MapReduce Running Jobs

Originals of slides and source code for examples: http://www.coreservlets.com/hadoop-tutorial/

Also see the customized Hadoop training courses (onsite or at public venues) – http://courses.coreservlets.com/hadoop-training.html

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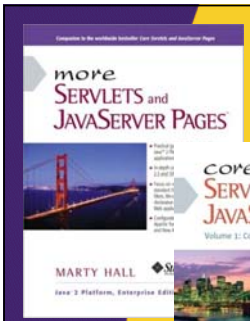
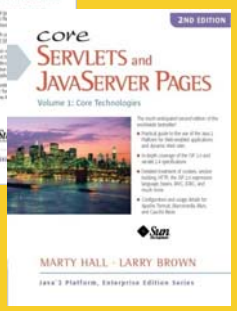
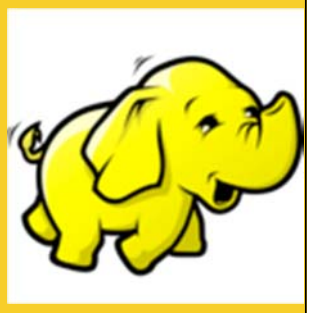






Agenda

- Tool, ToolRunner and GenericOptionsParser
- Running MapReduce Locally
- Running MapReduce on Cluster
- Packaging MapReduce Jobs
- MapReduce CLASSPATH
- Submitting Jobs
- Logs and Web UI

Tool and ToolRunner

- Utilize Tool and ToolRunner to stage and configure MapReduce jobs
- Tool – an interface designed to deal with command line arguments
  - Standard for any MapReduce application

```
public interface Tool extends Configurable {
  int run(String [] args) throws Exception;
}
```

  - Configurable interface defines a getter and setter for Configuration object

```
public interface Configurable {
  void setConf(Configuration conf);
  Configuration getConf();
}
```

ToolRunner

- **Utility to run classes that implement Tool**
- **Delegates to GenericOptionsParser**
  - Utility that parses command line arguments
  - Sets the arguments on Configuration object
  - Enables the command line usage we've already seen:
    - $yarn command [genericOptions]
  - Usually NOT used directly

Tool and ToolRunner Usage

```
public class MyTool extends Configured implements Tool{


  @Override
  public int run(String[] args) throws Exception {
       Job job =
          Job.getInstance(getConf(), "MyToolJob");
       ...
       ...
       return job.waitForCompletion(true) ? 0 : 1;
  }


  public static void main(String[] args) throws Exception {
       int exitCode = ToolRunner.run(new MyTool(), args);
       System.exit(exitCode);
  }
}
```

Configured implements getters and setters for Configuration object

Typical creation of Job object

Execute the job

GenericOptionsParser

```
$ yarn command [genericOptions] [commandOptions]
```

Generic Option	Description
-conf <conf_file.xml>	Adds the properties inside the provided file to the Configuration object
-Dproperty=value	Set's the provided property to the provided value in the Configuration object
-fs URI	-fs URI Overrides the default filesystem with the provided URI; similarly you can accomplish the same via -Dfs.default.name=URI
-files <file,file,file>	Makes the provided files readily available to MapReduce jobs by copying files to DistributedCache
-libjars <f.jar, f2.jar>	Adds the provided jars to the tasks' CLASSPATH for the MapReduce job

```
$ yarn jar $PLAY_AREA/HadoopSamples.jar  \
   mr.wordcount.StartWithCountJob_HBase \
   -libjars $HBASE_HOME/hbase-0.92.1-cdh4.0.0-security.jar
```


GenericOptionsParser Format and Example

```
$ yarn command [genericOptions] [commandOptions]
```

```
$yarn \
jar $PLAY_AREA/HadoopSamples.jar \
mr.wordcount.StartsWithCountJob \
-libjars hbase-0.92.1-cdh4.0.0b2-security.jar \
-D mapreduce.job.reduces=10 \
/training/playArea/hamlet.txt \
/training/playArea/wordCount/
```

command

generic Options

command Options

**Available MapReduce Options:
http://hadoop.apache.org/docs/r2.0.0-alpha/hadoop-mapreduce-client/hadoop-mapreduce-client-core/mapred-default.xml

