AVOID THE CALLBACK HELL WHEN USING NON-BLOCKING I/O

Use Reactive frameworks for scalable and resilient server applications

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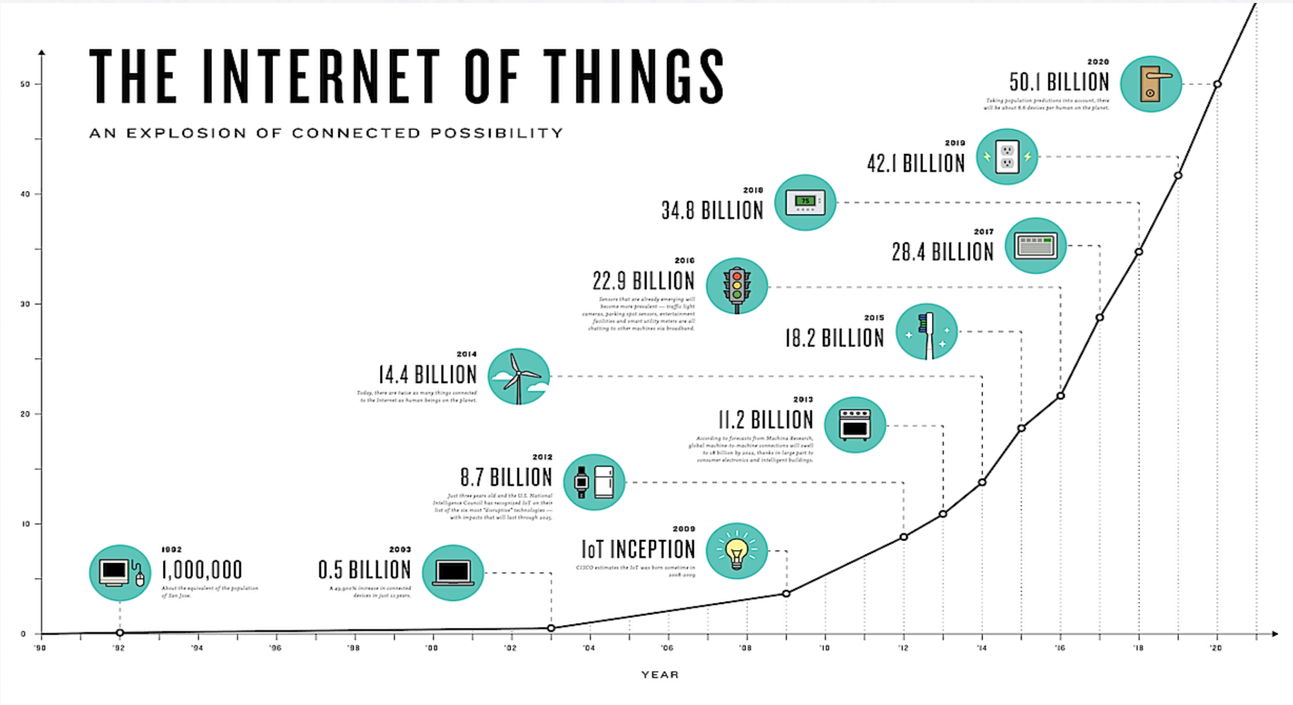
2014-12-04 | CALLISTAENTERPRISE.SE

AGENDA

- Recap - *Don't block your Mobiles and Internet of Things*
- Theory - *FRP, Functional Reactive Programming*
- Examples
  - Java 8 – *Lambdas and Streams*
  - RXJava – *Observables and Observers*
  - Next level – *Scala, Akka and Play*
- Summary & next step

Recap - *Don't block your Mobiles and Internet of Things*

THE SCALABILITY CHALLENGE...



THE INTERNET OF THINGS

AN EXPLOSION OF CONNECTED POSSIBILITY

1992
1,000,000
About the equivalent of the population of San Jose.

2003
0.5 BILLION
A 49,900% increase in connected devices in just 11 years.

2009
IoT INCEPTION
CISCO estimates the IoT was born sometime in 2008-2009

2012
8.7 BILLION
Just three years old and the U.S. National Intelligence Council has recognized IoT on their list of the six most "disruptive" technologies — with impacts that will last through 2025.

2013
11.2 BILLION
According to forecasts from Machina Research, global machine-to-machine connections will swell to 18 billion by 2022, thanks in large part to consumer electronics and intelligent buildings.

2014
14.4 BILLION
Today, there are twice as many things connected to the Internet as human beings on the planet.

2015
18.2 BILLION

2016
22.9 BILLION
Sensors that are already emerging will become more prevalent — traffic light cameras, parking spot sensors, entertainment facilities and smart utility meters are all chatting to other machines via broadband.

2017
28.4 BILLION

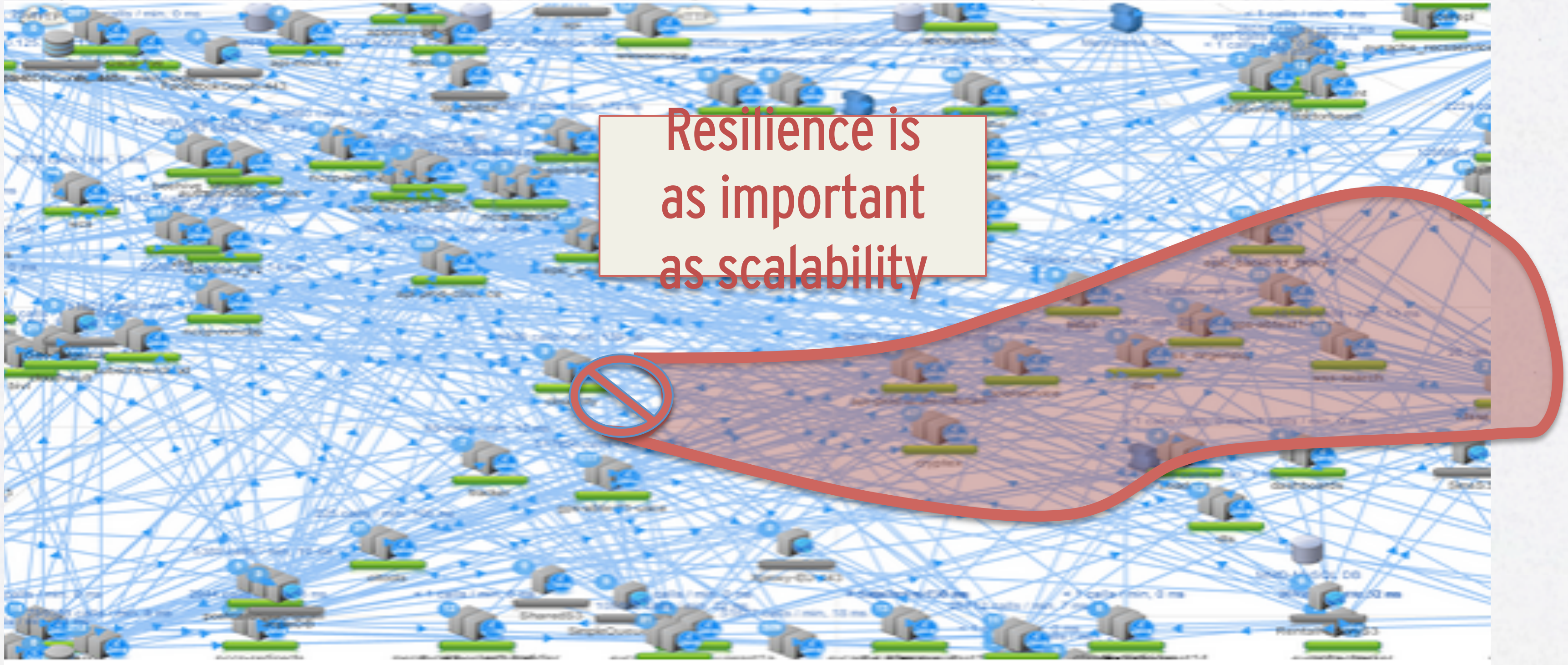
2018
34.8 BILLION

2019
42.1 BILLION

2020
50.1 BILLION
Taking population predictions into account, there will be about 6.6 devices per human on the planet.

Source: http://www.theconnectivist.com/2014/05/infographic-the-growth-of-the-internet-of-things/

WATCH OUT FOR THE DOMINO EFFECT!

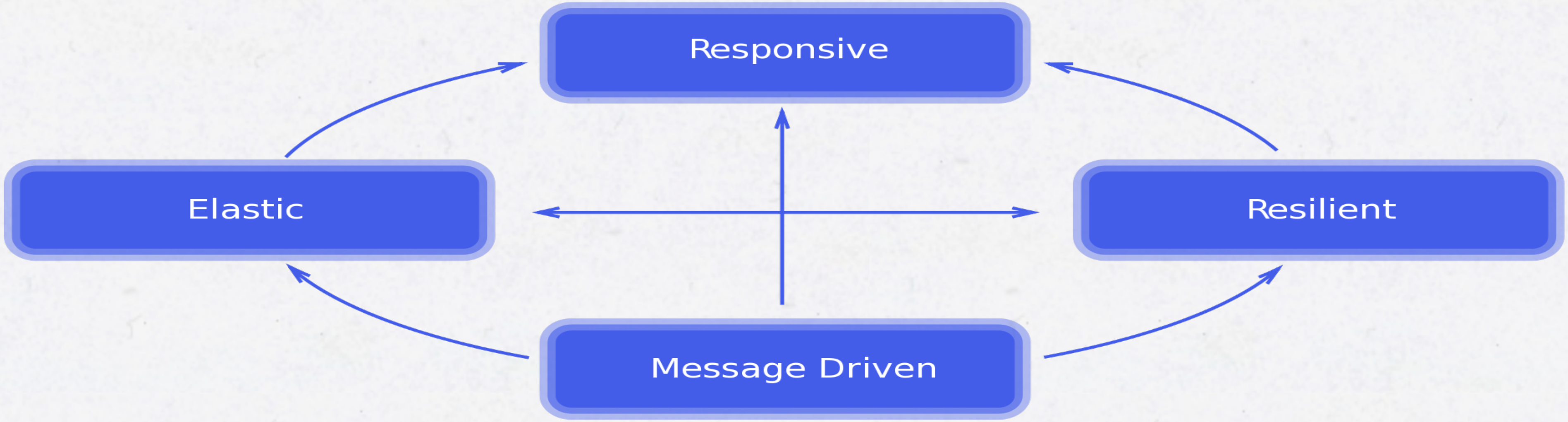


Resilience is as important as scalability

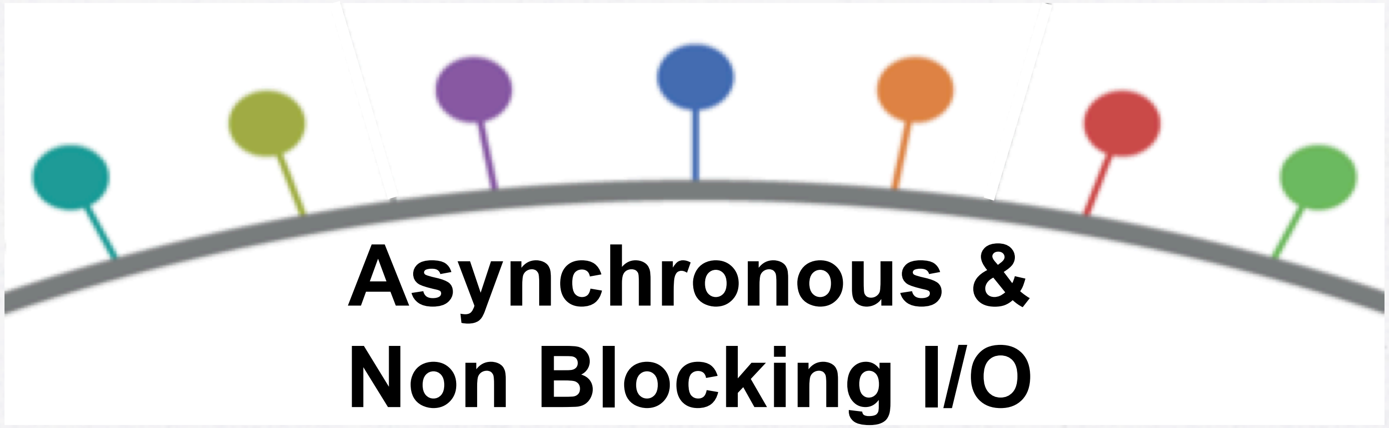
Source: http://techblog.netflix.com/2013/01/announcing-ribbon-tying-netflix-mid.html

THE REACTIVE MANIFESTO

- http://www.reactivemanifesto.org



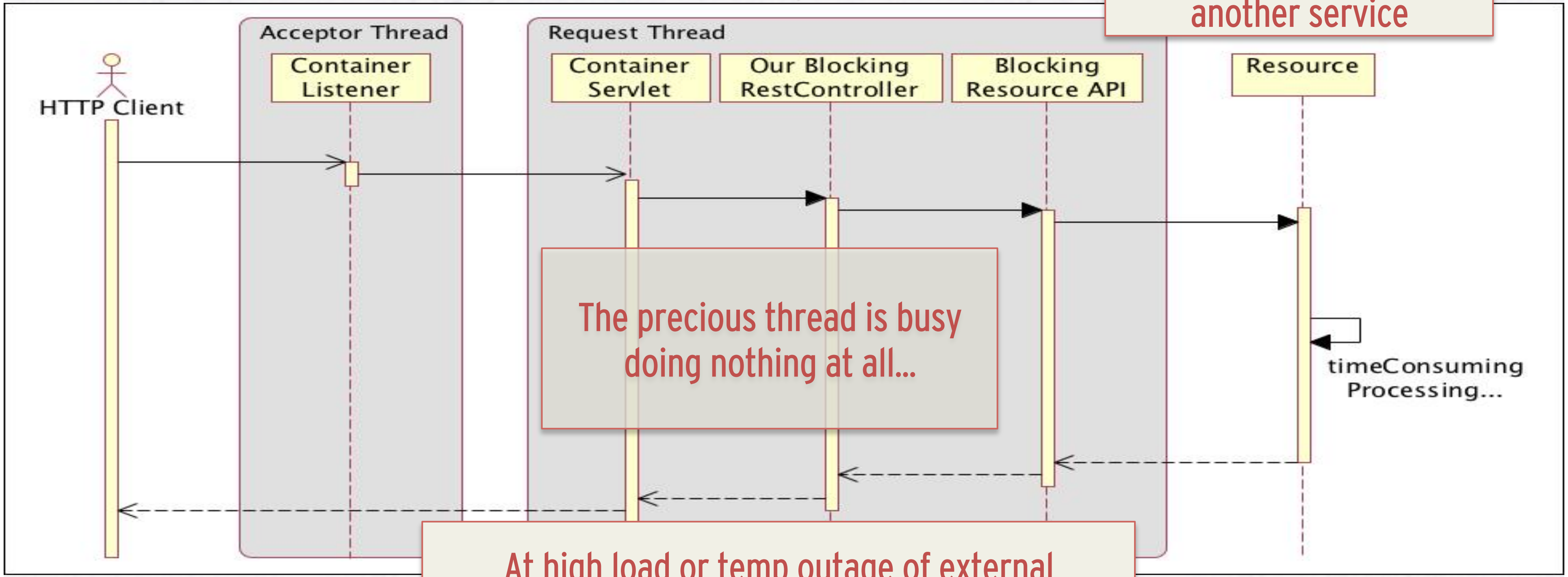
THE FUNDAMENT OF REACTIVE SYSTEMS



Asynchronous &
Non Blocking I/O

TRADITIONAL BLOCKING I/O

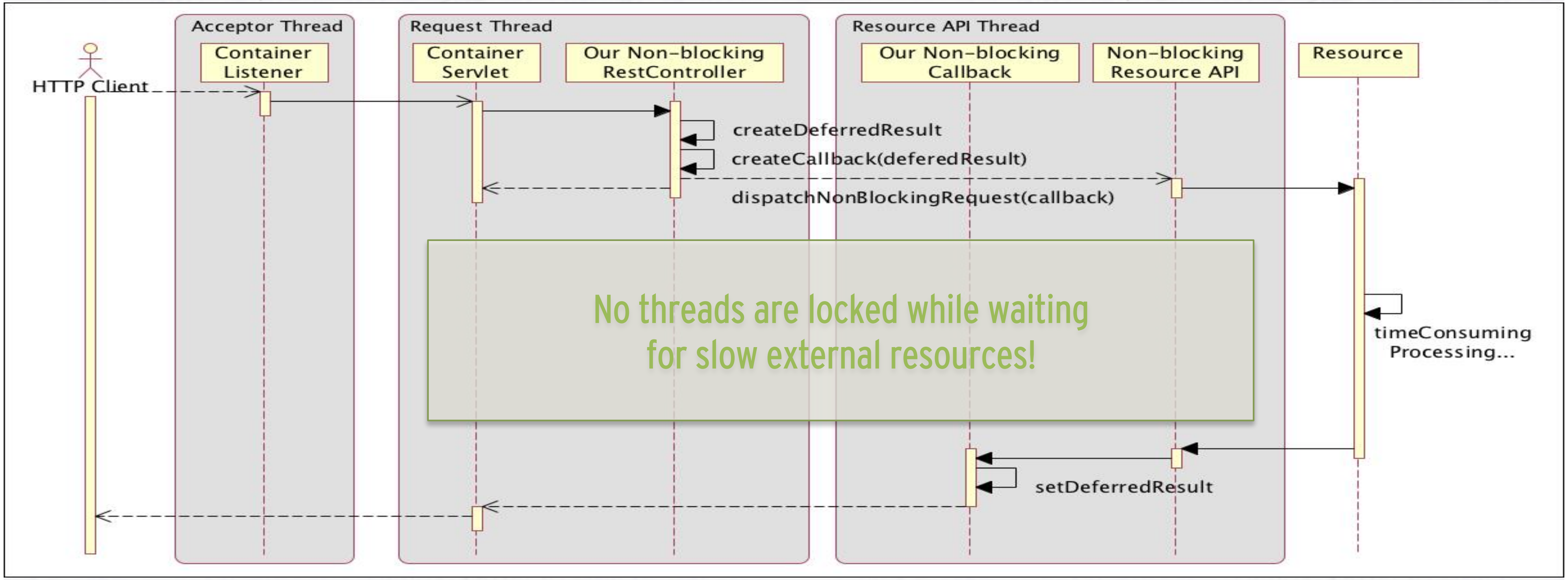
Slow external resource, e.g. a database or another service



The precious thread is busy doing nothing at all...

