Reactive programming

Reactive system

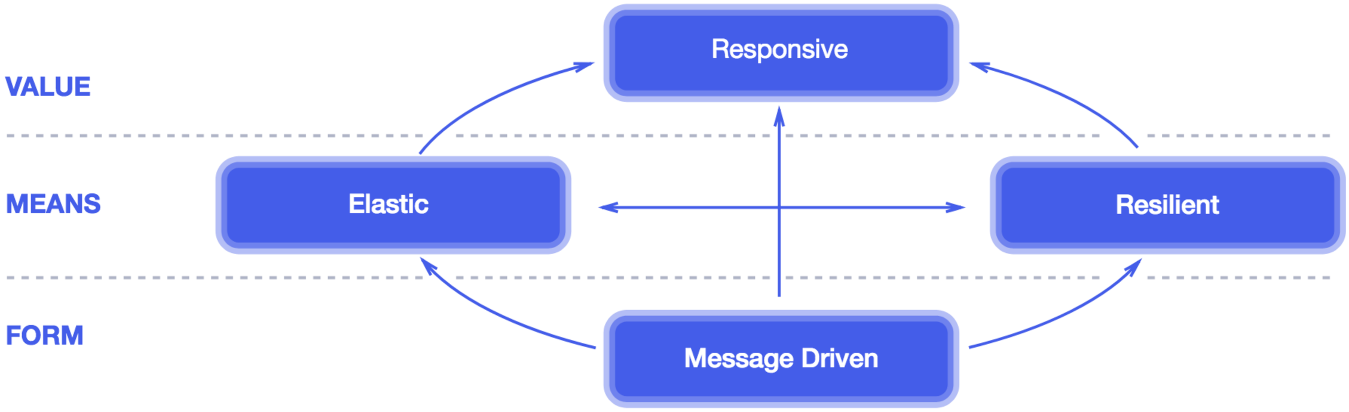
Any application should react to changes:

- any changes in demand (load)
- any changes in the availability of services

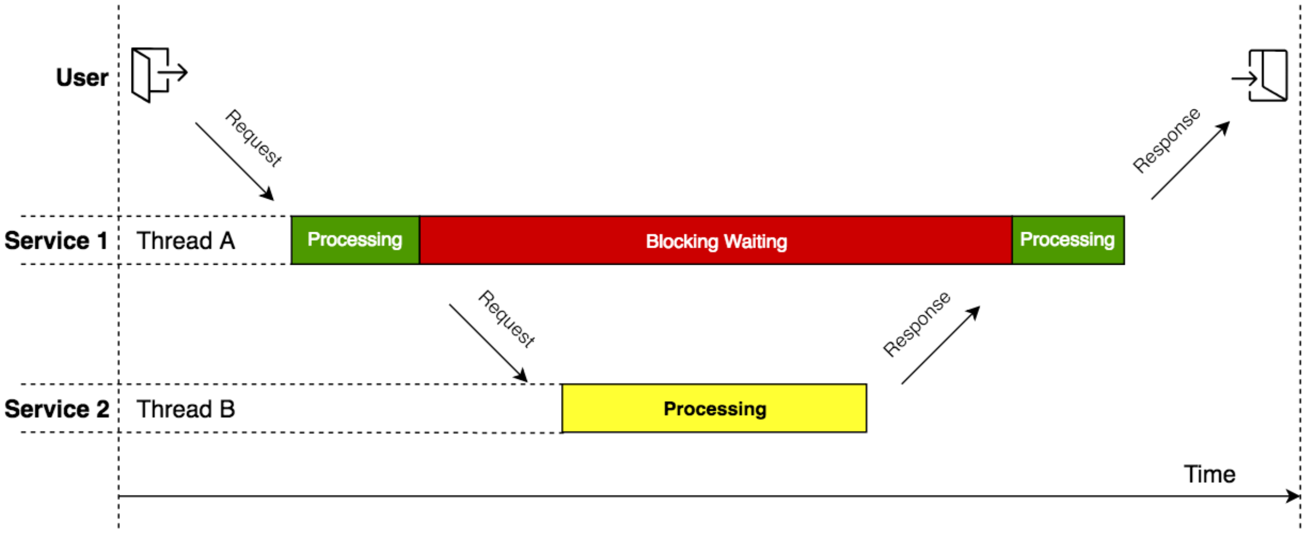
these kinf of app should be **reactive** to any changes that affects the system ability to response to user request

Main features of the **reactive** app :

- ability to stay responsive under a varying workload
- throughput of the system should increase automatically when more users start using it
- should decrease automatically when the demand goes down.



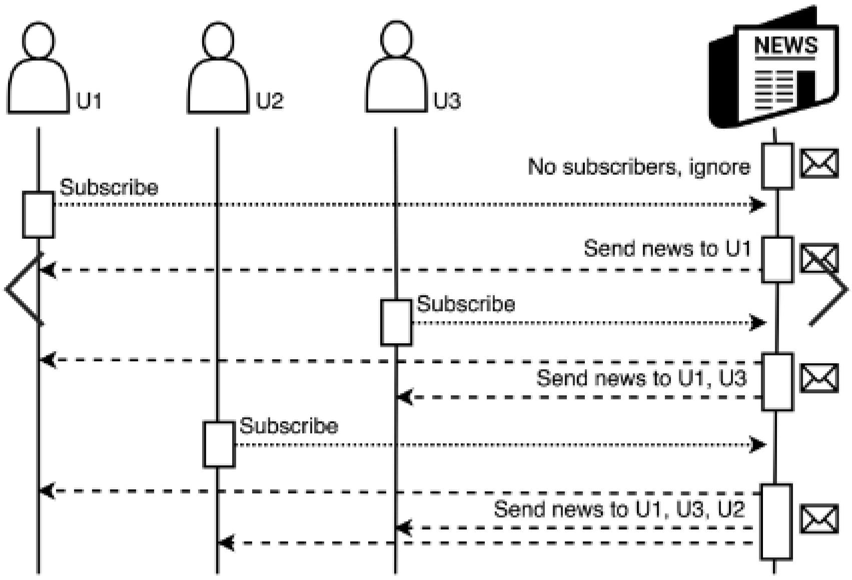
In the interconnected world of microservices one possible botleneck could be the blocking communication among microservices with ex Spring Boot + Servlet (less then 3.0) communication when the incoming request is served by a single dedicated thread.



