Oozie

Originals of Slides and Source Code for Examples:
http://www.coreservlets.com/hadoop-tutorial/

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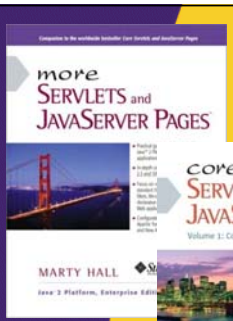
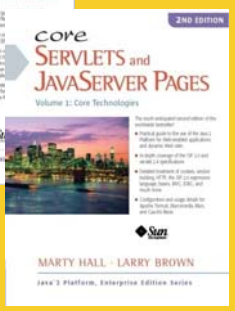
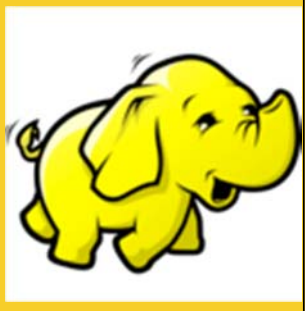






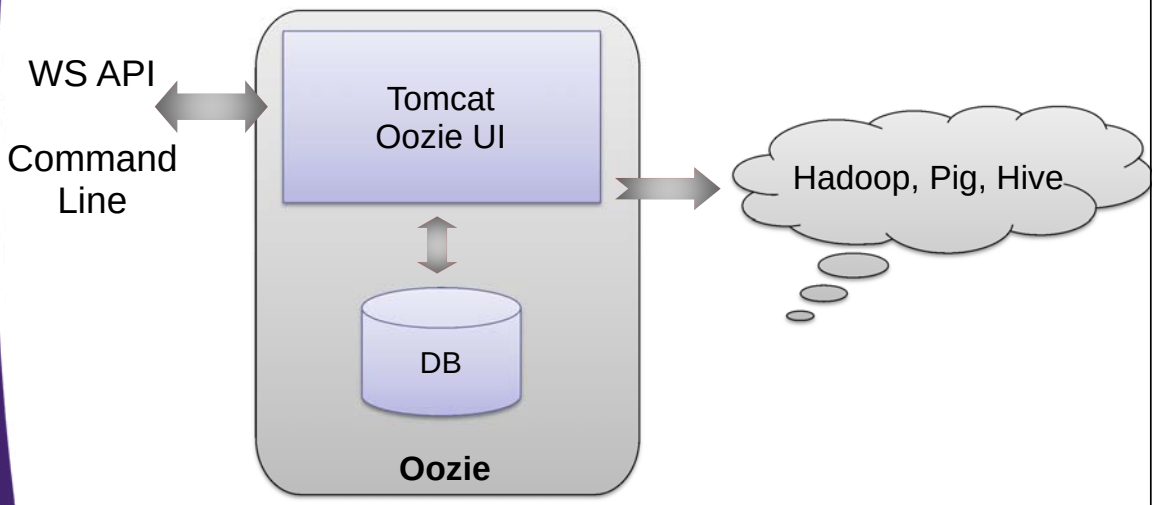
Agenda

- Introduce Oozie
- Oozie Installation
- Write Oozie Workflow
- Deploy and Run Oozie Workflow

Oozie

- Workflow scheduler for Hadoop
  - Java MapReduce Jobs
  - Streaming Jobs
  - Pig
- Top level Apache project
  - Comes packaged in major Hadoop Distributions
    - Cloudera Distribution for Hadoop (CDH)
  - http://incubator.apache.org/oozie
- Provides workflow management and coordination of those workflows
- Manages Directed Acyclic Graph (DAG) of actions

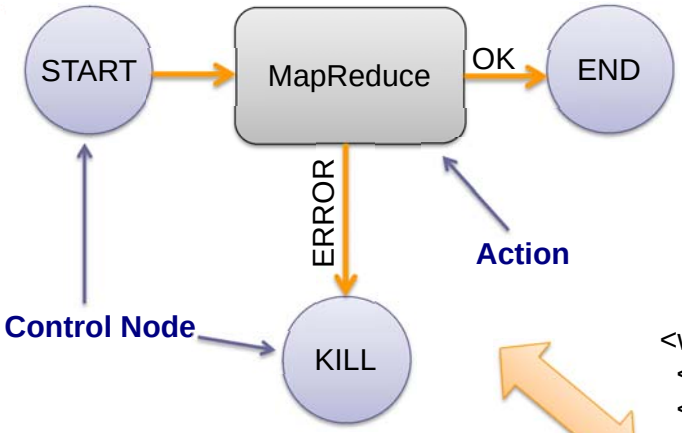
Oozie



Oozie

- **Runs HTTP service**
  - Clients interact with the service by submitting workflows
  - Workflows are executed immediately or later
- **Workflows are defined via XML**
  - Instead of writing Java code that implements Tool interface and extending Configured class