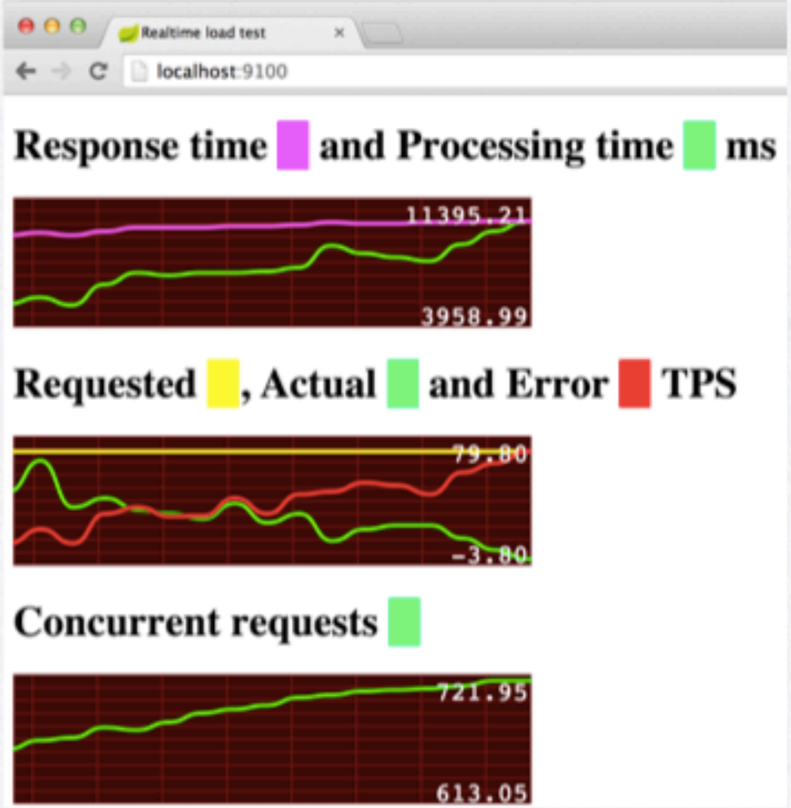
At high load or temp outage of external resources thread-pools are quickly filled up resulting in all kinds of problems...

NON-BLOCKING I/O


Acceptor Thread
Request Thread
Resource API Thread
HTTP Client
Container Listener
Container Servlet
Our Non-blocking RestController
Our Non-blocking Callback
Non-blocking Resource API
Resource
createDeferredResult
createCallback(deferedResult)
dispatchNonBlockingRequest(callback)
timeConsuming Processing...
setDeferredResult

No threads are locked while waiting for slow external resources!

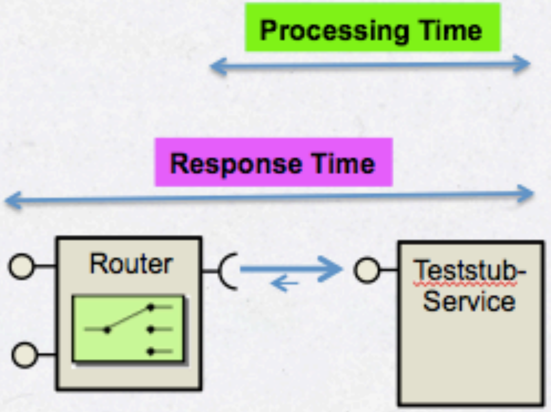
SAMPLE OUTPUT FROM A LOAD TEST



Response time 🟪 and Processing time 🟩 ms

Requested 🟨, Actual 🟩 and Error 🟥 TPS

Concurrent requests 🟩



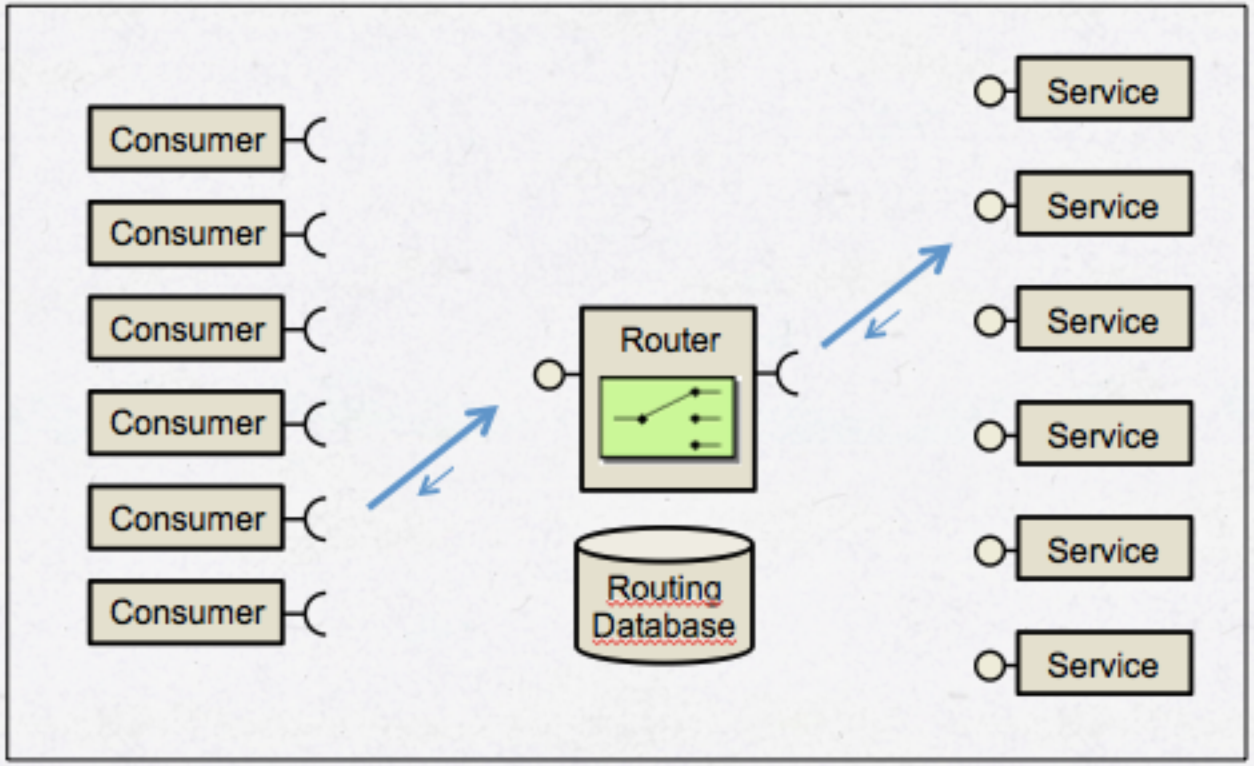
Processing Time

Response Time

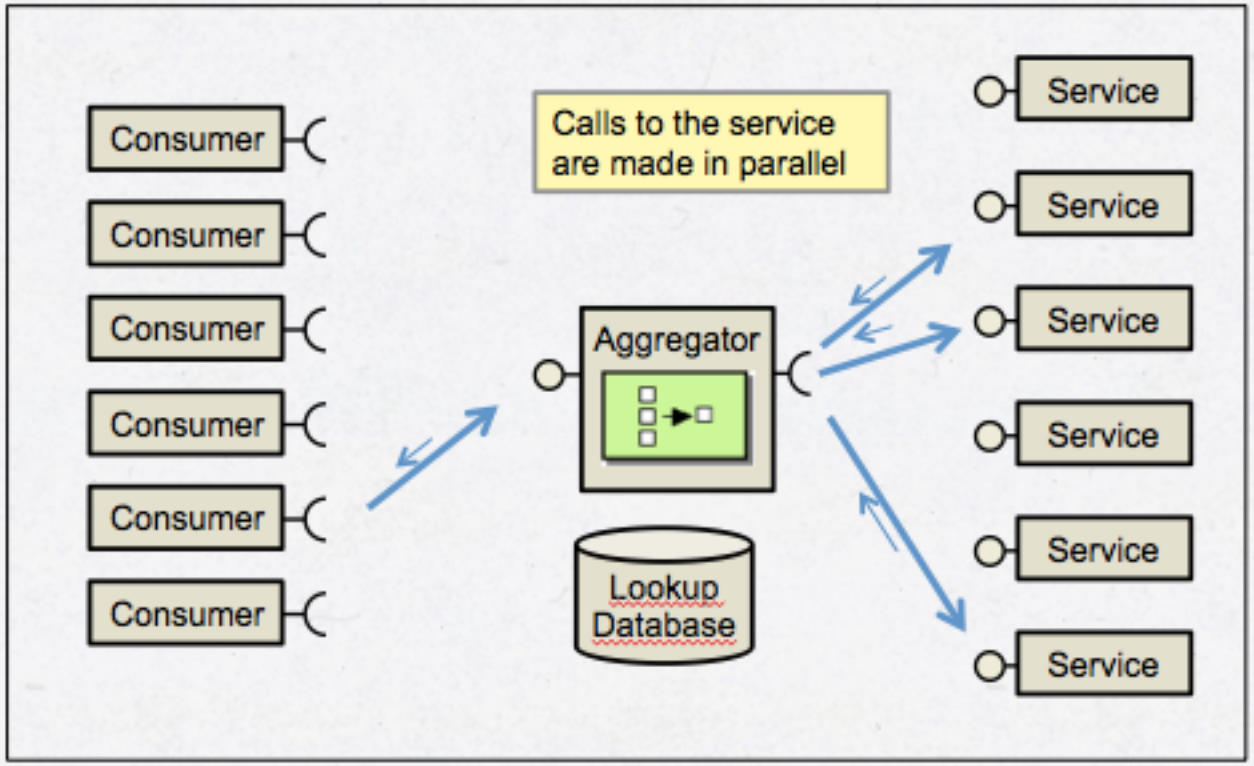
Router

Teststub-Service

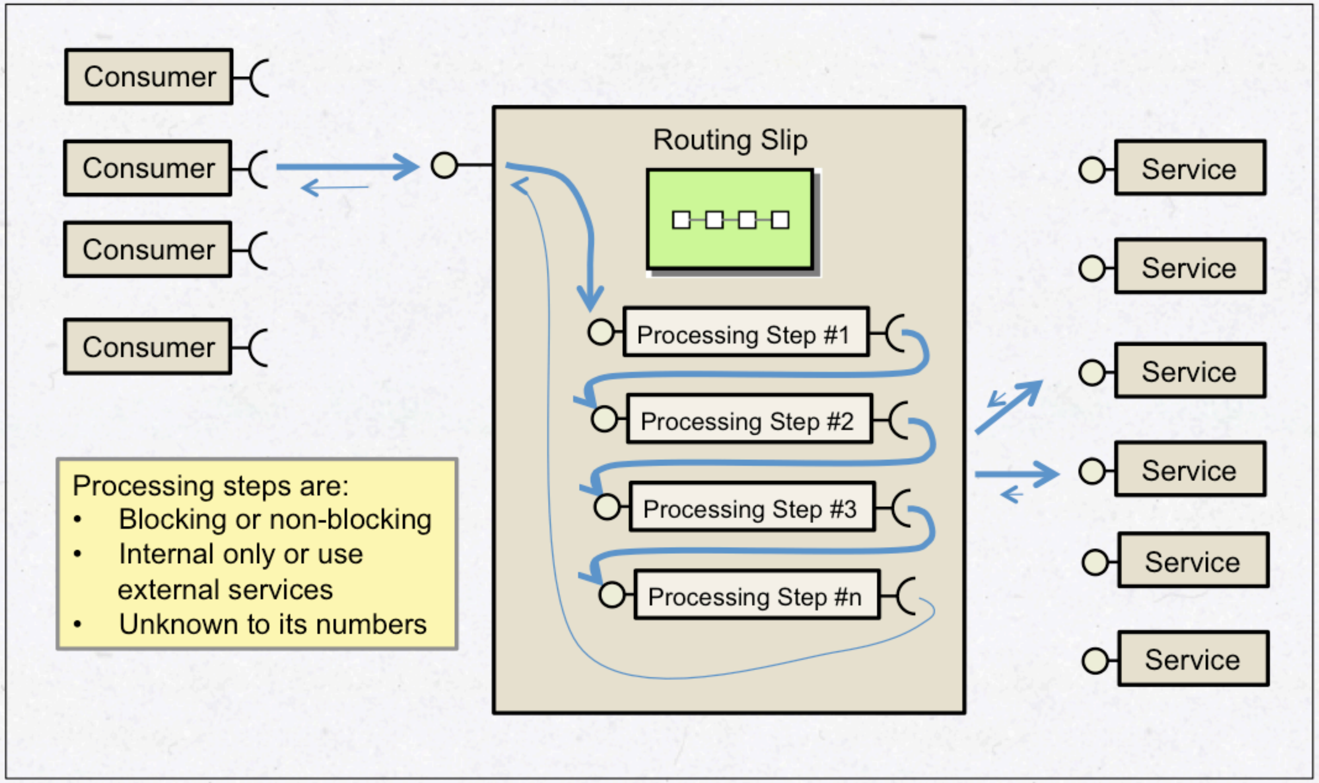
PATTERNS - ROUTER



PATTERNS - AGGREGATOR



PATTERNS - ROUTING SLIP



Processing steps are:
- Blocking or non-blocking
- Internal only or use external services
- Unknown to its numbers

1. SPRING MVC -BLOCKING I/O VS. NON BLOCKING I/O

BLOCKING I/O

```
@RestController
public class MyController {

  @RequestMapping("/block")
  public R block(...) {
    ...
    return new R(...);
  }
}
```

DeferredResult IS THE KEY SPRING MVC ABSTRACTION!

