CS 635 Advanced Object-Oriented Design & Programming
Spring Semester, 2019
Doc 4 Pattern Intro, Observer Pattern
Sep 10, 2019

Pattern Beginnings

"Each pattern describes a problem which occurs over and over again in our environment, and then describes the core of the solution to that problem, in such a way that you can use this solution a million times over, without ever doing it the same way twice"

"Each pattern is a three-part rule, which expresses a relation between a certain context, a problem, and a solution"

A Pattern Language, Christopher Alexander, 1977

A Place To Wait

The process of waiting has inherent conflicts in it.

Waiting for doctor, airplane etc. requires spending time hanging around doing nothing

Cannot enjoy the time since you do not know when you must leave

Classic "waiting room"
Dreary little room
People staring at each other
Reading a few old magazines
Offers no solution

Fundamental problem
How to spend time "wholeheartedly" and
Still be on hand when doctor, airplane etc arrive

Fuse the waiting with other activity that keeps them in earshot
- Playground beside Pediatrics Clinic
- Horseshoe pit next to terrace where people waited

Allow the person to become still meditative
- A window seat that looks down on a street
- A protected seat in a garden
- A dark place and a glass of beer
- A private seat by a fish tank

A Place To Wait

Therefore:

"In places where people end up waiting create a situation which makes the waiting positive. Fuse the waiting with some other activity - newspaper, coffee, pool tables, horseshoes; something which draws people in who are not simple waiting. And also the opposite: make a place which can draw a person waiting into a reverie; quiet; a positive silence"

Chicken And Egg

Problem

Two concepts are each a prerequisite of the other
To understand A one must understand B
To understand B one must understand A
A "chicken and egg" situation

Constraints and Forces

First explain A then B
  Everyone would be confused by the end

Simplify each concept to the point of incorrectness to explain the other one
  People don't like being lied to

Solution

Explain A & B correctly by superficially

Iterate your explanations with more detail in each iteration

Patterns for Classroom Education, Dana Anthony, pp. 391-406, Pattern Languages of Program Design 2, Addison We
1996

Design Principle 1

Program to an interface, not an implementation

Use abstract classes (and/or interfaces in Java) to define common interfaces for a set of classes

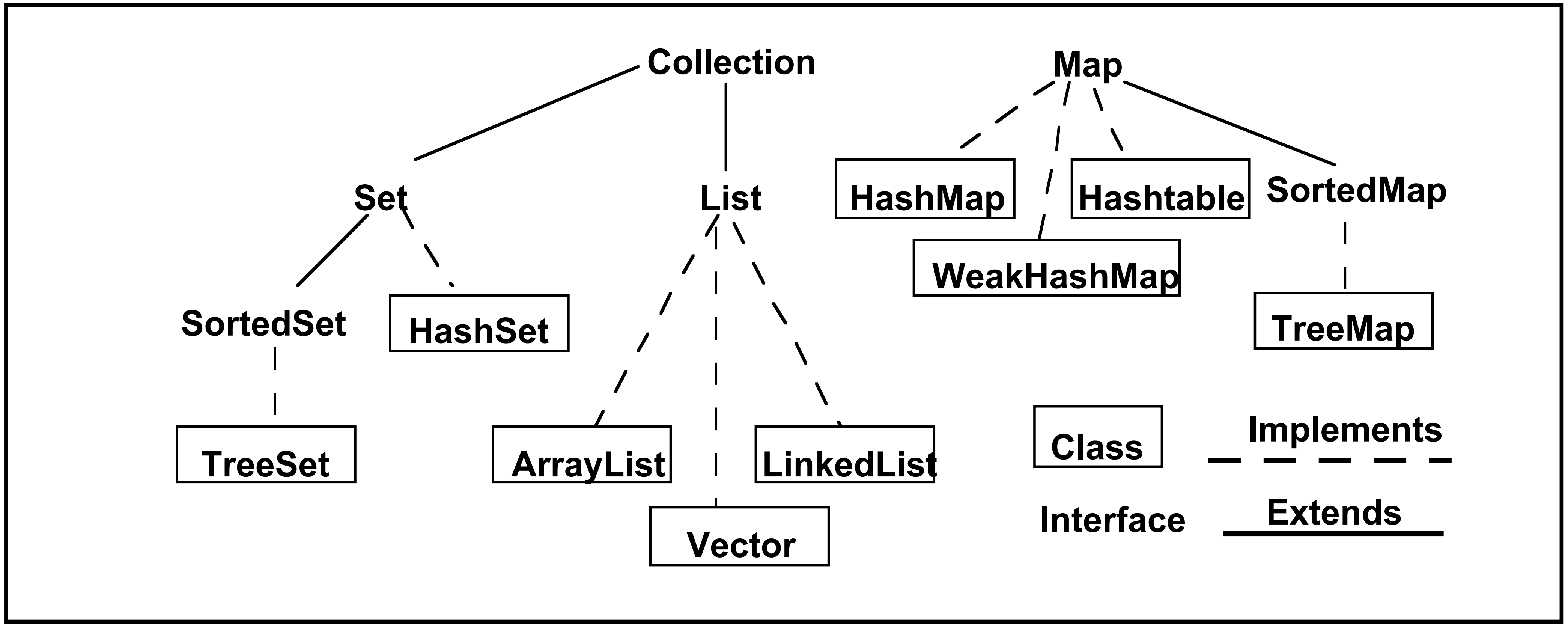
Declare variables to be instances of the abstract class not instances of particular classes

Benefits of programming to an interface

Client classes/objects remain unaware of the classes of objects they use,
as long as the objects adhere to the interface the client expects

Client classes/objects remain unaware of the classes that implement these objects.
Clients only know about the abstract classes (or interfaces) that define the interface.

Programming to an Interface



Collection students = new XXX;
students.add(aStudent);

students can be any collection type

We can change our mind on what type to use

Interface & Duck Typing

In dynamically typed languages programming to an interface is the norm

Dynamically typed languages tend to lack a way to declare an interface

Design Principle 2

Favor object composition over class inheritance

Composition

- Allows behavior changes at run time
- Helps keep classes encapsulated and focused on one task
- Reduce implementation dependencies

Inheritance

```
class A {
	Foo x
	public int complexOperation() {    blah }
}

class B extends A {
	public void bar() { blah}
}
```

Composition

```
class B {
	A myA;
	public int complexOperation() {
		return myA.complexOperation()
	}

	public void bar() { blah}
}
```

Designing for Change

Algorithmic dependencies
- Builder, Iterator, Strategy, Template Method, Visitor

Inability to alter classes conveniently
- Adapter, Decorator, Visitor

Dependence on specific operations
- Chain of Responsibility, Command

Dependence on hardware and software platforms
- Abstract factory, Bridge

Tight Coupling
- Abstract factory, Bridge, Chain of Responsibility, Command, Facade, Mediator, Observer

Extending functionality by subclassing
- Bridge, Chain of Responsibility, Composite, Decorator, Observer, Strategy

Dependence on object representations or implementations
- Abstract factory, Bridge, Memento, Proxy

Extending functionality by subclassing
- Bridge, Chain of Responsibility, Composite, Decorator, Observer, Strategy

Creating an object by specifying a class explicitly
- Abstract factory, Factory Method, Prototype

Kent Beck's Rules for Good Style

One and only once

In a program written in good style, everything is said once and only once

Methods with the same logic
Objects with same methods
Systems with similar objects

rule is not satisfied

Lots of little Pieces

"Good code invariably has small methods and small objects"

Small pieces are needed to satisfy "once and only once"

Make sure you communicate the big picture or you get a mess

Rates of change

Don't put two rates of change together

An object should not have a field that changes every second & a field that change once a month

A collection should not have some elements that are added/removed every second and some that are add/removed once a month

An object should not have code that has to change for each piece of hardware and code that has to change for each operating system

Replacing Objects

Good style leads to easily replaceable objects

"When you can extend a system solely by adding new objects without modifying any existing objects, then you have a system that is flexible and cheap to maintain"

Moving Objects

"Another property of systems with good style is that their objects can be easily moved to new contexts"

