
rhipe Documentation

Release 0.5

Saptarshi Guha

September 11, 2009

CONTENTS

1	Setting up RHIPE	3
1.1	Requirements	3
1.2	Installation	3
2	The <code>rhlappl</code>y Command	5
2.1	Introduction	5
2.2	Return Value	5
2.3	Function Usage	5
3	The <code>rhmr</code> Command	7
3.1	Introduction	7
3.2	Return Value	7
3.3	Function	7
3.4	RHIPE Options	8
3.5	Status, Counters and Writing Output	8
3.6	Side Effect files	9
4	Miscellaneous Commands	11
4.1	Introduction	11
4.2	Serialization	11
4.3	HDFS Related	11
5	Using RHIPE on EC2	15
5.1	Introduction	15
5.2	Usage	15
5.3	Some launch commands	15
5.4	Useful tools	16
6	Examples	17
6.1	<code>rhlappl</code> y	17
6.2	<code>rhmr</code>	18
7	FAQ	19
8	Protobuffer and R	21

Mainpage

SETTING UP RHIPE

1.1 Requirements

1. *Protobuffers*

RHIPE uses Google's Protobuf library for serialization. This(the C/C++ libraries) must be installed on *all* machines (master/workers). Get Protobuffers from <http://code.google.com/p/protobuf/>. RHIPE already has the protobuf jar file inside it.

Non Standard Locations If installing protobuf to a non standard location, update the PKG_CONFIG_PATH variable, e.g

```
export PKG_CONFIG_PATH=$PKG_CONFIG_PATH:$CUSTROOT/lib/pkgconfig/
```

2. *R* , tested on 2.8

3. *rJava* The R package needs rJava.

Tested on RHEL Linux, though *may* work on Windows

1.2 Installation

On every machine

```
R CMD INSTALL Rhipe_VERSION.tar.gz
```

To load it

```
library(Rhipe)
```


THE RHLAPPLY COMMAND

2.1 Introduction

`rhapply` applies a user defined function to the elements of a given R list or the function can be run over the set of numbers from 1 to `n`. In the former case the list is written to a sequence file, whose length is the default setting of `rhwrite`.

Running a hundreds of thousands of separate trials can be terribly inefficient, instead consider grouping them, i.e. set `mapred.max.tasks` to a value much smaller than the length of the list.

2.2 Return Value

`rhapply` returns a list, the names of which is equal to the names of the input list (if given).

2.3 Function Usage

```
1  rhapply <- function( ll=NULL,  
2                        fun,  
3                        ifolder="",  
4                        ofolder="",  
5                        readIn=T,  
6                        inout=c('lapply','sequence')  
7                        mapred=list()  
8                        setup=NULL, jobname="rhapply", ...  
9                        )
```

Description follows

ll The list object, optional. Applies `fun` to `ll[[i]]`. If instead `ll` is a numeric, applies `fun` to each element of `seq(1, ll)`. If not given, must provide a value for `ifolder`

fun A function that takes only one argument.

ifolder If `ll` is null, provide a source here. Also change the value of `inout[1]` to either `text` or `sequence`.

readIn The results are stored in a temporary sequence file on the DFS which is deleted. Should the results be returned in a list? Default is `TRUE`. For large number of output key-values (e.g 1MM) set this to `FALSE`, using the default options to `hread` is extremely slow.

ofolder If given the results are written to this folder and not deleted. If not, they are written to temporary folder, read back in (assuming `readIn` is `TRUE`) and deleted.

mapred Options passed onto `rhmr`

setup And expression that is called before running `func`. Called once per JVM.

... passed onto `RHMR`.

2.3.1 RETURN

An object that is passed onto `rhex`.

THE RHMR COMMAND

3.1 Introduction

The `rhmr` command runs a general mapreduce program using user supplied map and reduce commands.

3.2 Return Value

In general a set of files on the Hadoop Distributed File System. It can be of Text Format or a Sequence file format. In case of the latter, the key and values can be any R data structure.