CALLBACK MODEL

NON BLOCKING I/O

```
@RestController
public class ProcessingController {

  @RequestMapping("/non-block")
  public DeferredResult<R> nonBlock(...) {

    DeferredResult<R> dr =
      new DeferredResult<>();
    dispatch(new MyTask(dr, ...));
    return dr;
```

```
public class MyTask implements MyCallback {

  private DeferredResult<R> deferredResult;
  public MyTask(DeferredResult<R> dr, ...) {
    this.df = df;
  }
  public void done() {
    df.setResult(new R(...));
```

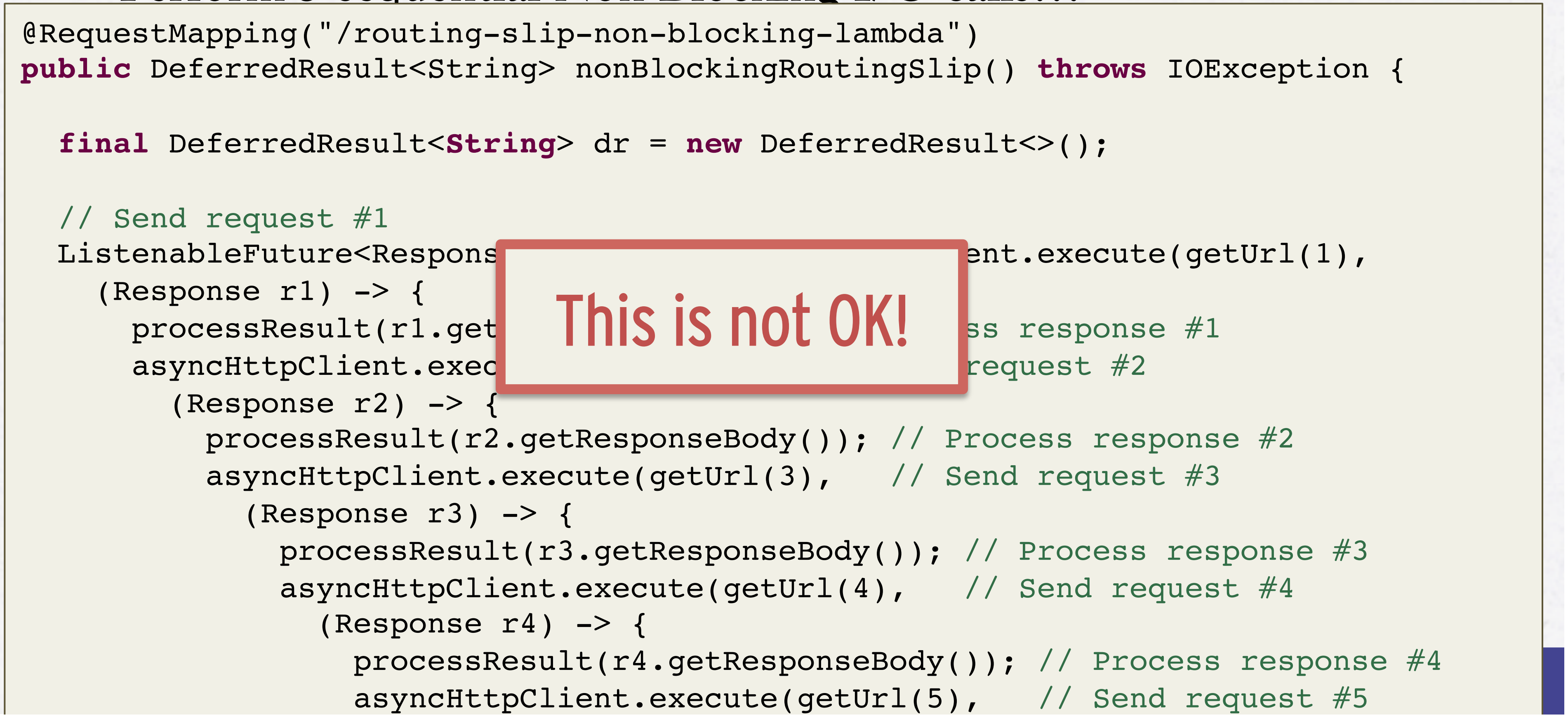
2.C JAVA 8 AND LAMBDAS

```
@RestController
public class MyController {

  @RequestMapping("/block")
  public String block(...) {
    ...
    resp = callUrl(...);
    return resp.getBody();
  }
}
```

```
@RestController
public class MyController {

  @RequestMapping(”/non-block")
  public DeferredResult<String>
    nonBlock (...) {

    final DeferredResult<String> dr =
      new DeferredResult<>();

    asyncHttpClient.execute(getUrl(...),
      (response) ->  {
        dr.setResult(
          response.getResponseBody());
      },
      (throwable) -> {...}
    );
```

ROUTING SLIP - EXAMPLE OF “THE CALLBACK HELL”

- Perform 5 sequential Non Blocking I/O calls…



```
@RequestMapping("/routing-slip-non-blocking-lambda")
public DeferredResult<String> nonBlockingRoutingSlip() throws IOException {

  final DeferredResult<String> dr = new DeferredResult<>();

  // Send request #1
  ListenableFuture<Respons                         ent.execute(getUrl(1),
    (Response r1) -> {
      processResult(r1.get                           ss response #1
      asyncHttpClient.exec                           request #2
        (Response r2) -> {
          processResult(r2.getResponseBody()); // Process response #2
          asyncHttpClient.execute(getUrl(3),   // Send request #3
            (Response r3) -> {
              processResult(r3.getResponseBody()); // Process response #3
              asyncHttpClient.execute(getUrl(4),   // Send request #4
                (Response r4) -> {
                  processResult(r4.getResponseBody()); // Process response #4
                  asyncHttpClient.execute(getUrl(5),   // Send request #5
```

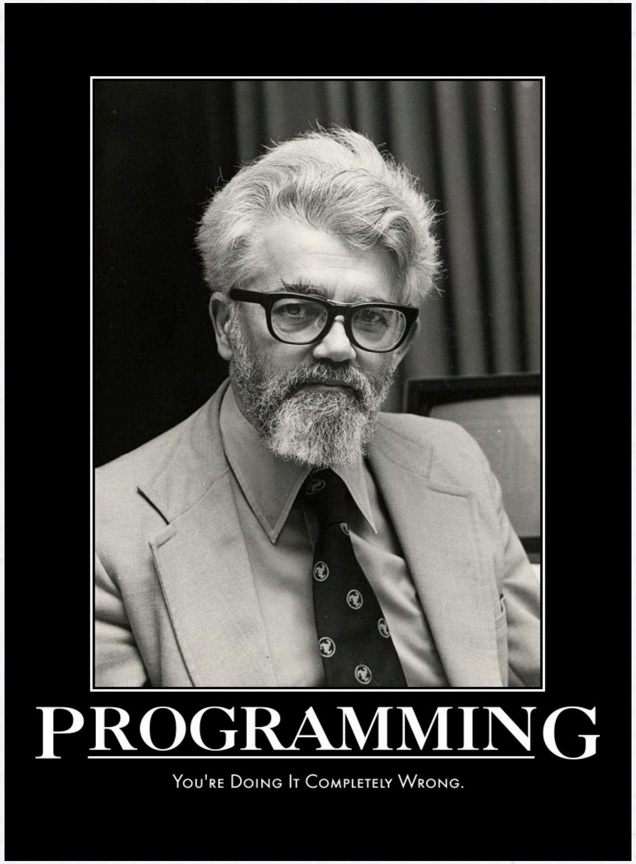
This is not OK!

PREVIEW - "THE WAY OUT OF CALLBACK HELL…"

```
final DeferredResult<String> dr = new DeferredResult<>();

ListenableFuture<Response> execute = asyncHttpClient.execute(getUrl(1),
  (Response r1) -> {
    processResult(r1.getResponseBody());
    asyncHttpClient.execute(getUrl(2),
      (Response r2) -> {
        processResult(r2.getResponseBody());
        asyncHttpClient.execute(getUrl(3),
          ...
                  (Response r5) -> {
                    processResult(r5.getResponseBody());
                    dr.setResult(getTotalResult());
```

```
final DeferredResult<String> deferredResult = new DeferredResult<>();

Subscription subscription = Observable.<List<String>>just(new ArrayList<>())
  .flatMap(result -> doAsyncCall(result, 1, this::processResult))
  .flatMap(result -> doAsyncCall(result, 2, this::processResult))
  .flatMap(result -> doAsyncCall(result, 3, this::processResult))
  .flatMap(result -> doAsyncCall(result, 4, this::processResult))
  .flatMap(result -> doAsyncCall(result, 5, this::processResult))
```

REACTIVE



Asynchronous programming, are we doing it wrong?

SYNCHRONOUS VS ASYNCHRONOUS

	Single item	Multiple items
Synchronous	T get ()	Iterable<T> get()
Asynchronous	Future<T> get()	Observable<T> get()

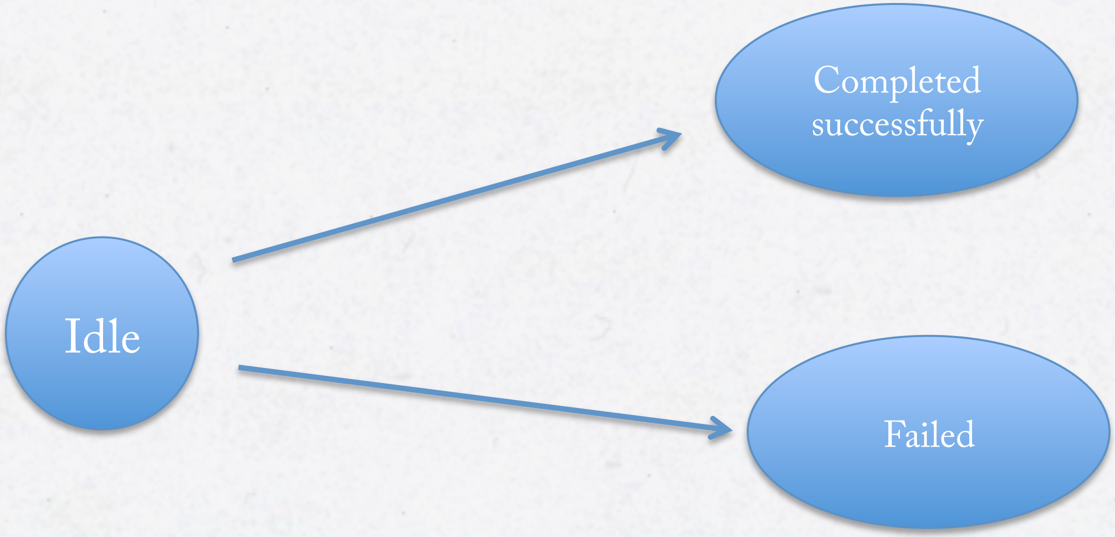
SYNCHRONOUS VS ASYNCHRONOUS

	Single item	Multiple items
Synchronous	T get ()	Iterable<T> get()
Asynchronous	Future<T> get()	Observable<T> get()

FUTURES

- Future is a placeholder for a value that does not yet exist
- The value of a future is calculated concurrently
- Futures are non-blocking (not Java Futures!)
- Futures are only assigned once
- Futures are read only
- Futures are composable without blocking or waiting

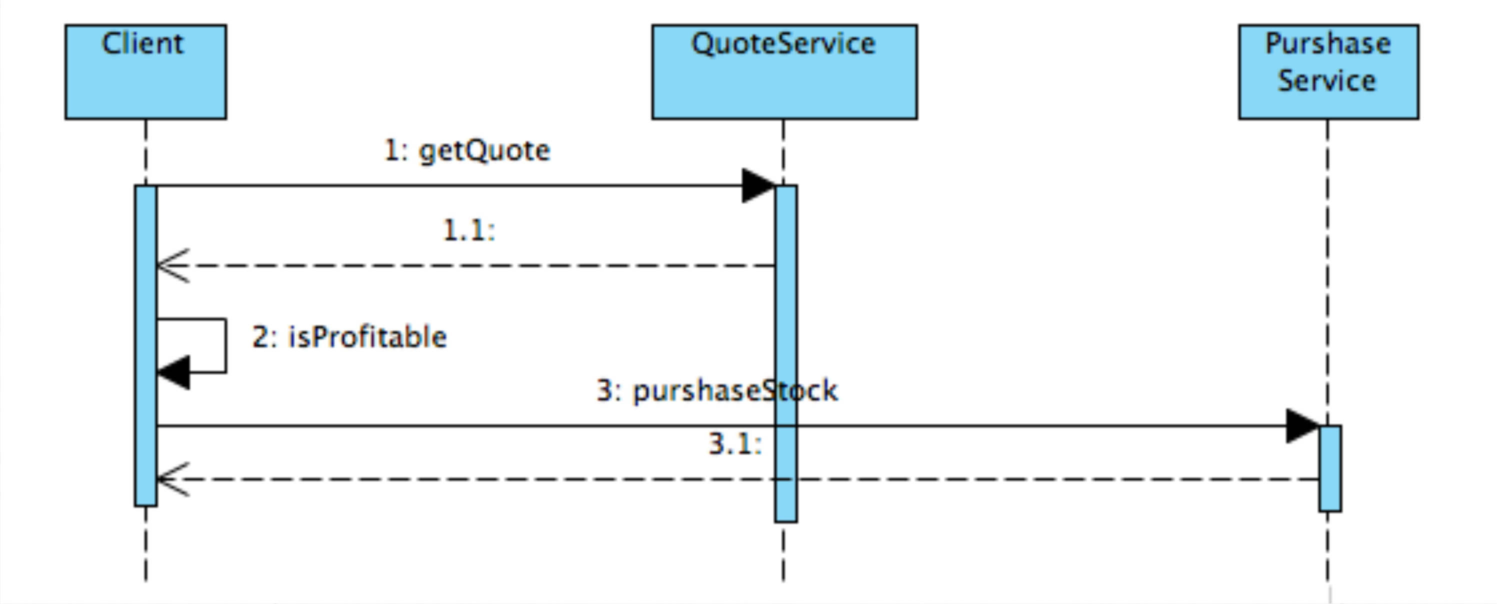
FUTURE STATES



LAMBDAS

```
name = (param1, param2): T-> { ... }

buyStock = (stockName, amount): Boolean -> { ... }
```

ASYNCHRONOUS WITH CALLBACK

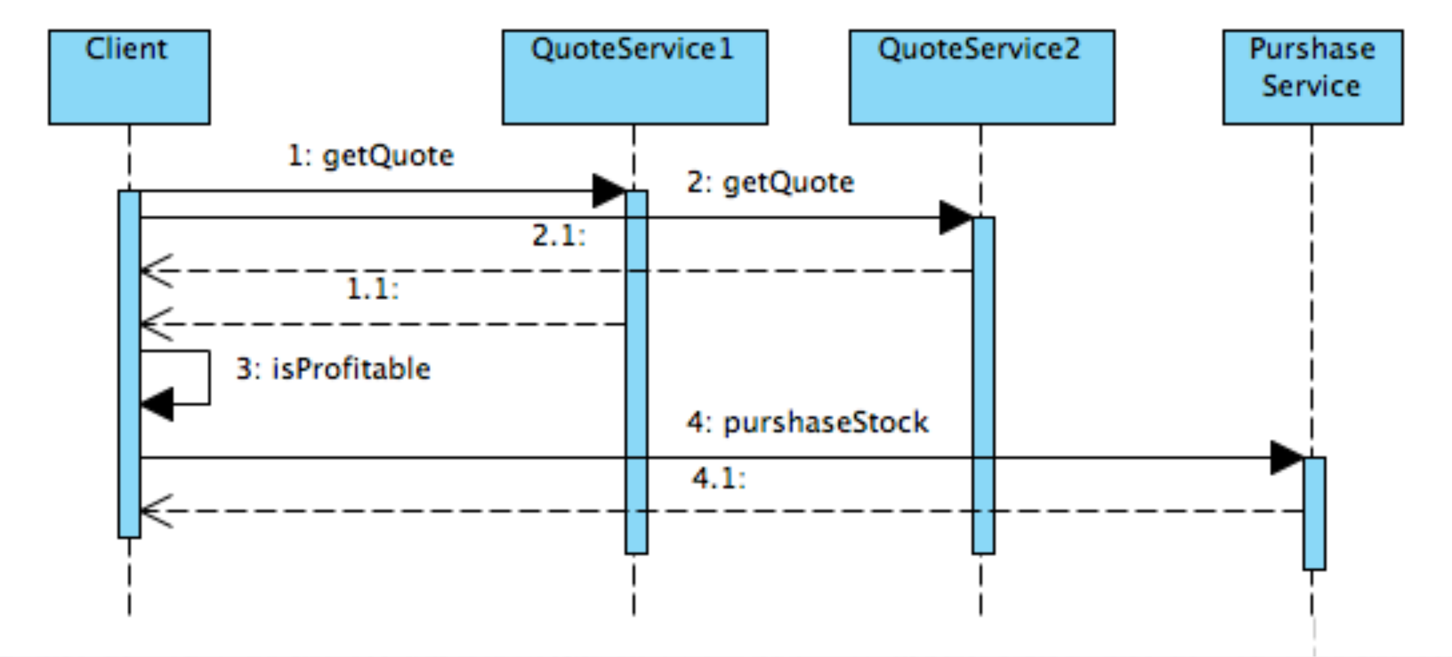


ASYNCHRONOUS WITH CALLBACK

```
getQuote = (stock, callback) -> { ... }
buyStock = (stock, callback) -> { ... }

getQuote( “ERICB”, quote -> {

   if( isProfitable(quote) ) buyStock( “ERICB”, result -> {

       if( result == OK )
          println( “Purshased $result” )
       }

   })

})
```

