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Importing Relational Data with Sqoop

Chapter 4

201509

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Importing Relational Data with Apache Sqoop

In this chapter you will learn

- **How to import tables from an RDBMS into your Hadoop cluster**
- **How to change the delimiter and file format of imported tables**
- **How to control which columns and rows are imported**
- **What techniques you can use to improve Sqoop's performance**
- **How the next-generation version of Sqoop compares to the original**

Chapter Topics

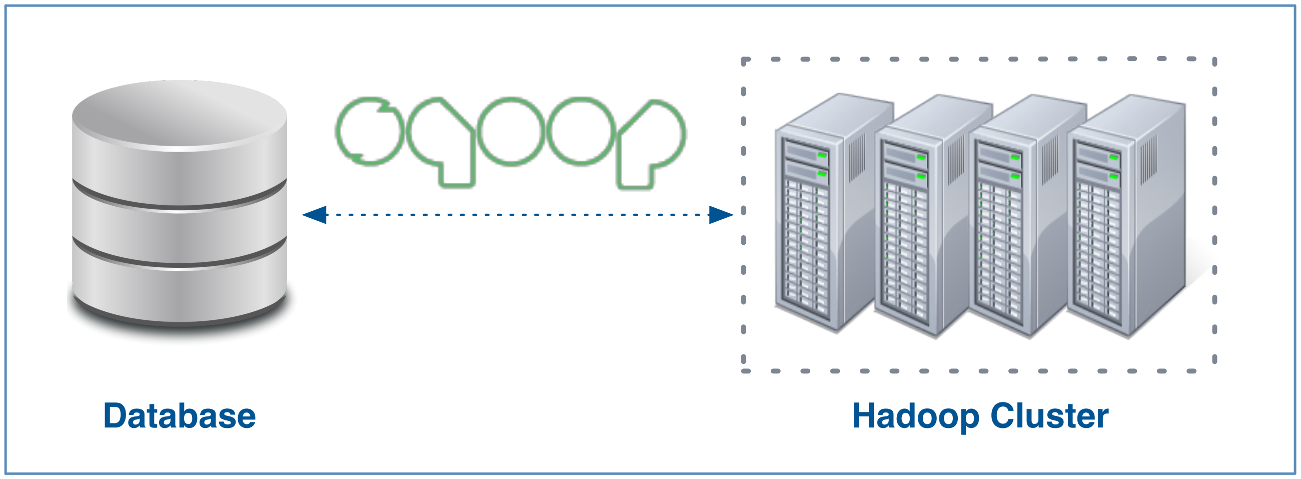
Importing Relational Data with Apache Sqoop

Importing and Modeling Structured Data

- **Sqoop Overview**
- Basic Imports and Exports
- Limiting Results
- Improving Sqoop's Performance
- Sqoop 2
- Conclusion
- Homework: Import Data from MySQL Using Sqoop

