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Big Data Analysis With RHadoop

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About Me

NumerInfo

- Co-Founder of NumerInfo
- Ex-Trend Micro Engineer
- ywchiu.com

R + Hadoop

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Why Using RHadoop

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- Scaling R
  - Hadoop enables R to do parallel computing
- Do not have to learn new language
  - Learning to use Java takes time


一切都是為了
生產力

Rhadoop Architecture

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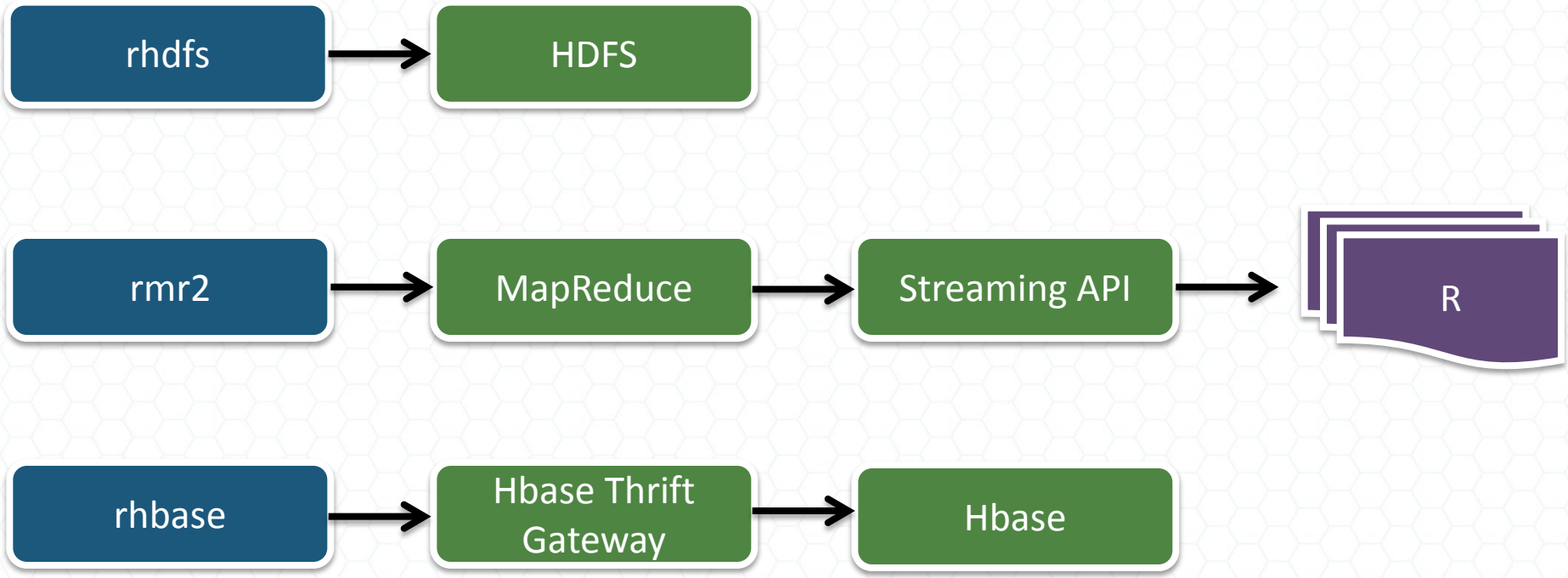

Streaming v.s. Native Java.

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- Enable developer to write Mapper/Reducer in any scripting language(R, python, perl)
- Mapper, reducer, and optional combiner processes are written to read from standard input and to write to standard output
- Streaming Job would have additional overhead of starting a scripting VM

rmr2

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- Writing MapReduce Using R
- mapreduce function
  - Mapreduce(input output, map, reduce…)
- Changelog
  - rmr 3.0.0 (2014/02/10): 10X faster than rmr 2.3.0
  - rmr 2.3.0 (2013/10/07): support **plyrmr**

rhdfs

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- Access HDFS From R
- Exchange data from R dataframe and HDFS

rhbase

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- Exchange data from R to Hbase
- Using Thrift API

NEW! plyrmr

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- Perform common data manipulation operations, as found in **plyr** and **reshape2**
- It provides a familiar plyr-like interface while hiding many of the mapreduce details
- **plyr: Tools for splitting, applying and combining data**

RHadoop Installation

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Prerequisites

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- R and related packages should be installed on each tasknode of the cluster
- A Hadoop cluster, CDH3 and higher or Apache 1.0.2 and higher but limited to mr1, not mr2. Compatibility with mr2 from Apache 2.2.0 or HDP2

Getting Ready (Cloudera VM)

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- Download

  http://www.cloudera.com/content/cloudera-content/cloudera-docs/DemoVMs/Cloudera-QuickStart-VM/cloudera_quickstart_vm.html

