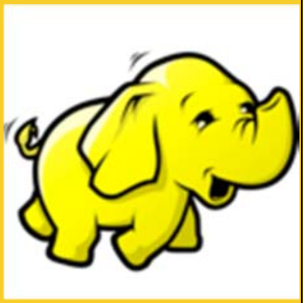
HDFS - Java API

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



Agenda

- Java API Introduction
- Configuration
- Reading Data
- Writing Data
- Browsing file system

File System Java API

- org.apache.hadoop.fs.FileSystem
  - Abstract class that serves as a generic file system representation
  - Note it’s a class and not an Interface
- Implemented in several flavors
  - Ex. Distributed or Local

FileSystem Implementations

- **Hadoop ships with multiple concrete implementations:**
  - org.apache.hadoop.fs.LocalFileSystem
    - Good old native file system using local disk(s)
  - org.apache.hadoop.hdfs.DistributedFileSystem
    - Hadoop Distributed File System (HDFS)
    - Will mostly focus on this implementation
  - org.apache.hadoop.hdfs.HftpFileSystem
    - Access HDFS in read-only mode over HTTP
  - org.apache.hadoop.fs.ftp.FTPFileSystem
    - File system on FTP server

FileSystem Implementations

- **FileSystem concrete implementations**
  - Two options that are backed by Amazon S3 cloud
    - org.apache.hadoop.fs.s3.S3FileSystem
    - http://wiki.apache.org/hadoop/AmazonS3
  - org.apache.hadoop.fs.kfs.KosmosFileSystem
    - Backed by CloudStore
    - http://code.google.com/p/kosmosfs

FileSystem Implementations

- **Different use cases for different concrete implementations**
- **HDFS is the most common choice**
  - org.apache.hadoop.hdfs.DistributedFileSystem

SimpleLocalLs.java Example

```
public class SimpleLocalLs {
  public static void main(String[] args) throws Exception{

    Path path = new Path("/");
    if ( args.length == 1){
      path = new Path(args[0]);
    }

    Configuration conf = new Configuration();
    FileSystem fs = FileSystem.get(conf);

    FileStatus [] files = fs.listStatus(path);
    for (FileStatus file : files ){
      System.out.println(file.getPath().getName());
    }
  }
}
```

Read location from the command line arguments

Acquire FileSystem Instance

List the files and directories under the provided path

Print each sub directory or file to the screen

FileSystem API: Path

- **Hadoop's Path object represents a file or a directory**
  - Not java.io.File which tightly couples to local filesystem
- **Path is really a URI on the FileSystem**
  - HDFS: hdfs://localhost/user/file1
  - Local: file:///user/file1
- **Examples:**
  - new Path("/test/file1.txt");
  - new Path("hdfs://localhost:9000/test/file1.txt");

Hadoop's Configuration Object

- **Configuration object stores clients' and servers' configuration**
  - Very heavily used in Hadoop
    - HDFS, MapReduce, HBase, etc...
- **Simple key-value paradigm**
  - Wrapper for java.util.Properties class which itself is just a wrapper for java.util.Hashtable
- **Several construction options**
  - Configuration conf1 = new Configuration();
  - Configuration conf2 = new Configuration(conf1);
    - Configuration object conf2 is seeded with configurations of conf1 object

Hadoop's Configuration Object

- **Getting properties is simple!**
- **Get the property**
  - String nnName = conf.get("fs.default.name");
    - returns null if property doesn't exist
- **Get the property and if doesn't exist return the provided default**
  - String nnName = conf.get("fs.default.name", "hdfs://localhost:9000");
- **There are also typed versions of these methods:**
  - getBoolean, getInt, getFloat, etc...
  - Example: int prop = conf.getInt("file.size");

Hadoop's Configuration Object

- **Usually seeded via configuration files that are read from CLASSPATH (files like conf/core-site.xml and conf/hdfs-site.xml):**

  Configuration conf = new Configuration();

  conf.addResource(new Path(HADOOP_HOME + "/conf/core-site.xml"));
- **Must comply with the Configuration XML schema, ex:**

```
<?xml version="1.0"?>
<?xml-stylesheet type="text/xsl" href="configuration.xsl"?>
<configuration>
   <property>
     <name>fs.default.name</name>
     <value>hdfs://localhost:9000</value>
   </property>
</configuration>
```