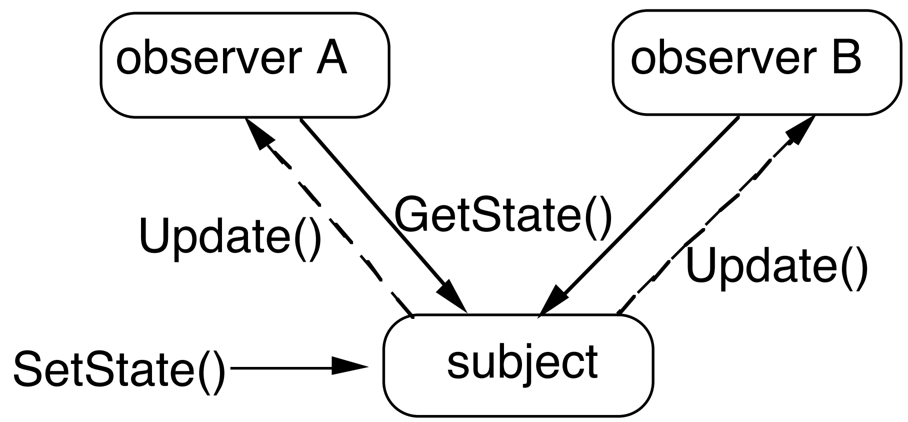
Observer

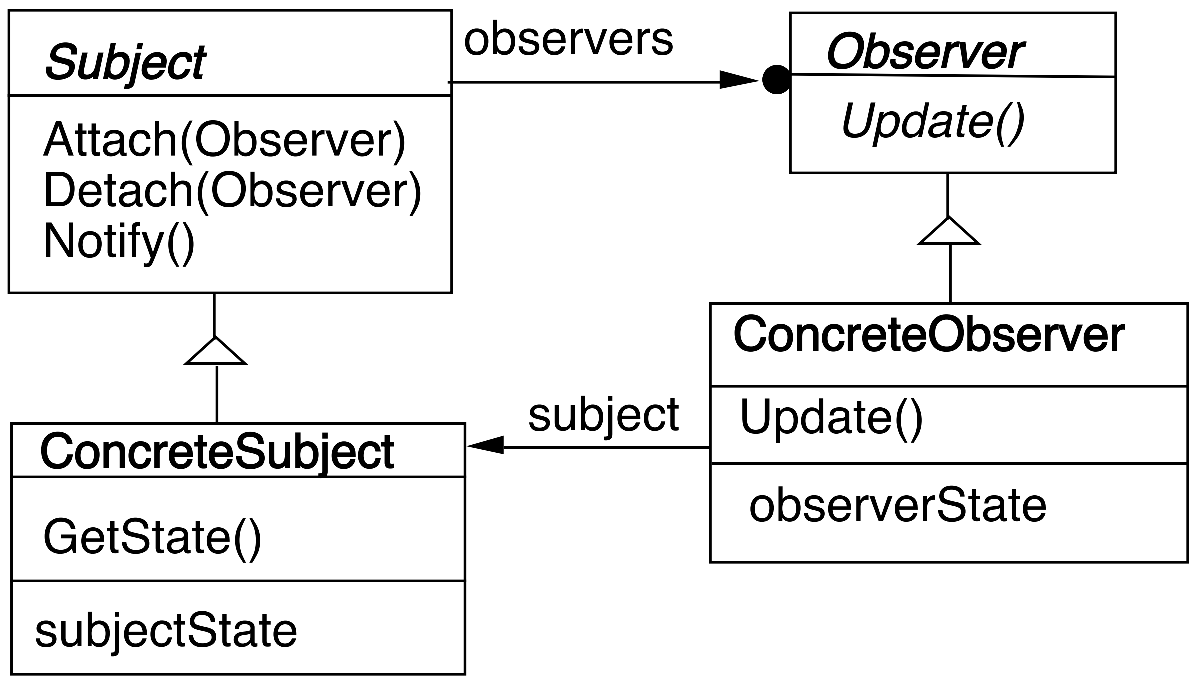
Observer

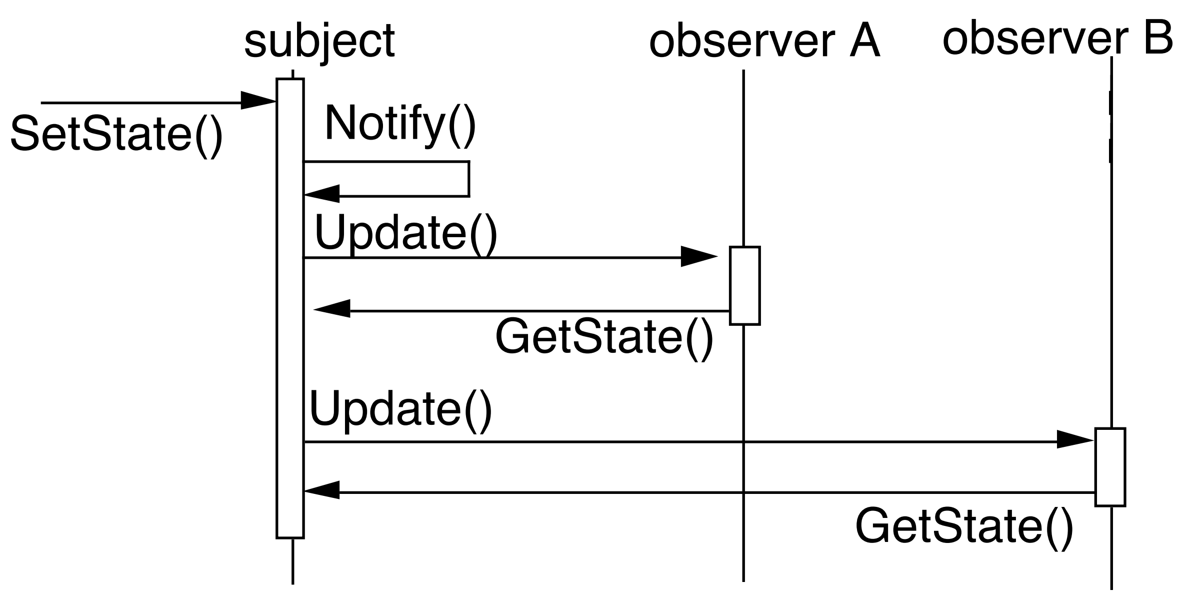
One-to-many dependency between objects

When one object changes state,
all its dependents are notified and updated automatically

Structure


observer A
observer B
Update()
GetState()
Update()
SetState()
subject


Subject
observers
Observer
Attach(Observer)
Detach(Observer)
Notify()
Update()
ConcreteObserver
subject
Update()
ConcreteSubject
observerState
GetState()
subjectState


subject
observer A
observer B
SetState()
Notify()
Update()
GetState()
Update()
GetState()

Common Java Example - Listeners

Java Interface

View.OnClickListener

abstract void onClick(View v)

Called when a view has been clicked.

Java Example

```
public class CreateUIInCodeActivity extends Activity implements View.OnClickListener{
    Button test;

    @Override
    public void onCreate(Bundle savedInstanceState) {
        super.onCreate(savedInstanceState);
        setContentView(R.layout.main);
        test = (Button) this.findViewById(R.id.test);
        test.setOnClickListener(this);
    }

    public void onClick(View source) {
        Toast.makeText(this, "Hello World", Toast.LENGTH_SHORT).show();
    }
}
```

Pseudo Java Example

```
public class Subject {
  Window display;
  public void someMethod() {
    this.modifyMyStateSomeHow();
    display.addText( this.text() );
  }
}
```

Abstract coupling - Subject & Observer

Broadcast communication

Updates can take too long

```
public class Subject {
  ArrayList observers = new ArrayList();

  public void someMethod() {
    this.modifyMyStateSomeHow();
    changed();
  }

  private void changed() {
    Iterator needsUpdate = observers.iterator();
    while (needsUpdate.hasNext() )
      needsUpdate.next().update( this );
  }
}

public class SampleWindow {
  public void update(Object subject) {
    text = ((Subject) subject).getText();
    Thread.sleep(10000).
  }
}
```

Some Language Support

Smalltalk	Java	Ruby	Clojure	Observer Pattern
Object	~~Observer~~		function	Abstract Observer class
Object & Model	~~Observable~~	Observable	watches on data	Subject class

Smalltalk Implementation

Object implements methods for both Observer and Subject.

Actual Subjects should subclass Model

Java's Observer

Class java.util.Observable

Deprecated in Java 9

void addObserver(Observer o)
void clearChanged()
int countObservers()
void deleteObserver(Observer o)
void deleteObservers()
boolean hasChanged()
void notifyObservers()
void notifyObservers(Object arg)
void setChanged()

Java	Observer Pattern
Interface Observer	Abstract Observer class
Observable class	Subject class

Observable object may have any number of Observers

Whenever the Observable instance changes,
it notifies all of its observers

Notification is done by calling the update() method on all observers.