Action and Control Nodes




```
<workflow-app name="foo-wf"..
  <start to="[NODE-NAME]"/>
  <map-reduce>
            ...
            ...
  </map-reduce>
  <kill name="[NODE-NAME]">
    <message>Error occurred</message
  </kill>
  <end name="[NODE-NAME]"/>
</workflow-app>
```


Action and Control Nodes

- **Control Flow**
  - start, end, kill
  - decision
  - fork, join
- **Actions**
  - map-reduce
  - java
  - pig
  - hdfs

Oozie Coordination Engine

- **Oozie Coordination Engine can trigger workflows by**
  - Time (Periodically)
  - Data Availability (Data appears in a directory)

Install Oozie

- **$ mkdir <OOZIE_HOME>/libext**
- **Download ExtJS and place under <OOZIE_HOME>/libext**
  - ext-2.2.zip
- **Place Hadoop libs under libext**
  - $ cd <OOZIE_HOME>
  - $ tar xvf oozie-hadooplibs-3.1.3-cdh4.0.0.tar.gz
  - $ cp oozie-3.1.3-cdh4.0.0/hadooplibs/hadooplib-2.0.0-cdh4.0.0/*.jar libext/
- **Configure Oozie with components under libext**
  - $ bin/oozie-setup.sh

Install Oozie

- **Create environment variable for default url**
  - export OOZIE_URL=http://localhost:11000/oozie
  - This allows you to use $oozie command without providing url
- **Update oozie-site.xml to point to Hadoop configuration**

```
<property>
  <name>oozie.service.HadoopAccessorService.hadoop.configurations</name>
  <value>*=/home/hadoop/Training/CDH4/hadoop-2.0.0-cdh4.0.0/conf</value>
</property>
```

- **Setup Oozie database**
  - $./bin/ooziedb.sh create -sqlfile oozie.sql -run DB Connection.

Install Oozie

- **Update core-site.xml to allow Oozie become "hadoop" and for that user to connect from any host**

```
<property>
  <name>hadoop.proxyuser.hadoop.groups</name>
  <value>*</value>
  <description>Allow the superuser oozie to impersonate any
members of the group group1 and group2</description>
</property>
<property>
  <name>hadoop.proxyuser.hadoop.hosts</name>
  <value>*</value>
  <description>The superuser can connect only from host1 and
host2 to impersonate a user</description>
</property>
```

- **Learn more: http://hadoop.apache.org/common/docs/r1.0.3/Secure_Impersonation.html**

