CS 523 – BDT

Big Data Technology

Lesson 9

Sqoop & Flume

Knowledge is gained from inside and outside

Maharishi International University

WHOLENESS OF THE LESSON

Sometimes there is a need to ingest data from outer sources into HDFS. Sqoop and Flume are two data integration frameworks that are heavily used for ingesting data into HDFS. This HDFS data can then be analyzed to get a better insight. Science & Technology of Consciousness: Nature of life is to grow. Similarly, we want more data into HDFS to gain better insights and grow in our understanding of the data.

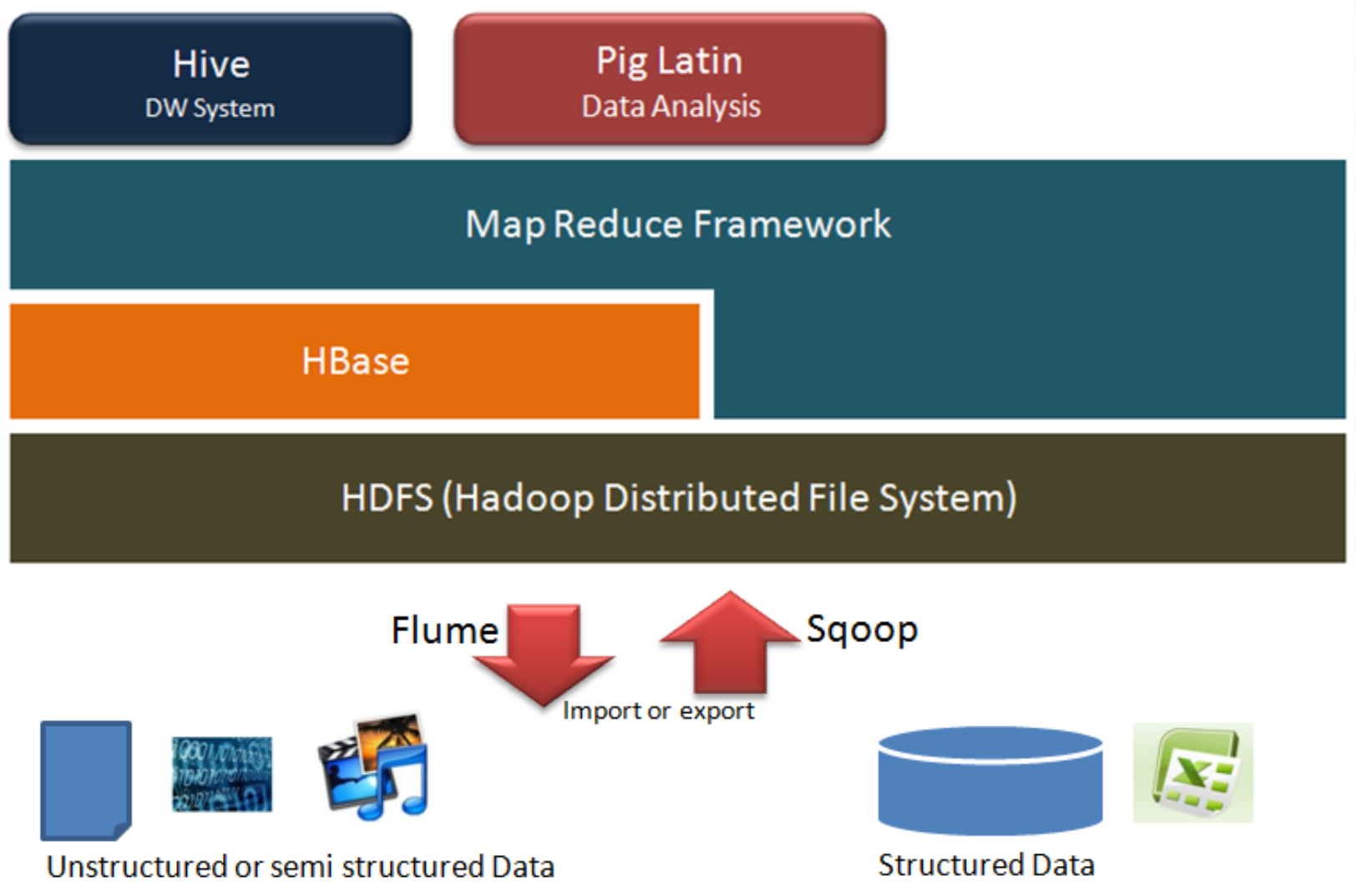
Need for Data Ingestion

- A great strength of the Hadoop platform is its ability to work with very large datasets in several different forms.
- HDFS can reliably store logs and other data formats from a plethora of sources, and MapReduce/Pig/Hive can parse diverse ad hoc data formats, extracting relevant information and combining multiple datasets into powerful results.
- It is often assumed that the data is already in HDFS, however, there are many systems that do not meet this assumption and so there is a need to ingest data from outer sources into HDFS for further processing.

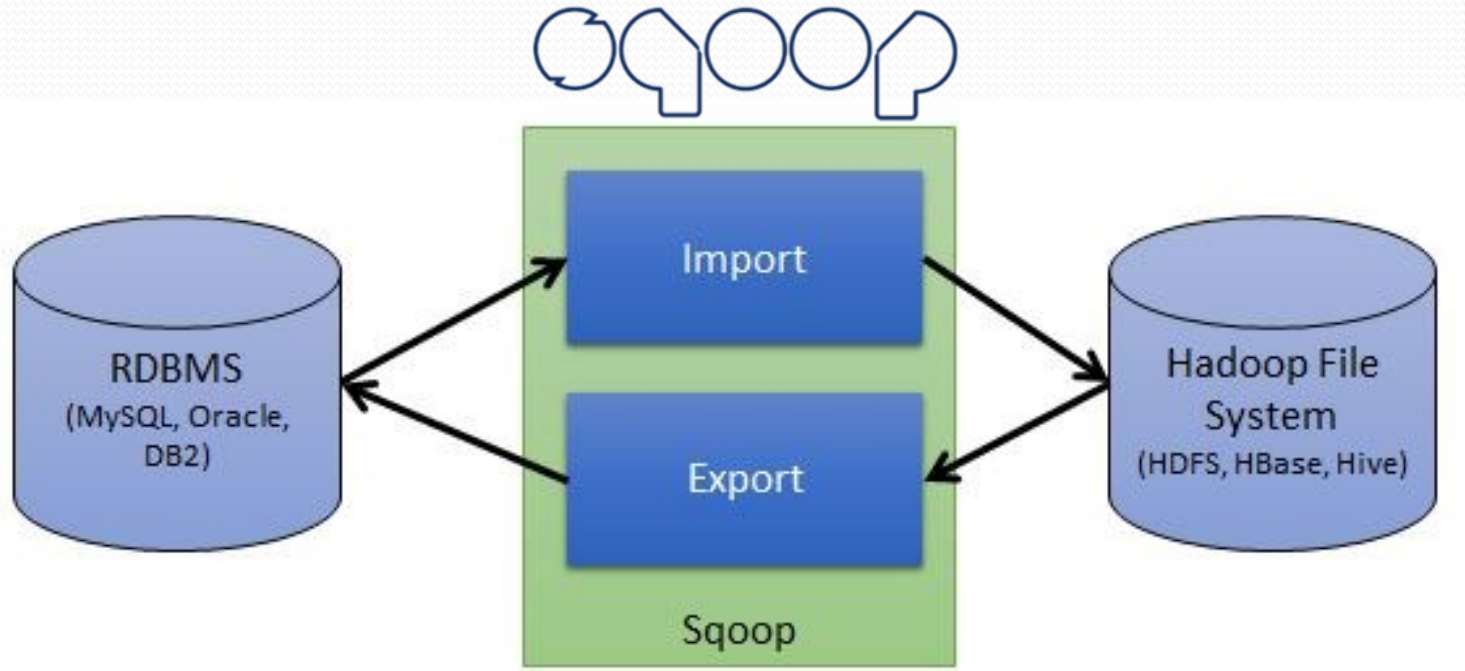
Data Ingestion

- Ingestion is the process of getting data into a system with minimal processing or transformation applied during ingestion.
- **Sqoop** and **Flume** are two data integration frameworks that are heavily used for ingesting data into HDFS.
- Which one of them you use depends on from where the data is coming and how you would need to use it.

