Procedure

1. From the Hive shell, create an HBase table:

```
CREATE EXTERNAL TABLE hbase_hive_table (key int, value string)
STORED BY 'org.apache.hadoop.hive.hbase.HBaseStorageHandler'
WITH SERDEPROPERTIES ("hbase.columns.mapping" = ":key,cf1:val")
```

```
TBLPROPERTIES ("hbase.table.name" = "hbase_hive_table", "hbase.mapred.o
utput.outputtable" = "hbase_hive_table");
```

The `hbase.columns.mapping` property is mandatory. The `hbase.table.name` property is optional. The `hbase.mapred.output.outputtable` property is optional; it is needed, if you plan to insert data to the table.

- From the HBase shell, access the `hbase_hive_table`:

```
$ hbase shell
hbase(main):001:0> list 'hbase_hive_table'

 1 row(s) in 0.0530 seconds
hbase(main):002:0> describe 'hbase_hive_table'
Table hbase_hive_table is ENABLED
hbase_hive_table COLUMN FAMILIES DESCRIPTION{NAME => 'cf', DATA_BLOCK_ENCO
DING => 'NONE', BLOOMFILTER => 'ROW', REPLICATION_SCOPE => '0', VERSIONS
=> '1', COMPRESSION => 'NONE', MIN_VERSIONS => '0', TTL => 'FOREVER', K
EEP_DELETED_CELLS => 'FALSE', BLOCKSIZE => '65536', IN_MEMORY => 'false',
BLOCKCACHE => 'true'} 1 row(s) in 0.2860 seconds

hbase(main):003:0> scan 'hbase_hive_table'
ROW          COLUMN+CELL

0 row(s) in 0.0060 seconds
```

- Insert the data into the HBase table through Hive:

```
INSERT OVERWRITE TABLE HBASE_HIVE_TABLE values (98, 'val_98');
```

- From the HBase shell, verify that the data got loaded:

```
hbase(main):009:0> scan "hbase_hive_table"
ROW          COLUMN+CELL

 98          column=cf1:val, timestamp=1267737987733, valu
e=val_98
1 row(s) in 0.0110 seconds
```

- From Hive, query the HBase data to view the data that is inserted in the `hbase_hive_table`:


```
hive> select * from HBASE_HIVE_TABLE;
Total MapReduce jobs = 1
Launching Job 1 out of 1
...
OK
98 val_98
Time taken: 4.582 seconds
```

### Example

Use the following steps to access the existing HBase table through Hive.

- You can access the existing HBase table through Hive using the `CREATE EXTERNAL TABLE`:

```
CREATE EXTERNAL TABLE hbase_table_2(key int, value string)
STORED BY 'org.apache.hadoop.hive.hbase.HBaseStorageHandler' WITH SERDEP
ROPERTIES
("hbase.columns.mapping" = ":key,cf1:val")
TBLPROPERTIES("hbase.table.name" = "some_existing_table",
"hbase.mapred.output.outputtable" = "some_existing_table");
```

- You can use different type of column mapping to map the HBase columns to Hive:
    - Multiple Columns and Families To define four columns, the first being the rowkey: “:key,cf:a,cf:b,cf:c”
    - Hive MAP to HBase Column Family When the Hive data type is a Map, a column family with no qualifier might be used. This will use the keys of the Map as the column qualifier in HBase: “cf:”
    - Hive MAP to HBase Column Prefix When the Hive data type is a Map, a prefix for the column qualifier can be provided which will be prepended to the Map keys: “cf:prefix\_.\*”
-  **Note:** The prefix is removed from the column qualifier as compared to the key in the Hive Map. For example, for the above column mapping, a column of “cf:prefix\_a” would result in a key in the Map of “a”.
- You can also define composite row keys. Composite row keys use multiple Hive columns to generate the HBase row key.
    - Simple Composite Row Keys. A Hive column with a datatype of Struct will automatically concatenate all elements in the struct with the termination character specified in the DDL.
    - Complex Composite Row Keys and HBaseKeyFactory Custom logic can be implemented by writing Java code to implement a KeyFactory and provide it to the DDL using the table property key “hbase.composite.key.factory”.