Callback functions

ASYNCHRONOUS WITH CALLBACK



ASYNCHRONOUS WITH CALLBACK

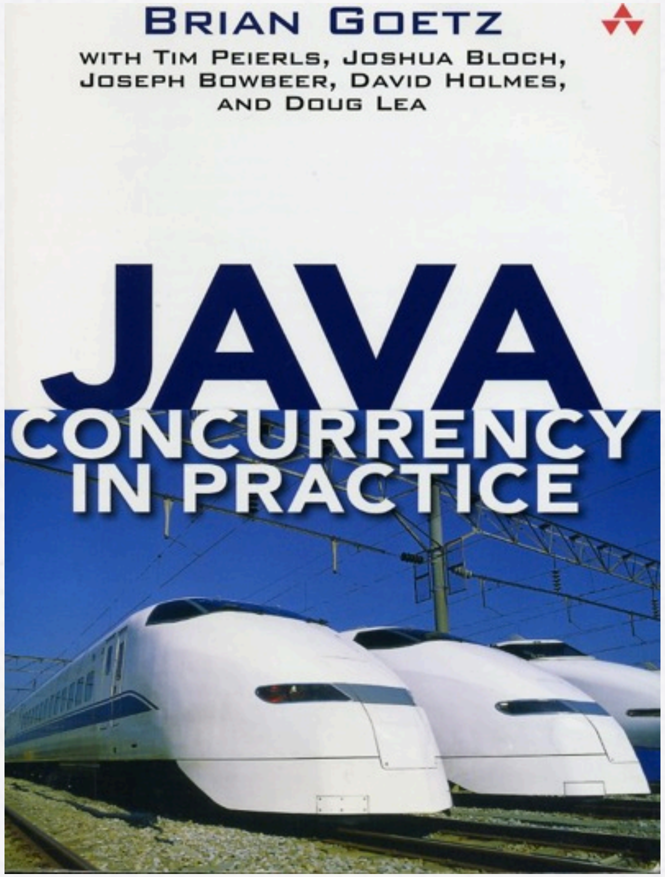
```
getQuote (stock, callback) -> { ... }

var ericQuote, volvoQuote
getQuote( “ERICB”, quote -> {
   ericQuote = quote
})
getQuote( “VOLVOB”, quote -> {
   volvoQuote = quote
})

wait…

if( isProfitable(ericQuote, volvoQuote) )
   buyStock(“ERICB” result -> …)
```

Parallel executions

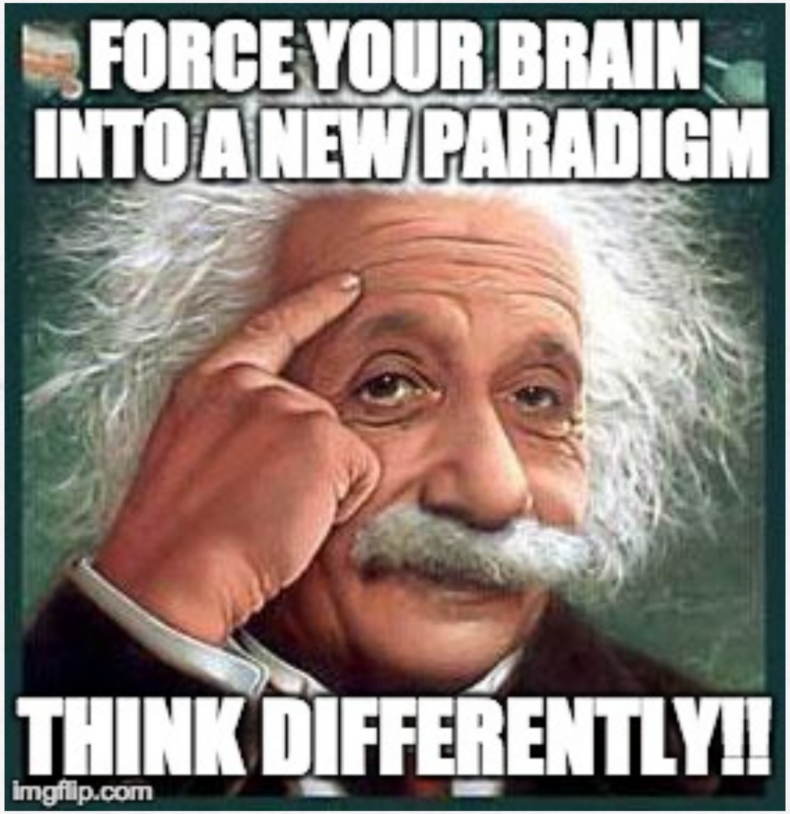
Wait for both to complete
BLOCKING!

Another non blocking call

SOLUTION?

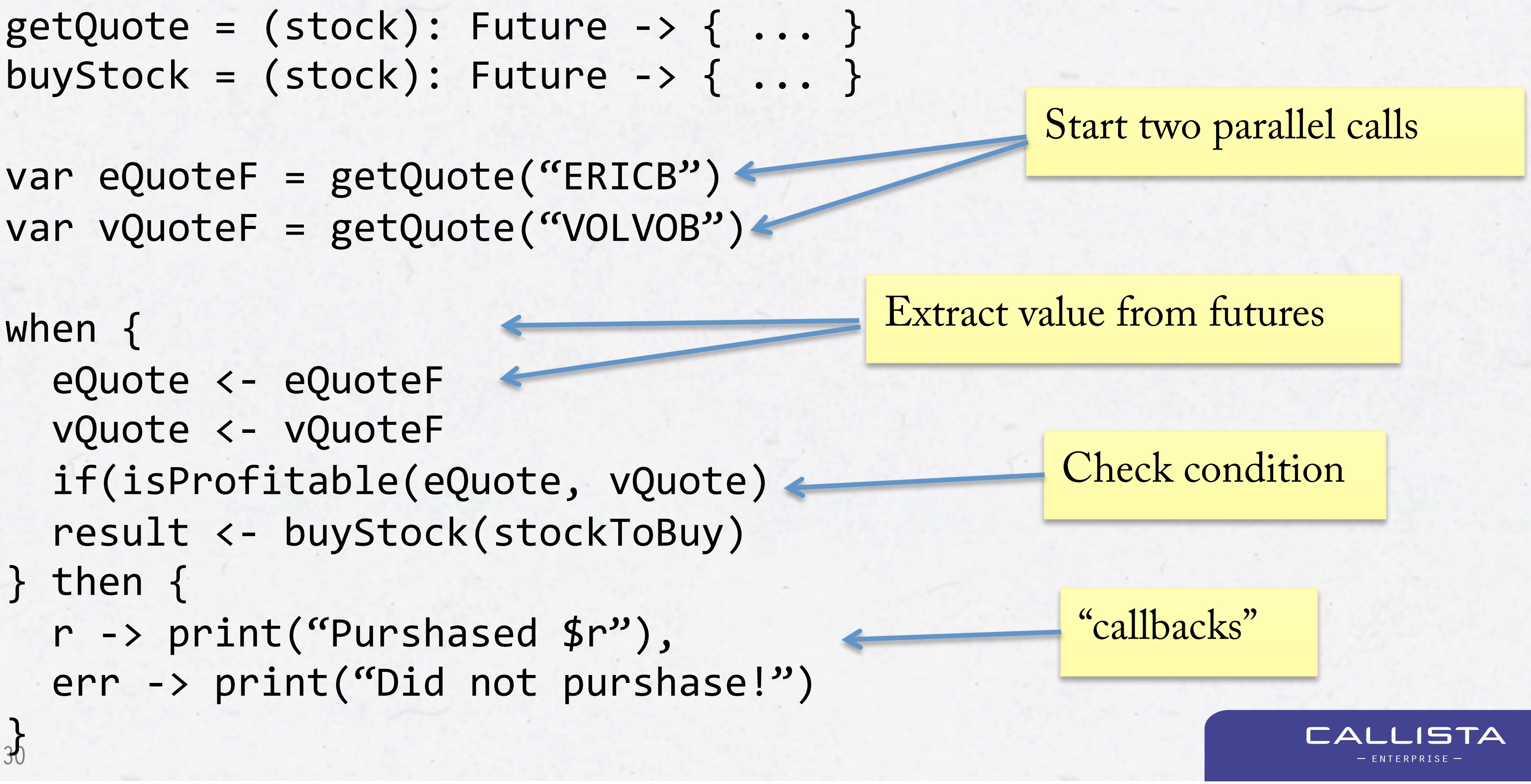

BRIAN GOETZ
WITH TIM PEIERLS, JOSHUA BLOCH, JOSEPH BOWBEER, DAVID HOLMES, AND DOUG LEA
JAVA CONCURRENCY IN PRACTICE

FUNCTIONAL



Let go of state and imperative programming…

ASYNCHRONOUS WITH FUTURES



```
getQuote = (stock): Future -> { ... }
buyStock = (stock): Future -> { ... }

var eQuoteF = getQuote(“ERICB”)
var vQuoteF = getQuote(“VOLVOB”)

when {
   eQuote <- eQuoteF
   vQuote <- vQuoteF
   if(isProfitable(eQuote, vQuote)
   result <- buyStock(stockToBuy)
} then {
   r -> print(“Purshased $r”),
   err -> print(“Did not purshase!”)
}
```

Start two parallel calls

Extract value from futures

Check condition

“callbacks”

FUTURES

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- Futures are composable without blocking or waiting

FUNCTION COMPOSITION

$$f: X \rightarrow Y$$
$$g: Y \rightarrow Z$$

$$f \circ g: X \rightarrow Z$$ *“f composed with g”*

$$(f \circ g)(x): g(f(x))$$

$$z{:}Z = g(f(x))$$

CALLISTA
— ENTERPRISE —

FUTURE COMPOSITION

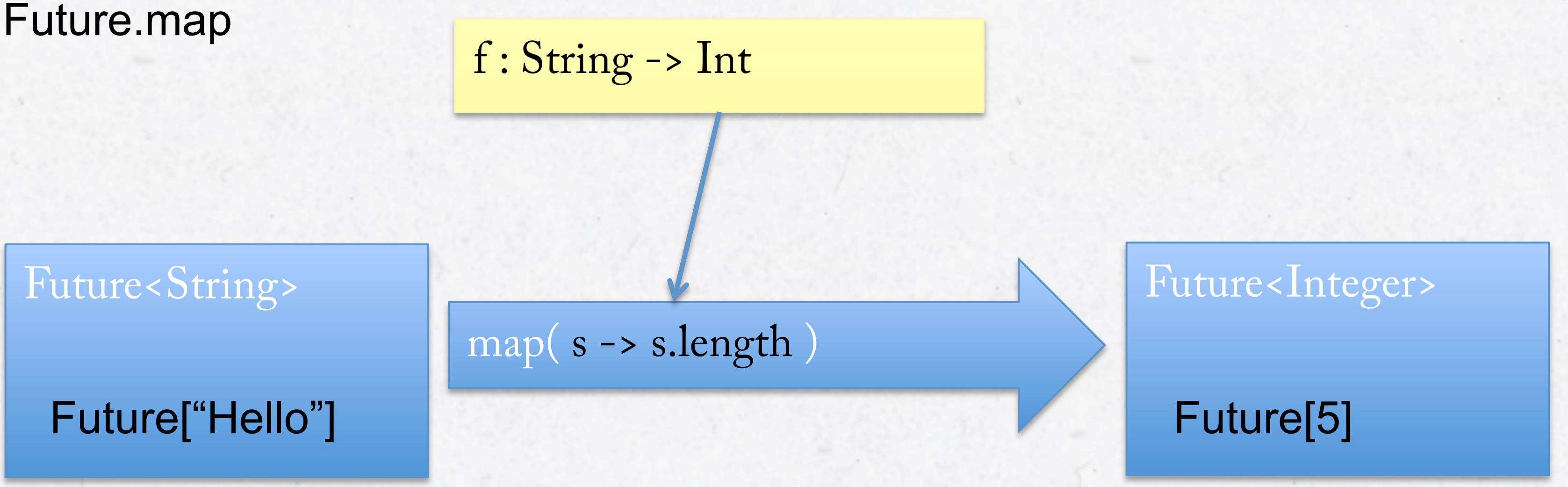
Create new futures by *transforming* and *combining* existing futures using the Future API.

FUTURE COMPOSITION

How do we transform a Future?

FUTURE COMPOSITION

Future.map



f : String -> Int

Future<String>

Future["Hello"]

map(s -> s.length)

Future<Integer>

Future[5]

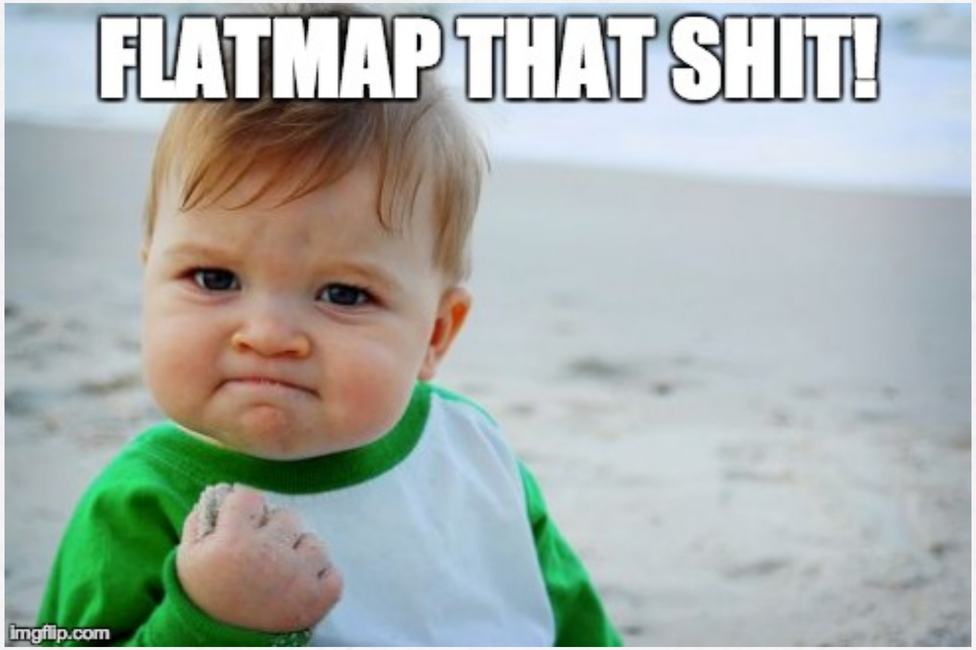
FUTURE COMPOSITION

```
Future.completed(1)
      .map((v) -> v + 10)
      .onSuccess((v) -> println(v))
```

```
> 11
```

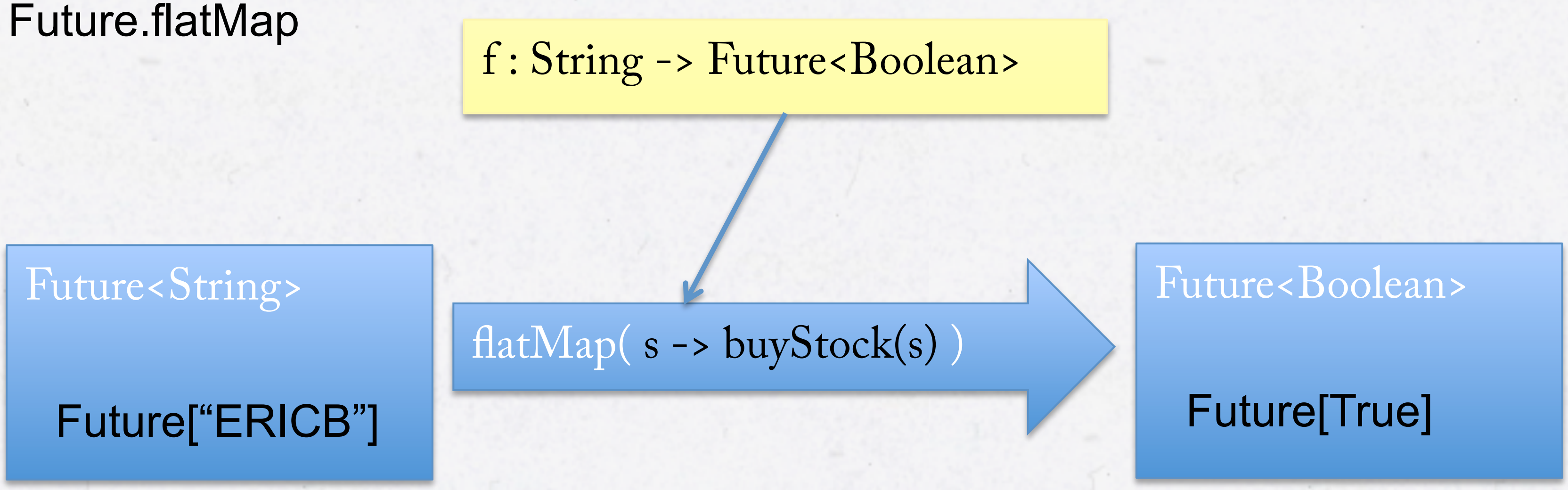
FUTURE COMPOSITION

How do we combine Futures?



