# Modern R Quick Start for System & Network Administrators

Part II of "Diagnosing Multi-Vendor Network Issues with an Introduction to R for System & Network Administrators"

Jon Meek
meekjt (at) gmail.com
meekj (at) ieee.org

4-Feb-2016 / LOPSA-NJ

## Why R?

- The standard statistics package in academia and industry
- Lots of users, lots of packages (6,000+ on CRAN)
- Can be very fast - vectorized functions & more
- Interactive data analysis
- Batch jobs as well
- IEEE language ranking, #6 in 2015, up from #9
- R Consortium - Microsoft, Google, Oracle, HPE, ...

## Why not R?

- Steep learning curve - Still true ?
- In general, all data need to be in memory
- Can be very slow
- Have to be careful when programming, e.g. loops are slow
- But, can always use C++ (Rcpp package)
- Command line flexibility is lacking
- Competition
  - SciPy / IPython - Probably good for Python experts
  - Julia - Supposedly fast, but Rcpp may be the more versatile choice

## Using R in the Modern Way

- This is a “Quick Start” guide and “Roadmap”
- You will need additional reference material, soon
- “It’s just one man’s opinion” F. Sinatra
- Avoid Many Base Features:
  - Base graphics
  - Functions: lapply, sapply, tapply, aggregate, subset
- Avoid time series (zoo, xts)
- Use the Hadleyverse!
- These suggestions should save time and reduce future refactoring

## The Hadleyverse

- Extremely popular packages by Hadley Wickham
  - RStudio, Rice University, R Foundation
- ggplot2 - Flexible and beautiful plotting, but avoid qplot
- dplyr - Data wrangling (avoid the older plyr)
- readr - Flexible (mostly) and fairly fast data file reading
- tidyr - Reshape data, long or wide
- lubridate - Date & time manipulation, but try the base functions first
- stringr - But try the base string functions first

## Running R

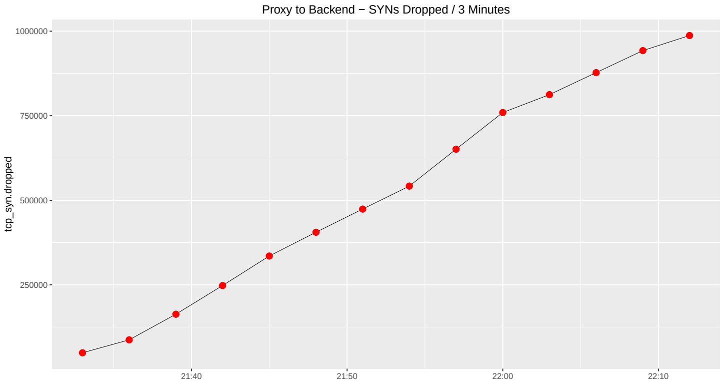
- Interactive data analysis & development
  - ESS - Emacs Speaks Statistics
  - RStudio - Best for non-Emacs users
- Running batch jobs
  - R CMD Sweave ~/wpl/talks/lopsanj-2016-1/modernR.Rnw
  - #!/usr/local/bin/Rscript
  - #!/usr/bin/env /usr/local/bin/r - “littler” better CLI
- Reports
  - R + LaTeX + Sweave → publication quality PDF
  - R + Markdown + knitr $\rightsquigarrow$ nice HTML output
- Interactive Web Applications
  - Shiny - Full featured interactive applications
  - ggvis, GoogleVis, etc - JavaScript active graphics

## Example 1 - Small Number of Data Points - Inline

```
IPSraw <- 'Time tcp_syn.dropped tcp_syn.forwarded
2015-09-17T21:33 49050 48483
2015-09-17T21:36 87309 85551
2015-09-17T21:39 163092 99578
2015-09-17T21:42 247875 114235
2015-09-17T21:45 335129 129098
2015-09-17T21:48 405430 135635
2015-09-17T21:51 473972 143137
2015-09-17T21:54 541985 149912
2015-09-17T21:57 651037 158139
2015-09-17T22:00 759434 166562
2015-09-17T22:03 812341 170244
2015-09-17T22:06 877437 174047
2015-09-17T22:09 942562 177693
2015-09-17T22:12 987158 180936'
```

## Example 1 - “Read” data and plot

```
library(readr)
library(ggplot2)

IPS <- read_delim(IPSraw, delim = ' ',
 col_types = list(Time = col_datetime('%Y-%m-%dT%H:%M')))

PointSize <- 1.0  # Also used in Example 2

Title <- 'Proxy to Backend - SYNs Dropped / 3 Minutes'

ggplot(IPS) +
    geom_line(aes(x = Time, y = tcp_syn.dropped), size=0.1) +
    geom_point(aes(x = Time, y = tcp_syn.dropped),
    size=PointSize + 2, color = 'red', shape=19) +
    xlab('') +
    ggtitle(Title)
```