3.3 Function

```
1 rhmr <- function(map, reduce=NULL,
2   combiner=F, #CANNOT BE CHANGED
3   setup=NULL,
4   cleanup=NULL,
5   ofolder='',
6   ifolder='',
7   inout=c("text", "text"),
8   mapred=NULL,
9   shared=c(),
10  jarfiles=c(),
11  copyFiles=F,
12  opts=rhoptions(), jobname="")
```

map A map expression, not a function. The map expression can expect a list of keys in `map.keys` and list of values in `map.values`.

reduce Can be null if only a map job. If not, reduce should be an expression with three attributes

pre Called for a new key, but no values have been read. The key is present in `reduce.key`.

reduce Called for reducing the incoming values. The values are in a list called `reduce.values`

post Called when all the values have been sent.

combiner Uses a combiner if TRUE. If so, then `reduce.values` present in the `reduce$reduce` expression will be a *subset* of values.

setup An expression that can be called to setup the environment. Called once for every task. It can be a list of two attributes `map` and `reduce` which are expressions to be run in the map and reduce stage. If a single expression then that is run for both map and reduce

cleanup Same as for `setup`, run when all work for a task is complete.

ifolder A folder or file to be processed. Can be a vector of strings.

ofolder The folder to store output in. Side effects will be copied here.

inout ` A vector of input type and output type. **text** indicates Text Format. Use `mapred.field.separator` to separate the elements of a vector.

sequence is a sequence format. Outputs in this form /can/ be used as an input.

binary is a simple binary format consisting of key-length, key data, value-length, value data where the lengths are integers in network order. Though *much* faster than sequence in terms of reading in data, it *cannot* be used as an input to a map reduce operation.

shared A vector of files on the HDFS that will be copied to the working directory of the R program. These files can then be loaded as easily as `load(filename)` (removed leading path)

jarfiles Copy jar files if required. Experimental, probably doesn't work.

copyFiles For side effects to be copied back to the DFS, set this to TRUE, otherwise they wont be copied.

mapred Set Hadoop options here and RHIFE options.

jobname the jobname, if not given, then current date and time is the job title.

3.4 RHIFE Options

rhipe_stream_buffer The size of the STDIN buffer used to write data to the R process(in bytes) *default:* 10*1024 bytes

mapred.textoutputformat.separator The text that separates the key from value when `inout[2]` equals text. *default:* Tab

mapred.field.separator The text that separates fields when `inout[2]` equals text. *default:* Space

rhipe_reduce_buff_size The maximum length of `reduce.values` *default:* 10,000

rhipe_map_buff_size The maximum length of `map.values` (and `map.keys`) *default:* 10,000

3.5 Status, Counters and Writing Output

3.5.1 Status

To update the status use `rhstatus` which takes a single string e.g `rhstatus("Nice")` This will also indicate progress.

3.5.2 Counter

To update the counter `C` in the group `G` with a number `N`, user `rhcounter(G,C,N)` where `C` and `G` are strings and `N` is a number.

3.5.3 Output

To output data use `rhcollect(KEY, VALUE)` where `KEY` and `VALUE` are R objects that can be serialized by `rhsz` (see the misc page). If one needs to send across complex R objects e.g the `KEY` is a function, do something like `rhcollect(serialize(KEY, NULL), VALUE)`

3.6 Side Effect files

Files written to `tmp/` (no leading slash !) e.g `pdf("tmp/x.pdf")` will be copied to the output folder.

MISCELLANEOUS COMMANDS

4.1 Introduction

This is a list of supporting functions for reading, writing sequence files and manipulating files on the Hadoop Distributed File System (HDFS).

4.2 Serialization

4.2.1 rhsz

```
rhsz <- function(object)
```

Serializes a given R object. Currently the only objects that can be serialized are vectors of Raws, Numerics, Integers, Strings (including NA), Logical (including NA) and lists of these and lists of lists of these. Attributes are copied to (e.g. names attributes). It appears objects like matrices, factors also get serialized and unserialized successfully.

4.2.2 rhuz

```
rhuz <- function(object)
```

Unserializes a raw object returned from rhsz

4.3 HDFS Related

4.3.1 rhsave

```
rhsave <- function(..., file)
```

Saves the objects in ... to file on the HDFS. All other options are passed onto the R function save

4.3.2 rhsave.image

```
rhsave.image <- function(..., file)
```

Same as R's `save.image`, except that the file goes to the HDFS.