Hadoop Ecosystem



- Often, valuable data in an organization is stored in structured data stores such as RDBMSs.
- Apache Sqoop is an open source, batch-oriented program that allows users to **import data from a database into HDFS or export data from HDFS back to a database**.



Apache Sqoop

- Open source ETL tool developed by Cloudera. Became a top-level Apache project in March 2012. Sqoop got the name from sql+hadoop.
- Uses JDBC to talk to the DataBases and that's why can talk to virtually any DataBase in the world.
- Can import single table or all tables in DataBases at a time
- As a developer you can specify the columns or rows that need to be imported. It also facilitates *select* query for selective imports.
- Sqoop takes the commands from user, analyzes the tables and generates Java code that'll take care of data import to HDFS.
- After the java code generation, a map only MapReduce job is run to import the data.
- By default, 4 mappers are run with each mapper importing 25% of the data.

Apache Sqoop

- Data ingested in HDFS using Sqoop can be further used for processing using MapReduce programs or other higher-level tools such as Hive.
- Can directly create Hive/HBase tables and push data into it.
- When the final results of an analytic pipeline are available, Sqoop can export these results back to the data store for consumption by other clients.
- Sqoop can create files in a variety of formats in a Hadoop cluster.
- It is a very useful tool due to the wide range of databases that it supports, but Sqoop is, by design, entirely batch-oriented.

Available Commands in Sqoop

codegen	Generate code to interact with database records
create-hive-table	Import a table definition into Hive
hive-import	Import a table definition and data into Hive
eval	Evaluate a SQL statement and display the results
export	Export an HDFS directory to a database table
help	List available commands
import	Import a table from a database to HDFS
import-all-tables	Import tables from a database to HDFS
list-databases	List available databases on a server
list-tables	List available tables in a database
version	Display version information

See “Sqoop help COMMAND” for information on a specific command.

Import & Export Commands

- **Import**
  - Full table or only a subset of a table (specific columns/ rows) can be imported from RDBMS to HDFS
  - The import process is performed in parallel. For this reason, the output will be in multiple files.
- **Export**
  - Data can be exported from HDFS file to RDBMS table
  - Sqoop's export process will read a set of delimited text files from HDFS in parallel, parse them into records, and insert them as new rows in a target database table, for consumption by external applications or users.

Incremental updates are also possible in both import and export.

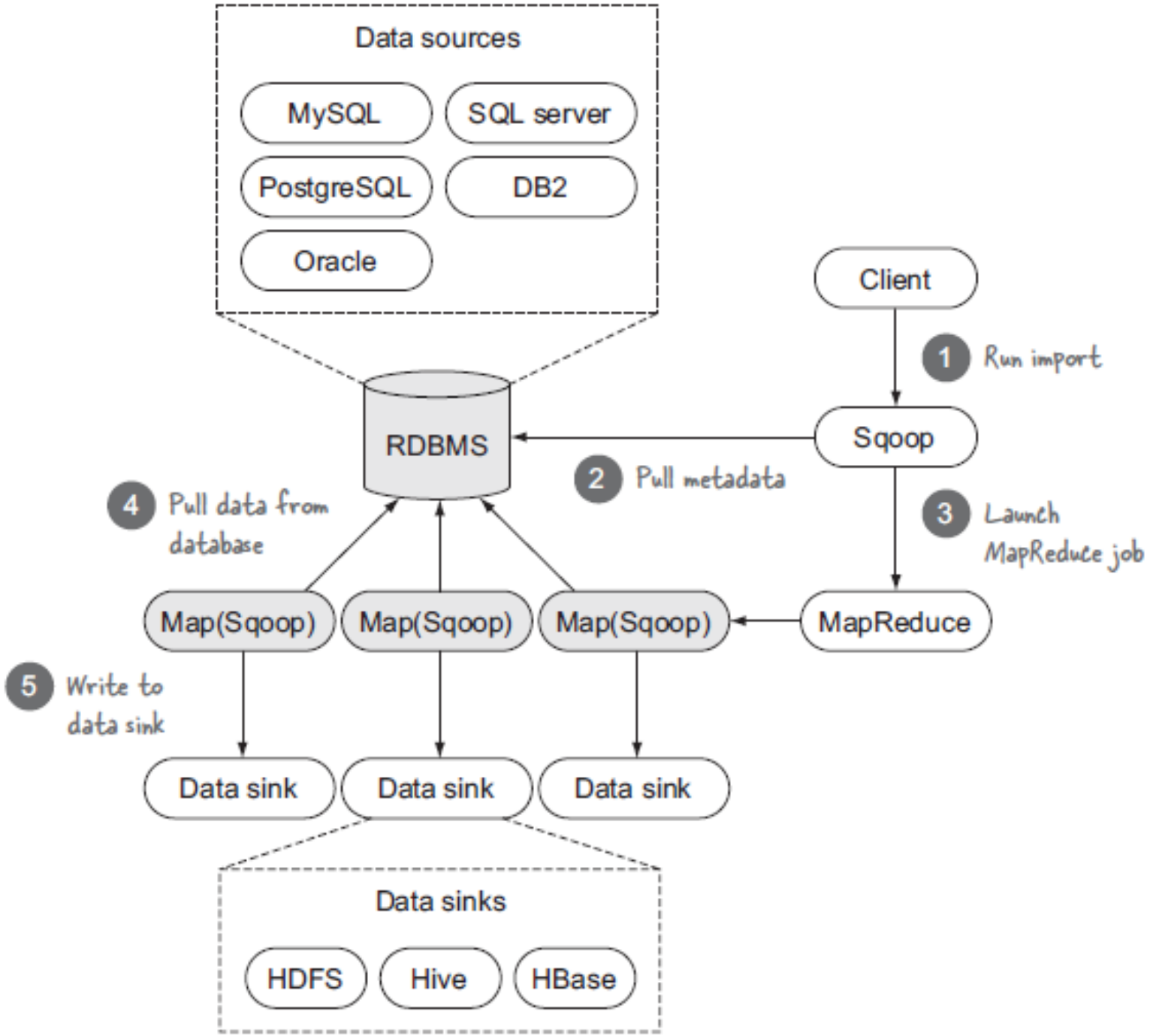
Sqoop Import Command

```
sqoop import
--connect jdbc:mysql://quickstart.cloudera/cs523
--username root –P
--table student
--target-dir /user/cloudera/sqoopImport
-m 2
```

Sqoop Import Command

- **import*:*** This is the sub-command that instructs Sqoop to initiate an import.
- ***--connect <connect string>, -username <user name>, -password <password>*** : These are connection parameters that are used to connect with the database. This is similar to the connection parameters that you use when connecting to the database via a JDBC connection.
- ***--table <table name> :*** This parameter specifies the table which will be imported.
- ***--target-dir :*** name of the directory in HDFS in which the imported data will be stored.
- ***-m :*** number of mappers to use for data import.