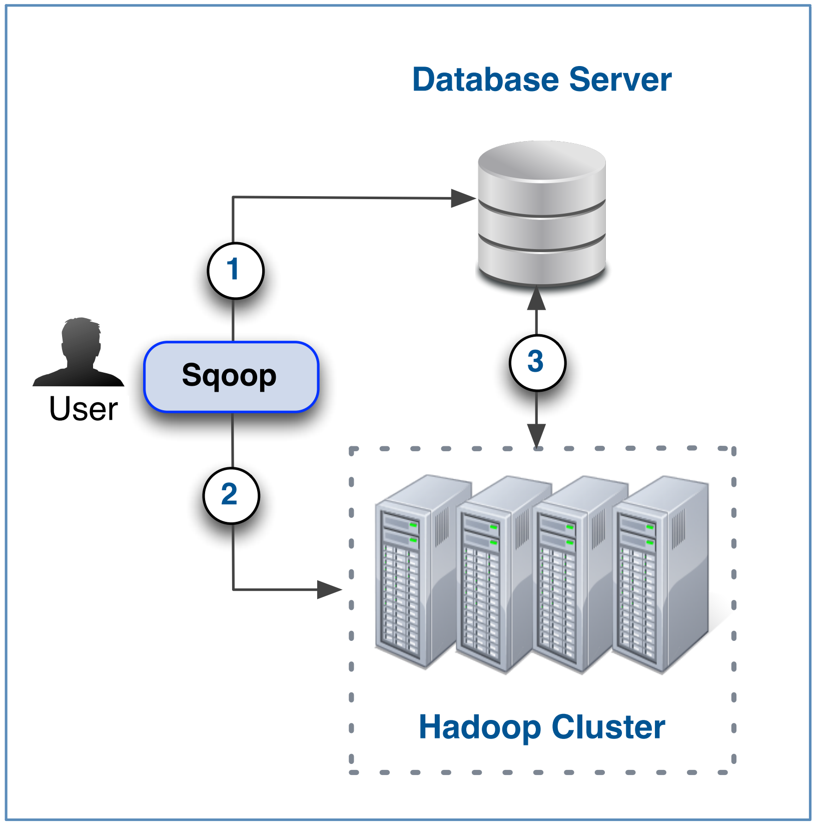
What is Apache Sqoop?

- **Open source Apache project originally developed by Cloudera**
  - The name is a contraction of “SQL-to-Hadoop”
- **Sqoop exchanges data between a database and HDFS**
  - Can import all tables, a single table, or a partial table into HDFS
  - Data can be imported a variety of formats
  - Sqoop can also export data from HDFS to a database



How Does Sqoop Work?

- **Sqoop is a client-side application that imports data using Hadoop MapReduce**
- **A basic import involves three steps orchestrated by Sqoop**
  1. Examine table details
  2. Create and submit job to cluster
  3. Fetch records from table and write this data to HDFS



Basic Syntax

- **Sqoop is a command-line utility with several subcommands, called *tools***
  - There are tools for import, export, listing database contents, and more
  - Run **`sqoop help`** to see a list of all tools
  - Run **`sqoop help`** ***`tool-name`*** for help on using a specific tool
- **Basic syntax of a Sqoop invocation**

```
$ sqoop tool-name [tool-options]
```

- **This command will list all tables in the `loudacre` database in MySQL**

```
$ sqoop list-tables \
    --connect jdbc:mysql://dbhost/loudacre \
    --username dbuser \
    --password pw
```

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Overview of the Import Process

- **Imports are performed using Hadoop MapReduce jobs**
- **Sqoop begins by examining the table to be imported**
  - Determines the primary key, if possible
  - Runs a *boundary query* to see how many records will be imported
  - Divides result of boundary query by the number of tasks (mappers)
    - Uses this to configure tasks so that they will have equal loads
- **Sqoop also generates a Java source file for each table being imported**
  - It compiles and uses this during the import process
  - The file remains after import, but can be safely deleted

Importing an Entire Database with Sqoop

- **The `import-all-tables` tool imports an entire database**
  - Stored as comma-delimited files
  - Default base location is your HDFS home directory
  - Data will be in subdirectories corresponding to name of each table

```
$ sqoop import-all-tables \
    --connect jdbc:mysql://dbhost/loudacre \
    --username dbuser --password pw
```

- **Use the `--warehouse-dir` option to specify a different base directory**

```
$ sqoop import-all-tables \
    --connect jdbc:mysql://dbhost/loudacre \
    --username dbuser --password pw \
    --warehouse-dir /loudacre
```

Importing a Single Table with Sqoop

- **The `import` tool imports a single table**
- **This example imports the `accounts` table**
  - It stores the data in HDFS as comma-delimited fields

```
$ sqoop import --table accounts \
    --connect jdbc:mysql://dbhost/loudacre \
    --username dbuser --password pw
```