Example 1 Plot

## Have a Look at the Data

Just type variable name at the R prompt:

```
> IPS
Source: local data frame [14 x 3]

                  Time tcp_syn.dropped tcp_syn.forwarded
                (time)           (int)             (int)
1  2015-09-17 21:33:00           49050             48483
2  2015-09-17 21:36:00           87309             85551
3  2015-09-17 21:39:00          163092             99578
4  2015-09-17 21:42:00          247875            114235
5  2015-09-17 21:45:00          335129            129098
6  2015-09-17 21:48:00          405430            135635
7  2015-09-17 21:51:00          473972            143137
8  2015-09-17 21:54:00          541985            149912
9  2015-09-17 21:57:00          651037            158139
10 2015-09-17 22:00:00          759434            166562
11 2015-09-17 22:03:00          812341            170244
12 2015-09-17 22:06:00          877437            174047
13 2015-09-17 22:09:00          942562            177693
14 2015-09-17 22:12:00          987158            180936
```

## Have a Look at the Data

Use the str() function to see the internal structure of the R object:

```
> str(IPS)
Classes 'tbl_df', 'tbl' and 'data.frame': 14 obs. of  3 variables:
 $ Time            : POSIXct, format: "2015-09-17 21:33:00" "2015-09-17 21:36:00" "2015-09-17 21:39:00" "2015-
 $ tcp_syn.dropped  : int  49050 87309 163092 247875 335129 405430 473972 541985 651037 759434 ...
 $ tcp_syn.forwarded: int  48483 85551 99578 114235 129098 135635 143137 149912 158139 166562 ...
```

- This is a Data Frame
  - Usually the best way to organize and operate on data sets
  - Each column can be a different type
- Note that Time is POSIXct
  - POSIXct is best format for Date + Time
  - Avoid POSIXlt, and the special time series types and packages: (ts, zoo, xts, etc)

## Notes on Reading Data

- We used read_delim from the readr package
- Warning: read_delim with delim = ' ' does not tolerate multiple spaces between fields
- Base R's read.table would have worked, but
  - It would have made Time be a "factor" data type
  - Converting to POSIXct would require one (ugly) line of code
  - read.table has no issue with multiple whitespace characters
- readr functions are much faster than Base R read.table and friends
- For extremely large data sets check out fread from the data.table package

# Example 2 - Data Wrangling - The Data File

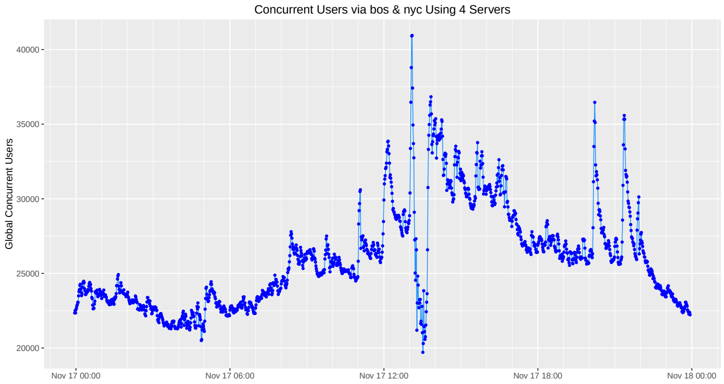
## UNIX Seconds - Server Name - %CPU - %Memory - Concurrent Users

```
utime Server CPU Memory Users
1447718220 chn-bc-sg-01 4 22 542
1447718220 chn-bc-sg-02 6 22 510
1447718220 lon-bc-sg-01 8 21 1806
1447718220 lon-bc-sg-02 9 20 1566
1447718220 tok-bc-ce-01 2 35 331
1447718220 tok-bc-sg-01 23 24 1714
1447718220 snd-bc-sg-01 8 24 405
1447718220 snd-bc-sg-02 8 23 360
1447718220 bos-bc-ce-03 1 17 0
1447718220 bos-bc-ce-04 1 24 0
1447718220 bos-bc-drp-01 24 55 11166
1447718220 bos-bc-drp-02 23 55 11182
1447718220 bos-bc-rp-01 10 16 74
1447718220 bos-bc-sg-01 15 23 1675
1447718220 bos-bc-sg-02 15 20 1631
1447718220 bos-bc-sg-03 14 20 1503
1447718220 sng-bc-ce-01 1 25 218
1447718220 nyc-bc-drp-01 0 20 0
1447718220 nyc-bc-drp-02 0 20 0
1447718220 nyc-bc-rp-01 2 24 0
1447718220 nyc-bc-rp-02 1 16 1
1447718220 nyc-bc-sg-01 14 21 1906
1447718220 nyc-bc-sg-02 20 22 1873
1447718220 nyc-bc-sg-03 12 22 1684
1447718220 syd-bc-ce-01 18 65 479
... 53,278 lines of data
```

