Cloud Computing Tools

Presented By,
Sasikumar Venkatesh,
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Apache Hadoop 2.7

Outline

- Hadoop - Basics
- HDFS
  - Goals
  - Architecture
- MapReduce
  - Basics
  - Word Count Example
- Setting up of Hadoop
  - Single Node (Pseudo Distributed Mode)

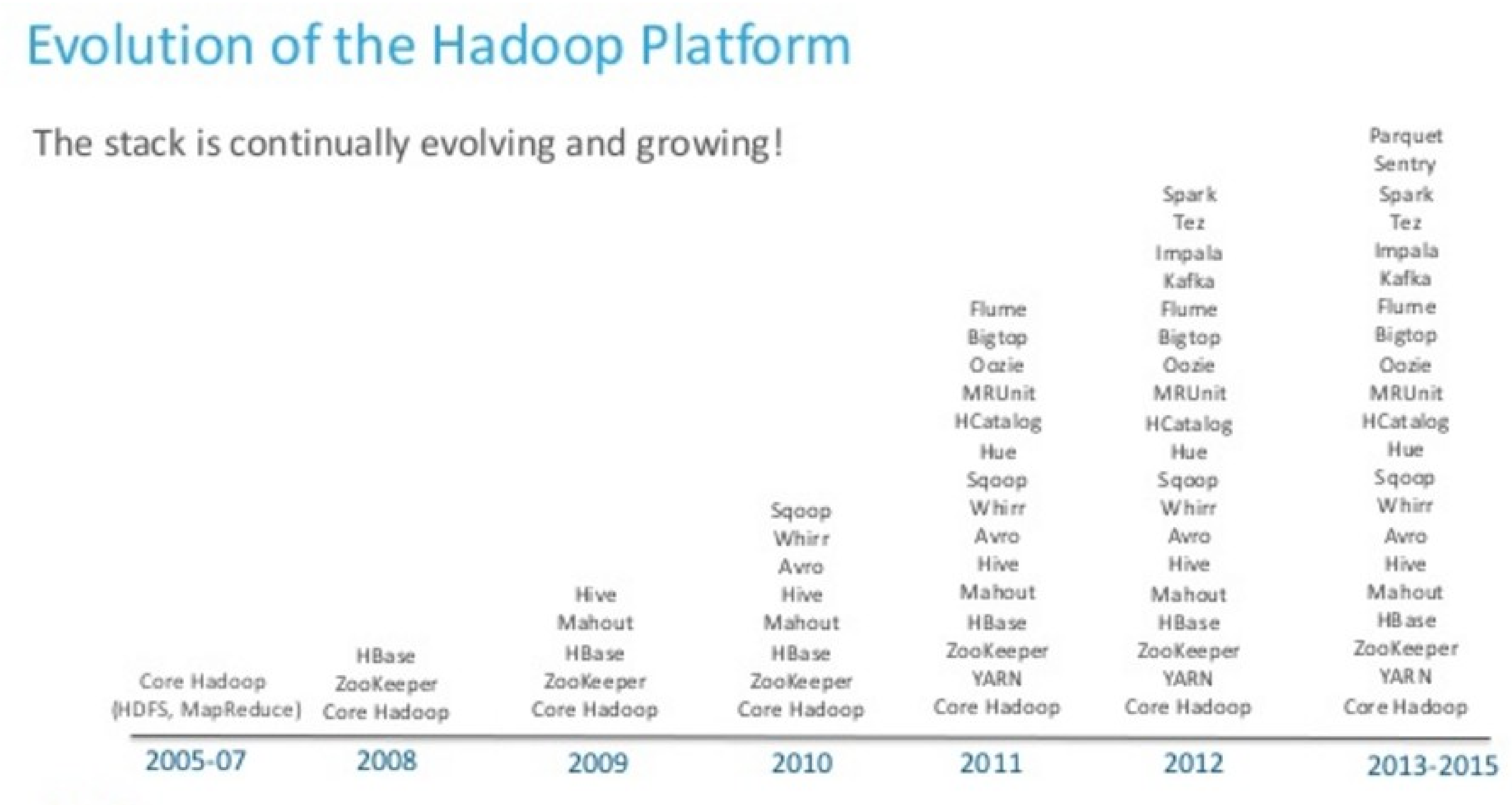
Hadoop - Why ?

