R Programming

What is R ?

- A programming "environment" developed by Rick Becker
- Similar to S & S-Plus developed by John chambers
- Object-oriented
- Has large integrated collection of tools for statistical data analysis and machine learning
- Provides easy calculations on matrices
- Excellent graphics capabilities

Why R?

- It is powerful
- It is free
- Extensive support documentation
- It is current (New algorithms)
- It is getting easier to learn
- It is independent of the platform

Things to be noted in R

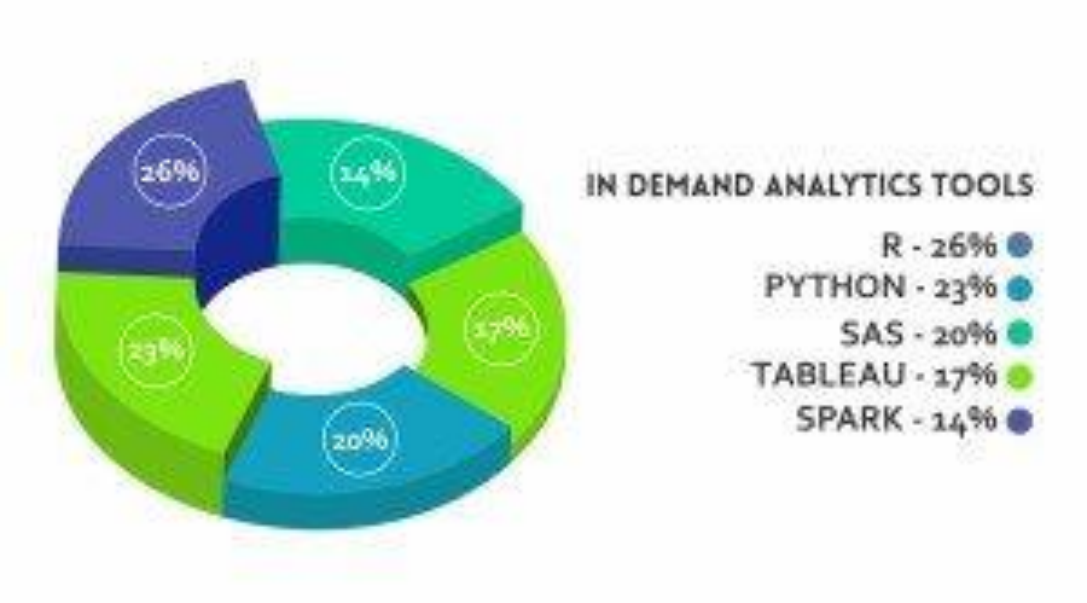
- It is a case-sensitive, interpreted language
- You can enter commands one at a time at the command prompt (>)
- You can run a set of commands from a source file
- Most functionality is provided through built-in and user-created functions
- All data objects are kept in memory during an interactive session

Things to be noted in R

- Basic functions are available by default
- Other functions are contained

  in packages that can be attached to a current session as needed.

Is it worth studying R



Src: https://imarticus.org/data-analytics-market-growth-and-scope-analysis-in-2018/

What is RStudio?

- R Studio is an IDE
- Allows to run R in a user-friendly environment
- Open Source
- Available at http://rstudio.com/

Why R Studio?

- Code highlighting that gives different colors to keywords and variables, making it easier to read
- Automatic bracket matching
- Code completion, so as to reduce the effort of typing the commands in full
- Easy access to R Help, with additional features for exploring functions and parameters of functions
- Easy exploration of variables and values.

Where to get the software?

- Web Resources
  - R - https://cran.r-project.org/
  - Rstudio – https://www.rstudio.com

Installation

- Web Resources
  - R - https://cran.r-project.org/
  - Rstudio – https://www.rstudio.com

Installation in Windows

Installing R

- www.cran.r-project.org/ - direct download
- www.r-project.org/ - download from CRAN (Comprehensive R Archive Network)
- Select a download site
- There are 25 packages that are supplied with R
- However, many packages are available in CRAN website which can be downloaded as needed

The R Project for Statistical Computing - Microsoft Internet Explorer

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Address http://www.r-project.org/ Go

The R Project for Statistical Computing

Important News:

The R Development Core Team would like to formally announce the creation of the

R Foundation for Statistical Computing

There are many reasons for this decision on our part, largely it is based on the belief that R has become a mature and valuable tool and we would like to ensure its continued development and the development of future innovations in software for statistical and computational research.

The R Foundation is a not for profit foundation whose general goals are to provide support for the R project and other innovations in statistical computing. The R Foundation will provide a reference point for individuals, instititutions or commercial enterprises that want to support or interact with the R development community.

We would like to solicit memberships from interested parties (individual and institutional) in the R Foundation. Details regarding fees and membership categories can be obtained from the web site and email enquiries can be sent to R-foundation@R-project.org.

Among the goals of the Foundation are the support of continued development of R, the exploration of new methodology, teaching and training of statistical computing and the organization of meetings and conferences with a statistical computing orientation. We hope to attract sufficient funding to make these goals realities.

For the R Development Core Team:

Robert Gentleman & Ross Ihaka
Presidents, R Foundation

Friedrich Leisch
Secretary General, R Foundation

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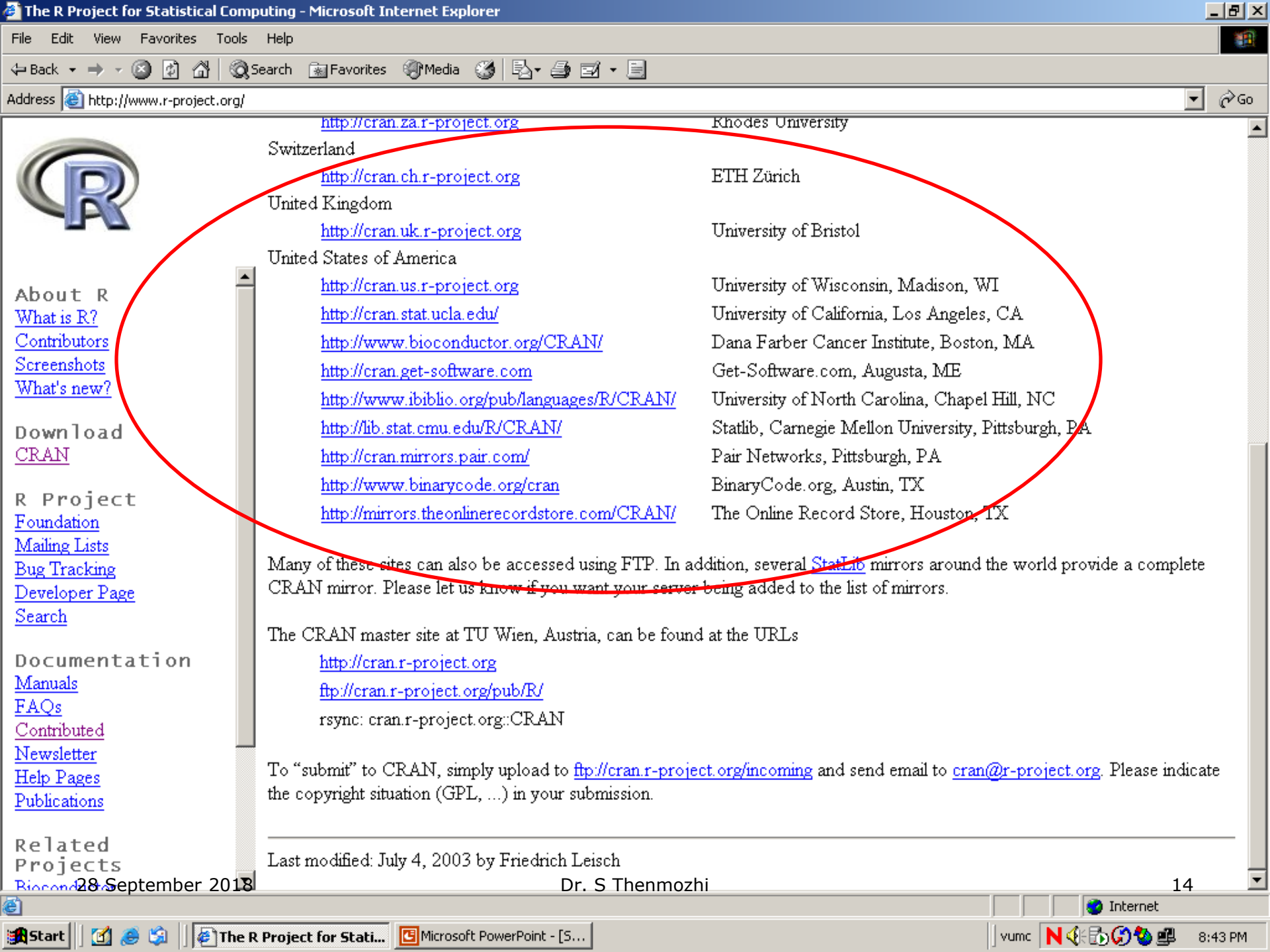
Internet