- This VM runs
  - CentOS 6.2
  - CDH4.4
  - R 3.0.1
  - Java 1.6.0_32

CDH 4.4

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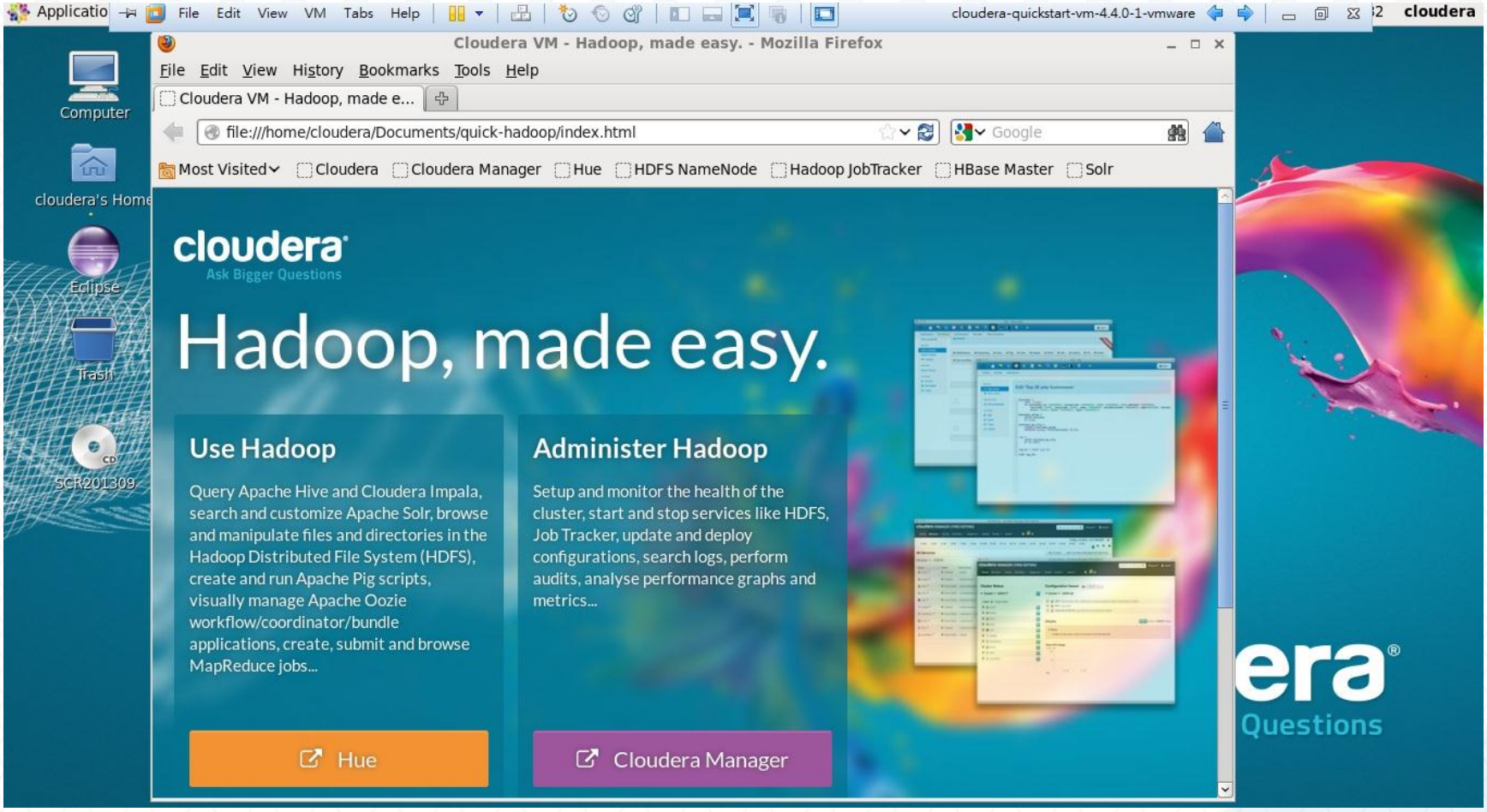
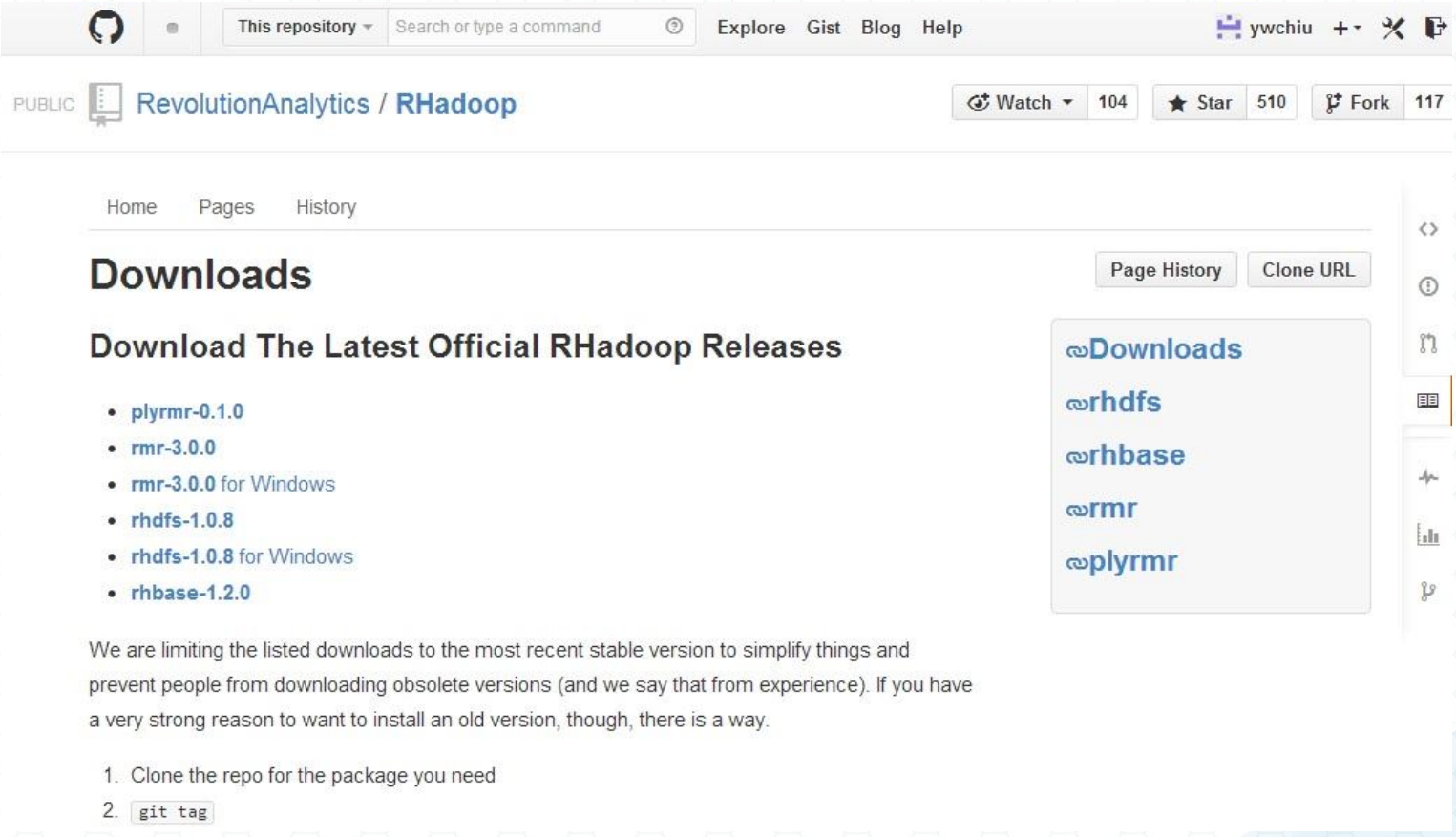