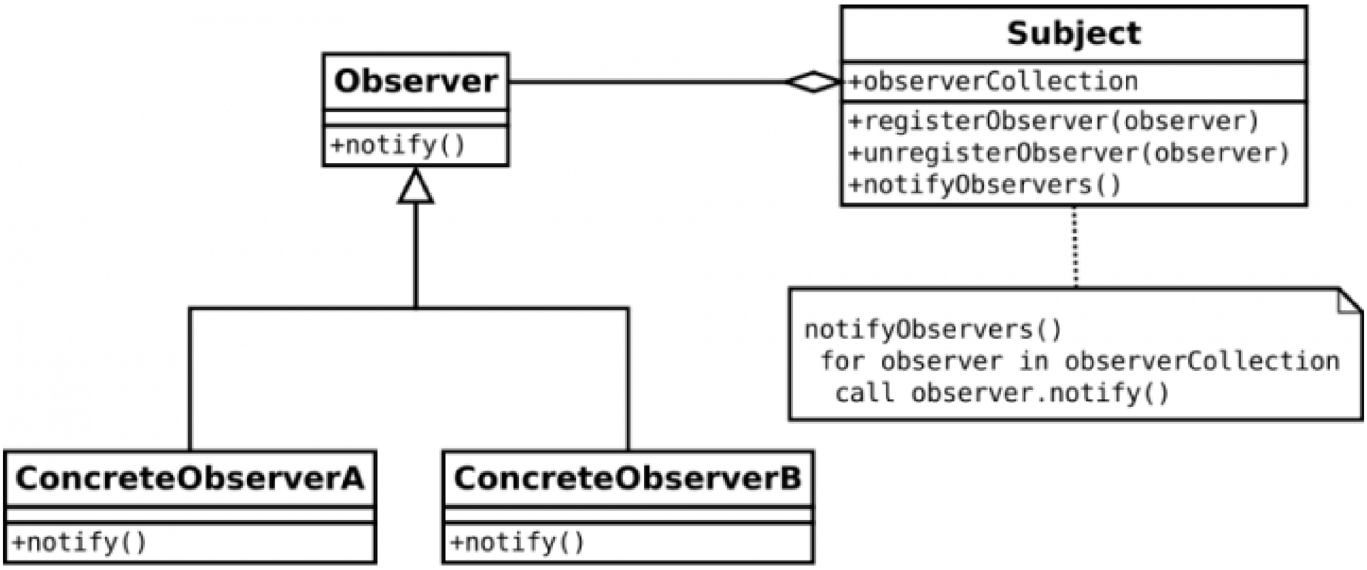
Reactive Programming ... the first solutions

Observer real life situation

The following design solution is a starting point to design(implement) reactive programming



Observer design pattern as a solution



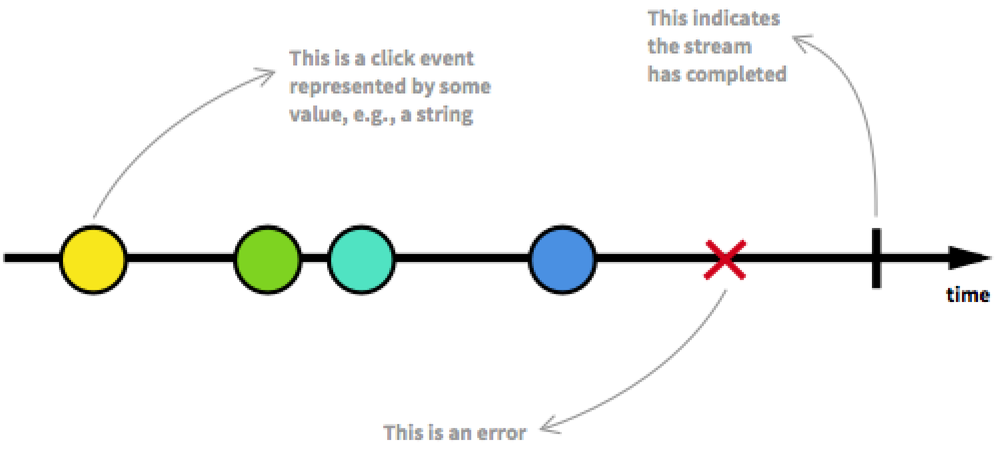
Reactive programming with Rx libraries

In reactive programming:

- a 'stream of data' OR a 'stream of event' OR etc. can be created
- the (reactive) app can listen and react to the streaming

Use Case : Backpressure : One of the big challenge of the IoT is the processing of the huge amount of teh generated data

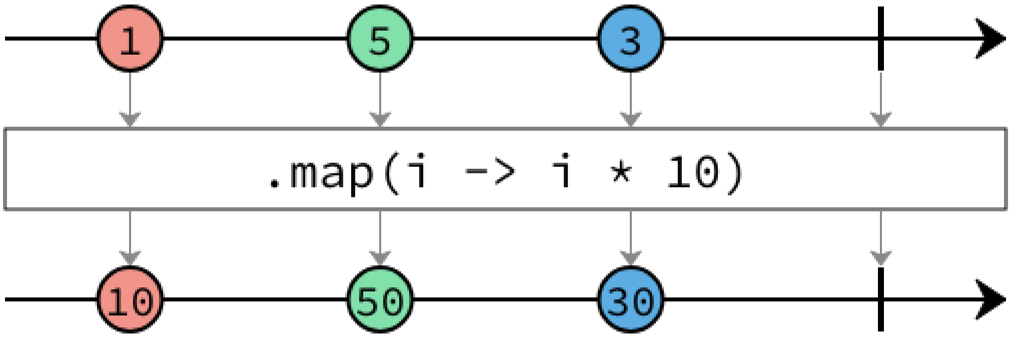
Modeling the observable with the `marble` diagram


This is a click event represented by some value, e.g., a string
This indicates the stream has completed
time
This is an error

Oberserver?