FUTURE COMPOSITION

Future.flatMap



f : String -> Future<Boolean>

Future<String>

Future["ERICB"]

flatMap(s -> buyStock(s))

Future<Boolean>

Future[True]

FUTURE COMPOSITION

```
Future.completed(1)
      .flatMap((v) -> Future.completed(v + 10))
      .onSuccess((v) -> println(v))
```

```
> 11
```

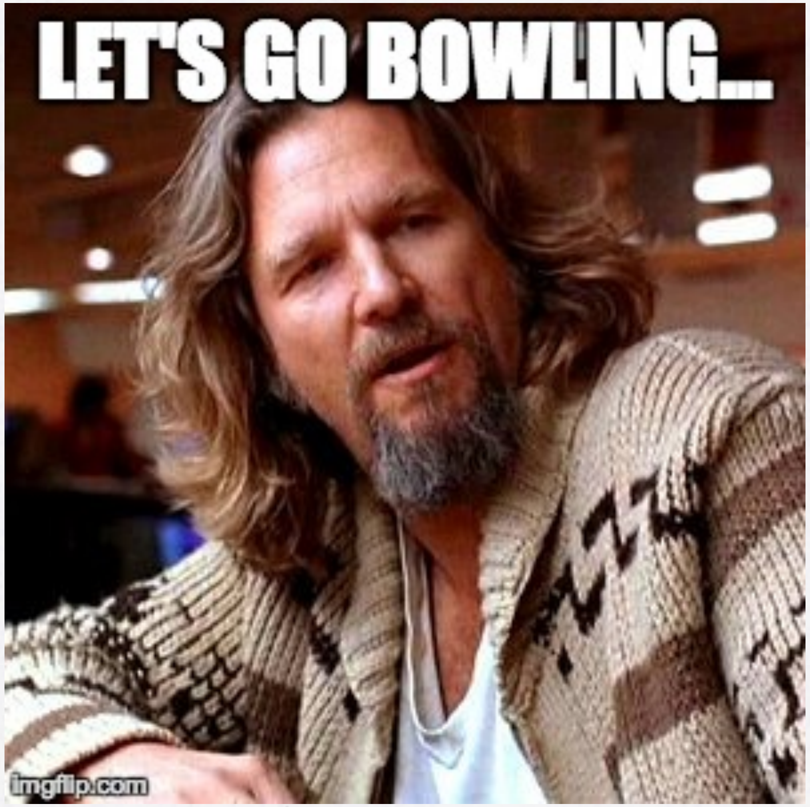
ASYNCHRONOUS WITH FUTURES

```
getQuote (stock): Future<Int> -> { ... }
buyStock (stock): Future<Int> -> { ... }

var eQuoteF = getQuote(“ERICB”)
var vQuoteF = getQuote(“VOLVOB”)

val resultF = eQuoteF.flatMap{ eQuote =>
   vQuoteF
      .filter(vQuote -> isProfitable(eQuote, vQuote))
      .flatMap(() -> buyStock("ERICB"))
}

resultF.onSuccess(() -> println(“Purshased ERICB”))
```

f : Int-> Future<Int>

f : ()-> Future<Int>

STREAMS



SYNCHRONOUS VS ASYNCHRONOUS

	Single items	Multiple items
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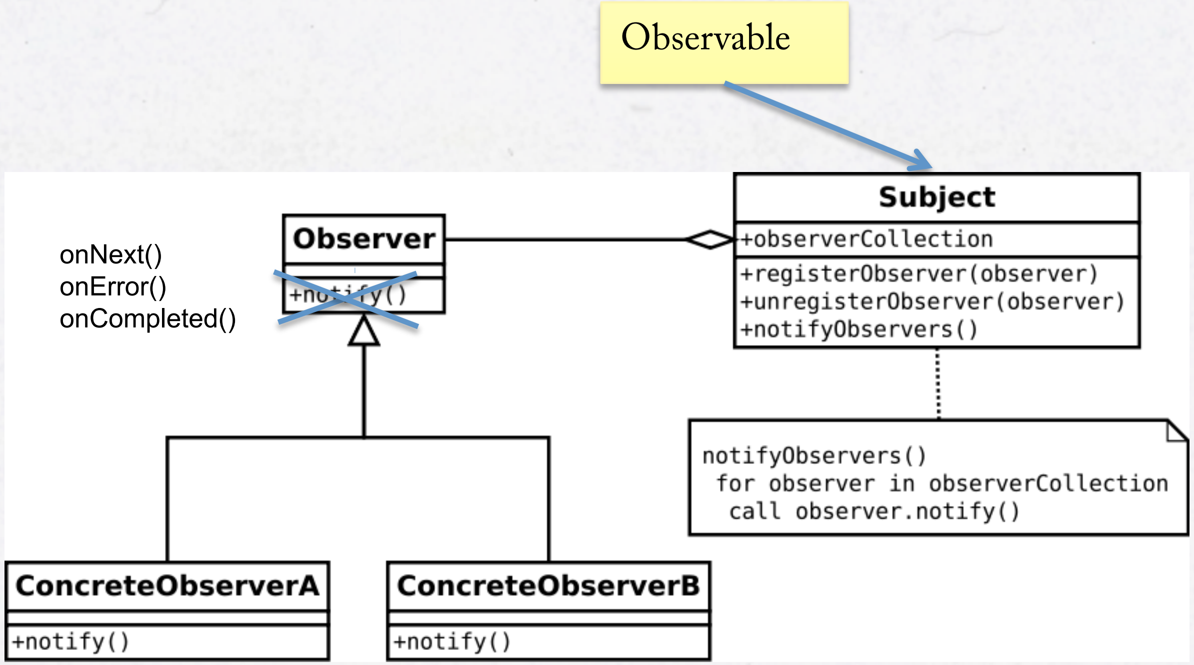
Asynchronous	Future<T> get()	Observable<T> get()

OBSERVABLE

Design Patterns
Elements of Reusable Object-Oriented Software
Erich Gamma
Richard Helm
Ralph Johnson
John Vlissides
Foreword by Grady Booch
ADDISON-WESLEY PROFESSIONAL COMPUTING SERIES



Observable

onNext()
onError()
onCompleted()

Observer

~~+notify()~~

Subject

+observerCollection

+registerObserver(observer)
+unregisterObserver(observer)
+notifyObservers()

```
notifyObservers()
 for observer in observerCollection
  call observer.notify()
```

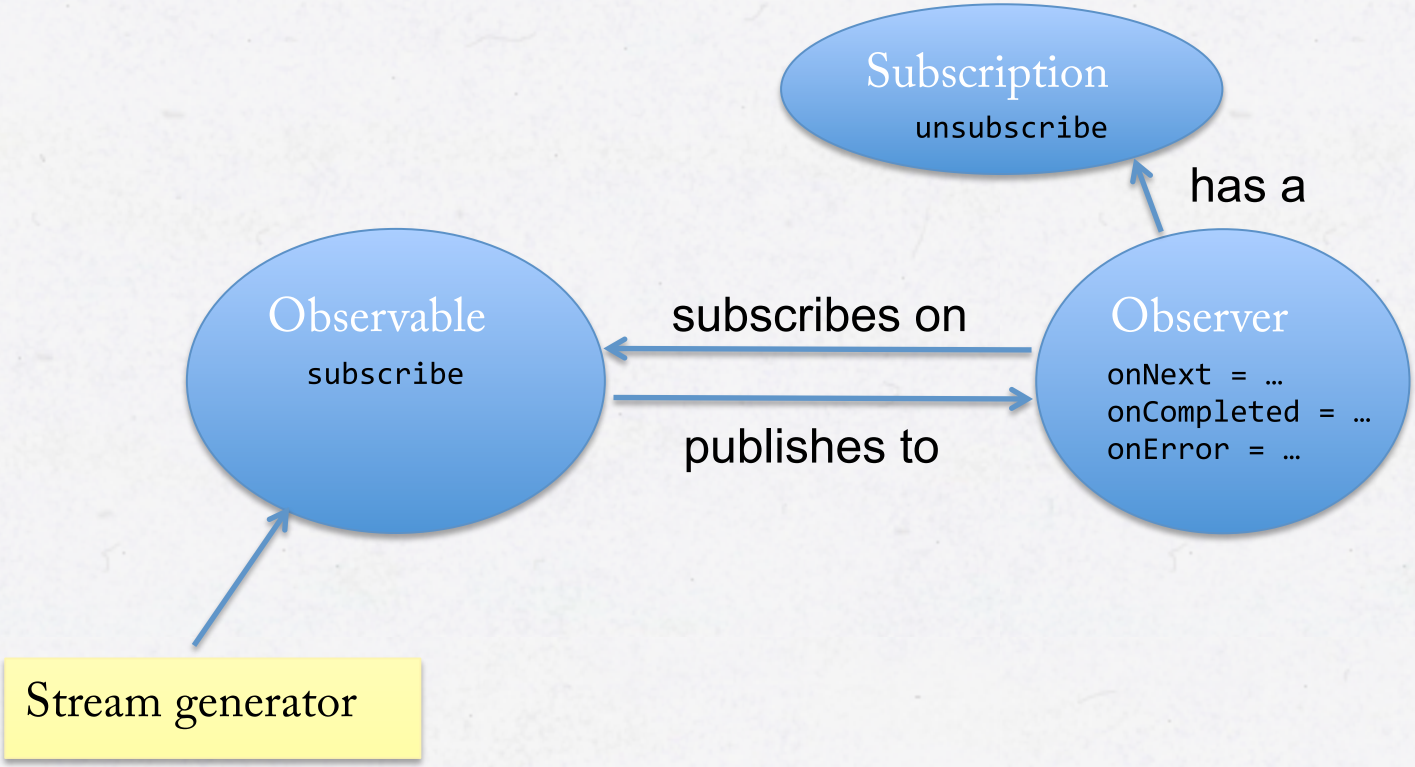
ConcreteObserverA

+notify()

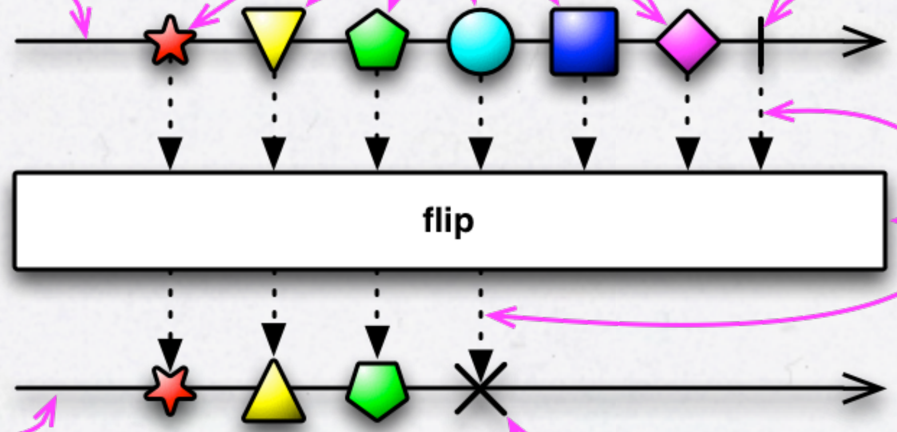
ConcreteObserverB

+notify()

COLLECTIONS WITH OBSERVABLES



MARBLE DIAGRAMS



This is the timeline of the Observable. Time flows from left to right.

These are items emitted by the Observable.

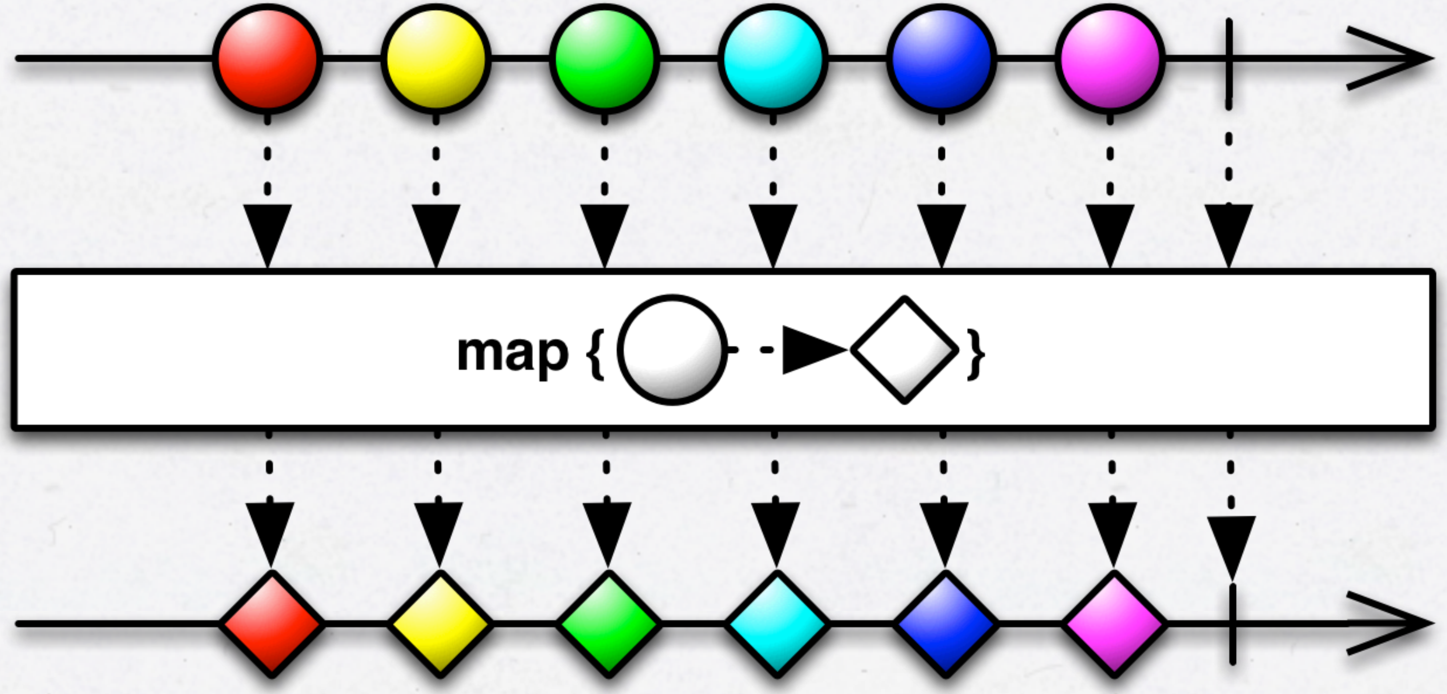
This vertical line indicates that the Observable has completed successfully.

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.

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.

