Intro to Functional Programming

Ray Shih

Hi

- My name is **Ray Shih**
- B.S., M.S. of NTU CSIE
- Worked in WOOMOO
- Work in Mobiusbobs
- A **Fullstack Software Engineer**, including
  - iOS, Android, Web backend/Frontend

Functional Programming is the future

TensorFlow

Today, I'll teach you how to programming

What?

I already know how to programming!

$$x = x + 1$$

WTF is this?

Well then….

Forget it.

Back to
math of high school

Problem 1

a = 1

b = 2

c = a + b

c = ?

b = 2

c = 1 + b

c = ?

$$c = 1 + 2$$

$$c = ?$$

$$c = 3$$

What are functions?

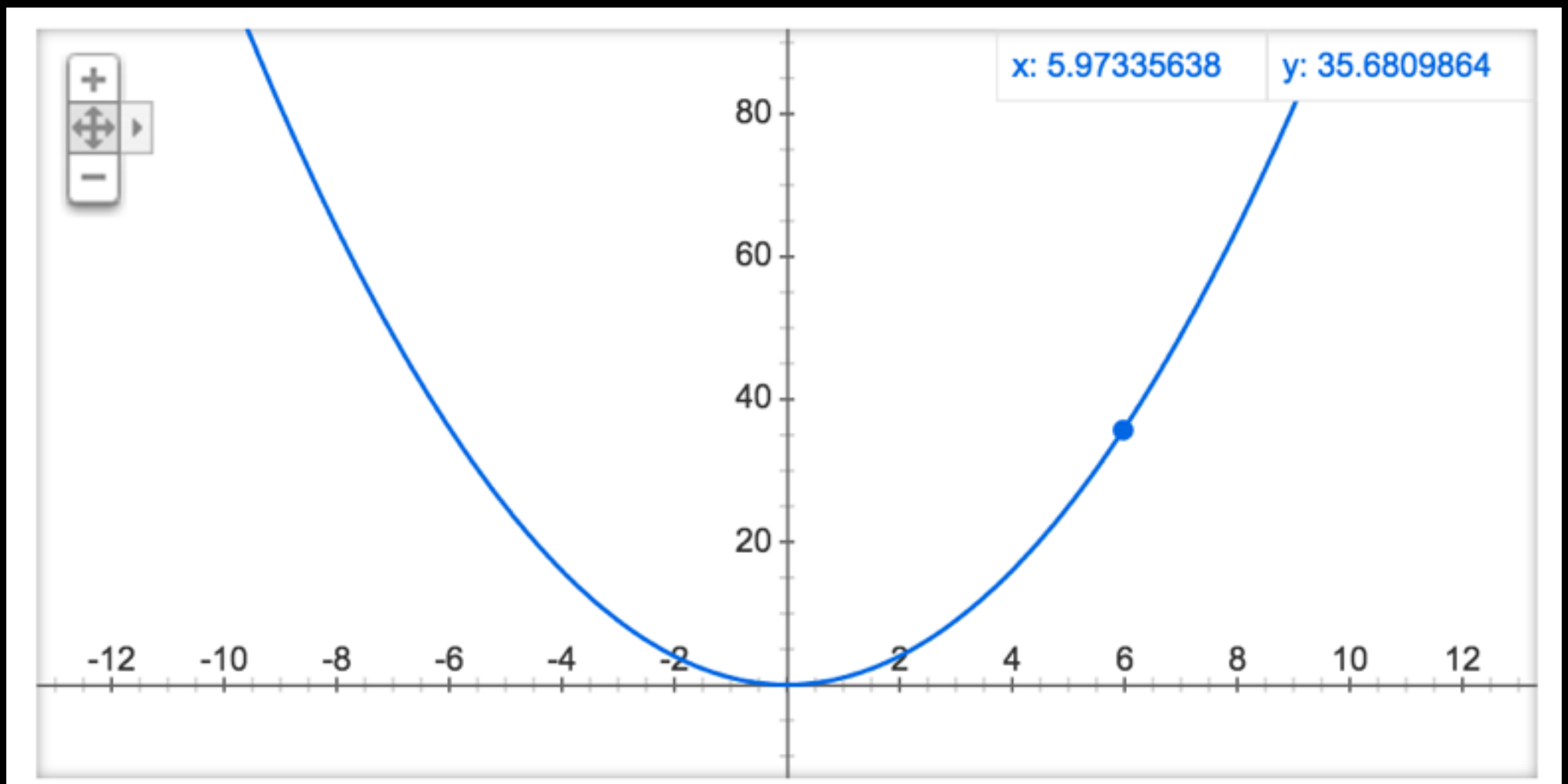
$$y = f(x)$$

$$f(x) = x^2$$

$$y = f(x)$$

$$y = x^2$$

$$y = x^2$$



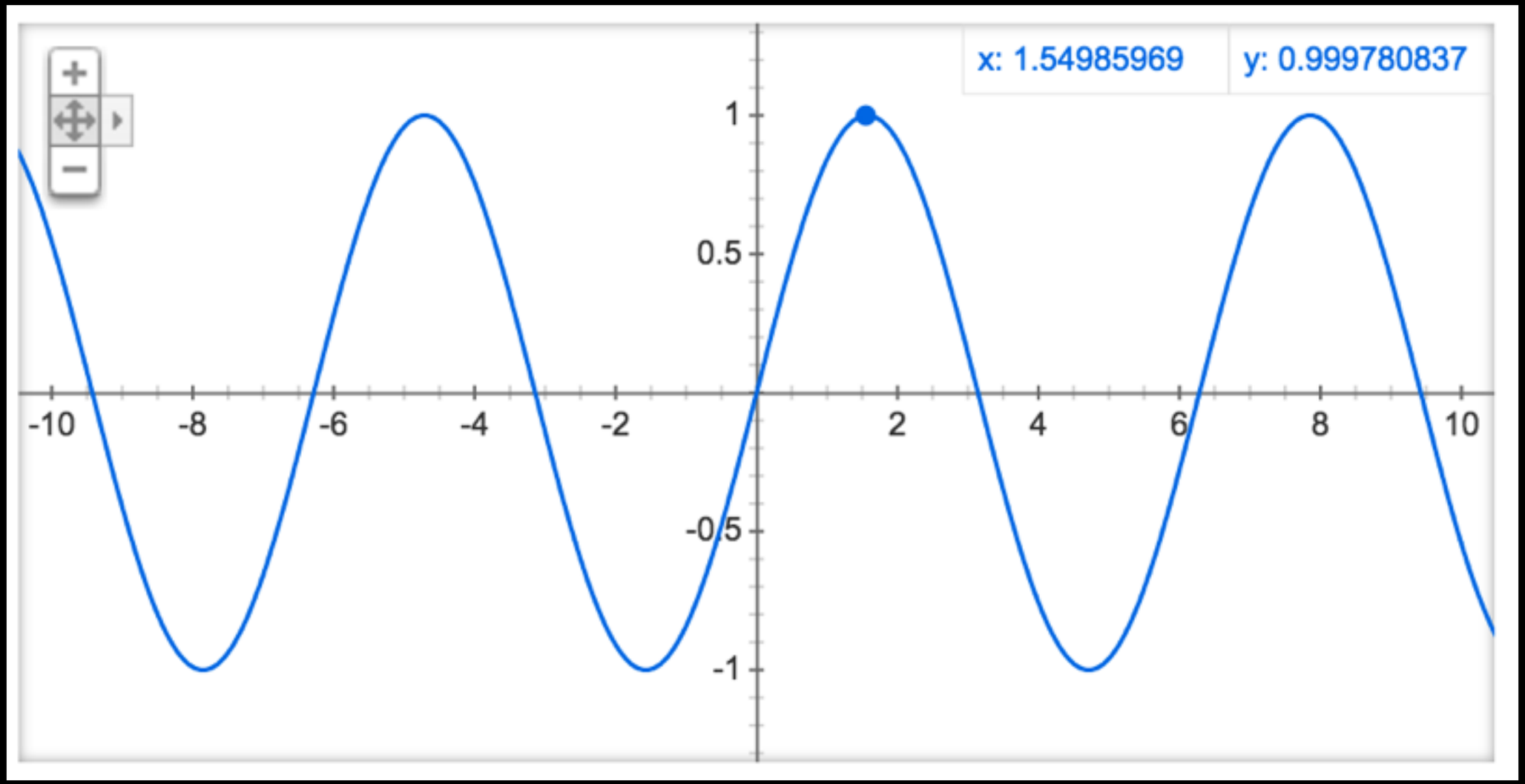
$$y = f(x)$$

$$f(x) = \sin(x)$$

$$y = f(x)$$

$$y = \sin(x)$$

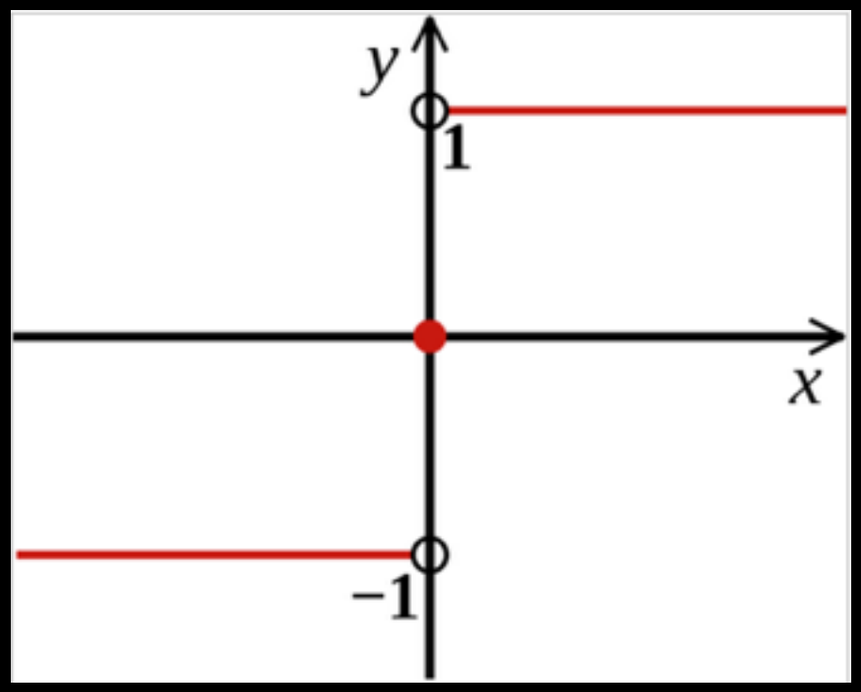
y = sin(x)



Conditional function

$$f(x) = \begin{cases} 1, & x > 0 \\ 0, & x == 0 \\ -1, & x < 0 \end{cases}$$

y = f(x)



+ is also a function

+ is also a function

add(a, b) = a + b

c = add(1, 2)

c = a + b

c = 1 + 2

c = 3

Now you know what are functions

So where is programming?

```
add(a, b) = a + b
c = add(1, 2)
c = 3
```

```
add a b = a + b

c = add 1 2
```

Problem 2

1 + 2 + ... + n

$$f(n) = 1 + 2 + ... + n$$

$$f(4) = 1 + 2 + 3 + 4$$

$$f(4) = 1 + 2 + 3 + 4$$

$$f(3) = 1 + 2 + 3$$

$$f(4) = f(3) + 4$$

$$f(3) = 1 + 2 + 3$$

$$f(2) = 1 + 2$$

$$f(3) = f(2) + 3$$

$$f(n) = f(n-1) + n$$

$$f(n) = \begin{cases} 1, & n == 1 \\ f(n-1) + n, & otherwise \end{cases}$$

$$f(n) = \begin{cases} 1, & n == 1 \\ f(n-1) + n, & otherwise \end{cases}$$

f(5) = f(4) + 5

$$f(n) = \begin{cases} 1, & n == 1 \\ f(n-1) + n, & otherwise \end{cases}$$

f(5) = f(4) + 5

f(5) = f(3) + 4 + 5

$$f(n) = \begin{cases} 1, & n == 1 \\ f(n-1) + n, & otherwise \end{cases}$$

$$f(5) = f(4) + 5$$

$$f(5) = f(3) + 4 + 5$$

$$f(5) = f(2) + 3 + 4 + 5$$

$$f(n) = \begin{cases} 1, & n == 1 \\ f(n-1) + n, & otherwise \end{cases}$$

$$f(5) = f(4) + 5$$

$$f(5) = f(3) + 4 + 5$$

$$f(5) = f(2) + 3 + 4 + 5$$

$$f(5) = f(1) + 2 + 3 + 4 + 5$$

$$f(n) = \begin{cases} 1, & n == 1 \\ f(n-1) + n, & otherwise \end{cases}$$

$$f(5) = f(4) + 5$$

$$f(5) = f(3) + 4 + 5$$

$$f(5) = f(2) + 3 + 4 + 5$$

$$f(5) = f(1) + 2 + 3 + 4 + 5$$

$$f(5) = 1 + 2 + 3 + 4 + 5$$

```
f 1 = 1
f n = f (n - 1) + n
```

```
f 5 = f 4 + 5
f 5 = f 3 + 4 + 5
f 5 = f 1 + 2 + 3 + 4 + 5
f 5 = 1 + 2 + 3 + 4 + 5
```

Problem 3

Fibonacci number

Fibonacci numbers (from wiki)

In mathematical terms, the seque

$$F_n = F_{n-1} + F_{n-2},$$

with seed values[1][2]

$$F_1 = 1,\ F_2 = 1$$

or[5]

$$F_0 = 0,\ F_1 = 1.$$

Fibonacci numbers
Written is conditional form

$$f(n) = \begin{cases} 0, & n == 0 \\ 1, & n == 1 \\ f(n-1) + f(n-2), & otherwise \end{cases}$$

$$f(n) = \begin{cases} 0, & n == 0 \\ 1, & n == 1 \\ f(n-1) + f(n-2), & otherwise \end{cases}$$

```
f(0) = 0
f(1) = 1
f(n) = f(n−1) + f(n−2)
```

$$f(n) = \begin{cases} 0, & n == 0 \\ 1, & n == 1 \\ f(n-1) + f(n-2), & otherwise \end{cases}$$

```
f 0 = 1
f 1 = 1
f n = f (n-1) + f (n-2)
```

Problem 4

sum

This is a list

[1, 2, 3, 4, 5]

They are same list

[1, 2, 3, 4, 5]

1:[2, 3, 4, 5]

1:2:3:[4, 5]

1:2:3:4:5:[]

```
x = [1, 2, 3, 4, 5]
total = sum(x)
```

$$sum(x) = \begin{cases} 0, & x \text{ match } [] \\ n + sum(ns), & x \text{ match } (n : ns) \end{cases}$$

$$sum(x) = \begin{cases} 0, & x \text{ match } [] \\ n + sum(ns), & x \text{ match } (n : ns) \end{cases}$$

sum([1, 2, 3, 4, 5]) =
1 + sum([2, 3, 4, 5]) =
1 + 2 + sum([3, 4, 5]) =
3 + 3 + sum([4, 5]) =
6 + 4 + sum([5]) =
10 + 5 + sum([]) =
15

$$sum(x) = \begin{cases} 0, & x \text{ match } [] \\ n + sum(ns), & x \text{ match } (n : ns) \end{cases}$$

```
sum []     = 0
sum (n:ns) = n + sum ns
```

Problem 5

map

```
x = [1, 2, 3]
y = doubleAll(x)
```

$$doubleAll(x) = \begin{cases} [], & x \text{ match } [] \\ 2n : doubleAll(ns), & x \text{ match } (n : ns) \end{cases}$$

```
doubleAll [] = []
doubleAll (n:ns) =
  (2 * n):doubleAll ns
```

$$doubleAll(x) = \begin{cases} [], & x \text{ match } [] \\ 2n : doubleAll(ns), & x \text{ match } (n : ns) \end{cases}$$

doubleAll([1, 2, 3]) =
2:doubleAll([2, 3]) =
2:4:doubleAll([3]) =
2:4:6:doubleAll([]) =
2:4:6:[] =
[2, 4, 6]

$$x = [1, 2, 3]$$

$$y = \text{incAll}(x)$$

$$incAll(x) = \begin{cases} [], & x \text{ match } [] \\ (n+1) : incAll(ns), & x \text{ match } (n : ns) \end{cases}$$

incAll([1, 2, 3]) =
2:incAll([2, 3]) =
2:3:incAll([3]) =
2:3:4:incAll([]) =
2:3:4:[] =
[2, 3, 4]

$$incAll(x) = \begin{cases} [], & x \text{ match } [] \\ (n+1) : incAll(ns), & x \text{ match } (n : ns) \end{cases}$$

```
incAll [] = []
incAll (n:ns) =
  (n + 1):incAll ns
```

```
doubleAll [] = []
doubleAll (n:ns) =
  (2 * n):doubleAll ns
```

```
incAll [] = []
incAll (n:ns) =
  (n + 1):incAll ns
```

```
map f [] = []
map f (n:ns) =
    (f n):map f ns

inc x = x + 1

incAll = map inc
```

```
map f [] = []
map f (n:ns) =
    (f n):map f ns

inc x = x + 1

incAll [] = map inc []
incAll (n:ns) = map inc (n:ns)
```

```
map f [] = []
map f (n:ns) =
   (f n):map f ns

inc x = x + 1

incAll [] = []
incAll (n:ns) =
  map inc (n:ns) =
  (f n):map f ns
```

```
map f [] = []
map f (n:ns) =
   (f n):map f ns

inc x = x + 1

incAll [] = []
incAll (n:ns) =
  map inc (n:ns) =
  (inc n):map inc ns

                  incAll x = map inc x
```

```
incAll [] = []
incAll (n:ns) =
  (n + 1):incAll ns
```

```
inc x = x + 1
```

```
incAll [] = []
incAll (n:ns) =
  (inc n):incAll ns
```

```
incAll [] = []
incAll (n:ns) =
  (n + 1):incAll ns
```

```
inc x = x + 1
```


```
incAll [] = []
incAll (n:ns) =
  (n + 1):incAll ns
```

```
doubleAll [] = []
doubleAll (n:ns) =
  (2 * n):doubleAll ns
```

```
incAll [] = []
incAll (n:ns) =
  (n + 1):incAll ns
```

```
double x = x * 2
doubleAll =
  map double
```

```
inc x = x + 1
incAll = map inc
```

Now we have map function!

How about reduce function?

Now we have map function!

How about reduce function?

Exercise! Hint: sum

Problem 6

Sort

list concat

[1,2,3] ++ [4,5,6]

[1,2,3,4,5,6]

```
inc x = x + 1

incAll = map inc
```

```
inc x = x + 1
inc = (+ 1)
inc 3 =
(+ 1) 3 =
3 + 1 =
4
```

```
incAll = map (+ 1)
```

where clause

```
inc n = n + a
  where a = 1
```

```
sort [] = []
```

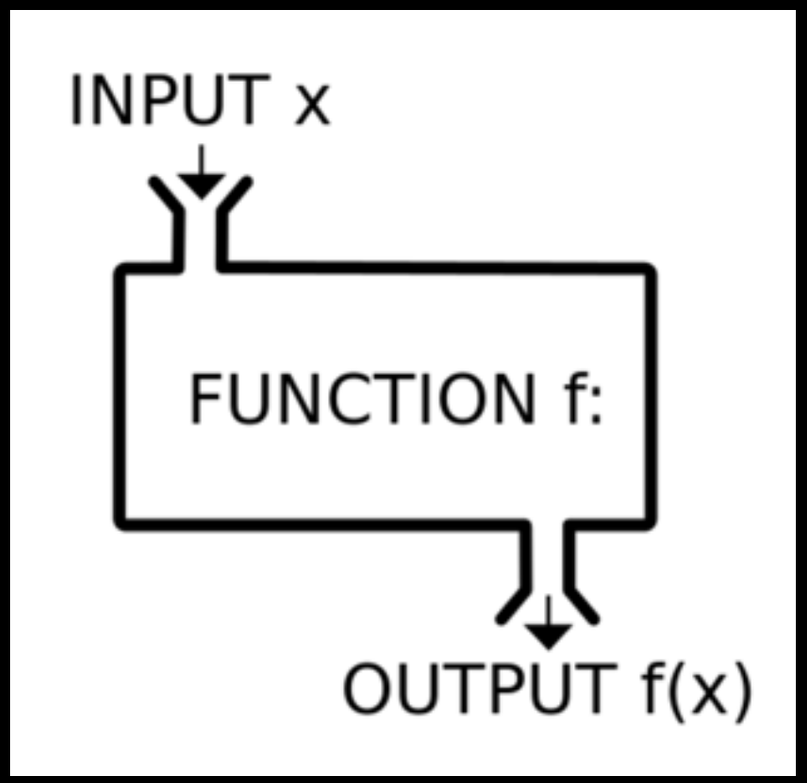
```
sort [] = []
sort (n:ns) =
  sort smaller ++ [n] ++ sort larger
  where
    smaller = filter (<  n) ns
    larger  = filter (=> n) ns
```

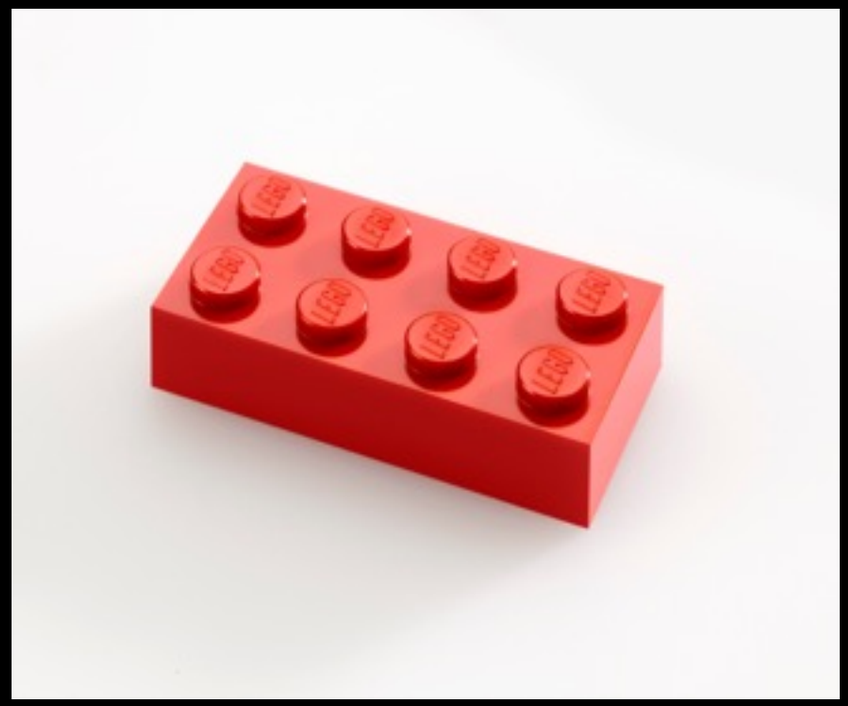
Great!

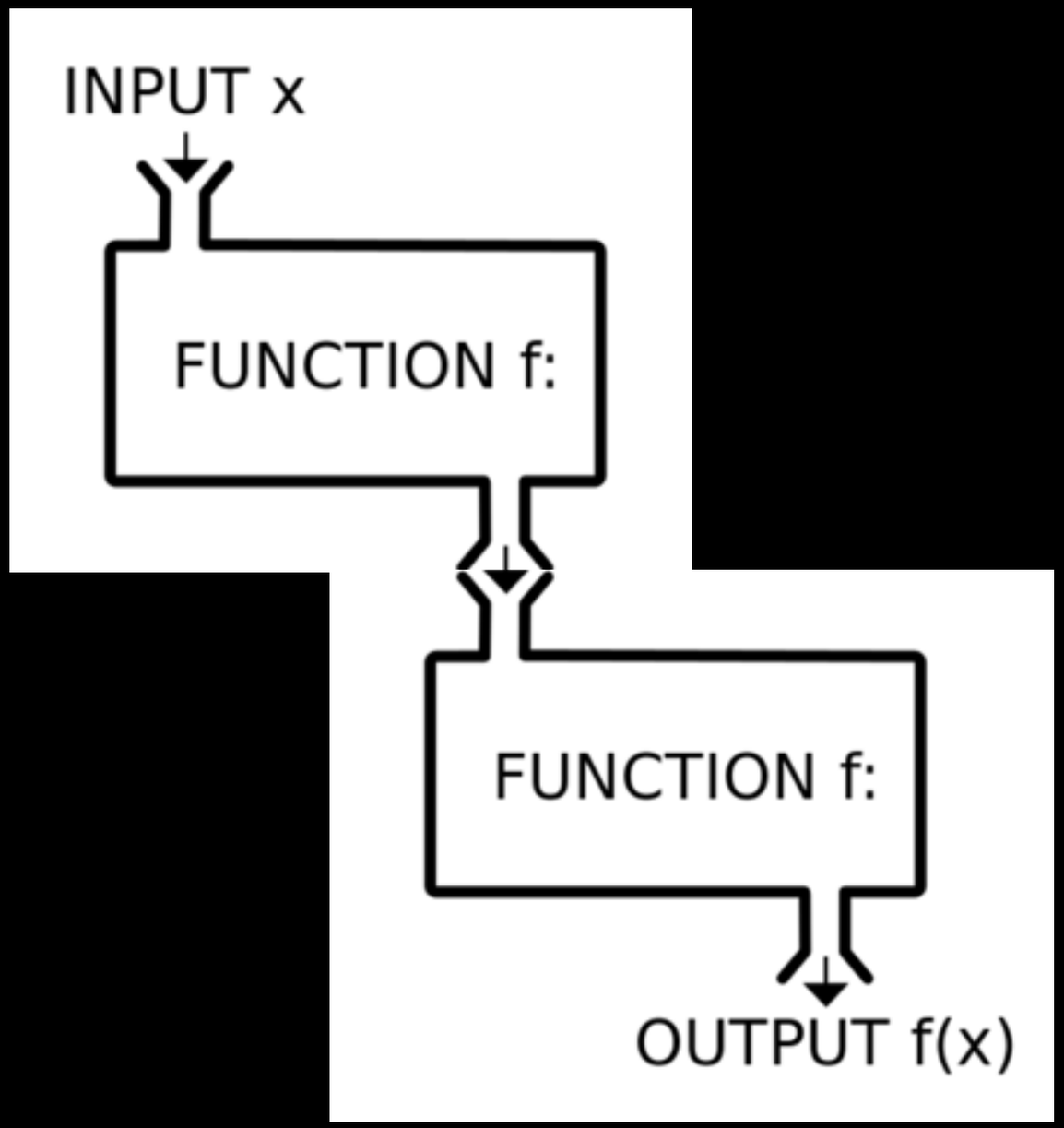
Now you know
functional programming

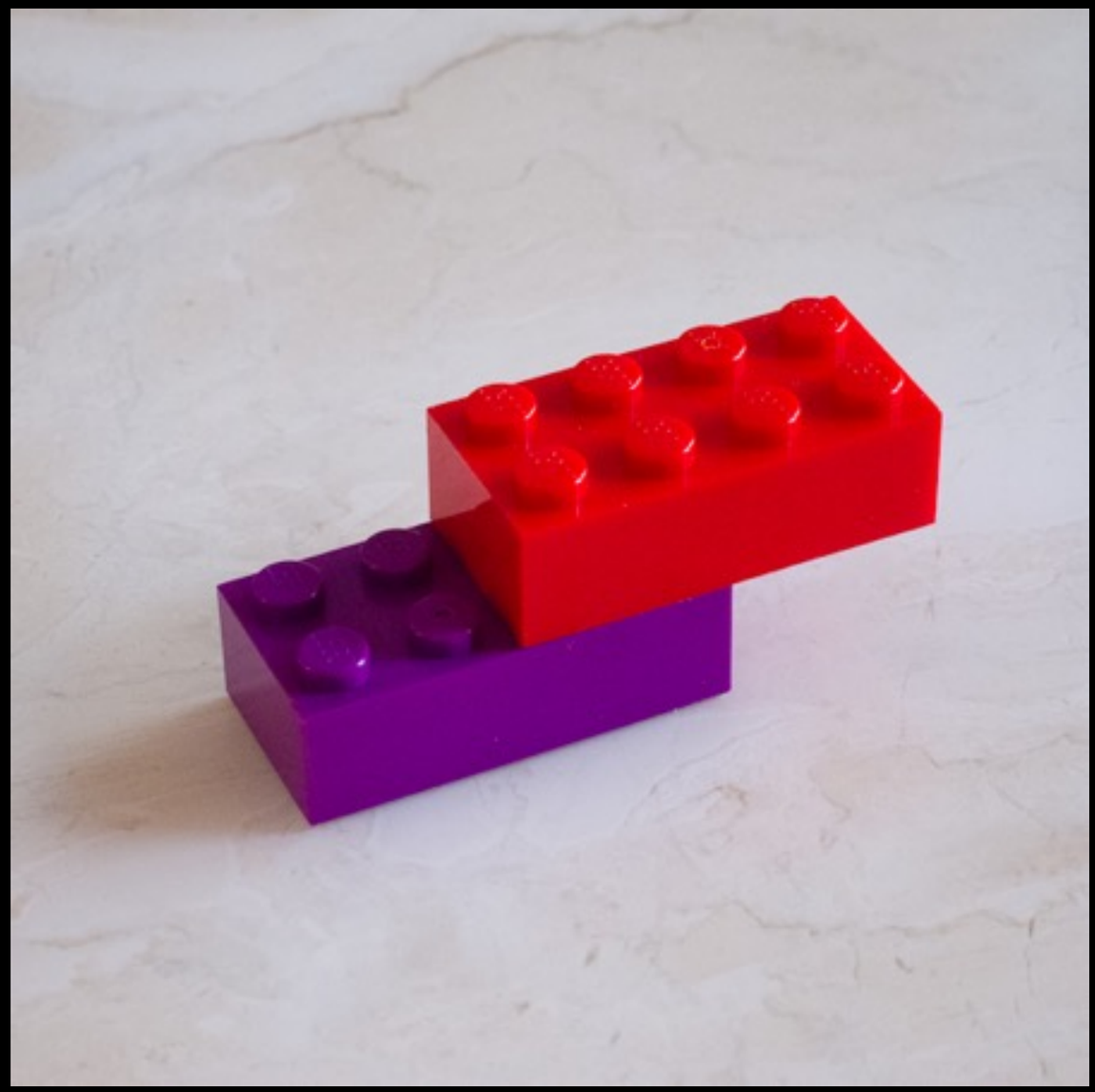
So why
functional programming?

Composability


INPUT x
FUNCTION f:
OUTPUT f(x)




INPUT x
FUNCTION f:
FUNCTION f:
OUTPUT f(x)



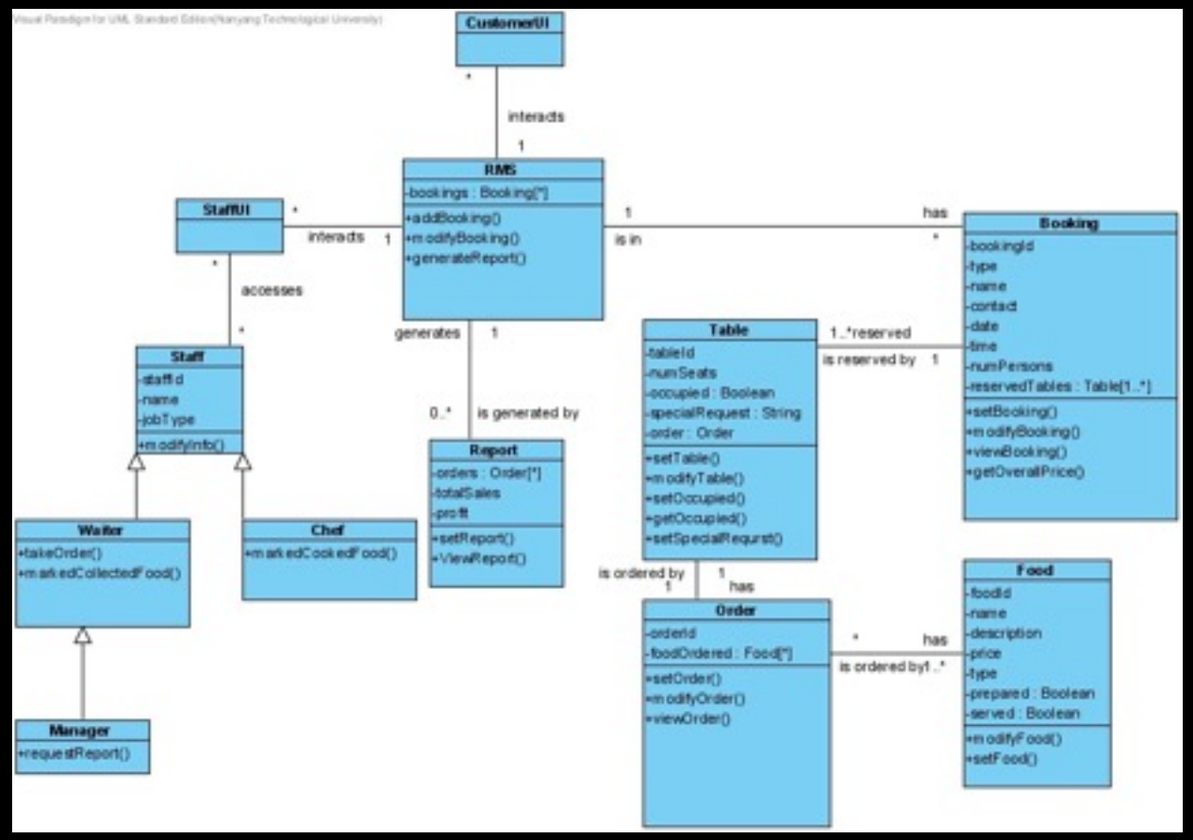
Easier to maintain

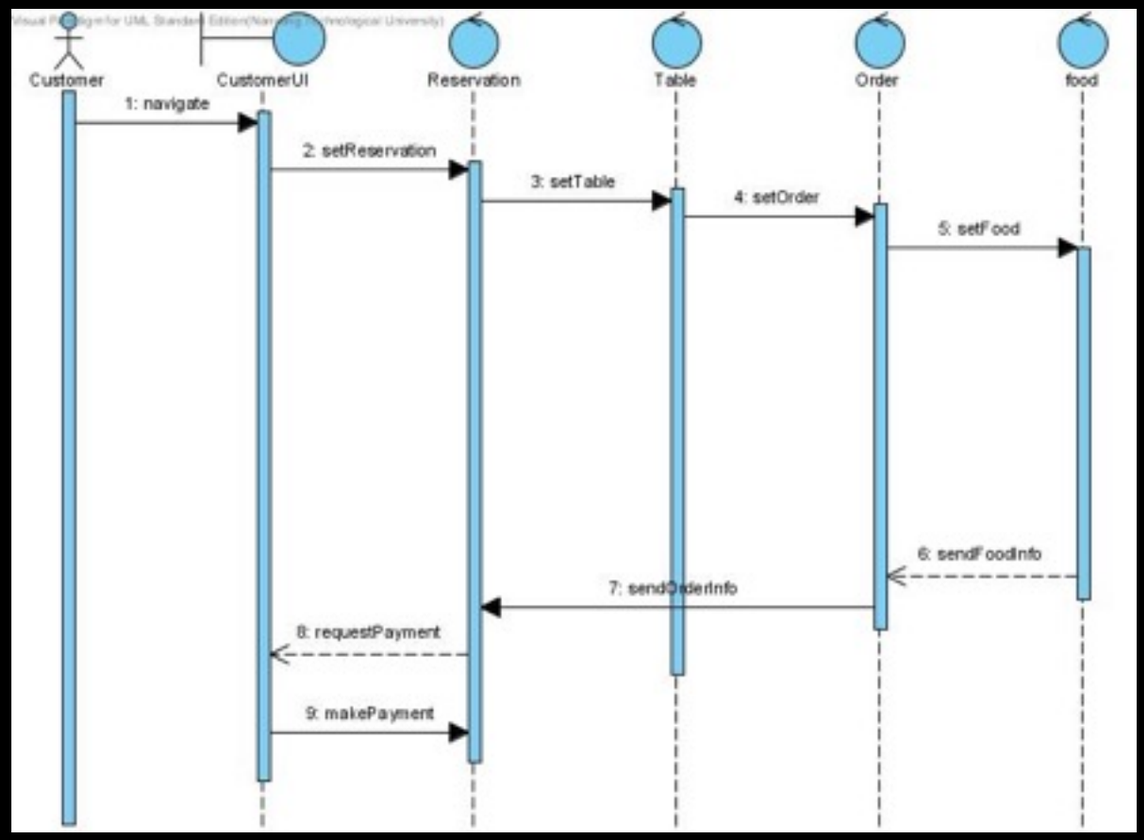
```
for (var i = 0; i < arr.length; i++) {
  // do something
  arr.push(i);
  // do other things
}
```

```
for (var i = 0; i < arr.length; i++) {
  // do something
  arr.push(i);
  // do other things
}
```

Easier to understand

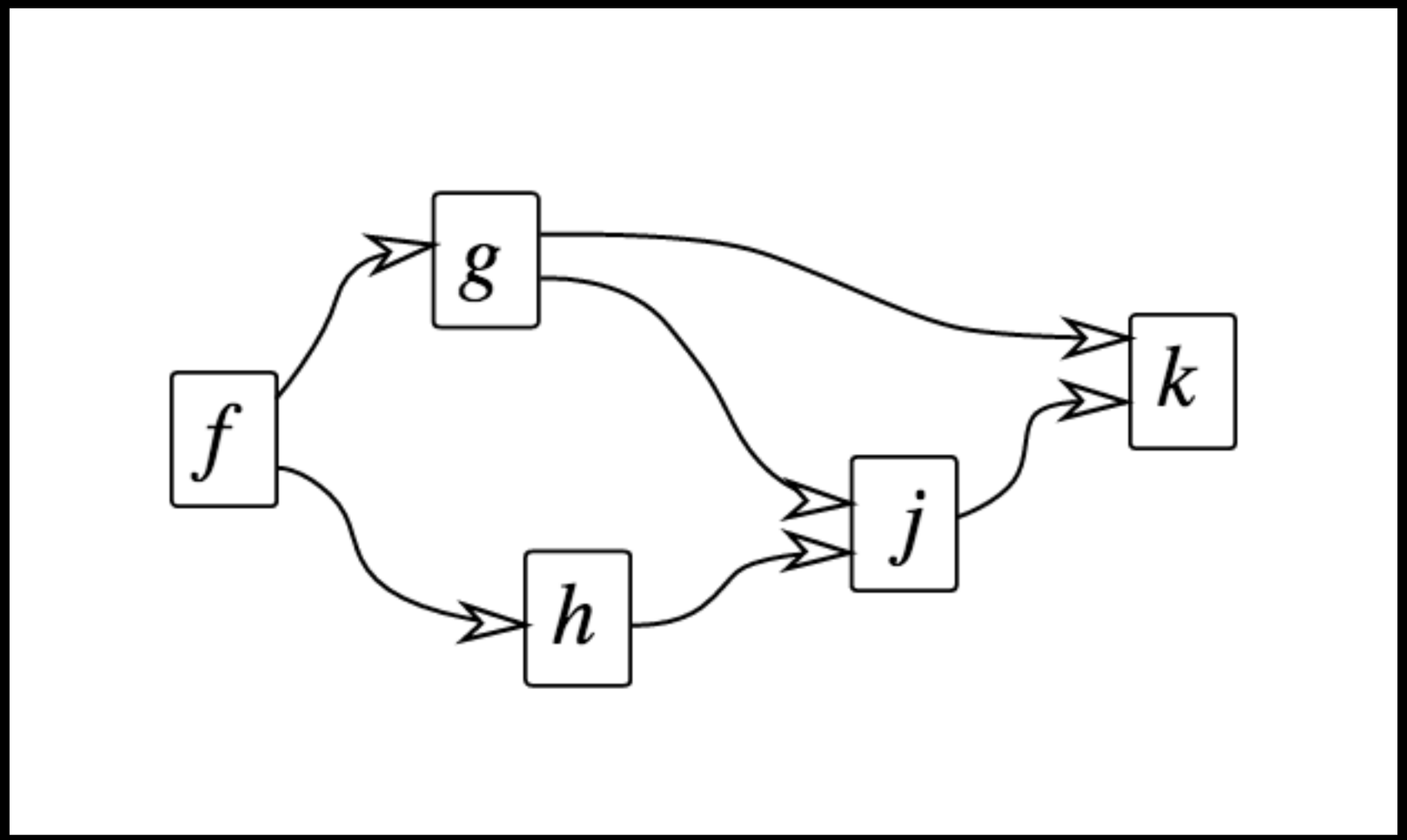
UML
Data flow ??????
No! you cannot





https://erestaurant.wordpress.com/2009/09/14/class-diagrams-sequence-diagram/

Data Flow Programming



http://www.macs.hw.ac.uk/~rs46/posts/2015-09-07-distributed-functional-futures.html

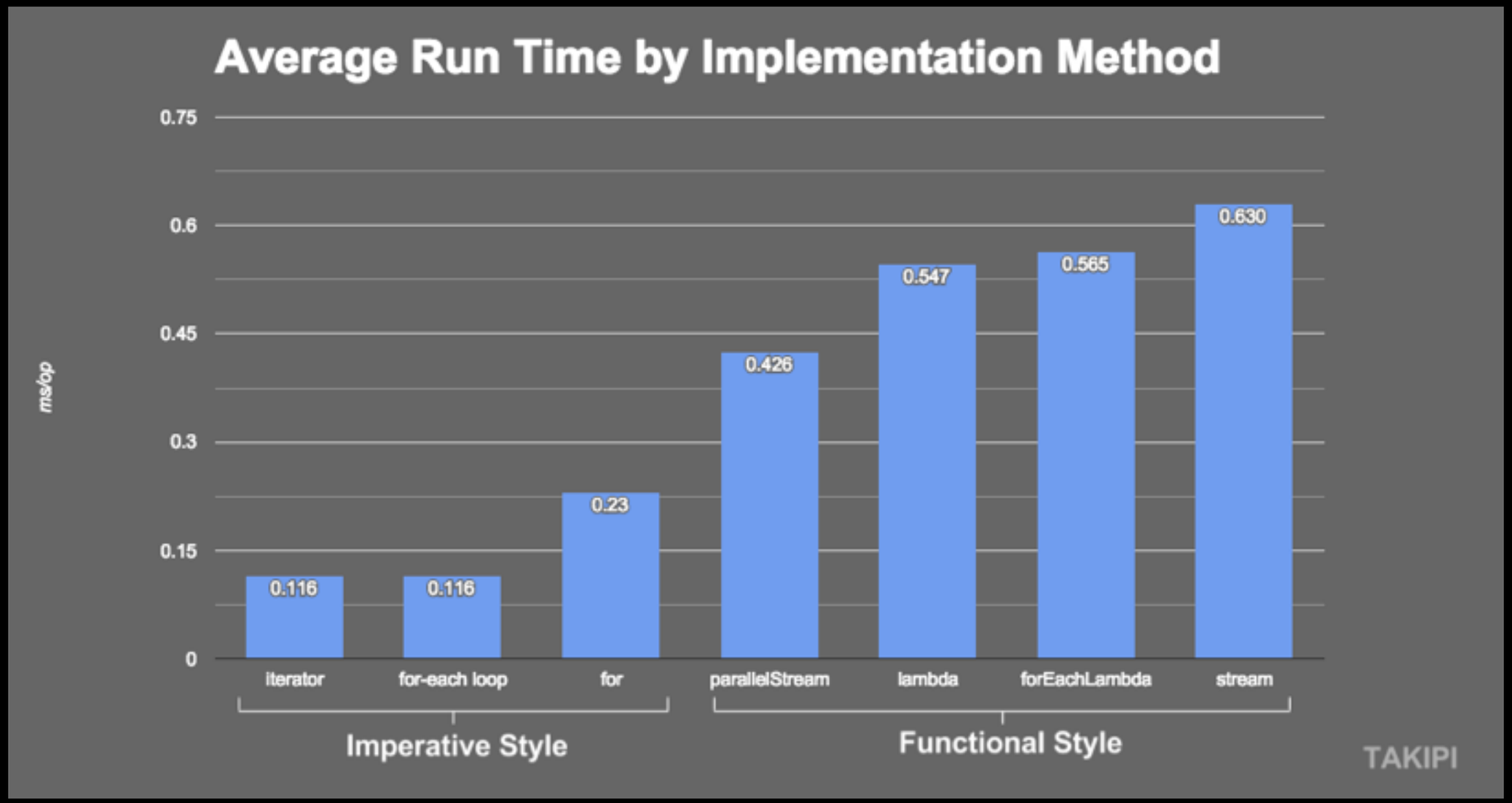
How about OO?

OO pattern/principle	FP pattern/principle
• Single Responsibility Principle	• Functions
• Open/Closed principle	• Functions
• Dependency Inversion Principle	• Functions, also
• Interface Segregation Principle	• Functions
• Factory pattern	• Yes, functions
• Strategy pattern	• Oh my, functions again!
• Decorator pattern	• Functions
• Visitor pattern	• Functions □

https://vimeo.com/113588389
http://www.slideshare.net/ScottWlaschin/fp-patterns-buildstuffIt

Faster?

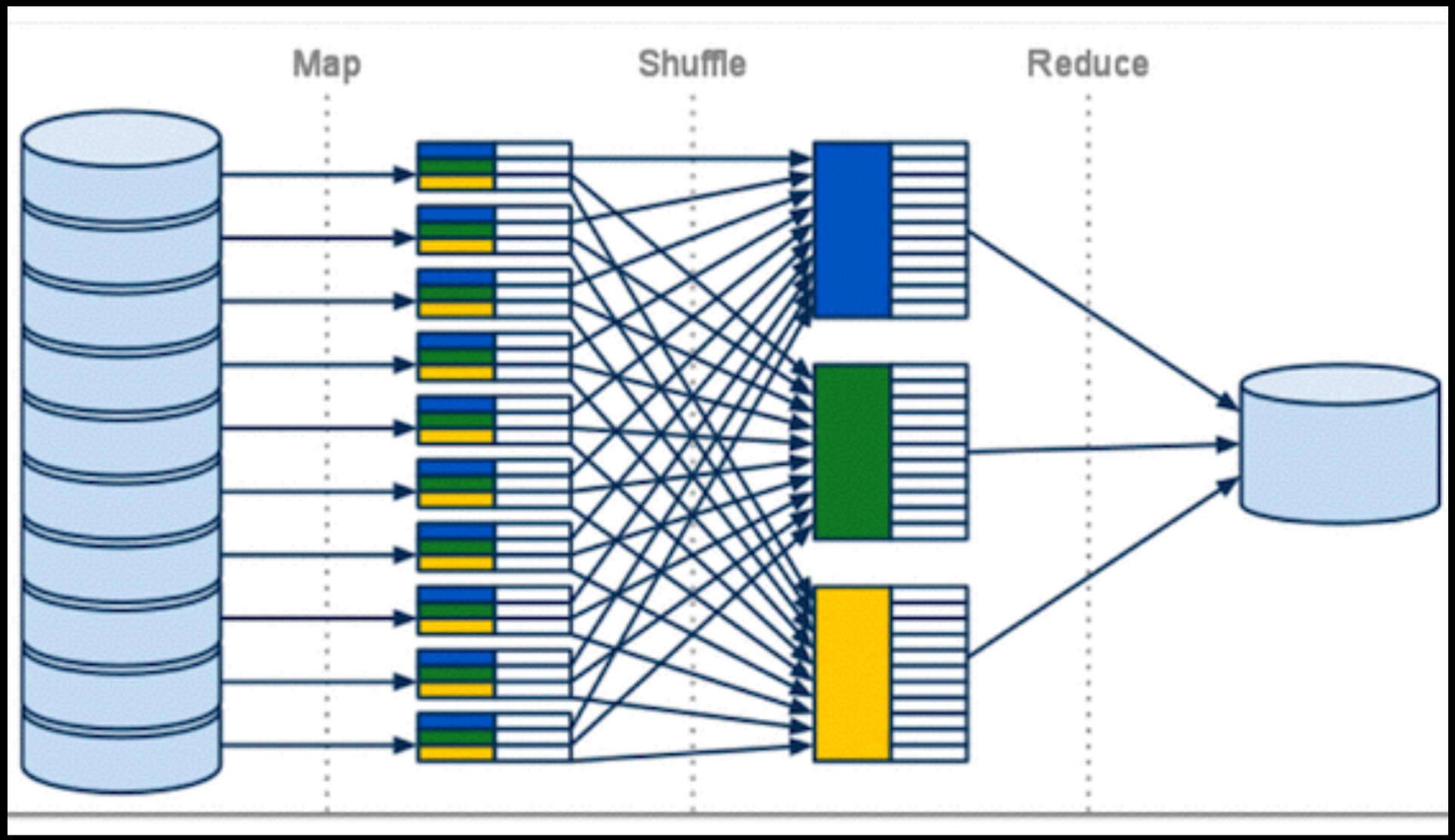
Faster? Nope



http://blog.takipi.com/benchmark-how-java-8-lambdas-and-streams-can-make-your-code-5-times-slower/

Slower?

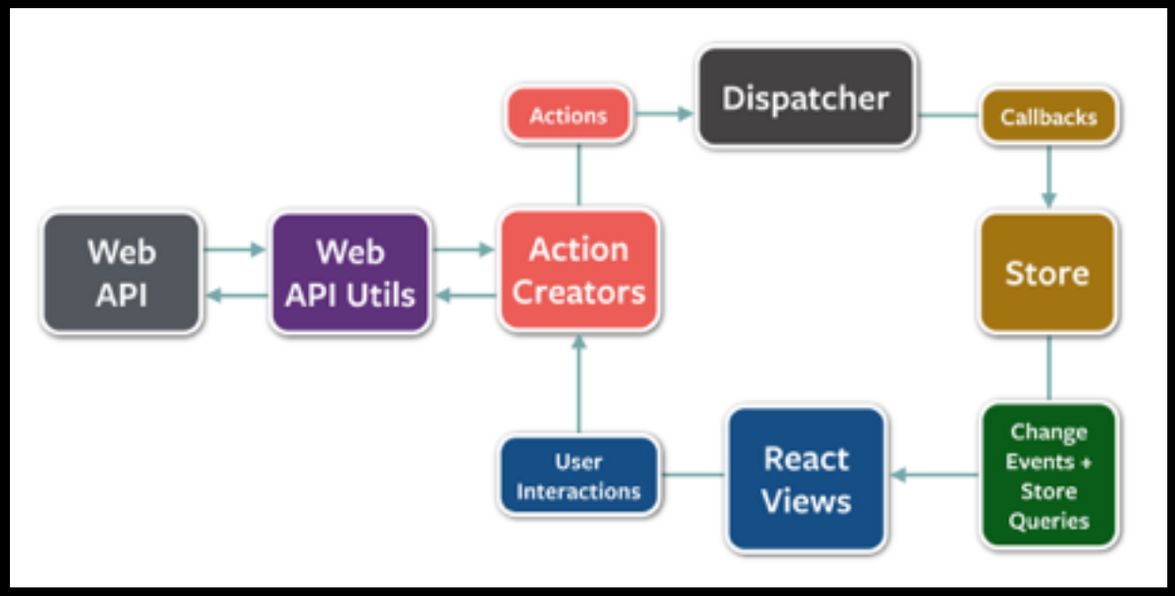
Slower? Nope

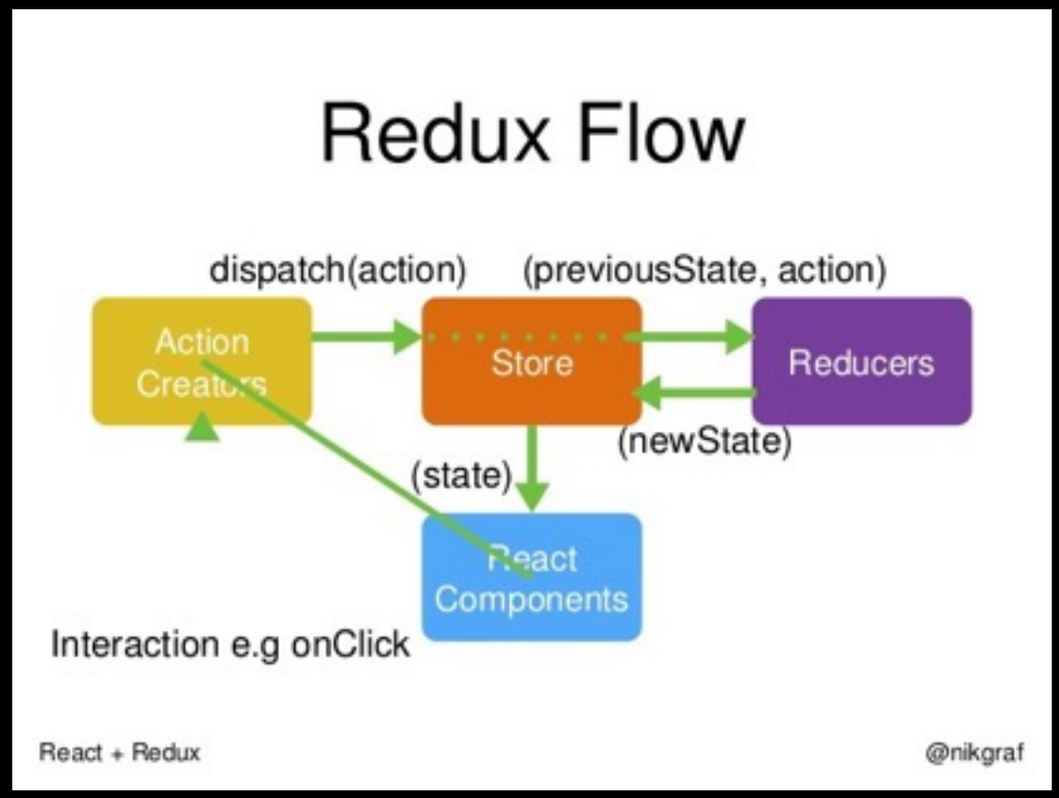


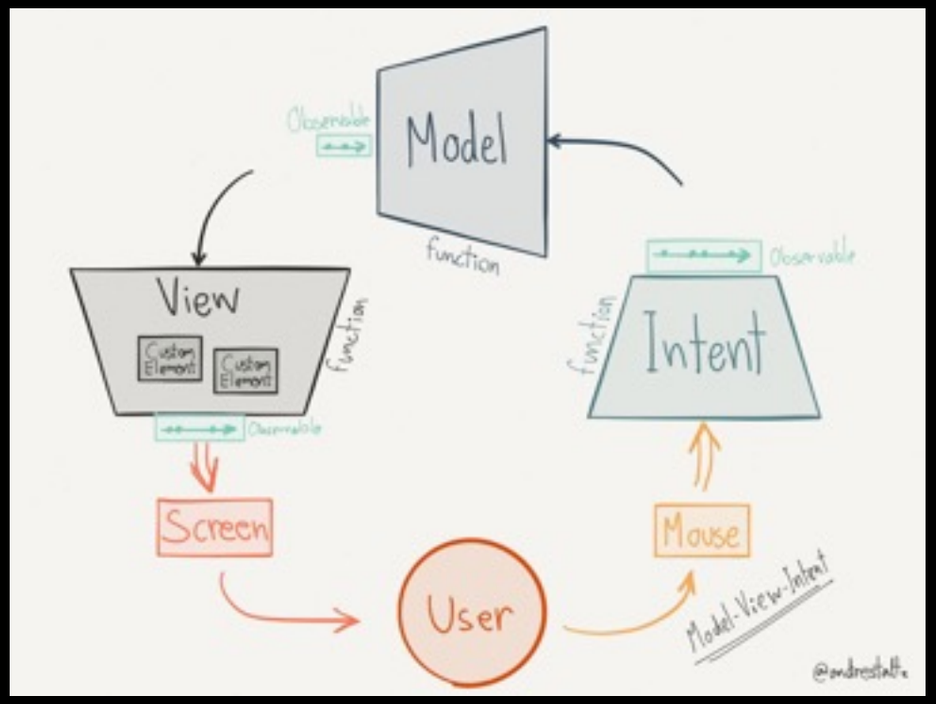
https://www.linkedin.com/pulse/20140818193221-22744472-big-data-analytics-mapreduce