Get RHadoop

- https://github.com/RevolutionAnalytics/RHadoop/wiki/Downloads



Installing rmr2 dependencies

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- Make sure the package is installed system wise

```
$ sudo R

> install.packages(c("codetools", "R", "Rcpp",
"RJSONIO", "bitops", "digest", "functional", "stringr",
"plyr", "reshape2", "rJava“, “caTools”))
```

Install rmr2

```
$ wget --no-check-certificate
https://raw.github.com/RevolutionAnalytics/rmr2/3.0.0/build/rmr2_3.0.0.tar.gz

$ sudo R CMD INSTALL rmr2_3.0.0.tar.gz
```

Installing…

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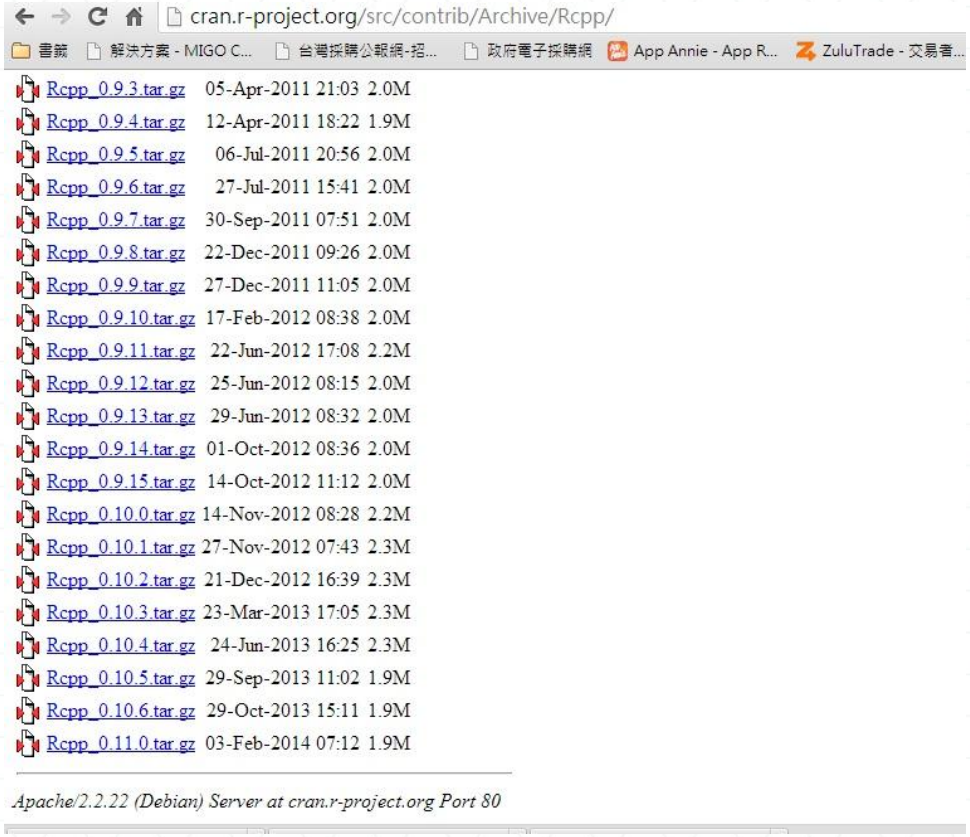
```
ePolicy>&) [with StoragePolicy = Rcpp::PreserveStorage]
/usr/lib64/R/library/Rcpp/include/Rcpp/RObject.h:49: note:                 Rcpp::RObject_Impl
<StoragePolicy>& Rcpp::RObject_Impl<StoragePolicy>::operator=(SEXPREC*) [with StoragePolicy =
 Rcpp::PreserveStorage]
typed-bytes.cpp:267: error: ambiguous overload for 'operator=' in 'new_object = unserialize_2
55_terminated_list(const raw&, unsigned int&)(((unsigned int&)((unsigned int*)start)))'
/usr/lib64/R/library/Rcpp/include/Rcpp/RObject.h:35: note: candidates are: Rcpp::RObject_Impl
<StoragePolicy>& Rcpp::RObject_Impl<StoragePolicy>::operator=(const Rcpp::RObject_Impl<Storag
ePolicy>&) [with StoragePolicy = Rcpp::PreserveStorage]
/usr/lib64/R/library/Rcpp/include/Rcpp/RObject.h:49: note:                 Rcpp::RObject_Impl
<StoragePolicy>& Rcpp::RObject_Impl<StoragePolicy>::operator=(SEXPREC*) [with StoragePolicy =
 Rcpp::PreserveStorage]
typed-bytes.cpp:270: error: ambiguous overload for 'operator=' in 'new_object = unserialize_m
ap(const raw&, unsigned int&)(((unsigned int&)((unsigned int*)start)))'
/usr/lib64/R/library/Rcpp/include/Rcpp/RObject.h:35: note: candidates are: Rcpp::RObject_Impl
<StoragePolicy>& Rcpp::RObject_Impl<StoragePolicy>::operator=(const Rcpp::RObject_Impl<Storag
ePolicy>&) [with StoragePolicy = Rcpp::PreserveStorage]
/usr/lib64/R/library/Rcpp/include/Rcpp/RObject.h:49: note:                 Rcpp::RObject_Impl
<StoragePolicy>& Rcpp::RObject_Impl<StoragePolicy>::operator=(SEXPREC*) [with StoragePolicy =
 Rcpp::PreserveStorage]
make: *** [typed-bytes.o] Error 1
ERROR: compilation failed for package 'rmr2'
* removing '/usr/lib64/R/library/rmr2'
[cloudera@localhost ~]$
```

Downgrade Rcpp

- http://cran.r-project.org/src/contrib/Archive/Rcpp/



Install Rcpp_0.11.0