Interface java.util.Observer

Allows all classes to be observable by instances of class Observer

Flow

Java Observer & Observable are replaced by

- java beans
- Reactive Streams (Flow)

Flow

- Publisher (Subject)
- Subscriber (Observer)
- Processor (Subject & Observer)
- Subscription
  - Link between publisher & subscriber

Coupling & Observer Pattern

Subject coupled to Observer interface

- Does not know the concrete type of the observers
- There can be 0+ observers

Implementation Issues

Mapping subjects(Observables) to observers

Use list in subject

Use hash table

```
public class Observable {
    private boolean changed = false;
    private Vector obs;

public Observable() {
        obs = new Vector();
    }

public synchronized void addObserver(Observer o) {
        if (!obs.contains(o)) {
            obs.addElement(o);
        }
    }
```

Observing more than one subject

If an observer has more than one subject how does it know which one changed?

Pass information in the update method

Deleting Subjects

In C++ the subject may no longer exist

Java/Smalltalk observer may prevent subject from garbage collection

Who Triggers the update?

Have methods that change the state trigger update

```
class Counter extends Observable  {            // some code removed
   public void increase()  {
       count++;
       setChanged();
       notifyObservers( INCREASE );
   }
}
```

Have clients call Notify at the right time

```
class Counter extends Observable  {       // some code removed
        public void increase()  {    count++;  }
}

Counter pageHits = new Counter();
pageHits.increase();
pageHits.increase();
pageHits.increase();
pageHits.notifyObservers();
```

Subject is self-consistent before Notification

```
class ComplexObservable extends Observable {
    Widget frontPart = new Widget();
    Gadget internalPart = new Gadget();

    public void trickyChange() {
        frontPart.widgetChange();
        internalpart.anotherChange();
        setChanged();
        notifyObservers( );
    }
}

class MySubclass extends ComplexObservable {
    Gear backEnd = new Gear();

    public void trickyChange() {
        super.trickyChange();
        backEnd.yetAnotherChange();
        setChanged();
        notifyObservers( );
    }
}
```

Adding information about the change

push models - add parameters in the update method

```
class IncreaseDetector extends Counter implements Observer { // stuff not shown

  public void update( Observable whatChanged, Object message) {
     if ( message.equals( INCREASE) )
        increase();
  }
}

class Counter extends Observable {        // some code removed
  public void increase()  {
     count++;
     setChanged();
     notifyObservers( INCREASE );
  }
}
```

Adding information about the change

pull model - observer asks Subject what happened

```
class IncreaseDetector extends Counter implements Observer {
 public void update( Observable whatChanged ) {
     if ( whatChanged.didYouIncrease() )
         increase();
 }
}

class Counter extends Observable {          // some code removed
 public void increase() {
     count++;
     setChanged();
     notifyObservers( );
 }
}
```

Rate of Updates

In single threaded operation

- All observers must finish before subject can continue operation

What to do when subject changes faster than observers can handle

Scaling the Pattern

Java Event Model

AWT/Swing components broadcast events to Listeners

JDK1.0 AWT components broadcast an event to all its listeners

A listener normally not interested all events

Broadcasting to all listeners was too slow with many listeners

Java 1.1+ Event Model

Each component supports different types of events:

Component supports

ComponentEvent	FocusEvent
KeyEvent	MouseEvent

Each event type supports one or more listener types:

MouseEvent

MouseListener	MouseMotionListener

Each listener interface replaces update with multiple methods

MouseListener

mouseClicked()	mouseEntered()
mousePressed()	mouseReleased()

Listeners

- Only register for events of interest
- Don't need case statements to determine what happened

Small Models

Often an object has a number of fields(aspects) of interest to observers

Rather than make the object a subject make the individual fields subjects

- Simplifies the main object
- Observers can register for only the data they are interested in

VisualWorks ValueHolder

Subject for one value

ValueHolder allows you to:

- Set/get the value
    - Setting the value notifies the observers of the change
- Add/Remove dependents

Reactive Programming

Reactive Manifesto

https://www.reactivemanifesto.org

Organizations working in disparate domains are independently discovering patterns for building software that look the same.

These systems are more robust, more resilient, more flexible and better positioned to meet modern demands.

Reactive Systems are

- Responsive
- Resilient
  - React to failure
- Elastic
  - React to load
- Message Driven

Motivation

- Need millisecond response
- 100% uptime
- Data is measured in Petabytes
- Applications run on
  - Mobile
  - Clusters of 1000s of multico

History

1997 - Elliott & Hudak

Fran - reactive animations Reactive Functional Programing

2009 Akka

Actor model + reactive streams

2009 Reactive Extension for .NET early version

2011 Reactive Extension for .NET Official release

2012 - Elm

RFP for the web

2013 React

Facebook's system for Web UI components

2014 RxJava 1.0

Port of Reactive Extensions (ReactiveX) to Java

2016 RxJava 2.0

ReactiveX 2.0 implementation in Java

ReactiveX

http://reactivex.io

Their claim

The Observer pattern done right

ReactiveX is a combination of the best ideas from
- Observer pattern,
- Iterator pattern,
- Functional programming

Ported to multiple languages
- Basic ideas same
- Syntax differs

Reactive Programming

datatypes that represent a value 'over time'

Spreadsheets

3	1	2
5	3	4
8		

Reactive Programming

Spreadsheets

Elm

React (Facebook)

Reagent (Clojure)

Android Architecture Components

SwiftUI

Swift Combine

Flutter (Google)

Fuchsia (Google)

Akka

Java Flow

ReactiveX

- RxJava (35,500 GitHub stars)
- RxJS
- Rx.NET
- RxPY
- RxSwift
- RxKotlin

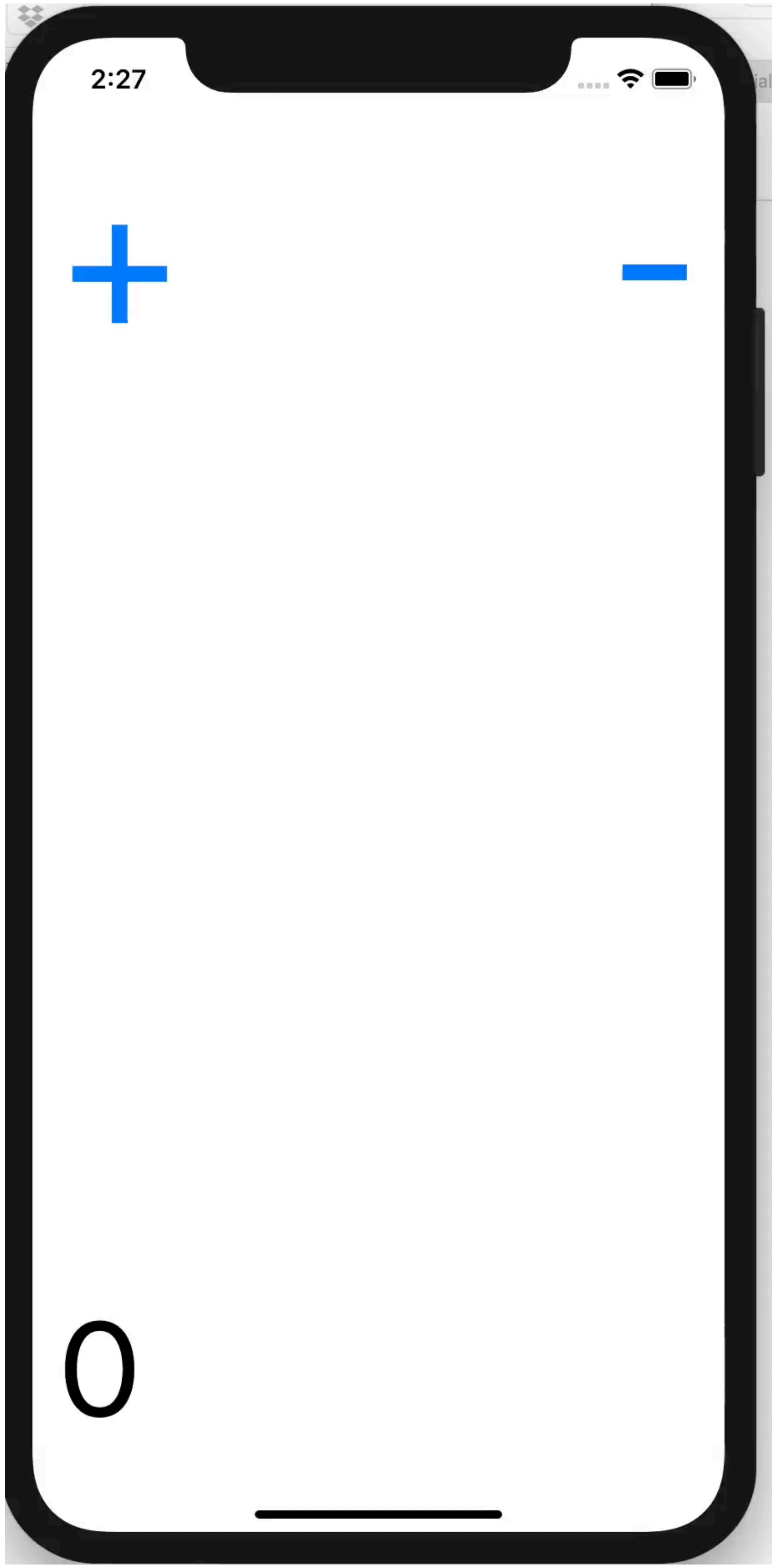
- RxAndroid (16,800 GitHub stars)
- RxCocoa