Start The R Project for Stati... Microsoft PowerPoint - [S... vumc 8:41 PM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About R
What is R?
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Related Projects
Many of these sites can also be accessed using FTP. In addition, several StatLib mirrors around the world provide a complete CRAN mirror. Please let us know if you want your server being added to the list of mirrors.
The CRAN master site at TU Wien, Austria, can be found at the URLs
http://cran.r-project.org
ftp://cran.r-project.org/pub/R/
rsync: cran.r-project.org::CRAN
To "submit" to CRAN, simply upload to ftp://cran.r-project.org/incoming and send email to cran@r-project.org. Please indicate the copyright situation (GPL, ...) in your submission.
Last modified: July 4, 2003 by Friedrich Leisch
Internet
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The R Project for Stati...
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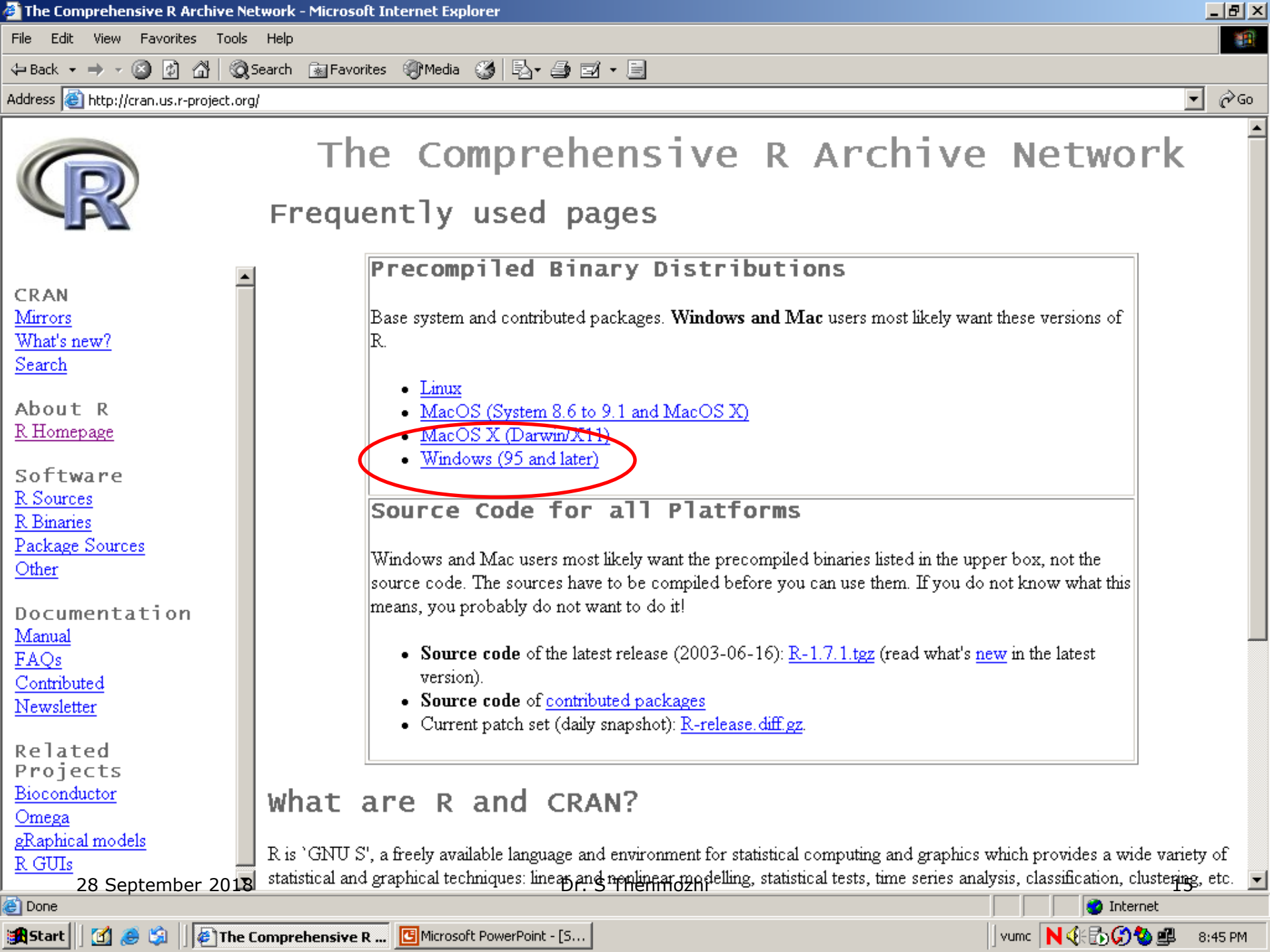
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Related Projects
Bioconductor
Omega
gRaphical models
R GUIs
Precompiled Binary Distributions
Base system and contributed packages. Windows and Mac users most likely want these versions of R.
Linux
MacOS (System 8.6 to 9.1 and MacOS X)
MacOS X (Darwin/X11)
Windows (95 and later)
Source Code for all Platforms
Windows and Mac users most likely want the precompiled binaries listed in the upper box, not the source code. The sources have to be compiled before you can use them. If you do not know what this means, you probably do not want to do it!