Running MapReduce Locally

- **Hadoop is packaged with a local job runner**
  - Run MapReduce code in a single JVM
  - Great for IDE usage, can even use a debugger
  - Handy for testing
  - Note: Can only support single Reducer and silently ignores when more than 1 reduce is configured
- **Enable local mode by setting mapreduce.framework.name property to local**

```
$ yarn jar $PLAY_AREA/HadoopSamples.jar    \
      mr.wordcount.StartsWithCountJob      \
      -D mapreduce.framework.name=local    \
      /training/playArea/hamlet.txt        \
     /training/playArea/wordCount/
```


Running MapReduce Locally

- **Previous call still utilized HDFS**
  - HDFS is set as the default FileSystem in core-site.xml
- **You can override default file system so full MapReduce life-cycle is executed locally**
  - fs generic option

```
$ yarn jar $PLAY_AREA/HadoopSamples.jar              \
       mr.wordcount.StartsWithCountJob               \
       -D mapreduce.framework.name=local             \
       -fs file:///                                  \
       /home/hadoop/Training/exercises/sample_data   \
       $PLAY_AREA/wordCountOutput/
```

  - Specify filesystem in each path

```
$ yarn jar $PLAY_AREA/HadoopSamples.jar                    \
       mr.wordcount.StartsWithCountJob                     \
       -D mapreduce.framework.name=local                   \
       file:/home/hadoop/Training/exercises/sample_data    \
       file:$PLAY_AREA/wordCountOutput/
```

LocalJobRunner in Unit Test - StartsWithCountJobTests.java

```
public class StartsWithCountJobTests {

  private File inputFile =
       new File("./target/test/input.txt");
  private File output = new File("./target/test-result/");

  @Before
  public void setUpTest() throws IOException{
       FileUtils.deleteQuietly(inputFile);
       FileUtils.deleteQuietly(output);
       FileUtils.writeStringToFile(inputFile,
                    "this is just a test, yes it is");
  }
...
...
...
```

This will serve as an input text to the job under test

StartsWithCountJobTests.java

```
@Test
public void testRun() throws Exception {
  Configuration conf = new Configuration();
  conf.set("mapreduce.framework.name", "local");
  conf.set("fs.default.name", "file:///");

  StartsWithCountJob underTest = new StartsWithCountJob();
  underTest.setConf(conf);

  int exitCode = underTest.run(
       new String[]{inputFile.getAbsolutePath(),
                output.getAbsolutePath()});
  assertEquals("Returned error code.", 0, exitCode);
  assertTrue(new File(output, "_SUCCESS").exists());
  Map<String,Integer> resAsMap =
       getResultAsMap(new File(output, "part-r-00000"));

  assertEquals(5, resAsMap.size());
  assertEquals(2, resAsMap.get("t").intValue());
  assertEquals(3, resAsMap.get("i").intValue());
  assertEquals(1, resAsMap.get("j").intValue());
  assertEquals(1, resAsMap.get("a").intValue());
  assertEquals(1, resAsMap.get("y").intValue());
}
```

Configure the job to run locally

Use local filesystem

Execute the job

For verification, convert contents of reduce output to a map

StartsWithCountJobTests.java

```
private Map<String, Integer> getResultAsMap(File file)
              throws IOException {

  Map<String, Integer> result = new HashMap<String, Integer>();
  String contentOfFile = FileUtils.readFileToString(file);
  for (String line : contentOfFile.split("\n")){
    String [] tokens = line.split("\t");
    result.put(tokens[0], Integer.parseInt(tokens[1]));
  }
  return result;
}
```

Parse expected file
(1) there is a key-value pair per line
(2) key is tab separated from value
Here is sample format

a	1
i	3
j	1
t	2
y	1

Provide Local Configuration File

- **Another way to configure your job is to create a configuration file and provide it via -conf options**

```
$ yarn jar $PLAY_AREA/HadoopSamples.jar            \
      mr.wordcount.StartsWithCountJob              \
      -conf $PLAY_AREA/local/run-local-config.xml  \
      /home/hadoop/Training/exercises/sample_data  \
      $PLAY_AREA/wordCountOutput/
```

- **Each property specified in run-local-config.xml will be set on StartsWithCountJob's Configuration object**

run-local-config.xml

```
<?xml version="1.0"?>
<?xml-stylesheet type="text/xsl" href="configuration.xsl"?>
<configuration>
  <property>
    <name>fs.default.name</name>
    <value>file:///</value>
  </property>
  <property>
    <name>mapreduce.framework.name</name>
    <value>local</value>
  </property>
</configuration>
```