$ wget --no-check-certificate http://cran.r-project.org/src/contrib/Archive/Rcpp/Rcpp_0.11.0.tar.gz

$sudo R CMD INSTALL Rcpp_0.11.0.tar.gz

Install rmr2 again

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$ sudo R CMD INSTALL rmr2_3.0.0.tar.gz

cloudera@localhost:~

File Edit View Search Terminal Help

```
** help
*** installing help indices
  converting help for package 'rmr2'
    finding HTML links ... done
    bigdataobject                           html
    dfs.empty                               html
    equijoin                                html
    fromdfstodfs                            html
    keyval                                  html
    make.io.format                          html
    mapreduce                               html
    rmr-package                             html
    rmr.options                             html
    rmr.sample                              html
    rmr.str                                 html
    scatter                                 html
    status                                  html
    tomaptoreduce                           html
    vsum                                    html
** building package indices
** testing if installed package can be loaded
* DONE (rmr2)
Making 'packages.html' ... done
[cloudera@localhost ~]$
```


嚇不到我的

Install RHDFS

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```
$ wget -no-check-certificate
https://raw.github.com/RevolutionAnalytics/rhdfs/master/build/rhdfs_1.0.8.tar.gz

$ sudo HADOOP_CMD=/usr/bin/hadoop  R CMD
INSTALL rhdfs_1.0.8.tar.gz
```

Enable hdfs

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```
> Sys.setenv(HADOOP_CMD="/usr/bin/hadoop")
> Sys.setenv(HADOOP_STREAMING="/usr/lib/hadoop-0.20-mapreduce/contrib/streaming/hadoop-streaming-2.0.0-mr1-cdh4.4.0.jar")
> library(rmr2)
> library(rhdfs)
> hdfs.init()
```

```
Be sure to run hdfs.init()
> hdfs.init()
14/03/16 00:55:13 ERROR security.UserGroupInformation: Unable to find JAAS classes:com.sun.se
curity.auth.UnixPrincipal not found in gnu.gcj.runtime.SystemClassLoader{urls=[file:/usr/lib6
4/R/library/rJava/java/boot/], parent=gnu.gcj.runtime.ExtensionClassLoader{urls=[], parent=nu
ll}}
14/03/16 00:55:14 WARN util.NativeCodeLoader: Unable to load native-hadoop library for your p
latform... using builtin-java classes where applicable
Error in .jcall("RJavaTools", "Ljava/lang/Object;", "invokeMethod", cl,  :
  java.io.IOException: failure to login
>
```