Source code of the latest release (2003-06-16): R-1.7.1.tgz (read what's new in the latest version).
Source code of contributed packages
Current patch set (daily snapshot): R-release.diff.gz.
What are R and CRAN?
R is 'GNU S', a freely available language and environment for statistical computing and graphics which provides a wide variety of statistical and graphical techniques: linear and nonlinear modelling, statistical tests, time series analysis, classification, clustering, etc.
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The Comprehensive R ...
Microsoft PowerPoint - [S...
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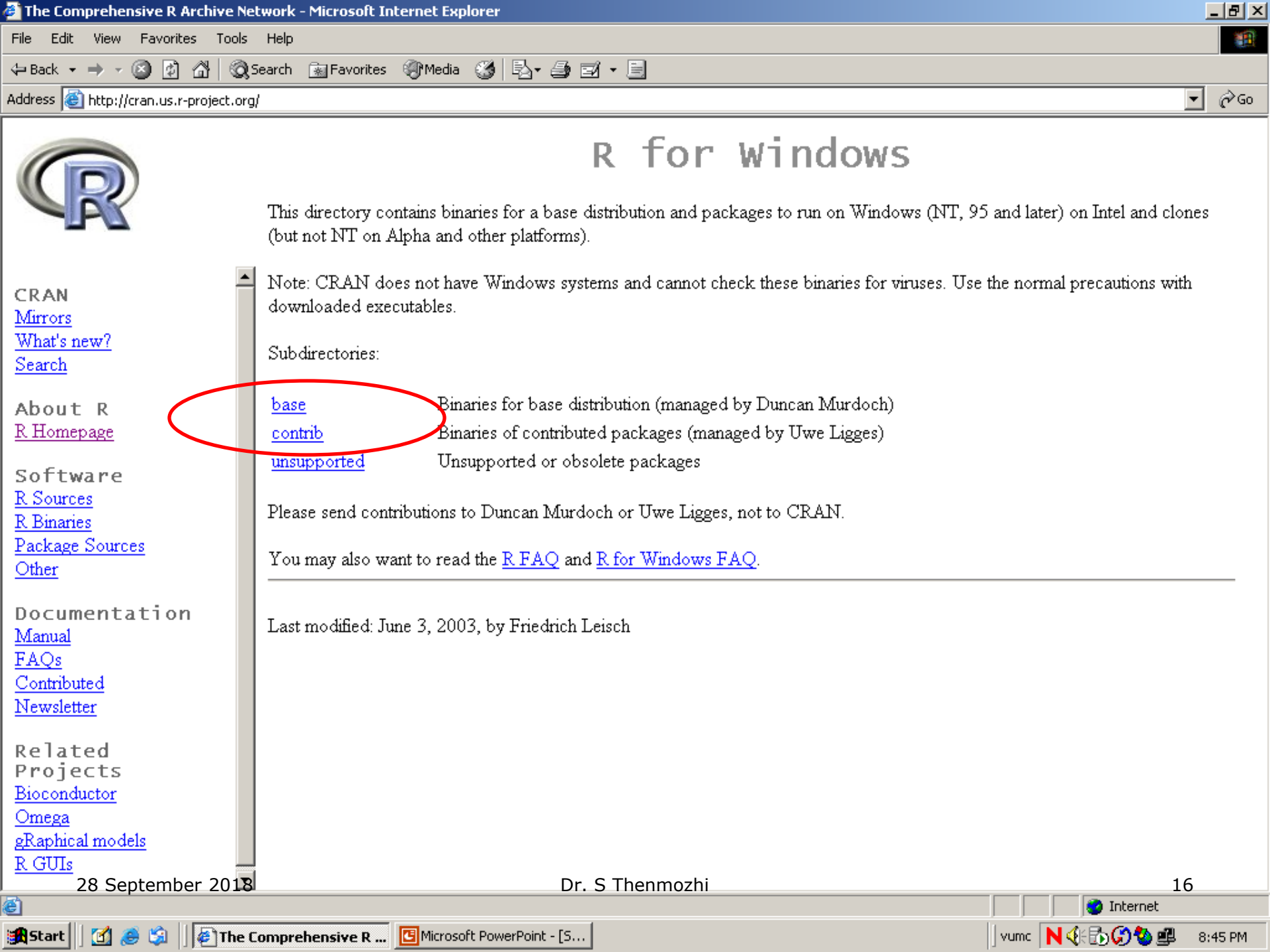
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Address http://cran.us.r-project.org/
Go
R for Windows
This directory contains binaries for a base distribution and packages to run on Windows (NT, 95 and later) on Intel and clones (but not NT on Alpha and other platforms).
Note: CRAN does not have Windows systems and cannot check these binaries for viruses. Use the normal precautions with downloaded executables.
Subdirectories:
base Binaries for base distribution (managed by Duncan Murdoch)
contrib Binaries of contributed packages (managed by Uwe Ligges)
unsupported Unsupported or obsolete packages
Please send contributions to Duncan Murdoch or Uwe Ligges, not to CRAN.
You may also want to read the R FAQ and R for Windows FAQ.
Last modified: June 3, 2003, by Friedrich Leisch
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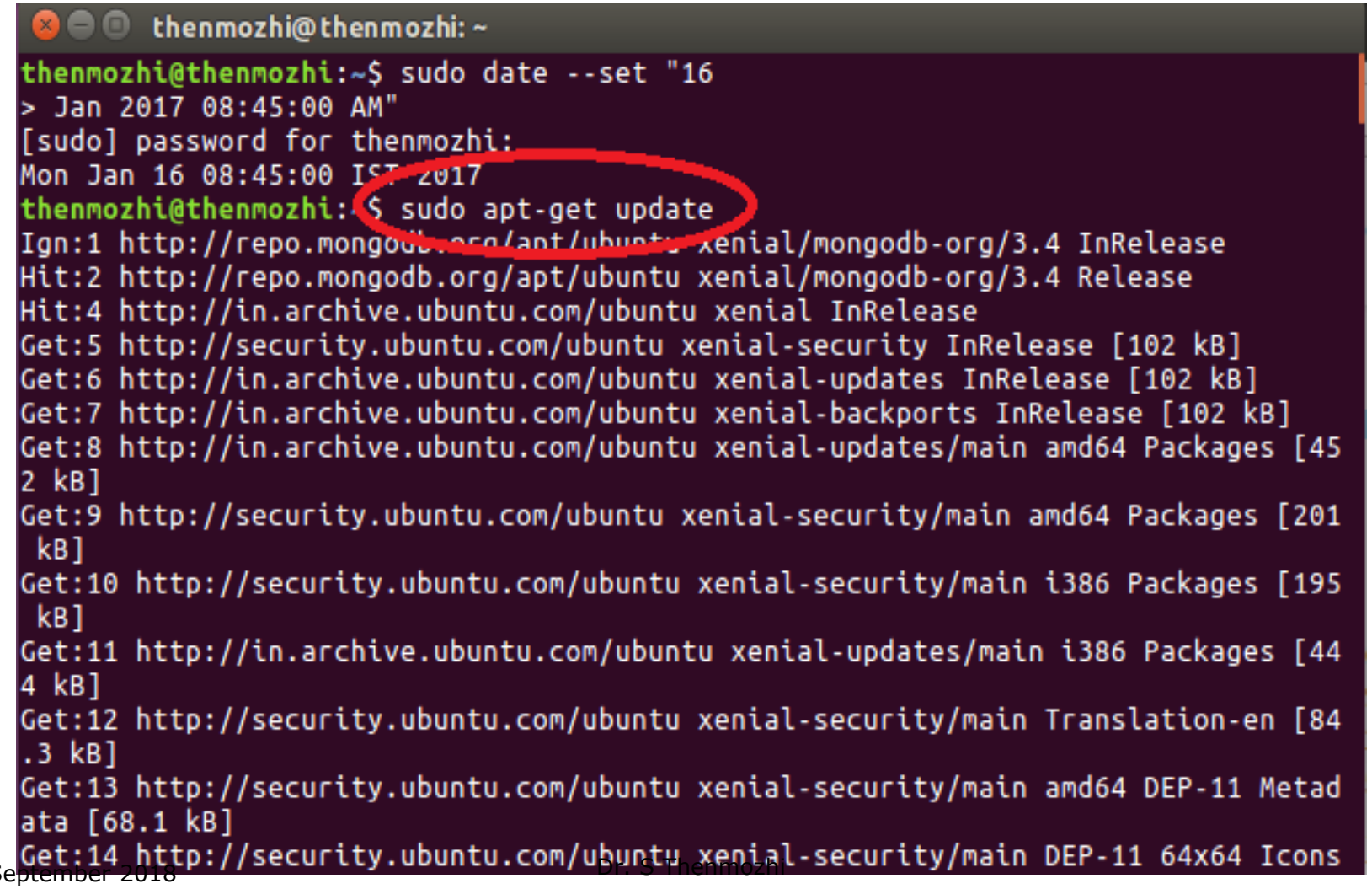
Installation in Ubuntu