- **This variation writes tab-delimited fields instead**

```
$ sqoop import --table accounts \
    --connect jdbc:mysql://dbhost/loudacre \
    --username dbuser --password pw \
    --fields-terminated-by "\t"
```

Incremental Imports (1)

- **What if records have changed since last import?**
  - Could re-import all records, but this is inefficient
- **Sqoop's `incremental lastmodified` mode imports new and modified records**
  - Based on a timestamp in a specified column
  - You must ensure timestamps are updated when records are added or changed in the database

```
$ sqoop import --table invoices \
    --connect jdbc:mysql://dbhost/loudacre \
    --username dbuser --password pw \
    --incremental lastmodified \
    --check-column mod_dt \
    --last-value '2015-09-30 16:00:00'
```

Incremental Imports (2)

- **Or use Sqoop's `incremental append` mode to import only *new* records**
  - Based on value of last record in specified column

```
$ sqoop import --table invoices \
    --connect jdbc:mysql://dbhost/loudacre \
    --username dbuser --password pw \
    --incremental append \
    --check-column id \
    --last-value 9478306
```

Exporting Data from Hadoop to RDBMS with Sqoop

- **Sqoop's `import` tool pulls records from an RDBMS into HDFS**
- **It is sometimes necessary to *push* data in HDFS back to an RDBMS**
  - Good solution when you must do batch processing on large data sets
  - Export results to a relational database for access by other systems
- **Sqoop supports this via the `export` tool**
  - The RDBMS table must already exist prior to export

```
$ sqoop export \
    --connect jdbc:mysql://dbhost/loudacre \
    --username dbuser --password pw \
    --export-dir /loudacre/recommender_output \
    --update-mode allowinsert \
    --table product_recommendations
```

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Importing Partial Tables with Sqoop

- **Import only specified columns from `accounts` table**

```
$ sqoop import --table accounts \
    --connect jdbc:mysql://dbhost/loudacre \
    --username dbuser --password pw \
    --columns "id,first_name,last_name,state"
```

- **Import only matching rows from `accounts` table**

```
$ sqoop import --table accounts \
    --connect jdbc:mysql://dbhost/loudacre \
    --username dbuser --password pw \
    --where "state='CA'"
```

Using a Free-Form Query

- **You can also import the results of a query, rather than a single table**
- **Supply a complete SQL query using the `--query` option**
  - You must add the *literal* `WHERE $CONDITIONS` token
  - Use `--split-by` to identify field used to divide work among mappers
  - The `--target-dir` option is required for free-form queries

```
$ sqoop import \
    --connect jdbc:mysql://dbhost/loudacre \
    --username dbuser --password pw \
    --target-dir /data/loudacre/payable \
    --split-by accounts.id \
    --query 'SELECT accounts.id, first_name,
last_name, bill_amount FROM accounts JOIN invoices ON
(accounts.id = invoices.cust_id) WHERE $CONDITIONS'
```

Using a Free-Form Query with WHERE Criteria

- **The --where option is ignored in a free-form query**
  - You must specify your criteria using AND following the WHERE clause

```
$ sqoop import \
    --connect jdbc:mysql://dbhost/loudacre \
    --username dbuser --password pw \
    --target-dir /data/loudacre/payable \
    --split-by accounts.id \
    --query 'SELECT accounts.id, first_name,
last_name, bill_amount FROM accounts JOIN invoices ON
(accounts.id = invoices.cust_id) WHERE $CONDITIONS AND
bill_amount >= 40'
```

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Options for Database Connectivity

- **Generic (JDBC)**
  - Compatible with nearly any database
  - Overhead imposed by JDBC can limit performance
- **Direct Mode**
  - Can improve performance through use of database-specific utilities
  - Currently supports MySQL and Postgres (use `--direct` option)
  - Not all Sqoop features are available in direct mode
- **Cloudera and partners offer high-performance Sqoop connectors**
  - These use native database protocols rather than JDBC
  - Connectors available for Netezza, Teradata, and Oracle
    - Download these from Cloudera's Web site
    - Not open source due to licensing issues, but free to use