Hadoop Configuration Object

- **conf.addResource() - the parameters are either String or Path**
  - conf.addResource("hdfs-site.xml")
    - CLASSPATH is referenced when String parameter is provided
  - conf.addResource(new Path("/exact/location/file.xml") :
    - Path points to the exact location on the local file system
- **By default Hadoop loads**
  - core-default.xml
    - Located at hadoop-common-X.X.X.jar/core-default.xml
  - core-site.xml
- **Looks for these configuration files on CLASSPATH**

LoadConfigurations.java Example

```
public class LoadConfigurations {
  private final static String PROP_NAME = "fs.default.name";

  public static void main(String[] args) {
     Configuration conf = new Configuration();

     System.out.println("After construction: " +
                 conf.get(PROP_NAME));

     conf.addResource(new Path(Vars.HADOOP_HOME +
                 "/conf/core-site.xml"));
     System.out.println("After addResource: "+
                 conf.get(PROP_NAME));

     conf.set(PROP_NAME, "hdfs://localhost:8111");
     System.out.println("After set: " + conf.get(PROP_NAME));
  }
}
```

1. Print the property with empty Configuration

2. Add properties from core-dsite.xml

3. Manually set the property

Run LoadConfigurations

```
$ java -cp
$PLAY_AREA/HadoopSamples.jar:$HADOOP_HOME/share/had
common/hadoop-common-2.0.0-
cdh4.0.0.jar:$HADOOP_HOME/share/hadoop/common/lib/*
hdfs.LoadConfigurations
```

```
After construction: file:///
After addResource: hdfs://localhost:9000
After set: hdfs://localhost:8111
```

1. Print the property with empty Configuration

2. Add properties from core-site.xml

3. Manually set the property

FileSystem API

- **Recall FileSystem is a generic abstract class used to interface with a file system**
- **FileSystem class also serves as a factory for concrete implementations, with the following methods**
  – public static FileSystem get(Configuration conf)
    - Will use information from Configuration such as scheme and authority
    - Recall hadoop loads conf/core-site.xml by default
    - Core-site.xml typically sets fs.default.name property to something like hdfs://localhost:8020
      – org.apache.hadoop.hdfs.DistributedFileSystem will be used by default
      – Otherwise known as HDFS

Simple List Example

```
public class SimpleLocalLs {
    public static void main(String[] args) throws Exception
      Path path = new Path("/");
      if ( args.length == 1){
          path = new Path(args[0]);
      }
      Configuration conf = new Configuration();
      FileSystem fs = FileSystem.get(conf);
      FileStatus [] files = fs.listStatus(path);
      for (FileStatus file : files ){
         System.out.println(file.getPath().getName());
      }
  }
}
```

What happens when you run this code?

Execute Simple List Example

- **The Answer is.... it depends**

```
$ java -cp
$PLAY_AREA/HadoopSamples.jar:$HADOOP_HOME/share/hadoop/commo
n/hadoop-common-2.0.0-
cdh4.0.0.jar:$HADOOP_HOME/share/hadoop/common/lib/*
hdfs.SimpleLs
lib
...
...
var
sbin
etc
```

- Uses java command, not yarn
- core-site.xml and core-default.xml are not on the CLASSPATH
- properties are then NOT added to Configuration object
- Default FileSystem is loaded => local file system

```
$ yarn jar $PLAY_AREA/HadoopSamples.jar hdfs.SimpleLs
hbase
lost+found
test1
tmp
training
user
```

- Yarn script will place core-default.xml and core-site-xml on the CLASSPATH
- Properties within those files added to Configuration object
- HDFS is utilized, since it was specified in core-site.xml

Reading Data from HDFS

1. Create FileSystem
2. Open InputStream to a Path
3. Copy bytes using IOUtils
4. Close Stream

1: Create FileSystem

- **FileSystem fs = FileSystem.get(new Configuration());**
  - If you run with yarn command, DistributedFileSystem (HDFS) will be created
    - Utilizes fs.default.name property from configuration
    - Recall that Hadoop framework loads core-site.xml which sets property to hdfs (hdfs://localhost:8020)