RX MAP

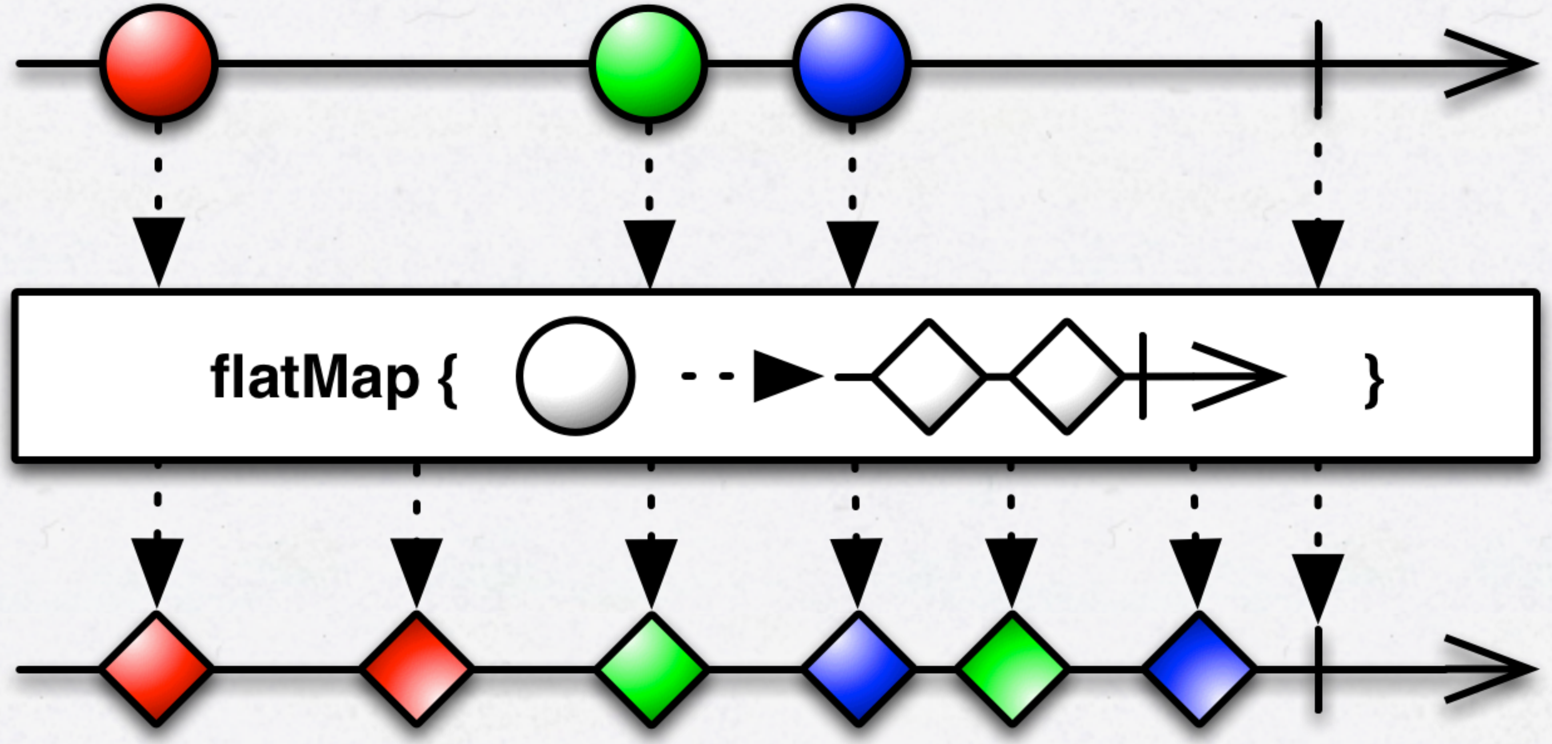


RX MAP

```
Observable<Integer> o = Observable.range(1,5);

o.map(v -> v * 10).subscribe(System.out::println);
```

```
10
20
30
40
50
```

RX FLATMAP

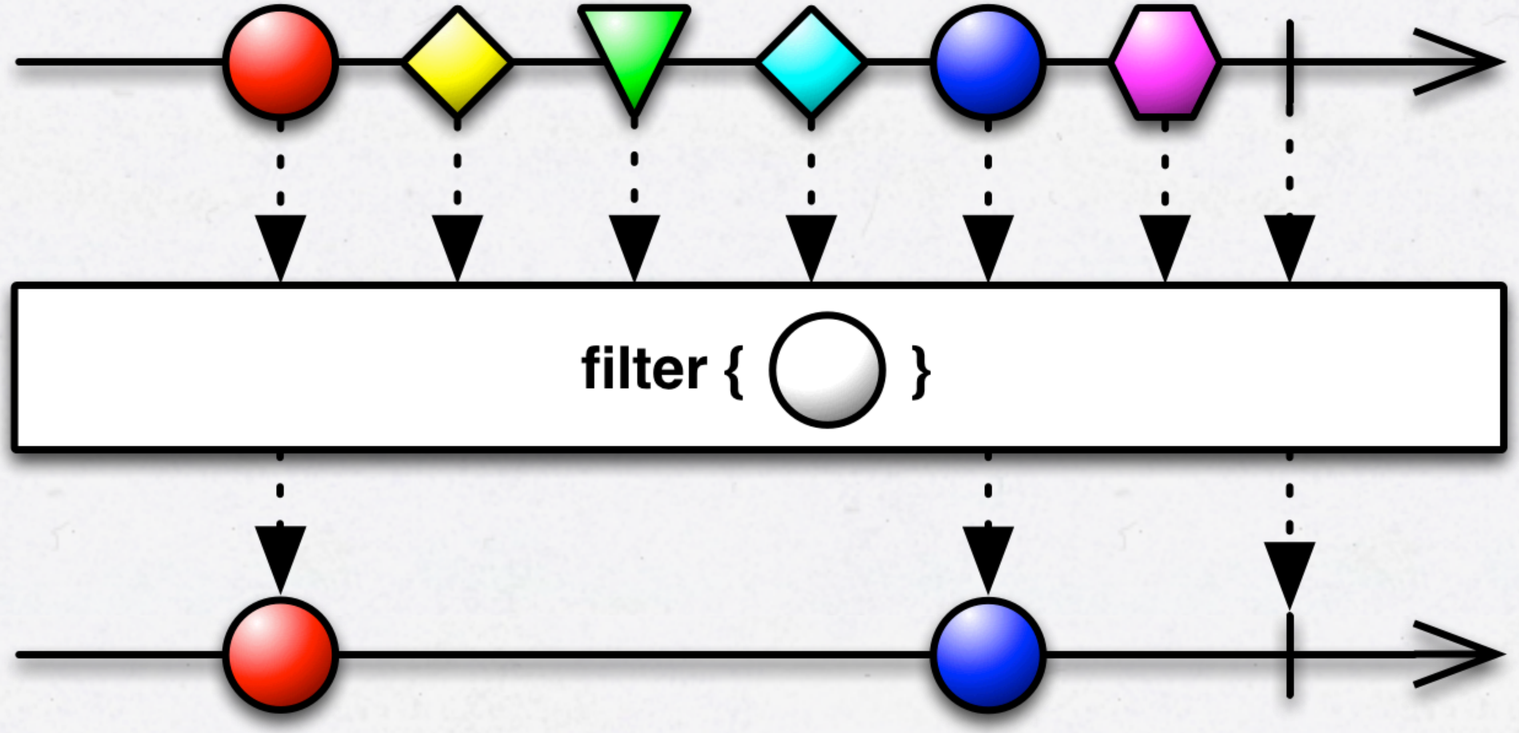


RX FLATMAP

```
Observable<Integer> o = Observable.range(1,5);

o.flatMap(v -> Observable.range(v*10, 2)).subscribe(System.out::println);
```

```
10
11
20
21
30
31
40
41
50
51
```

RX FILTER



RX FILTER

```
Observable<Integer> o = Observable.range(1,10);

o.filter(s -> s % 3 == 0).subscribe(System.out::println);
```

```
3
6
9
```

NEXT STEP

SYNCHRONOUS VS ASYNCHRONOUS

	Single item	Multiple items
Synchronous	T get ()	Iterable<T> get()
Asynchronous	Future<T> get()	Observable<T> get()

FUTURES

- Since 1.5
- Future – Blocking api

- Since 1.8
- CompletableFuture – Non-Blocking

API REVIEW - FUTURE

Future

- Create
  - new CompletableFuture<T>()

- Complete
  - Successfully

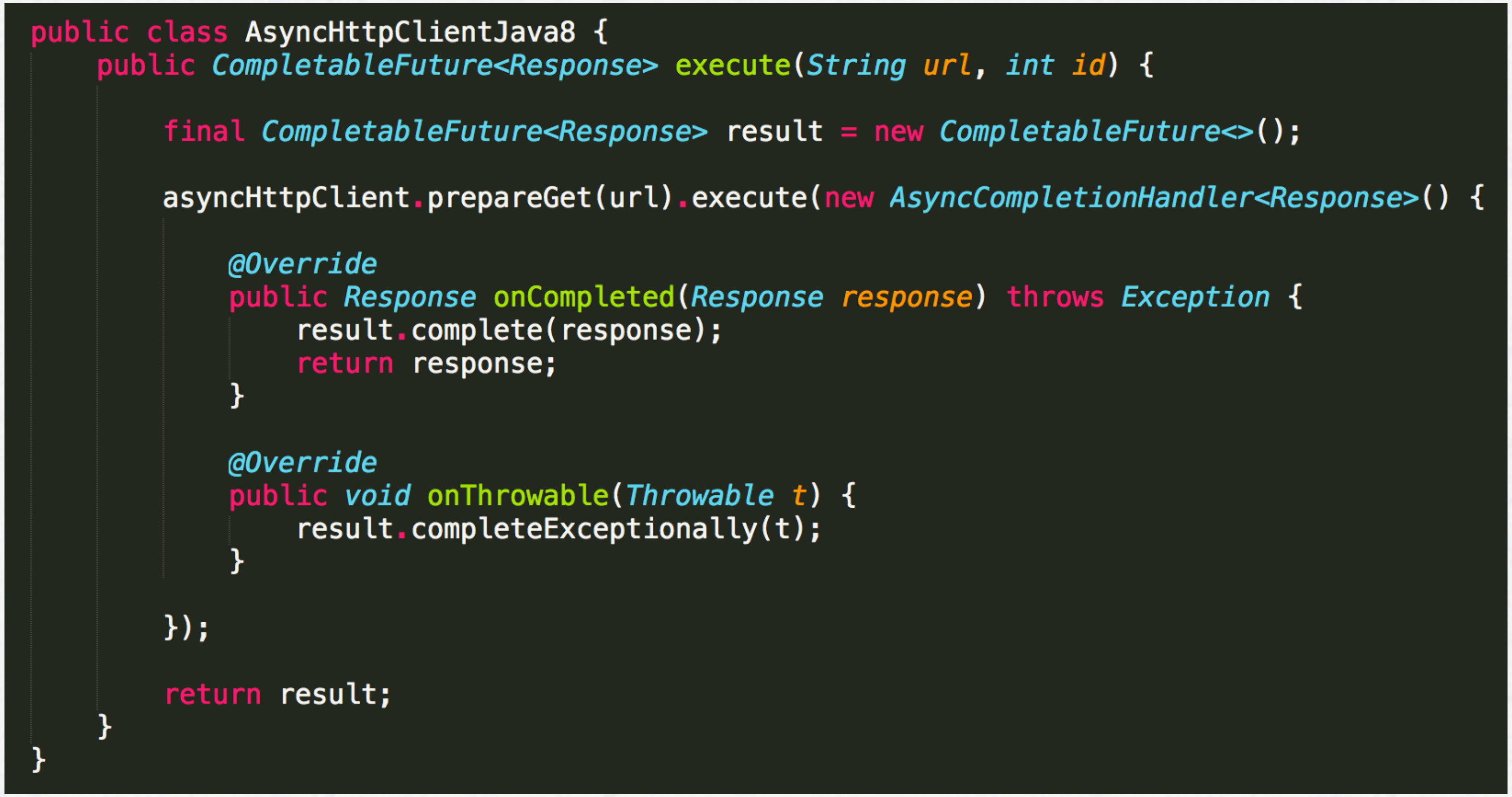
    Value

    - » complete(T value)
  - With Error

    Throwable

    - » completeExceptionally(Throwable t)

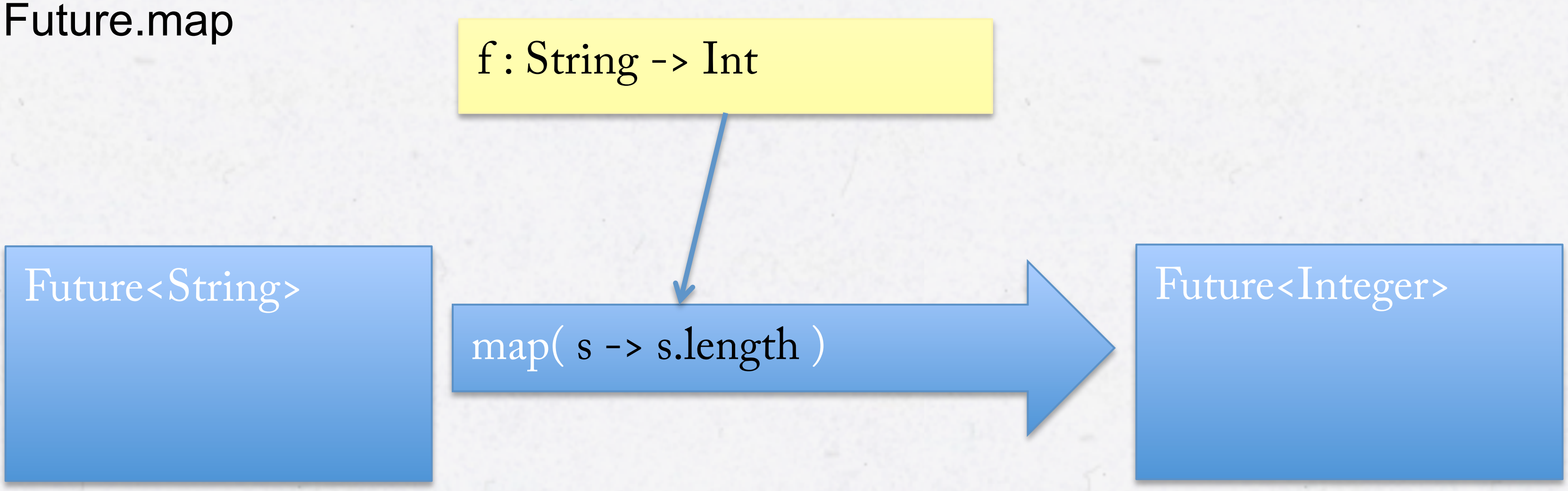
EXAMPLE - ASYNC HTTP CLIENT



```java
public class AsyncHttpClientJava8 {
    public CompletableFuture<Response> execute(String url, int id) {

        final CompletableFuture<Response> result = new CompletableFuture<>();

        asyncHttpClient.prepareGet(url).execute(new AsyncCompletionHandler<Response>() {

            @Override
            public Response onCompleted(Response response) throws Exception {
                result.complete(response);
                return response;
            }

            @Override
            public void onThrowable(Throwable t) {
                result.completeExceptionally(t);
            }

        });

        return result;
    }
}
```

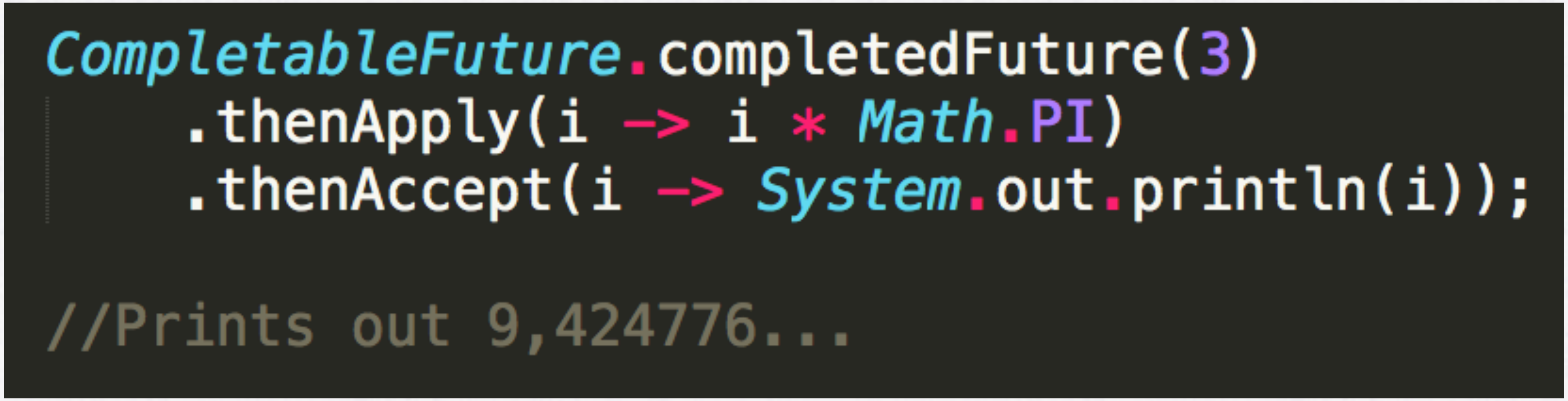
FUTURE COMPOSITION

Future.map



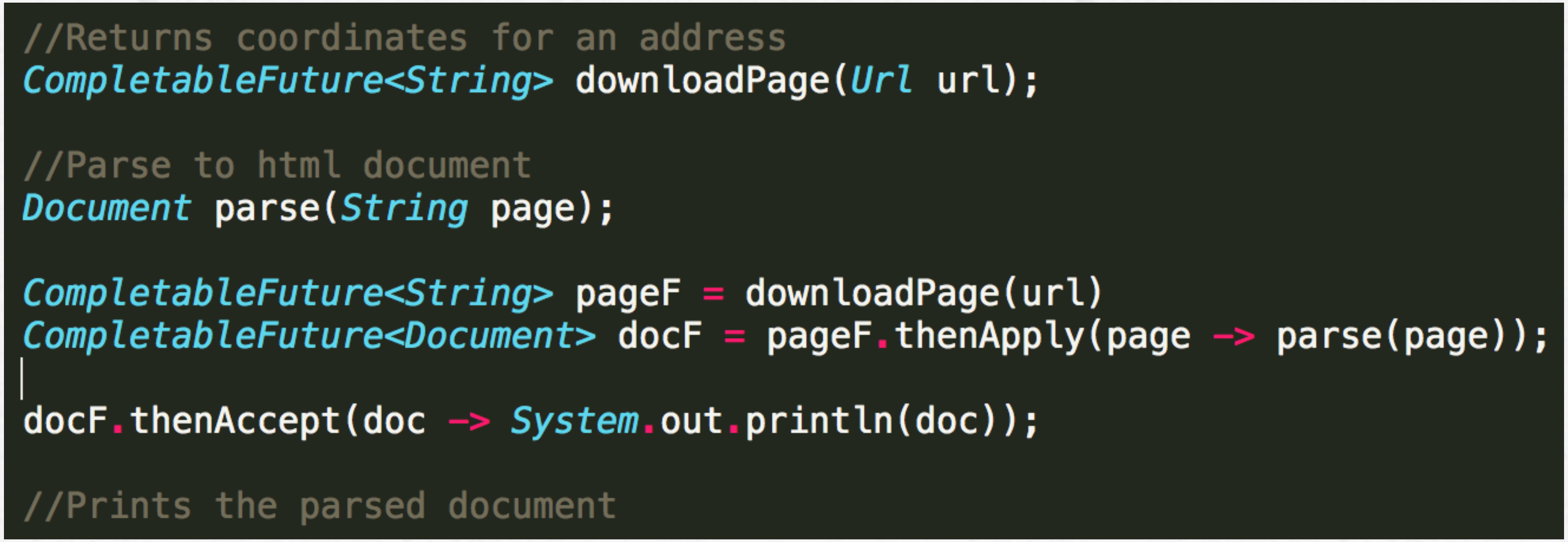
COMPLETABLEFUTURE - MAP

- Transforming
  - thenApply / thenApplyAsync ⇔ Map
- Completion (Callback)
  - thenAccept / thenAcceptAsync



```
CompletableFuture.completedFuture(3)
    .thenApply(i -> i * Math.PI)
    .thenAccept(i -> System.out.println(i));

//Prints out 9,424776...
```