Observers are more hidden ... usually we define some `code` responses to the data(elements) flow generated by Observables

Operator



Use Case with RxJS (version 4.1)

```
npm install rx --save
```

Creating Observable

```
Rx.Observable.from(iterable,[mapFunction],[otherFunction],[otherFunction])
```

> > `iterable`: the iterable object to be converted into an observable (can be an array, set, map, and so on)

> > `mapFunction`: the function to be called for every element in the array to map it to a different value

Creating observers/subscribers

```
Observable.subscribe(onNext,onError,onCompleted);
```

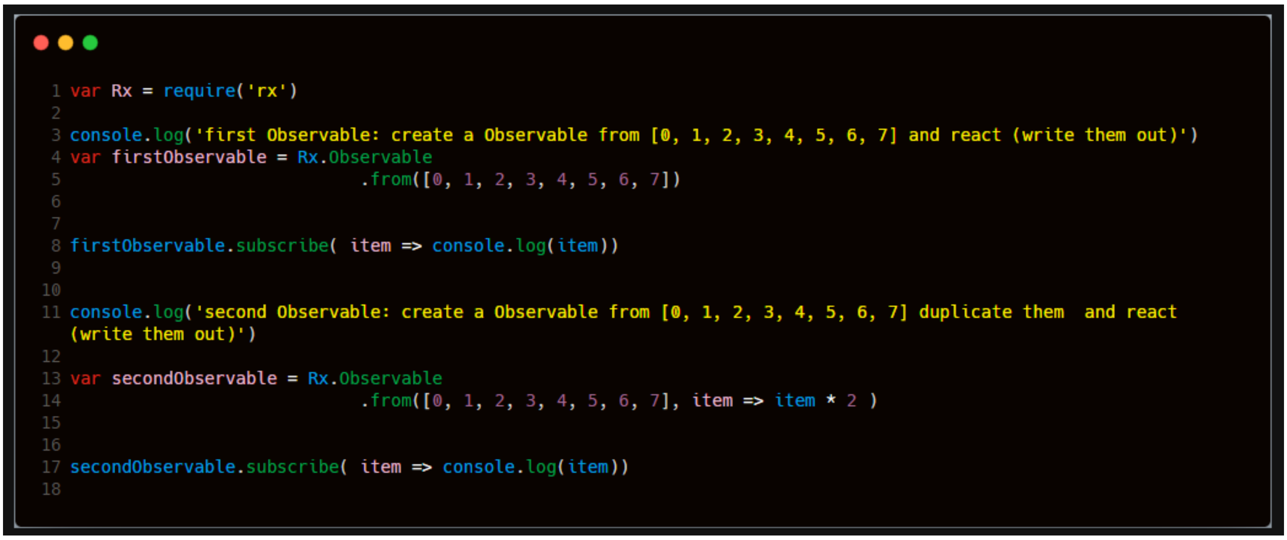
> > `onNext`: This is a function to be called every time new data is propagated through the observable

> > `onError`: This is a function to be called every time an error occurs in the observable

> > `onCompleted`: This is a function to be called when the observable is completed