## Using the HBase-Spark connector

You can use HBase-Spark connector on your secure cluster to perform READ and WRITE operations. The HBase-Spark Connector bridges the gap between the simple HBase Key Value store and complex relational SQL queries and enables users to perform complex data analytics on top of HBase using Spark.

An HBase DataFrame is a standard Spark DataFrame, and is able to interact with any other data sources such as Hive, ORC, Parquet, JSON, etc.

## Configure HBase-Spark connector using Cloudera Manager

The HBase-Spark Connector bridges the gap between the simple HBase Key Value store and complex relational SQL queries. It enables users to perform complex data analytics on top of HBase using Spark.

### Before you begin

If an application needs to interact with other secure Hadoop filesystems, their URIs need to be explicitly provided to Spark at launch time.

- Spark 2 configuration property: `spark.yarn.access.hadoopFileSystems`

A comma-separated list of secure Hadoop filesystems your Spark application is going to access. For example:

```
spark.yarn.access.hadoopFileSystems=hdfs://nn1.com:8032,hdfs://nn2.com:8032,abfs://test1@example1.dfs.core.windows.net,abfs://test2@example2.dfs.core.windows.net
```

For more information see *Spark 2 documentation*.

- Spark 3 configuration property: `spark.kerberos.access.hadoopFileSystems`

A comma-separated list of secure Hadoop filesystems your Spark application is going to access. For example:

```
spark.kerberos.access.hadoopFileSystems=hdfs://nn1.com:8032,hdfs://nn2.com:8032,abfs://test1@example1.dfs.core.windows.net,abfs://test2@example2.dfs.core.windows.net
```

For more information see *Spark 3 documentation*.

## Procedure

1. Go to the Spark or Spark3 service.
2. Click the Configuration tab.
3. Ensure that the HBase service is selected in Spark Service as a dependency.
4. Select Scope Gateway .
5. Select Category Advanced .
6. Locate the spark-defaults.conf.
  - Spark2: Locate the Spark Client Advanced Configuration Snippet (Safety Valve) for spark-conf/spark-defaults.conf property or search for it by typing its name in the Search box.
  - Spark3: Locate the Spark 3 Client Advanced Configuration Snippet (Safety Valve) for spark3-conf/spark-defaults.conf property or search for it by typing its name in the Search box.
7. Add the required properties to ensure that all required Phoenix and HBase platform dependencies are available on the classpath for the Spark executors and drivers.
  - a) Upload all necessary jar files to the distributed filesystem, for example HDFS (it can be GS, ABFS, or S3A). If the CDH version is different on the remote HBase cluster, run the `hbase mapredcp` command on the HBase cluster and copy them to `/path/hbase_jars_common` location so that the Spark applications can use them.

- Spark3 related files:

```
hdfs dfs -mkdir /path/hbase_jars_spark3
```

- Spark2 related files:

```
hdfs dfs -mkdir /path/hbase_jars_spark2
```

- Common files for both Spark2 and Spark3:

```
hdfs dfs -mkdir /path/hbase_jars_common
hdfs dfs -put `hbase mapredcp | tr : " "` /path/hbase_jars_common
```

- b) Download the `/etc/hbase/conf/hbase-site.xml` from the remote HBase cluster. Create the `hbase-site.xml.jar` file. The `hbase-site.xml` is added to the classpath with the `spark.jars` parameter because it is part of the jar file's root path.

```
jar cf hbase-site.xml.jar hbase-site.xml
hdfs dfs -put hbase-site.xml.jar /path/hbase_jars_common
```