Start Oozie

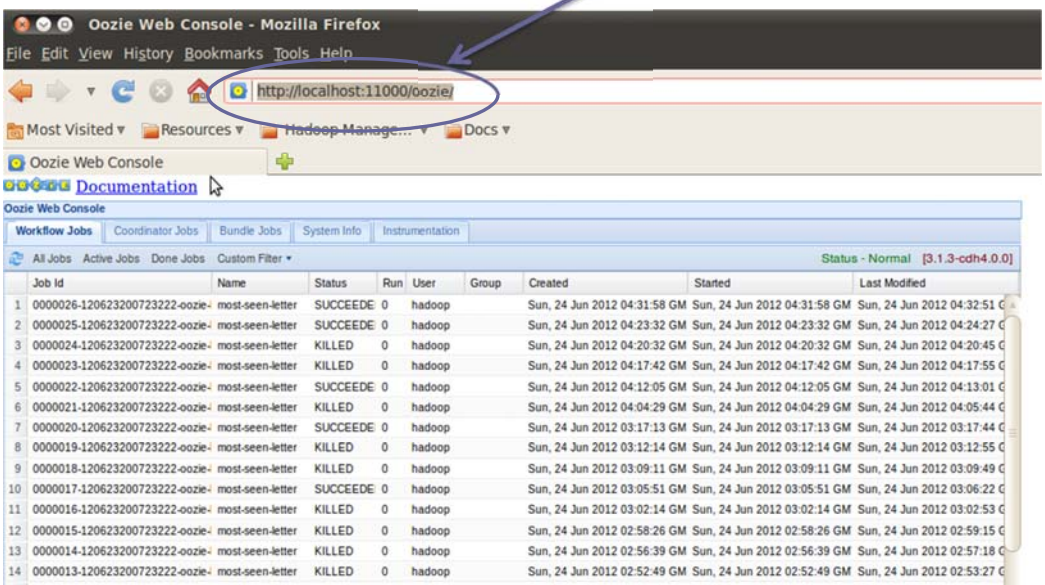
```
$ oozie-start.sh
```

```
Setting OOZIE_HOME:          /home/hadoop/Training/CDH4/oozie-3.1.3-cdh4.0.0
Setting OOZIE_CONFIG:        /home/hadoop/Training/CDH4/oozie-3.1.3-cdh4.0.0/conf
Sourcing:                    /home/hadoop/Training/CDH4/oozie-3.1.3-cdh4.0.0/conf/oozie-env.sh
  setting OOZIE_LOG=/home/hadoop/Training/logs/oozie
  setting CATALINA_PID=/home/hadoop/Training/hadoop_work/pids/oozie.pid
Setting OOZIE_CONFIG_FILE:   oozie-site.xml
Setting OOZIE_DATA:          /home/hadoop/Training/CDH4/oozie-3.1.3-cdh4.0.0/data
Using   OOZIE_LOG:           /home/hadoop/Training/logs/oozie
Setting OOZIE_LOG4J_FILE:    oozie-log4j.properties
Setting OOZIE_LOG4J_RELOAD:  10
Setting OOZIE_HTTP_HOSTNAME: localhost
Setting OOZIE_HTTP_PORT:     11000
Setting OOZIE_ADMIN_PORT:    11001
...
...
...
```


Test Installation

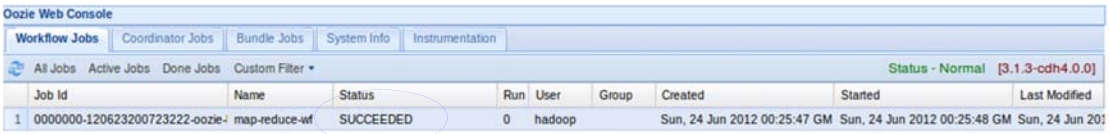
```
$ oozie admin -status
System mode: NORMAL
```

http://localhost:11000/oozie/



Running Oozie Examples

- **Extract examples packaged with Oozie**
  - $ cd $OOZIE_HOME
  - $ tar xvf oozie-examples.tar.gz
- **Copy examples to HDFS to user's home directory**
  - $ hdfs dfs -put examples examples
- **Run an example**
  - $ oozie job -config examples/apps/map-reduce/job.properties -run
- **Check Web Console**
  - http://localhost:11000/oozie/