2: Open Input Stream to a Path

```
...
InputStream input = null;
      try {
          input = fs.open(fileToRead);
...
```

- **fs.open returns org.apache.hadoop.fs.FSDataInputStream**
  - Another FileSystem implementation will return their own custom implementation of InputStream
- **Opens stream with a default buffer of 4k**
- **If you want to provide your own buffer size use**
  - fs.open(Path f, int bufferSize)

3: Copy bytes using IOUtils

```
IOUtils.copyBytes(inputStream, outputStream, buffer);
```

- **Copy bytes from InputStream to OutputStream**
- **Hadoop's IOUtils makes the task simple**
  - buffer parameter specifies number of bytes to buffer at a time

4: Close Stream

```
...
} finally {
        IOUtils.closeStream(input);
...
```

- **Utilize `IOUtils` to avoid boiler plate code that catches `IOException`**

ReadFile.java Example

```
public class ReadFile {
  public static void main(String[] args)
                          throws IOException {
      Path fileToRead = new Path("/training/data/readMe.txt");
      FileSystem fs = FileSystem.get(new Configuration());

      InputStream input = null;
      try {
          input = fs.open(fileToRead);

          IOUtils.copyBytes(input, System.out, 4096);

      } finally {
        IOUtils.closeStream(input);
     }
  }
}
```

1: Open FileSystem

2: Open InputStrean

3: Copy from Input to Output Stream

4: Close stream

```
$ yarn jar $PLAY_AREA/HadoopSamples.jar hdfs.ReadFile
Hello from readme.txt
```

Reading Data - Seek

- **FileSystem.open returns FSDataInputStream**
  - Extension of java.io.DataInputStream
  - Supports random access and reading via interfaces:
    - PositionedReadable : read chunks of the stream
    - Seekable : seek to a particular position in the stream

Seeking to a Position

- **FSDataInputStream implements Seekable interface**
  - void seek(long pos) throws IOException
    - Seek to a particular position in the file
    - Next read will begin at that position
    - If you attempt to seek past the file boundary IOException is emitted
    - Somewhat expensive operation – strive for streaming and not seeking
  - long getPos() throws IOException
    - Returns the current position/offset from the beginning of the stream/file

SeekReadFile.java Example

```
public class SeekReadFile {
  public static void main(String[] args) throws IOException {
    Path fileToRead = new Path("/training/data/readMe.txt");
    FileSystem fs = FileSystem.get(new Configuration());
    FSDataInputStream input = null;
    try {
      input = fs.open(fileToRead);
      System.out.print("start postion=" + input.getPos() + ":
      IOUtils.copyBytes(input, System.out, 4096, false);

      input.seek(11);
      System.out.print("start postion=" + input.getPos() + ":
      IOUtils.copyBytes(input, System.out, 4096, false);

      input.seek(0);
      System.out.print("start postion=" + input.getPos() + ":
      IOUtils.copyBytes(input, System.out, 4096, false);
    } finally {
      IOUtils.closeStream(input);
    }
  }
}
```

Start at position 0

Seek to position 11

Seek back to 0

Run SeekReadFile Example

```
$ yarn jar $PLAY_AREA/HadoopSamples.jar hdfs.SeekReadFile

start position=0: Hello from readme.txt

start position=11: readme.txt

start position=0: Hello from readme.txt
```

Write Data

1. **Create FileSystem instance**
2. **Open OutputStream**
   – FSDataOutputStream in this case
   – Open a stream directly to a Path from FileSystem
   – Creates all needed directories on the provided path
3. **Copy data using IOUtils**

WriteToFile.java Example

```
public class WriteToFile {
  public static void main(String[] args) throws IOException {
    String textToWrite = "Hello HDFS! Elephants are awesome!\n"
    InputStream in = new BufferedInputStream(
             new ByteArrayInputStream(textToWrite.getBytes()));
    Path toHdfs = new Path("/training/playArea/writeMe.txt");
    Configuration conf = new Configuration();

                                    1: Create FileSystem instance

    FileSystem fs = FileSystem.get(conf);

                                    2: Open OutputStream

    FSDataOutputStream out = fs.create(toHdfs);

                                    3: Copy Data

    IOUtils.copyBytes(in, out, conf);
  }
}
```