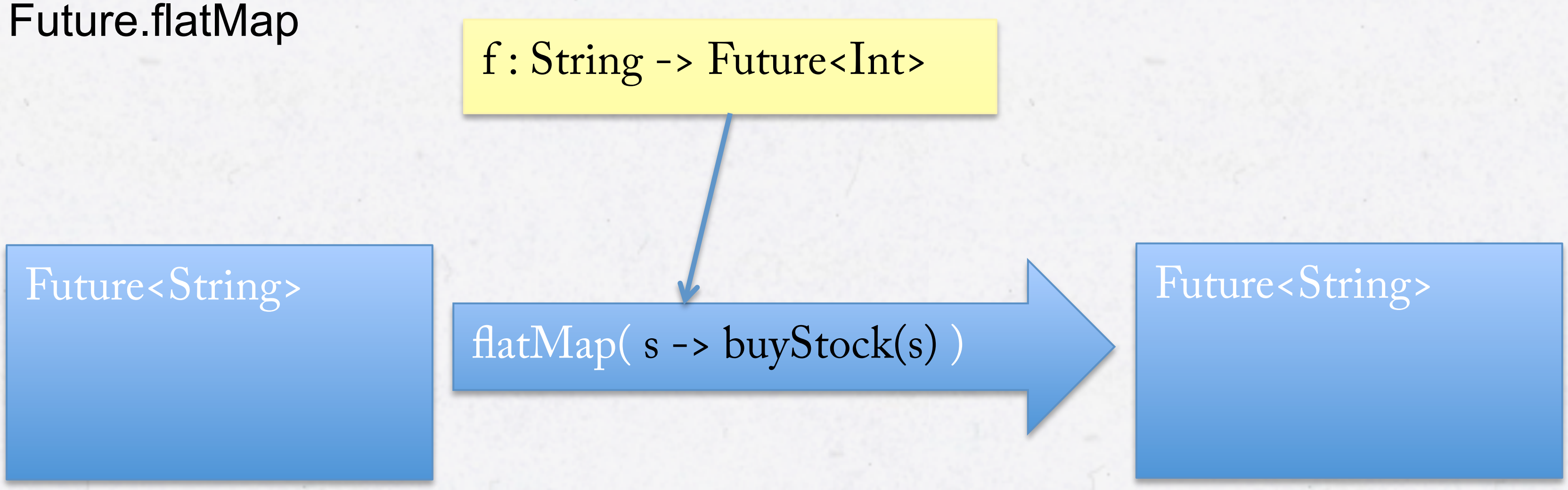
COMPLETABLEFUTURE - MAP



```
//Returns coordinates for an address
CompletableFuture<String> downloadPage(Url url);

//Parse to html document
Document parse(String page);

CompletableFuture<String> pageF = downloadPage(url)
CompletableFuture<Document> docF = pageF.thenApply(page -> parse(page));

docF.thenAccept(doc -> System.out.println(doc));

//Prints the parsed document
```

FUTURE COMPOSITION

Future.flatMap



f : String -> Future<Int>

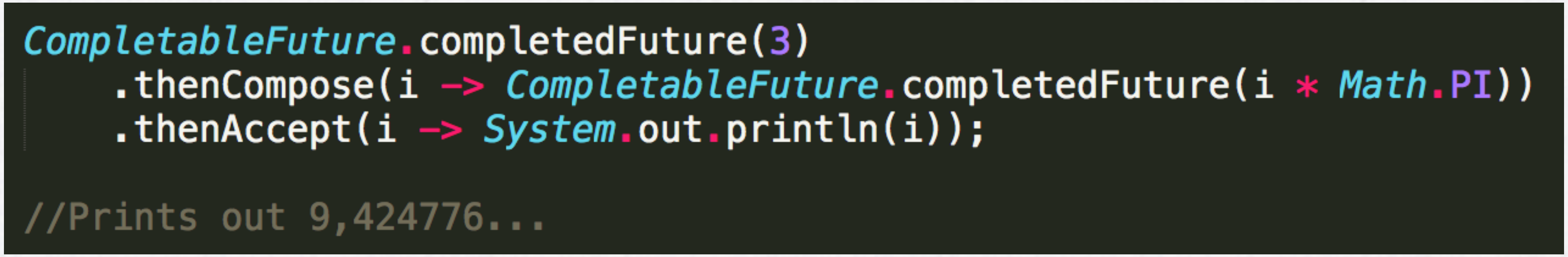
Future<String>

flatMap(s -> buyStock(s))

Future<String>

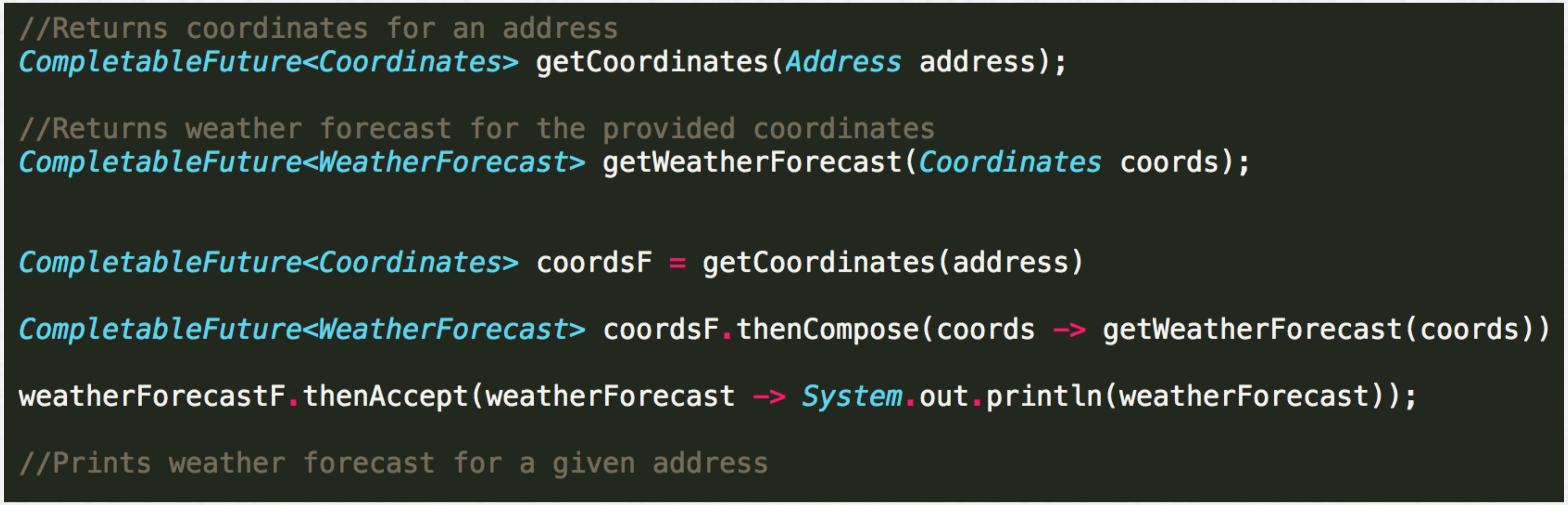
COMPLETABLEFUTURE - FLATMAP

thenCompose(…) / thenComposeAsync(…) ⇔ flatMap



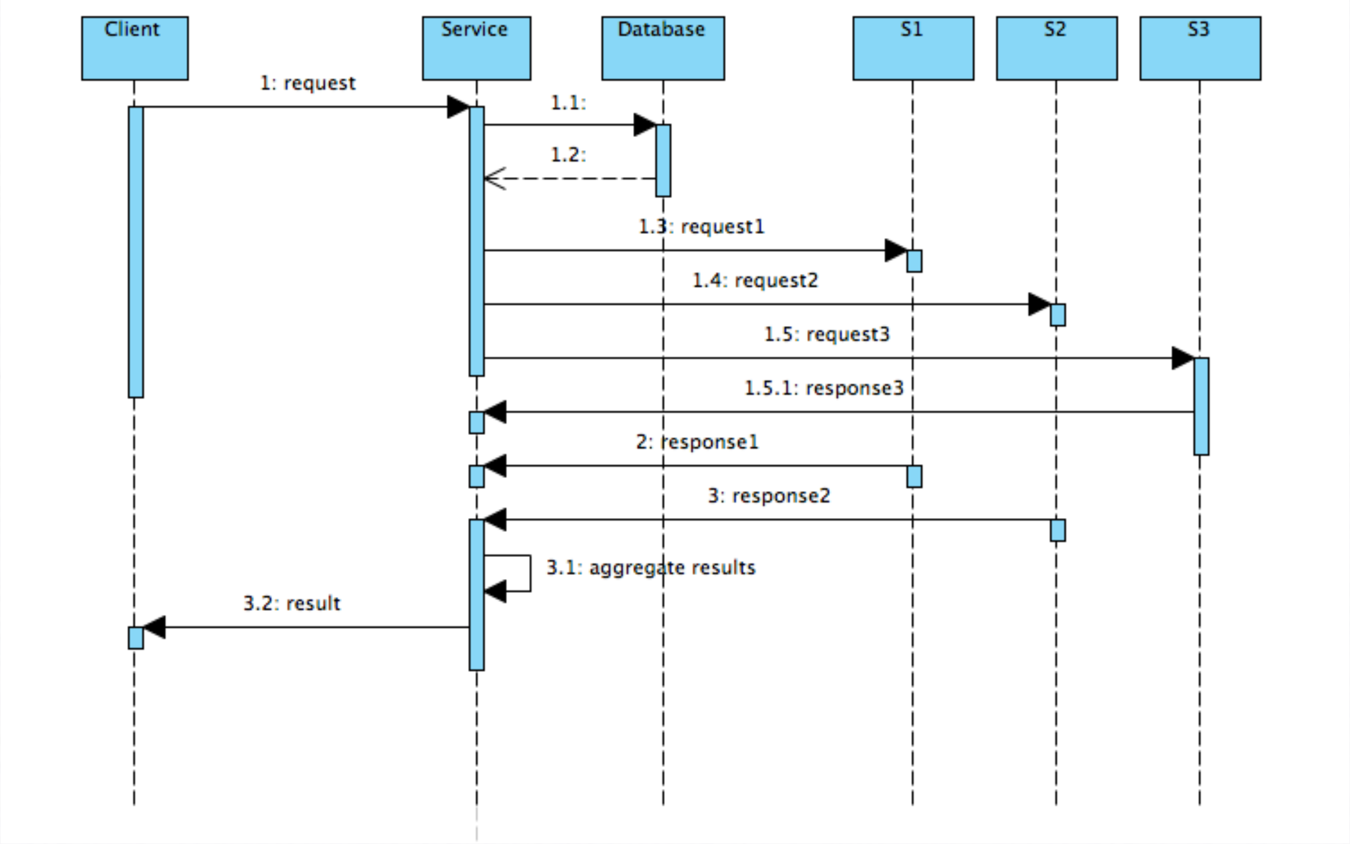
```
CompletableFuture.completedFuture(3)
    .thenCompose(i -> CompletableFuture.completedFuture(i * Math.PI))
    .thenAccept(i -> System.out.println(i));

//Prints out 9,424776...
```

COMPLETABLEFUTURE - FLATMAP

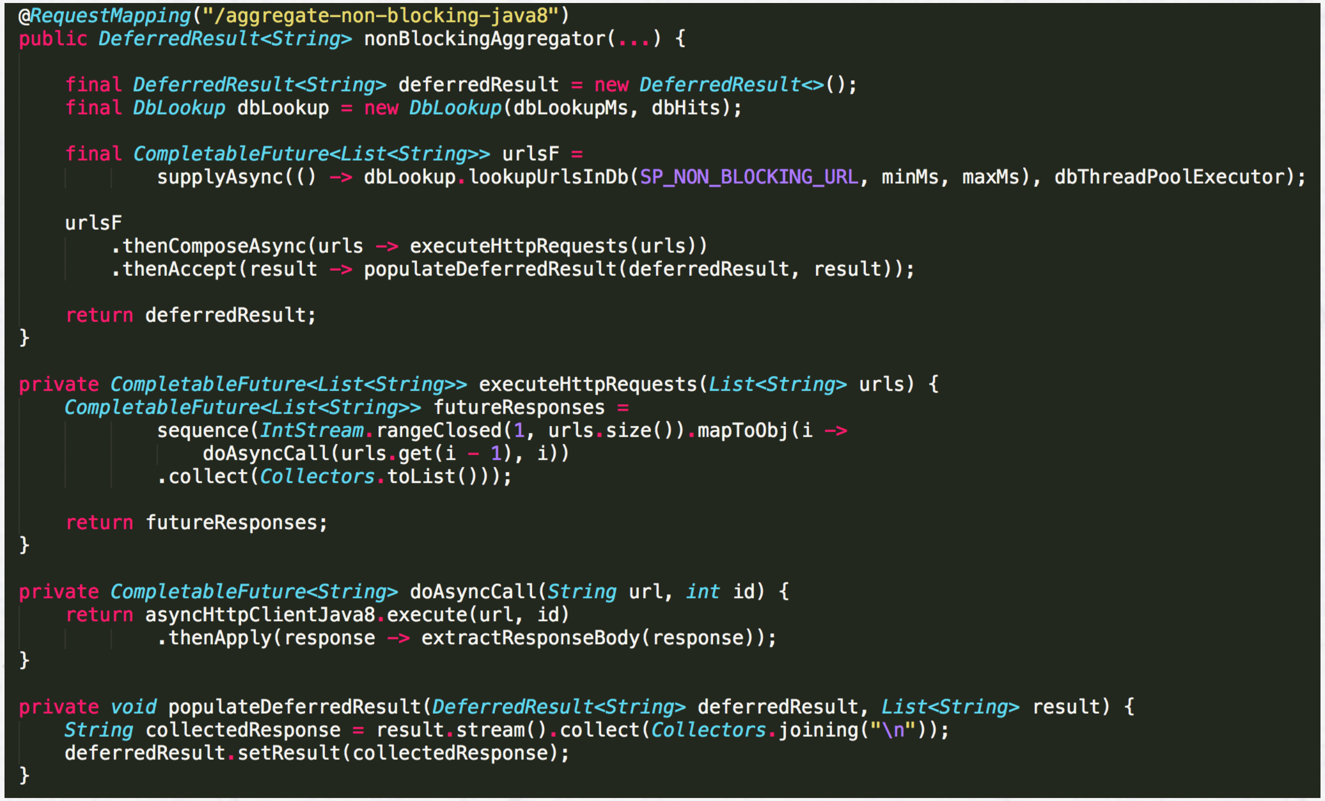


```
//Returns coordinates for an address
CompletableFuture<Coordinates> getCoordinates(Address address);

//Returns weather forecast for the provided coordinates
CompletableFuture<WeatherForecast> getWeatherForecast(Coordinates coords);


CompletableFuture<Coordinates> coordsF = getCoordinates(address)

CompletableFuture<WeatherForecast> coordsF.thenCompose(coords -> getWeatherForecast(coords))

weatherForecastF.thenAccept(weatherForecast -> System.out.println(weatherForecast));

//Prints weather forecast for a given address
```

