FE8828 Programming Web Applications in Finance

Week 1

What's Internet? What's Web?

Launch into the Cloud

Catch-up with R

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Introduction: Topics for Week 1-3

- Week 1:
  - *What's Internet? What's Web?*
  - *Launch into the Cloud: AWS*
  - *R catch-up: R Markdown and Shiny layout*
- Week 2:
  - *Data, visualization, and web: part 1/2*
- Week 3:
  - *Data, visualization, and web: part 2/2*

Introduction: Topics for Week 4-6

- Week 4:
  - *Finance applications*
- Week 5:
  - *Bitcoin and Blockchain*
- Week 6:
  - *Further topics of Blockchain*
  - *Presentation of Assignment: Web applicaiton.*
- Week 7:
  - *Presentation of Assignment: Blockchain.*

Introduction: Assingments

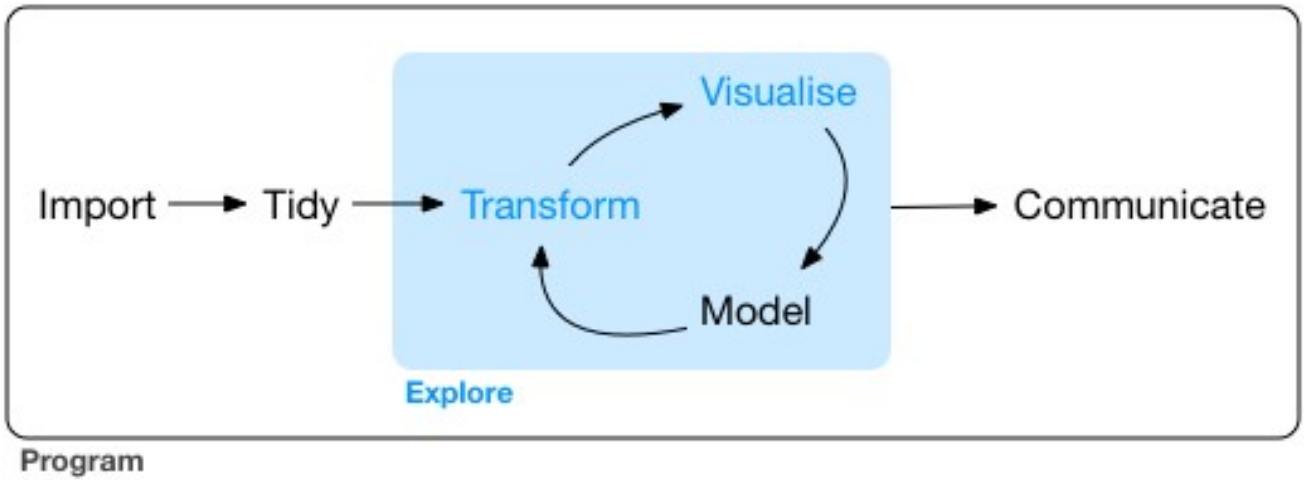
- Week 1: A static website. A front page, a about page and a description page. (due by Week 2)
- Week 2: A dynamic website that can do CRUD. (due by Week 3)
- Week 3: A data-driven website that does data analytics. (due by Week 4)
- Week 4: A finance-data application website. (due by Week 6)
- Week 5: Reading on Blockchain. (due by Week 7) Working on web assignment. (due by Week 6)
- Week 6: Reading on Blockchain. (due by Week 7)

Introduction: Objective

1. Know the way of Internet: the network, the cloud and the application.
2. Build real-world data-driven reports and dashboard, data visualization.
3. Latest Internet technology in cryptocurrency and payment system like Bitcoin and Blockchain.

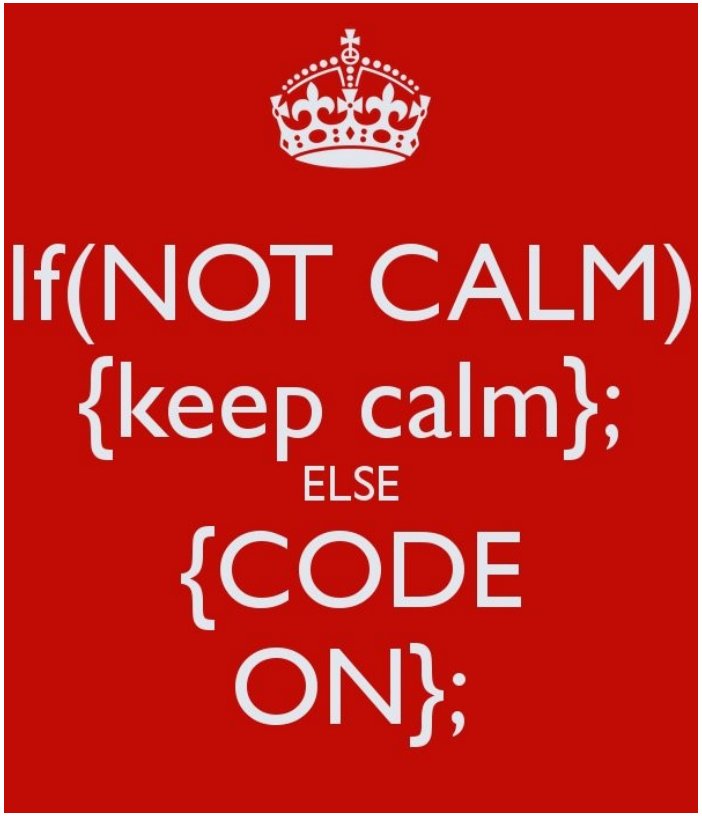
Where does this course stands on?

- It's about "Data science" Data -> Model -> Application



- We deep dive into R.
  - *R is a system that has been designed to process data. Later in career you will expose Python, Julia, Hadoop.*
  - *The principle will be the same.*