Run WriteToFile

```
$ yarn jar $PLAY_AREA/HadoopSamples.jar hdfs.WriteToFile
$ hdfs dfs -cat /training/playArea/writeMe.txt
Hello HDFS! Elephants are awesome!
```

FileSystem: Writing Data

- **Append to the end of the existing file**

```
fs.append(path)
```

  - Optional support by concrete FileSystem
  - HDFS supports
- **No support for writing in the middle of the file**

FileSystem: Writing Data

- **FileSystem's `create` and append methods have overloaded version that take callback interface to notify client of the progress**

```
FileSystem fs = FileSystem.get(conf);
FSDataOutputStream out = fs.create(toHdfs, new Progressable(){
    @Override
    public void progress() {
        System.out.print("..");
    }
});
```

Report progress to the screen

Overwrite Flag

- **Recall FileSystem's create(Path) creates all the directories on the provided path**
  - create(new Path("/doesnt_exist/doesnt_exist/file/txt"))
  - can be dangerous, if you want to protect yourself then utilize the following overloaded method:

```
public FSDataOutputStream create(Path f, boolean overwrite)
```

Set to false to make sure you do not overwrite important data

Overwrite Flag Example

```
Path toHdfs = new
          Path("/training/playArea/writeMe.txt");
FileSystem fs = FileSystem.get(conf);
FSDataOutputStream out = fs.create(toHdfs, false);
```

Set to false to make sure you do not overwrite important data

```
$ yarn jar $PLAY_AREA/HadoopSamples.jar hdfs.BadWriteToFile
Exception in thread "main"
org.apache.hadoop.ipc.RemoteException: java.io.IOException:
failed to create file
/training/playArea/anotherSubDir/writeMe.txt on client
127.0.0.1 either because the filename is invalid or the file
exists
...
...
```

Error indicates that the file already exists

Copy/Move from and to Local FileSystem

- **Higher level abstractions that allow you to copy and move from and to HDFS**
  - copyFromLocalFile
  - moveFromLocalFile
  - copyToLocalFile
  - moveToLocalFile

Copy from Local to HDFS

```
FileSystem fs = FileSystem.get(new Configuration());
Path fromLocal = new
   Path("/home/hadoop/Training/exercises/sample_data/hamlet.txt");
Path toHdfs = new Path("/training/playArea/hamlet.txt");

fs.copyFromLocalFile(fromLocal, toHdfs);
```

Copy file from local file system to HDFS

Empty directory before copy

```
$ hdfs dfs -ls /training/playArea/

$ yarn jar $PLAY_AREA/HadoopSamples.jar hdfs.CopyToHdfs

$ hdfs dfs -ls /training/playArea/
Found 1 items
-rw-r—r-- hadoop supergroup    /training/playArea/hamlet.txt
```

File was copied

Delete Data

```
FileSystem.delete(Path path,Boolean recursive)
```

If recursive == true then non-empty directory will be deleted otherwise IOException is emitted

```
Path toDelete =
 new Path("/training/playArea/writeMe.txt");
boolean isDeleted = fs.delete(toDelete, false);
System.out.println("Deleted: " + isDeleted);
```

```
$ yarn jar $PLAY_AREA/HadoopSamples.jar hdfs.DeleteFile
Deleted: true


$ yarn jar $PLAY_AREA/HadoopSamples.jar hdfs.DeleteFile
Deleted: false
```

File was already deleted by previous run

FileSystem: mkdirs

- **Create a directory - will create all the parent directories**

```
Configuration conf = new Configuration();
Path newDir = new Path("/training/playArea/newDir");
FileSystem fs = FileSystem.get(conf);
boolean created = fs.mkdirs(newDir);
System.out.println(created);
```

```
$ yarn jar $PLAY_AREA/HadoopSamples.jar hdfs.MkDir
true
```

FileSystem: listStatus

Browse the FileSystem with listStatus() methods

```
Path path = new Path("/");
Configuration conf = new Configuration();
FileSystem fs = FileSystem.get(conf);
FileStatus [] files = fs.listStatus(path);
for (FileStatus file : files ){
    System.out.println(file.getPath().getName());
}
```

```
$ yarn jar $PLAY_AREA/HadoopSamples.jar
hdfs.SimpleLs
training
user
```