Ubuntu

- Through Terminal
  - Open Terminal (Press Ctrl+Alt+T)
  - Then execute sudo apt-get update
  - After that, sudo apt-get install r-base
- To run R statistical package, execute R in the Terminal


thenmozhi@thenmozhi: ~
thenmozhi@thenmozhi:~$ sudo date --set "16
> Jan 2017 08:45:00 AM"
[sudo] password for thenmozhi:
Mon Jan 16 08:45:00 IST 2017
thenmozhi@thenmozhi:~$ sudo apt-get update
Ign:1 http://repo.mongodb.org/apt/ubuntu xenial/mongodb-org/3.4 InRelease
Hit:2 http://repo.mongodb.org/apt/ubuntu xenial/mongodb-org/3.4 Release
Hit:4 http://in.archive.ubuntu.com/ubuntu xenial InRelease
Get:5 http://security.ubuntu.com/ubuntu xenial-security InRelease [102 kB]
Get:6 http://in.archive.ubuntu.com/ubuntu xenial-updates InRelease [102 kB]
Get:7 http://in.archive.ubuntu.com/ubuntu xenial-backports InRelease [102 kB]
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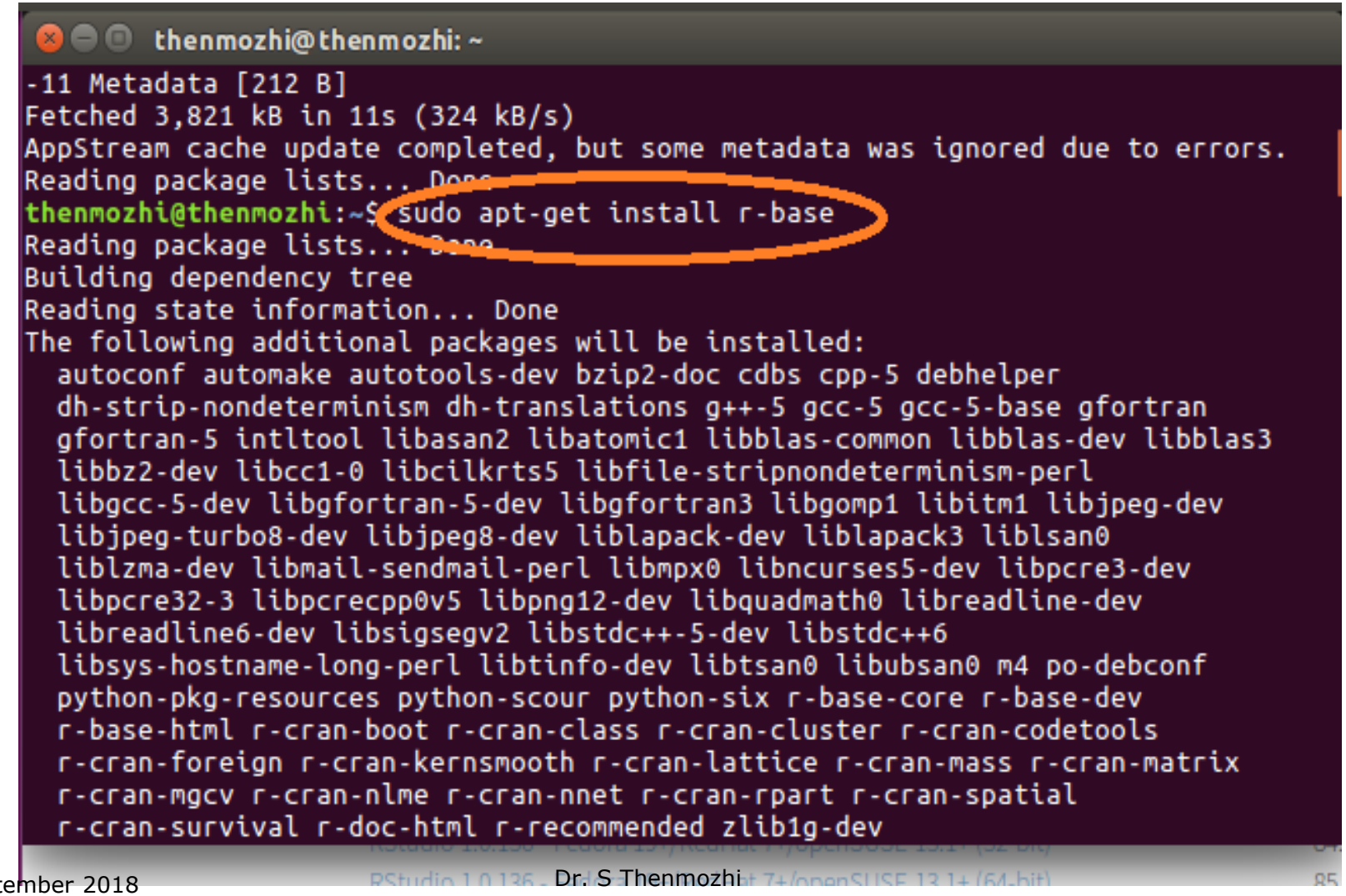
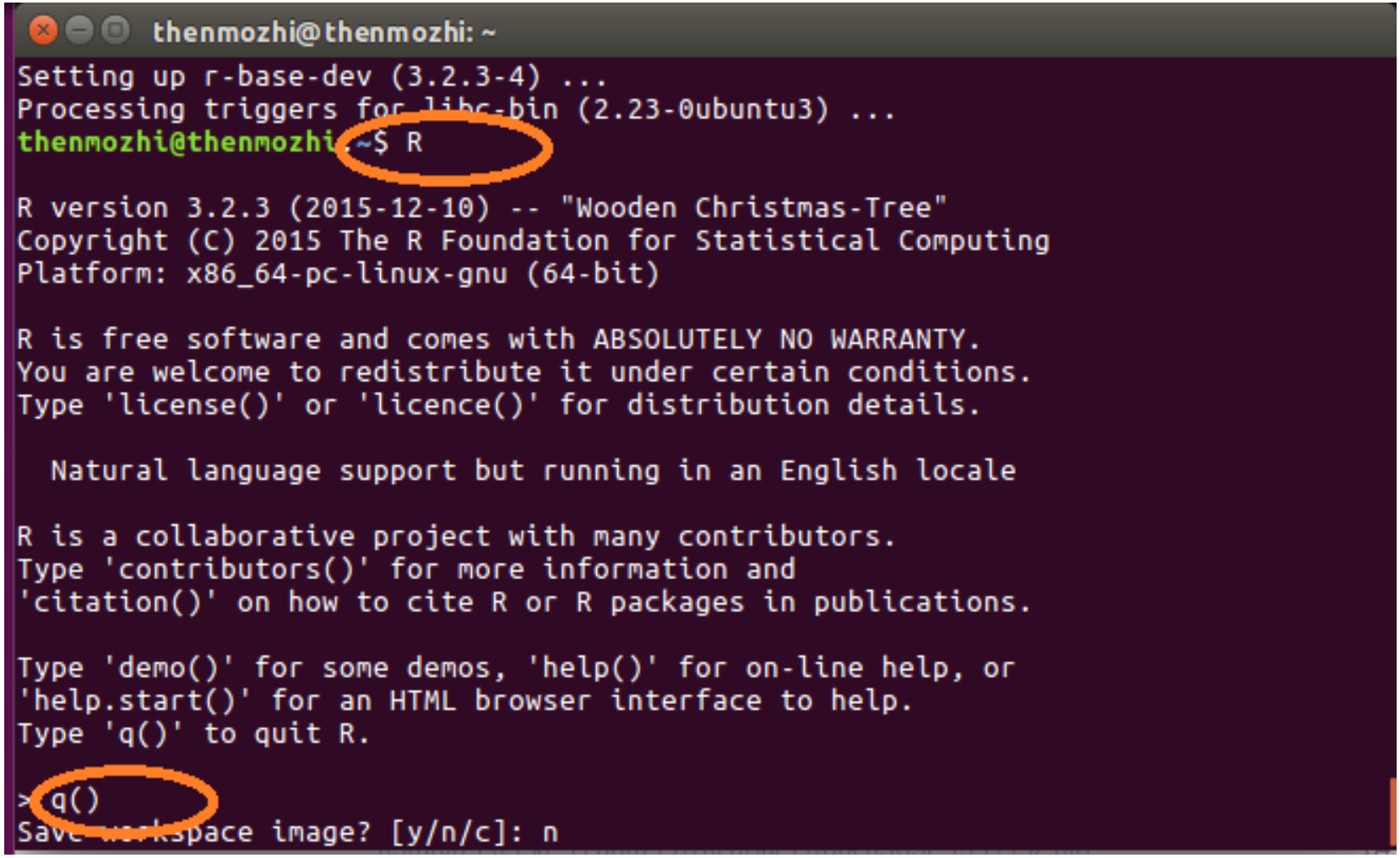
Get:11 http://in.archive.ubuntu.com/ubuntu xenial-updates/main i386 Packages [444 kB]
Get:12 http://security.ubuntu.com/ubuntu xenial-security/main Translation-en [84.3 kB]
Get:13 http://security.ubuntu.com/ubuntu xenial-security/main amd64 DEP-11 Metadata [68.1 kB]
Get:14 http://security.ubuntu.com/ubuntu xenial-security/main DEP-11 64x64 Icons