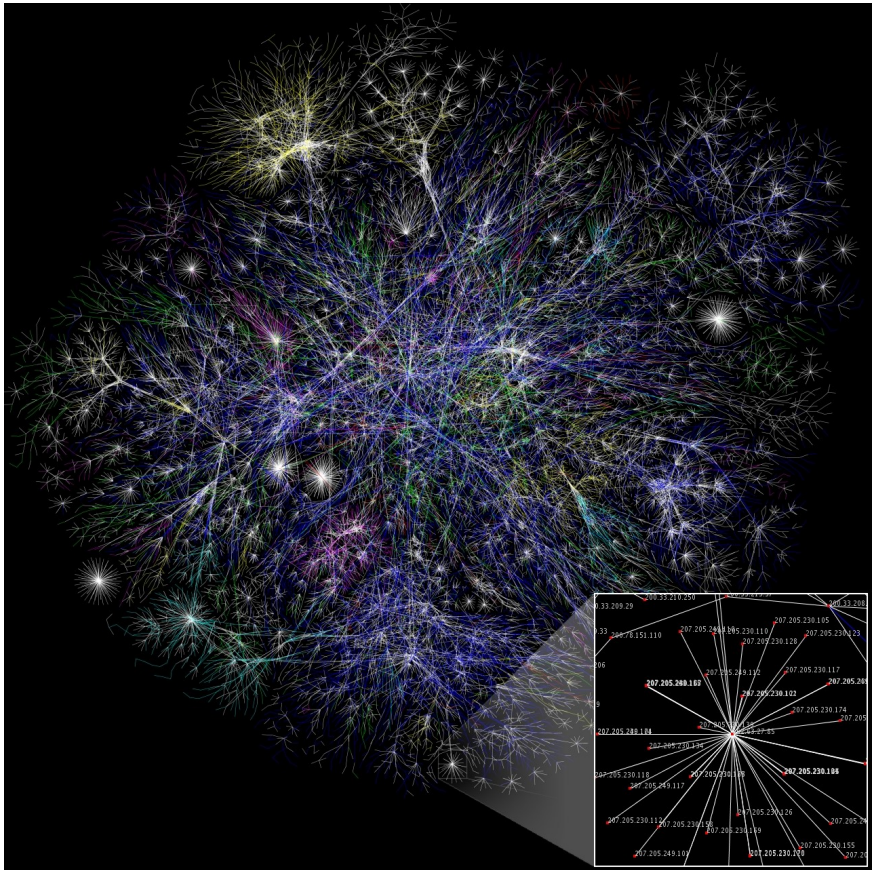
Keep calm and code on



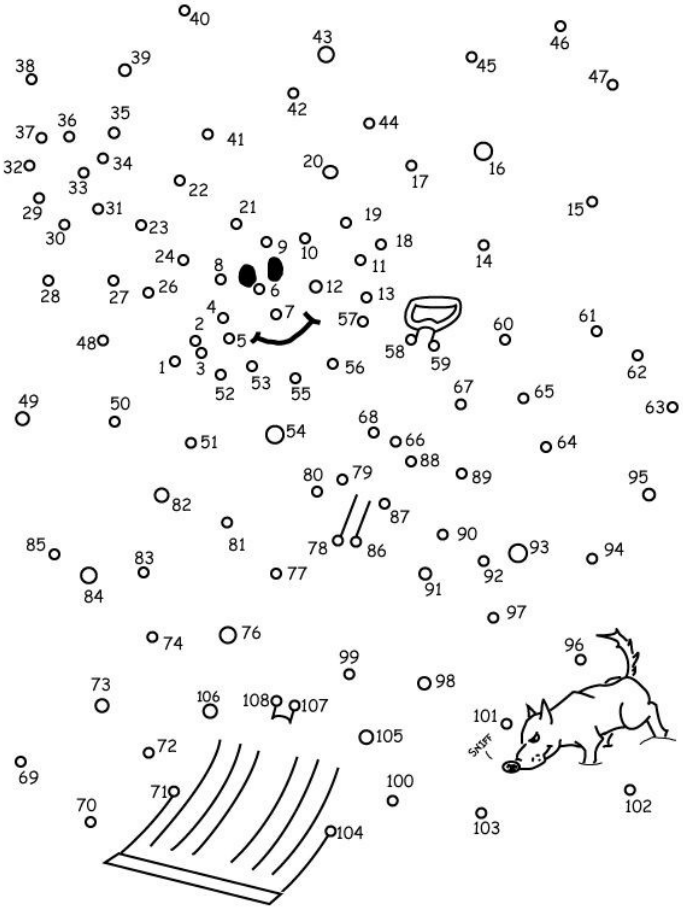
Lecture 01: What's Internet? What's Web?

- Network
- Internet
- HTTP/HTML/Web

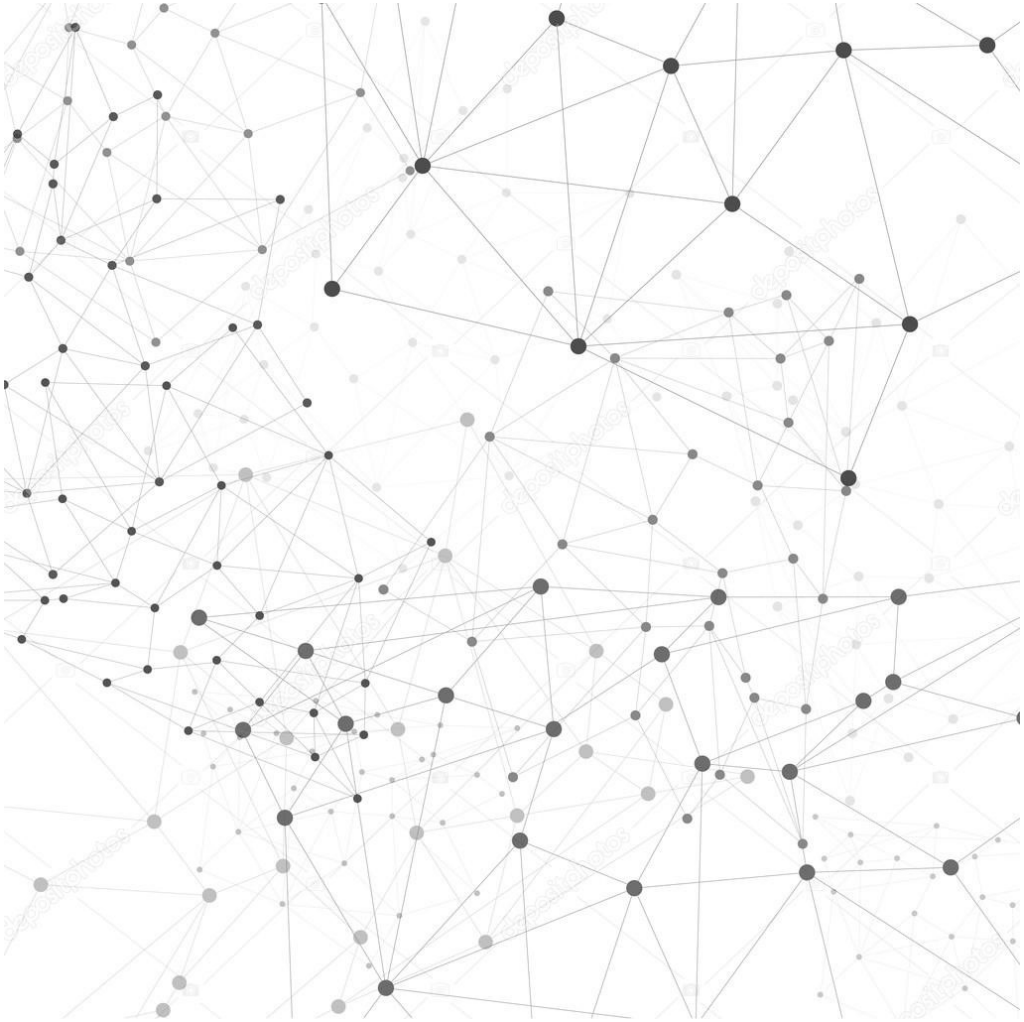
Network



Network is to connect the dots

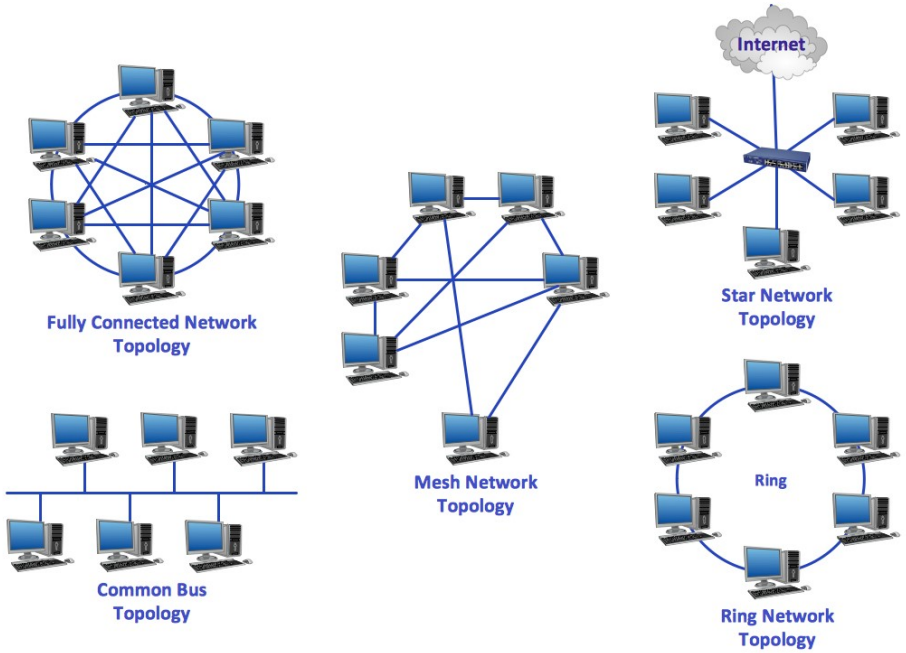


Network is to connect the ~~dots~~ devices



Building network

- There are many ways to connect the devices: Network topology



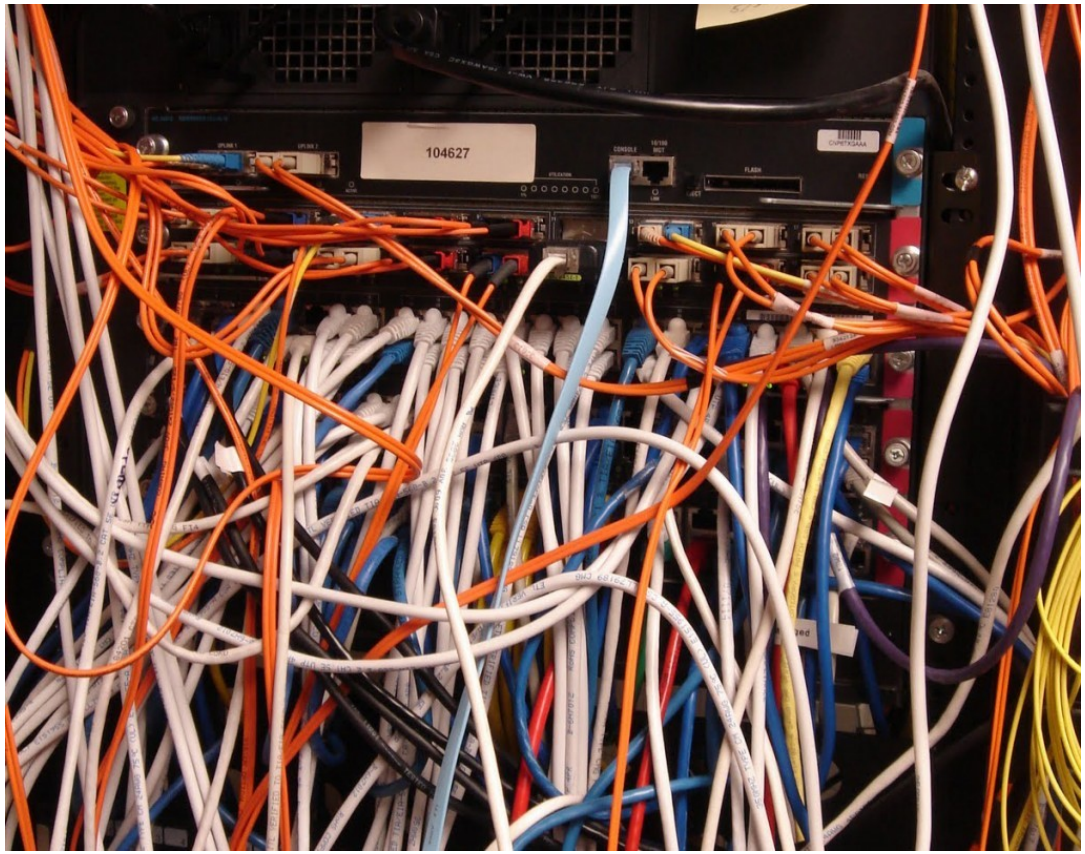
- Which network topology is our home Wi-Fi?

Building network

- Different network topology takes different way of communications.
- Fully-connected network is the most costly and robust. Ring is the cheapest but vulnerable.

Network talks

After laying down the wires, what runs inside?

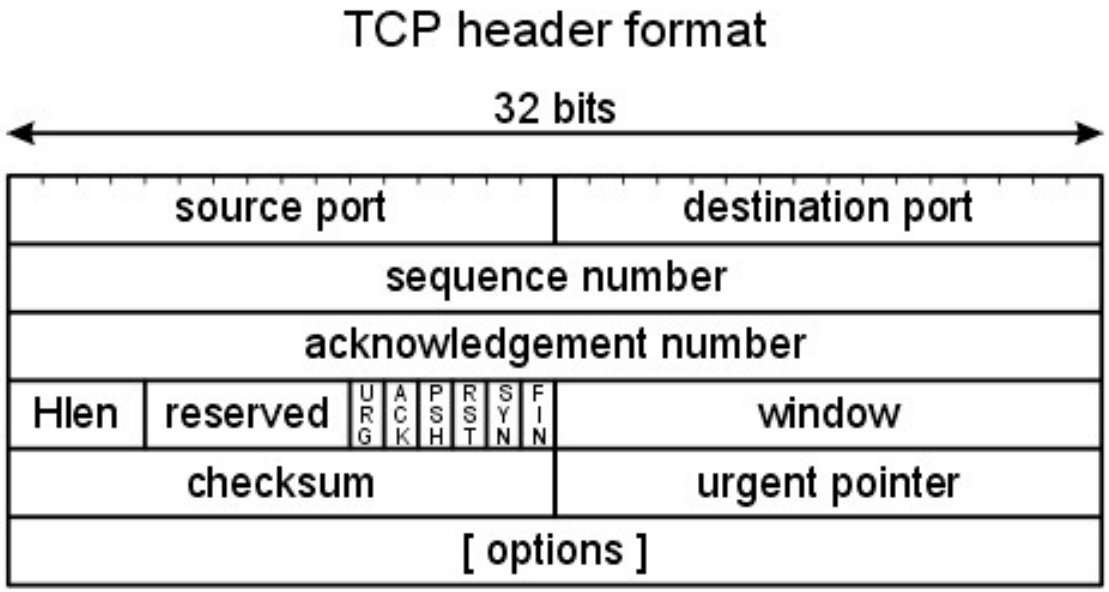


Network talks

1. Information turns to *packet*
2. Protocol designs the packet and process
3. Infrastructure is to route the packets to the destination.

Packet

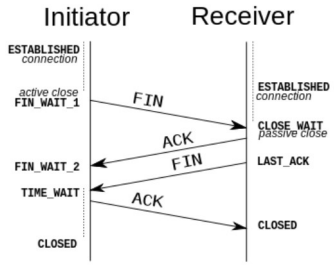
1. Information turns to packet



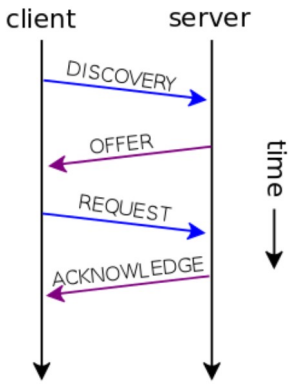
Protocol

2. Protocol designs the packet and process

TCP Session

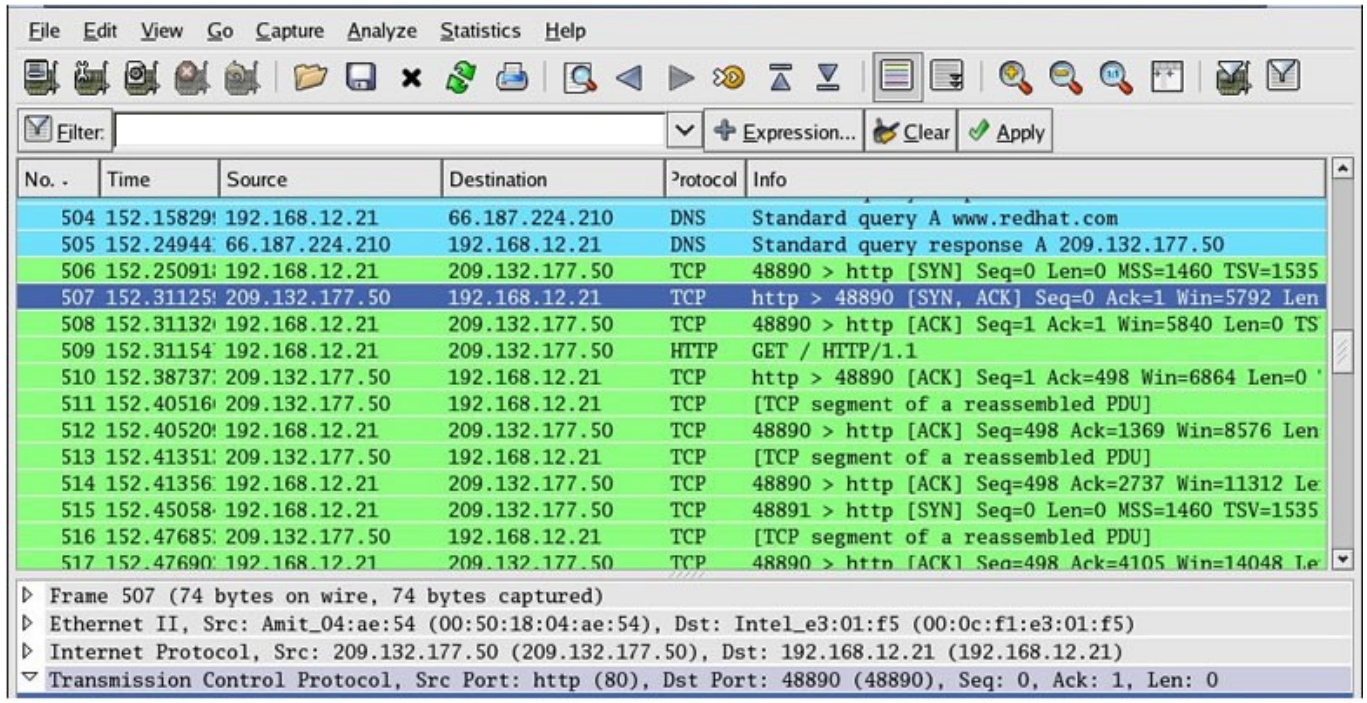


DHCP Session



Routing/Gateway

3. Infrastructure helps to transmit and route the packets to the destination.

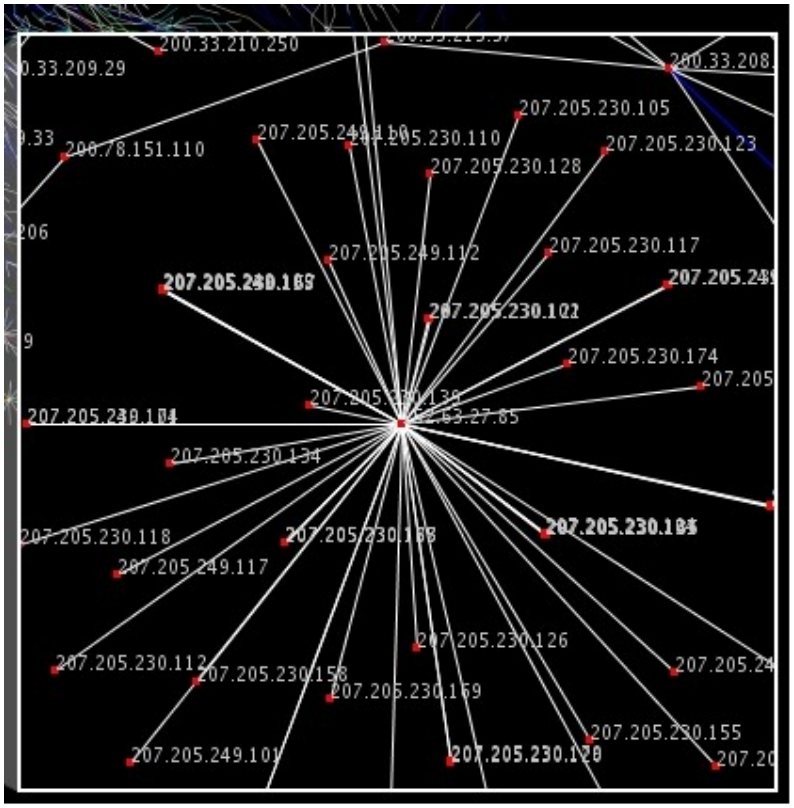


TCP/IP and Internet

The Defense Advanced Research Projects Agency (DARPA) created the TCP/IP model in the 1970s to build ARPANET. ARPANET is a wide area network that preceded the internet.

What does TCP/IP gives?

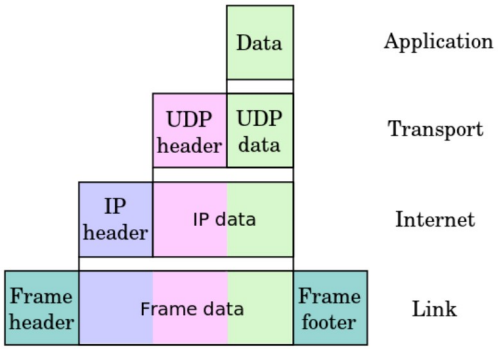
1. IP (Internet Protocol, IP address)



2. TCP (Transmission Control Protocol) TCP provides reliable, ordered, and error-checked delivery of a stream

TCP/IP

- Four Layers



- Application layer runs many protocols

Internet protocol suite

Application layer
BGP · DHCP · DNS · FTP · HTTP · IMAP · LDAP · MGCP · NNTP · NTP · POP · ONC/RPC · RTP · RTSP · RIP · SIP · SMTP · SNMP · SSH · Telnet · TLS/SSL · XMPP · *more...*

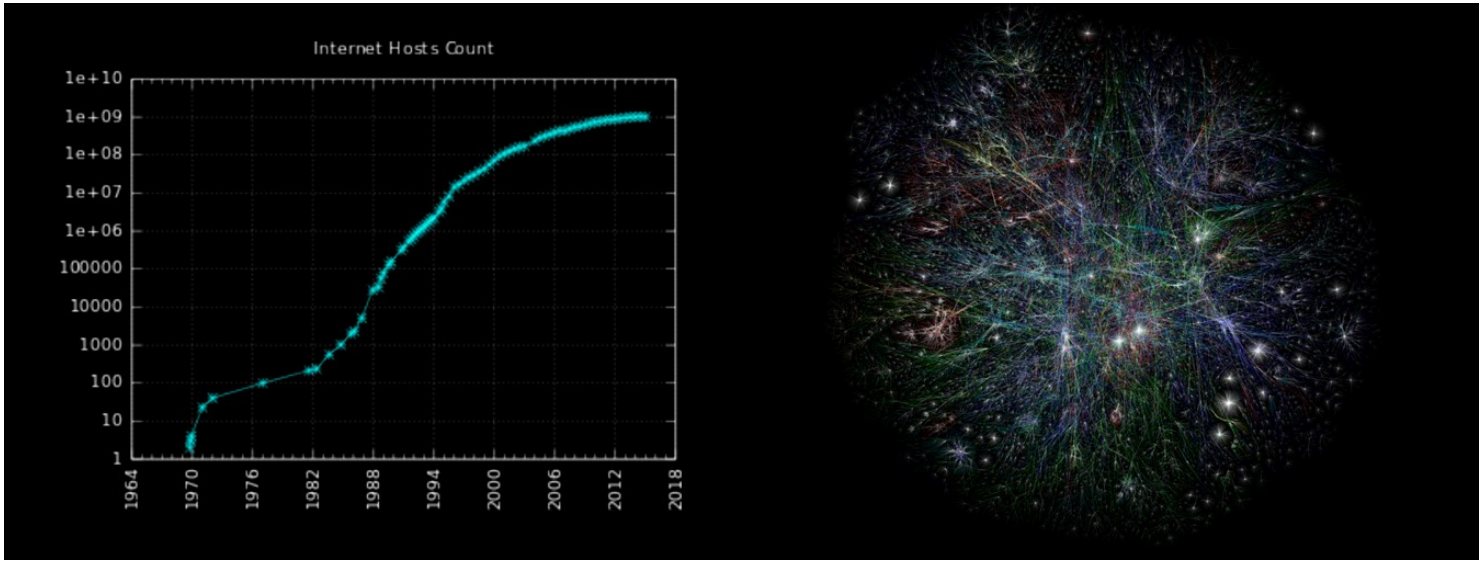
Transport layer
TCP · UDP · DCCP · SCTP · RSVP · *more...*

Internet layer
IP (IPv4 · IPv6) · ICMP · ICMPv6 · ECN · IGMP · IPsec · *more...*

Link layer
ARP · NDP · OSPF · Tunnels (L2TP) · PPP · MAC (Ethernet · DSL · ISDN · FDDI) · *more...*

V · T · E

This is why and how Internet growed in size



What happens after ~~plugging cable~~, turning on Wi-Fi?

- Every network device has a hardware address
- DHCP client, a component of the operating system sends out a DHCP request and recieves an offer from a DHCP server running on the router.
- Device accepts the IP address and use it to label for itself. Router also knows where to send the packet.

When it wants to visit someone on the network? 1/2

- Domain Name System:
  - *We don't use 123.456.789.012 but www.google.com.*
  - *DNS is the directory service for internet.*
  - *Your device also receives One or more DNS server addresses so the computer knows where to send DNS requests.*

Demo with nslookup.

When it wants to visit someone on the network? 2/2

- Then, your device creates and send the packet "request". Wait for response.
- Router and gateway will relay the packets to the receiver.

HTTP/HTML

- Initiated by Tim Berners-Lee at CERN in 1989.
- HTML was also invented by Tim, “HTML tags”

HTTP Request/Response

- Request

```
GET /index.html HTTP/1.1
Host: www.example.com
```

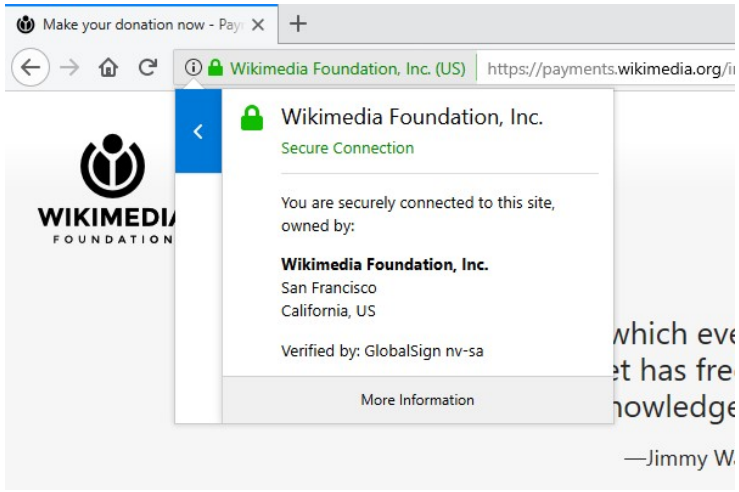
- Response

```
HTTP/1.1 200 OK
Date: Mon, 23 May 2005 22:38:34 GMT
Content-Type: text/html; charset=UTF-8
Content-Encoding: UTF-8
Content-Length: 138
Last-Modified: Wed, 08 Jan 2003 23:11:55 GMT
Server: Apache/1.3.3.7 (Unix) (Red-Hat/Linux)
ETag: "3f80f-1b6-3e1cb03b"
Accept-Ranges: bytes
Connection: close

<html>
<head>
    <title>An Example Page</title>
</head>
<body>
    Hello World, this is a very simple HTML document.
</body>
</html>
```

HTTP/HTML

- Hypertext Transfer Protocol (HTTP) but obviously, it does file, music, anything now.
- It's a clear text protocol. That's why we need to use HTTPS (HTTP on SSL) to secure the communication.



In browser, you can see the green lock in address bar. App doesn't show it, we just trust that they are using HTTPS.

Web

When you have HTML and URL (Uniform Resource Locator), Web is born.

- Website: https://en.wikipedia.org/
- Document: https://en.wikipedia.org/wiki/World_Wide_Web
- Resource: https://en.wikipedia.org/wiki/World_Wide_Web#/media/File:Web_Index.svg

How this resource is used in the document.

```
<div class="thumbinner" style="width:302px;">
    <a href="/wiki/File:Web_Index.svg" class="image">
    <img alt="" src="//upload.wikimedia.org/wikipedia/commons/thumb/6/65/Web_Index.svg/
        width="300" height="154" class="thumbimage"  />
    </a>
</div>
```

Web Browser

First generation

Web application

- Static v.s. Dynamic
- Dynamic website display content based on user input.
- Supported by HTML/CSS/JavaScript. HTML 5, CSS 3 and JavaScript 7 .
- App also uses HTML/CSS/JS.

Web application

- Why it is important?

- Needless to say. It is not 1995 anymore.
- Easy to develop
- Easy to deploy
- Runs fast

To recap

Why the Internet succeeded?

- Information flows by packet.
  - *IP protocol sets the address for the device*
  - *TCP protocol transmit the packet reliably*
  - *UDP, for real-time transmission which can accept failure.*
- Local device just needs to send the packet
- Transmission is done by the network devices
- Efficient and scalable

To recap

Web application

- Browser => HTML/CSS/JavaScript => HTTP => TCP => IP => Network physical.
- We will write in R, which subsequently writes HTML/CSS/JavaScript.

Lecture 03: R Markdown and Shiny (layout)

Introduction

- *Markdown* is a format that is easy to read and can be converted to other formats, HTML, PDF, Word, Slides.
- R Studio extends it further to create R notebook, interactive document and web application, which is *R Markdown*.
- Shiny is a web programming framework in R. We use it extensively in this course. We begin with the layout part.

Markup and Markdown

- Document stores information.
- Web is a superset of interlinked documents.
- HTML is a markup language, built for machines.
- Markdown is for humans to write doc, with minimal added to decorate it, created by John Gruber in collaboration with Aaron Swartz in 2004.

> A Markdown-formatted document should be publishable as-is, as plain text, without looking like it's been marked up with tags or formatting instructions. - John Gr

Markdown example

```
---
title: My first bitcoin
subtitle: and how I bought a pizza!
author: "Gru"
date: "Jul 9, 2010"
---

# How I bought it

I found someone was selling _10000_ on ebay for __$30__.
I think that's

- cool
- fun
- hacker

# How I used it

I forgot to bring my wallet the other day.
So I used **the bitcoins** to buy some pizza.

![Pizza](../notes/imgs/bitcoin-pizza.png)
```

Markdown doc example

title	subtitle	author	date
My first bitcoin	and how I bought a pizza!	Despicable me	Jul 9, 2010

How I bought it

I found someone was selling *10000* on ebay for **$30**. I think that's

- cool
- fun
- hacker

How I used it

I forgot to bring my wallet the other day. I was hungry so I used **the bitcoins** to buy some pizza.

Markdown: Header and Code

Headers

More hashtag, deeper level.

```
# Header1
## Header2
### Header3
```

Code

Give four spaces before it

```
    if (a > 0) {
      print(a)
    }
```

```
if (a > 0) {
  print(a)
}
```

Markdown: List

```
* First paragraph.
Continued.

* Second paragraph. With a code block, which must be indented
eight spaces:

        { code }
```

- First paragraph. Continued.
- Second paragraph. With a code block, which must be indented eight spaces:

Markdown: Multi-level lists

Put four more spaces for each level.

```
* fruits
    + apples
        - macintosh
        - red delicious
    + pears
* vegetables
    + broccoli
    + chard
```

- fruits
  - *apples*
    - macintosh
    - red delicious
  - *pears*
- vegetables
  - *broccoli*
  - *chard*

Markdown: Ordered Lists

Put 4 more spaces for each level.

```
#. Chapter 1
    #. Section 1.1
    #. Section 1.2
#. Chapter 2
#. Chapter 3
```

1. Chapter 1

    1. *Section 1.1*
    2. *Section 1.2*

2. Chapter 2
3. Chapter 3

Table

```
| Tables        | Are           | Cool  |
| ------------- |:-------------:| -----:|
| col 3 is      | right-aligned | $1600 |
| col 2 is      | centered      |   $12 |
| zebra stripes | are neat      |    $1 |
```

Tables	Are	Cool
col 3 is	right-aligned	$1600
col 2 is	centered	$12
zebra stripes	are neat	$1

Markdown: Inline formatting

Emphasis

To emphasize some text, surround it with *s or _, like this:

```
This text is \_emphasized with underscores\_, and this
is \*emphasized with asterisks\*.
Double * or _ produces strong emphasis:

This is \*\*strong emphasis\*\* and \_\_with underscores\_\_.
```

This text is *emphasized with underscores*, and this is *emphasized with asterisks*. Double * or _ produces strong emphasis.

This is **strong emphasis** and **with underscores**. A * or _ character surrounded by spaces, or backslash-escaped, will not trigger emphasis.

Markdown: Inline formatting

Strikthrough

This ~~is deleted text.~~ This ~~is deleted text.~~

Superscripts and subscripts

H~2~O is a liquid. 2^10^ is 1024. H_2O is a liquid. 2^{10} is 1024.

Verbatim. inline code

Use backtick `. What is the difference between `>>=` and `>>`? What is the difference between >>= and >>?

Note:

- If the verbatim text includes a backtick, use two backticks.
- Use \ to turn off \~~, \^.

Markdown: Links

```
<http://google.com>
```

http://google.com

Images

A link immediately preceded by a ! will be treated as an image. The link text will be used as the image's alt text:

```
![Pizza](imgs/bitcoin-pizza.png)
```

Pizza

Formula

MathJax. Use laTex syntax. There are many online references.

Inline with text

```
$x = {-b \pm \sqrt{b^2-4ac} \over 2a}$
```

$x = {-b \pm \sqrt{b^2-4ac} \over 2a}$

Centered

```
$$\sum_{i=1}^n X_i$$
```

$$\sum_{i=1}^n X_i$$

R Markdown

Reference in R Studio

- R Markdown Cheat Sheet: Help > Cheatsheets > R Markdown Cheat Sheet,
- R Markdown Reference Guide: Help > Cheatsheets > R Markdown Reference Guide.

Create it via File > New File > R Markdown.

- Document
- Presentation
- Shiny

R Markdown Document example

````
---
title: "Data Analysis Report"
author: "Yang Ye"
date: "October 23, 2017"
output: html_document
---

```{r setup, include=FALSE}
knitr::opts_chunk$set(echo = TRUE)
```

## Report
```{r cars}
summary(cars)
```

## Including Plots
```{r pressure, echo=FALSE}
plot(pressure)
```
````

R Markdown Document Output

In the header, you can change the output to other types:

- html_document
- pdf_document
- word_document
- Ctrl+Shift+K or "Knitr"

Code block for R Markdown

- R Markdown is a extension to Markdown that you can execute code among the code. If you name the file as **.Rmd** and *knit* in R Studio.

````
```{r Calculate_7}
a <- 3
b <- 4
print(a + b)
```
````

```
## [1] 7
```

- Calculate_7 is the chunk name. It's optional to give a chunk name. If included, each code chunk needs a distinct name. It's usually best to give each code chunk a name, for easier debug.

- R code can also be inline. For example, to generate a random number everytime, include this `runif(1, 0, 1)`, 0.8516547.

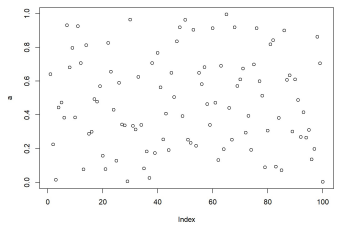
Chunk options

- *echo* is to decide whether to display code, default is FALSE.
- *result* is to decide whether to display result, default is show, set to "hide" to hide.
- *include* is to hide both code and result, default is FALSE.

````
```{r cars, echo = TRUE}
a <- runif(100, 0, 1)
```


```{r plot}
plot(a)
```
````

```
a <- runif(100, 0, 1)
```



R Markdown example: Table

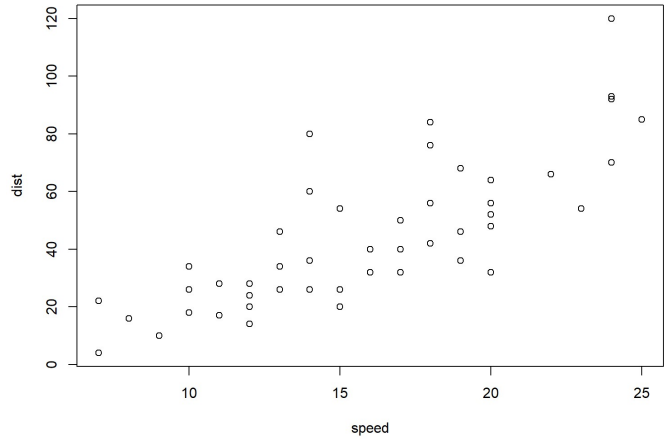
````
```{r kable}
knitr::kable(
  mtcars[1:5, ],
  caption = "A knitr kable."
)
```
````

A knitr kable.

	mpg	cyl	disp	hp	drat	wt	qsec	vs	am	gear	carb
Mazda RX4	21.0	6	160	110	3.90	2.620	16.46	0	1	4	4
Mazda RX4 Wag	21.0	6	160	110	3.90	2.875	17.02	0	1	4	4
Datsun 710	22.8	4	108	93	3.85	2.320	18.61	1	1	4	1
Hornet 4 Drive	21.4	6	258	110	3.08	3.215	19.44	1	0	3	1
Hornet Sportabout	18.7	8	360	175	3.15	3.440	17.02	0	0	3	2

R Markdown example: plot

```
```{r plot1, echo = FALSE}
a <- filter(cars, speed > 4)
plot(a)
```
```



R Shiny

- To start, use R Studio.
- File > New File > Shiny Web App…
- Choose single file
- Give a name and folder
- Ctrl+Shift+S or “Run App”

UI First

I removed everything in functions `server` and `ui`. This is the minimal Shiny.

```
library(shiny)

# Define UI for application that draws a histogram
ui <- fluidPage(
)

# Define server logic required to draw a histogram
server <- function(input, output) {
}

# Run the application
shinyApp(ui = ui, server = server)
```

Sidebar Layout

Let's add a minimal sidebarLayout

```
library(shiny)

# Define UI for application that draws a histogram
ui <- fluidPage(
  fluidPage(sidebarLayout(
    sidebarPanel(),
    mainPanel()
  ))
)

# Define server logic required to draw a histogram
server <- function(input, output) {
}

# Run the application
shinyApp(ui = ui, server = server)
```

fluidPage

- fluidPage means to place the controls from left-right, top-down order.
- `fluidPage` function can take any number of input parameter.

```
fluidPage(sidebarLayout(
    sidebarPanel(),
    mainPanel()
))
```

Add some things

- `titlePanel("Hello Shiny!"), h1("Introduction to Layout"),h2("Sidebar Layout")`

```
library(shiny)

# Define UI for application that draws a histogram
ui <- fluidPage(
  fluidPage(
    titlePanel("Hello Shiny!"),
    sidebarLayout(
      sidebarPanel(
        h1("Introduction to Layout"),
        h2("Sidebar Layout"),
        a("A link to Google", href="http://www.google.com"),
        tags$ul("About",
          tags$li("Who are we"),
          tags$li("What we do")
        ),
        tags$ol("Steps",
          tags$li("Write"),
          tags$li("Run")
        )
      ),
      mainPanel(
        img(src = "p19-Hero-Image-796x398.jpg")
      )
    )
  )
)
```

```
# Define server logic required to draw a histogram
server <- function(input, output) {
}

# Run the application
shinyApp(ui = ui, server = server)
```

Sidebar layout with bar on the right

```
fluidPage(
    sidebarLayout(position = "right",
    sidebarPanel(),
    mainPanel()
    )
)
```

More tags

Each tag is a function.

```
h1("A header")
p("some text as a paragraph")
a("A link to Google", href="http://www.google.com")
img(src = "p19-Hero-Image-796x398.jpg", width = "100%")
tags$ul("title", tags$li("Item 1"), tags$li("Item 2"))
tags$ol("Step", tags$li("Item 1"), tags$li("Item 2"))
```

Note:

- For image, you need to create a sub-directory `www` together with the R source file. Place the file under it.
- tags is a list of functions. To avoid name conflict, I prefer to use `tags$img()`, even `img()` is available to use.

Panels

`titlePanel()` and `wellPanel()`

```
library(shiny)

# Define UI for application that draws a histogram
ui <- fluidPage(
  fluidPage(
    titlePanel("Hello Shiny!"),
    sidebarLayout(
      sidebarPanel(
        h1("Well 1"),
        wellPanel(
          h2("Well 1.1"),
          actionButton("goButton", "Go!")
        ),
        h1("Well 2"),
        wellPanel(
          h2("Well 2.1"),
          actionButton("goButton2", "Go!")
        )
      ),
      mainPanel(
      )
    )
  )
)

# Define server logic required to draw a histogram
server <- function(input, output) {
}
```

```
# Run the application
shinyApp(ui = ui, server = server)
```

Navlist panel

```
library(shiny)

# Define UI for application that draws a histogram
ui <- fluidPage(
  fluidPage(
    titlePanel("Hello Shiny!"),
    navlistPanel(
      "Header A",
      tabPanel("Section 1",
               h1("Section 1")),
      tabPanel("Section 2",
               h1("Section 2")),
      "Header B",
      tabPanel("Section 3",
               h1("Section 3")),
      "-----",
      tabPanel("Component 5")
    )
  )
)

# Define server logic required to draw a histogram
server <- function(input, output) {
}

# Run the application
shinyApp(ui = ui, server = server)
```

tabPanel

```
library(shiny)

# Define UI for application that draws a histogram
ui <- fluidPage(
  fluidPage(
    titlePanel("Hello Shiny!"),
    tabsetPanel(
      tabPanel("Plot", h1("plot")),
      tabPanel("Summary", h1("summary")),
      tabPanel("Image", img(src = "p19-Hero-Image-796x398.jpg"))
    )
  )
)

# Define server logic required to draw a histogram
server <- function(input, output) {
}

# Run the application
shinyApp(ui = ui, server = server)
```

navBar

```
library(shiny)

ui <- fluidPage(
  fluidPage(
    navbarPage(title = "Runchee Technology",
               tabPanel("Product",
                        titlePanel("Hello!"),
                        "One more thing!"),
               tabPanel("About us",
                        titlePanel("Hello!"),
                        "Exordinary people"),
               navbarMenu(title = "Contact Us",
                          tabPanel("Address", "3/4 platform"),
                          tabPanel("Phone", "+123.456")
               )
    )
  )
)

# Define server logic required to draw a histogram
server <- function(input, output) {
}

# Run the application
shinyApp(ui = ui, server = server)
```

Column-based layout

- Caveat: There is fluidRow, but no fluidColumn.
- Column counts always add up to 12 = 4 + 6 + 2; otherwise, it will appear in the next line.

```
library(shiny)

ui <- fluidPage(
  fluidPage(
    fluidPage(
      titlePanel("Hello Shiny!"),
      fluidRow(
        column(4,
               wellPanel(
                 dateInput("date", "How's weather today?")
               )
        ),
        column(6,
               h3("Plot"),
               wellPanel(plotOutput("distPlot"))
        ),
        column(2, h3("Extra"),
               wellPanel(plotOutput("extraPlot"))
               )
      )
    )

    )
)
```

```
# Define server logic required to draw a histogram
server <- function(input, output) {
}

# Run the application
shinyApp(ui = ui, server = server)
```

Composition layout: Top and Down

```
library(shiny)
library(ggplot2)

ui <- fluidPage(
  fluidPage(
    fluidPage(
      title = "Diamonds Explorer",
      fluidRow(
        column(12,
               img(src = "p19-Hero-Image-796x398.jpg", width = "100%")
               )
      ),

      hr(),
      fluidRow(
        column(3,
               h4("Diamonds Explorer"),
               sliderInput('sampleSize', 'Sample Size',
                           min=1, max=nrow(diamonds), value=min(1000, nrow(diamonds)),
                           step=500, round=0),
               br(),
               checkboxInput('jitter', 'Jitter'),
               checkboxInput('smooth', 'Smooth')
        ),
        column(4, offset = 1,
               selectInput('x', 'X', names(diamonds)),
               selectInput('y', 'Y', names(diamonds), names(diamonds)[[2]]),
               selectInput('color', 'Color', c('None', names(diamonds)))
        ),
        column(4,
               selectInput('facet_row', 'Facet Row', c(None='.', names(diamonds))),
```

```
                selectInput('facet_col', 'Facet Column', c(None='.', names(diamonds)))
        )
      )
    )
  )
)

# Define server logic required to draw a histogram
server <- function(input, output) {
}

# Run the application
shinyApp(ui = ui, server = server)
```

R Markdown can also contain Shiny

````
---
title: "MFE FE8828 Assignment 1"
date: 2017-11-03
output: html_document
runtime: shiny
---

```{r setup, include = FALSE}
```

```{r, echo = FALSE}
wellPanel("Inputs",
          numericInput("fav_num", "What's your favorite number?", 3))
```
````

Inputs

What's your favorite number? 3

This is interactive document.

Assignments

- (Optional) Setup AWS and run EC2.
- Create a website with Shiny using navBar layout
  - *You are starting a company to offer.*
  - *Decide what you want to do*
  - *Create three pages. Name the pages depending on what you want to do. e.g. Product, About Us and Contact Us*
  - *Use different layouts for the pages: sideBar, column-based layout, Navlist.*
  - *Be creative!*

Runchee Technology Product About Us Contact Us

Hello!

One more thing!

New breakthrough

Lorem ipsum dolor sit amet, consectetur adipiscing elit, sed do

To be Released

Lorem ipsum dolor sit amet, consectetur adipiscing elit, sed do eiusmod tempor incididunt ut labore et dolore magna aliqua. Ut

Talk to Us!

Lorem ipsum dolor sit amet, consectetur adipiscing elit, sed do eiusmod tempor incididunt ut labore et dolore magna aliqua. Ut