Oozie Workflows

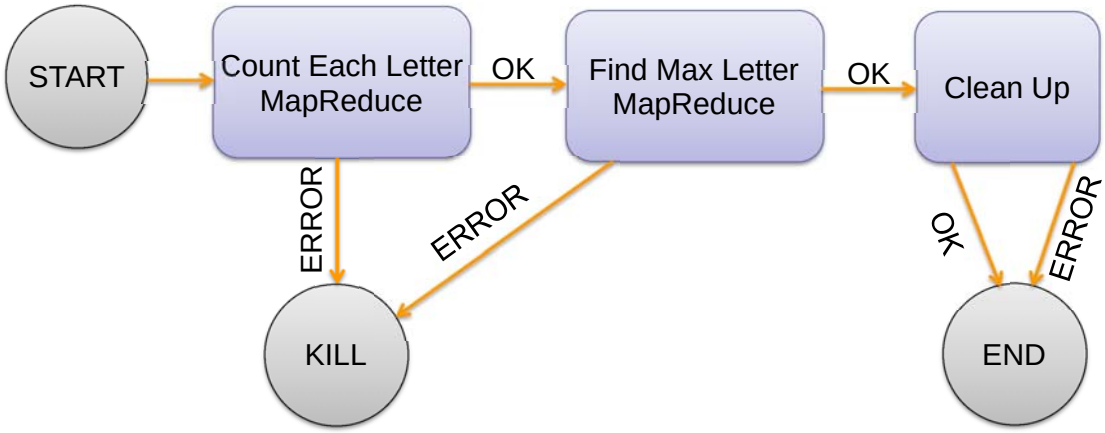
- **Defined in XML**
- **Uses Process Definition Language**
  - http://incubator.apache.org/oozie/docs/3.2.0-incubating/docs/WorkflowFunctionalSpec.html

```
<workflow-app name="foo-wf" xmlns="uri:oozie:workflow:0.1">
  ...
  <decision name="mydecision">
    <switch>
      <case to="reconsolidatejob">
         ${fs:fileSize(secondjobOutputDir) gt 10 * GB}
      </case>
      <case to="rexpandjob">
         ${fs:filSize(secondjobOutputDir) lt 100 * MB}
      </case>
      <case to="recomputejob">
         ${ hadoop:counters('secondjob')[RECORDS][REDUCE_OUT] lt 1000000 }
      </case>
      <default to="end"/>
    </switch>
  </decision>
  ...
</workflow-app>
```

Oozie Workflows

- **Workflows consist of**
  - Action nodes
    - MapReduce, Pig, Hive
    - Streaming, Java, etc...
  - Control flow nodes
    - Logic decisions between action nodes
    - Execute actions based on conditions or in parallel
- **Workflows begin with START node**
- **Workflows succeed with END node**
- **Workflows fail with KILL node**
- **Several actions support JSP Expression Language (EL)**

Most Occurrences Workflows



- Action Node

- Control Flow Node

- Control Node

This source is in *HadoopSamples* project under `/src/main/resources/mr/workflows`

Most Occurrences Workflows

```
<workflow-app xmlns="uri:oozie:workflow:0.2" name="most-seen-letter">
    <start to="count-each-letter"/>
    <action name="count-each-letter">
        <map-reduce>
            <job-tracker>${jobTracker}</job-tracker>
            <name-node>${nameNode}</name-node>
            <prepare>
                <delete path="${nameNode}${outputDir}"/>
                <delete path="${nameNode}${intermediateDir}"/>
            </prepare>
            <configuration>
                                ...
                <property>
                    <name>mapreduce.job.map.class</name>
                    <value>mr.wordcount.StartsWithCountMapper</value>
                </property>
                                ...
            </configuration>
        </map-reduce>
        <ok to="find-max-letter"/>
        <error to="fail"/>
    </action>
...
```

START Action Node to count-each-letter MapReduce action

MapReduce have optional Prepare section

Pass property that will be set on MapReduce job's Configuration object

In case of success, go to the next job; in case of failure go to fail node

First map-reduce Action

```
<map-reduce>
  <job-tracker>${jobTracker}</job-tracker>
  <name-node>${nameNode}</name-node>
  <prepare>
    <delete path="${nameNode}${outputDir}"/>
    <delete path="${nameNode}${intermediateDir}"/>
  </prepare>
  <configuration>
    <property>
      <name>mapred.mapper.new-api</name>
      <value>true</value>
    </property>
    <property>
      <name>mapred.reducer.new-api</name>
      <value>true</value>
    </property>
    <property>
      <name>mapred.job.queue.name</name>
      <value>${queueName}</value>
    </property>
...
...
```

Administrative items to indicate where namenode and resource manager is

Optional prepare section; allows to execute command prior running the job

By default "old api" is used; specify to use new api

Specify which queue to submit this job to Resource Manager

First map-reduce Action

```
...
<property>
  <name>mapreduce.job.map.class</name>
  <value>mr.wordcount.StartsWithCountMapper</value>
</property>
<property>
  <name>mapreduce.job.combine.class</name>
  <value>mr.wordcount.StartsWithCountReducer</value>
</property>
<property>
  <name>mapreduce.job.reduce.class</name>
  <value>mr.wordcount.StartsWithCountReducer</value>
</property>
<property>
  <name>mapreduce.job.inputformat.class</name>
  <value>org.apache.hadoop.mapreduce.lib.input.TextInputFormat</value>
</property>
<property>
  <name>mapreduce.job.outputformat.class</name>
  <value>org.apache.hadoop.mapreduce.lib.output.TextOutputFormat</value>
</property>
...
```