Javareconf error

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$ sudo R CMD javareconf

cloudera@localhost:~

File Edit View Search Terminal Help

```
[cloudera@localhost ~]$ sudo R CMD javareconf
Java interpreter : /usr/bin/java
Java version     : 1.5.0
Java home path   : /usr/lib/jvm/java-1.5.0-gcj-1.5.0.0/jre
Java compiler    : /usr/bin/javac
Java headers gen.: /usr/bin/javah
Java archive tool: /usr/bin/jar

trying to compile and link a JNI progam
detected JNI cpp flags    : -I$(JAVA_HOME)/../include -I$(JAVA_HOME)/../include/linux
detected JNI linker flags : -L/usr/lib64/gcj-4.4.7 -ljvm
gcc -m64 -std=gnu99 -I/usr/include/R -DNDEBUG -I/usr/lib/jvm/java-1.5.0-gcj-1.5.0.0/jre/../in
clude -I/usr/lib/jvm/java-1.5.0-gcj-1.5.0.0/jre/../include/linux -I/usr/local/include    -fpi
c  -O2 -g -pipe -Wall -Wp,-D_FORTIFY_SOURCE=2 -fexceptions -fstack-protector --param=ssp-buff
er-size=4 -m64 -mtune=generic  -c conftest.c -o conftest.o
gcc -m64 -std=gnu99 -shared -L/usr/local/lib64 -o conftest.so conftest.o -L/usr/lib64/gcj-4.4
.7 -ljvm -L/usr/lib64/R/lib -lR


Java library path: /usr/lib64/gcj-4.4.7
JNI cpp flags    : -I$(JAVA_HOME)/../include -I$(JAVA_HOME)/../include/linux
JNI linker flags : -L/usr/lib64/gcj-4.4.7 -ljvm
Updating Java configuration in /usr/lib64/R
Done.
```

javareconf with correct JAVA_HOME

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$ echo $JAVA_HOME

$ sudo JAVA_HOME=/usr/java/jdk1.6.0_32 R CMD javareconf

cloudera@localhost:~

File Edit View Search Terminal Help

```
[cloudera@localhost ~]$ sudo JAVA_HOME=/usr/java/jdk1.6.0_32 R CMD javareconf
Java interpreter : /usr/java/jdk1.6.0_32/jre/bin/java
Java version     : 1.6.0_32
Java home path   : /usr/java/jdk1.6.0_32
Java compiler    : /usr/java/jdk1.6.0_32/bin/javac
Java headers gen.: /usr/java/jdk1.6.0_32/bin/javah
Java archive tool: /usr/java/jdk1.6.0_32/bin/jar

trying to compile and link a JNI progam
detected JNI cpp flags    : -I$(JAVA_HOME)/include -I$(JAVA_HOME)/include/linux
detected JNI linker flags : -L$(JAVA_HOME)/jre/lib/amd64/server -ljvm
gcc -m64 -std=gnu99 -I/usr/include/R -DNDEBUG -I/usr/java/jdk1.6.0_32/include -I/usr/java/jdk
1.6.0_32/include/linux -I/usr/local/include    -fpic  -O2 -g -pipe -Wall -Wp,-D_FORTIFY_SOURC
E=2 -fexceptions -fstack-protector --param=ssp-buffer-size=4 -m64 -mtune=generic  -c conftest
.c -o conftest.o
gcc -m64 -std=gnu99 -shared -L/usr/local/lib64 -o conftest.so conftest.o -L/usr/java/jdk1.6.0
_32/jre/lib/amd64/server -ljvm -L/usr/lib64/R/lib -lR


Java library path: $(JAVA_HOME)/jre/lib/amd64/server
JNI cpp flags    : -I$(JAVA_HOME)/include -I$(JAVA_HOME)/include/linux
JNI linker flags : -L$(JAVA_HOME)/jre/lib/amd64/server -ljvm
Updating Java configuration in /usr/lib64/R
Done.

[cloudera@localhost ~]$
```

