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Multi-node multi-core R/Shiny apps on Amazon EC2

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Dallas R Users Group
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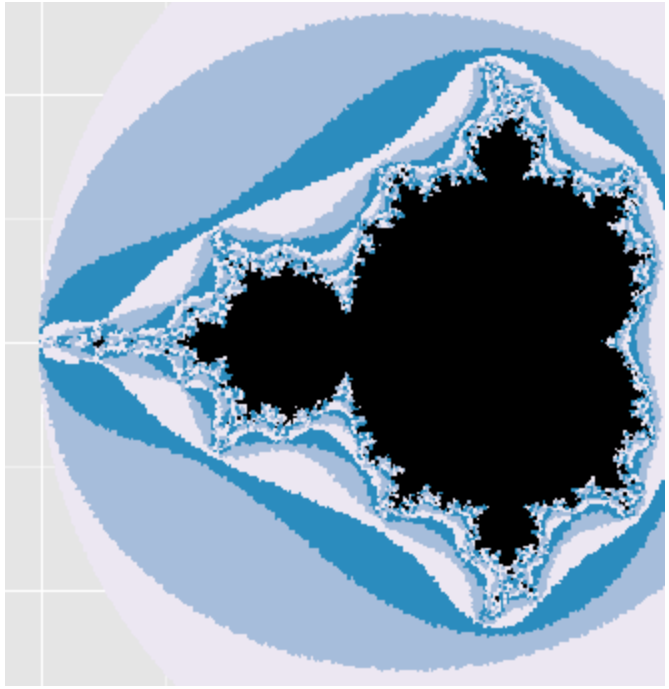

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Firm Presentation

- **Numeract**
  - Data Science and Economics/Finance consulting services

- **Mike Badescu, PhD**
  - Data Scientist and Founder
  - Romania **%>%** Ireland **%>%** Lehigh U. (PA) **%>%** Dallas
  - Economics, Finance, Statistics, Valuation, Expert Witness
  - Programming: BASIC (ZX Spectrum), assembly, VBA, Pascal, C++, MATLAB, SQL, SAS, Stata, **R, Python**

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Case Study

Prototype Financial app

- *Embarrassingly parallel problem*
- Engine in R
- User interface with Shiny
- *shinyapps.io* not very fast
- Using seven cores on the laptop, slightly better
- Code rewrite, ~20x improvement, not good enough
- Amazon EC2 **c4.8xlarge** (36 vCPU), we are getting there

How can I run several instances with Shiny on top?

- Simple configuration

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Perspective (stylized)

Optimization: reach the peak of the mountain

Many peaks, many paths and tools to use

- **RStudio**: switchbacks, nice tools and beautiful views
- **Revolution Analytics**: engines and robustness
- **AWS**: bungee jumping tanks and elephants

Approach:

- engine from **Revolution Analytics**
- tanks from **AWS** (skip the elephants)
- climb to see a great view (**RStudio**)

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Warnings and Disclaimers

- Build and test locally
- Deploy it fast, present the UI, tear it down
- Not a robust tool, rather fragile
  - Think of a Ferrari rather than a Toyota

- Not secure (not configured to be)

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It will break (or hang)

- Don't fight it, work with is
  - Sometimes more of a Fiat than a Ferrari

- Multiple `ssh` connections
  - `top`
  - `kill`
  - `restart rstudio-server`
  - `restart rstudio-server`
- Task Manager
- One step at a time
- Ask for help – volunteers?

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Battle plan

- R and parallel computations
  - **`parallel`** and **`foreach`**
- Build and test the local setup
- AWS
  - Review AMIs
  - Launch 3 large instances
  - Re-test configuration
  - Shiny App

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R and parallel computing

- CRAN Task View: High-Performance and Parallel Computing with R
- Direct support in R since 2.14
  - package **`parallel`** (revised `multicore` and `snow`)
  - base functionality only
    - `makeCluster, stopCluster`
    - `clusterCall, clusterApply, clusterApplyLB, …`
  - `other approaches based on` **`MPI`**
- **`foreach`** (Revolution Analytics, Steve Weston)
  - looping without side effects
  - needs a backend connector like `doParallel`

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Steps

1. **`makeCluster`**
   - Documentation rather incomplete → trial and error
   - The most difficult step
   - Steve Weston on stackoverflow