Controlling Parallelism

- **By default, Sqoop typically imports data using four parallel tasks (called mappers)**
  - Increasing the number of tasks might improve import speed
  - Caution: Each task adds load to your database server
- **You can *influence* the number of tasks using the `–m` option**
  - Sqoop views this only as a hint and might not honor it

```
$ sqoop import --table accounts \
    --connect jdbc:mysql://dbhost/loudacre \
    --username dbuser --password pw \
    -m 8
```

- **Sqoop assumes all tables have an evenly-distributed numeric primary key**
  - Sqoop uses this column to divide work among the tasks
  - You can use a different column with the `--split-by` option

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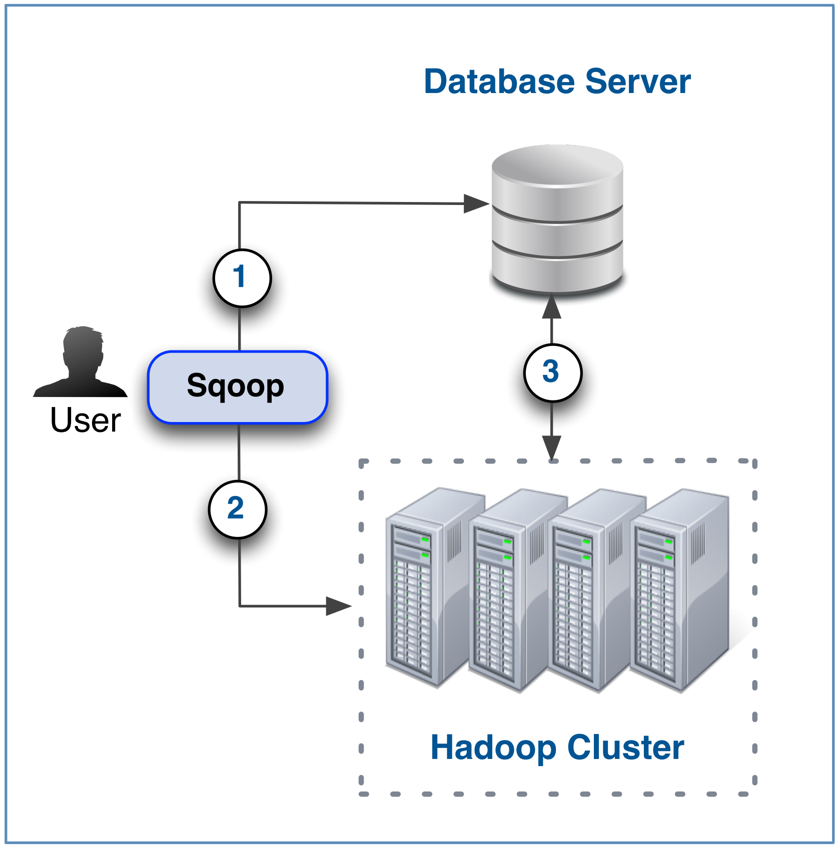
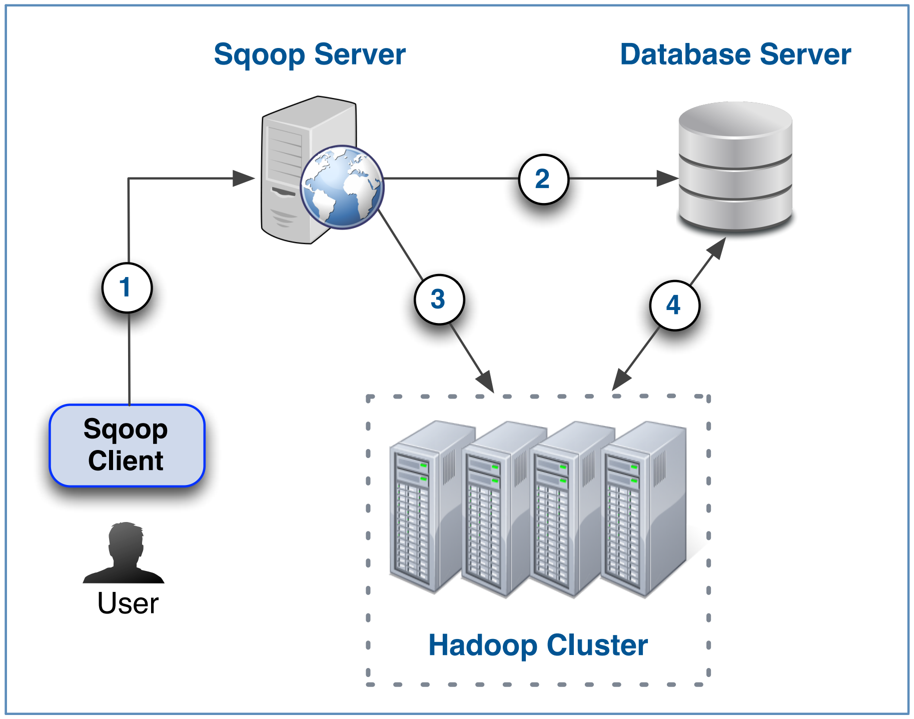
Limitations of Sqoop