Install Rstudio

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```
$ wget http://download2.rstudio.org/rstudio-server-0.98.501-x86_64.rpm
$ sudo yum install --nogpgcheck rstudio-server-0.98.501-x86_64.rpm
```

Login into RStudio

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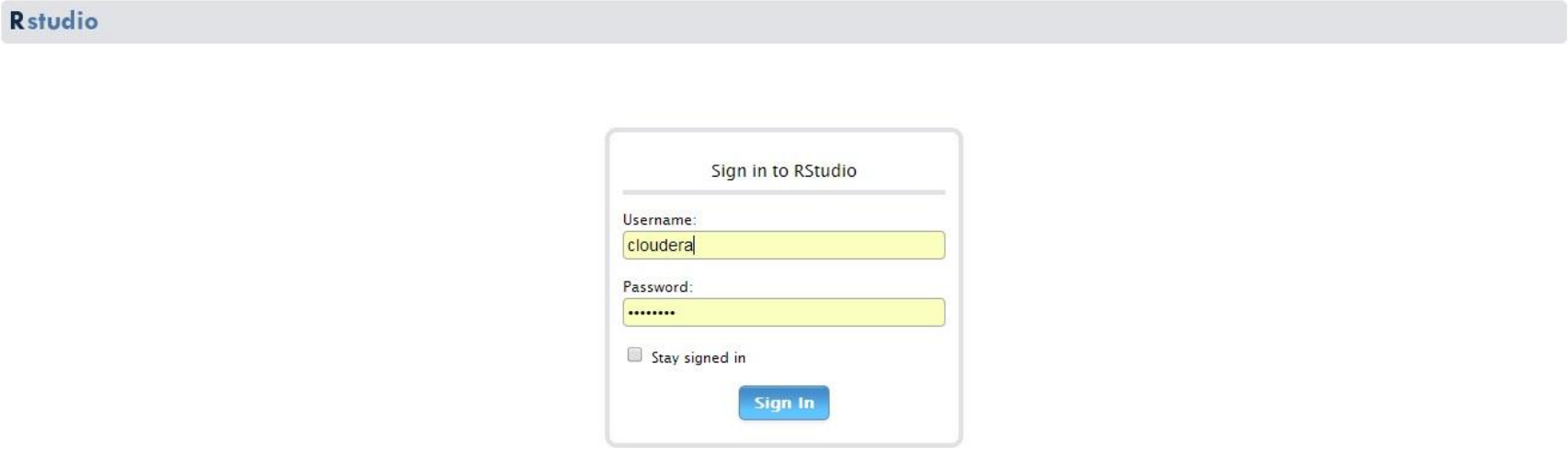
Username: cloudera
Password: cloudera



MapReduce
With RHadoop

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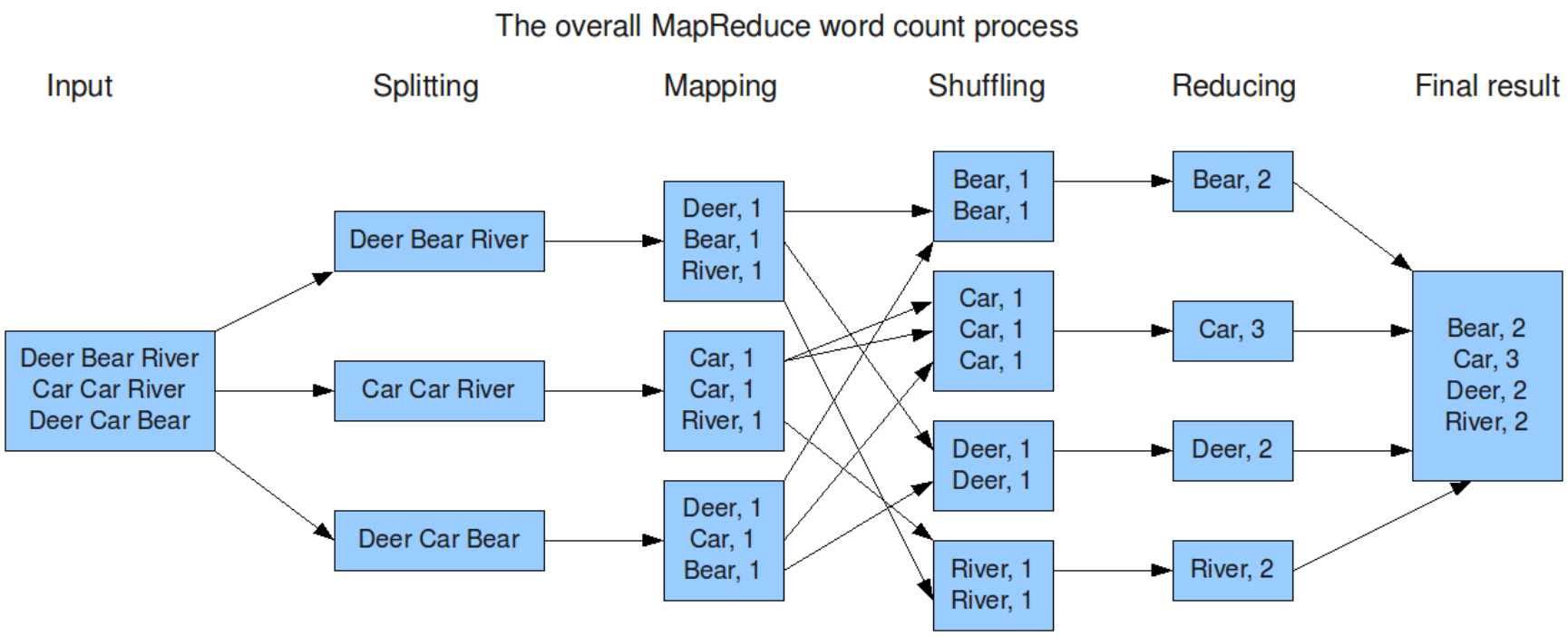
MapReduce

- mapreduce(input, output, map, reduce)
- Like sapply, lapply, tapply within R

Hello World – For Hadoop



http://www.rabidgremlin.com/data20/MapReduceWordCountOverview1.png

Move File Into HDFS

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Put data into hdfs