4.3.3 rhput

```
rhput <- function(src,dest,deleteDest=TRUE)
```

Copies the file in `src` to the `dest` on the HDFS, deleting destination if `deleteDest` is `TRUE`.

4.3.4 rhget

```
rhget <- function(src,dest)
```

Copies `src` (on the HDFS) to `dest` on the local. If `src` is a directory and `dest` exists, `src` is copied inside `dest` (i.e a folder inside `dest`). If not (i.e `dest` does not exist), `src`'s contents is copied to a new folder called `dest`. If `src` is a file, and `dest` is a directory `src` is copied inside `dest`. If `dest` does not exist, it is copied to that file

Wildcards allowed

OVERWRITES!

4.3.5 rhls

```
rhls <- function(dir)
```

Lists the path at `dir`. Wildcards allowed.

4.3.6 rhdel

```
rhdel <- function(dir)
```

Deletes file(s) at/in `dir`. Wildcards allowed.

4.3.7 rhwrite

```
rhwrite <- function(lo,f,n=NULL,...)
```

Writes the list `lo` to the file `f`. `n` is the number of sequence files to split the list into. The default value of `n` is `mapred.map.tasks * mapred.tasktracker.map.tasks.maximum`.

4.3.8 rhread

```
rhread <- function(files,max=NA,batch=100,length=1000)
```

Reads files(s) from `files` (which could be a directory). Wildcards allowed.

`max` is the maximum number of key-values to be read.

`batch` is how many to key-value pairs to request from Java in one go.

`length` is the initial size of the return list(a larger value will makes things faster if one is expecting to read in many items).

The latter two are important when it comes to reading sequence files with many values(100K+), set `batch` to a large number and `length` to an equally large number to reduce the number of JNI calls and vector resizes.

4.3.9 rhreadBin

```
rhreadBin <- function(filename, max=as.integer(-1), bf=as.integer(0))
```

Reads data outputed in 'binary' form. `max` is the maximum number to read, -1 is all. `bf` is the read buffer, 0 implies the os specified default `BUFSIZ`

USING RHIPE ON EC2

5.1 Introduction

There is one 32 bit EC2 AMI with R-2.8, Hadoop 0.21 and the latest RHIPE. [s3sync](#) is also present.

The following describes the usage of the EC2 scripts.

5.2 Usage

- Get an Amazon EC2 account and confirm the ability to start and instance from the command line (using `ec2-tools`).
- Unzip the `rhipe-ec2` distribution (see the downloads page)
- OPTIONS

In `bin/hadoop-ec2-env.sh` template there are several options:

AWS_ACCOUNT_ID fill this from the Amazon Account Identifiers

AWS_ACCESS_KEY_ID same as above

AWS_SECRET_ACCESS_KEY same as above

R_USER_FILE a URL to an R script. This file is executed on machine boot up. Useful to install R packages. Read `bin/hadoop-ec2-env.sh.template` for details.

INSTANCE_TYPE choose the Amazon machine instance type. For details, go to <http://aws.amazon.com/ec2/instance-types/>

- Save the file as `bin/hadoop-ec2-env.sh`

5.3 Some launch commands

- launch

`bin/hadoop-ec2 launch-cluster clustername number-of-workers`

Replace `clustername` with the name of the cluster and `number-of-workers` with the number of workers. Use Elasticfox to check all the instances are running, this can some time.

- login

```
bin/hadoop-ec2 login clustername
```

- terminate

```
bin/hadoop-ec2 terminate-cluster clustername
```

- You can check the status of jobs at masterip:50030 in your web browser.

5.4 Useful tools

s3fox A S3 file browser that works within Firefox.

Elasticfox EC2 management tools, a Firefox add-on.