- c) Upload the Spark3 related files:

```
hdfs dfs -put /opt/cloudera/parcels/CDH/lib/hbase_connectors_for_spark3/
lib/hbase-spark3.jar /path/hbase_jars_spark3
hdfs dfs -put /opt/cloudera/parcels/CDH/lib/hbase_connectors_for_spark3/
lib/hbase-spark3-protocol-shaded.jar /path/hbase_jars_spark3
```

- d) Upload the Spark2 related files:

```
hdfs dfs -put /opt/cloudera/parcels/CDH/lib/hbase_connectors/lib/hbase-s
park.jar /path/hbase_jars_spark2
hdfs dfs -put /opt/cloudera/parcels/CDH/lib/hbase_connectors/lib/hbase-
spark-protocol-shaded.jar /path/hbase_jars_spark2
hdfs dfs -put /opt/cloudera/parcels/CDH/lib/hbase_connectors/lib/scala-
library.jar /path/hbase_jars_spark2
```

e) Add all the Spark version related files and the hbase mapredcp files to the spark.jars parameter:

- Spark2:

```
spark.jars=hdfs:///path/hbase_jars_common/hbase-site.xml.jar,hdfs:///path/hbase_jars_spark2/hbase-spark-protocol-shaded.jar,hdfs:///path/hbase_jars_spark2/hbase-spark.jar,hdfs:///path/hbase_jars_spark2/scala-library.jar,/path/hbase_jars_common(other common files)...
```

- Spark3:

```
spark.jars=hdfs:///path/hbase_jars_common/hbase-site.xml.jar,hdfs:///path/hbase_jars_spark3/hbase-spark3.jar,hdfs:///path/hbase_jars_spark3/hbase-spark3-protocol-shaded.jar,/path/hbase_jars_common(other common files)...
```

8. Enter a Reason for change, and then click Save Changes to commit the changes.

9. Restart the role and service when Cloudera Manager prompts you to restart.

### Perform the following steps while using HBase RegionServer:

Edit the HBase RegionServer configuration for running Spark Filter. Spark Filter is used when Spark SQL Where clauses are in use.

- In Cloudera Manager, select the HBase service.
- Click the Configuration tab.
- Search for regionserver environment.
- Find the RegionServer Environment Advanced Configuration Snippet (Safety Valve).
- Click the plus icon to add the following property:

Key: HBASE\_CLASSPATH

Value:

```
/opt/cloudera/parcels/CDH/lib/hbase_connectors/lib/hbase-spark-***VERSION NUMBER***-198.jar:/opt/cloudera/parcels/CDH/lib/hbase_connectors/lib/hbase-spark-protocol-shaded-***VERSION NUMBER***-198.jar:/opt/cloudera/parcels/CDH/jars/scala-library-2.11.12.jar
```

- Ensure that the listed jars have the correct version number in their name.
- Click Save Changes.
- Restart the Region Server.

### What to do next

Build a Spark or Spark3 application using the dependencies that you provide when you run your application. If you follow the previous instructions, Cloudera Manager automatically configures the connector for Spark. If you have not:

- Consider the following example while using a Spark2 application:

```
spark-shell --conf spark.jars=hdfs:///path/hbase_jars_common/hbase-site.xml.jar,hdfs:///path/hbase_jars_spark2/hbase-spark-protocol-shaded.jar,hdfs:///path/hbase_jars_spark2/hbase-spark.jar,hdfs:///path/hbase_jars_spark2/scala-library.jar,hdfs:///path/hbase_jars_common/hbase-shaded-mapreduce-***VERSION NUMBER***.jar,hdfs:///path/hbase_jars_common/opentelemetry-api-***VERSION NUMBER***.jar,hdfs:///path/hbase_jars_common/opentelemetry-context-***VERSION NUMBER***.jar
```