```
Sys.setenv(HADOOP_CMD="/usr/bin/hadoop")
Sys.setenv(HADOOP_STREAMING="/usr/lib/hadoop-0.20-mapreduce/contrib/streaming/hadoop-streaming-2.0.0-mr1-cdh4.4.0.jar")
library(rmr2)
library(rhdfs)
hdfs.init()
hdfs.mkdir("/user/cloudera/wordcount/data")
hdfs.put("wc_input.txt", "/user/cloudera/wordcount/data")
```

```
$ hadoop fs –mkdir /user/cloudera/wordcount/data
$ hadoop fs –put wc_input.txt /user/cloudera/word/count/data
```

Wordcount Mapper

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#Mapper

```
map <- function(k,lines) {
  words.list <- strsplit(lines, '\\s')
  words <- unlist(words.list)
  return( keyval(words, 1) )
}
```

```
public static class Map extends MapReduceBase implements Mapper<LongWritable, Text, Text, IntWritable>
{
    private final static IntWritable one = new IntWritable(1);
    private Text word = new Text();
    public void map(LongWritable key, Text value, OutputCollector<Text, IntWritable> output, Reporter
reporter) throws IOException {
    String line = value.toString();
    StringTokenizer tokenizer = new StringTokenizer(line);
          while (tokenizer.hasMoreTokens()) {
                    word.set(tokenizer.nextToken());
                    output.collect(word, one);
          }
    }
}
```

Wordcount Reducer

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#Reducer

```
reduce <- function(word, counts) {
  keyval(word, sum(counts))
}
```

```
public static class Reduce extends MapReduceBase implements
Reducer<Text, IntWritable, Text, IntWritable> {
    public void reduce(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));
    }
}
```

Call Wordcount

```
hdfs.root <- 'wordcount'
hdfs.data <- file.path(hdfs.root, 'data')
hdfs.out <- file.path(hdfs.root, 'out')

wordcount <- function (input, output=NULL) {
  mapreduce(input=input, output=output,
input.format="text", map=map, reduce=reduce)
}
out <- wordcount(hdfs.data, hdfs.out)
```

Read data from HDFS

```
results <- from.dfs(out)

results$key[order(results$val, decreasing
= TRUE)][1:10]
```

```
$ hadoop fs –cat /user/cloudera/wordcount/out/part-00000 |
sort –k 2 –nr | head –n 10
```

MapReduce Benchmark

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```
> a.time <- proc.time()
> small.ints2=1:100000
> result.normal = sapply(small.ints2, function(x) x^2)
> proc.time() - a.time
```

```
> b.time <- proc.time()
> small.ints= to.dfs(1:100000)
> result = mapreduce(input = small.ints, map = function(k,v)
                     cbind(v,v^2))
> proc.time() - b.time
```

sapply

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Elapsed 0.982 second

```
> a.time <- proc.time()
> small.ints2=1:100000
> result.normal = sapply(small.ints2, function(x) x^2)
> proc.time() - a.time
   user  system elapsed
  0.323   0.292   0.982
```

mapreduce

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Elapsed 102.755 seconds

```
> b.time <- proc.time()
> small.ints= to.dfs(1:100000)
14/03/16 01:45:13 INFO zlib.ZlibFactory: Successfully loaded & initialized native-zlib l
ibrary
14/03/16 01:45:13 INFO compress.CodecPool: Got brand-new compressor [.deflate]
Warning message:
In to.dfs(1:1e+05) : Converting to.dfs argument to keyval with a NULL key
> result = mapreduce(input = small.ints, map = function(k,v) cbind(v,v^2))
packageJobJar: [/tmp/RtmpN2yqhK/rmr-local-env6219109c860a, /tmp/RtmpN2yqhK/rmr-global-en
v6219891ce2b, /tmp/RtmpN2yqhK/rmr-streaming-map6219fd52f9, /tmp/hadoop-cloudera/hadoop-u
njar4261759795176283750/] [] /tmp/streamjob2063587612495148779.jar tmpDir=null
14/03/16 01:45:22 WARN mapred.JobClient: Use GenericOptionsParser for parsing the argume
nts. Applications should implement Tool for the same.
14/03/16 01:45:23 INFO mapred.FileInputFormat: Total input paths to process : 1
14/03/16 01:45:24 INFO streaming.StreamJob: getLocalDirs(): [/tmp/hadoop-cloudera/mapred
/local]
14/03/16 01:45:24 INFO streaming.StreamJob: Running job: job_201403151827_0002
14/03/16 01:45:24 INFO streaming.StreamJob: To kill this job, run:
14/03/16 01:45:24 INFO streaming.StreamJob: UNDEF/bin/hadoop job  -Dmapred.job.tracker=l
ocalhost.localdomain:8021 -kill job_201403151827_0002
14/03/16 01:45:24 INFO streaming.StreamJob: Tracking URL: http://0.0.0.0:50030/jobdetail
s.jsp?jobid=job_201403151827_0002
14/03/16 01:45:25 INFO streaming.StreamJob:  map 0%  reduce 0%
14/03/16 01:46:10 INFO streaming.StreamJob:  map 50%  reduce 0%
14/03/16 01:46:12 INFO streaming.StreamJob:  map 100%  reduce 0%
14/03/16 01:46:33 INFO streaming.StreamJob:  map 100%  reduce 100%
14/03/16 01:46:33 INFO streaming.StreamJob: Job complete: job_201403151827_0002
14/03/16 01:46:33 INFO streaming.StreamJob: Output: /tmp/RtmpN2yqhK/file621977a6faca
> proc.time() - b.time
   user  system elapsed
 28.903   1.812 102.755
```