Reactive Programming - Elm

datatypes that represent a value 'over time'

SwiftUI Example

```
import SwiftUI

struct ContentView : View {
    @State private var count : Int = 0

    var body: some View {
        VStack(alignment: .leading) {
            HStack {
                Button(action: {self.count = self.count + 1}){
                    Text("+").font(.system(size: 120))
                }
                Spacer()
                Button(action: {self.count = self.count - 1}){
                    Text("-").font(.system(size: 120))
                }
            }
            Spacer()
            Text("\(count)").font(.system(size: 80))
        }.padding()
    }
}
```



Reactive Programming Concepts

Unify data types into stream of events/data

- Events
- Collections
- Value changing
- Asynchronous callbacks

One-way data flows

- React & Flux

Unify Data Types

```
Iterator<String> list = strings.iterator();
while (list.hasNext()){
    String element = list.next();
    processEachElement(element);
    }
}
```

When Elements are processes

Time

But some elements take longer to process

Time

Unify Data Types

class Foo {
  int bar;

bar changes value over time

When bar changed

Time

The Basics

Subjects (Observables) generate a stream or flow of events/data

Streams

- Support map, filter and other functions
- Send three types of messages/events
  - onNext - the next data in the stream
  - onCompleted - The stream is at the end
  - onError - An error occurred

Observers subscribe to streams

- Some subjects give all the events/data to new subscribers
- Some give only current value and future changes
- Some subjects allow observers to tell subjects to slow down

RxJava - Basic Classes

io.reactivex.Flowable:
  0..N flows, supporting Reactive-Streams and backpressure

io.reactivex.Observable:
  0..N flows, no backpressure

io.reactivex.Single:
  a flow of exactly 1 item or an error

io.reactivex.Completable:
  a flow without items but only a completion or error signal

io.reactivex.Maybe:
  a flow with no items, exactly one item or an error.

RxJava HelloWorld

```
import io.reactivex.*;

public class Example {
    public static void main(String[] args) {
        Flowable.just("Hello world")
                    .subscribe(System.out::println);
    }
}
```

RxJava Subscribe methods

```
subscribe(Consumer<? super T> onNext)

subscribe(Consumer<? super T> onNext,
          Consumer<? super Throwable> onError)

subscribe(Consumer<? super T> onNext,
          Consumer<? super Throwable> onError,
          Action onComplete)
```

Java Consumer

Lambda or function that has one argument and no return value

```
Consumer<String> print = text -> System.out.println(text);
print.accept("hello World");
```

```java
import io.reactivex.*;

public class Example {
    public static void main(String[] args) {
        Flowable<Integer> flow = Flowable.range(1, 5)
                .map(v -> v * v)
                .filter(v -> v % 2 == 0);
        System.out.println("Start");
        flow.subscribe(System.out::println);
        System.out.println("Second");
        flow.subscribe(value -> System.out.println("Second " + value));
    }
}
```

Output

```
Start
4
16
Second
Second 4
Second 16
```

Observables with Varying Number of Events

Flowable<Integer> flow = Flowable.range(1, 5)

flow has fixed number of data points

So more like iterator over a collection

How to create observable with varying number of data points/events

Emitters

Subjects

Emitter Interface

onComplete()
onError(Throwable error)
onNext(T value)

Example

```
import io.reactivex.*;

public class Example {
    public static void main(String[] args) {
        Observable<String> observable = Observable.create(emitter -> {
                emitter.onNext("A");
                emitter.onNext("B");
                emitter.onNext("B");
                emitter.onComplete();
                });
        System.out.println("Start");
        observable.subscribe(System.out::println,Throwable::printStackTrace,
                                                    () -> System.out.println("Done"));
    }
}
```

Longer Running Example

```
import io.reactivex.*;

public class Example {
    public static void main(String[] args) {
        Observable<Long> observable = Observable.create(emitter -> {
            while (!emitter.isDisposed()) {
                long time = System.currentTimeMillis();
                emitter.onNext(time);
                if (time % 2 != 0) {
                    emitter.onError(new IllegalStateException("Odd millisecond!"));
                    break;
                }
            }
        });
        System.out.println("Start");
        observable.subscribe(System.out::println,Throwable::printStackTrace);
    }
}
```

Important Notes

Data generation all done in lambda

- But could have called a method on an object

Observable just knows to pass emitter to observer

Subjects

Subjects are
- Observable
- Observers

Multiple Types
- BehaviorSubject
  - Sends current value and future values to observers
- PublishSubject
  - Sends future values to observers
- ReplaySubject
  - Sends past, current and future values to observers

PublishSubject Example

```
import io.reactivex.subjects.PublishSubject;
import io.reactivex.subjects.Subject;

public class Example {
    public static void main(String[] args) {
        Subject<String> subject = PublishSubject.create();
        subject.subscribe(System.out::println,
                                Throwable::printStackTrace,
                                () ->System.out.println("Done"));

        subject.onNext("Start");
        subject.onNext("A");

        subject.subscribe(text -> System.out.println("Later " + text));
        subject.onNext("B");
        subject.onNext("C");
        subject.onComplete();
    }
}
```

Output

```
Start
A
B
Later B
C
Later C
Done
```

BehaviorSubject Example

```
import io.reactivex.subjects.BehaviorSubject;
import io.reactivex.subjects.Subject;

public class Example {
    public static void main(String[] args) {
        Subject<String> subject = BehaviorSubject.create();
        subject.subscribe(System.out::println,
                                Throwable::printStackTrace,
                                () ->System.out.println("Done"));

        subject.onNext("Start");
        subject.onNext("A");

        subject.subscribe(text -> System.out.println("Later " + text));
        subject.onNext("B");
        subject.onNext("C");
        subject.onComplete();
    }
}
```

Output
Start
A
Later A
B
Later B
C
Later C
Done

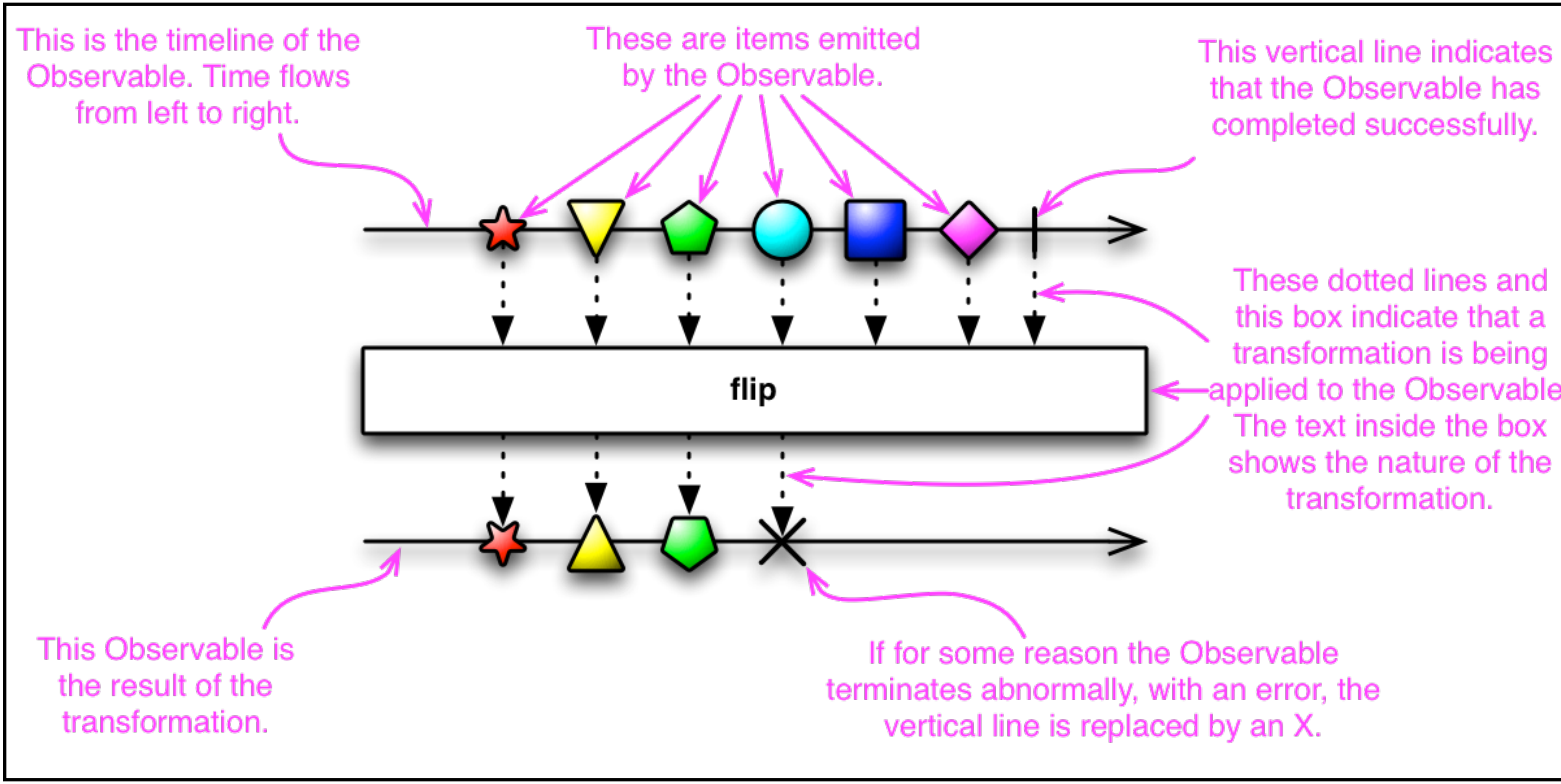
ReplaySubject Example

```
import io.reactivex.subjects.ReplaySubject;
import io.reactivex.subjects.Subject;

public class Example {
    public static void main(String[] args) {
        Subject<String> subject = ReplaySubject.create();
        subject.subscribe(System.out::println,
                          Throwable::printStackTrace,
                          () ->System.out.println("Done"));

        subject.onNext("Start");
        subject.onNext("A");

        subject.subscribe(text -> System.out.println("Later " + text));
        subject.onNext("B");
        subject.onNext("C");
        subject.onComplete();
    }
}
```