- Consider the following example while using a Spark3 application:

```
spark3-shell --conf spark.jars=hdfs:///path/hbase_jars_common/hbase-site.xml.jar,hdfs:///path/hbase_jars_spark3/hbase-spark3-protocol-shaded.jar,hdfs:///path/hbase_jars_spark3/hbase-spark3.jar,hdfs:///path/hbase_jars
```

```
_common/hbase-shaded-mapreduce-***VERSION NUMBER***.jar,hdfs:///path/hbase_jars_common/opentelemetry-api-***VERSION NUMBER***.jar,hdfs:///path/hbase_jars_common/opentelemetry-context-***VERSION NUMBER***.jar
```

### Related Information

[Example: Using the HBase-Spark connector](#)

[Configure Phoenix-Spark connector using Cloudera Manager](#)

[Spark 2 documentation](#)

[Spark 3 documentation](#)

## Example: Using the HBase-Spark connector

Learn how to use the HBase-Spark connector by following an example scenario.



**Note:** If an application needs to interact with other secure Hadoop filesystems, their URIs need to be explicitly provided to Spark at launch time.

- Spark 2 configuration property: `spark.yarn.access.hadoopFileSystems`

A comma-separated list of secure Hadoop filesystems your Spark application is going to access. For example:

```
spark.yarn.access.hadoopFileSystems=hdfs://nn1.com:8032,hdfs://nn2.com:8032, abfs://test1@example1.dfs.core.windows.net,abfs://test2@example2.dfs.core.windows.net
```

For more information see *Spark 2 documentation*.

- Spark 3 configuration property: `spark.kerberos.access.hadoopFileSystems`

A comma-separated list of secure Hadoop filesystems your Spark application is going to access. For example:

```
spark.kerberos.access.hadoopFileSystems=hdfs://nn1.com:8032,hdfs://nn2.com:8032, abfs://test1@example1.dfs.core.windows.net,abfs://test2@example2.dfs.core.windows.net
```

For more information see *Spark 3 documentation*.

If you follow the instructions mentioned in *Configure HBase-Spark connector using Cloudera Manager* topic, Cloudera Manager automatically configures the connector for Spark. If you have not, add the following parameters to the command line while running `spark-submit`, `spark3-submit`, `spark-shell`, `spark3-shell`, `pyspark`, or `pyspark3` commands.

- Spark2:

```
--conf spark.jars=/path/to/hbase-site.xml.jar,/opt/cloudera/parcels/CDH/lib/hbase_connectors/lib/hbase-spark.jar,/opt/cloudera/parcels/CDH/lib/hbase_connectors/lib/hbase-spark-protocol-shaded.jar,/opt/cloudera/parcels/CDH/lib/hbase_connectors/lib/scala-library.jar,`hbase mapredcp | tr : ,`
```

- Spark3:

```
--conf spark.jars=/path/to/hbase-site.xml.jar,/opt/cloudera/parcels/SPARK3/lib/spark3/hbase_connectors/lib/hbase-spark3.jar,/opt/cloudera/parcels/SPARK3/lib/spark3/hbase_connectors/lib/hbase-spark3-protocol-shaded.jar,`hbase mapredcp | tr : ,`
```

You can use the following command to create the hbase-site.xml.jar file. The hbase-site.xml is added to the classpath with the spark.jars parameter because it is part of the jar file's root path.

```
jar cf hbase-site.xml.jar hbase-site.xml
```

## Schema

In this example we want to store personal data in an HBase table. We want to store name, email address, birth date and height as a floating point number. The contact information (email) is stored in the c column family and personal information (birth date, height) is stored in the p column family. The key in HBase table will be the name attribute.

|               | Spark           | HBase       |
|---------------|-----------------|-------------|
| Type/Table    | Person          | person      |
| Name          | name: String    | key         |
| Email address | email: String   | c:email     |
| Birth date    | birthDate: Date | p:birthDate |
| Height        | height: Float   | p:height    |

## Create HBase table

Use the following command to create the HBase table:

```
shell> create 'person', 'p', 'c'
```