Running Your Job on a Cluster

1. **Package a Job**
   - Set up Job's and Task's CLASSPATH
2. **Submit a Job**
3. **Monitor a Job**

Package a Job

- **Package classes into a JAR file**
  - Already been doing that
  - Will submit the job to the Hadoop/YARN cluster
    - $yarn jar MyJar.jar com.jobs.JobTool
  - May want to utilize a tool to create a jar file such as Maven or Ivy
- **In the implementation of Tool call Job.setJarByClass()**
  - Provide a class that exists in your jar
  - Framework will locate the jar by scanning classpath for the provided class
- **Optionally package dependencies**
  - Package jar files in a lib sub-directory inside your jar
  - Package resource files in the classes sub-directory inside your jar

MapReduce CLASSPATH

- **Client's CLASSPATH**
  - "$yarn jar blah.jar com.JobClass" command executes within "client" JVM
  - Tool's implementation CLASSPATH
- **Task's CLASSPATH**
  - Map and Reduce tasks
  - Executes on the cluster => remote machine(s)

Client's CLASSPATH

- **CLASSPATH is made of**
  - The classes in the provided JAR which contains the job
  - Jar files in the lib sub-directory of the job's Jar
  - Resource files in the classes sub-directory of the job's Jar
  - JARs specified on the HADOOP_CLASSPATH environment variable
    - IMPORTANT: set in the $HADOOP_CONF_DIR/hadoop-env.sh
- **To see what is on CLASSPATH**

```
$ yarn classpath
/home/hadoop/Training/CDH4/hadoop-2.0.0-
cdh4.0.0/conf:/home/hadoop/Training/CDH4/hadoop-2.0.0-
cdh4.0.0/conf:/home/hadoop/Training/CDH4/hadoop-2.0.0-
cdh4.0.0/conf:/home/hadoop/Training/CDH4/hadoop-2.0.0-
cdh4.0.0/share/hadoop/common/lib/*....
```


Task's CLASSPATH

- **Task's CLASSPATH is made of**
  - The classes in the actual JAR that contains the job
  - Jar files in the lib sub-directory of the job's Jar
  - Resource files in the classes sub-directory of the job's Jar
  - Jars added to classpath via DistributedCache
    - $yarn jar job.jar com.Job -libjars jar1.jar,jar2.jar
    - job.addFileToClassPath(path)
- **Does NOT use $HADOOP_CLASSPATH environment variable**
- **Benefit vs. Fallback for DistributedCache usage**
  - Add them once, no need to build them into the JAR
  - Reduces bandwidth usage
  - NOT as flexible as other approach - if you package classes into a JAR then each job can utilize their own unique dependencies

Dependency Conflicts

- **Hadoop's Jars are added to the CLASSPATH as well**
  - User's and Framework's code runs off the same CLASSPATH
- **Hadoop's internal dependencies by default take priority over the provided Jars**
- **User can override jar loading precedence**
  - Client's CLASSPATH by setting HADOOP_USER_CLASSPATH_FIRST environment variable to true
  - Task's CLASSPATH by setting mapreduce.task.classpath.first property to true.
  - WARNING: Changing will alter class loading for the Hadoop itself which may cause unexpected results. Use with caution.

Submit a Job

```
yarn jar ~/Training/play_area/HadoopSamples.jar \
       mr.wordcount.StartsWithCountJob \
       /training/playArea/hamlet.txt \
       /training/playArea/wordCount/
...
...
(Job.java:monitorAndPrintJob(1270)) - Running job:
job_1339291219653_0026
(Job.java:monitorAndPrintJob(1291)) - Job job_1339291219653_0026
running in uber mode : false
(Job.java:monitorAndPrintJob(1298)) -  map 0% reduce 0%
(Job.java:monitorAndPrintJob(1298)) -  map 100% reduce 0%
(Job.java:monitorAndPrintJob(1298)) -  map 100% reduce 100%
(Job.java:monitorAndPrintJob(1309)) - Job job_1339291219653_0026
completed successfully
(Job.java:monitorAndPrintJob(1316)) - Counters: 43
  File System Counters
    FILE: Number of bytes read=798
    FILE: Number of bytes written=99384
    FILE: Number of read operations=0
    FILE: Number of large read operations=0
...
```