- **Sqoop is stable and has been used successfully in production for years**
- **However, its client-side architecture does impose some limitations**
  - Requires connectivity to RDBMS from the client (client must have JDBC drivers installed)
  - Requires connectivity to cluster from the client
  - Requires user to specify RDBMS username and password
  - Difficult to integrate a CLI within external applications
- **Also tightly coupled to JDBC semantics**
  - A problem for NoSQL databases



Sqoop 2 Architecture

- **Sqoop 2 is the next-generation version of Sqoop**
  - Client-server design addresses limitations described earlier
  - API changes also simplify development of other Sqoop connectors
- **Client requires connectivity only to the Sqoop server**
  - DB connections are configured on the server by a system administrator
  - End users no longer need to possess database credentials
  - Centralized audit trail
  - Better resource management
  - Sqoop server is accessible via CLI, REST API, and Web UI



Sqoop 2 Status

- **Sqoop 2 is being actively developed**
  - It began shipping (alongside Sqoop) starting in CDH 4.2
- **Sqoop 2 is not yet at feature parity with Sqoop**
  - Implemented features are regarded as stable
  - Consider using Sqoop 2 unless you require a feature it lacks
- **We use Sqoop, rather than Sqoop 2, in this class**
  - Primarily due to memory constraints in the VM

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Essential Points

- **Sqoop exchanges data between a database and the Hadoop cluster**
  - Provides subcommands (*tools*) for importing, exporting, and more
- **Tables are imported using MapReduce jobs**
  - These are written as comma-delimited text by default
  - You can specify alternate delimiters or file formats
  - Uncompressed by default, but you can specify a codec to use
- **Sqoop provides many options to control imports**
  - You can select only certain columns or limit rows
  - Supports using joins in free-form queries
- **Sqoop 2 is the next-generation version of Sqoop**
  - Client-server design improves administration and resource management

Bibliography

The following offer more information on topics discussed in this chapter

- **Sqoop User Guide**
  - `http://tiny.cloudera.com/sqoopuserguide`
- ***Apache Sqoop Cookbook*** **(published by O'Reilly)**
  - `http://tiny.cloudera.com/sqoopcookbook`
- **A New Generation of Data Transfer Tools for Hadoop: Sqoop 2**
  - `http://tiny.cloudera.com/adcc05c`

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- **Homework: Import Data from MySQL Using Sqoop**

Homework: Import Data from MySQL Using Sqoop

- **In this homework , you will**
  - Use Sqoop to import web page and customer account data from an RDBMS to HDFS
  - Perform incremental imports of new and updated account data
- **Please refer to the Homework description**