## Insert data (Scala)

Use the following spark code in spark-shell or spark3-shell to insert data into our HBase table:

```
val sql = spark.sqlContext
import java.sql.Date

case class Person(name: String,
                  email: String,
                  birthDate: Date,
                  height: Float)
var personDS = Seq(
  Person("alice", "alice@alice.com", Date.valueOf("2000-01-01"), 4.5f),
  Person("bob", "bob@bob.com", Date.valueOf("2001-10-17"), 5.1f)
).toDS

personDS.write.format("org.apache.hadoop.hbase.spark")
  .option("hbase.columns.mapping",
    "name STRING :key, email STRING c:email, " +
    "birthDate DATE p:birthDate, height FLOAT p:height")
  .option("hbase.table", "person")
  .option("hbase.spark.use.hbasecontext", false)
  .save()
```

## Insert data (Python)

Use the following spark code in pyspark or pyspark3 to insert data into our HBase table:

```
from datetime import datetime
from pyspark.sql.types import StructType, StructField, StringType, DateType,
FloatType
```

```

data = [("alice","alice@alice.com", datetime.strptime("2000-01-01", '%Y-%m-%d'), 4.5),
        ("bob","bob@bob.com", datetime.strptime("2001-10-17", '%Y-%m-%d'), 5.1)
       ]

schema = StructType([ \
    StructField("name",StringType(),True), \
    StructField("email",StringType(),True), \
    StructField("birthDate", DateType(),True), \
    StructField("height", FloatType(), True)
])

personDS = spark.createDataFrame(data=data,schema=schema)

personDS.write.format("org.apache.hadoop.hbase.spark").option("hbase.columns.mapping", "name STRING :key, email STRING c:email, birthDate DATE p:birthDate, height FLOAT p:height").option("hbase.table", "person").option("hbase.spark.use.hbasecontext", False).save()

```

### Scan data

The previously inserted data can be tested with a simple scan:

```

shell> scan 'person'
ROW COLUMN+CELL
  alice column=c:email, timestamp=1568723598292, value=alice@alice.com
  alice column=p:birthDate, timestamp=1568723598292, value=\x00\x00\x00\xDC1
\x87 \x00
  alice column=p:height, timestamp=1568723598292, value=@\x90\x00\x00
  bob column=c:email, timestamp=1568723598521, value=bob@bob.com
  bob column=p:birthDate, timestamp=1568723598521, value=\x00\x00\x00\xE9\
x99u\x95\x80
  bob column=p:height, timestamp=1568723598521, value=@\xA333
2 row(s)

```

### Read data back (Scala)

Use the following snippet in spark-shell or spark3-shell to read the data back:

```

val sql = spark.sqlContext

val df = sql.read.format("org.apache.hadoop.hbase.spark")
  .option("hbase.columns.mapping",
    "name STRING :key, email STRING c:email, " +
    "birthDate DATE p:birthDate, height FLOAT p:height")
  .option("hbase.table", "person")
  .option("hbase.spark.use.hbasecontext", false)
  .load()
df.createOrReplaceTempView("personView")

val results = sql.sql("SELECT * FROM personView WHERE name = 'alice'")
results.show()

```

The result of this snippet is the following Data Frame:

```

+-----+-----+-----+-----+
| name|height|          email| birthDate|
+-----+-----+-----+-----+
|alice|   4.5|alice@alice.com|2000-01-01|
+-----+-----+-----+-----+

```



## Read data back (Python)

Use the following snippet in pyspark or pyspark3 to read the data back:

```
from pyspark.sql import SparkSession
spark = SparkSession.builder.appName("Test HBase Connector from Python").getOrCreate()
df = spark.read.format("org.apache.hadoop.hbase.spark").option("hbase.columns.mapping", "name STRING :key, email STRING c:email, birthDate DATE p:birthDate, height FLOAT p:height").option("hbase.table", "person").option("hbase.spark.use.hbasecontext", False).load()
df.createOrReplaceTempView("personView")
results = spark.sql("SELECT * FROM personView WHERE name = 'alice'")
results.show()
```