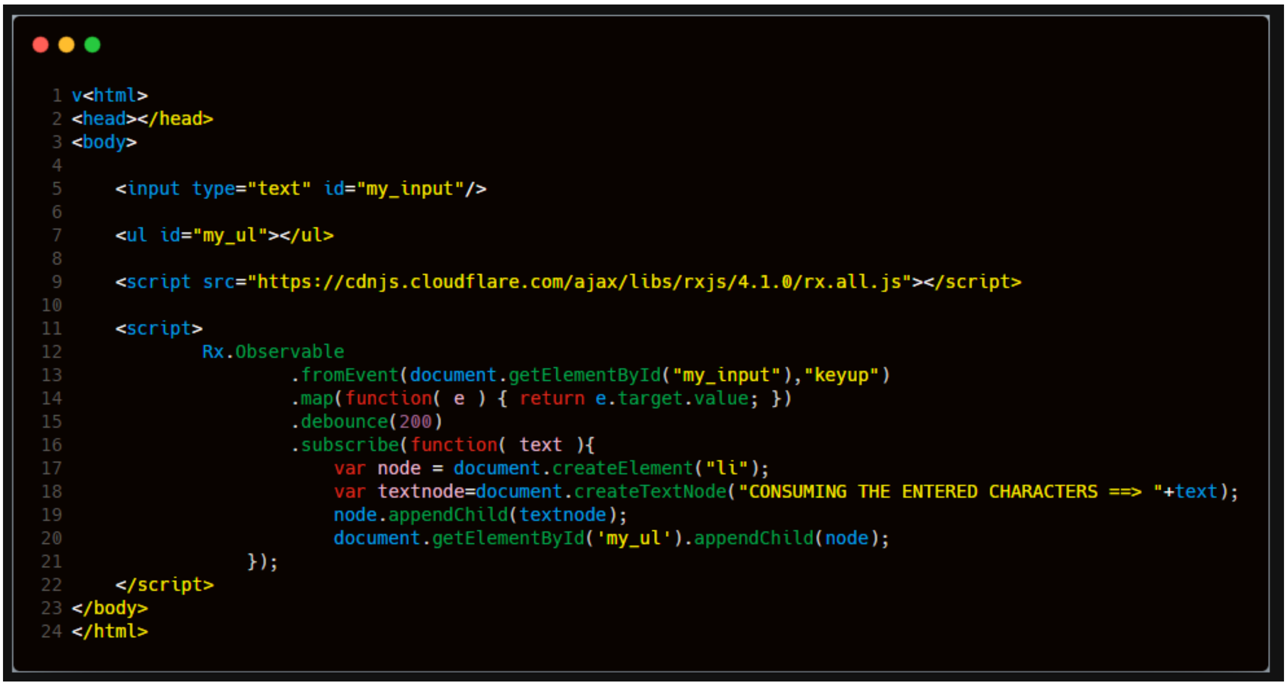
Examples

Observable creation with `from`

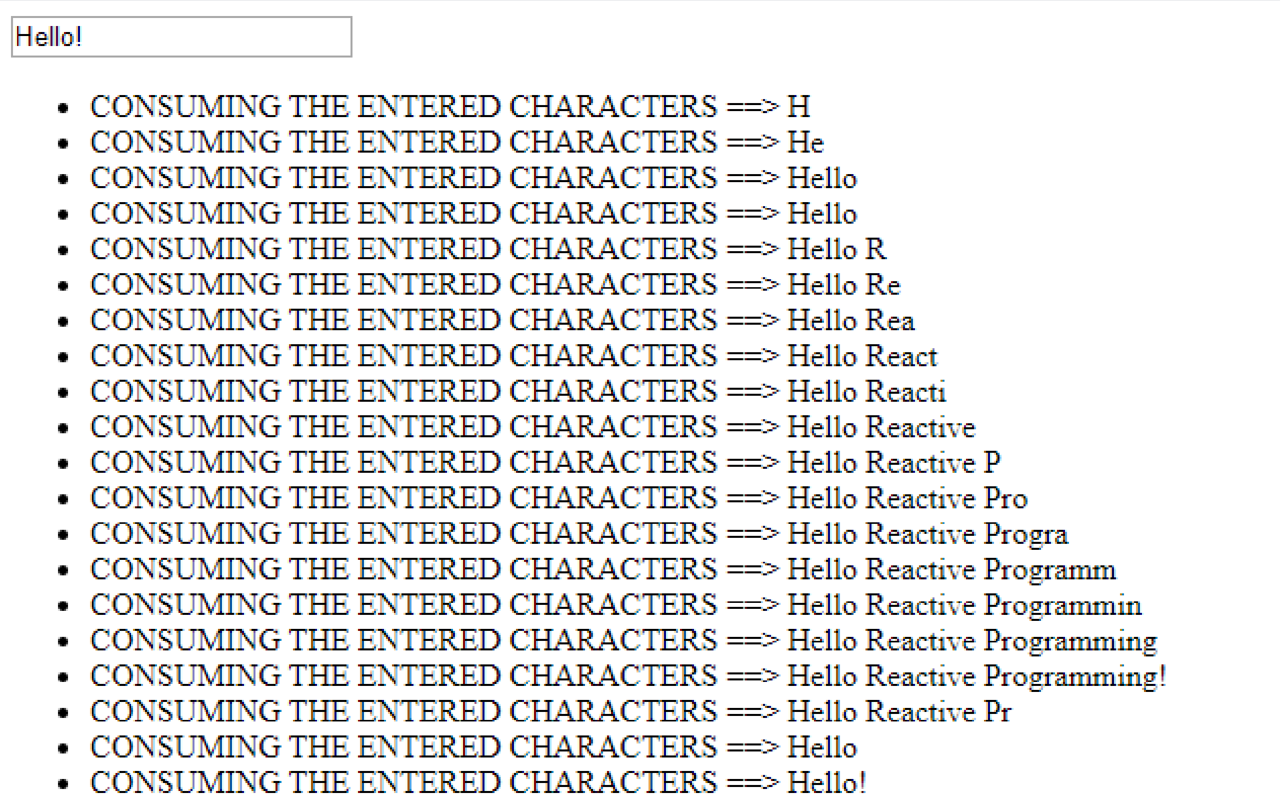
- 

```
var Rx = require('rx')

console.log('first Observable: create a Observable from [0, 1, 2, 3, 4, 5, 6, 7] and react (write them out)')
var firstObservable = Rx.Observable
                            .from([0, 1, 2, 3, 4, 5, 6, 7])


firstObservable.subscribe( item => console.log(item))


console.log('second Observable: create a Observable from [0, 1, 2, 3, 4, 5, 6, 7] duplicate them  and react (write them out)')

var secondObservable = Rx.Observable
                            .from([0, 1, 2, 3, 4, 5, 6, 7], item => item * 2 )


secondObservable.subscribe( item => console.log(item))

```

Observable creation with `event`

- 

```
v<html>
<head></head>
<body>

    <input type="text" id="my_input"/>

    <ul id="my_ul"></ul>

    <script src="https://cdnjs.cloudflare.com/ajax/libs/rxjs/4.1.0/rx.all.js"></script>

    <script>
            Rx.Observable
                   .fromEvent(document.getElementById("my_input"),"keyup")
                   .map(function( e ) { return e.target.value; })
                   .debounce(200)
                   .subscribe(function( text ){
                       var node = document.createElement("li");
                       var textnode=document.createTextNode("CONSUMING THE ENTERED CHARACTERS ==> "+text);
                       node.appendChild(textnode);
                       document.getElementById('my_ul').appendChild(node);
               });
    </script>
</body>
</html>
```



Hello!

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Reactive solution with Rx java libraries

Reactive solution main building blocks: Observer + Iterator design pattern implemented in