thenmozhi@thenmozhi: ~
-11 Metadata [212 B]
Fetched 3,821 kB in 11s (324 kB/s)
AppStream cache update completed, but some metadata was ignored due to errors.
Reading package lists... Done
thenmozhi@thenmozhi:~$ sudo apt-get install r-base
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following additional packages will be installed:
autoconf automake autotools-dev bzip2-doc cdbs cpp-5 debhelper
dh-strip-nondeterminism dh-translations g++-5 gcc-5 gcc-5-base gfortran
gfortran-5 intltool libasan2 libatomic1 libblas-common libblas-dev libblas3
libbz2-dev libcc1-0 libcilkrts5 libfile-stripnondeterminism-perl
libgcc-5-dev libgfortran-5-dev libgfortran3 libgomp1 libitm1 libjpeg-dev
libjpeg-turbo8-dev libjpeg8-dev liblapack-dev liblapack3 liblsan0
liblzma-dev libmail-sendmail-perl libmpx0 libncurses5-dev libpcre3-dev
libpcre32-3 libpcrecpp0v5 libpng12-dev libquadmath0 libreadline-dev
libreadline6-dev libsigsegv2 libstdc++-5-dev libstdc++6
libsys-hostname-long-perl libtinfo-dev libtsan0 libubsan0 m4 po-debconf
python-pkg-resources python-scour python-six r-base-core r-base-dev
r-base-html r-cran-boot r-cran-class r-cran-cluster r-cran-codetools
r-cran-foreign r-cran-kernsmooth r-cran-lattice r-cran-mass r-cran-matrix
r-cran-mgcv r-cran-nlme r-cran-nnet r-cran-rpart r-cran-spatial
r-cran-survival r-doc-html r-recommended zlib1g-dev

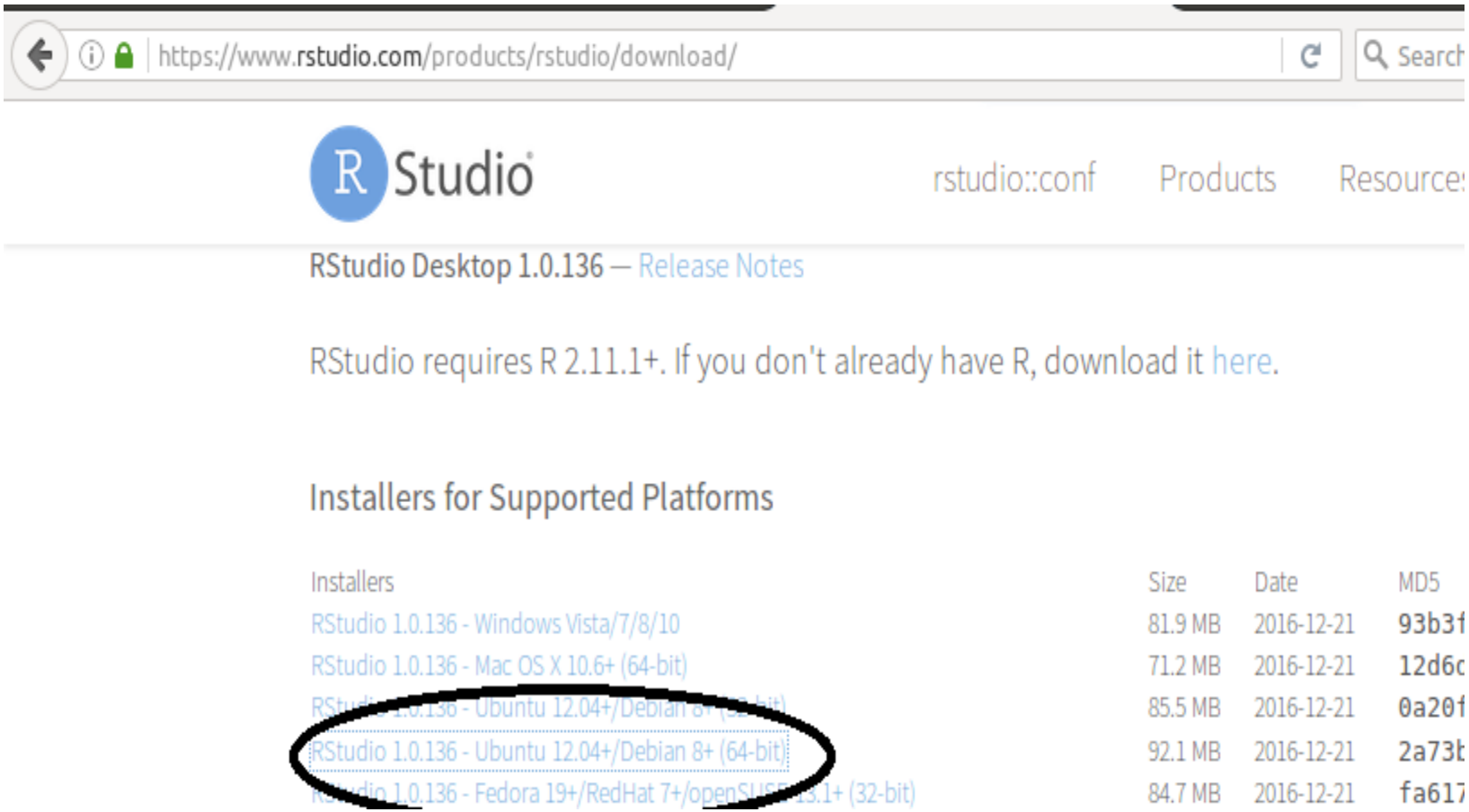

thenmozhi@thenmozhi: ~
Setting up r-base-dev (3.2.3-4) ...
Processing triggers for libc-bin (2.23-0ubuntu3) ...
thenmozhi@thenmozhi:~$ R
R version 3.2.3 (2015-12-10) -- "Wooden Christmas-Tree"
Copyright (C) 2015 The R Foundation for Statistical Computing
Platform: x86_64-pc-linux-gnu (64-bit)
R is free software and comes with ABSOLUTELY NO WARRANTY.
You are welcome to redistribute it under certain conditions.
Type 'license()' or 'licence()' for distribution details.
Natural language support but running in an English locale
R is a collaborative project with many contributors.
Type 'contributors()' for more information and
'citation()' on how to cite R or R packages in publications.
Type 'demo()' for some demos, 'help()' for on-line help, or
'help.start()' for an HTML browser interface to help.
Type 'q()' to quit R.
> q()
Save workspace image? [y/n/c]: n