Refer to this job by this id

job.waitForCompletion(true) executes the job and prints progress to the screen

Job ID

Resource Manager Start Timestamp

Counter

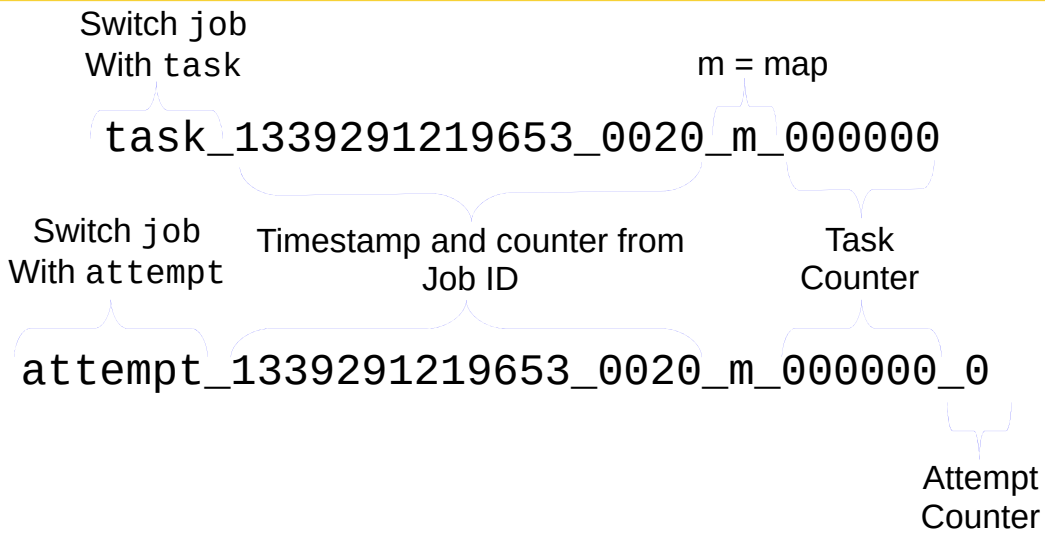
```
job_1339803233775_0002
```

- **Use Job ID as a reference**
  - In the logs
  - In the Web UI
  - Via $mapred job command

$mapred job Commandx

- **Get the status of a job**
  - $ mapred job -status <job_id>
- **Kill a Job**
  - $ mapred job -kill <job_id>
- **View logs of a task attempt**
  - $ mapred job -logs <job_id> <attempt_id>
    - Can not view logs of a running job – use management Web UI
- **Learn about other options**
  - $ mapred job

Task ID and Attempt ID



- **Job is made of tasks**
- **Tasks are made of attempts**

Logs

- **Hadoop uses Log4j for logging, to learn more about log4j please visit http://logging.apache.org/log4j/1.2/**
- **Hadoop maintains several log types**
  - System Daemon Logs
  - Audit Logs
  - MapReduce Job and Task History Logs

System Daemon Logs

- **Logs' format**

  product + username + daemon + machine hostname . out

- **HDFS Logs located under $HADOOP_LOG_DIR**
  - set hadoop-env.sh.
    - hadoop-dima-namenode-host.out
    - hadoop-dima-datanode-host.out
    - hadoop-dima-secondarynamenode-host.out
- **MapReduce and Yarn Logs located under $YARN_LOG_DIR**
  - Set in yarn-env.sh
    - yarn-dima-resourcemanager-host.out
    - yarn-dima-nodemanager-host.out
    - yarn-dima-historyserver-host.out

System Daemon Logs

- **Daemon Logs are configured by editing log4j configuration**
  - $HADOOP_CONF_DIR/log4j.properties

Audit Log(s)

- **Hadoop is capable of logging audit events**
  - HDFS Audit
  - MapReduce Audit
- **Implemented via log4j**
- **Modify $HADOOP_CONF_DIR/log4j.properties**
  - For example: log4j.logger.org.apache.hadoop.hdfs.server.namenode.FSNamesystem.audit = INFO
- **Full instructions can be found at**
  - http://wiki.apache.org/hadoop/HowToConfigure