- RxJava 1.X
- RxJava 2.x

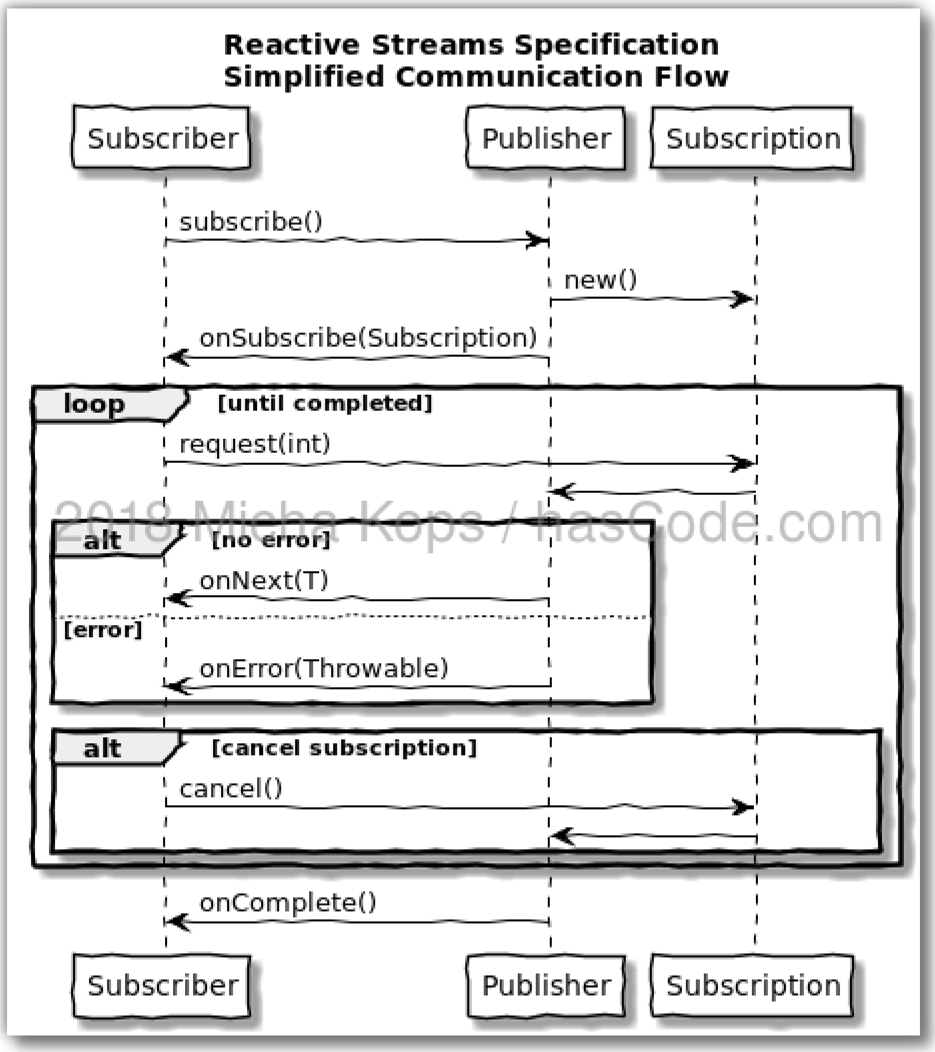
The Rx solutions not fully solved the `backpressure` issue: Rx implemented just the `pull` principle.

Reactive Stream spec

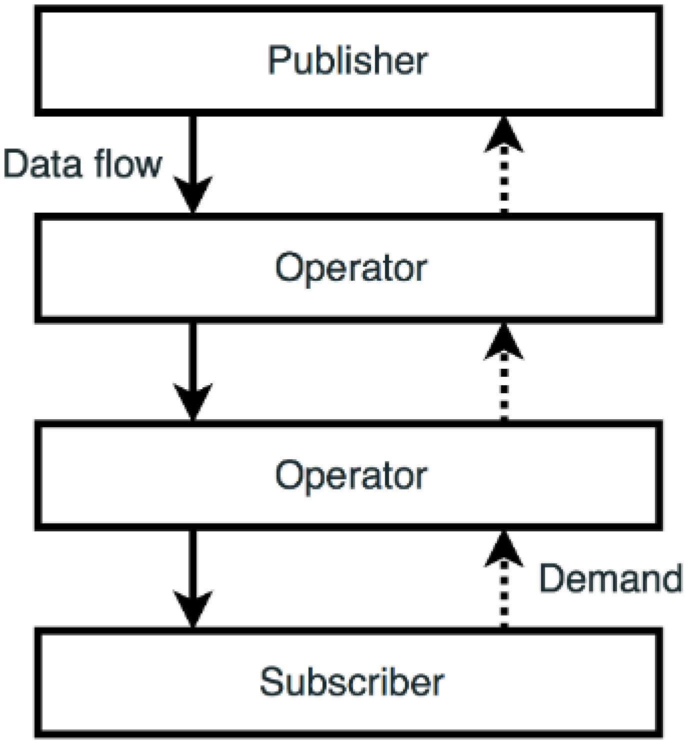
The Reactive Streams **specification** defines the following interfaces:

- `Publisher<T>` (start point of the communication)
- `Subscriber<T>` (end point of the communication),
- `Subscription` (handle the start - end points relation),
- and `Processor <T, R>` (some transformation logic).

by introducing the *pull-push* data exchange model resolves the *backpressure* issue.



2018 Micha Kops / hasCode.com



Projector Reactor as implementation of the Reactive Stream Spec

- Project Reactor 1.x

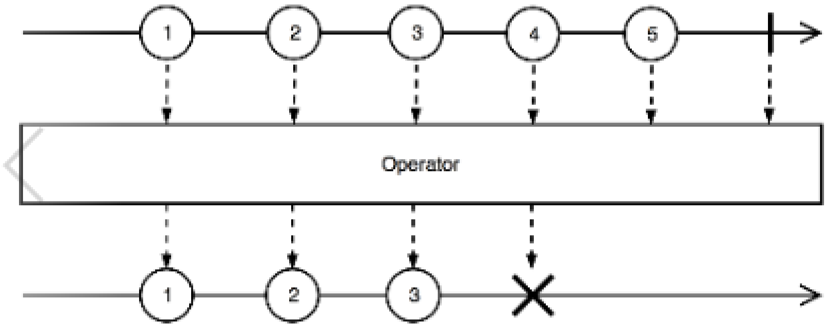
- Project Reactor 2.x

Adding Reactor to the Spring (5.x) project

```
compile("io.projectreactor:reactor-core:3.2.0.RELEASE")
//...
testCompile("io.projectreactor:reactor-test:3.2.0.RELEASE")
```

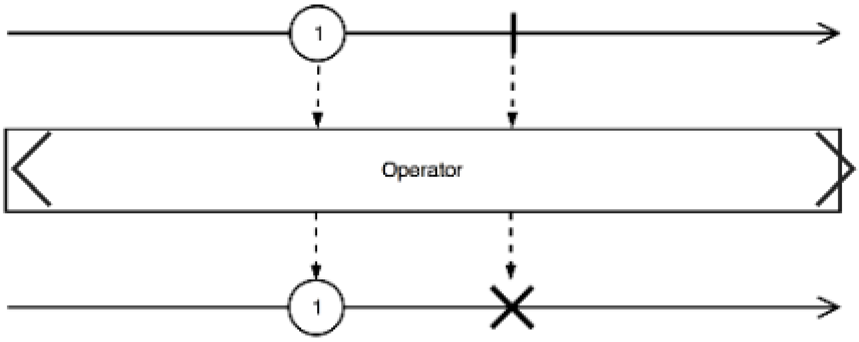
Reactive types – Flux and Mono as `Publisher<T>` implementation