Sqoop In Action



Sqoop Import Command

- By default, all columns within a table are selected for import. Imported data is written to HDFS in its "natural order".
- By default, the files that are getting stored in HDFS contain comma delimited fields, with new lines separating different records.
- You can easily override the format in which data is copied over by explicitly specifying the field separator and record terminator characters **(--fields-terminated-by**).
- Sqoop also supports different data formats for importing data.
  - For example, you can easily import data in Avro data format by simply specifying the option ***--as-avrodatafile*** with the import command.
- There are many other options that Sqoop provides which can be used to further tune the import operation to suit your specific requirements.

Controlling Parallelism

- Sqoop imports data in parallel from most DB sources. You can specify the number of map tasks to use to perform the import by using the -m or --num-mappers argument.
- Each of these arguments takes an integer value which corresponds to the degree of parallelism to employ. By default, 4 map tasks are used.
  - Do not increase the degree of parallelism higher than that which your db can reasonably support. Connecting 100 concurrent clients to your db may increase the load on the db server to a point where performance suffers as a result.
- When performing parallel imports, Sqoop needs a criterion by which it can split the workload.
- Sqoop uses a splitting column to split the workload.
- By default, Sqoop will identify the primary key column (if present) in a table and use it as the splitting column.

Controlling Parallelism

- If a table does not have a primary key defined or is not suitable to use as splitting column, then use ***–split-by*** argument with *Sqoop import* command. You can explicitly choose a different integer column with this argument for optimal performance.
- If a table does not have a PK defined and the –split-by <col> is not provided, then import will fail unless the number of mappers is explicitly set to one like ***–num-mappers 1***
- The low and high values for the splitting column are retrieved from the database, and the map tasks operate on evenly-sized components of the total range.
  - E.g., if you had a table with a PK column of id whose min value was 0 and max value was 999, and Sqoop was directed to use 4 tasks, Sqoop would run four processes; each of them will execute SQL statements of the form *SELECT * FROM sometable WHERE id >= lo AND id < hi* with (lo, hi) set to (0, 250), (250, 500), (500, 750), and (750, 1000) in the different tasks.

Selective Import

- You can select a subset of columns and control their ordering by using the --columns argument. This should include a comma-delimited list of columns to import.

  For example: --columns "name, student_id"

- You can control which rows are imported by adding a SQL where clause to the import statement.
- By default, Sqoop generates statements of the form *SELECT <column list> FROM <table name>.* You can append a where clause to this with the --where argument.
  - For example: --where "id > 400" : Only rows where the id column has a value greater than 400 will be imported.

Import : direct argument

- By default, the import process will use JDBC which provides a reasonable cross-vendor import channel.
- Some databases can perform imports in a more high-performance fashion by using database-specific data movement tools.
- For example, MySQL provides the **mysqldump** tool which can export data from MySQL to other systems very quickly.
- By supplying the --direct argument, you are specifying that Sqoop should attempt the direct import channel. This channel may be higher performance than using JDBC.
- Currently, direct mode does not support imports of large object columns.

Incremental Import Mode - append

- Sqoop provides an incremental import mode which can be used to retrieve only rows newer than some previously-imported set of rows.
- Performing an incremental import of new data, after having already imported the first 100,000 rows of a table:

```
sqoop import
--connect jdbc:mysql://10.0.2.15:3306/cs523
--username root –P
--table student
--where "id > 100000“
--target-dir /user/cloudera/sqoopImport
--append
```

- Will need to run sqoop-merge job to merge the part-m files into one.

Import Control Arguments

Argument	Description
`--append`	Append data to an existing dataset in HDFS
`--as-avrodatafile`	Imports data to Avro Data Files
`--as-sequencefile`	Imports data to SequenceFiles
`--as-textfile`	Imports data as plain text (default)
`--boundary-query <statement>`	Boundary query to use for creating splits
`--columns <col,col,col…>`	Columns to import from table
`--direct`	Use direct import fast path
`--direct-split-size <n>`	Split the input stream every *n* bytes when importing in direct mode
`--inline-lob-limit <n>`	Set the maximum size for an inline LOB
`-m,--num-mappers <n>`	Use *n* map tasks to import in parallel
`-e,--query <statement>`	Import the results of *statement*.
`--split-by <column-name>`	Column of the table used to split work units
`--table <table-name>`	Table to read
`--target-dir <dir>`	HDFS destination dir
`--warehouse-dir <dir>`	HDFS parent for table destination
`--where <where clause>`	WHERE clause to use during import
`-z,--compress`	Enable compression
`--compression-codec <c>`	Use Hadoop codec (default gzip)
`--null-string <null-string>`	The string to be written for a null value for string columns
`--null-non-string <null-string>`	The string to be written for a null value for non-string columns

Sqoop Export

- In some cases, data processed by Hadoop pipelines may be needed in production systems to help run additional critical business functions.
- Sqoop can be used to export such data into external datastores as necessary.
- For example, data generated by the pipeline on Hadoop corresponded to the STUDENTS table in a DataBase somewhere, you could populate it using the Export command:

Sqoop Export Command

```
sqoop export
--connect jdbc:mysql://localhost/cs523
--username root –P
--table student
--export-dir /user/cloudera/sqoopImport
```

- ***export***: This is the sub-command that instructs Sqoop to initiate an export.
- ***--table*** *<table name>*: This parameter specifies the table which will be populated.
- ***--export-dir*** *<directory path>*: This is the directory from which data will be exported.

Sqoop Export

- The export tool exports a set of files from HDFS to RDBMS.
- The target table must already exist in the database.
- The input files are read and parsed into a set of records according to the user-specified delimiters.
- The default operation is to transform these into a set of INSERT statements that inject the records into the database.
- If your table has constraints (e.g., a primary key column whose values must be unique) and already contains data, you must take care to avoid inserting records that violate these constraints.
  - The export process will fail if an INSERT statement fails. This mode is primarily intended for exporting records to a new, empty table intended to receive these results.
- In "update mode," Sqoop will generate UPDATE statements that replace existing records in the database.

Incremental Updates from HDFS to MySQL

```
sqoop export

--connect jdbc:mysql://localhost/cs523

--username root –P

--table student

--update-key id

--update-mode updateonly

--export-dir /user/cloudera/sqoopImport/
```

Export Control Arguments

Argument	Description
`--direct`	Use direct export fast path
`--export-dir <dir>`	HDFS source path for the export
`-m,--num-mappers <n>`	Use *n* map tasks to export in parallel
`--table <table-name>`	Table to populate
`--update-key <col-name>`	Anchor column to use for updates. Use a comma separated list of columns if there are more than one column.
`--update-mode <mode>`	Specify how updates are performed when new rows are found with non-matching keys in database.
	Legal values for `mode` include `updateonly` (default) and `allowinsert`.
`--input-null-string <null-string>`	The string to be interpreted as null for string columns
`--input-null-non-string <null-string>`	The string to be interpreted as null for non-string columns
`--staging-table <staging-table-name>`	The table in which data will be staged before being inserted into the destination table.
`--clear-staging-table`	Indicates that any data present in the staging table can be deleted.
`--batch`	Use batch mode for underlying statement execution.