List files under '/' for HDFS

LsWithPathFilter.java example

```
FileSystem fs = FileSystem.get(conf);

FileStatus [] files = fs.listStatus(path, new PathFilter() {

    @Override
    public boolean accept(Path path) {
        if (path.getName().equals("user")){
            return false;
        }
        return true;
    }
});

for (FileStatus file : files ){
    System.out.println(file.getPath().getName());
}
```

Do not show path whose name equals to "user"

Restrict result of listStatus() by supplying PathFilter object

Run LsWithPathFilter Example

```
$ yarn jar $PLAY_AREA/HadoopSamples.jar hdfs.SimpleLs

 training
 user

$yarn jar $PLAY_AREA/HadoopSamples.jar hdfs.LsWithPathFilter

 training
```

FileSystem: Globbing

- FileSystem supports file name pattern matching via globStatus() methods
- Good for traversing through a sub-set of files by using a pattern
- Support is similar to bash glob: *, ?, etc...

SimpleGlobbing.java

```
public class SimpleGlobbing {
  public static void main(String[] args)
                                  throws IOException {
    Path glob = new Path(args[0]);

    FileSystem fs = FileSystem.get(new Configuration());
    FileStatus [] files = fs.globStatus(glob);



    for (FileStatus file : files ){
      System.out.println(file.getPath().getName());
    }
  }
}
```

Read glob from command line

Similar usage to listStatus method

Run SimpleGlobbing

```
$ hdfs dfs -ls /training/data/glob/
Found 4 items
  drwxr-xr-x   - hadoop supergroup          0 2011-12-24 11:20 /training/data/glob/2007
  drwxr-xr-x   - hadoop supergroup          0 2011-12-24 11:20 /training/data/glob/2008
  drwxr-xr-x   - hadoop supergroup          0 2011-12-24 11:21 /training/data/glob/2010
  drwxr-xr-x   - hadoop supergroup          0 2011-12-24 11:21 /training/data/glob/2011

$ yarn jar $PLAY_AREA/HadoopSamples.jar hdfs.SimpleGlobbing /training/data/glob/201*
  2010
  2011
```

Usage of glob with *

FileSystem: Globbing

Glob	Explanation
?	Matches any single character
*	Matches zero or more characters
[abc]	Matches a single character from character set {a,b,c}.
[a-b]	Matches a single character from the character range {a...b}. Note that character a must be lexicographically less than or equal to character b.
[^a]	Matches a single character that is not from character set or range {a}. Note that the ^ character must occur immediately to the right of the opening bracket.
\c	Removes (escapes) any special meaning of character c.
{ab,cd}	Matches a string from the string set {ab, cd}
{ab,c{de,fh}}	Matches a string from the string set {ab, cde, cfh}

Source: FileSystem.globStatus API documentation

FileSystem

- **There are several methods that return ‘true’ for success and ‘false’ for failure**
  - delete
  - rename
  - mkdirs
- **What to do if the method returns 'false'?**
  - Check Namenode's log
    - Located at $HADOOP_LOG_DIR/

BadRename.java

```
FileSystem fs = FileSystem.get(new Configuration());
Path source = new Path("/does/not/exist/file.txt");
Path nonExistentPath = new Path("/does/not/exist/file1.txt");
boolean result = fs.rename(source, nonExistentPath);
System.out.println("Rename: " + result);
```

```
$ yarn jar $PLAY_AREA/HadoopSamples.jar hdfs.BadRename
Rename: false
```

Namenode's log at $HADOOP_HOME/logs/hadoop-hadoop-namenode-hadoop-laptop.log

```
2011-12-25 01:18:54,684 WARN
  org.apache.hadoop.hdfs.StateChange: DIR*
  FSDirectory.unprotectedRenameTo: failed to rename
  /does/not/exist/file.txt to /does/not/exist/file1.txt
  because source does not exist
```

Wrap-Up

Summary

- **We learned about**
  - HDFS API
  - How to use Configuration class
  - How to read from HDFS
  - How to write to HDFS
  - How to browse HDFS

Questions?