- Need to process huge datasets on large clusters of computers
- Very expensive to build reliability into each application
- Nodes fail every day
  - Failure is expected, rather than exceptional
  - The number of nodes in a cluster is not constant
- Need a common infrastructure
  - Efficient, reliable, easy to use
  - Open Source, Apache License

Who uses Hadoop?

- Amazon/A9
- Facebook
- Google
- New York Times
- Veoh
- Yahoo!
- Netflix
- .... many more

Evolution of Hadoop



Evolution of the Hadoop Platform

The stack is continually evolving and growing!

Core Hadoop
(HDFS, MapReduce)
2005-07

HBase
ZooKeeper
Core Hadoop
2008

Hive
Mahout
HBase
ZooKeeper
Core Hadoop
2009

Sqoop
Whirr
Avro
Hive
Mahout
HBase
ZooKeeper
Core Hadoop
2010

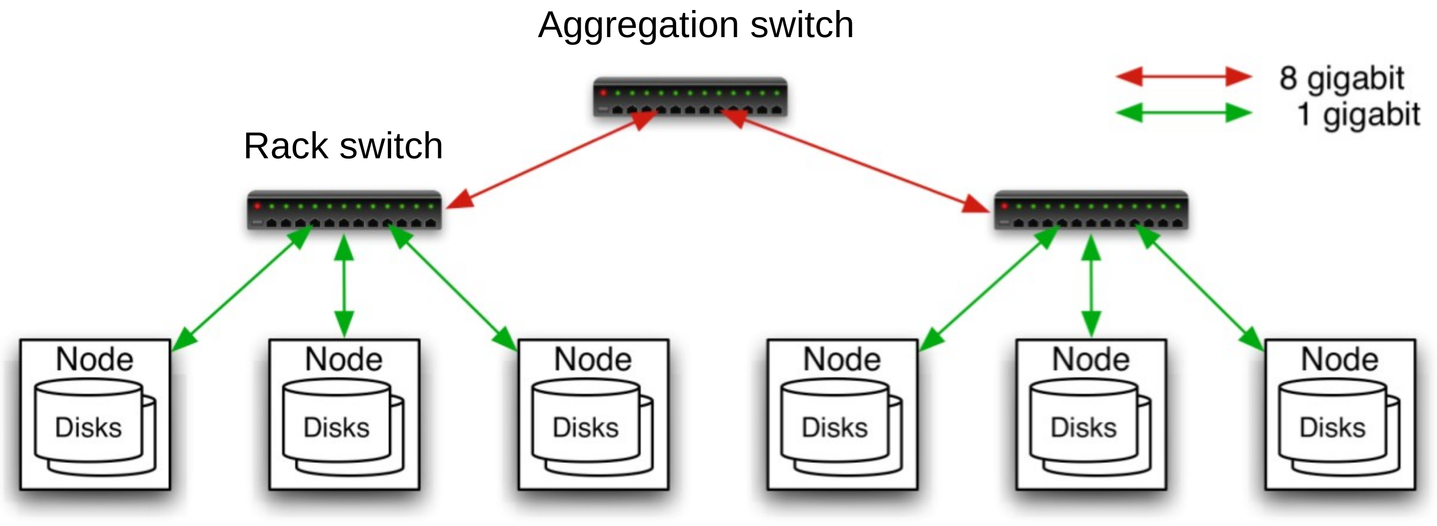
Flume
Bigtop
Oozie
MRUnit
HCatalog
Hue
Sqoop
Whirr
Avro
Hive
Mahout
HBase
ZooKeeper
YARN
Core Hadoop
2011