Specify Mapper, Reducer, Input and Output formats; this is instead of Tool implementation

This action will produce a file of tab separated key-value pairs as specified by TextOutputFormat

First map-reduce Action (continued)

```
...
...
    <property>
      <name>mapreduce.job.output.key.class</name>
      <value>org.apache.hadoop.io.Text</value>
    </property>
    <property>
      <name>mapreduce.job.output.value.class</name>
      <value>org.apache.hadoop.io.IntWritable</value>
    </property>
    <property>
      <name>mapreduce.input.fileinputformat.inputdir</name>
      <value>${inputFile}</value>
    </property>
    <property>
      <name>mapreduce.output.fileoutputformat.outputdir</name>
      <value>${intermediateDir}</value>
    </property>
  </configuration>
</map-reduce>
```

These properties are substituted from job.properties file

Most Occurrences Workflows

```
<action name="find-max-letter">
  <map-reduce>
    <job-tracker>${jobTracker}</job-tracker>
    <name-node>${nameNode}</name-node>
    <configuration>
    ...
    ...
      <property>
        <name>mapreduce.job.map.class</name>
        <value>mr.workflows.MostSeenStartLetterMapper</value>
      </property>
      <property>
        <name>mapreduce.job.combine.class</name>
        <value>mr.workflows.MostSeendStartLetterReducer</value>
    ...
    ...
    </configuration>
  </map-reduce>
  <ok to="clean-up"/>
  <error to="fail"/>
</action>
```

Second MapReduce job

Namenode and Yarn Resource Manager Location

Token substituted from application properties file

Control Flow Node

Second map-reduce Action

```
...
<property>
    <name>mapreduce.job.map.class</name>
    <value>mr.workflows.MostSeenStartLetterMapper</value>
</property>
<property>
    <name>mapreduce.job.combine.class</name>
    <value>mr.workflows.MostSeendStartLetterReducer</value>
</property>
<property>
    <name>mapreduce.job.reduce.class</name>
    <value>mr.workflows.MostSeendStartLetterReducer</value>
</property>
...
```

Specify Mapper, Reducer and Combiner

Second map-reduce Action (continued)

First map-reduce action produced a file with tab separated key-value pairs; second step utilizes KeyValueTextInputFormat to read these pairs as text

```
...
<property>
    <name>mapreduce.job.inputformat.class</name>
    <value>org.apache.hadoop.mapreduce.lib.input.KeyValueTextInputFormat</value>
</property>
<property>
    <name>mapreduce.job.outputformat.class</name>
    <value>org.apache.hadoop.mapreduce.lib.output.TextOutputFormat</value>
</property>
<property>
    <name>mapreduce.job.output.key.class</name>
    <value>org.apache.hadoop.io.Text</value>
</property>
<property>
    <name>mapreduce.job.output.value.class</name>
    <value>org.apache.hadoop.io.IntWritable</value>
</property>
...
```


Most Occurrences Workflows

```
...
...
    <action name="clean-up">
        <fs>
            <delete path='${nameNode}${intermediateDir}'/>
        </fs>
        <ok to="end"/>
        <error to="end"/>
    </action>


    <kill name="fail">
        <message>Map/Reduce failed, error
message[${wf:errorMessage(wf:lastErrorNode())}]</message>
    </kill>

    <end name="end"/>
</workflow-app>
```

Clean node, remove temporary folder

Workflow has failed, display error message

JSP expression language

Workflow ended with success

Package and Run Your Workflow

1. **Create application directory structure with workflow definitions and resources**
   - Workflow.xml, jars, etc..
2. **Copy application directory to HDFS**
3. **Create application configuration file**
   - specify location of the application directory on HDFS
   - specify location of the namenode and resource manager
4. **Submit workflow to Oozie**
   - Utilize oozie command line
5. **Monitor running workflow(s)**

1: Oozie Application Directory

- **Must comply to directory structure spec**

```
mostSeenLetter-oozieWorkflow
|--lib/
|     |--HadoopSamples.jar
|--workflow.xml
```