- Through Ubuntu Software Center
  - Open Ubuntu Software Center
  - Search for r-base
  - And click Install
- Run R by executing R in the Terminal

Installation of RStudio

To Install R Studio

- To install RStudio IDE, do the following:
  - Go to rstudio.com web page
  - Click Download RStudio Desktop
  - Click for the download link recommended for your system
- Run the downloaded file (double click the file) to start the setup wizard
- Click “Next” until “Finish”


https://www.rstudio.com/products/rstudio/download/
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rstudio::conf
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Resources
RStudio Desktop 1.0.136 — Release Notes
RStudio requires R 2.11.1+. If you don't already have R, download it here.
Installers for Supported Platforms
Installers
Size
Date
MD5
RStudio 1.0.136 - Windows Vista/7/8/10
81.9 MB
2016-12-21
93b3f
RStudio 1.0.136 - Mac OS X 10.6+ (64-bit)
71.2 MB
2016-12-21
12d6c
85.5 MB
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RStudio 1.0.136 - Ubuntu 12.04+/Debian 8+ (64-bit)
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Tutorials

- From R website under "Documentation"
  - "Manual" is the listing of official R documentation
    - An Introduction to R
    - R Language Definition
    - Writing R Extensions
    - R Data Import/Export
    - R Installation and Administration
    - The R Reference Index

Exploring RStudio

- Script / Workspace Window
- Environment Window
- Console window
- Explore Window/Support Window/service window

Working Directory

- Create working directory for convenience
  - Menu -> Session->set working directory->choose directory

Installing/Listing Packages

- To install packages
  - install.packages("labstats")
- To list all the packages enabled or used in the session
  - (.packages())
- To list all the packages available with the system
  - (.packages(all.available=TRUE))

To know keyboard shortcuts

- https://support.rstudio.com/hc/en-us/articles/200711853-Keyboard-Shortcuts

R Basics

Arithmetic with R

- Calculator
  - Write any expression in the command prompt
- Any expression or statement not to be interpreted --- Comment (#)

Arithmetic with R- Contd..

- Arithmetic with R
  - Addition: +
  - Subtraction: -
  - Multiplication: *
  - Division: /
  - Exponentiation: ^
  - Modulo: %%

Variable Assignment

- A variable allows you to store a value (e.g. 4) or an object (e.g. a function description) in R
- Access values with the name of the variable at later point of time.
  - my_var <- 4 or
  - my_var=4 [acceptable format version >1.4]
- To print the value of the variable
  - print(my_var)

Naming Convention

- Must start with a letter (A-Z or a-z)
- Can contain letters, digits (0-9), and/or periods "."
- Is case-sensitive
  - `mydata` different from `MyData`

- Create variable my_oranges and store 6
- Create variable my_apples and store 5
- Create my_fruits which has total fruits of my_oranges and my_apples
- Print my_fruits

Basic Modes of Data

- Numeric – Decimal Values (Eg. 4.5)
- Logical – Boolean Values (Eg: TRUE)
- Characters – Text values (Eg: Rama)

Functions for Managing Modes

- To check the type of the variable
  - **class()**
- To check whether it belongs to data type
  - **is.numeric(), is.character()**
- To type coerce the data
  - **as.numeric(), as.character()**
  - Do it meaningfully

Extended modes of Data

- Integers – Natural numbers (Eg: 4)
- Date – Date format (Eg:2007/03/09”)

1. Create my_n=42.4, my_c="Universal" & my_l=FALSE
2. Print the values
3. Find the class of each variable
4. Change the my_n as integer
5. How to check whether my_l is a boolean variable?
6. Type my_cc=universe. What is the output?
7. Type my_ll=false,. What is the output?
8. Type my_ll=F. what is the output?
9. Print my_ll. Check the class of my_ll.

1. Type my_ll at the prompt. What you get? What is your observation?
2. Do my_n=my_n+5
3. Do my_c=my_c+5
4. Do my_c=my_c + ”truth”. What is the output?
5. Do paste(my_c,”truth”). What is the output?

R Objects

- Vector – homogeneous values (1D)
- Matrix – homogeneous values (2D)
- List – heterogeneous (1D)
- Data frame – heterogeneous (2D)
- Factor – Categorical values (1D)

Vector

- A **vector** is a sequence of data elements of the same basic type.
- Vector Elements are called components.

Numeric Vector

- A numeric vector contains all numeric components.
- c() is function that is used to create vectors. It is called as combine/concatenate function
- Vector can hold any number of elements

Creation of numeric vectors

```
> x =c(0,1,2,3,4) # creation of vectors

> x # display of vectors

> print(x)      # display of vectors
```

Easy way of creating sequence numbers

```
> y = 1:50        #sequence of numbers

> y

>z=seq(1,50,by=2) #seq of odd numbers
```

Creating vectors with variables

```
> a=10

> b=15

> c=c(a,b)
```

Creating Vectors with repeated elements

```
>  a=rep(1,10)  #1st  -  element,2nd  no  of
times
```

Creating named vectors

```
> my_fruits=c(apple=1,guava=1,
                    strawberry=10)

> my_fruits
```

Character Vectors

```
> fruits <- c("apple","orange","banana")
> fruits
```

Easy way of creating Sequence of Letters

```
> alphabets=LETTERS[1:26]
```

Logical Vectors

- Vectors created using logical values

```
> a=c(T,F,F,T,T,T,F)

> b=c(1,1,0,0,0) #0- False, 1-True

> b=as.logical(b)
```

Type Coercion of Vectors

```
> a=10
> b=TRUE
> My_v<-c(a,b)
> class(My_v)  # it is numeric
> My_c
     10 1
> test<- c(1,2,"red","orange")
> test
     "1"       "2"       "red"    "orange"
```

Checking the Vector

- To check whether it is vector?

```
> is.vector(test)
    [1] TRUE
```

- To Check the mode of the vector

```
> is.character(test)
      [1] TRUE
```

Conversion of vectors

```
> test = as.integer(c(1,2,3.14,1.29))

> test

      [1] 1 2 3 1
```

Associating names for the vector

```
>a=c(10,20,30,40,50)

>b=c("Eng","Kann","Mat","Sci","Social")

>names(a)=b > a

Eng Kann Mat Sci Social

 10   20   30    40   50
```

Subscripting Vectors

- select only one element
  - `x[2]`
- select range of elements
  - `x[1:3]`
- select all but one element
  - `x[-3]`

Subscripting Vectors

- slicing: including only part of the object
  - `x[c(1,2,5)]`
- select elements based on logical operator
  - `x[x>3]`