Spark
Tez
Impala
Kafka
Flume
Bigtop
Oozie
MRUnit
HCatalog
Hue
Sqoop
Whirr
Avro
Hive
Mahout
HBase
ZooKeeper
YARN
Core Hadoop
2012

Parquet
Sentry
Spark
Tez
Impala
Kafka
Flume
Bigtop
Oozie
MRUnit
HCatalog
Hue
Sqoop
Whirr
Avro
Hive
Mahout
HBase
ZooKeeper
YARN
Core Hadoop
2013-2015

Credit goes to, Cloudera

Commodity Hardware



- Typically in 2 level architecture
  - Nodes are commodity PCs
  - 30-40 nodes/rack
  - Uplink from rack is 3-4 gigabit
  - Rack-internal is 1 gigabit

Hadoop Distributed File System (HDFS)

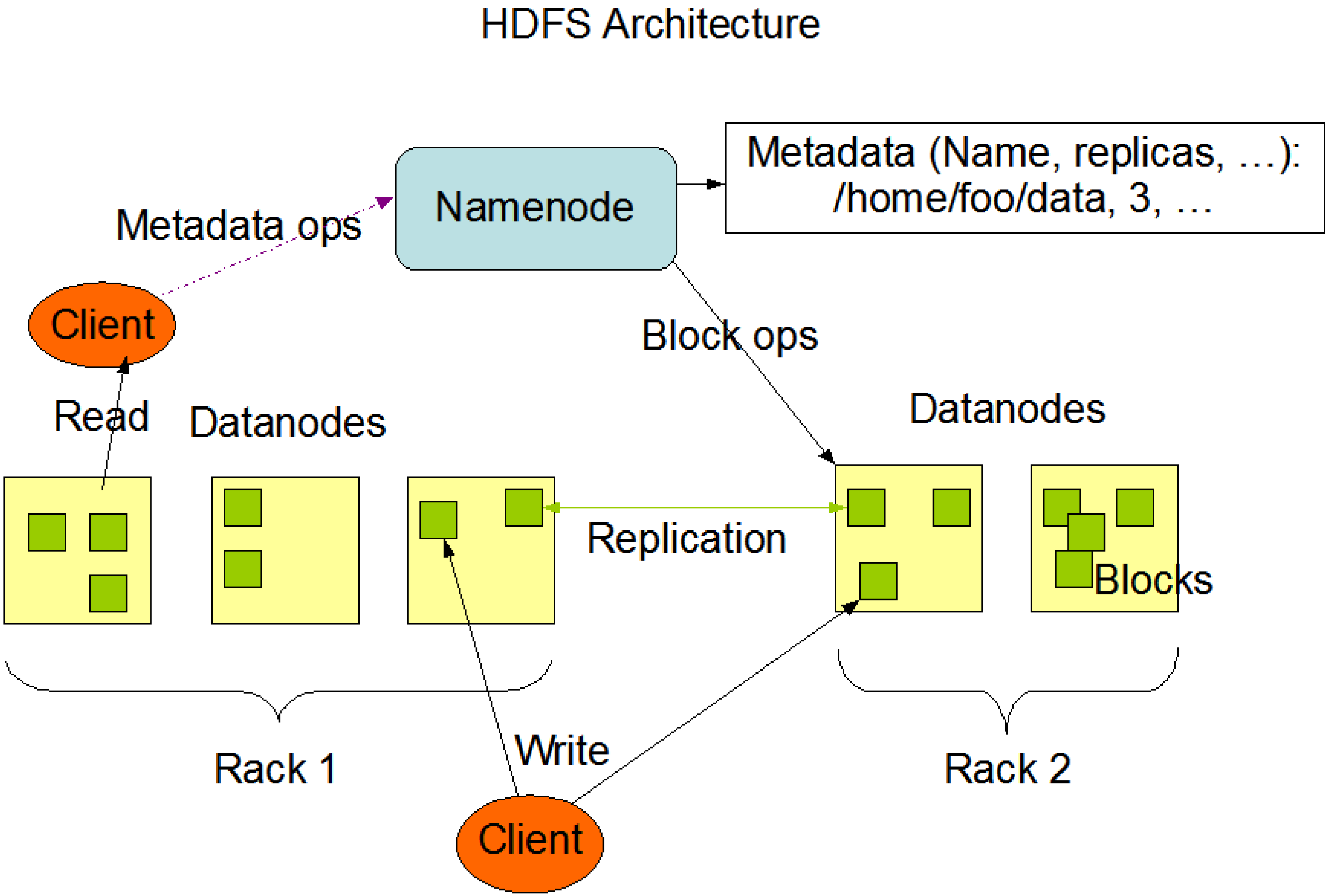
Goals of HDFS

- Very Large Distributed File System
  - 10K nodes, 100 million files, 10PB
- Assumes Commodity Hardware
  - Files are replicated to handle hardware failure
  - Detect failures and recover from them
- Optimized for Batch Processing
  - Data locations exposed so that computations can move to where data resides
  - Provides very high aggregate bandwidth

Distributed File System

- Single Namespace for entire cluster
- Data Coherency
  - Write-once-read-many access model
  - Client can only append to existing files
- Files are broken up into blocks
  - Typically 64MB block size
  - Each block replicated on multiple DataNodes
- Intelligent Client
  - Client can find location of blocks
  - Client accesses data directly from DataNode

HDFS Architecture



Functions of a NameNode

- Manages File System Namespace
  - Maps a file name to a set of blocks
  - Maps a block to the DataNodes where it resides
- Cluster Configuration Management
- Replication Engine for Blocks

NameNode Metadata

- Metadata in Memory
  - The entire metadata is in main memory
  - No demand paging of metadata