Application Workflow Root

Libraries should be placed under lib directory

Workflow.xml defines workflow

1: Oozie Application Directory

- **Can use a build tool to generate this structure**
  - Samples use maven plugins (see pom.xml)
    - Maven-dependency-plugin
    - Maven-resources-plugin
  - Run ‘mvn clean package’
    - Will create ‘mostSeenLetter-oozieWorkflow’ directory with dependencies and workflow definitions

2: Copy Application Directory to HDFS

- **Oozie utilizes HDFS to load applications**

```
hdfs dfs -put mostSeenLetter-oozieWorkflow
```

Copies directory from local files system onto HDFS; directory gets copied to user’s home directory

3: Create Application Configuration File

- **job.properties - Needs to exist locally, required for submission**

```
nameNode=hdfs://localhost:8020
jobTracker=localhost:8021
queueName=default
```

Properties for required locations such as namenode and resource manage

```
inputFile=/training/data/hamlet.txt
intermediateDir=/training/playArea/mostSeenLetter-oozieWorkflow-tmp
outputDir=/training/playArea/oozieWorkflow
```

Properties needed for the MapReduce actions in the workflow

```
oozie.wf.application.path=${nameNode}/user/${user.name}/mostS
eenLetter-oozieWorkflow
```

Most importantly HDSF location of the application must be specified

4: Submit Workflow to Oozie

- **Use oozie command line tool**
  - For usage: $oozie help

Application configuration file

```
$ oozie job -config job.properties -run
job: 0000001-120711224224630-oozie-hado-W
```

Application ID; use this ID to get status

5: Monitor Running Workflow(s)

- **Two options**
  - Command line ($oozie)
  - Web Interface (http://localhost:11000/oozie)

5: Monitor Running Workflow(s) - Command Line

```
$ oozie job -info 0000001-120711224224630-oozie-hado-W
Job ID : 0000001-120711224224630-oozie-hado-W
------------------------------------------------------------------------------------------------------------------------
Workflow Name : most-seen-letter
App Path      : hdfs://localhost:8020/user/hadoop/mostSeenLetter-oozieWorkflow
Status        : RUNNING
Run           : 0
User          : hadoop
Group         : -
Created       : 2012-07-13 03:08
Started       : 2012-07-13 03:08
Last Modified : 2012-07-13 03:08
Ended         : -
CoordAction ID: -

Actions
------------------------------------------------------------------------------------------------------------------------
ID                                                    Status    Ext ID                 Ext Status Err Code
------------------------------------------------------------------------------------------------------------------------
0000001-120711224224630-oozie-hado-W@count-each-letter  OK        job_1342136595052_0006 SUCCEEDED -
------------------------------------------------------------------------------------------------------------------------
0000001-120711224224630-oozie-hado-W@find-max-letter     RUNNING   job_1342136595052_0008
------------------------------------------------------------------------------------------------------------------------
```