Adding Elements to the vector

```
> a=1:10

> a=c(a,11:15)
```

Vector Arithmetic

```
> x <- c(0,1,2,3,4)
> y <- 1:5
> z <- 1:50
> x + y
[1] 1 3 5 7 9
> x * y
[1]  0  2  6 12 20
> x * z (cycling)
 [1]   0   2   6  12  20   0   7  16  27  40   0
[12]  12  26  42  60   0  17  36  57  80   0  22
[23]  46  72 100   0  27  56  87 120   0  32  66
[34] 102 140   0  37  76 117 160   0  42  86 132
[45] 180   0  47  96 147 200
```

Arithmetic operators

Operator	Description
+	addition
-	subtraction
*	multiplication
/	division
^ or **	exponentiation
x %% y	modulus (x mod y) 5%%2 is 1
x %/% y	integer division 5%/%2 is 2

Logical & Relational operators

Operator	Description
<	less than
<=	less than or equal to
>	greater than
>=	greater than or equal to
==	exactly equal to
!=	not equal to
!x	Not x

Logical and Relational operators

Operator	Description
x | y	element wise OR
x & y	Element wise AND
isTRUE(x)	test if X is TRUE
x&&y	Object wise AND
X||y	Object wise OR

Basic operations

```
> x=c(1:10)
> (x>=10)|(x<10)
[1] TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE
 > (x>=10)&(x<10)
 [1] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
> (x>=10)&& (x<10)
 [1] FALSE
>(x>=10)|| (x<10)
[1] TRUE
```

Few Understanding

- What happens if any element is of different data type?
  - Type coercion happens
- What happens if arithmetic operations done on a variable length vectors?
  - Cycling
- Is it possible to create an empty vector?
  - Yes `a=c()`

Few Understanding – Contd..

- How to check whether it is a vector?
  - `is.vector()`
- Can we repeat same element in a vector multiple times?
  - rep(number,no of times)
  - rep(0,3)

Factor

- Categorical values stored in Levels
- They can store both strings and integers.
- They are useful in the columns which have a limited number of unique values.
- Eg: Gender:"Male, "Female"

  Grades:S,A,B,C,D,E

  Rating:1,2,3,4,5

Creation of Factors

- Factor has to be created as form of vectors
  - a=factor(c("1","2","5","5"))
- It is created as a vector and then it has to be converted as factor using as.factor(vector)
  - data <- c("East","West","East","North","North","East","West", "West","West","East","North")
  - factor_data <- as.factor(data)

Matrix

- A matrix is a vector with an additional attribute (dim) that defines the number of columns and rows
- Can be created using `matrix()`

```
x<-matrix(data=0,nrow=2,ncol=2) or

x<-matrix(0,2,2)
```

- mat1=matrix(1:6,nrow=3)
- mat1=matrix(1:6, nrow=2, byrow=FALSE)
- Identical matrix
  - `mat2=diag(3)` # all diagonal element is 1
- Edit a matrix
  - `fix(mat2)`

Matrix Subscripting

- Accessing elements row wise/column wise
  - `All rows of column1 - mat[,1]`
  - `All columns of row2 – mat[2,]`
  - `Element of row1 col2 – mat[1,2]`
  - `All columns expect col3 – mat[,-3]`
  - `All rows expect row2 – mat[-2,]`

rbind(),cbind()

- Add a new row to the existing matrix
  - rbind(mat2,7:9)
- Add a new column to the existing matrix
  - cbind(mat2,c(10,15,12))
- Naming of column and row names
  - colnames(mat2)=c("col1","col2","col3")

List

- Ordered collections of objects
- Each component can be of variable length
- Creation of List
  - `a=list("Teachers",3,c("Radha","Krishna","Bama"))`

List – Contd..

- Accessing a list
  - double bracket **[[ ]]** is used to select components of the list
  - single bracket **[ ]** is used to select elements of the I component
  - `Eg: a[[3]][2:3] – retrieves krishna, bama`
  - `A[[3]] – retrieves all elements of the 3rd component`

Data Frame

- Fundamental data structure to store to start typical datasets
- Can contain heterogenous data
- All rows should be of equal length
- Column should have same data type
- Several modes allowed within a single data frame

Data Frame – Contd..

- Can be created using `data.frame()`

```
L<-LETTERS[1:4] #A B C D

x<-1:4          #1 2 3 4

a=data.frame(x,L) #create data frame
```

Ex: Creating Employee data frame

```
> emp.data <- data.frame(

emp_id = c (1:5),

emp_name=

c("Ricky","Danish","Mini","Ryan","Gary"),

salary = c(643.3,515.2,671.0,729.0,943.25),

start_date = as.Date(c("2012-01-01", "2013-09-

23", "2014-11-15", "2014-05-11","2015-03-27")))
```

Data Frame – Contd..

- Accessing - $
  - Eg:a$x
- Testing
  - is.data.frame()
- Coercing
  - as.data.frame()

Data Frame – Contd..

- Structure of data frame
  - str()
- To find number of rows
  - nrows()
- To find the dimension
  - dim()

Subscripting DataFrame

- Creating a data frame from another dataframe

```
result=data.frame(emp.data$emp_name,emp.data$salary)
```

- Extracting first two rows

```
emp.data[1:2,]
```

- Extracting first and third rows

```
emp.data[c(1,3),]
```

Subscripting DataFrame

- Extract 3rd and 5th row with 2nd and 4th column

```
emp.data[c(3,5),c(2,4)]
```

Operations

- Adding a new column

```
>emp.data$dept= c("IT","Operations","IT","HR","Finance")
```

- Adding a new row

```
> newrow=data.frame(emp_id=6, emp_name="Raksha",
salary=900,start_date="2018-09-22",dept="Finance")
> emp.data=rbind(emp.data,newrow)
```

- Find those who work in finance dept

```
emp.data[emp.data$dept==“Finance”,]
```

- Find those who work in finance dept and salary > 925

```
emp.data[emp.data$dept=="Finance"&emp.data$salary>925,]
```

1. Create a vector weekdays which has seven days of the week
2. Create a vector temp which has temp on seven days of the week
3. Create a vector sale which has the data of sale of icecreams on seven days of the week
4. Create a dataframe named soi which comprises weekdays, temp and sale
5. Change the weekdays as factor
6. Check the data frame components types
7. Print the temp column from soi

8. Print the weekdays and sale from soi
9. Print when the sale is more than 10
10. Print the records where temp is more than 32 and sale of icecream is more than 15

Reading resources

- https://www.listendata.com/p/r-programming-tutorials.html