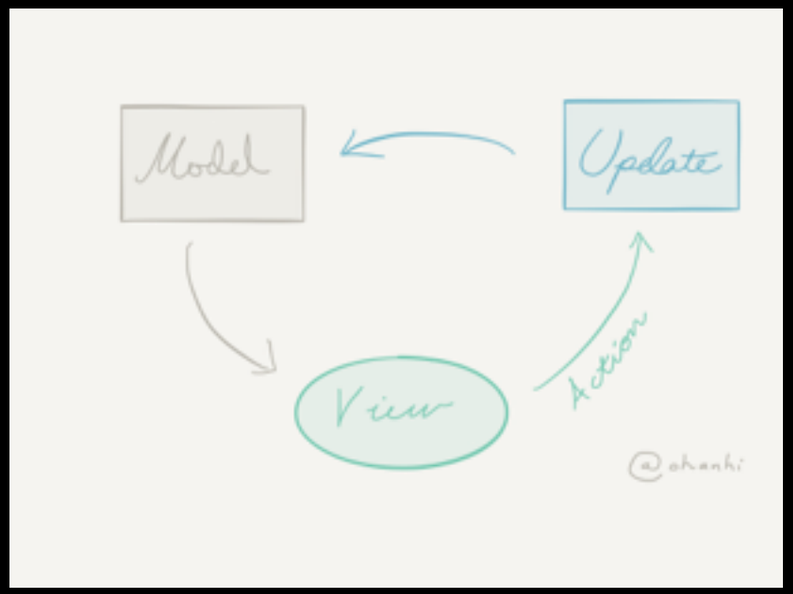
Where to use?

Web frontend









Mobile?
Actually all client side

GitHub - trikita/jedux: Redux architecture for Android in good old java
https://github.com/trikita/jedux ▾ 翻譯這個網頁
Redux architecture for Android in good old java. Contribute to jedux development by creating an account on GitHub.

GitHub - glung/redux-java: The java version of Redux : a predictable ...
https://github.com/glung/**redux**-java ▾ 翻譯這個網頁
redux-java. The java version of Redux : a predictable state container for java apps. Redux-java has been designed Android in mind but is not constrained to it ...

GitHub - brianegan/bansa: A state container for Java & Kotlin, inspired ...
https://github.com/brianegan/bansa ▾ 翻譯這個網頁
bansa - A state container for Java & Kotlin, inspired by Redux & Elm. ... this little project: An easier way to write Android UIs & Apps. Perhaps an easy way to start ...

Writing a Todo app with Redux on Android – Medium
https://medium.com/.../writing-a-todo-app-with-**redux**-on-**android**-5de3... ▾ 翻譯這個網頁
Writing a Todo app with Redux on Android. Android community seems to be actively looking for the right architecture for their apps. We've passed through the ...

The evolution of Android architecture
zserge.com/blog/**android**-mvp-mvvm-**redux**-history.html ▾ 翻譯這個網頁
2016年3月28日 - Android history: from no architecture to MVP to MVVM to Redux.

Android架构移植"Redux" - 简书
www.jianshu.com/p/a5bccd56b71e ▾ 轉為繁體網頁
2016年6月22日 - 本篇是基于AndroidFlux背景写的关于Redux在Android上应用的一文，需要提前了解一些Flux的知识。ReduxRedux是Flux模式的一种实现,目前 ...

GitHub - ReduxKit/ReduxKit: Redux for Swift - a predictable state ...
https://github.com/**ReduxKit**/**ReduxKit** ▾ 翻譯這個網頁
ReduxKit - Redux for Swift - a predictable state container for Swift apps. ... source 'https://github.com/CocoaPods/Specs.git' platform :ios, '8.0' pod 'ReduxKit', ...

GitHub - ReSwift/ReSwift: Unidirectional Data Flow in Swift - Inspired ...
https://github.com/ReSwift/ReSwift ▾ 翻譯這個網頁
ReSwift - Unidirectional Data Flow in Swift - Inspired by Redux. ... source 'https://github.com/CocoaPods/Specs.git' platform :ios, '8.0' pod 'ReSwift'. And run pod ...

GitHub - oursky/Redux: Swift implementation of Redux
https://github.com/oursky/**Redux** ▾ 翻譯這個網頁
Contribute to Redux development by creating an account on GitHub. ... source 'https://github.com/CocoaPods/Specs.git' platform :ios, '8.0' pod "Redux", ...

用Objective-C 實作Redux 架構« Nelson 寫些iOS 開發的東東
nelson.logdown.com/posts/2016/08/03/**redux**-in-objective-c ▾
2016年8月3日 - Flux / Redux 一開始提出是給網站使用的架構，後來有人把它套用到iOS 開發，不過我查到的資料都是使用Swift 實作。無可否認使用Swift 來實作這 ...

Brushes Redux on the App Store - iTunes - Apple
https://itunes.apple.com/tw/app/brushes-**redux**/id932089074?mt=8 ▾
免費 - iOS
2016年4月7日 - Brushes Redux is a painting app designed exclusively for iOS. Rewritten from the ground up, Brushes Redux is universal — the same version ...

Redux for iOS - jtribe
blog.jtribe.com.au/**redux**-for-**ios**/ ▾ 翻譯這個網頁
2016年1月30日 - In the center of both Flux and Redux is the unidirectional data flow. This blog describes how Redux can be used a an iOS application ...

User Interfaces

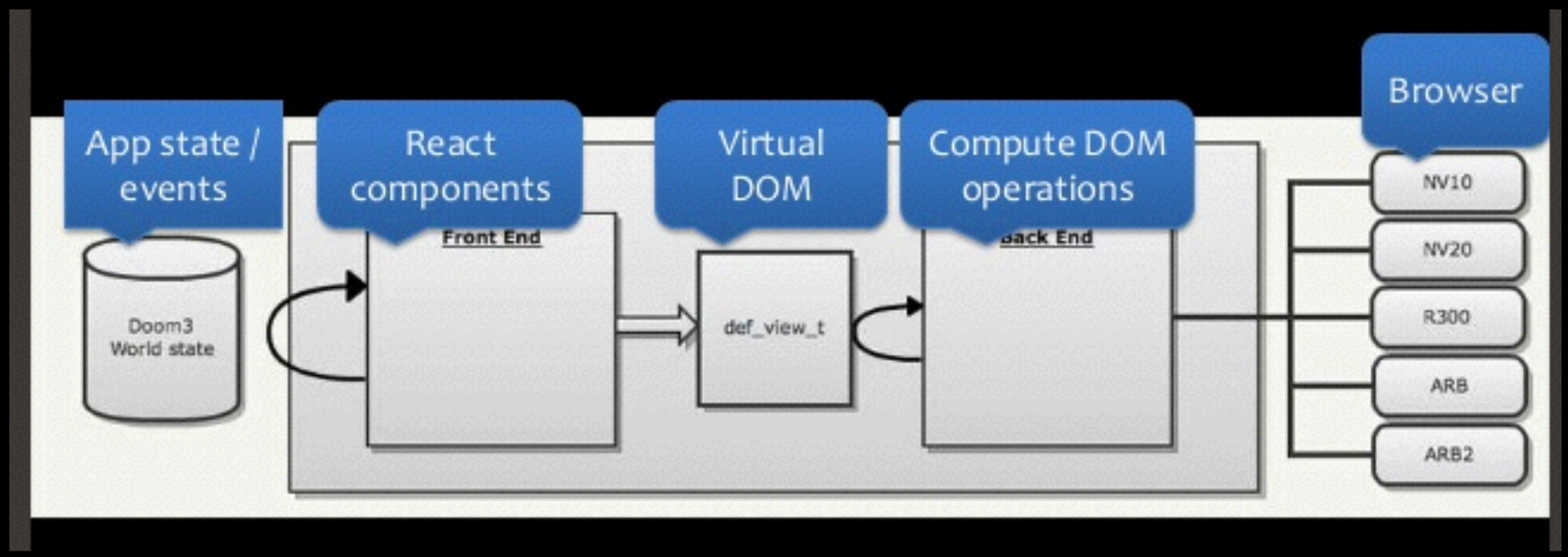
- events (keydown, mouse move/click…etc)
- state
- update **function**: (event, state) -> state
- render **function**: state -> view

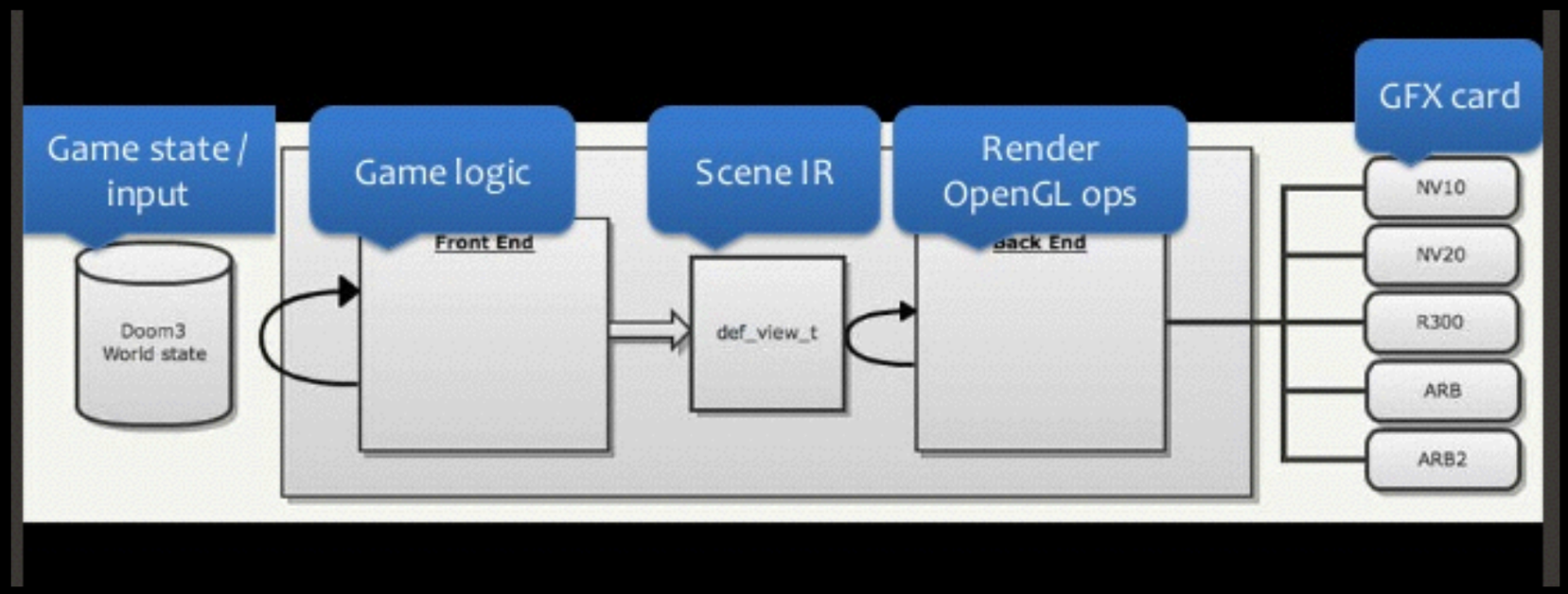
Web backend

Of course!

request -> response

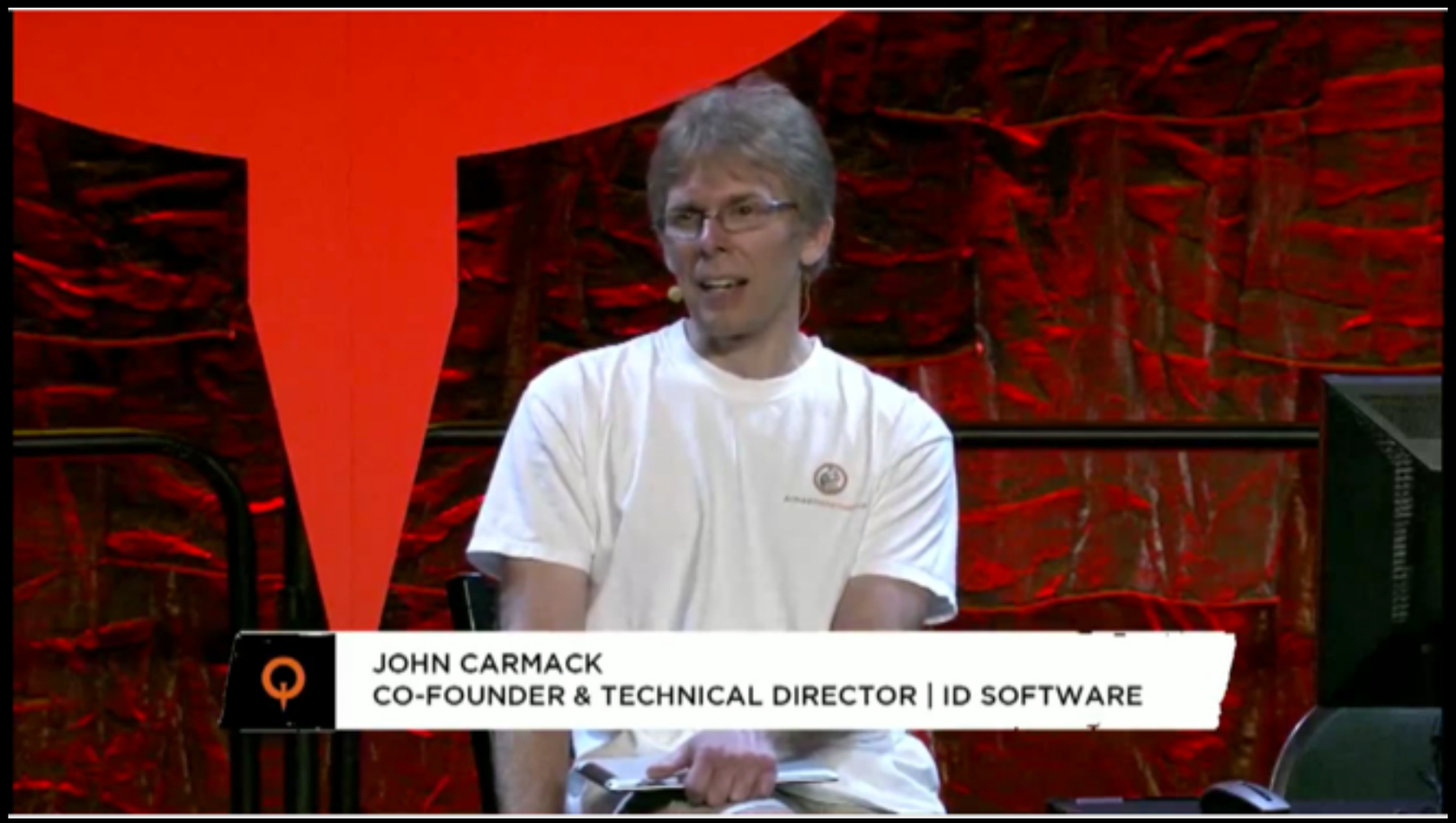
Game Programming!
data -> view





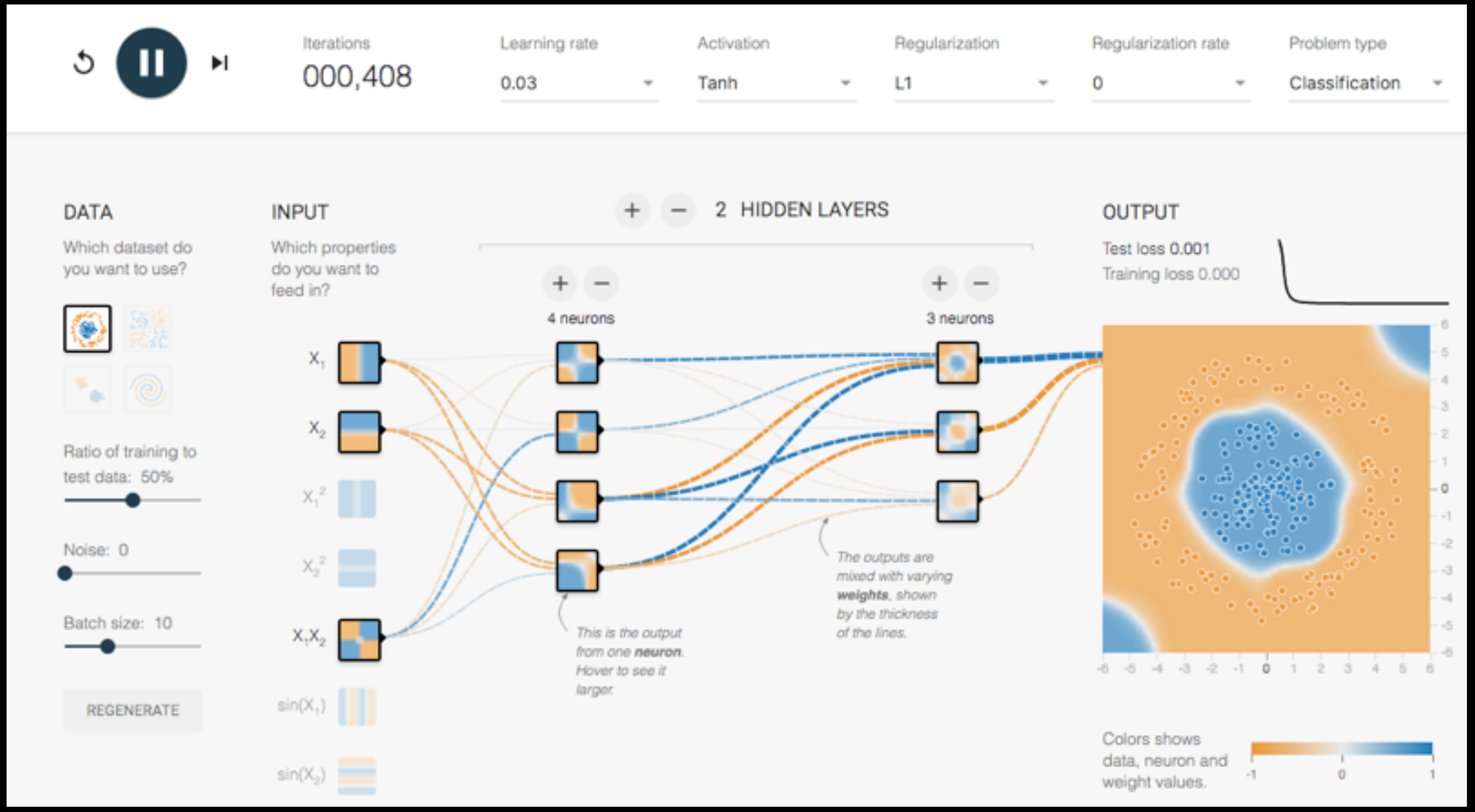
Game Programming

- https://www.youtube.com/watch?v=eNWAcEu1jpU



Machine learning!

TensorFlow



https://techcrunch.com/2016/04/13/google-launches-distributed-version-of-its-tensorflow-machine-learning-library/

Where to use?

Almost anywhere

How to learn?

- Think more when you're programming
- Learn Haskell! learnyouahaskell.com