AGGREGATOR EXAMPLE

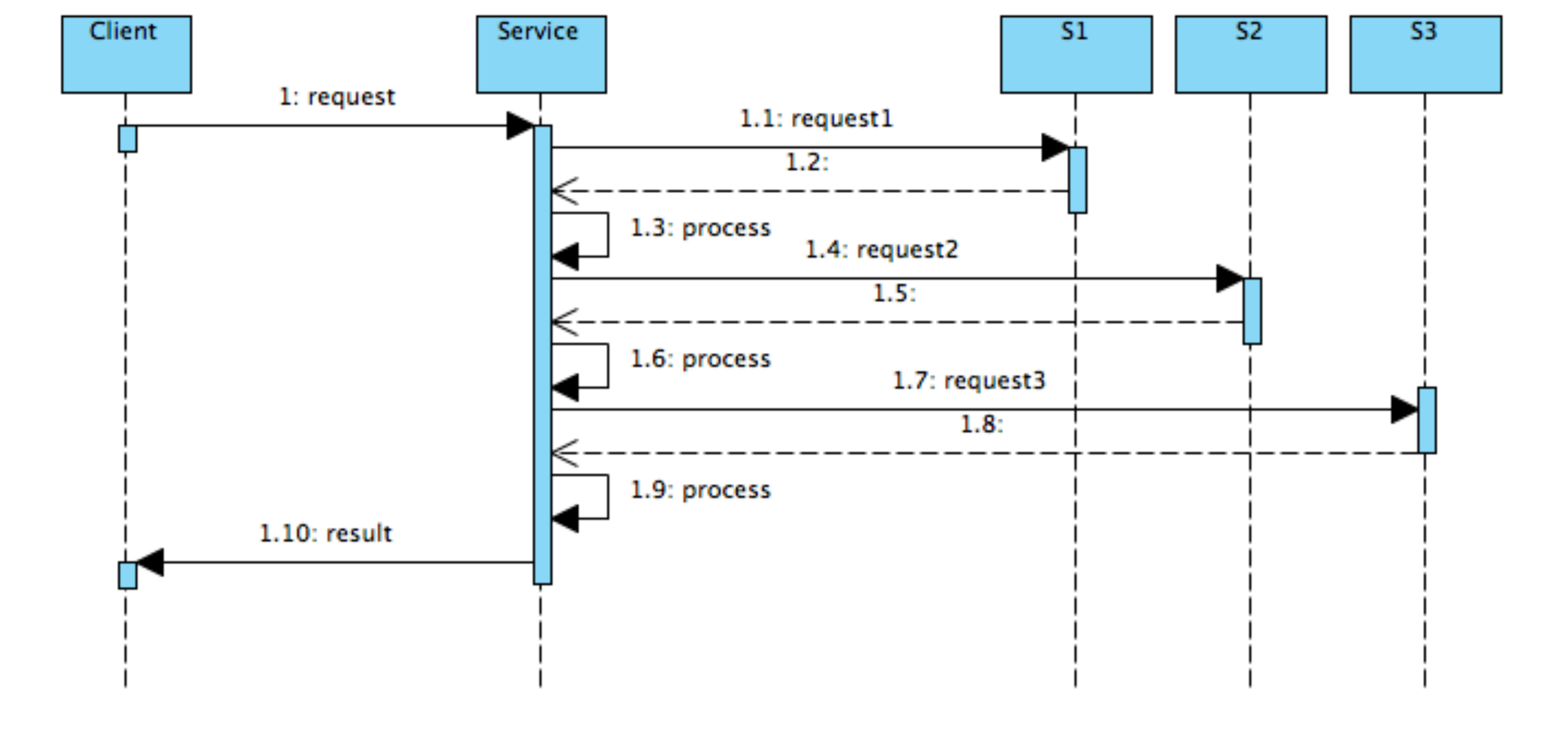


AGGREGATOR - JAVA8



```
@RequestMapping("/aggregate-non-blocking-java8")
public DeferredResult<String> nonBlockingAggregator(...) {

    final DeferredResult<String> deferredResult = new DeferredResult<>();
    final DbLookup dbLookup = new DbLookup(dbLookupMs, dbHits);

    final CompletableFuture<List<String>> urlsF =
            supplyAsync(() -> dbLookup.lookupUrlsInDb(SP_NON_BLOCKING_URL, minMs, maxMs), dbThreadPoolExecutor);

    urlsF
        .thenComposeAsync(urls -> executeHttpRequests(urls))
        .thenAccept(result -> populateDeferredResult(deferredResult, result));

    return deferredResult;
}

private CompletableFuture<List<String>> executeHttpRequests(List<String> urls) {
    CompletableFuture<List<String>> futureResponses =
            sequence(IntStream.rangeClosed(1, urls.size()).mapToObj(i ->
                doAsyncCall(urls.get(i - 1), i))
            .collect(Collectors.toList()));

    return futureResponses;
}

private CompletableFuture<String> doAsyncCall(String url, int id) {
    return asyncHttpClientJava8.execute(url, id)
            .thenApply(response -> extractResponseBody(response));
}

private void populateDeferredResult(DeferredResult<String> deferredResult, List<String> result) {
    String collectedResponse = result.stream().collect(Collectors.joining("\n"));
    deferredResult.setResult(collectedResponse);
}
```

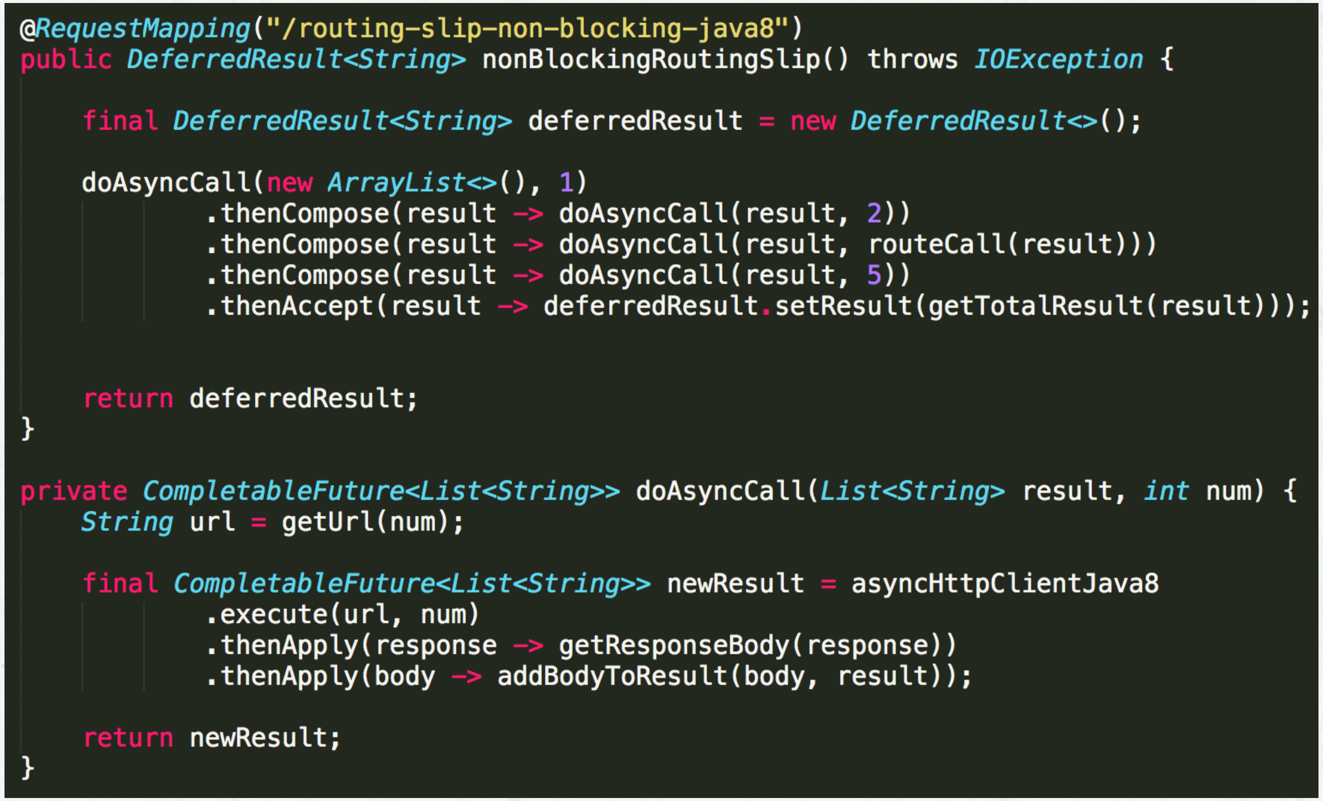
ROUTING SLIP EXAMPLE



ROUTING SLIP - DO YOU REMEMBER?

```
@RequestMapping("/routing-slip-non-blocking-lambda")
public DeferredResult<String> nonBlockingRoutingSlip() throws IOException {

  final DeferredResult<String> dr = new DeferredResult<>();

  // Send request #1
  ListenableFuture<Response> execute = asyncHttpClient.execute(getUrl(1),
    (Response r1) -> {
      processResult(r1.getResponseBody()); // Process response #1
      asyncHttpClient.execute(getUrl(2),   // Send request #2
        (Response r2) -> {
          processResult(r2.getResponseBody()); // Process response #2
          asyncHttpClient.execute(getUrl(3),   // Send request #3
            (Response r3) -> {
              processResult(r3.getResponseBody()); // Process response #3
              asyncHttpClient.execute(getUrl(4),   // Send request #4
                (Response r4) -> {
                  processResult(r4.getResponseBody()); // Process response #4
                  asyncHttpClient.execute(getUrl(5),   // Send request #5
                    (Response r5) -> {
                      processResult(r5.getResponseBody()); // Process response #5
                      // Get the total result and set it on the deferred result
                      dr.setResult(getTotalResult());
                      ...
```

ROUTING SLIP - JAVA8



```java
@RequestMapping("/routing-slip-non-blocking-java8")
public DeferredResult<String> nonBlockingRoutingSlip() throws IOException {

    final DeferredResult<String> deferredResult = new DeferredResult<>();

    doAsyncCall(new ArrayList<>(), 1)
            .thenCompose(result -> doAsyncCall(result, 2))
            .thenCompose(result -> doAsyncCall(result, routeCall(result)))
            .thenCompose(result -> doAsyncCall(result, 5))
            .thenAccept(result -> deferredResult.setResult(getTotalResult(result)));


    return deferredResult;
}

private CompletableFuture<List<String>> doAsyncCall(List<String> result, int num) {
    String url = getUrl(num);

    final CompletableFuture<List<String>> newResult = asyncHttpClientJava8
            .execute(url, num)
            .thenApply(response -> getResponseBody(response))
            .thenApply(body -> addBodyToResult(body, result));

    return newResult;
}
```

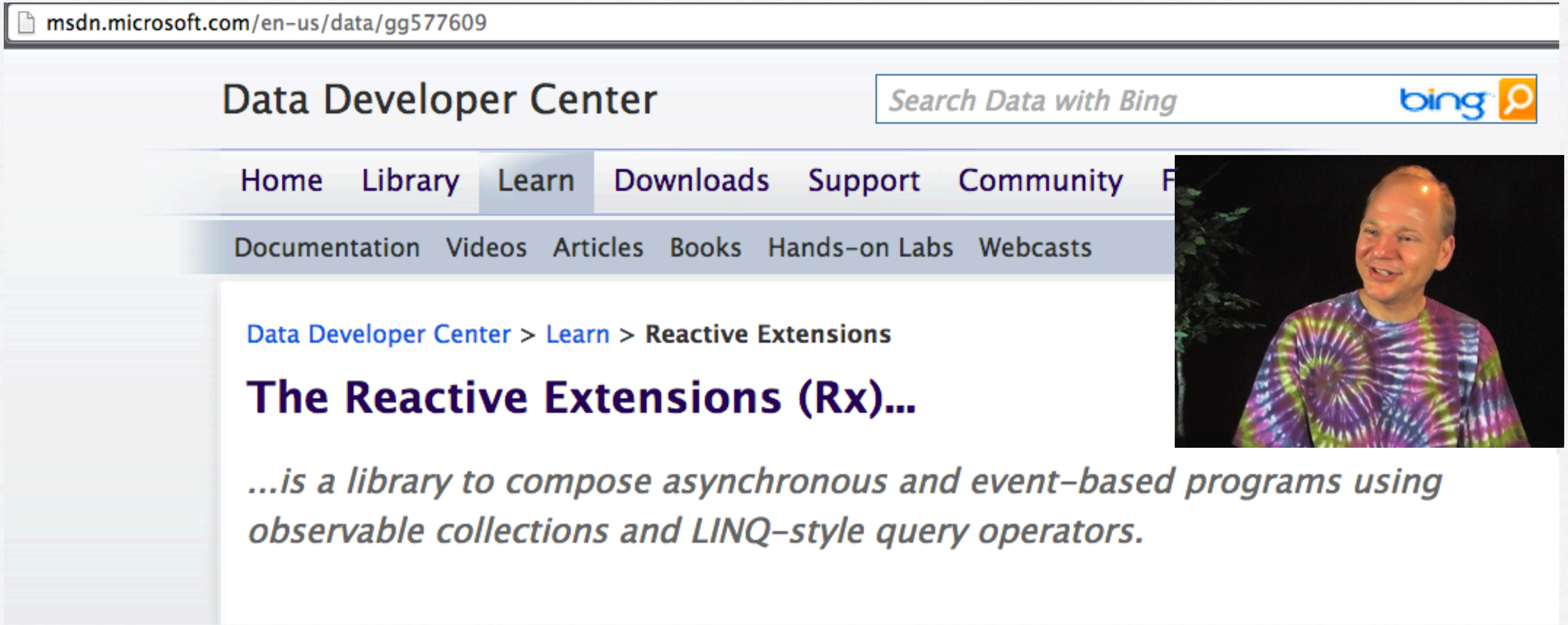
SUMMARY - JAVA 8

- Sequential programming model
- No framework needed
- Big api
- Stream and CompletableFuture api differs

SYNCHRONOUS VS ASYNCHRONOUS

	Single item	Multiple items
Synchronous	T get ()	Iterable<T> get()
Asynchronous	Future<T> get()	Observable<T> get()

REACTIVE EXTENSIONS



msdn.microsoft.com/en-us/data/gg577609

Data Developer Center

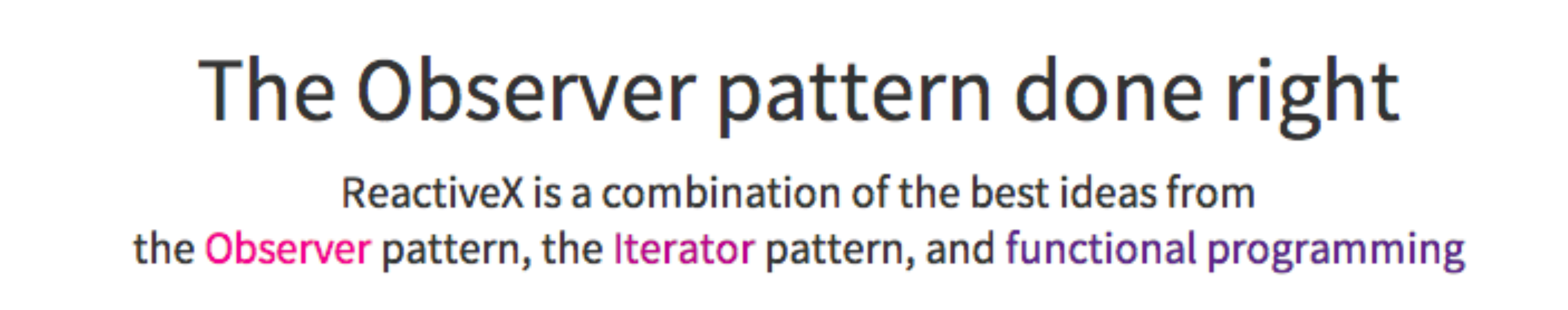
Data Developer Center > Learn > