



## Denodo HBase Custom Wrapper

Revision 20160719

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# 1 INTRODUCTION

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The hbase-customwrapper is a Virtual DataPort custom wrapper that enables VDP to perform read operations on an HBase database.

HBase is a column-oriented **NoSQL** database management system that runs on top of Hadoop infrastructure, that allows you to store and process large amounts of data on multiple machines.

As usually happens in the NoSQL database world, HBase does not support SQL queries, therefore it is necessary to use a binary client API to access to the database system.

**NOTE:** *The scope of this wrapper is limited because it depends on the specific version and configuration of the HBase server you are accessing. Besides, there are direct dependencies between the binary files of the server and the client. For this reason, it is likely that it will be necessary to perform minor code-level modifications to the wrapper in order to make it compatible with specific HBase installations: version of the API client libraries, configuration entries at the `hbase-site.xml` file, etc.*

*Also note that this wrapper contains the HBase client libraries themselves (a requirement of HBase), so in order to guarantee the wrapper will work, the machine on which VDP runs must meet all the HBase client libraries configuration requirements (network reachability, DNS configuration, etc.). Said in other words: this wrapper should work OK if a standalone java application using the HBase client libraries works OK, in the same machine.*

## 2 FEATURES

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### 2.1 JAVA ARTIFACT ORGANIZATION

This wrapper uses the HBase Java client API, which in turn has a dependency on the `hadoop common`, `zookeeper`, and `thrift` libraries. These binary dependencies have two undesirable, but unavoidable effects:

- Increase the size of the binary artifacts deployed into Virtual DataPort.
- Un-generalize the custom wrapper, by binding it (and its distribution) to specific Hadoop/HBase software versions.

### 2.2 ARCHITECTURE

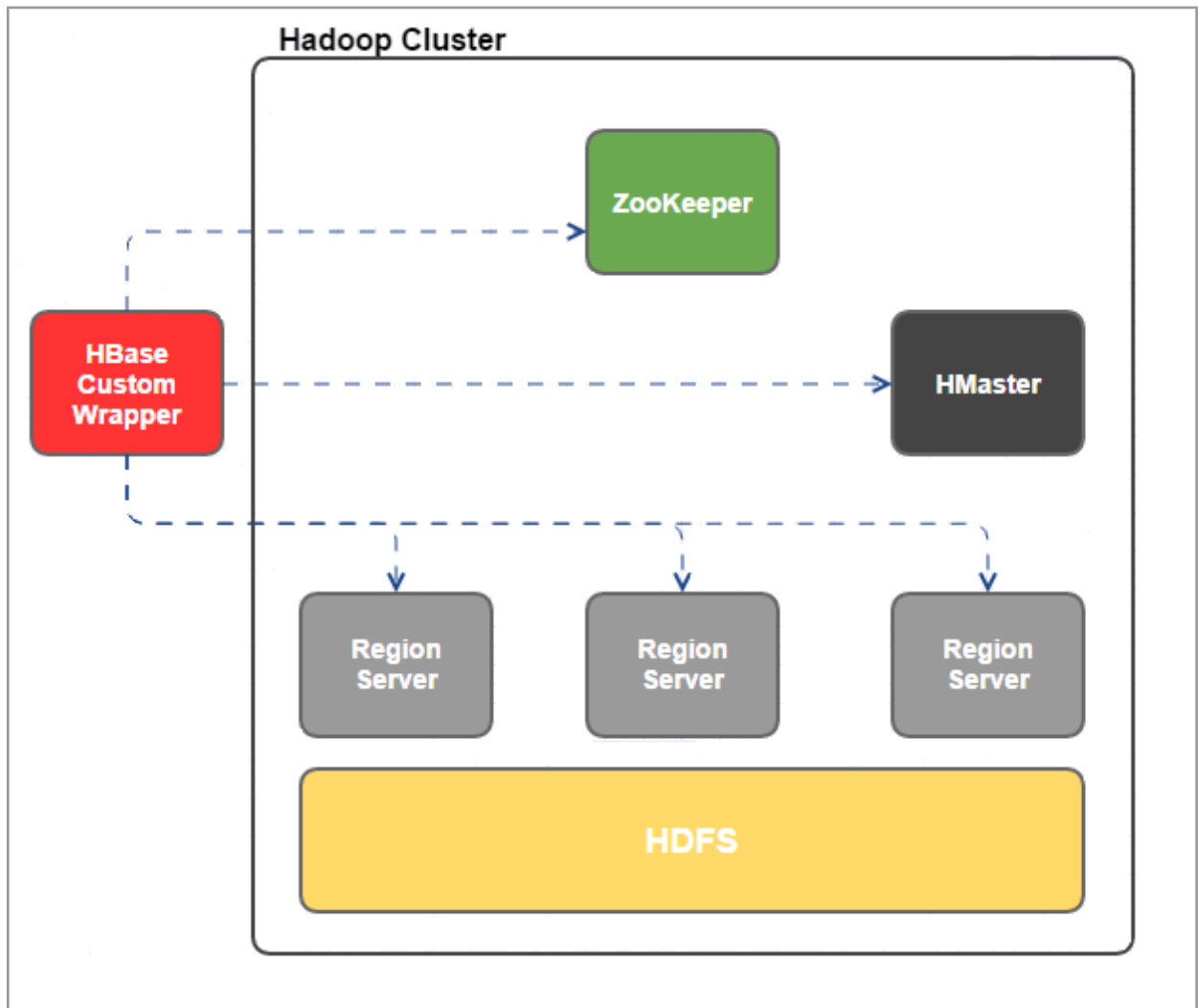
The HBase architecture has two main components:

- One **HMaster** node/process that is responsible for coordinating the cluster and executing administrative operations like region allocation and failover, log splitting, and load balancing.
- One or several **HRegionServers** that are responsible for handling a subset of the table's data and I/O requests to the hosting regions, flushing the in-memory data store (MemStore) to HDFS, and splitting and compacting regions.

The wrapper accesses the HBase cluster through the Java API. The ZooKeeper cluster acts as a coordination service for the entire HBase cluster, handling master selection, root region server lookup, node registration, configuration information, hierarchical naming space, and so on.

In terms of connectivity this wrapper needs to be able to access **HMaster** to check if HBase is running. And then it contacts to **ZooKeeper** to learn the location of two special catalog tables named `-ROOT-` and `.META.` within which HBase maintains the current list, state, and location of all regions on the cluster. Once the wrapper has been told where the specific data resides (i.e., in what region), it caches this information and directly access the **HRegionServer** hosting that region.

The next diagram provides a general overview of the system architecture and the interactions between the custom wrapper and HBase:



## 2.3 DATA MODEL

- **Tables** in HBase are made up of rows and columns.
- **Columns** are grouped into family columns. A column name is made of its column family name and a qualifier `familyName:columnName`.
- **Column families** regroup data of the same nature; they are stored together on the filesystem.
- **Rows** have one row key. They are lexicographically sorted with the lowest order appearing first in a table.

- **Cells** are identified by row, column and version. The cell contents are an uninterpreted array of bytes.
- **Versions** are cells that have the same column and table, every version has associated a timestamp, that it is a long (milliseconds). The HBase version dimension is stored in decreasing order, the latest value is found first. The number of versions that we can fetch when a cell is retrieved is configurable. HBase, by default, returns the latest version.

You can read more about the data model in the next link:

<http://hbase.apache.org/book/datamodel.html>.

## 2.4 CAPABILITIES

This wrapper allows only read operations. It can delegate to HBase the following query artifacts and operators:

- Operators: =, <>, REGEXP\_LIKE, LIKE, IN, IS TRUE, IS FALSE, IS NULL, IS NOT NULL, CONTAINS\_AND, CONTAINS\_OR.
- AND operations.
- OR operations.
- StartRow and StopRow: HBase stores rows sorted lexicographically by comparing the key bytes arrays. We can perform a scan to effectively select the start row and the stop row. So, HBase can return all the rows that pass the filter without having to read the whole table. Start row is **inclusive** while stop row is **exclusive**.
- Data types: Text, Long, Integer, Float, Double, Boolean.
- Projection of row\_key column and column families but not individual columns.

Due to the delegation of the previous operators, the performance of the custom wrapper is better because many operations will be performed by HBase itself, instead of having to rely on VDP in-memory post-filtering.

## 2.5 LIMITATIONS

There are some limitations which should be taken into account when using this wrapper:

- Read-only. Update and delete operations could be developed in the future, but they are not available as of current versions.
- Row keys are uninterpreted bytes, so we have to be careful if we want to make VDP read data types different to the string one.

- The <, <=, >, >= operators cannot be delegated to HBase because its API-driven comparison operations are byte-only based, which makes it unsuitable for comparing numbers.
- The wrapper cannot make the most out of the possibilities of HBase because of the difference in paradigm between this column-oriented NoSQL system and the relational paradigm VDP implements.

## 3 USAGE

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In order to use the hbase-customwrapper, first it is necessary to add its jar file (the jar-with-dependencies version) into the VDPAdmin Tool in File → Extensions.

After this, a data source should be created in File → DataSource → Custom, selecting the pertinent jar, and writing a name for the data source. The custom wrapper is implemented by class `com.denodo.connect.hadoop.hbase.HBaseConnector`, and it will be shown when selecting the jar in the field `Class name` in this view.

The hbase-customwrapper includes the configuration file `hbase-site.xml`, with the default values commented out. When required we can change any of these parameter uncommenting that specific attribute and changing its value. For instance, when using the **Hortonworks Sandbox** it is necessary to **change the property** `zookeeper.znode.parent` from its value by default `/hbase` to `/hbase-secure` or to `/hbase-unsecure` when Kerberos is enabled.

### 3.1 CREATING BASE VIEWS

The base views created from the `HBaseConnector` need the following **mandatory** parameters:

- `hbaseIP`: Name of the HBase machine or its IP address. It can be a list of HBase IPs separated by commas.
- `tableName`: HBase table from which we want to extract the data.
- `tableMapping`: A fragment of JSON, giving information about the queried HBase data structure and defining the elements, the column families and columns, that will be projected into the base view.

Curly braces, `{` and `}`, must be escaped with a backslash: `\{` and `\}`.



For example:

```
\{
  'post': \{
    'title': 'text',
    'body': 'text'
  },
  'image': \{
    'bodyimage': 'text',
    'header': 'text',
    'active': 'boolean'
  }
}
```

where post and image are column families and the other sub-elements are columns.

There is also an special case that allows retrieving only the row\_key field of a data set, for performance reasons:

```
\{
  'row_key': 'text'
}
```

And two **optional** parameters:

- hbasePort: ZooKeeper port, default is 2181.
- cachingSize: the number of rows that a scanner will fetch at once. If cachingSize is not set, we will use the caching value of the HTable we want to access.  
Higher caching values will enable faster scanners but will use more memory.
- Hbase configuration file: Local route of hbase configuration file hbase-site.xml. It allows to add or override configuration resources like **the property value of** zookeeper.znode.parent.

## 3.2 EXAMPLE HBASE SHELL

In the next example we want to extract the rows of the table `blogposts` table which title value, in the post family, starts with 'Hello World'. So, in the HBase Shell we execute the next command:

```
hbase(main):001:0> scan 'blogposts', {FILTER =>
  "(SingleColumnValueFilter('post','title',=,'regexstring:Hello World'))"}

```

In the following image we can see the results of this query:

```
HBase Shell; enter 'help<RETURN>' for list of supported commands.
Type "exit<RETURN>" to leave the HBase Shell
Version 0.94.2.21, rUnknown, Thu Jan 10 03:45:56 PST 2013

hbase(main):001:0> scan 'blogposts', {FILTER => "(SingleColumnValueFilter('post','title',=,'regexstring:Hello World'))"}
ROW COLUMN+CELL
post1 column=image:active, timestamp=1368536115329, value=true
post1 column=image:bodyimage, timestamp=1368536102858, value=5
post1 column=image:header, timestamp=1368536090247, value=image1
.jpg
post1 column=post:author, timestamp=1368536076921, value=The Aut
hor
post1 column=post:body, timestamp=1368536083159, value=This is a
blog post
post1 column=post:title, timestamp=1368536070847, value=Hello Wo
rld
post2 column=image:active, timestamp=1368537884925, value=false
post2 column=image:bodyimage, timestamp=1368537896082, value=0
post2 column=image:header, timestamp=1368537831101, value=imghea
der2
post2 column=post:author, timestamp=1368537743990, value=PLC
post2 column=post:body, timestamp=1368537800137, value=This is t
he second history
post2 column=post:title, timestamp=1368537706887, value=Hello Wo
rld2
post3 column=image:bodyimage, timestamp=1368537903556, value=10
post3 column=image:header, timestamp=1368537838765, value=imghea
der3
post3 column=post:title, timestamp=1368537714692, value=Hello Wo
rld3
3 row(s) in 2.7590 seconds

hbase(main):002:0>
```

It is possible to obtain the same result using VDP and the hbase-customwrapper.

### 3.3 EXAMPLE WITH VDP

Using the following JSON fragment, we create a base view:

```
\{
  'hour': \{
    '00-total': 'text',
    '00-US': 'text',
    '00-France': 'text',
    '00-Italy': 'text'
  },
  'day': \{
    '000-total': 'text',
    '000-US': 'text',
    '000-France': 'text',
    '000-Italy': 'text'
  },
  'total': \{
    'total': 'text',
    'US': 'text',
    'France': 'text',
    'Italy': 'text'
  }
}
```

### Edit Wrapper Parameter values

Enter values for the following wrapper parameters:

hbaseIP	<input type="text" value="melkus.denodo.com"/>
hbasePort	<input type="text" value="2181"/>
tableName	<input type="text" value="analytics_demo"/>
tableMapping	<input type="text" value="{ 'Italy': 'text' }"/> <div> <input type="button" value="↕"/> <input type="button" value="↕"/> </div>
cachingSize	<input type="text"/>
HBase Configuration File	<input type="text" value="None"/> <input type="button" value="Configure"/>
<input type="checkbox"/> Kerberos enabled	
Kerberos principal name	<input type="text"/>
Kerberos keytab file	<input type="text" value="None"/> <input type="button" value="Configure"/>
Kerberos password	<input type="text"/>
Kerberos Distribution Center	<input type="text"/>

Ok Cancel

View name:

<input type="checkbox"/>	PK	Field Name	Field Type
<input type="checkbox"/>		row_key	text
<input type="checkbox"/>		total	hbase_ds_total
<input type="checkbox"/>		day	hbase_ds_day
<input type="checkbox"/>		hour	hbase_ds_day
<input type="checkbox"/>		start_row	text
<input type="checkbox"/>		stop_row	text

Once the base view is created, it can be used in VDP just like any other views. Let's see a VQL sentence equivalent to the above HBase Shell command:

```
SELECT * FROM hbase_ds WHERE (hour).us_0 = 14
```

Results	Execution Trace				Query: SELECT row_key AS row_key, total AS total, day AS day, hour AS hour, start_row AS start_
Total rows received: 3 (shown 3)					
△ ▽					
row_key	total	day	hour	start_row	stop_row
domain.0	[Register]...	[Register]...	[Register]...	<null>	<null>
domain.16	[Register]...	[Register]...	[Register]...	<null>	<null>
domain.37	[Register]...	[Register]...	[Register]...	<null>	<null>

From the row\_key values, we can check that the same results are obtained as if the HBase Shell had been used instead.

The previous image does not allow to see the array itself, it would require flattening, so here it is for the first returned tuple:

RESU... -> hour			
us_0	france_0	italy_0	total_0
14	84	76	174

## 4 SECURE CLUSTER WITH KERBEROS

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The configuration required for accessing a Hadoop cluster with Kerberos enabled is the same as the one needed to access HBase and, additionally, the user must supply the Kerberos credentials.

The Kerberos parameters are:

- Kerberos enabled: Check it when accessing a Hadoop cluster with Kerberos enabled (required).
- Kerberos principal name: Kerberos v5 Principal name to access HBase, e.g. `primary/instance@realm` (optional).
- Kerberos keytab file: Keytab file containing the key of the Kerberos principal (optional).
- Kerberos password: Password associated with the principal (optional).
- Kerberos Distribution Center: Kerberos Key Distribution Center (optional).

hbase-customwrapper provides **three ways** for accessing a kerberized Hadoop cluster:

1. The client has a valid Kerberos ticket in the **ticket cache** obtained, for example, using the `kinit` command in the Kerberos Client.

In this case only the `Kerberos enabled` parameter should be checked. The HBase wrapper would use the Kerberos ticket to authenticate itself against the Hadoop cluster.

2. The client does not have a valid Kerberos ticket in the ticket cache. In this case you should provide the `Kerberos principal name` parameter and
  - 2.1. `Kerberos keytab file` parameter or
  - 2.2. `Kerberos password` parameter

In all these **three scenarios** the **`krb5.conf` file should be present in the file system**. Below there is an example of the Kerberos configuration file:

```
[libdefaults]
renew_lifetime = 7d
forwardable = true
default_realm = EXAMPLE.COM
ticket_lifetime = 24h
dns_lookup_realm = false
dns_lookup_kdc = false
```

```
[domain_realm]
sandbox.hortonworks.com = EXAMPLE.COM
cloudera = CLOUDERA

[realms]
EXAMPLE.COM = {
    admin_server = sandbox.hortonworks.com
    kdc = sandbox.hortonworks.com
}

CLOUDERA = {
    kdc = quickstart.cloudera
    admin_server = quickstart.cloudera
    max_renewable_life = 7d 0h 0m 0s
    default_principal_flags = +renewable
}

[logging]
default = FILE:/var/log/krb5kdc.log
admin_server = FILE:/var/log/kadmind.log
kdc = FILE:/var/log/krb5kdc.log
```

The algorithm to locate the `krb5.conf` file is the following:

- If the system property `java.security.krb5.conf` is set, its value is assumed to specify the path and file name.
- If that system property value is not set, then the configuration file is looked for in the directory
  - `<java-home>\lib\security` (Windows)
  - `<java-home>/lib/security` (Solaris and Linux)
- If the file is still not found, then an attempt is made to locate it as follows:
  - `/etc/krb5/krb5.conf` (Solaris)
  - `c:\winnt\krb5.ini` (Windows)
  - `/etc/krb5.conf` (Linux)

There is an **exception**. If you are planning to create HBase views that use the **same Key Distribution Center and the same realm** the Kerberos Distribution Center parameter can be provided instead of having the `krb5.conf` file in the file system:



### Edit Wrapper Parameter values

Enter values for the following wrapper parameters:

hbaseIP	<input type="text" value="melkus.denodo.com"/>
hbasePort	<input type="text" value="2181"/>
tableName	<input type="text" value="analytics_demo"/>
tableMapping	<input type="text" value="{ 'hour': '{ '00-total': 'text' }"/>
cachingSize	<input type="text"/>
HBase Configuration File	<input type="text" value="None"/> <input type="button" value="Configure"/>
	<input checked="" type="checkbox"/> Kerberos enabled
Kerberos principal name	<input type="text" value="test@DENODO.COM"/>
Kerberos keytab file	<input type="text" value="None"/> <input type="button" value="Configure"/>
Kerberos password	<input type="password" value="••••••••"/>
Kerberos Distribution Center	<input type="text" value="melkus.denodo.com"/>

## 5 SOFTWARE REQUIREMENTS

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hbase-customwrapper has been tested in Cloudera QuickStart VM 5.5.0 using Hadoop 2.6.0+cdh5.5.4+1072, HBase 1.0.0+cdh5.5.4+318 and ZooKeeper 3.4.5+cdh5.5.4+97.

**Cloudera** provides a virtual machine that gives a working Apache Hadoop environment out-of-the-box. It can be downloaded from:

<http://www.cloudera.com/content/support/en/downloads.html>

hbase-customwrapper also has been tested with HDP 2.3 in Hortonworks Sandbox using Hadoop 2.7.1, HBase 1.1.1 and Apache ZooKeeper 3.4.6.

**Hortonworks** provides Sandbox that is a personal and portable Apache Hadoop environment. It can be downloaded from: <http://hortonworks.com/downloads/>

## 6 TROUBLESHOOTING

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### Symptom

Error message: "The node /hbase (/hbase-unsecure or /hbase-secure) is not in ZooKeeper. It should have been written by the master. Check the value configured in 'zookeeper.znode.parent'. There could be a mismatch with the one configured in the master."

or

Error message: Received exception with message 'Error accessing HBase: java.lang.NullPointerException

This exception could mean that there is a error in the authentication, though this might not be the only possible cause. Check the value configured in 'zookeeper.znode.parent'. There could be a mismatch with the one configured in the HMaster.

### Resolution

Edit the configuration file hbase-site.xml included in the hbase-customwrapper jar or use the parameter hbase configuration file to add a new configuration file. Change the property zookeeper.znode.parent from its value /hbase to /hbase-unsecure or to /hbase-secure when Kerberos is enabled.

### Symptom

Error message: "com.google.protobuf.ServiceException: java.io.IOException: Call to <your domain/your IP:your port> failed on local exception: java.io.EOFException".

To see the real error message enable Hadoop **debugging** by adding these settings to VDP log4j.xml:

```
<logger name="org.apache.hadoop">  
  <level value="debug"/>  
</logger>
```

And you will see the following message in VDP log file:

```
"org.apache.hadoop.ipc.RpcClient - IPC Client (...) exception
{ exception_class_name:
"org.apache.hadoop.security.AccessControlException"          stack_trace:
"Authentication is required" do_not_retry: false } (...)"
```

## Resolution

You are trying to connect to a Kerberos-enabled Hadoop cluster. You should configure the custom wrapper accordingly. See [Secure cluster with Kerberos](#) for **configuring Kerberos** on this custom wrapper.

## Symptom

Error message: "com.google.protobuf.ServiceException: java.io.IOException: Couldn't setup connection for <Kerberos principal> to <HBase principal>".

To see the real error message enable Hadoop **debugging** by adding these settings to VDP log4j.xml:

```
<logger name="org.apache.hadoop">
  <level value="debug"/>
</logger>
```

And you will see the following message in VDP log file: org.apache.hadoop.ipc.RpcClient - (...) Server not found in Kerberos database (7) - UNKNOWN\_SERVER)]

## Resolution

Check that nslookup is returning the fully qualified hostname of the KDC. If not, modify the /etc/hosts of the client machine for the KDC entry to be of the form "IP address fully.qualified.hostname alias".

## Symptom

Error message: "org.apache.hadoop.hbase.security.AccessDeniedException: Insufficient permissions for user '<user>' for scanner open on table <table>"

## Resolution

After securing an HBase cluster, if user has not be given appropriate privileges, HBase access will fail with an error "Insufficient permissions for user". It is an expected behavior.

Once the cluster has been secured, a user has to authenticate itself to Kerberos by doing a kinit. By default, hbase is a superuser who was full access and can be used to grant privileges to other users. So you can use hbase keytab file to perform a kinit. Then, you cand login to the HBase Shell and grant privileges to other users.

```
$ sudo -u hbase kinit -kt
/var/run/cloudera-scm-agent/process/305-hbase-MASTER/hbase.keytab
hbase/melkus.denodo.com@DENODO.COM

$ sudo -u hbase hbase shell
14/07/17 04:27:19 INFO Configuration.deprecation: hadoop.native.lib
is deprecated. Instead, use io.native.lib.available
HBase Shell; enter 'help<RETURN>' for list of supported commands.
Type "exit<RETURN>" to leave the HBase Shell
Version 0.96.1.1-cdh5.0.0, rUnknown, Thu Mar 27 23:03:17 PDT 2014

hbase(main):001:0> grant 'test', 'R'
0 row(s) in 5.4110 seconds
```