## Test spark-submit or spark3-submit

Use the following snippet to test spark-submit or spark3-submit commands in Spark cluster mode.

pyspark\_app.py:

```
from pyspark.sql import SparkSession
spark = SparkSession.builder.appName("Test HBase Connector from Python").getOrCreate()
df = spark.read.format("org.apache.hadoop.hbase.spark").option("hbase.columns.mapping", "name STRING :key, email STRING c:email, birthDate DATE p:birthDate, height FLOAT p:height").option("hbase.table", "person").option("hbase.spark.use.hbasecontext", False).load()
df.createOrReplaceTempView("personView")
results = spark.sql("SELECT * FROM personView WHERE name = 'alice'")
results.show()
spark.stop()
```

Test commands:

- Spark2:

```
spark-submit --deploy-mode cluster --conf spark.jars=/path/to/hbase-site.xml.jar,/opt/cloudera/parcels/CDH/lib/hbase_connectors/lib/hbase-spark.jar,/opt/cloudera/parcels/CDH/lib/hbase_connectors/lib/hbase-spark-protocol-shaded.jar,/opt/cloudera/parcels/CDH/lib/hbase_connectors/lib/scalalibrary.jar,`hbase mapredcp | tr : ,` pyspark_app.py
```

- Spark3:

```
spark3-submit --deploy-mode cluster --conf spark.jars=/path/to/hbase-site.xml.jar,/opt/cloudera/parcels/CDH/lib/hbase_connectors_for_spark3/lib/hbase-spark3.jar,/opt/cloudera/parcels/CDH/lib/hbase_connectors_for_spark3/lib/hbase-spark3-protocol-shaded.jar,`hbase mapredcp | tr : ,` pyspark_app.py
```

## Related Information

[Configure HBase-Spark connector using Cloudera Manager](#)

[Spark 2 documentation](#)

[Spark 3 documentation](#)

## Use the Hue HBase app

Hue is a web-based interactive query editor that enables you to interact with data warehouses. You can use the HBase Browser application in Hue to create and browse HBase tables.

The HBase Hue app enables you to insert a new row or bulk upload CSV files, TSV files, and type data into your table. You can also insert columns into your row. If you need more control or data about your cell, you can use the full editor to edit a cell.

The screenshot shows the Hue HBase app interface. At the top, there is a search bar and a user profile for 'admin'. The main area displays a table with the following data:

| cf1: val | cf1: purchase |
|----------|---------------|
| Krishna  | 12            |
| Eva      | 1000          |
| Anna     |               |

Below the table, it indicates 'Fetched 10 entries starting from null in 13.397 seconds.' At the bottom right, there are buttons for 'Drop Rows', 'Bulk Upload', and 'New Row'.

If you are using the HBase Thrift interface, Hue fits in between the Thrift Server and the HBase client, and the Thrift Server assumes that all HBase operations come from the hue user and not the client. To ensure that users in Hue are only allowed to perform HBase operations assigned to their own credentials, and not those of the hue user, you must enable doAs Impersonation for the HBase Browser Application.

### Related Information

[Hue](#)

## Configure the HBase thrift server role

You must configure the Thrift Server Role to access certain features such as the Hue HBase browser.

### About this task

The Thrift Server role is not added by default when you install HBase, but it is required before you can use certain other features such as the Hue HBase browser. To add the Thrift Server role:

### Procedure

1. Go to the HBase service.
2. Click the Instances tab.

3. Click the Add Role Instances button.
4. Select the host(s) where you want to add the Thrift Server role (you only need one for Hue) and click Continue. The Thrift Server role should appear in the instances list for the HBase server.
5. Select the Thrift Server role instance.
6. Select Actions for Selected > Start.