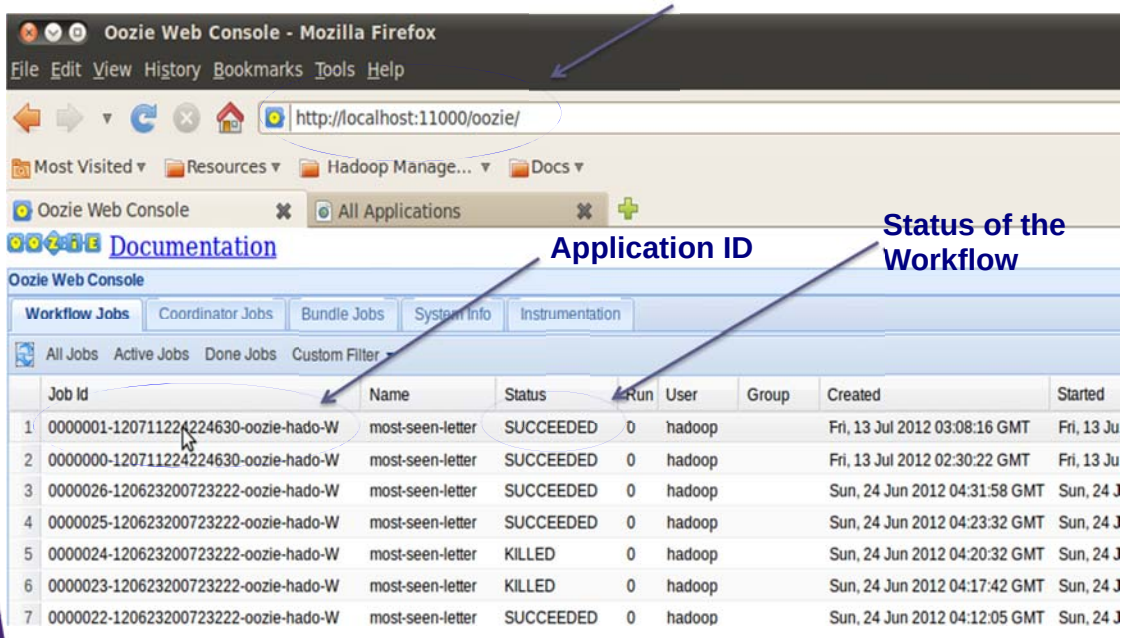
Get info by Application ID

Workflow overview

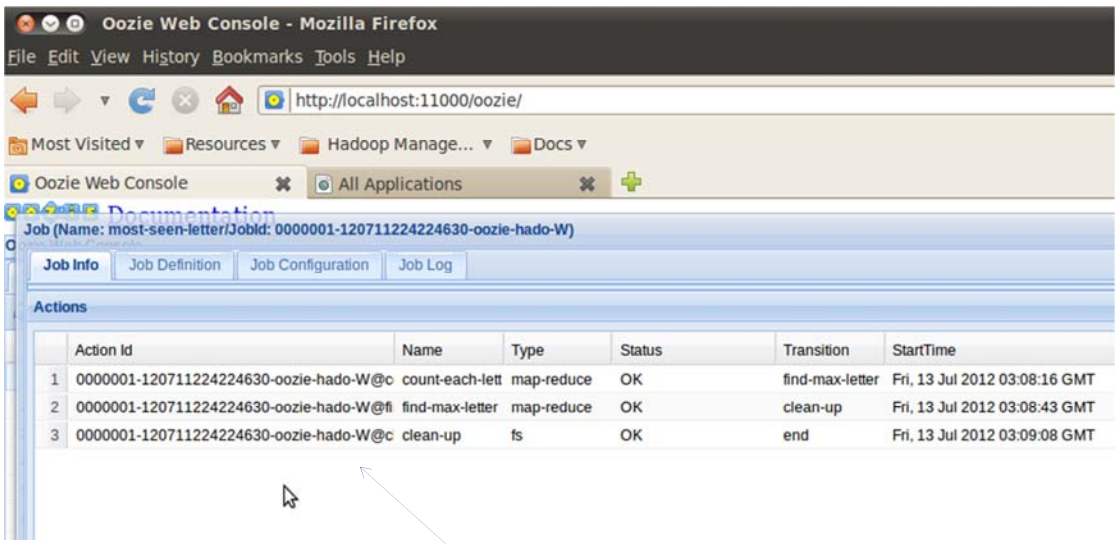
Completed and executing tasks

5: Monitor Running Workflow(s) - Web Interface

http://localhost:11000/oozie

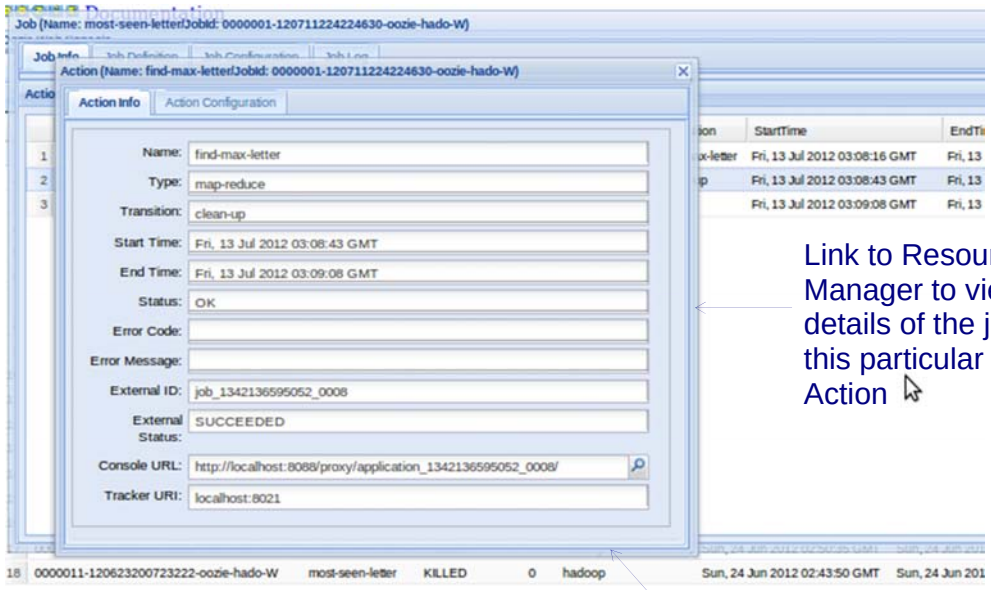


5: Monitor Running Workflow(s) - Web Interface



Clicking on a particular application/job will bring up list of all the actions; click on each action to get further details

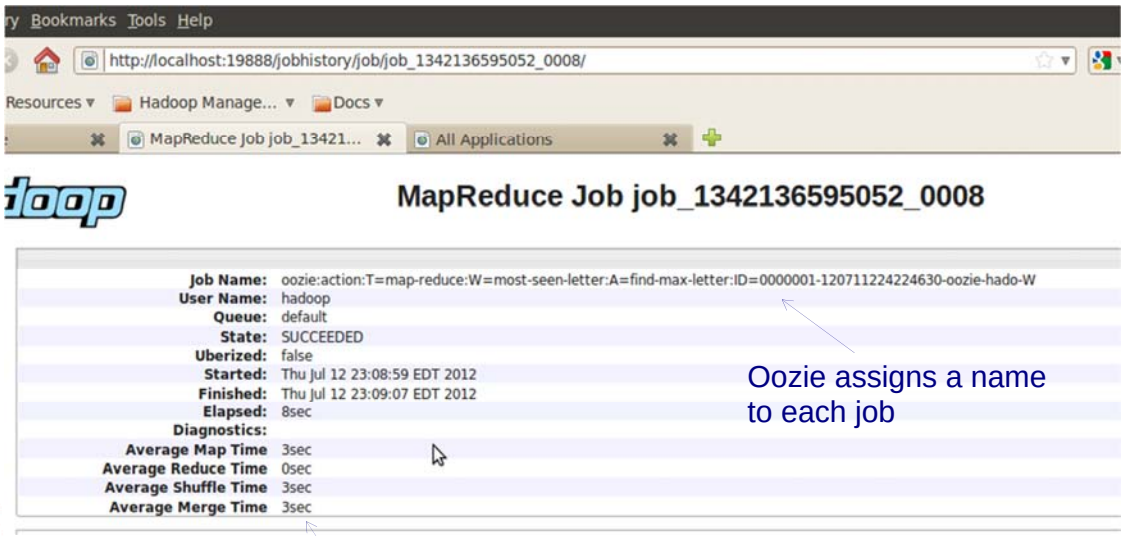
5: Monitor Running Workflow(s) - Web Interface



Link to Resource Manager to view details of the job for this particular Oozie Action

This view displays details for a selected action.

5: Monitor Running Workflow(s) - Web Interface



Oozie assigns a name to each job

Clicking on the “Console Url” from action view will take you to the details of the job for that action

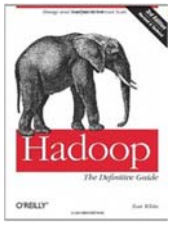
mostSeenLetter-oozieWorkflow Result

```
$ hdfs dfs -cat /training/playArea/oozieWorkflow/part-r-00000
t      3711
```

Reminder: This source is in *HadoopSamples* project under `/src/main/resources/mr/workflows`

Oozie Resources

- **Home Page:**
  - http://incubator.apache.org/oozie/
  - Quick start, functional specifications for workflows, coordinators, and expression language
- **Mailing Lists**
  - http://oozie.apache.org/mail-lists.html
- **Chapter about Oozie**



Hadoop: The Definitive Guide
Tom White (Author)
O'Reilly Media; 3rd Edition (May6, 2012)

Wrap-Up

Summary

- **We learned about**
  - Oozie Features
  - Oozie Installation
- **We learned how to**
  - Implement an Oozie Workflow
  - Deploy and Run Oozie Workflow

Questions?