EXAMPLES

6.1 rhlapply

6.1.1 Simple Example

Take a sample of 100 iid observations X_i from $N(0,1)$. Compute the mean of the eight closest neighbours to X_1 . This is repeated 1,000,000 times.

```
1 nbrmean <- function(r) {  
2   d <- matrix(rnorm(200), ncol=2)  
3   orig <- d[1,]  
4   ds <- sort(apply(d, 1, function(r) sqrt(sum((r-orig)^2)))[-1])[1:8]  
5   mean(ds)  
6 }  
7 trials <- 1000000
```

One Machine

trials is 1,000,000

```
system.time({r <- sapply(1:trials, nbrmean)})  
user system elapsed  
1603.414 0.127 1603.789
```

Distributed, output to file

```
mapred <- list(mapred.map.tasks=1000)  
r <- rhlapply(1000000, fun=nbrmean, ofolder="/test/one", mapred=mapred)  
rhex(r)
```

Which took 7 minutes on a 4 core machine running 6 JVMs at once.

6.1.2 Using Shared Files and Side Effects

```
1 h=rhlapply(length(simlist)  
2 , func=function(r) {  
3   ## do something from data loaded from session.Rdata  
4   pdf("tmp/a.pdf")  
5   plot(animage)  
6   dev.off()},
```

```
7   setup=expression({
8     load("session.Rdata")
9   }),
10  hadoop=list(mapred.map.tasks=1000),
11  shared.files=("/tmp/session.Rdata"))
```

Here `session.Rdata` is copied from HDFS to local temporary directories (making for faster reads). This is a useful idiom for loading code that the `rhlaply` function might depend on. For example, assuming the image is not *huge*

```
1  rhsave.image("/tmp/myimage.Rdata")
2  rhlaply(N,function(r) {
3    object <- dataset[[r]]
4    G(object)
5  },setup=expression({load("myimage.Rdata")}))
```

In the above example, I wish to apply the `G` to every element in `dataset`.

6.2 rhmr

6.2.1 Word Count

Generate the words, 1 word every line

```
rhlaply(10000,function(r) paste(sample(letters[1:10],5),collapse=""),output.folder="/tmp/words")
```

Word count using the sequence file

Run it

```
z <- rhmr(map=m,reduce=r,inout=c("sequence","sequence"),
  ifolder="/tmp/words",ofolder="/tmp/wordcount")
rhex(z)
```

6.2.2 Subset a file

We can use this RHIPE to subset files. Setting `mapred.reduce.tasks` to 5 writes the subsetted data across 5 files (even though we haven't provided a reduce task)

```
1  m <- expression({
2    for(x in map.values){
3      y <- strsplit(x," +")[[1]]
4      for(w in y) rhcollect(w,T)
5    }})
6  z <- rhmr(map=m,inout=c("text","binary"),
7    ifolder="X",ofolder='Y',mapred=list(mapred.reduce.tasks=5))
8  rhex(z)
```

FAQ

1. Local Testing?

Easily enough. In `rhmr` or `rhlappl`y, set `mapred.job.tracker` to 'local' in the `mapred` option of the respective command. This will use the local jobtracker to run your commands.

However keep in mind, `shared.files` will not work, i.e those files will not be copied to the working directory and side effect files will not be copied back.

1. Speed?

Similar to Hadoop Streaming. The bottlenecks are writing and reading to STDIN pipes and R.

PROTOBUFFER AND R

A package called `rprotobuf` which implements a simple serialization using Googles protocol buffers[1]. The package also includes some miscellaneous functions for writing/reading variable length encoded integers, and Base64 encoding/decoding related functions. The package can be downloaded from http://ml.stat.purdue.edu/rprotobuf_1.0.tar.gz it requires one to install `libproto` (Googles protobuf library)

Brief Description

The R objects that can be serialized are numerics, integers, strings, logicals, raw, nulls and lists. Attributes of the aforementioned are preserved. NA is also preserved (for the above) As such, the objects include factors and matrices. The proto file can be found in the source.

Todo:

Very possible though needs some reading on my part: it is possible to extend this to serialize functions, expressions, environments and several other objects. However that is some time in the future.

Download package(with source) : http://ml.stat.purdue.edu/rprotobuf_1.0.tar.gz

Install

```
R CMD INSTALL rprotobuf_1.0.tar.gz
```

[1] <http://code.google.com/apis/protocolbuffers/docs/overview.html>