Output

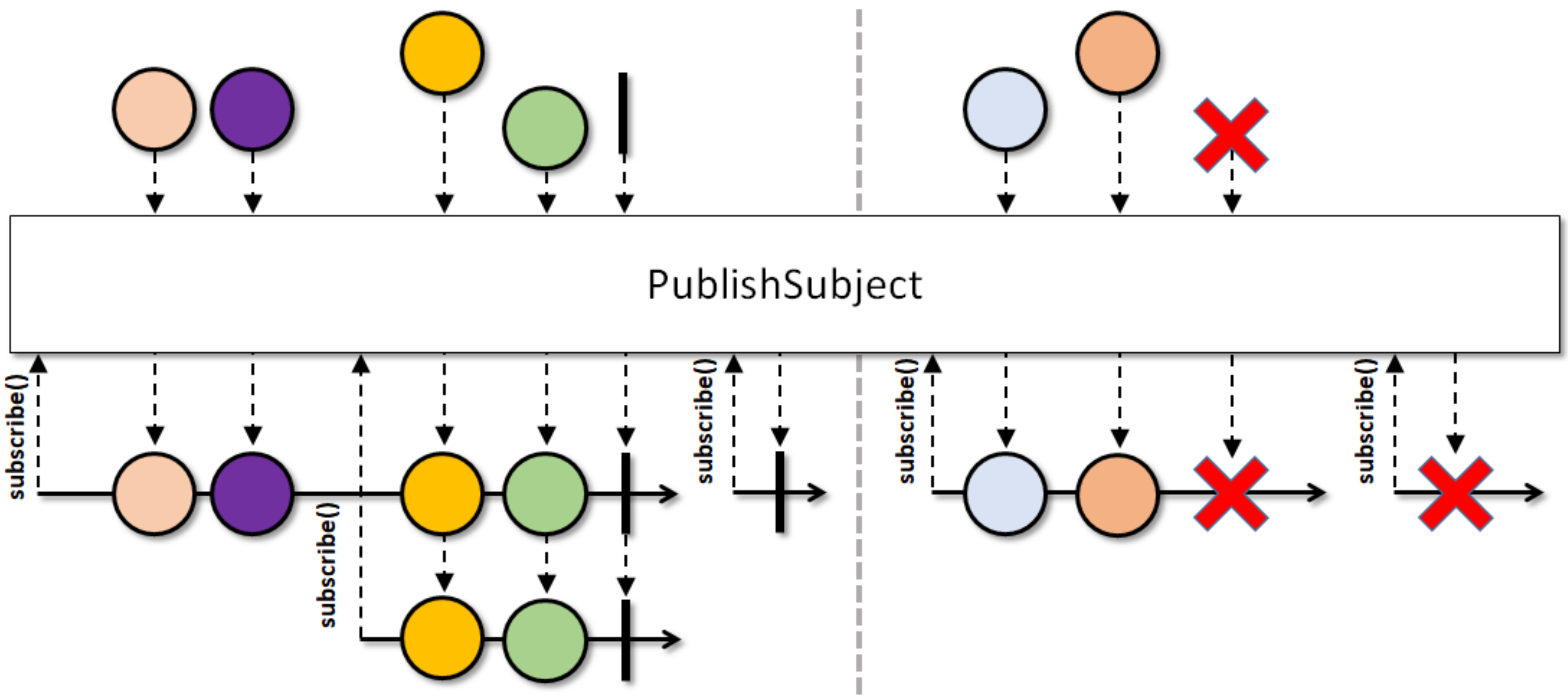
```
Start
A
Later Start
Later A
B
Later B
C
Later C
Done
```

Diagrams

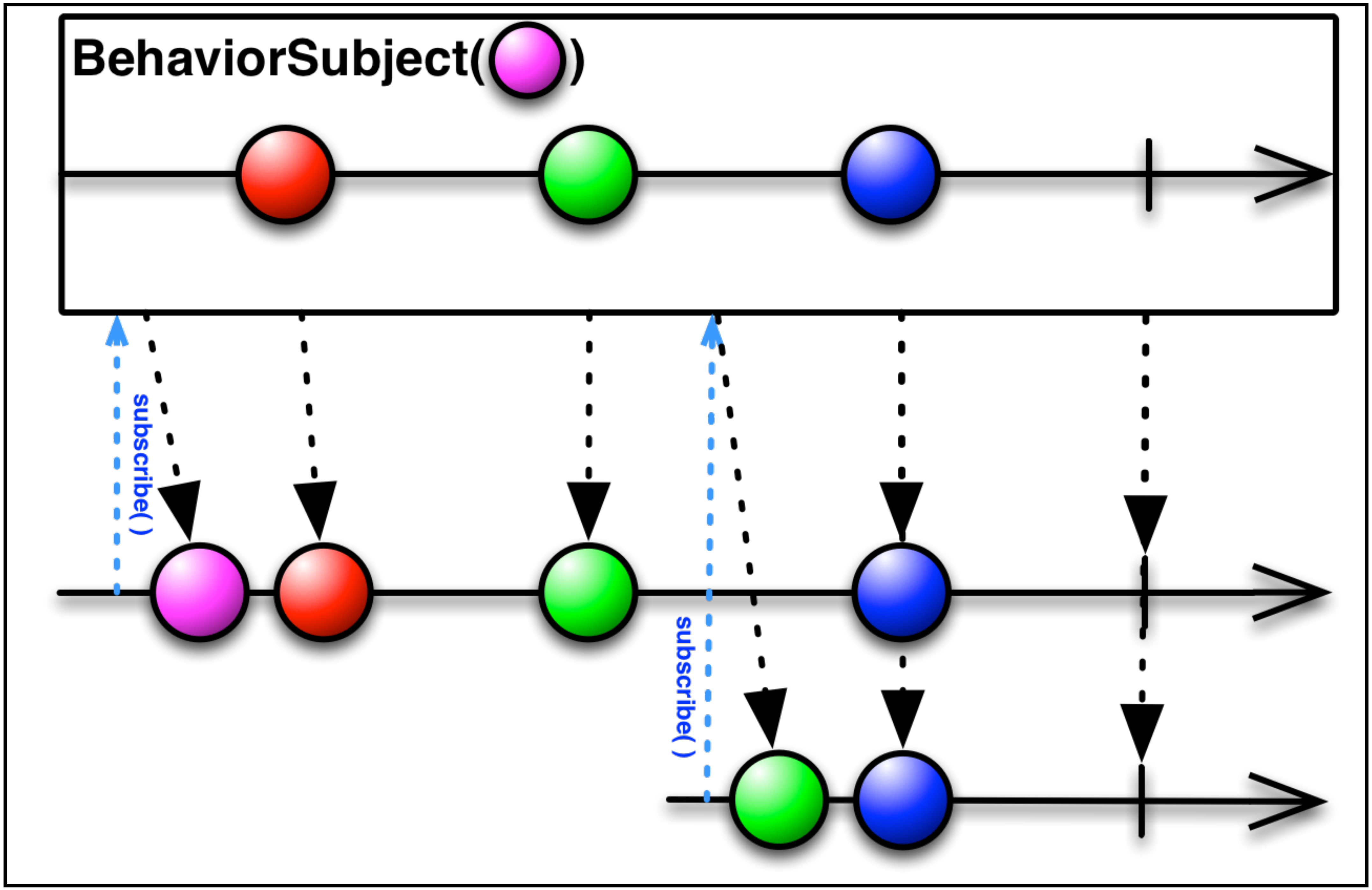


This is the timeline of the Observable. Time flows from left to right.
These are items emitted by the Observable.
This vertical line indicates that the Observable has completed successfully.
These dotted lines and this box indicate that a transformation is being applied to the Observable. The text inside the box shows the nature of the transformation.
flip
This Observable is the result of the transformation.
If for some reason the Observable terminates abnormally, with an error, the vertical line is replaced by an X.

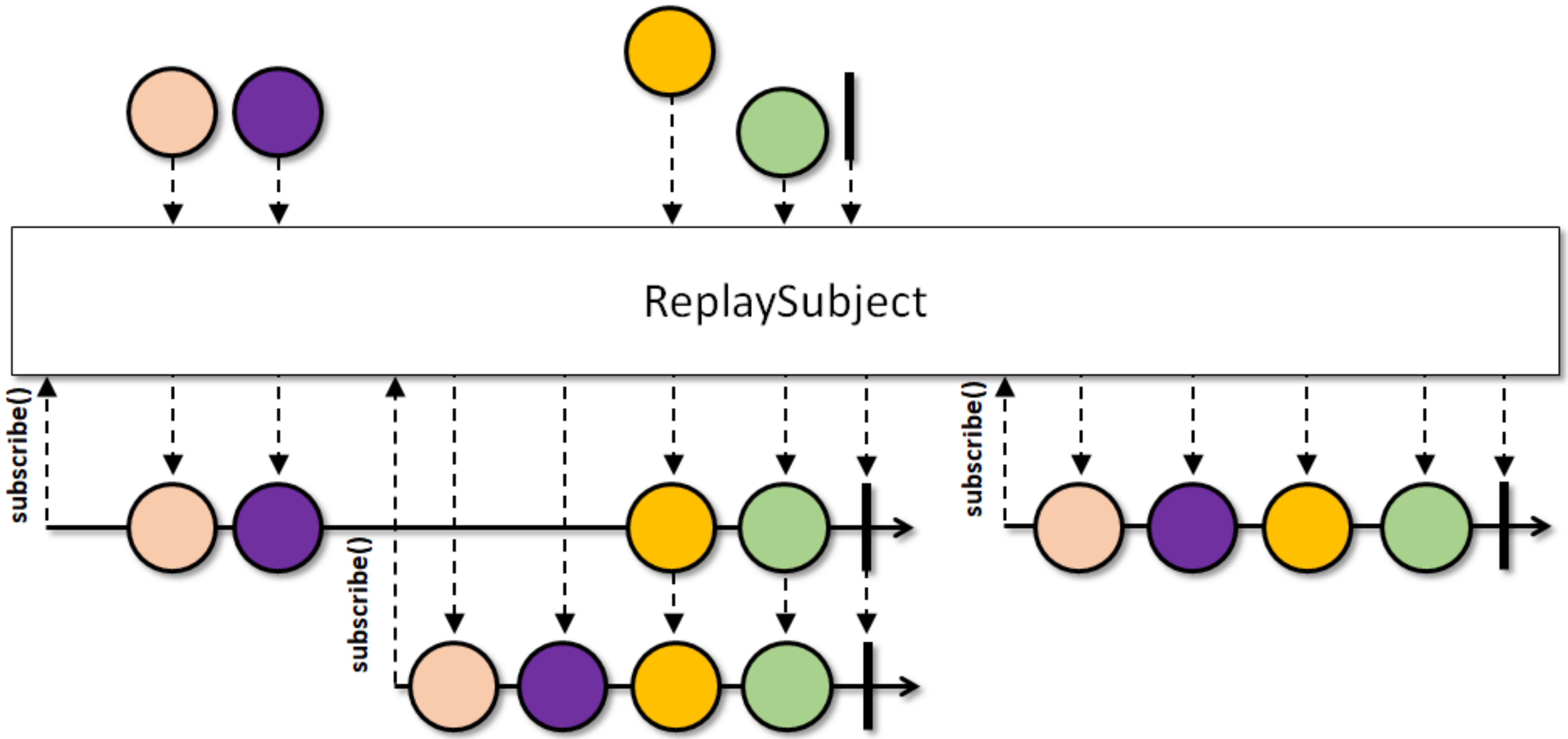
PublishSubject



BehaviorSubject



ReplaySubject



RxPy

```
from rx import Observable

source = Observable.of("Alpha", "Beta", "Gamma", "Delta", "Epsilon")

source.subscribe(on_next=lambda value: print("Received {0}".format(value)),
                 on_completed=lambda: print("Done!"),
                 on_error=lambda error: print("Error Occurred: {0}".format(error))
                 )

source.subscribe(on_completed=lambda: print("Done!"),
                   on_next=lambda value: print("Received {0}".format(value))
                 )

source.subscribe(lambda value: print("Received {0}".format(value)))


source.subscribe(print)
```

RxPy

```
from rx import Observable

xs = Observable.from_(range(10))
d = xs.filter(lambda x: x % 2)
        .map(lambda x: x * 2)
        .subscribe(print)
```

```
2
6
10
14
18
```

```
xs = Observable.range(1, 5)
ys = Observable.from_("abcde")
zs = xs.merge(ys).subscribe(print)
```

```
a
1
b
2
c
3
d
4
e
5
```

PublishSubject

```
from rx.subjects import Subject

stream = Subject()
stream.subscribe(on_next=lambda value: print("Received {0}".format(value)),
                 on_completed=lambda: print("Done!"),
                 on_error=lambda error: print("Error Occurred: {0}".format(error))
                 )
stream.on_next("Start")
stream.on_next("A")
d = stream.subscribe(lambda x: print("Got: %s" % x))

stream.on_next("B")

d.dispose()
stream.on_next("C")
stream.on_next(10)

stream.on_completed()
```

```
Received Start
Received A
Received B
Got: B
Received C
Received 10
Done!
```

ReplaySubject

```
from rx.subjects import ReplaySubject

stream = ReplaySubject()
stream.subscribe(on_next=lambda value: print("Received {0}".format(value)),
                 on_completed=lambda: print("Done!"),
                 on_error=lambda error: print("Error Occurred: {0}".format(error))
                 )
stream.on_next("Start")
stream.on_next("A")
d = stream.subscribe(lambda x: print("Got: %s" % x))

stream.on_next("B")

d.dispose()
stream.on_next("C")
stream.on_next(10)

stream.on_completed()
```

```
Received Start
Received A
Got: Start
Got: A
Received B
Got: B
Received C
Received 10
Done!
```

RxSwift

```swift
import RxSwift

let dataSequence = Observable.from([1, 2, 3])
dataSequence.subscribe(onNext: {print($0)})
```

```
1
2
3
```

```swift
dataSequence.subscribe(
                    onNext: {print($0)},
                    onCompleted: {print("Done")})
```

```
1
2
3
Done
```

```swift
dataSequence
   .map {$0 + 1}
   .scan(0) {$0 + $1}
   .subscribe(onNext: {print($0)},onCompleted: {print("Done")})
```

```
2
5
9
Done
```