   "Unfortunately, there are a lot of things that can go wrong when creating a snow (or parallel) cluster object, and the most common failure mode is to hang indefinitely. " [link]

1. `registerDoParallel` (if using `foreach`)
2. `clusterApplyLB / foreach`
3. `stopCluster`

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More advice from Steve Wetson

"In my experience, the single most useful troubleshooting technique is manual mode which you enable by specifying **`manual=TRUE`** *when creating the cluster object."*

"[…] will display an Rscript command to execute in a terminal on the specified machine, and then it will wait for you to execute that command. In other words, makeSOCKcluster will hang until you manually start the worker on host"

"[…] if you can create a SOCK cluster successfully in manual mode, then probably **`ssh`** *is your problem."*

"If [it] still just hangs after you've executed the specified Rscript command on the specified machine, then you probably have a networking or firewall issue."

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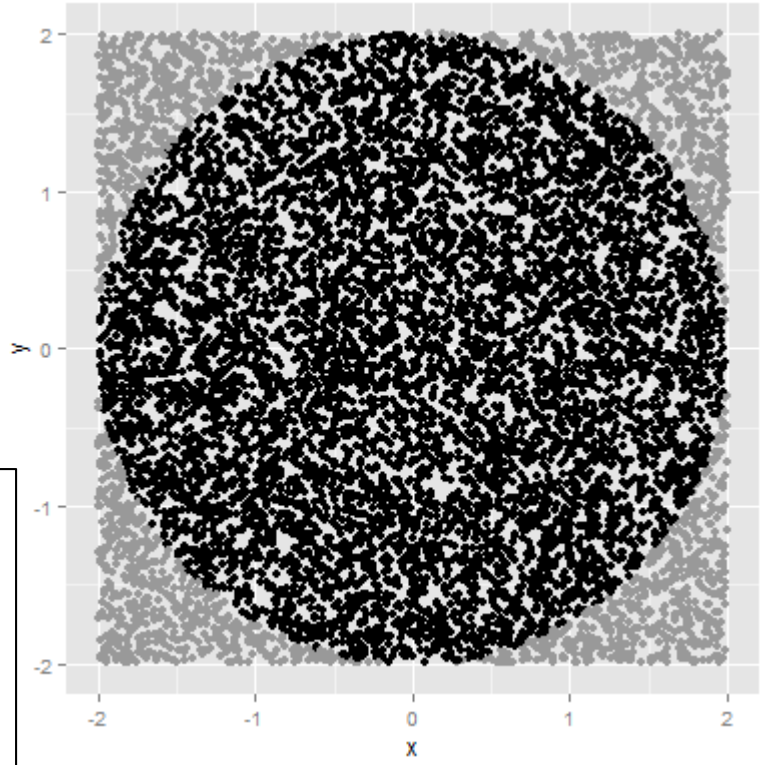
Test App: Calculate pi using simulation

$$\frac{Area\ Circle}{Area\ Square} = \frac{pi\ *\ r^2}{(2r)^2} = \frac{\#\ points\ inside}{\#\ total\ points}$$

$$pi = 4\ * \frac{\#\ points\ inside}{\#\ total\ points}$$




```
calc_pi <- function(max_level = NULL,
                    sample_size = 1e+6) {
    # ignore max_level
    r <- 2
    x <- runif(sample_size, min = -r, max = +r)
    y <- runif(sample_size, min = -r, max = +r)
    c <- complex(real = x, imaginary = y)
    count_inside <- sum( Mod(c) <= r )
    return( 4 * count_inside / sample_size )
}
```

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Local setup - R

- Ubuntu VM with R
- Must be able to connect using `PuTTY/ssh` without a password
- The keys are
  - WinR_rsa.pem (if using OSX / Ubuntu)
  - WinR_rsa.ppk (if using PuTTY / plink)
  - WinR_rsa.pub (public key, located on Ubuntu VM)
- Find your IP addresses
- Walk though **`explore_makeCluster_local.R`**