Sqoop pros and cons

- Sqoop provides a simplified usage model compared to using the format classes (*DBInputFormat)* that are provided in MapReduce.
- But using the *DBInputFormat* classes will give you the added flexibility to transform or pre-process your data in the same MapReduce job that performs the database export.
- The advantage of Sqoop is that it doesn't require you to write any code, and it has some useful notions, such as staging, to help you achieve your idempotent goals.
  - Some connectors support staging tables that help isolate production tables from possible corruption in case of job failures due to any reason. Staging tables are first populated by the map tasks and then merged into the target table once all of the data has been delivered to it.

Main Point

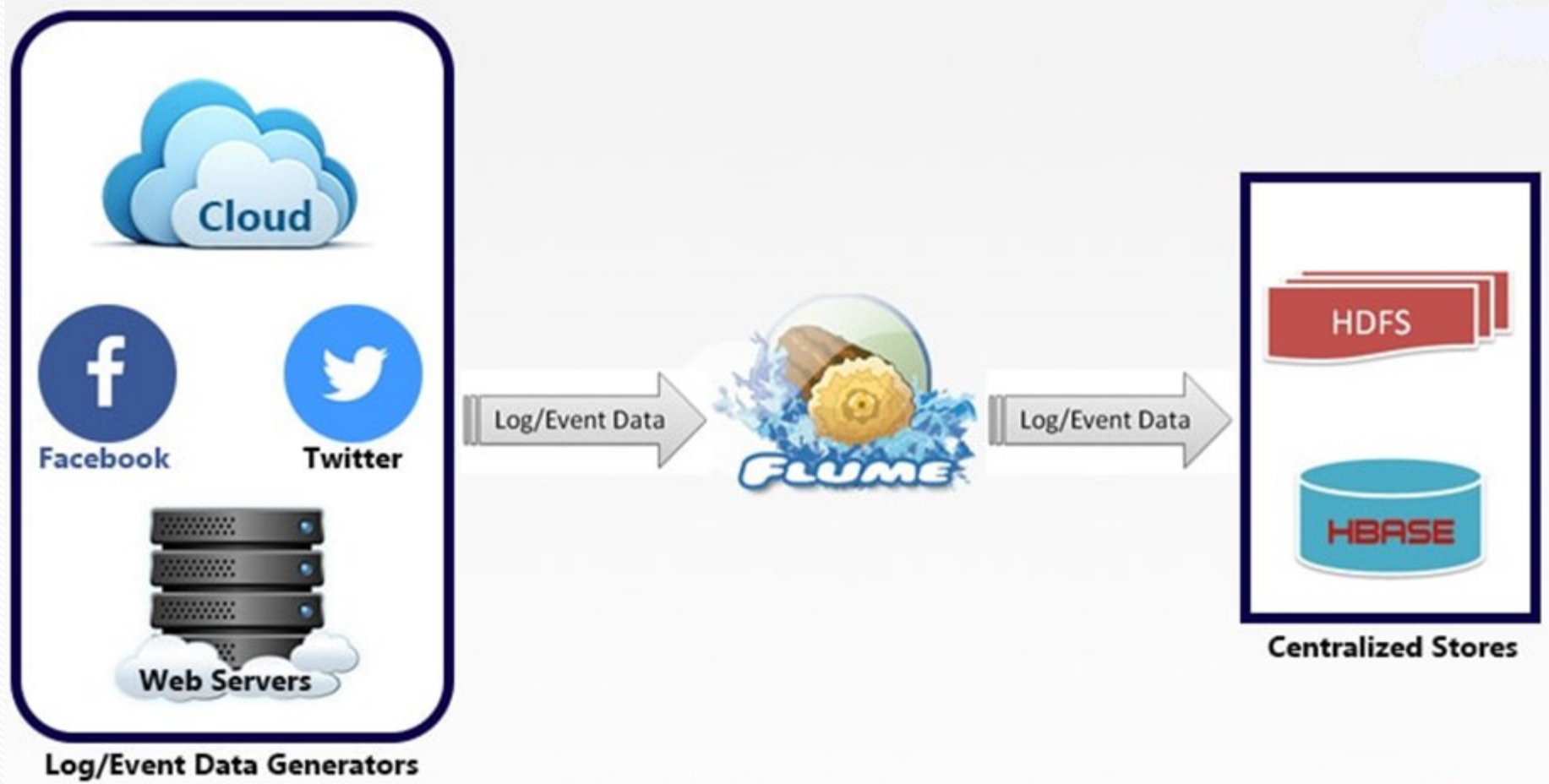
Apache Sqoop allows users to import data from a database into HDFS or export data from HDFS back to a database. To use Sqoop, you specify the tool you want to use and the arguments that control the tool. Sqoop uses MapReduce to import and export the data, which provides parallel operation as well as fault tolerance.

Science & Technology of Consciousness: TM is a tool which imports all the Nature support in our lives and exports the creative potential within into the atmosphere, thereby creating a blissful surrounding.

Apache Flume

- There are many systems which produce streams of data that we would like to aggregate, store, and analyze using Hadoop.
  - E.g. A bunch of log files are being produced by multiple applications and systems across multiple servers. There's no doubt that there's valuable information to be analyzed from these logs, but your first challenge is how to move these logs into your Hadoop cluster so that you can perform some analysis.
- So to push all of your production server system log files into HDFS, you'll use **Flume.**
- Flume is a service that basically lets you ingest streaming data (typically file data) into HDFS.
- Flume is developed by Cloudera for high-volume ingestion of event-based data into Hadoop.

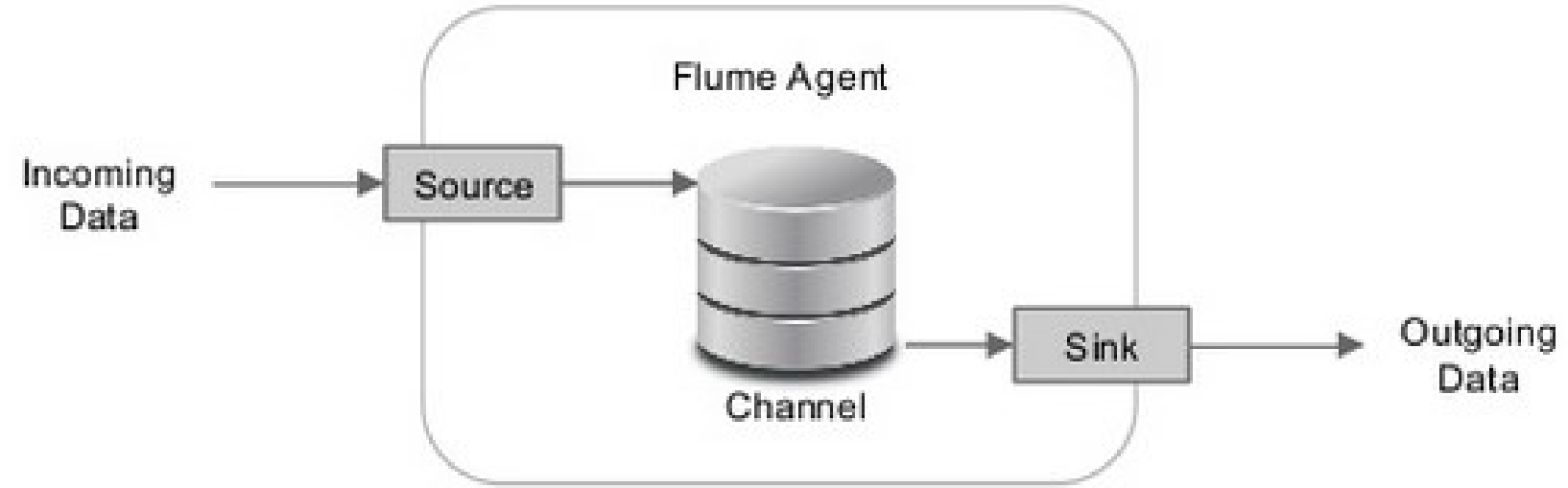
Apache Flume



Apache Flume

- Flume is a log file collection and distribution system and collecting system logs and transporting them to HDFS is its bread and butter.
- Flume is highly fault tolerant with many failover and recovery mechanisms which makes it a one-stop solution for data collection of all formats!
- To use Flume, we need to run a **Flume agent**, which is a long-lived Java process that runs ***sources*** and ***sinks***, connected by ***channels*** through which events flow from an external source to the next destination (hop).
- A **source** in Flume produces events and delivers them to the **channel**, which stores the events until they are forwarded to the **sink**.
- You can think of the **source-channel-sink** combination as a basic Flume building block.

Flume Building Blocks



Source

- Accepts incoming Data
- Scales as required
- Writes data to Channel

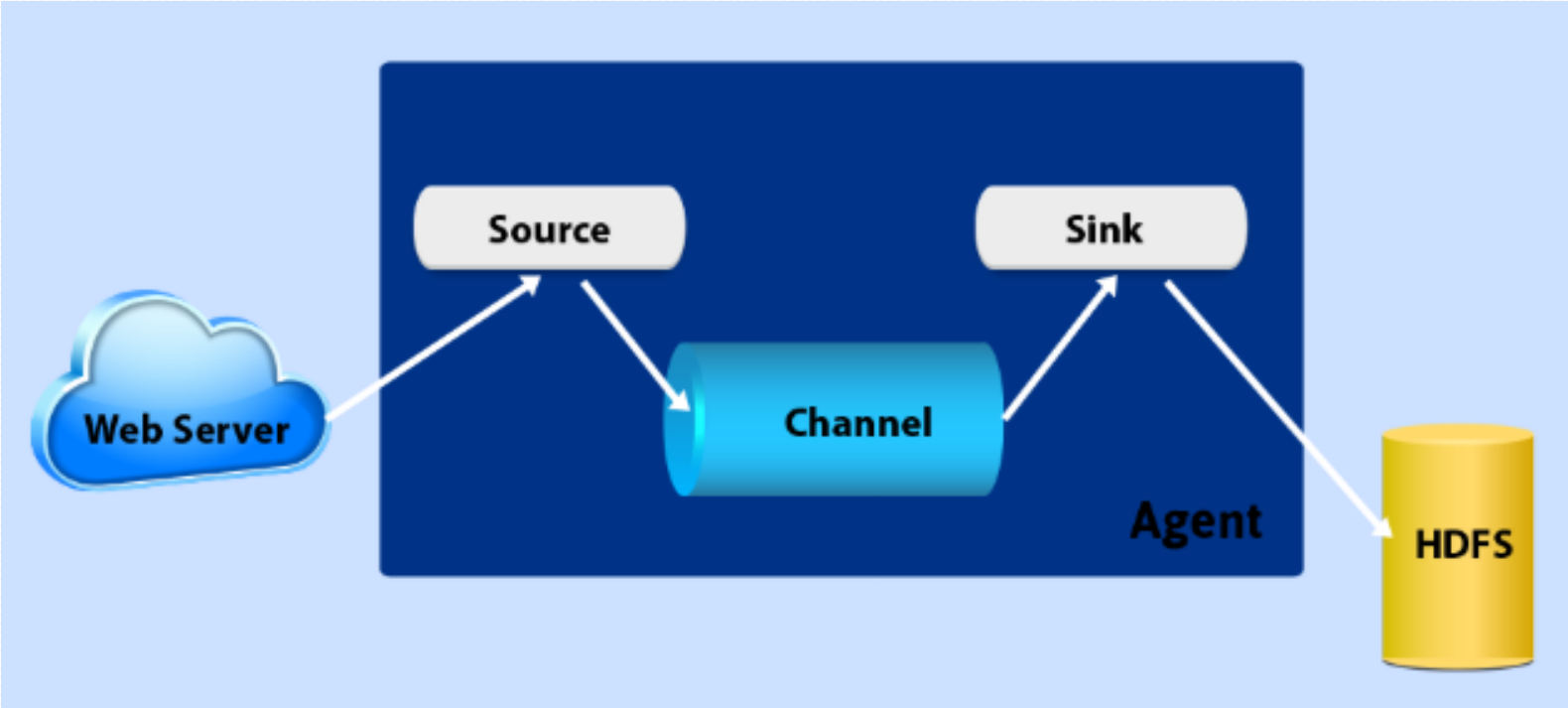
Channel

- Stores data in the order received

Sink

- Removes data from Channel
- Sends data to downstream Agent or Destination

Data Flow Model



- A Flume source consumes ***events*** delivered to it by an external source like a web server which sends events in a format that is recognized by the target Flume source.
- A ***Flume event*** is defined as a unit of data flow having a byte payload and an optional set of string attributes (header).

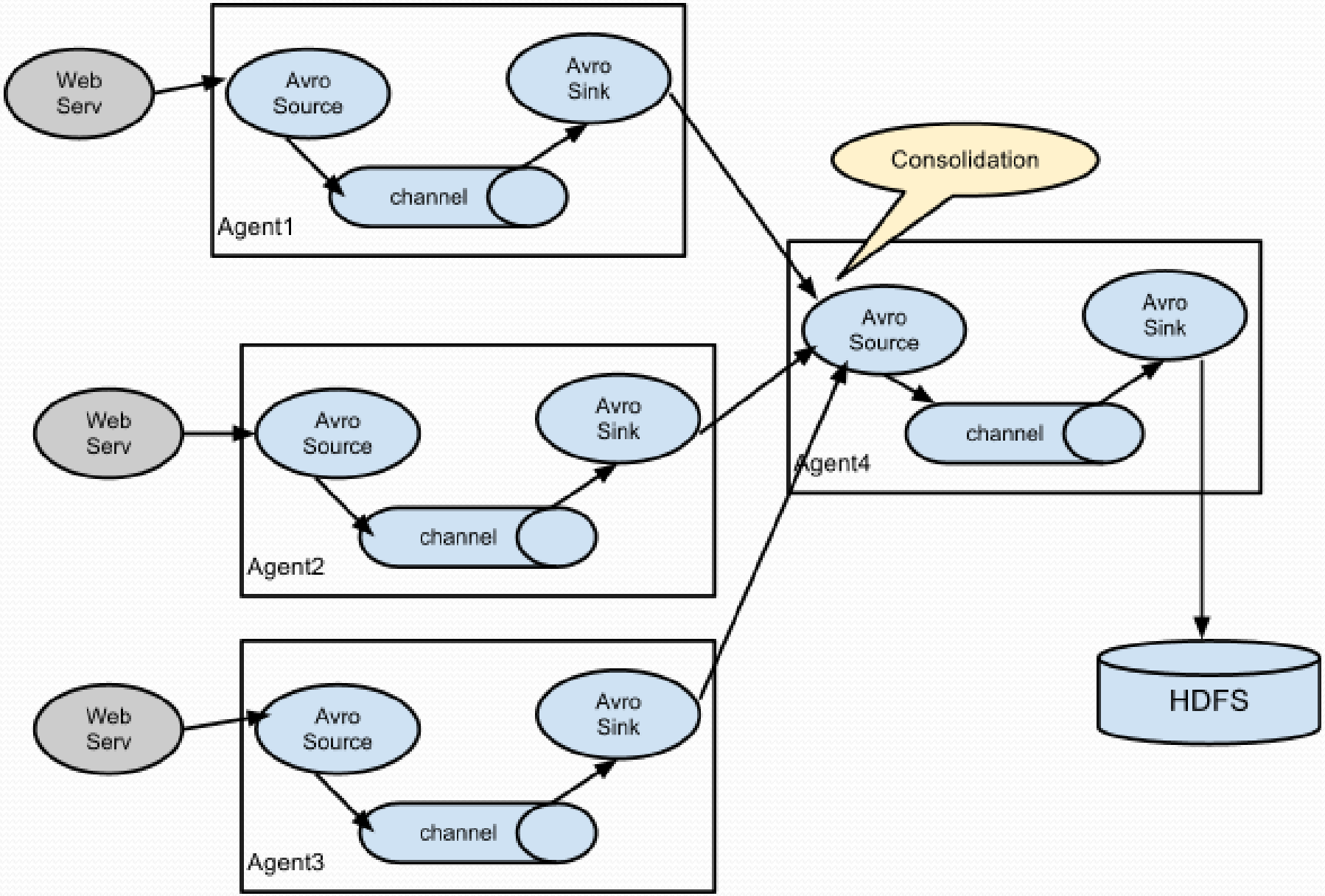
Data Flow Model contd..

- When a Flume source receives an event, it stores it into one or more channels.
- The channel is a passive store that keeps the event until it's consumed by a Flume sink.
  - The file channel is one example – it is backed by the local filesystem.
- The sink removes the event from the channel and puts it into an external repository like HDFS (via Flume HDFS sink) or forwards it to the Flume source of the next Flume agent (next hop) in the flow.
- The source and sink within the given agent run asynchronously with the events staged in the channel.

Complex Data Flows

- A Flume installation can be made up of a collection of connected agents running in a distributed topology.
- Agents on the edge of the system (co-located on web server machines, for example) collect data and forward it to agents that are responsible for aggregating and then storing the data in its final destination.
- Agents are configured to run a collection of particular sources and sinks, so using Flume is mainly a configuration exercise in wiring the pieces together.

Complex Data Flows



Channels

- Flume Channels are buffers that sit in between sources and sinks providing data storage facilities inside an agent.
- As such, channels allow sources and sinks to operate at different rates. Channels are key to Flume's guarantees of not losing data (of course, when configured properly)
- Sources add events to a channel, and sinks remove events from a channel.
- Channels provide durability properties inside Flume, and you pick a channel based on which level of durability and throughput you need for your application.

Types of Channels

- There are three main channels bundled with Flume:
  - **Memory channels** store events in an in-memory queue. This is very useful for high-throughput data flows, but they have no durability guarantees, meaning that if an agent goes down, you'll lose data.
  - **File channels** persist events to disk. The implementation uses an efficient write-ahead log and has strong durability properties.
  - **JDBC channels** store events in a database. This provides the strongest durability and recoverability properties, but at a cost to performance.
- Additional details on Flume channels

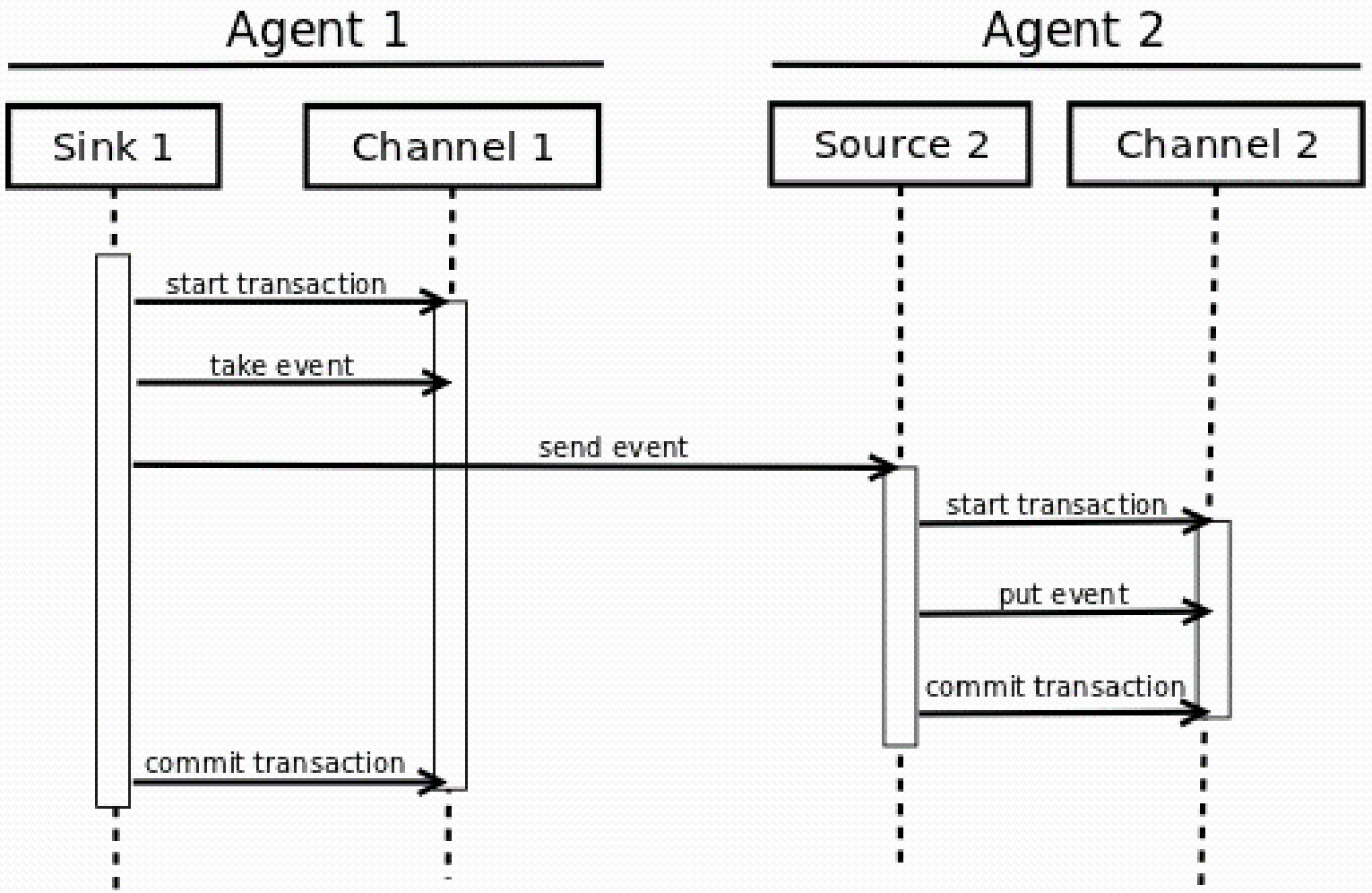
Transactions in Flume

- Flume is a transactional system.
  - Transactions are essentially batches of events written into or read from a channel atomically.
- Channels are transactional in nature. Each write to a channel and each read from a channel happens within the context of a transaction.
- Transactions are important to provide guarantees of exactly when an event is written to or removed from the channel.
  - For example, a sink could take an event from the channel and attempt to write it to HDFS and fail. In this case, the event should go back to the channel and be available for this sink or another one to take and write to HDFS.
- A Flume transaction consists of either *Puts* or *Takes*, but not both, and either a *commit* or a *rollback*.
  - Each transaction implements both a *Put* and *Take* method.
- Multiple events can be either *Put* or *Taken* in a single transaction.

Transactions in Flume contd...

- Sources do *Puts* onto the channel and Sinks do *Takes* from the channel.
- Events from a transaction will be readable by any sink only after the write transaction is committed.
- Also, if a sink has successfully *taken* an event, the event is not available for other sinks to take unless and until the sink rolls back the transaction.
  - Making sure that "*takes*" cause events to be removed only on transaction commit, guarantees that events are not lost even if the write fails once, at which point the sink can just roll back this transaction.
- Transactions could have one event or many events, but for performance reasons it is always recommended to have a reasonably large number of events per transaction.

Transactional Exchange Of Events Between Agents



Reliability in Flume

- An Event is staged in a Flume agent's Channel. Then it's the Sink's responsibility to deliver the Event to the next agent or terminal repository (like HDFS) in the flow.
- Sink removes an Event from the Channel only after the Event is stored into the Channel of the next agent or stored in the terminal repository.
- This is how the single-hop or multi-hop message delivery semantics in Flume provide end-to-end reliability of the flow.
- Flume uses the transactional approach (discussed earlier) to guarantee reliable delivery of the Events.
- The Sources and Sinks encapsulate the storage/retrieval of the Events in a Transaction provided by the Channel.
- This ensures that the set of Events are reliably passed from point to point in the flow.

Flume Agent Setup

- Flume agent configuration is stored in a local configuration file. This is a text file that follows the Java properties file format.
- Configurations for one or more agents can be specified in the same configuration file.
- The configuration file includes properties of each source, sink and channel in an agent and how they are wired together to form data flows.
- Each component (source, sink or channel) in the flow has a name, type, and set of properties that are specific to the type and instantiation.
- For example, an HDFS sink needs to know the file system URI, path to create files, frequency of file rotation (“hdfs.rollInterval”) etc. All such attributes of a component need to be set in the properties file of the hosting Flume agent.

Configuration File - Defining the Flow

- To define the flow within a single agent, you need to link the sources and sinks via a channel.
- List the sources, sinks and channels for the given agent, and then point the source and sink to a channel.
- A source instance can specify multiple channels, but a sink instance can only specify one channel.
- The format is as follows:

```
# list the sources, sinks and channels for the agent
<Agent>.sources = <Source>
<Agent>.sinks = <Sink>
<Agent>.channels = <Channel1> <Channel2>

# set channel for source
<Agent>.sources.<Source>.channels = <Channel1> <Channel2> ...

# set channel for sink
<Agent>.sinks.<Sink>.channel = <Channel1>
```

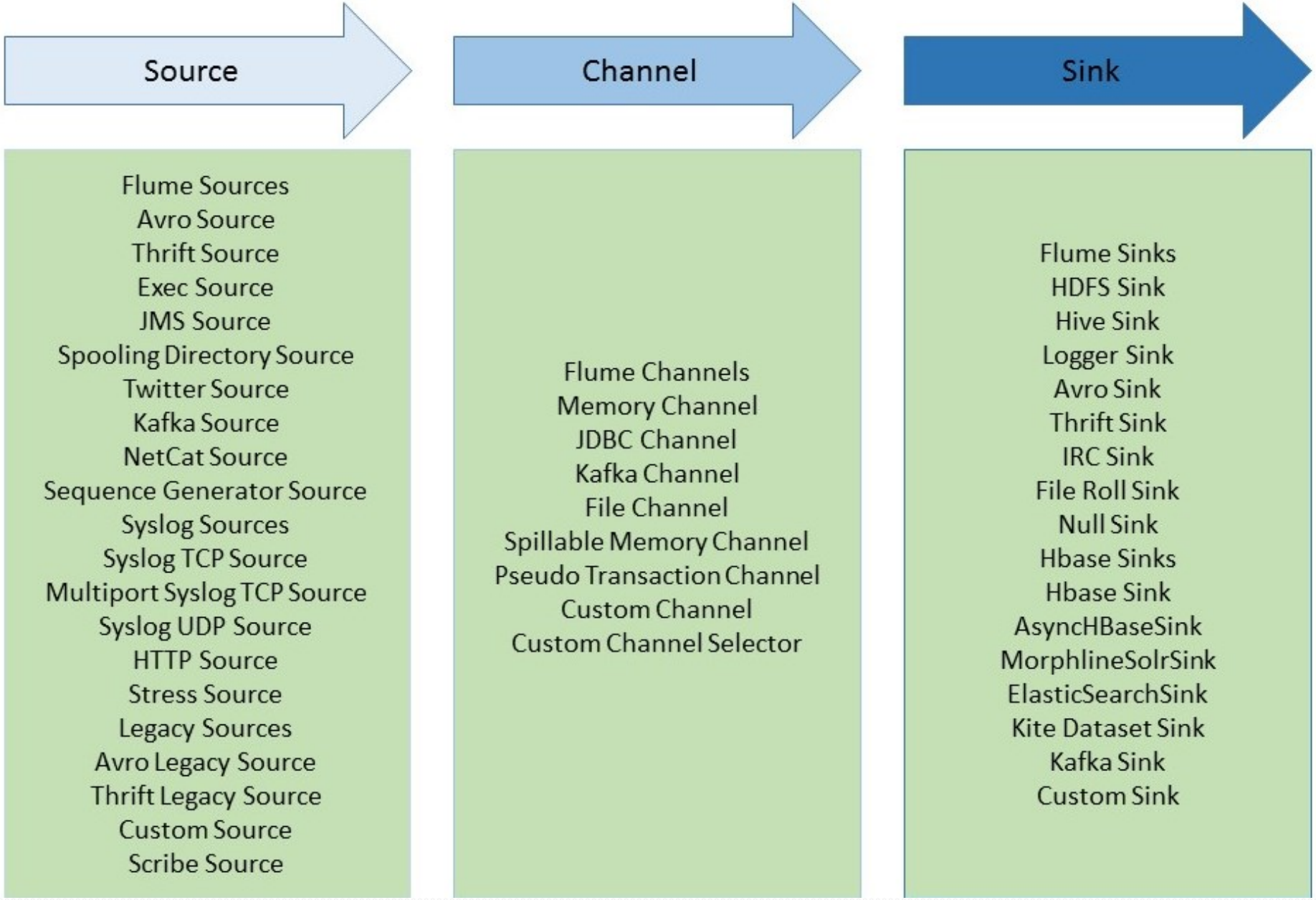
Complete Flume Configuration File Example

- Example of a flume configuration file which will setup all the components for the flume agent:
- The configuration file is for a simple sequence generator that continuously generates events with a counter that starts from 0, increments by 1 and stops at *totalEvents*.
- It retries when it can’t send events to the channel.
- Useful mainly for testing.

Flume Configuration File

```
# The configuration file needs to define the sources, the channels and the sinks.
# Sources, channels and sinks are defined per agent, in this case called 'myAgent'.
myAgent.sources = seqGenSrc
myAgent.channels = memoryChannel
myAgent.sinks = loggerSink

# For each one of the sources, the type is defined
myAgent.sources.seqGenSrc.type = seq

# The channel for the source can be defined as follows
myAgent.sources.seqGenSrc.channels = memoryChannel

# Each sink's type must be defined – logger sink for logging events to the console
myAgent.sinks.loggerSink.type = logger

#Specify the channel the sink should use
myAgent.sinks.loggerSink.channel = memoryChannel

# Each channel's type is defined.
myAgent.channels.memoryChannel.type = memory

# Other config values specific to each type of channel (or sink or source) can be
defined as well. In this case, it specifies the capacity of the memory channel
myAgent.channels.memoryChannel.capacity = 100
```

Examples of Source, Channel & Sink



Sources

- Flume *sources* are responsible for reading data from external clients or from other Flume sinks.
- A Flume source sends Flume events to one or more Flume channels, which deal with storage and buffering.
- Flume has an extensive set of built-in sources, including HTTP, JMS, and RPC.
  - Complete set of flume sources
- Let's take a look at the source-specific configuration properties that need to be set for an application that writes to a log file on disk and Flume tails the file, sending each line as an event.

Source Configuration

```
agent1.sources = tail_source1
# define tail source properties
agent1.sources.tail_source1.type = exec
agent1.sources.tail_source1.command = tail -F /cs523/log/messages
agent1.sources.tail_source1.channels = ch1
agent1.sources.tail_source1.shell = /bin/bash -c
agent1.sources.tail_source1.interceptors = ts
agent1.sources.tail_source1.interceptors.ts.type = timestamp
```

- The **exec** source allows you to execute a Unix command, and each line emitted in standard o/p is captured as an event (standard error is ignored by default).
- In the above example, the tail -F command is used to capture system messages as they are produced.

Interceptors in Sources

- **Interceptors** allow you to add metadata to events. They also give Flume the capability to modify/drop events in the flow.
- They are attached to sources and are run on events before the events have been placed in a channel.

- **Host interceptor**
  - This interceptor inserts the hostname or IP address of the host that this agent is running on.
  - It inserts a header with key host or a configured key whose value is the hostname or IP address of the host, based on configuration.

Timestamp Interceptors

- This interceptor inserts into the event headers, the time in millis at which it processes the event.
- It inserts a header with key *timestamp* whose value is the relevant timestamp.
- It can preserve an existing timestamp if it is already present in the configuration.
- The following extra configuration lines add a timestamp interceptor to source1, which adds a timestamp header to every event produced by the source:

```
agent1.sources.source1.interceptors = ts
agent1.sources.source1.interceptors.ts.type = timestamp
```

Channel Configuration

```
agent1.channels = ch1
# define in-memory channel
agent1.channels.ch1.type = memory
agent1.channels.ch1.capacity = 100000
agent1.channels.ch1.transactionCapacity = 1000
```

- The above configuration defined an in-memory channel and capped the number of events that it would store at 100,000.
- Once the max number of events is reached in a memory channel, it will start refusing additional requests from sources to add more events. Depending on the type of source, this means that the source will either retry or drop the event (*exec* source will drop the event).
- *TransactionCapacity* which is the maximum number of events the channel will take from a source or give to a sink per transaction is capped at 1000.

Sink

- A Flume sink drains events out of one Flume channel and will either forward these events to another Flume source (in a multihop flow) or handle the events in a sink-specific manner.
- A sink can read only from one channel, while multiple sinks can read from the same channel for better performance.
- There are a number of sinks built into Flume, including HDFS, HBase, Solr, and ElasticSearch.

Sink Configuration

```
agent1.sinks = hdfs_sink1
# define HDFS sink properties
agent1.sinks.hdfs_sink1.type = hdfs
agent1.sinks.hdfs_sink1.hdfs.path = /flume/%y%m%d/%H%M%S
agent1.sinks.hdfs_sink1.hdfs.fileType = DataStream
agent1.sinks.hdfs_sink1.channel = ch1
```

- Sink is configured here to write files based on a timestamp (note the %y and other timestamp aliases). This was possible because you decorated the events with a timestamp interceptor in the exec source earlier.
- In fact, you can use any header value to determine the output location for events (e.g, you can add a host interceptor and then write files according to which host produced the event).

HDFS Sink

- The HDFS sink can be configured in various ways to determine how files are rolled.
  - When a sink reads the first event, it will open a new file (if one isn't already open) and write to it.
  - By default, the sink will continue to keep the file open and write events into it for 30 seconds, after which it will close the file.
  - The rolling behaviour can be changed with the properties shown on the next slide.
- The default HDFS sink settings shouldn't be used in production, as they'll result in a large number of potentially small files. It's recommended that you either bump up the values or use a downstream compaction job to merge these small files.

Rollover Properties for Flume's HDFS Sinks

Name	Default	Description
hdfs.rollInterval	30	Number of seconds to wait before rolling current file (0 = never roll based on time interval)
hdfs.rollSize	1024	File size to trigger roll, in bytes (0: never roll based on file size)
hdfs.rollCount	10	Number of events written to file before it rolled (0 = never roll based on number of events)
hdfs.idleTimeout	0	Timeout after which inactive files get closed (0 = disable automatic closing of idle files)
hdfs.batchSize	100	number of events written to file before it is flushed to HDFS

Starting an Agent

- An agent is started using a shell script called flume-ng which is located in the bin directory of the Flume distribution.
- You need to specify the agent name, the config directory, and the config file on the command line:

```
$flume-ng agent –n $agent_name –c conf –f conf/flume-conf.properties.template
```

- Now the agent will start running source and sinks configured in the given properties file.

Main Point

Flume is a service that lets you ingest high-volume streaming data into HDFS. To use Flume, we need to run a Flume agent, which is a long-lived Java process that runs sources and sinks, connected by transactional channels through which events flow from an external source to the next destination.

Science & Technology of Consciousness: Maharishi's Science of Consciousness locates three components to any kind of knowledge: the knower, the object of knowledge, and the process of knowing. These can be found in the structure of a Flume Agent: the data that is coming into the Source is the "object of knowledge." The "knower" aspect of the agent is the Sink which is the destination of the data and the Channels are like the "process of knowing".