

# Workshop on Building Web-enabled Geospatial Analytics Applications

## Getting to Know Shiny

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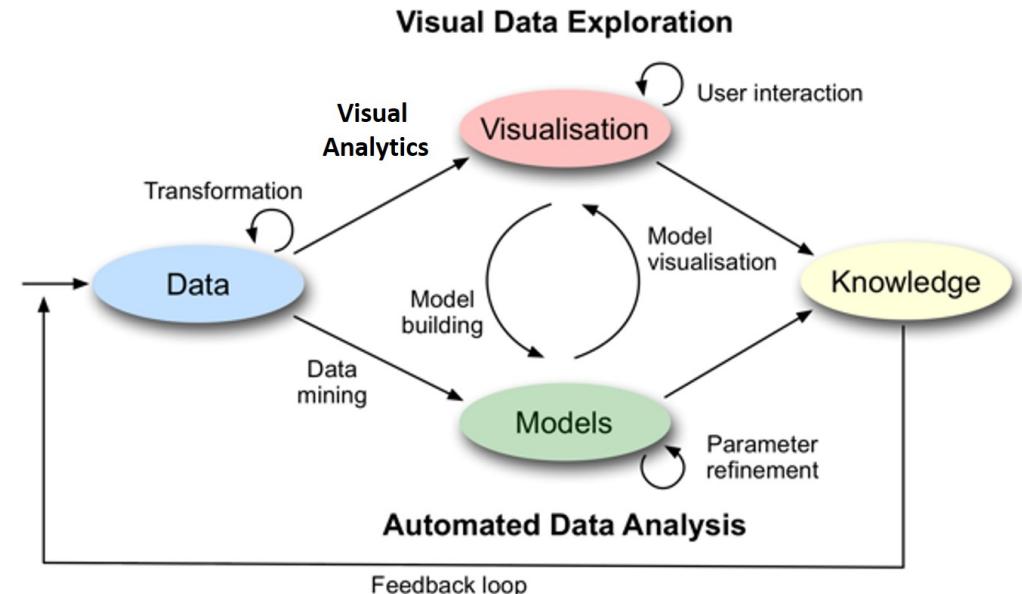
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# Content

- What is a Web-enabled Visual Analytics Application?
- Why building Web-enabled Visual Analytical Application?
- Evolution of web-based Technology
- Getting to Know Shiny

# What is a Web-enabled Visual Analytics Application?

- Focuses and emphasises on **interactivity** and effective integration of techniques from **data analytics**, **visualization** and **human-computer interaction (HCI)**.



# Why building a Web-enabled Visual Analytics Application?

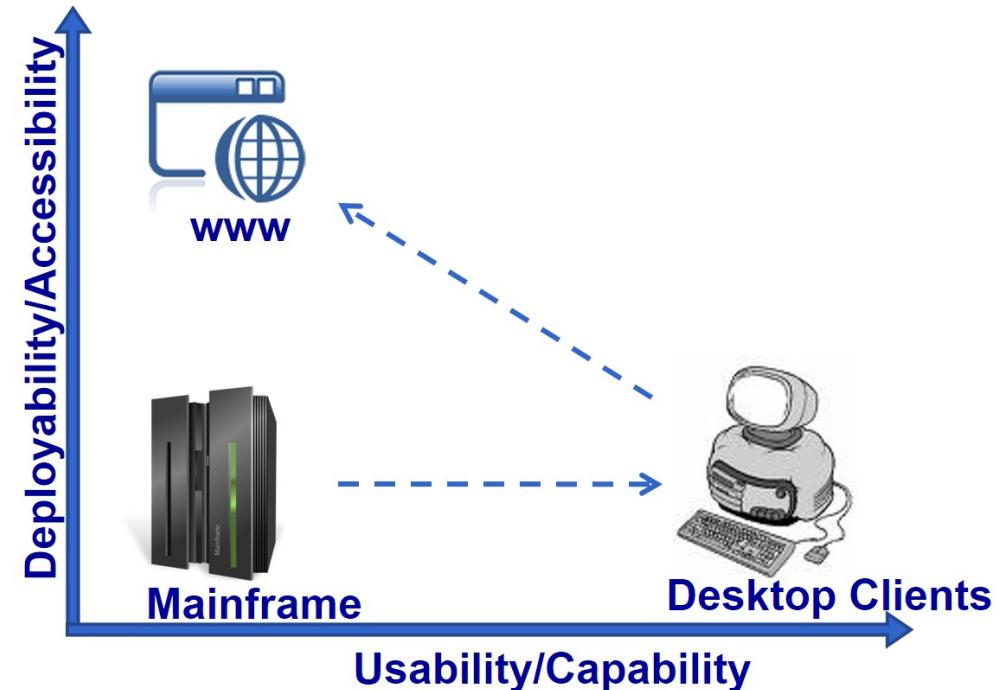
- To explore how the best of these different but related domains can be combined such that **the sum is greater than the parts**.
- To **democratise data and analytics** through web-based analytical applications for data exploration, visualisation analysis and modelling.



Source: <https://www.rekener.com/blog/democratize-data-analytics-customer-data-platform-B2B>

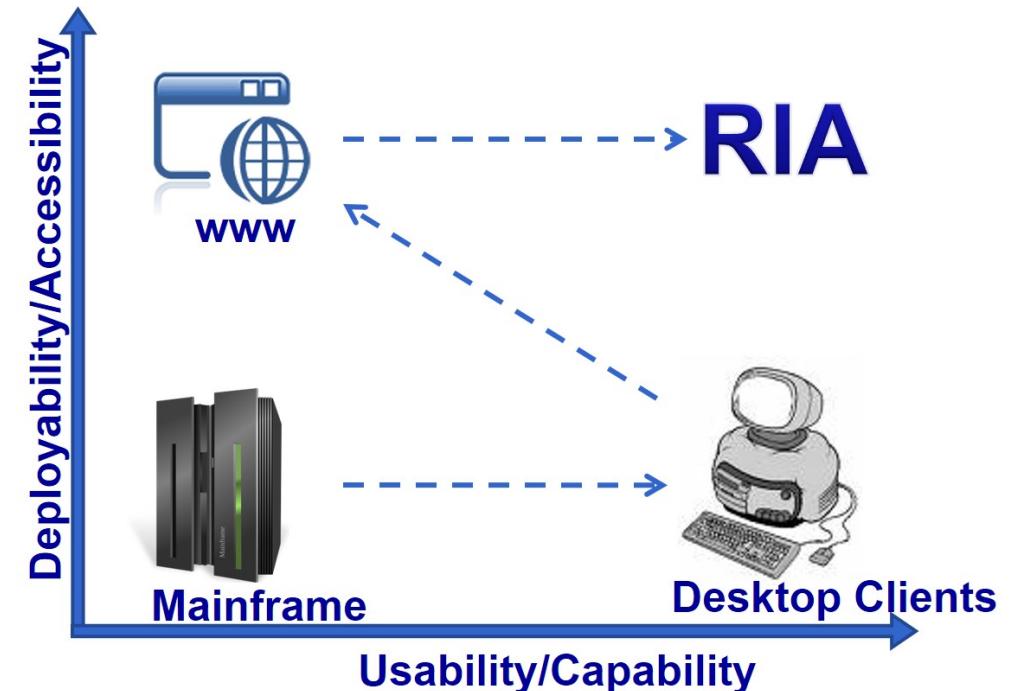
# Technology Challenges

- Mainframe computing tend to have low usability and low accessibility.
- Desktop computing tend to have high usability but low accessibility.
- Web-based computing (including mobile computing) are highly accessible but with relatively low capability



# Web-based data visualisation

- The break-through is Rich Internet Applications (RIA)



Reference: <https://www.computerworld.com/article/2551058/rich-internet-applications.html>

# Development of RIA

## First generation RIA data visualisation

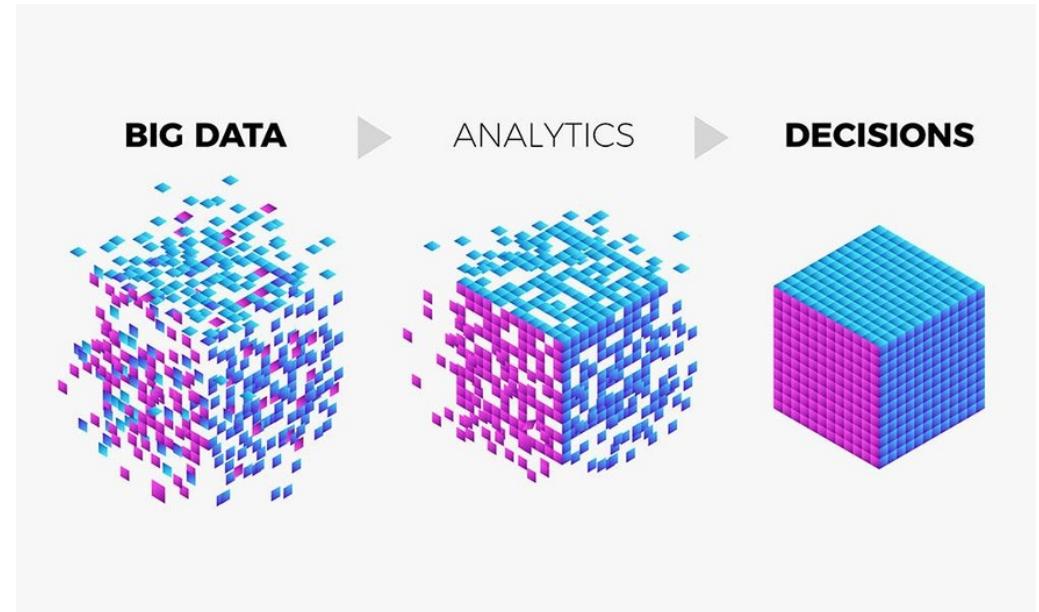
- Adobe Flex Builder
  - Flare (<http://flare.prefuse.org/>)
- Microsoft Silverlight
- JavaFX

## Second generation RIA data visualisation

- HTML 5 + JavaScript + SVG + CSS
  - Client-side rendering
  - No plug-in is required
  - Mobile computing enabled
- D3.js (<https://d3js.org/>) - Data Driven Document

# Methodological Challenges

- Lack of analysis functions.
- Not reproducible.
- Not extendable.
- Require to learn multiple technologies and methods.



# Getting to Know Shiny

## Shiny: Overview

- Shiny is an open package from RStudio.
- It provides a **web application framework** to create interactive web applications (visualization) called "Shiny apps".
- It can be found at  
<https://shiny.rstudio.com/>



# Getting to Know Shiny

## What is so special about Shiny?

It allows R users:

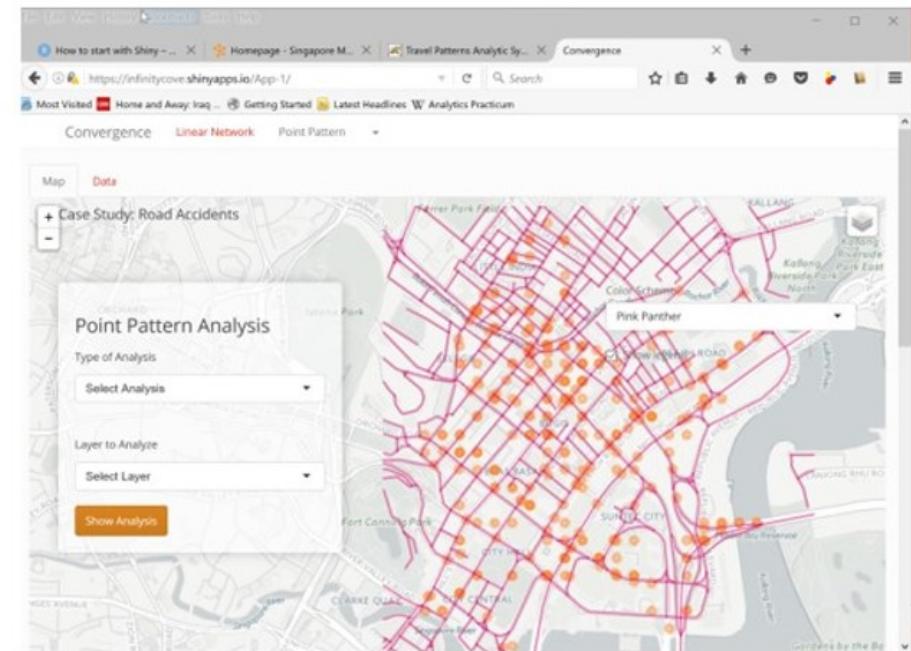
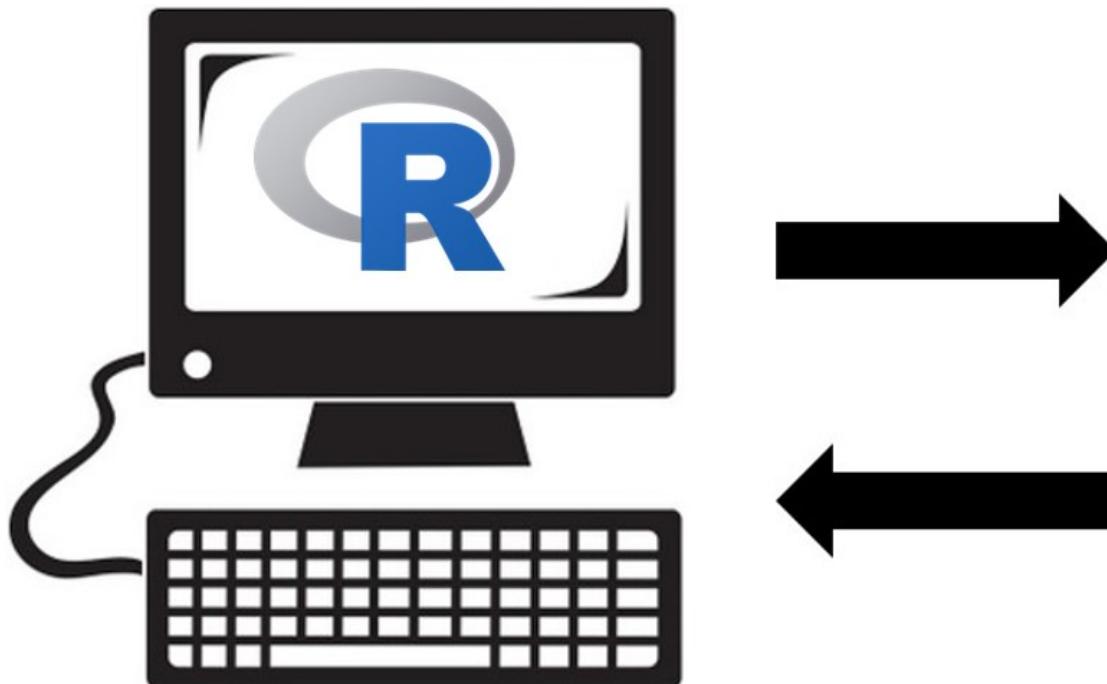
- to build and share highly interactive web-enabled applications without having to invest significant amount of time and efforts to master core web design technologies such as html5, Javascript and CSS.
- to integrate the analytical and visualisation packages of R without having to change from one programming language to another.



# Getting to Know Shiny

## Understanding the architecture

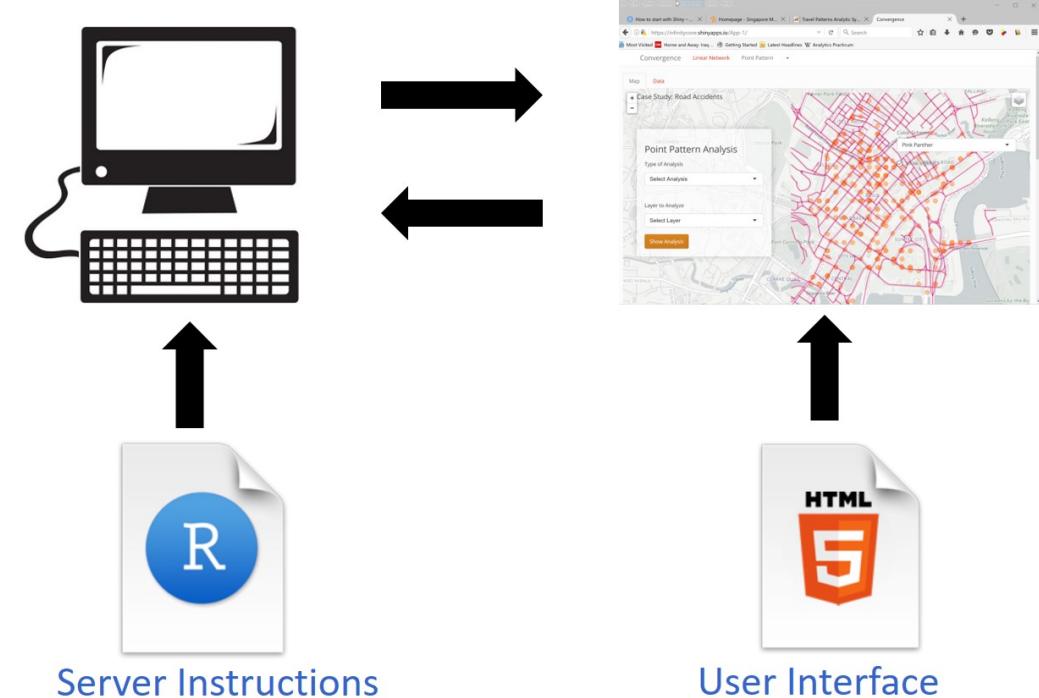
- Every Shiny app is maintained by a computer running R.



# Getting to Know Shiny

## The Structure of a Shiny app

- A Shiny app comprises of two components, namely:
  - a user-interface script, and
  - a server script.



# Getting to Know Shiny

## Shiny's user-interface, *ui.R*

- The *ui.R* script controls the layout and appearance of a shiny app.
  - It is defined in a source script name *ui.R*.
  - Actually, *ui* is a web document that the user gets to see, it is based on the famous Twitter bootstrap framework, which makes the look and layout highly customizable and fully responsive.
  - In fact, you only need to know R and how to use the shiny package to build a pretty web application. Also, a little knowledge of HTML, CSS, and JavaScript may help.

# Getting to Know Shiny

## Shiny's server *server.R*

- The *server.R* script contains the instructions that your computer needs to build your Shiny app.
- You are expected to:
  - know how to programme with R.
  - familiar with Tidyverse, specifically dplyr, tidyr and ggplot2

# Getting to Know Shiny

## Shiny Examples

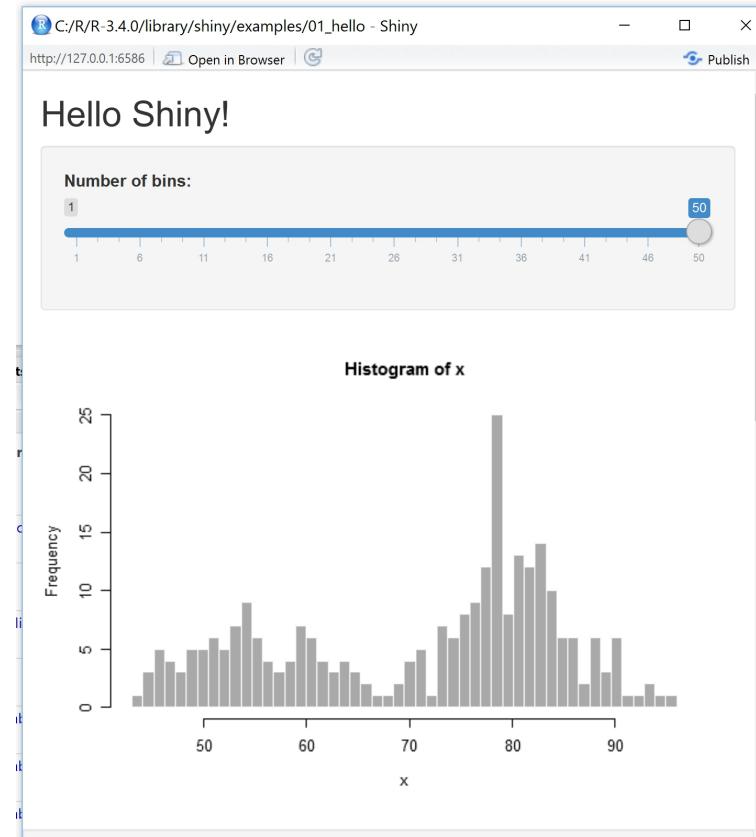
The Shiny package has eleven built-in examples that each demonstrates how Shiny works.

```
runExample("01_hello") # a histogram  
runExample("02_text") # tables and data frames  
runExample("03_reactivity") # a reactive expression  
runExample("04_mpg") # global variables  
runExample("05_sliders") # slider bars  
runExample("06_tabssets") # tabbed panels  
runExample("07_widgets") # help text and submit buttons  
runExample("08_html") # Shiny app built from HTML  
runExample("09_upload") # file upload wizard  
runExample("10_download") # file download wizard  
runExample("11_timer") # an automated timer
```

# Getting to Know Shiny

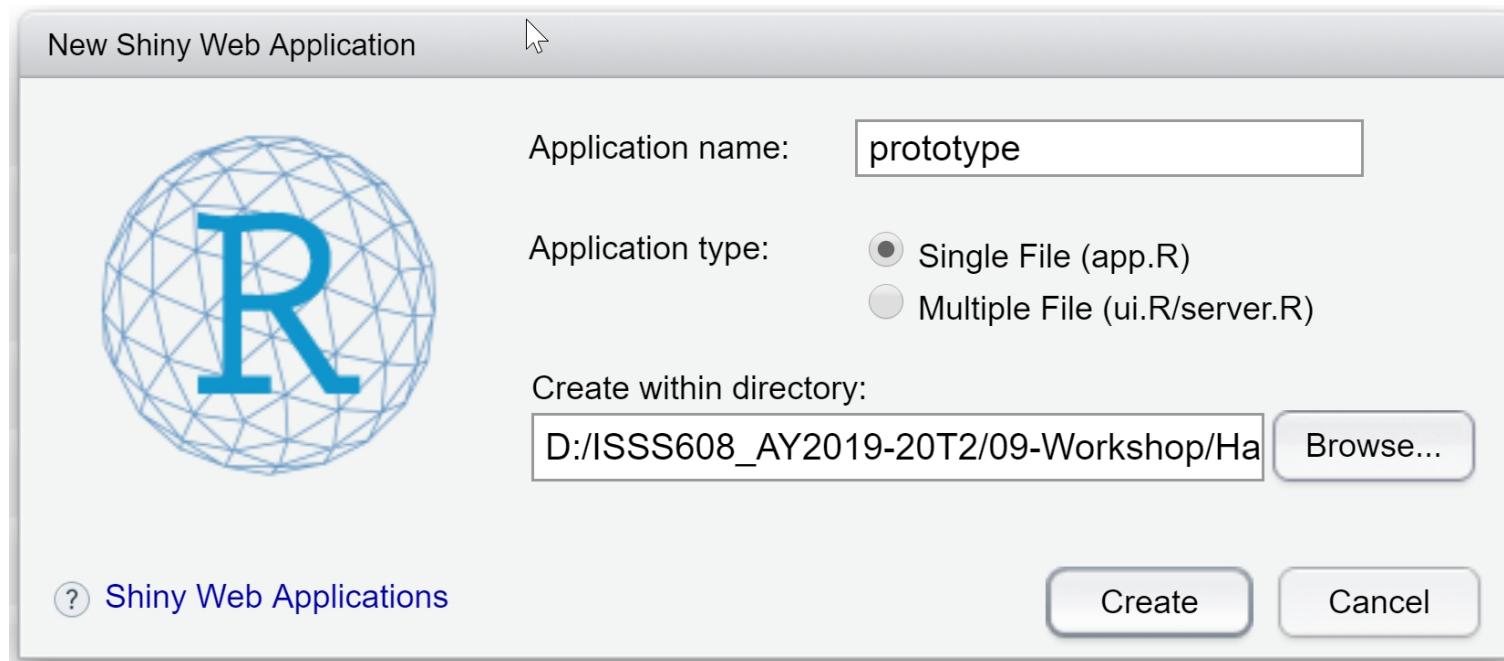
## Runing Shiny example

```
library(shiny)  
runExample("01_hello")
```



# Building a Shiny app

- A Shiny app can be in a form of a single file called *app.R*.
- Alternatively, a Shiny app can be also created using separate *ui.R* and *server.R* files.
- The separate files way is preferred when the app is complex and involves more codes.



# Building a Shiny app

## Survival Tips

- Always run the entire script, not just up to the point where you're developing code.
- Sometimes the best way to see what's wrong is to run the app and review the error.
- Watch out for commas!

# Building a Shiny app

## A basic Shiny app script

```
library(shiny)  
ui <- fluidPage()
```

### User interface

controls the layout and appearance of app

```
server <- function(input, output) {}
```

### Server function

contains instructions needed to build app

```
shinyApp(ui = ui, server = server)
```

### shinyApp()

Creates the Shiny app object

# Building a Shiny app

## Important tips of Shiny app file

- It is very important that the name of the file is *app.R*, otherwise it would not be recognized as a Shiny app.
- You should not have any R code after the `shinyApp(ui = ui, server = server)` line. That line needs to be the last line in your file.
- It is good practice to place this app in its own folder, and not in a folder that already has other R scripts or files, unless those other files are used by your app.

# Loading the dataset

```
library(shiny)
library(tidyverse)

exam <- read_csv("data/Exam_data.csv")

ui <- fluidPage()
server <- function(input, output) {}
shinyApp (ui=ui, server=server)
```

- Make sure that the data file path and file name are correct.
- To check if the dataset has been added correctly, you can add a *print()* argument after reading the data.

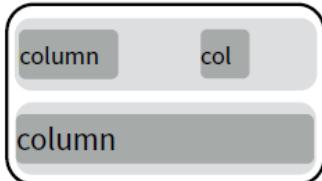
# Shiny Layout

- Shiny ui.R scripts use the function *fluidPage* to create a display that automatically adjusts to the dimensions of your user's browser window.
- You lay out your app by placing elements in the *fluidPage* function.
- *titlePanel* and *sidebarLayout* are the two most popular elements to add to *fluidPage*. They create a basic Shiny app with a sidebar.

# Shiny Layout Panels

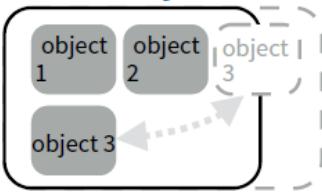
## An overview

### fluidRow()



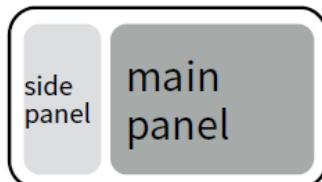
```
ui <- fluidPage(  
  fluidRow(column(width = 4),  
            column(width = 2, offset = 3)),  
  fluidRow(column(width = 12))  
)
```

### flowLayout()



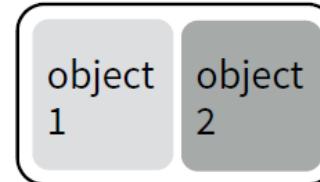
```
ui <- fluidPage(  
  flowLayout(# object 1,  
             # object 2,  
             # object 3)  
)
```

### sidebarLayout()



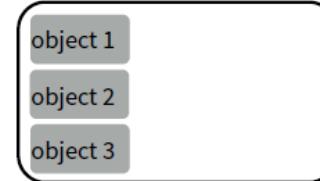
```
ui <- fluidPage(  
  sidebarLayout(  
    sidebarPanel(),  
    mainPanel())  
)
```

### splitLayout()



```
ui <- fluidPage(  
  splitLayout(# object 1,  
             # object 2)  
)
```

### verticalLayout()



```
ui <- fluidPage(  
  verticalLayout(# object 1,  
                 # object 2,  
                 # object 3)  
)
```

# Building the basic UI

## Working with *titlePanel*

- *titlePanel* is used to add the application title.

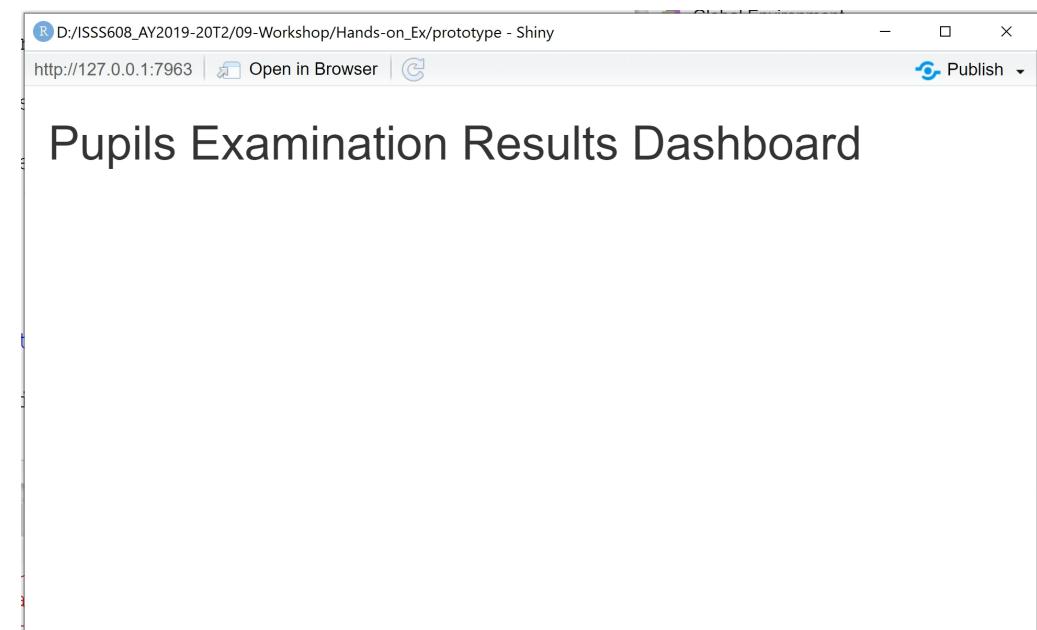
```
library(shiny)
library(tidyverse)

exam <- read_csv("data/Exam_data.csv")

ui <- fluidPage(
  titlePanel("Pupils Examination Results Dashboard")
)

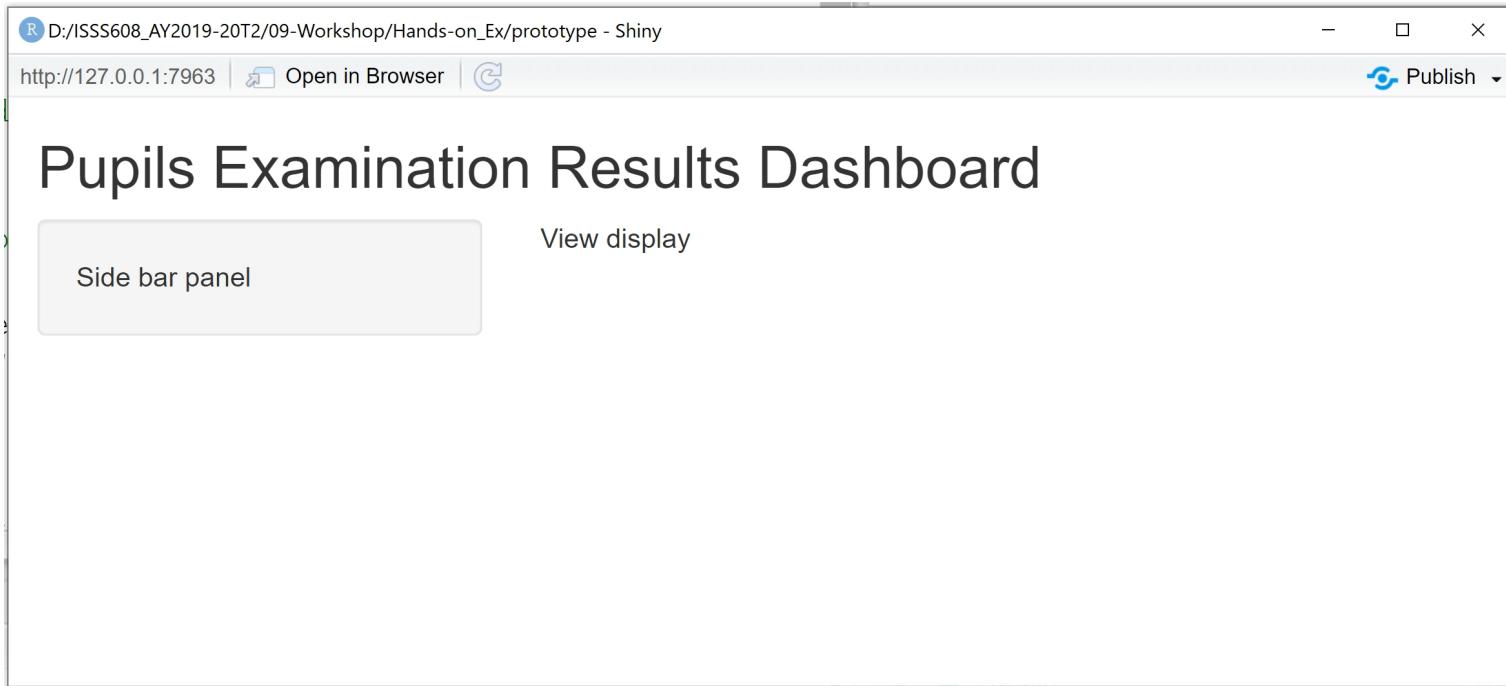
server <- function(input, output) {}

shinyApp(ui=ui, server=server)
```



# Building the basic UI

## Working with *sidebarLayout()*



# Building the basic UI

## Working with *sidebarLayout()*

- *sidebarLayout()* always takes two arguments:
  - *sidebarPanel()* function output
  - *mainPanel()* function output
- These functions place content in either the sidebar or the main panels.
- The *sidebarPanel()* will appear on the left side of your app by default. You can move it to the right side by giving *sidebarLayout()* the optional argument `position = "right"`.
- You can use *navbarPage* to give your app a multi-page user-interface that includes a navigation bar. Or you can use *fluidRow()* and *column()* to build your layout up from a grid system.
- To learn more about the advanced options, read the [Shiny Application Layout Guide](#).

# Building the basic UI

## Working with *sidebarLayout()*

```
library(shiny)
library(tidyverse)

exam <- read_csv("data/Exam_data.csv")

ui <- fluidPage(
  titlePanel("Pupils Examination Results Dashboard"),
  sidebarLayout(
    sidebarPanel("Side bar panel"),
    mainPanel("View display")
  )
)

server <- function(input, output) {}
shinyApp(ui=ui, server=server)
```

- Note that in a fluid design your sidebar and other elements may "collapse" if your browser view is not wide enough.

# Shiny Inputs

## An overview of Shiny Inputs

- Inputs are what gives users a way to interact with a Shiny app.
- Shiny provides many input functions to support many kinds of interactions that the user could have with an app.

### Inputs

collect values from the user

Access the current value of an input object with `input$<inputId>`. Input values are **reactive**.

Action

`actionButton(inputId, label, icon, ...)`

Link

`actionLink(inputId, label, icon, ...)`

Choice 1  
 Choice 2  
 Choice 3  
 Check me



`checkboxGroupInput(inputId, label, choices, selected, inline)`

`checkboxInput(inputId, label, value)`

`dateInput(inputId, label, value, min, max, format, startview, weekstart, language)`

`dateRangeInput(inputId, label, start, end, min, max, format, startview, weekstart, language, separator)`

`Choose File`

`fileInput(inputId, label, multiple, accept)`

1

`numericInput(inputId, label, value, min, max, step)`

.....

`passwordInput(inputId, label, value)`

Choice A  
 Choice B  
 Choice C

Choice 1  
Choice 2

0 5 10

`radioButtons(inputId, label, choices, selected, inline)`

`selectInput(inputId, label, choices, selected, multiple, selectize, width, size) (also selectizeInput())`

`Apply Changes`

`sliderInput(inputId, label, min, max, value, step, round, format, locale, ticks, animate, width, sep, pre, post)`

Enter text

`submitButton(text, icon)`  
(Prevents reactions across entire app)

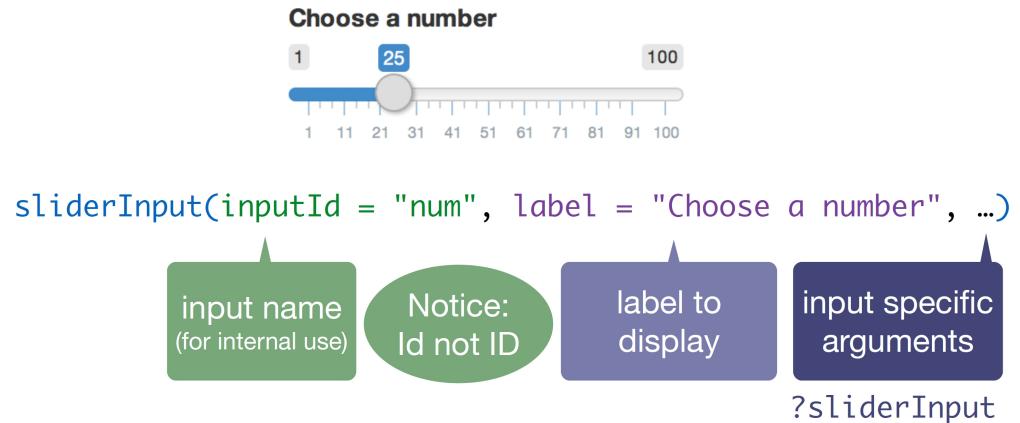
`textInput(inputId, label, value)`

Reference: Refer to [2 Basic UI](#) of Master Shiny to learn more about Shiny UI usage and arguments.

# Shiny Inputs

## Inputs syntax

- All input functions have the same first two arguments: `inputId` and `label`.
- The `inputId` will be the name that Shiny will use to refer to this input when you want to retrieve its current value.
- It is important to note that every input must have a unique `inputId`.
- The `label` argument specifies the text in the display label that goes along with the input widget.
- Every input can also have multiple other arguments specific to that input type.



# Shiny Inputs

## Adding inputs to the UI (*selectInput()* and *sliderInput()* functions)

```
ui <- fluidPage(  
  titlePanel("Pupils Examination Results Dashboard"),  
  sidebarLayout(  
    sidebarPanel(  
      selectInput(inputId = "variable",  
                  label = "Subject:",  
                  choices = c("English" = "ENGLISH",  
                             "Maths" = "MATHS",  
                             "Science" = "SCIENCE"),  
                  selected = "ENGLISH"),  
      sliderInput(inputId = "bins",  
                  label = "Number of Bins",  
                  min = 5,  
                  max = 20,  
                  value= 10)  
    ),  
    mainPanel()  
  )  
)
```

# Shiny Inputs

## Adding `checkboxInput()`

Add a checkbox input to specify whether the data plotted should be shown in a data table.

- ui: Add an input widget that the user can interact with to check/uncheck the box.
- ui: Add an output defining where the data table should appear.
- server: Add a reactive expression that creates the data table if the checkbox is checked.

# Shiny Inputs

## Adding *checkboxInput()*

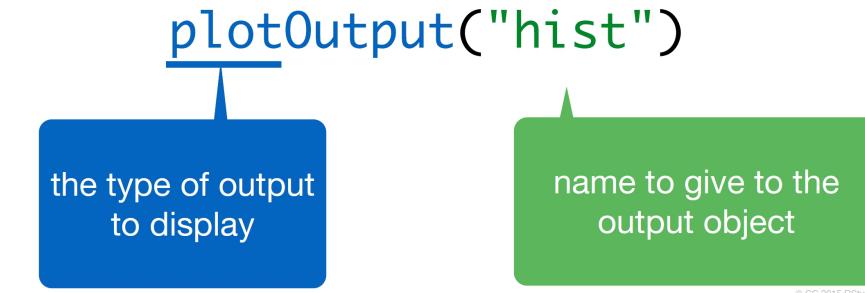
- ui: Add an input widget that the user can interact with to check/uncheck the box.

```
sliderInput(inputId = "bin",
            label = "Number of Bins",
            min = 5,
            max = 20,
            value = c(10)),
checkboxInput(inputId = "show_data",
              label = "Show data table",
              value = TRUE)
),
mainPanel()
)
)
```

# Shiny *Output()*

## An overview of Shiny *Output()*

- After creating all the inputs, we should add elements to the UI to display the outputs.
- To display output, add it to *fluidPage()* with an *Output()* function.



- Similarly to the input functions, all the ouput functions have a `outputId` argument that is used to identify each output, and this argument must be unique for each output.
- Each output needs to be constructed in the server code later.

# *Shiny Output()*

## *Shiny Output() options*

- Outputs can be any object that R creates and that we want to display in our app - such as a plot, a table, or text.

Function	Inserts
dataTableOutput()	an interactive table
htmlOutput()	raw HTML
imageOutput()	image
plotOutput()	plot
tableOutput()	table
textOutput()	text
uiOutput()	a Shiny UI element
verbatimTextOutput()	text

# Shiny *Output()*

## Adding *plotOutput()*

```
ui <- fluidPage(  
  titlePanel("Pupils Examination Results Dashboard"),  
  sidebarLayout(  
    sidebarPanel("Side bar panel"),  
    mainPanel(  
      plotOutput("distPlot")  
    )  
  )  
)
```

# Shiny *Output()*

## Adding *dataTableOutput()*

- ui: Add an output defining where the data table should appear.

```
mainPanel(  
  plotOutput("distPlot"),  
  DT::dataTableOutput(outputId = "examtable")  
)
```

# Shiny server.R

## Building an output

There are three rules to build an output in Shiny, they are:

- Save the output object into the output list (remember the app template - every server function has an output argument).
- Build the object with a *render()* function, where is the type of output.
- Access input values using the input list (every server function has an input argument)

Note: The third rule is only required if you want your output to depend on some input.

# Shiny server.R

## A generic Shiny *Render()* syntax

```
renderPlot({ hist(rnorm(100)) })
```

type of object to build

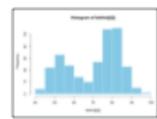
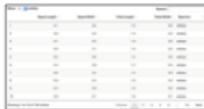
code block that builds the object

# Shiny server.R

## Shiny *Render()*

### Outputs -

render\*() and \*Output() functions work together to add R output to the UI



```
'data.frame': 3 obs. of  2 variables:  
 $ Sepal.Length: num  5.1 4.9 4.7  
 $ Sepal.Width : num  3.5 3 3.2
```

Sepal.Length	Sepal.Width
5.1	3.5
4.9	3.0
4.7	3.2

foo



**DT::renderDataTable(expr, options, callback, escape, env, quoted)**

**renderImage(expr, env, quoted, deleteFile)**

**renderPlot(expr, width, height, res, ..., env, quoted, func)**

**renderPrint(expr, env, quoted, func, width)**

**renderTable(expr, ..., env, quoted, func)**

**renderText(expr, env, quoted, func)**

**renderUI(expr, env, quoted, func)**

works  
with

**dataTableOutput(outputId, icon, ...)**

**imageOutput(outputId, width, height, click, dblclick, hover, hoverDelay, inline, hoverDelayType, brush, clickId, hoverId)**

**plotOutput(outputId, width, height, click, dblclick, hover, hoverDelay, inline, hoverDelayType, brush, clickId, hoverId)**

**verbatimTextOutput(outputId)**

**tableOutput(outputId)**

**textOutput(outputId, container, inline)**

& **uiOutput(outputId, inline, container, ...)**

**htmlOutput(outputId, inline, container, ...)**

# Shiny server.R

## Building a basic output

Let's first see how to build a very basic output using only the first two rules. We'll create a plot and send it to the ***distPlot*** output.

```
server <- function(input, output){  
  output$distPlot <- renderPlot({  
    ggplot(exam, aes(ENGLISH)) +  
      geom_histogram(bins = 20,  
                      color="black",  
                      fill="light blue")  
  })  
}
```

- This simple code shows the first two rules: we're creating a plot inside the *renderPlot()* function, and assigning it to ***distPlot*** in the output list.
- Remember that every output created in the UI must have a unique ID, now we see why. In order to attach an R object to an output with ID x, we assign the R object to ***output\$distPlot***.
- Since ***distPlot*** was defined as a ***plotOutput***, we must use the *renderPlot()* function, and we must create a plot inside the *renderPlot()* function.

# Shiny server.R

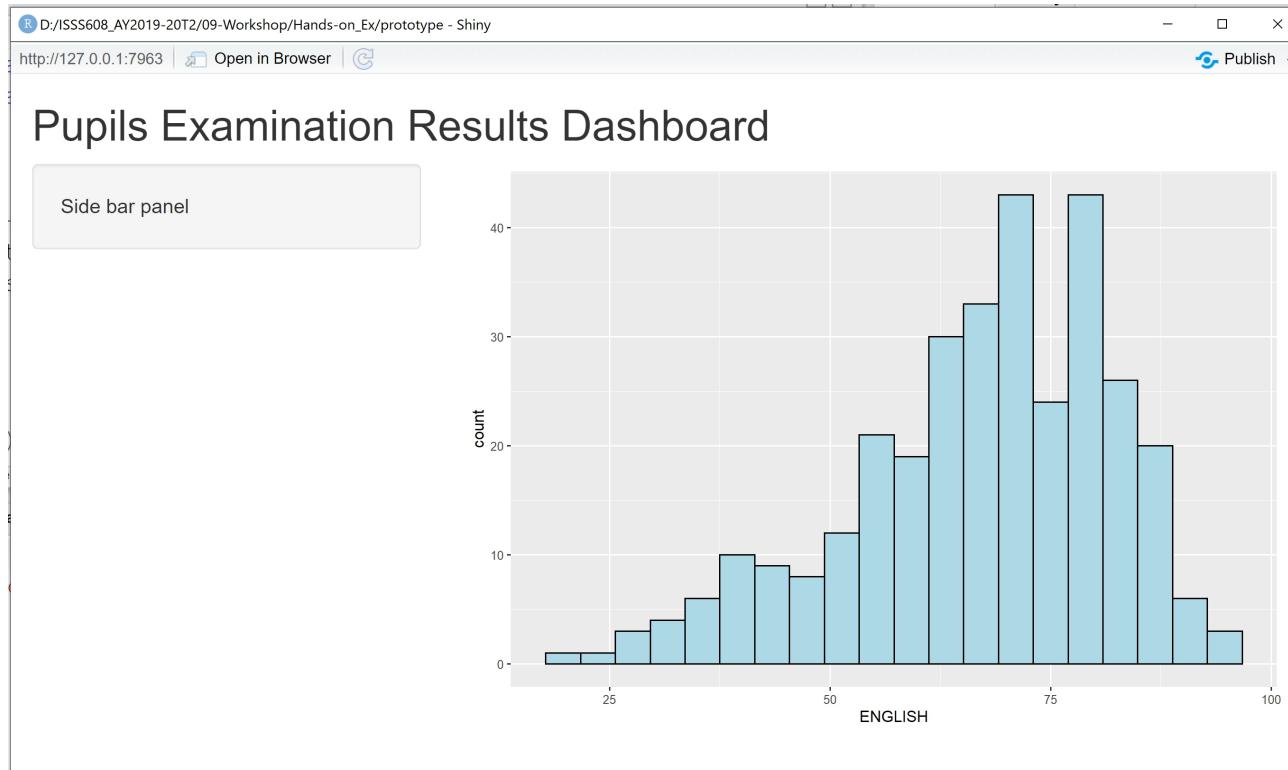
## Building a complete output

```
server <- function(input, output){  
  output$distPlot <- renderPlot({  
    x <- unlist(exam[,input$variable])  
  
    ggplot(exam, aes(x)) +  
      geom_histogram(bins = input$bin,  
                     color="black",  
                     fill="light blue")  
  })  
  
  output$examtable <- DT:::renderDataTable({  
    if(input$show_data){  
      DT:::datatable(data = exam %>% select(1:7),  
                     options= list(pageLength = 10),  
                     rownames = FALSE)  
    }  
  })  
}
```

# The shinyApp()

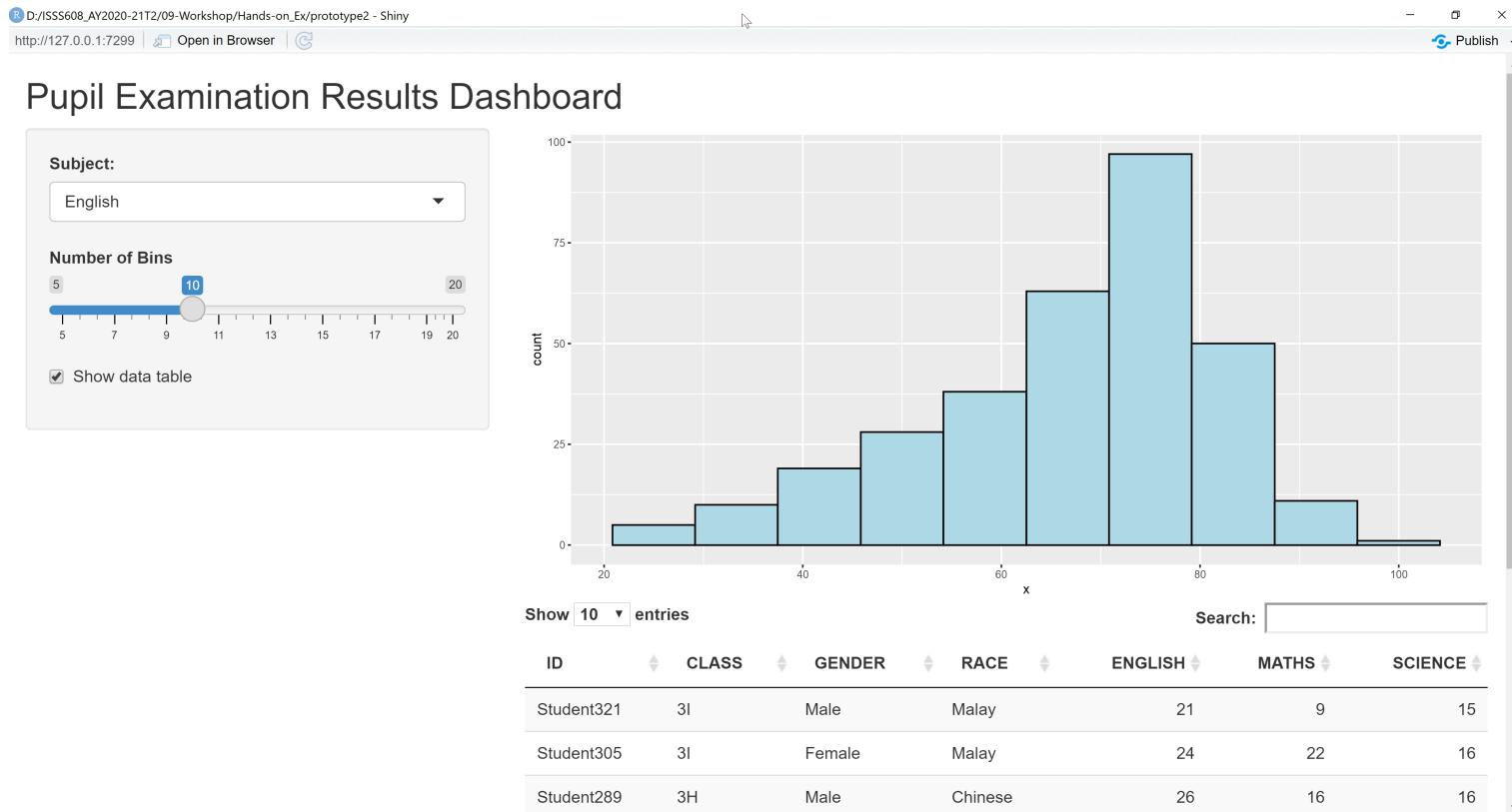
- It is important to add *shinyApp()* at the end of your Shiny application.

```
shinyApp(ui = ui, server = server)
```

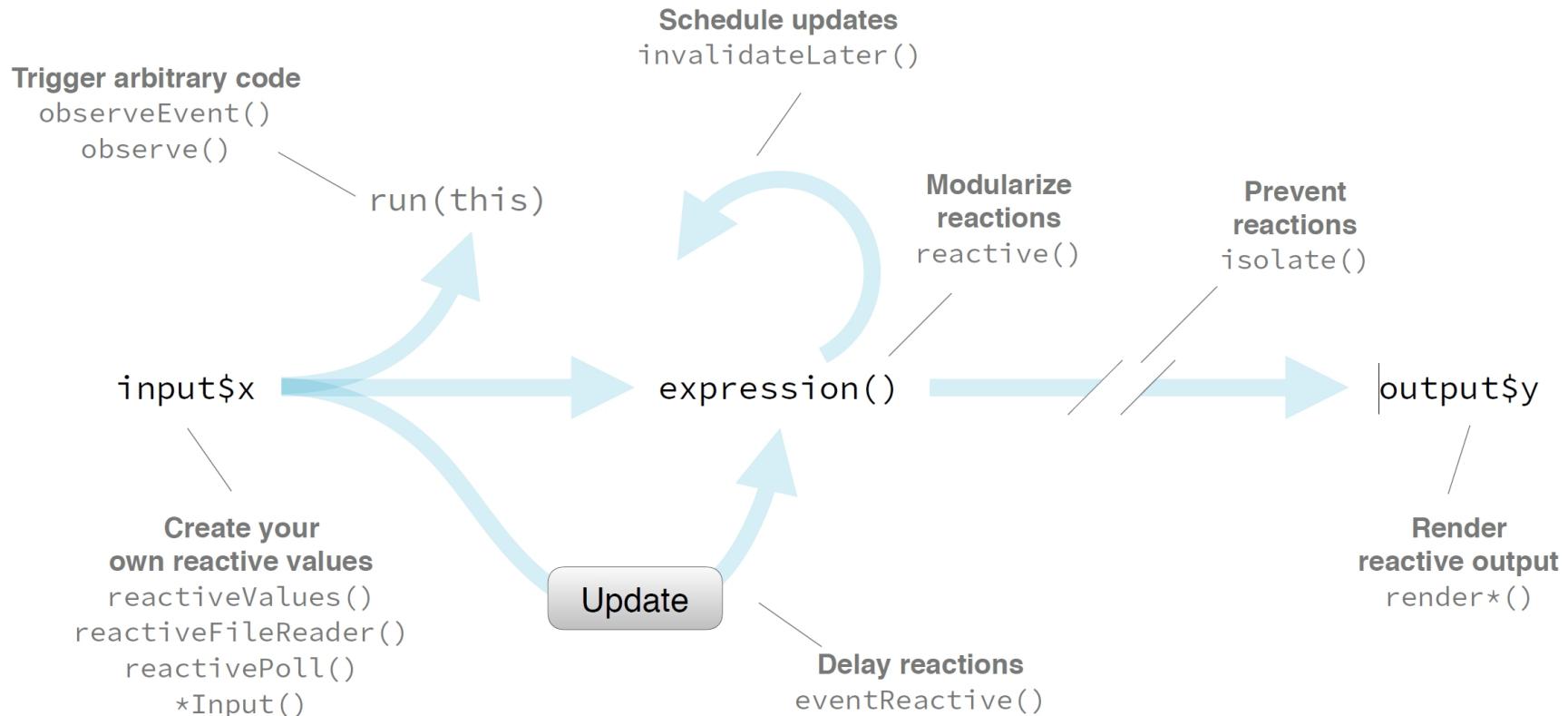


# Shiny app is Reactive

- Reactivity automatically occurs when an input value is used to render an output object.

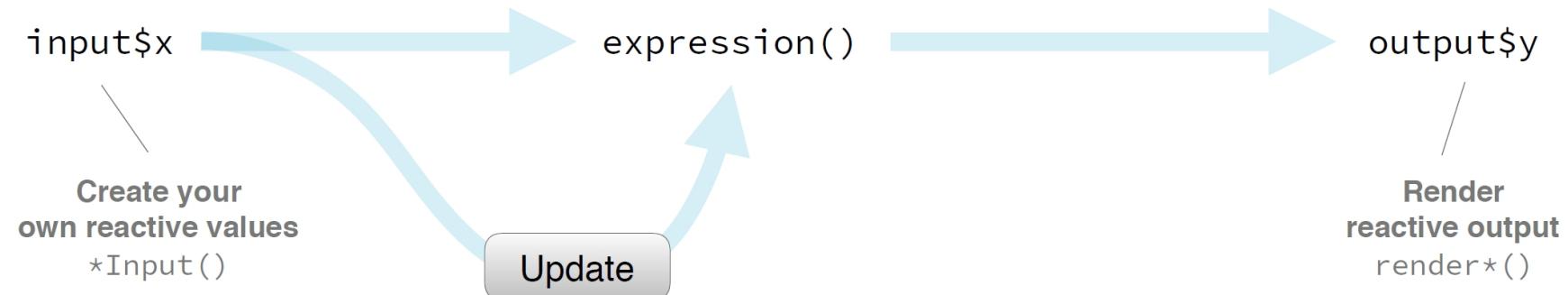


# Reactive Flow



# Reactive Flow

## Reactive flow, simplified



# References

- Hadley Wickham (2021) ['"Mastering Shiny"'](#), O'Reilly Media. This is a highly recommended book.
- [Building Web Applications with Shiny](#), especially Module 1 and 2.
- [Shiny Three Parts Tutorial](#).
- [Online Function reference](#)
- [The basic parts of a Shiny app](#)
- [How to build a Shiny app](#)
- [The Shiny Cheat sheet](#)

**Beyond Uncle Google!** Last but not least, when you need help

- [How to get help](#)