幹什麼呀？！

Hadoop Latency

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- HDFS stores your files as data chunk distributed on multiple datanodes
- M/R runs multiple programs called mapper on each of the data chunks or blocks. The (key,value) output of these mappers are compiled together as result by reducers.
- It takes time for mapper and reducer being spawned on these distributed system.

Kmeans Clustering

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```
kcluster=[illegible]eans((m[illegible]ta, 4, iter.ma[illegible]10)
```

Kmeans in MapReduce Style

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```
kmeans =
  function(points, ncenters, iterations = 10, distfun = NULL) {
    if(is.null(distfun))
      distfun = function(a,b) norm(as.matrix(a-b), type = 'F')

    newCenters =
      kmeans.iter(
        points,
        distfun,
        ncenters = ncenters)
    # interatively choosing new centers
    for(i in 1:iterations) {
        newCenters = kmeans.iter(points, distfun,
              centers = newCenters)
    }
    newCenters
}
```

Kmeans in MapReduce Style

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```
kmeans.iter =
  function(points, distfun, ncenters = dim(centers)[1], centers = NULL)
{
    from.dfs(mapreduce(input = points,
         map =
          if (is.null(centers)) { #give random point as sample
              function(k,v) keyval(sample(1:ncenters,1),v)}
          else {
              function(k,v) { #find center of minimum distance
                 distances = apply(centers, 1, function(c) distfun(c,v))
                 keyval(centers[which.min(distances),], v)}},
         reduce = function(k,vv) keyval(NULL,
                 apply(do.call(rbind, vv), 2, mean))),
    to.data.frame = T)
}
```

One More Thing…
plyrmr

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NEW! plyrmr

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- Perform common data manipulation operations, as found in **plyr** and **reshape2**
- It provides a familiar plyr-like interface while hiding many of the mapreduce details
- **plyr: Tools for splitting, applying and combining data**

Installation plyrmr dependencies

```
$ yum install libxml2-devel
$ sudo yum install curl-devel
$ sudo R

> Install.packages(c(“ Rcurl”, “httr”),  dependencies = TRUE
> Install.packages(“devtools”, dependencies = TRUE)
> library(devtools)
> install_github("pryr", "hadley")
> Install.packages(c(“ R.methodsS3”, “hydroPSO”),  dependencies = TRUE)
```

Installation plyrmr

```
$ wget https://raw.github.com/RevolutionAnalytics/plyrmr/master/build/plyrmr_0.1.0.tar.gz

$ sudo R CMD INSTALL plyrmr_0.1.0.tar.gz
```

Transform in plyrmr

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```
> data(mtcars)
> head(mtcars)
> transform(mtcars, carb.per.cyl = carb/cyl)
```

```
> library(plyrmr)
> output(input(mtcars), "/tmp/mtcars")
> as.data.frame(transform(input("/tmp/mtcars"),
carb.per.cyl = carb/cyl))
> output(transform(input("/tmp/mtcars"), carb.per.cyl =
carb/cyl), "/tmp/mtcars.out")
```

select and where

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```
where(
    select(
        mtcars,
        carb.per.cyl = carb/cyl,
        .replace = FALSE),
    carb.per.cyl >= 1)
```

```
               mpg cyl disp  hp drat   wt qsec vs am gear carb carb.per.cyl
Ferrari Dino  19.7   6  145 175 3.62 2.77 15.5  0  1    5    6            1
Maserati Bora 15.0   8  301 335 3.54 3.57 14.6  0  1    5    8            1
```

Group by

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```
as.data.frame(
    select(
        group(
            input("/tmp/mtcars"),
            cyl),
        mean.mpg = mean(mpg)))
```

```
    cyl mean.mpg
1     6    19.74
1.1   4    26.66
1.2   8    15.10
```

Reference

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- https://github.com/RevolutionAnalytics/RHadoop/wiki
- http://www.slideshare.net/RevolutionAnalytics/rhadoop-r-meets-hadoop
- http://www.slideshare.net/Hadoop_Summit/enabling-r-on-hadoop

Contacts

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THANK YOU