PublishSubject

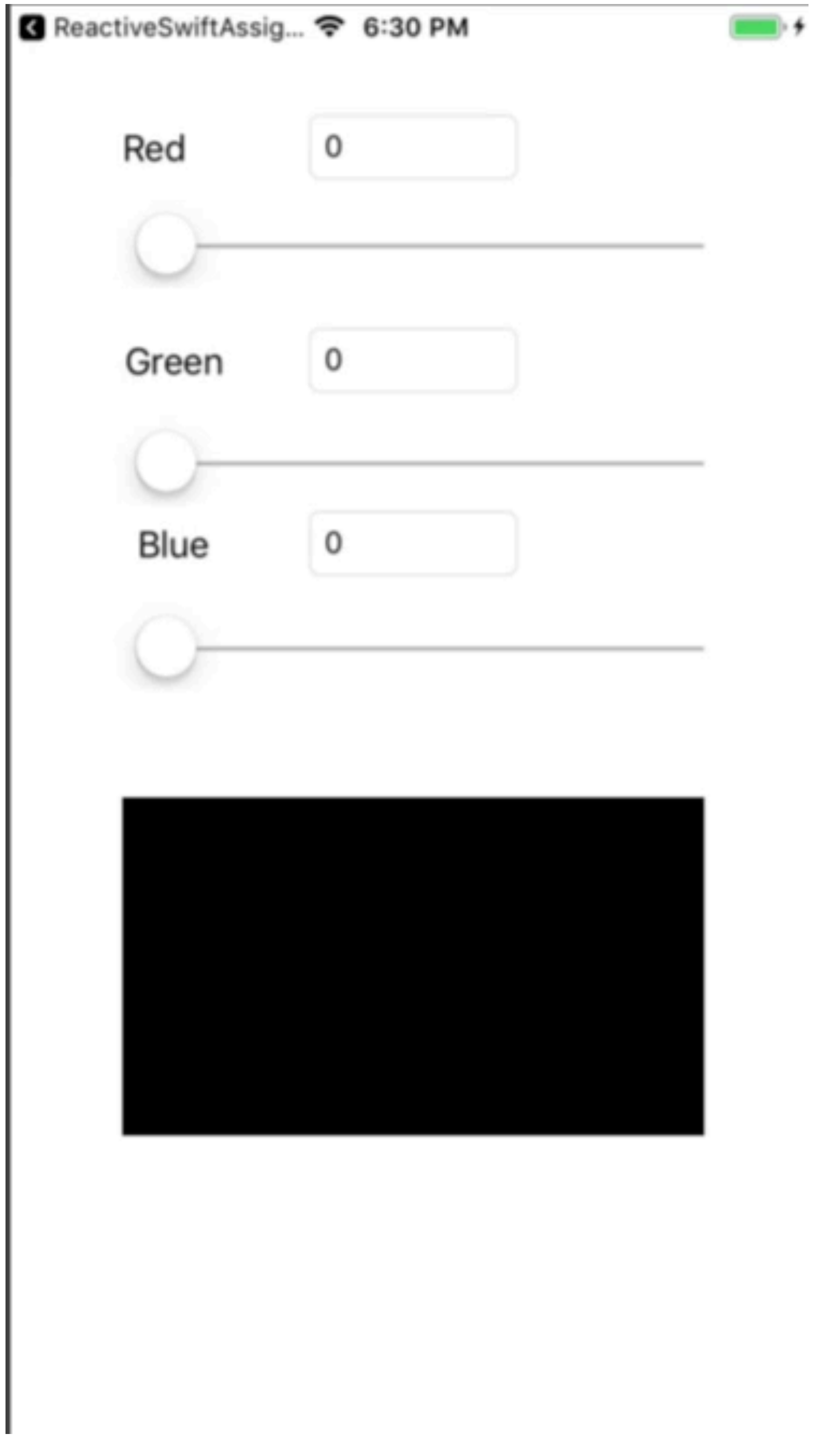
```
let subject = PublishSubject<Int>()
subject.subscribe(onNext: {print("Subject = \($0)")},
                  onCompleted: {print("Done")})

subject.map {$0 + 10}
       .subscribe(onNext: {print("Plus 10 = \($0) ")})

print("Start")
subject.onNext(2)
print("After 2")
subject.onNext(4)
print("No more")
```

```
Start
Subject = 2
Plus 10 = 12
After 2
Subject = 4
Plus 10 = 14
No more
```

Network Calls

```
if let url = URL(string: "https://bismarck.sdsu.edu/registration/subjectlist") {
    let request = URLRequest(url: url)

    let responseJSON = URLSession.shared.rx.json(request: request)

    let cancelRequest = responseJSON.subscribe(
                                        onNext: { json in print(json) },
                                        onCompleted: {print("Done")})
}
```

Sample App



Specs

Color values
- Integers
- 0 - 100

Change in slider
- Changes text field
- Changes color of box

Change in text field
- Changes slider
- Changes color of box

Standard Solution

Have reference to

- redSlider
- greenSlider
- blueSlider

- redText(field)
- greenText(field)
- blueText(field)

Have callback function called on change

- redSlider
- greenSlider
- blueSlider

- redText(field)
- greenText(field)
- blueText(field)

Color class

- Stores value of red, green, blue

Standard Solution

Slider call back function - each slider

- Called when slider changes
- Get value of slider
- Convert value to string
  - Set text field with string value of slider
- Change color of box
- Store the current color value

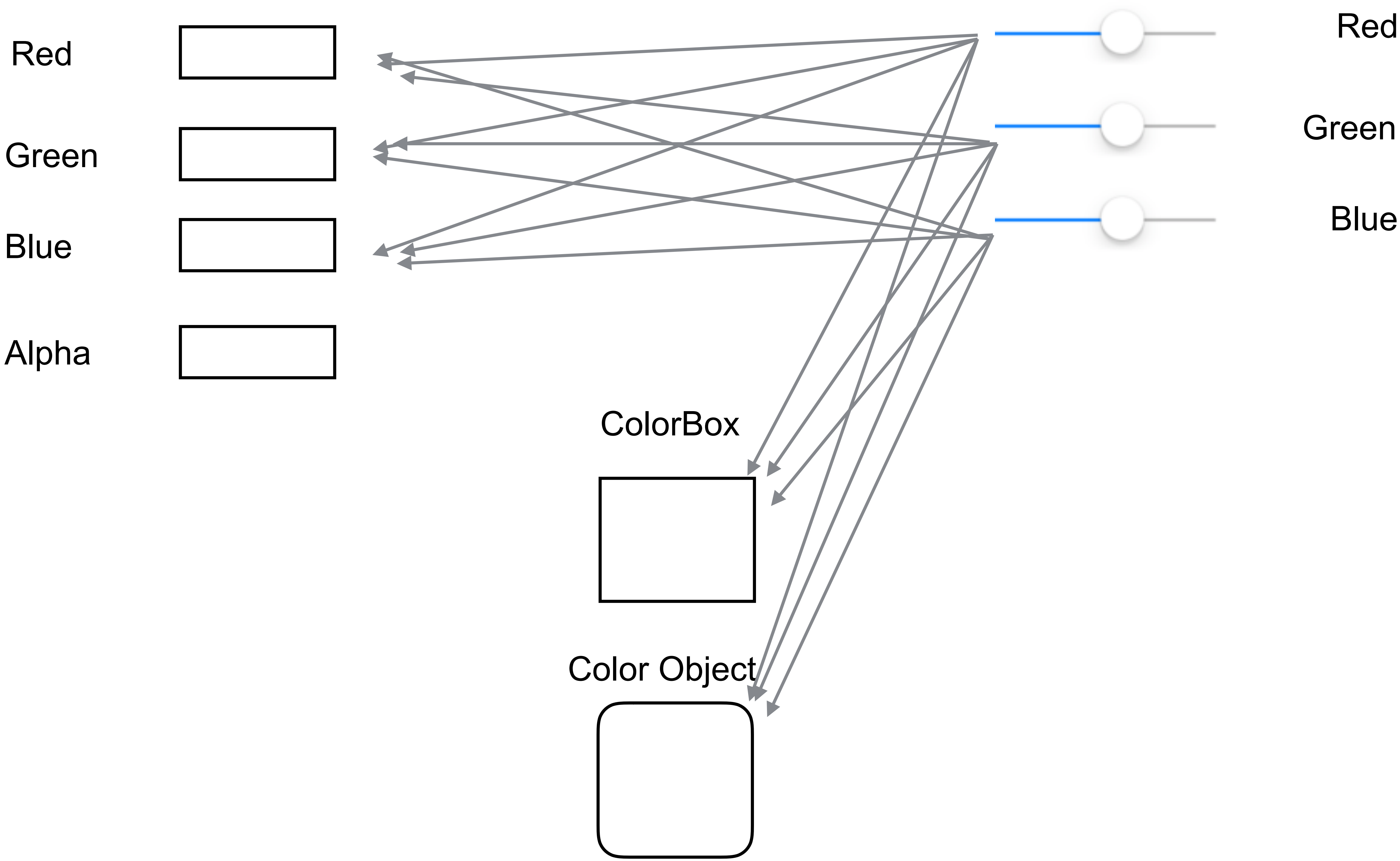
Textfield call back function

- Called when user types character or deletes a character
- Get value of textfield
- Convert string to float
  - Set value of slider to float value of textfield
- Change color of box
- Store the current color value