- `Flux` defines a reactive stream that can produce zero, one, or many elements



Flux stream transformed into another Flux stream

`Mono` defines a reactive stream that can produce zero, or one element



Example of Reactive Flux streams

```
Flux<String>  stream1 = Flux.just("Hello","world");
Flux<Integer> stream2 = Flux.fromArray(newInteger[]{1,2,3});
Flux<Integer> stream3 = Flux.fromIterable(Arrays.asList(9, 8, 7));
//....
Flux<Integer> stream4 = Flux.range(2019, 9); // starting with 2019 generate 9
elements
```

Example of Reactive Mono streams

```
Mono<String> stream5 = Mono.just("One");
Mono<String> stream6 = Mono.justOrEmpty(null);
Mono<String> stream7 = Mono.justOrEmpty(Optional.empty());
//...
Mono<String> stream8 = Mono.fromCallable(()->httpRequest()); // handling a asynchronous requests http|db
// shorthener way
Mono<String> stream8 = Mono.fromCallable(this::httpRequest);
```

Use cases with different `subscribe` functions.

```
Flux.just("A","B","C")
  .subscribe(
        data -> log.info("onNext: {}", data),
        err ->{ /* ignored  */ },
        ()-> log.info("onComplete")
      );
```

```
  Flux.range(1, 100)
                .subscribe(
                        data -> log.info("onNext: {}", data),
                        err -> { /* ignore */ },
                        () -> log.info("onComplete"),
                        subscription -> {
                            subscription.request(4);
                            //subscription.cancel();
                            log.info("Request end for 4 ");
                            subscription.request(4);
                        }
                );
```

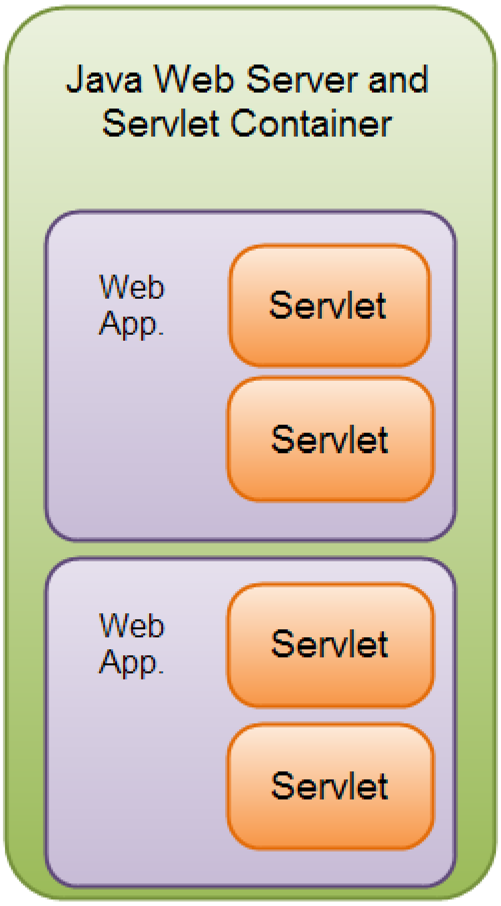
Reactive Spring

Spring as "classic"

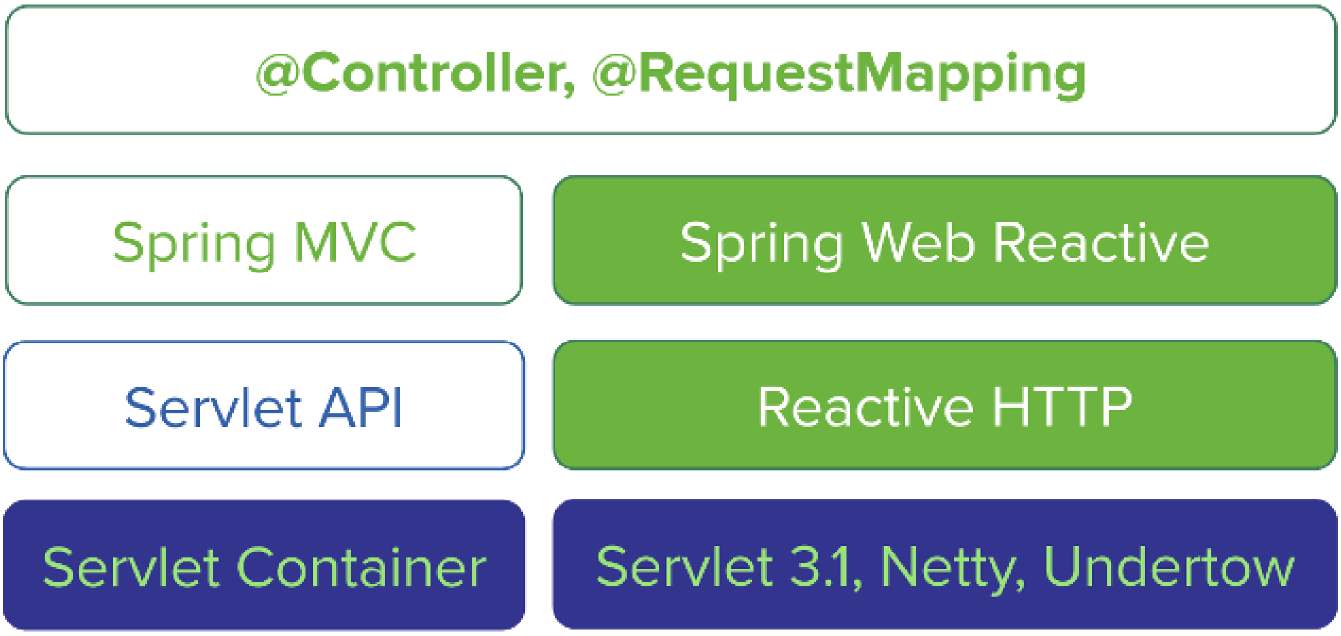
Main concept are the

- Servlet Container
- Servlet

Servlet Container for ex. is the embedded Jetty/Tomcat/etc. webserver



Reactive Sping with Netty

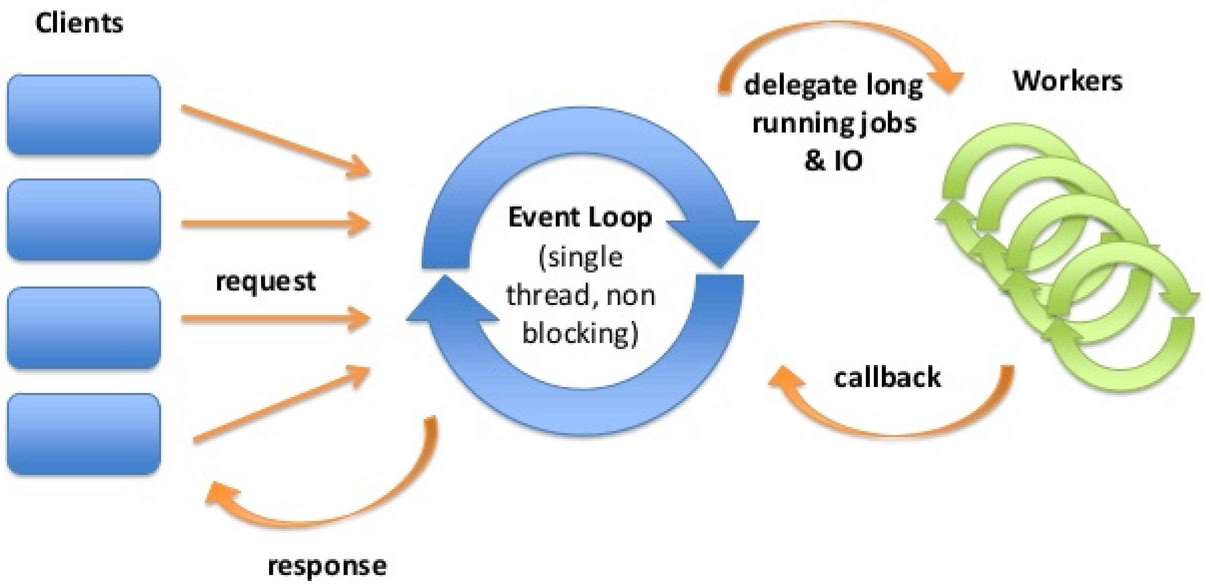


Netty:

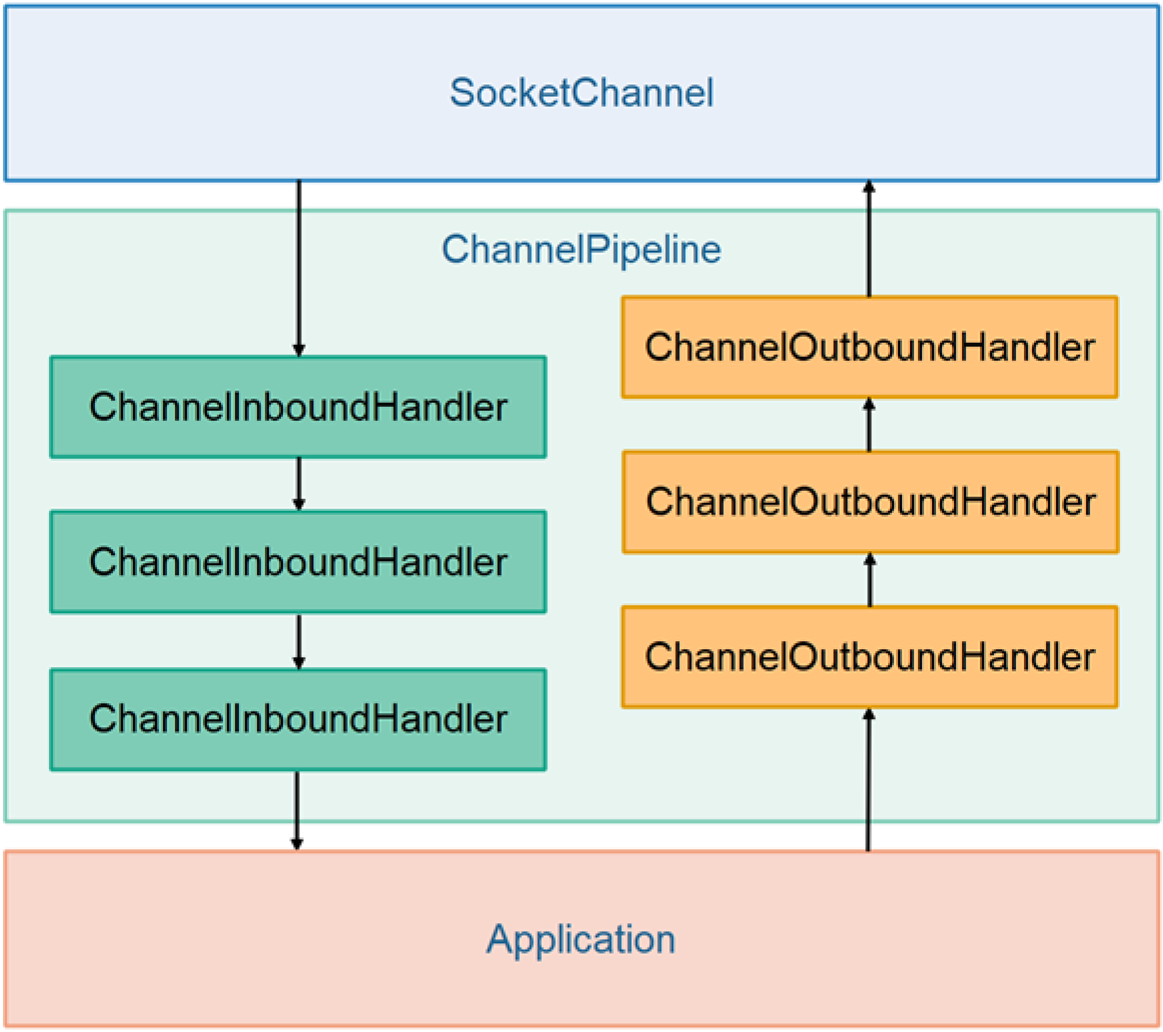
- asynchronous
- event-driven
- network

based `application framework` for network intesnsive IO applications.

Uses a single thread concurrency models and designed around non-blocking IO

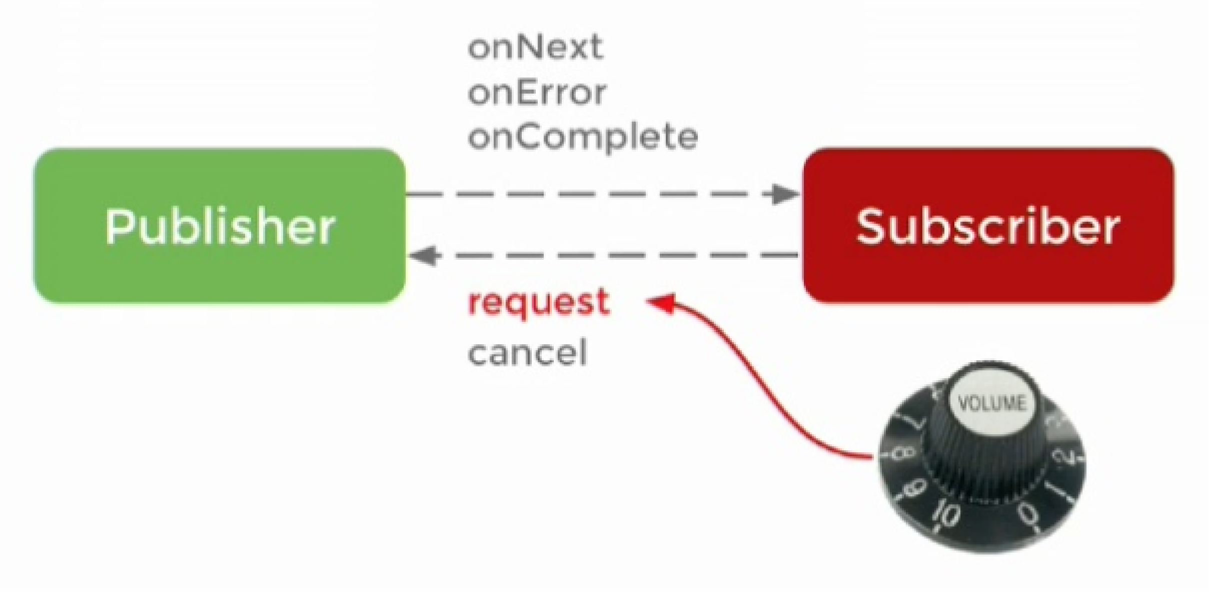


The main buildig blocks in actions:



The core features are :

- handle the backpressure `backpressure` is a mechanism that permits a receiver to ask how much dat it wants to receive from the emitter.
- implements the push-pull strategy|model



- reactive `stream` based controllers , and alternatives to different handler design
- functional programming (lambda oriented routing, processing)
- non-blocking: make asynchronous calls and respond as the results of those calls are returned

Initializing Spring with reactive features (Use Case)

- Web -> Reactive Web (Includes Spring WebFlux)
- NoSQL -> Reactive MongoDB (includes the drivers)
- NoSQL -> Embedded MongoDB (run embedded version of MongoDB)
- Core -> Lombok (special annotation will generate getters, setters. etc...)

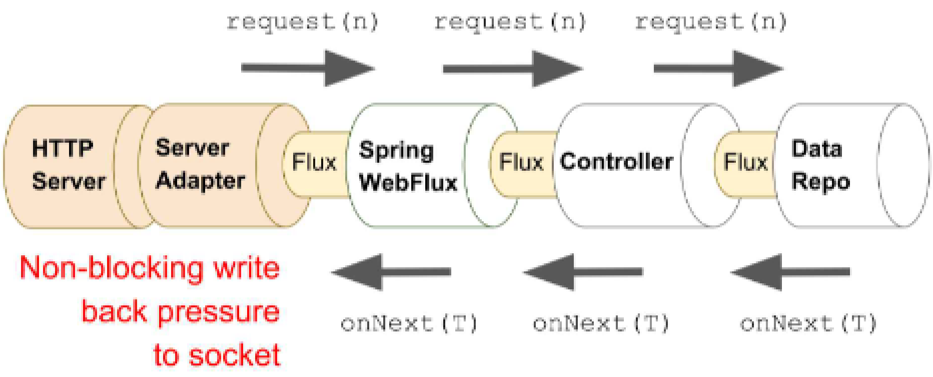
Application dependencies (starters)

```
dependencies {
    compile('org.springframework.boot:spring-boot-starter-data-mongodb-reactive')
    compile('org.springframework.boot:spring-boot-starter-webflux')
    compile('org.projectlombok:lombok')
    compile('de.flapdoodle.embed:de.flapdoodle.embed.mongo')
    runtime('org.springframework.boot:spring-boot-devtools')
    testCompile('org.springframework.boot:spring-boot-starter-test')
    testCompile('io.projectreactor:reactor-test')
}
```

(Webflux) application main elements

- DeliveryModel - define the model returned by the repository
- DeliveryRepository - define the interface of the repository, to persist to and from the DB (reactive DB!!!)
- DeliveryService (Interface and Implementation) - implement the service logic (interact with the repository)

- DeliveryController - receives the requests and return reactive responses (Mono and FLuxes)



Important notes regarding the DB

```
@EnableReactiveMongoRepositories
@SpringBootApplication
public class AnnotationdemoApplication {

    public static void main(String[] args) {
        SpringApplication.run(AnnotationdemoApplication.class, args);
    }

}
```

Functional reactive services with Spring WebFlux

Functional Spring WebFlux application is based on

- a router responsible for routing HTTP requests to handler functions.
- handler functions are responsible for executing business functionality and building responses.

In the handler functions

- The handler functions return Mono.
- each method is passed a `ServerRequest` argument
- the `ok()` method returns a `BodyBuilder` with an HTTP status code of 200;
- the `body()` method sets the contents to be returned to the caller and returns a `Mono<ServerResponse>`.