- Types of metadata
  - List of files
  - List of Blocks for each file
  - List of DataNodes for each block
  - File attributes, e.g. creation time, replication factor
- A Transaction Log
  - Records file creations, file deletions etc

DataNode

- A Block Server
  - Stores data in the local file system (e.g. ext3)
  - Stores metadata of a block (e.g. CRC)
  - Serves data and metadata to Clients
- Block Report
  - Periodically sends a report of all existing blocks to the NameNode
- Facilitates Pipelining of Data
  - Forwards data to other specified DataNodes

Heartbeats

- DataNodes send hearbeat to the NameNode
  - Once every 3 seconds
- NameNode uses heartbeats to detect DataNode failure

Replication Engine

- NameNode detects DataNode failures
  - Chooses new DataNodes for new replicas
  - Balances disk usage
  - Balances communication traffic to DataNodes

Data Correctness

- Use Checksums to validate data
  - Use CRC32
- File Creation
  - Client computes checksum per 512 bytes
  - DataNode stores the checksum
- File access
  - Client retrieves the data and checksum from DataNode
  - If Validation fails, Client tries other replicas

NameNode Failure

- A single point of failure
- Transaction Log stored in multiple directories
  - A directory on the local file system
  - A directory on a remote file system (NFS/CIFS)
- Need to develop a real HA solution

Secondary NameNode

- Copies FsImage and Transaction Log from Namenode to a temporary directory
- Merges FSImage and Transaction Log into a new FSImage in temporary directory
- Uploads new FSImage to the NameNode
  - Transaction Log on NameNode is purged