We will select only the *-drp-* proxy data

# Example 2 - Data Wrangling - The Code

```
library(dplyr) # Provides %>% and functions used for filtering and aggregation - See Data Wrangling Cheatsheet

site_servers <- list() # Servers of interest
site_servers[["nyc"]] <- c("nyc-bc-drp-01", "nyc-bc-drp-02")   # A form of hash
site_servers[["bos"]] <- c("bos-bc-drp-01", "bos-bc-drp-02")

servers_of_interest <- unique(unlist(site_servers))            # Vector of server names

File <- '/home/meekj/wpl/talks/lopsanj-2016-1/si20151117.dat'

bc <- read.table(File, header = TRUE)                          # Base R read.table
bc <- bc %>% filter(Server %in% servers_of_interest)           # Keep only servers of interest
bc$Time <- as.POSIXct(bc$utime, tz="UTC", origin="1970-01-01") # UNIX seconds to POSIXct

global_agg <- bc %>% group_by(Time) %>% summarise(TotalUsers = sum(Users), ServerCount = n()) # Pipe-like

MedianServerCount <- median(global_agg$ServerCount)                   # How many servers?
global_agg <- global_agg %>% filter(ServerCount == MedianServerCount) # Drop times with missing server data

bc$Egress  <- substr(bc$Server, 1, 3)           # Get data center site code from server name
SiteCodes  <- unique(bc$Egress)                 # Character vector of unique DC names
cSiteCodes <- paste(SiteCodes, collapse = ' & ') # Collapse into simple string

Title <- paste('Concurrent Users via', cSiteCodes, 'Using', MedianServerCount, 'Servers')

ggplot(global_agg) +
    geom_line(aes(x = Time, y = TotalUsers), size=PointSize - 0.6, color = 'dodgerblue') + # Line first
    geom_point(aes(x = Time, y = TotalUsers), size=PointSize, color = 'blue', shape=19) +  # Points on top
    xlab("") + ylab("Global Concurrent Users") +
    scale_x_datetime(date_minor_breaks = "1 hour") + # ggplot2 2.0.0, remove 'date_' for previous versions!
    ggtitle(Title)
```



Example 2 Plot

## Generating Reports

- These slides were made with R + LaTeX + Beamer + Sweave
- R + LaTeX + Sweave
  - Publication quality PDF
  - Page breaks are a pain !
  - LaTeX is somewhat complex, and can be a pain with syntax errors
- R + Markdown + knitr $\rightsquigarrow$ nice HTML output
  - Simple syntax
  - Easy to show R code
  - No page constraints

## Resources

- Get R: `https://cran.r-project.org/`
- Daily news: `http://www.r-bloggers.com/`
- `https://www.r-consortium.org/`
- Cheatsheets: `https://www.rstudio.com/resources/cheatsheets/`
  - Data Visualization Cheat Sheet
  - Data Wrangling Cheat Sheet
  - and others
- Many books are available, a few to get started
  - Project documentation
  - Base R programming: The Art of R Programming by Norman Matloff
  - Visualization: R Graphics Cookbook by Winston Chang
  - "Modern R": Mastering Data Analysis with R by Gergely Daróczi
  - Advanced R Programming by Hadley Wickham: `http://adv-r.had.co.nz/`
- Google → Stackoverflow are your friends, as expected
- Many courses are available, watch out for age and topics covered

## Installing R

- Mac and Windows (& personal Linux), just get from `https://cran.r-project.org/`
- Then add a few packages
  - sudo R –no-site-file –no-init-file –quiet
  - install.packages(c(”ggplot2”, ”plyr”, ”reshape2”, ”dplyr”, ”tidyr”))
  - install.packages(c(”lubridate”, ”readr”, ”stringr”, ”knitr”))
  - To exit R: 'q()' (don't save the workspace)