MapReduce Job's Logs

- **Job and task information and their logs are archived to the history server**
  - View Job and Tasks Logs
  - History Server Hosts Web UI
    - http://localhost:19888/jobhistory
- **Can also use $mapred job command**
  - $ mapred job -logs job_1339817050993_0001 | more
    - Get logs for the job
  - $ mapred job -logs job_1339817050993_0001 attempt_1339817050993_0001_m_000000_0 | more
    - Get logs for the task's attempt

MapReduce Job's Logs

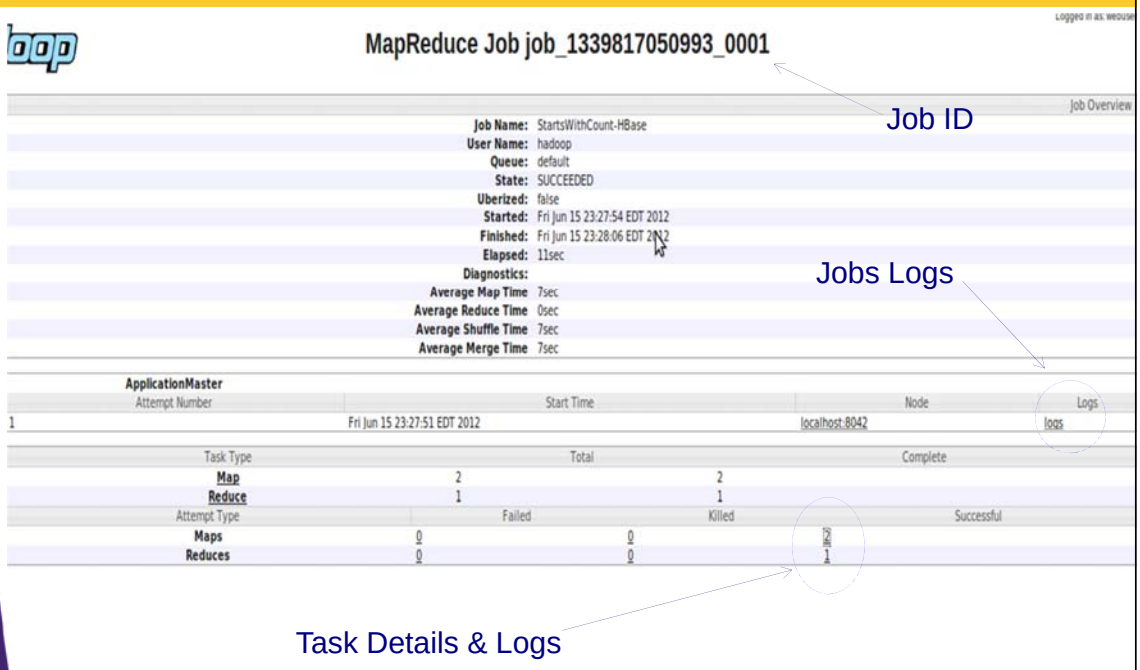
- **By default history logs are archived to HDFS**
  - /tmp/logs
  - /tmp/hadoop-yarn
- **The location of the log can be affected by several properties**
  - mapred-site.xml
    - mapreduce.jobhistory.intermediate-done-dir: MapReduce jobs write their history files here
    - mapreduce.jobhistory.done-dir: History Server achives job files here
  - yarn-site.xml
    - yarn.nodemanager.remote-app-log-dir: Application logs are moved here after completion, yarn.log-aggregation-enable property needs to be set to true

MapReduce Job's Logs

- **By default Map and Reduce tasks will log at INFO level**
- **Modify logging level by setting Hadoop Job properties**
  - Map Tasks: mapred.map.child.log.level
  - Reduce Tasks: mapred.reduce.child.log.level
- **You can also modify logging level at the command line**

```
$ yarn jar $PLAY_AREA/Solutions.jar \
      mapRed.inputAndOutput.UniqueCounterTool \
      -Dmapred.map.child.log.level=DEBUG
```

History Server - Web UI



Wrap-Up

Summary

- **We learned how to**
  - Utilize Tool, ToolRunner and GenericOptionsParser
  - Run MapReduce Locally
  - Run MapReduce on Cluster
  - Package MapReduce Jobs
  - Control MapReduce CLASSPATH
  - Submit Jobs
  - View logs via script and Web UI

Questions?