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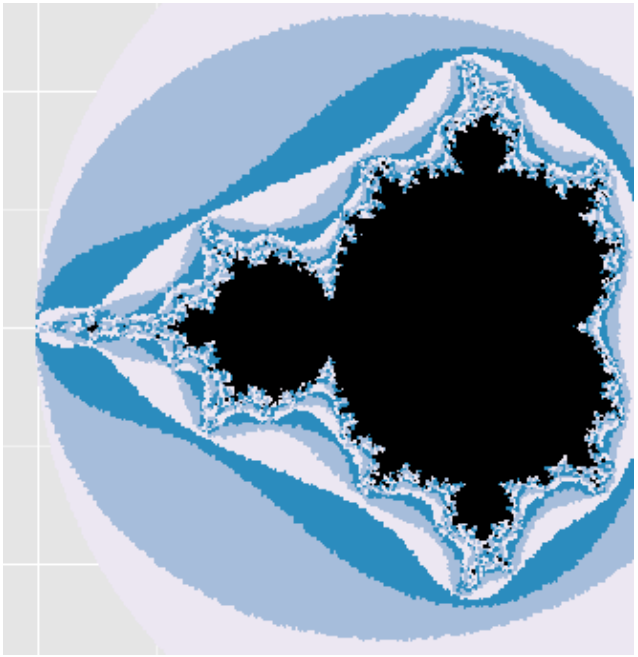
Local setup - Shiny

Point c in the complex plane

- $z_0 = c$
- $z_1 = z_0^2 + c$
- $z_2 = z_1^2 + c$
- $z_3 = z_2^2 + c$
- ...
- some z's will move away
- some will stay within an area around `0+i0`



Points that do not diverge belong to the [Mandelbrot set]
- fractal (self similar at different scales)

What is the area of the Mandelbrot set?
- there is a Shiny app for that: **`mandelbrot_app/`**

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AWS EC2

- Some large instances: c4.8xlarge has 36 vCPU
  - Pay by the hour (use spot instances)
- Amazon Machine Image (AMI)
  - R + RStudio Server AMI maintained by Louis Aslett
    - Notice support for OpenMPI
- I created a public AMI (region: US East, Virginia)

  `ami-c693afae` / R-RStudio-Shiny
  - R + RStudio Server + Shiny Server + packages
  - use as future starting point
  - default configuration / no security
  - Install packages as root (`sudo R`) to make them available to all users, including `rstudio` and `shiny`

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AMI for this meeting

ami-042e106c / R-RStudio-Shiny-DallasRUG_2015-04-11

```
ami-c693afae +
explore_makeCluster_ec2.R +
mandelbrot_app +
configure /etc/ssh/ssh_config +
for each user (root, ubuntu, rstudio, shiny),
    copy id_rsa file to ~/.ssh/ folder, and
    set permissions
```

You need:

- Firewall rules: open ports `22, 80, 3838, 11011`
- Private key (`DallasRUG.pem == id_rsa`)

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Package foreach

- read the PDFs, full of useful information

  http://cran.r-project.org/web/packages/doParallel/

  http://cran.r-project.org/web/packages/foreach/index.html

- Simple example

```
x <- foreach(i = 1:3) %do% sqrt(i)
```

  - by default, it returns a list
  - operators `%do%`, `%dopar%` and `%:%` (nesting)

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Package foreach

- Main options:

```
.combine = c,  .combine = rbind, …
```

(I like to return a `data.frame / matrix` row)

```
.errorhandling = c('stop', 'remove', 'pass')

.packages = c('vector of packages')

.export = c('vector of variables and functions to
export')
```

- Look at code in **`server.R`**

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AWS

- Pick one instance be the master
  - connect to its public IP address
  - port :80 for RStudio (user = `rstudio`, pass = `rstudio`)
  - port :3838 for Shiny
- Files

  `explore_makeCluster_ec2.R` in `/home/rstudio/`

  `mandelbrot_app/` in `/srv/shiny-server/`
    - chmod-ed 777 so that it can be modified from RStudio
    - not the best place to place the app, but it is the first place to look
    - can launch the app from RStudio or by going to port :3838
- Do not forget to:
  - save your files / data / graphs
  - **terminate the instances**

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Other approaches

- OpenMPI
- Redis with doRedis as backend
- JD Long / Jeffrey Breen
  - Segue / Amazon Elastic Mapreduce
- Whit Armstrong
  - AWS.tools

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Inspiration and Thanks

- Christian Gunning

  snow and ssh -- secure inter-machine parallelism with R
- Steve Wetson
  - detailed answers on stackoverflow
- David A. Andrews
  - talk “MapReduce with R” (some time ago)
- Jeff Allen
  - Deploying Shiny Server on Amazon EC2

    (old, but good reading)

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Thank you!

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