## Almost All of the Packages I Install

### Dependencies will cause other packages to be installed

```
install.packages(c("ggplot2", "plyr", "reshape2", "dplyr", "tidyr", "lubridate", "readr", "stringr", "knitr"))
install.packages(c("digest", "gtable", "munsell", "pspline", "hash", "getopt", "littler"))
install.packages(c("devtools", "RCurl", "RColorBrewer", "rbenchmark", "quantmod", "httr"))
install.packages(c("forecast", "RSQLite", "data.table", "ggvis"))
install.packages("caret")
install.packages(c("googleVis", "gridExtra"))
install.packages(c("TTR", "maps", "gdata", "spc", "scales"))
install.packages(c("xtable", "zoo", "xts", "chron", "lattice"))

install.packages(c("doParallel", "doMC", "labeling", "microbenchmark", "shiny", "jsonlite", "iptools"))
install.packages(c("wmtsa", "fftw", "fftwtools", "signal", "numDeriv", "ChemometricsWithR", "ptw"))
install.packages(c("hyperSpec", "sfsmisc", "baseline", "Peaks", "robfilter", "FKF", "KFAS"))
install.packages(c("StreamMetabolism", "PerformanceAnalytics", "qcc", "scatterplot3d"))
install.packages(c("BenfordTests", "RcppDE", "pryr", "purrr", "timeline", "tm", "wordcloud"))
install.packages(c("svglite", "rsvg", "webp", "", "", "", "", ""))

library(devtools)
devtools::install_github("twitter/BreakoutDetection")
devtools::install_github("twitter/AnomalyDetection")
devtools::install_github("slowkow/ggrepel")
install_github("hrbrmstr/resolv")
install_github("jayjacobs/tldextract")
install_github("hrbrmstr/ipapi")
nstall_github("hrbrmstr/taucharts@dev")

source("http://bioconductor.org/biocLite.R")
biocLite("aroma.light")
```

## Building R on Linux

- Good for full control, and retention of previous versions
- Under tcsh (sorry)

```
set BUILDDIR=/home/meekj/build
set TARDIR=~/Downloads
set RVERSION=3.2.3
cd $BUILDDIR
tar zxf $TARDIR/R-$RVERSION.tar.gz
cd R-$RVERSION

./configure --enable-R-shlib  --prefix /usr/local/R-$RVERSION
make
make check
sudo make install

sudo /usr/local/R-$RVERSION/bin/R --no-site-file --no-init-file
```

- Install packages as shown on previous slides

# Building R on Linux - Finish

- Test as needed using full paths
- Change default R version when ready, Update /usr/bin/ only if needed

```
Check current symlinks, or actual files (rename if needed):

ls -l /usr/bin/R /usr/bin/Rscript /usr/bin/r
ls -l /usr/local/bin/R /usr/local/bin/Rscript /usr/local/bin/r

sudo rm /usr/bin/R /usr/bin/Rscript /usr/bin/r
sudo rm /usr/local/bin/R /usr/local/bin/Rscript /usr/local/bin/r

sudo ln -s /usr/local/R-$RVERSION/bin/R        /usr/bin/R
sudo ln -s /usr/local/R-$RVERSION/bin/Rscript  /usr/bin/Rscript
sudo ln -s /usr/local/R-$RVERSION/lib/R/library/littler/bin/r /usr/bin/r

sudo ln -s /usr/local/R-$RVERSION/bin/R        /usr/local/bin/R
sudo ln -s /usr/local/R-$RVERSION/bin/Rscript  /usr/local/bin/Rscript
sudo ln -s /usr/local/R-$RVERSION/lib/R/library/littler/bin/r /usr/local/bin/r

ls -l /usr/bin/R /usr/bin/Rscript /usr/bin/r
ls -l /usr/local/bin/R /usr/local/bin/Rscript /usr/local/bin/r
```

- On Redhat the library path may be /usr/local/R-$RVERSION/lib64

## Loading Libraries in a “Good” Order

- Function overloading can be a problem
- Note that wmtsa is not a commonly used package, but it loads the more often used MASS package
- I usually run the lines below in new interactive sessions
- And use a similar order in batch jobs

```
## Load common libraries in a good order
## not complete

library(wmtsa) # Wavelet Methods for peak detection, uses MASS which overloads dplyr::select

library(ggplot2)
library(plyr)  # plyr, followed by dplyr
library(dplyr)
library(readr)
library(lubridate)

Sys.setenv(TZ="UTC") # Yes, timezone issues can arise, nip them at the bud
```

# A Sample .Rprofile File - Mostly commented out

```
# http://www.r-bloggers.com/fun-with-rprofile-and-customizing-r-startup/

# General options
options(tab.width = 2)
options(width = 130)

options(max.print=500)
options(scipen=10)

q <- function (save="no", ...) { # Don't ask to save workspace
  quit(save=save, ...)
}

.First <- function(){
# library(Hmisc)
# library(R2HTML)

#    if(interactive()){
#        library(ggplot2)
#        library(dplyr)
#        library(readr)
#        library(stringr)
#        library(lubridate)
#    }

 cat("\nWelcome Jon at", date(), "\n")
}

.Last <- function(){
 cat("\nGoodbye Jon at ", date(), "\n")
}

message("\n*** Successfully loaded .Rprofile ***\n")
```