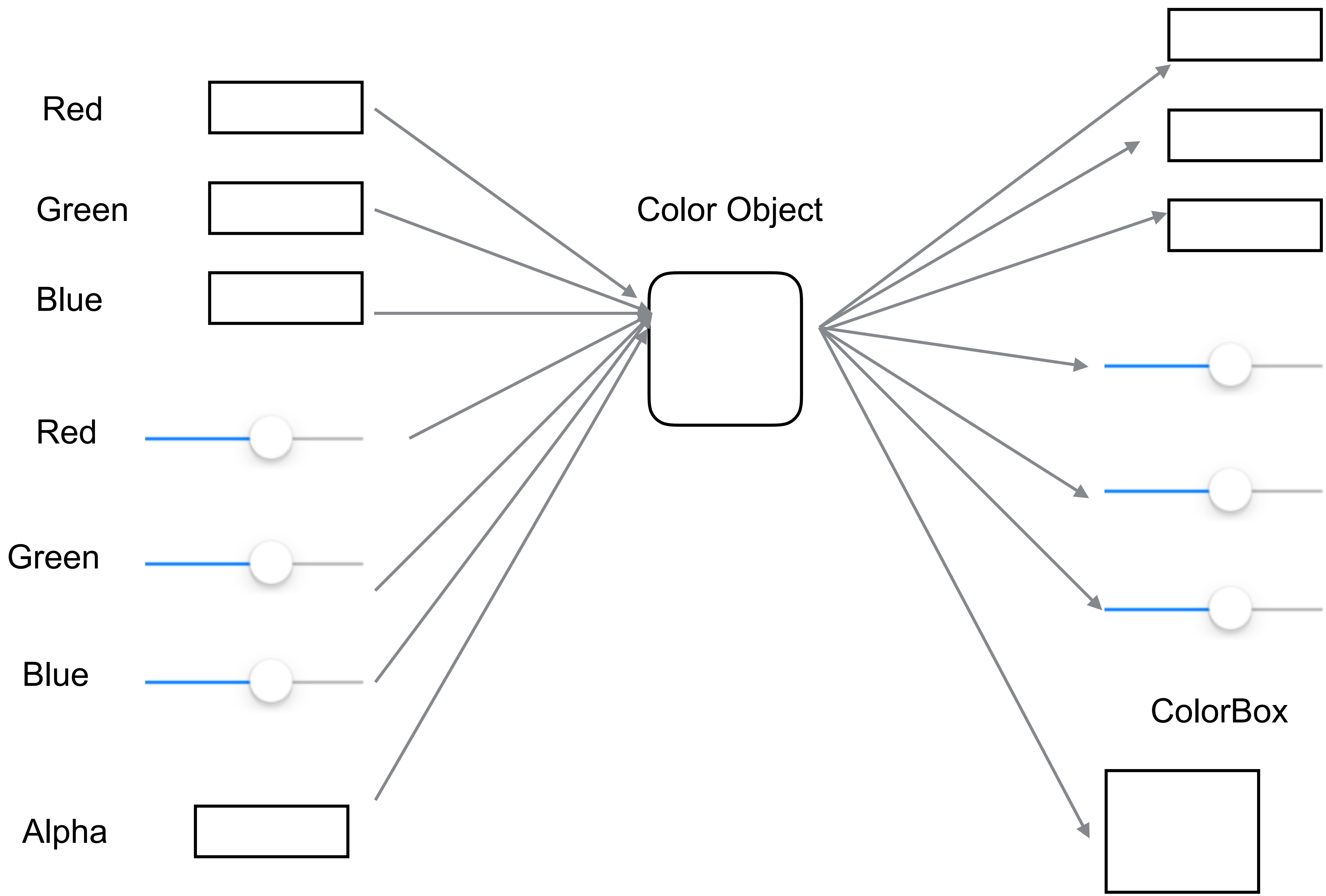
One Slider Callback

```
@IBAction func redSliderChanged(_ sender: Any) {
   redText.text = Int(redSlider.value).description
   guard   let redString = redText?.text,
             let red = Double(redString),
             let greenString = greenText?.text,
             let green = Double(greenString),
             let blueString = blueText?.text,
             let blue = Double(blueString) else {
      return
   }
   colorBox.backgroundColor = UIColor(red: CGFloat(red)/100,
                                      green: CGFloat(green)/100,
                                      blue: CGFloat(blue)/100, alpha: 1)
   color.red = red
}
```

Slider Callback Functions



Color as Subject/Observable



One Slider Callback

```
@IBAction func redSliderChanged(_ sender: Any) {
    color.red = Int(redSlider.value)
}
```

Color Updating UI

```
override func viewDidLoad() {
    super.viewDidLoad()
    color.observable.subscribe(onNext: {(type) in
        self.colorBox.backgroundColor = self.color.asUIColor()
        switch type {
            case .Red:
                self.redText.text = String(self.color.red)
                self.redSlider.value = Float(self.color.red)
            case .Green:
                self.greenText.text = String(self.color.green)
                self.greenSlider.value = Float(self.color.green)
            case .Blue:
                self.blueText.text = String(self.color.blue)
                self.blueSlider.value = Float(self.color.blue)
        }
    })
```

Functional Reactive Programming

Mathematical Variables

x = y

x remains equal to y

redSlider.value = Float(self.color.red)

So why can't we mean redSlider.value is always the same value as:
Float(self.color.red)

ReactiveSwift

Reactive library for Swift

Same ideas as ReactiveX (RxSwift)
- Uses different terms for same ideas

Not tied to ReactiveX
- So syntax is more Swift-like
- Claims simpler than RxSwift

ReactiveSwift <~ operator

```
redSlider.reactive.value <~ color.red.map {Float($0)}
```

Whenever color.red changes then perform

```
redSlider.reactive.value = color.red.map {Float($0)}
```

```
color.redProperty.map {Float($0)}.signal.observeValues({self.redSlider.value = $0})
```

```
overload func viewDidLoad() {
    redSlider.reactive.value <~ color.red.map {Float($0)}
    redText.reactive.text <~ color.red.map { String($0)}
    greenSlider.reactive.value <~ color.green.map {Float($0)}
    greenText.reactive.text <~ color.green.map { String($0)}
    blueSlider.reactive.value <~ color.blue.map {Float($0)}
    blueText.reactive.text <~ color.blue.map { String($0)}

    //update data when sliders move
    color.red <~ redSlider.reactive.values.map {Int($0)}
    color.green <~ greenSlider.reactive.values.map {Int($0)}
    color.blue <~ blueSlider.reactive.values.map {Int($0)}

    //update data when text fields change
    color.redProperty <~ redText.reactive.continuousTextValues.map {
                                    self.stringToInt(value: $0)}
    color.greenProperty <~ greenText.reactive.continuousTextValues.map {
                                    self.stringToInt(value: $0)}
    color.blueProperty <~ blueText.reactive.continuousTextValues.map {
                                    self.stringToInt(value: $0)}
```

```
class Color {
    var red: MutableProperty<Int> = MutableProperty(0)
    var green: MutableProperty<Int> = MutableProperty(0)
    var blue: MutableProperty<Int> = MutableProperty(0)

    convenience init() {
        self.init(red: 30, green: 40, blue: 100)
    }

    init(red: Int, green: Int, blue: Int) {
        self.red.value = red
        self.green.value = green
        self.blue.value = blue
    }
}
```

Property generates a Signal(Channel)

Observers can listen for events
on the signal(channel)

What We Want Done vs How To Do it

```
@IBAction func redSliderChanged(_ sender: Any) {
    let redValue: Float = redSlider.value
    color.red = Int(redValue)
}
```

```
redSlider.reactive.value <~ color.red.map {Float($0)}
```

Reactive Programming

New terms

- Channels, Signals
- Events
- Producers
- etc

Needs to rethink how to write code

Aside

```
color.red.signal.observeValues
   {self.redSlider.value = Float($0)
     self.redText.text = String($0)}
color.green.signal.observeValues
   {self.greenSlider.value = Float($0)
     self.greenText.text = String($0)}
color.blue.signal.observeValues
   {self.blueSlider.value = Float($0)
     self.blueText.text = String($0)}
```

verses

```
redSlider.reactive.value <~ color.red.map {Float($0)}
redText.reactive.text <~ color.red.map { String($0)}
greenSlider.reactive.value <~ color.green.map {Float($0)}
greenText.reactive.text <~ color.green.map { String($0)}
blueSlider.reactive.value <~ color.blue.map {Float($0)}
blueText.reactive.text <~ color.blue.map { String($0)}
```