User Interface

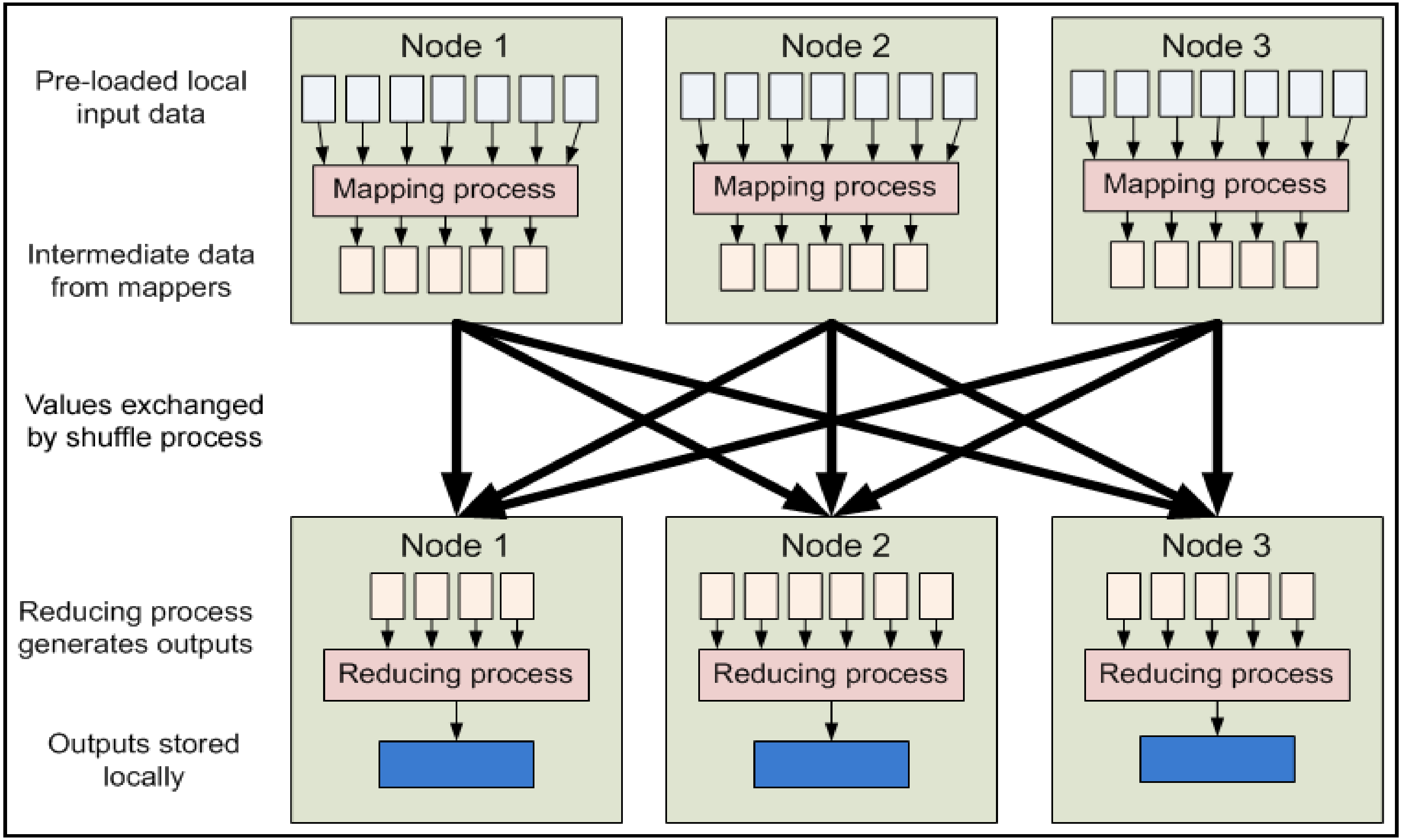
- Commads for HDFS User:
  - hadoop dfs -mkdir /foodir
  - hadoop dfs -cat /foodir/myfile.txt
  - hadoop dfs -rm /foodir/myfile.txt
- Commands for HDFS Administrator
  - hadoop dfsadmin -report
  - hadoop dfsadmin -decommision datanodename
- Web Interface
  - http://localhost:50070/dfshealth.jsp

MapReduce

MapReduce - What?

- MapReduce is a programming model for efficient distributed computing
- It works like a Unix pipeline
  - cat input | grep | sort | uniq -c | cat > output
  - **Input** | **Map** | Shuffle & Sort | **Reduce** | **Output**
- Efficiency from
  - Streaming through data, reducing seeks
  - Pipelining
- A good fit for a lot of applications
  - Log processing
  - Web index building

MapReduce - Dataflow



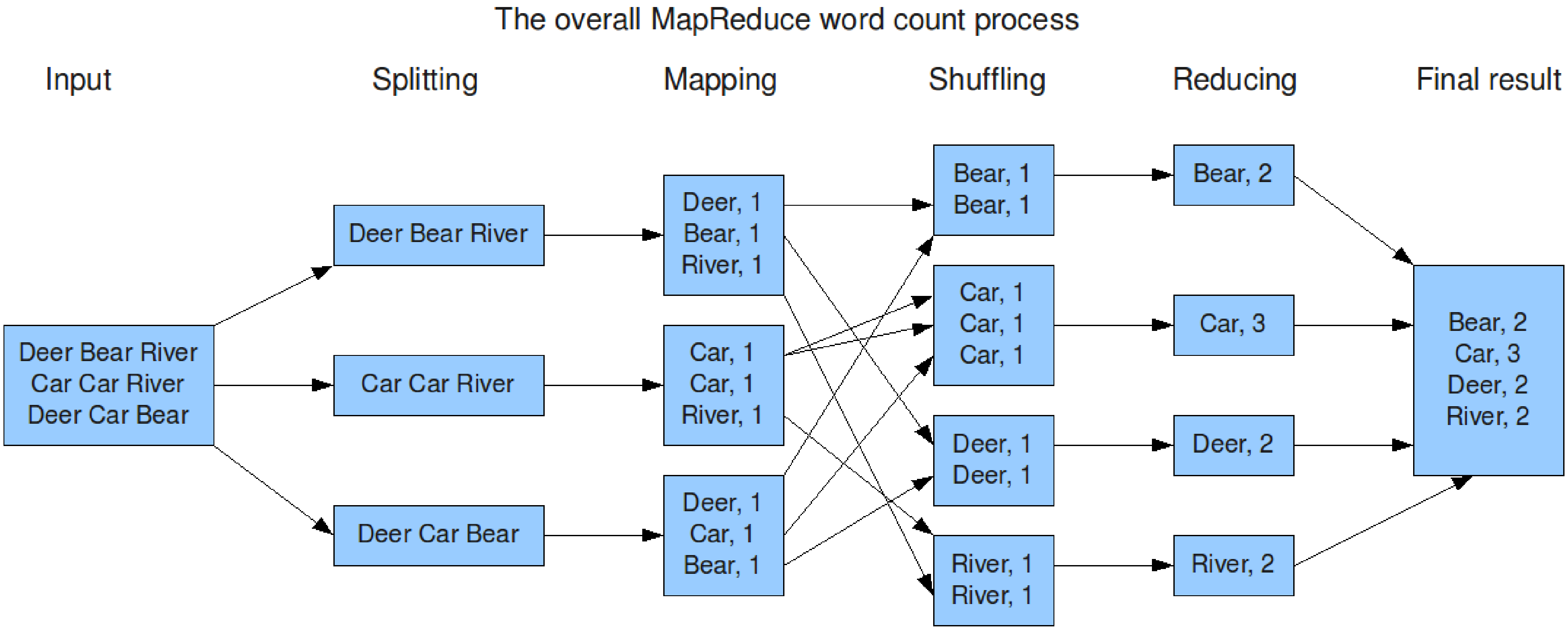
MapReduce - Features

- Fine grained Map and Reduce tasks
  - Improved load balancing
  - Faster recovery from failed tasks
- Automatic re-execution on failure
  - In a large cluster, some nodes are always slow or flaky
  - Framework re-executes failed tasks
- Locality optimizations
  - With large data, bandwidth to data is a problem
  - Map-Reduce + HDFS is a very effective solution
  - Map-Reduce queries HDFS for locations of input data
  - Map tasks are scheduled close to the inputs when possible

Word Count Example

- Mapper
  - Input: value: lines of text of input
  - Output: key: word, value: 1
- Reducer
  - Input: key: word, value: set of counts
  - Output: key: word, value: sum
- Launching program
  - Defines this job
  - Submits job to cluster

Word Count Dataflow



Word Count Mapper

```
public static class Map extends MapReduceBase implements
    Mapper<LongWritable,Text,Text,IntWritable> {
  private static final IntWritable one = new IntWritable(1);
  private Text word  = new Text();

  public static void map(LongWritable key, Text value,
    OutputCollector<Text,IntWritable> output, Reporter reporter) throws
    IOException {
     String line = value.toString();
     StringTokenizer = new StringTokenizer(line);
     while(tokenizer.hasNext()) {
        word.set(tokenizer.nextToken());
        output.collect(word,one);
        }
     }
  }
```

Word Count Reducer

```
public static class Reduce extends MapReduceBase implements
    Reducer<Text,IntWritable,Text,IntWritable> {
public static void map(Text key, Iterator<IntWritable> values,
    OutputCollector<Text,IntWritable> output, Reporter reporter)
    throws IOException {
         int sum = 0;
         while(values.hasNext()) {
            sum += values.next().get();
         }
         output.collect(key, new IntWritable(sum));
      }
  }
```

Word Count Example

- Jobs are controlled by configuring *JobConfs*
- JobConfs are maps from attribute names to string values
- The framework defines attributes to control how the job is executed
  - `conf.set(“mapred.job.name”, “MyApp”);`
- Applications can add arbitrary values to the JobConf
  - `conf.set(“my.string”, “foo”);`
  - `conf.set(“my.integer”, 12);`
- JobConf is available to all tasks

Hadoop Installation

Single Node (Pseudo Distributed Mode)

Steps to Follow

- Prerequisite
  - Ubuntu 14.04 / 15.04 LTS 64-Bit Machines
- Login as root/sudo user

```
Linux > sudo apt-get update
```

- Download the JDK1.8 tar.gz file from the following URL http://www.oracle.com/technetwork/java/javase/downloads/jdk8-downloads-2133151.html
- Untar the file using the following command,

```
Linux > tar xfz jdk-8u45-linux-x64.tar.gz
```

- Move the java to /usr/local/java

```
Linux > mv jdk1.8.0_45 /usr/local/java
```

-Contd,

- Set the Path and ClassPath Variables in ~/.bashrc

```
Linux > gedit ~/.bashrc
```

- Add the following line in the editor, save the file and exit.

```
export JAVA_HOME=/usr/local/java
export PATH=$JAVA_HOME/bin:{$PATH}
export CLASSPATH=$JAVA_HOME/lib
```

- `Linux> source ~/.bashrc or . ~/.bashrc`
- Verify JAVA is Installed or not using this Command

```
Linux> java -version
```

make sure that you can see the JAVA version

-Contd, **Installing Secure Shell**

```
Linux> sudo apt-get install ssh
Linux> sudo apt-get install rsync
```

- Best Practice,
  - Create a new user hadoop or hduser for running hadoop
  - Create and Setup SSH Certificates (Setup passphraseless ssh)
  - To enable password-less login, generate a new SSH key with an empty passphrase:
  - Use Hadoop User(hduser/hadoop):

```
Linux>ssh-keygen -t dsa -P '' -f ~/.ssh/id_dsa
Linux>cat ~/.ssh/id_dsa.pub >> ~/.ssh/authorized_keys
```

- Verify SSH,

```
Linux > ssh localhost
```

  - Make sure that you are able to connect localhost without the password.

Now, You are Ready to Install Hadoop ☺

- Fetcth Hadoop (Stable Version)
  - `Linux > wget http://apache.tradebit.com/pub/hadoop/common/current/hadoop-2.6.0.tar.gz`
  - Extract File,
  - `Linux> tar xfz hadoop-2.6.0.tar.gz`
  - Move the hadoop to local dir,
  - `Linux> mv hadoop-2.6.0 /usr/local/hadoop`
- Add the JAVA_HOME to hadoop-env.sh file
  - `Linux> gedit /usr/local/hadoop/etc/hadoop/hadoop-env.sh`
  - `Locate java_home and set`
  - `JAVA_HOME=/usr/local/java`
  - `Now, save and Exit the file.`

-Contd,

- Add the following lines to ~/.bashrc
  - Linux> gedit ~/.bashrc

```
        #HADOOP VARIABLES START
export HADOOP_INSTALL=/usr/local/hadoop
export PATH=$PATH:$HADOOP_INSTALL/bin
export PATH=$PATH:$HADOOP_INSTALL/sbin
export HADOOP_MAPRED_HOME=$HADOOP_INSTALL
export HADOOP_COMMON_HOME=$HADOOP_INSTALL
export HADOOP_HDFS_HOME=$HADOOP_INSTALL
export YARN_HOME=$HADOOP_INSTALL
export HADOOP_COMMON_LIB_NATIVE_DIR=$HADOOP_INSTALL/lib/native
export HADOOP_OPTS="-Djava.library.path=$HADOOP_INSTALL/lib"
export HADOOP_CLASSPATH=$JAVA_HOME/lib/tools.jar
#HADOOP VARIABLES END
```

Now, save the file and Exit.

```
Linux> . ~/.bashrc
```

-Contd,

- Add the following <property> tag to core-site.xml

```
Linux> gedit /usr/local/hadoop/etc/hadoop/core-site.xml
   <property>
         <name>fs.default.name</name>
         <value>hdfs://localhost:9000</value>
   </property>
```

Now, save the file and Exit.

- Add the following <property> tags to yarn-site.xml

```
   Linux> gedit /usr/local/hadoop/etc/hadoop/yarn-site.xml
<property>
   <name>yarn.nodemanager.aux-services</name>
   <value>mapreduce_shuffle</value>
</property>
<property>
   <name>yarn.nodemanager.aux-services.mapreduce.shuffle.class</name>
   <value>org.apache.hadoop.mapred.ShuffleHandler</value>
</property>
```

Now, save the file and Exit.

-Contd,

- Add the following <property> tag to core-site.xml
- Copy the MapRed-site.xml.template file to MapRed-site.xml
- Linux>cp /usr/local/hadoop/etc/hadoop/mapred-site.xml.template /usr/local/hadoop/etc/hadoop/mapred-site.xml
- Linux> gedit /usr/local/hadoop/etc/hadoop/mapred-site.xml

```
<property>
          <name>mapreduce.framework.name</name>
          <value>yarn</value>
</property>
```

Now, save the file and Exit.

- Add the following <property> tags to hdfs-site.xml
- Create Namenode and Datanode directories
- Linux> mkdir -p /usr/local/hadoop_store/hdfs
- Linux> gedit /usr/local/hadoop/etc/hadoop/hdfs-site.xml

```
<property>
          <name>dfs.replication</name>
          <value>1</value>
</property>
<property>
          <name>dfs.namenode.name.dir</name>
          <value>file:/usr/local/hadoop_store/hdfs/namenode</value>
</property>
<property>
          <name>dfs.datanode.data.dir</name>
          <value>file:/usr/local/hadoop_store/hdfs/datanode</value>
</property>
```

Now, save the file and Exit.

Cheers, two more steps to go.

- Replace sasz: with your hadoop users(hduser/hadoop) to be the owner of the folder

```
Linux> sudo chown sasz:sasz -R /usr/local/hadoop
Linux> sudo chown sasz:sasz -R /usr/local/hadoop_store
```

also give the folder the full permission

```
Linux> sudo chmod -R 777 /usr/local/hadoop
Linux> sudo chmod -R 777 /usr/local/hadoop_store
```

- Format your HDFS, make sure you have logged in as hadoop/hduser user.

```
Linux> hdfs namenode -format
```

- Start/Stop the Hadoop Cluster.

```
Linux> start-all.sh or stop-all.sh
```

Congratulations!!, You have successfully done installation of Hadoop

- Access the User Inerfaces
- ResourceManager @- http://localhost:8088/
- NameNode @- http://localhost:50070/

Thank You!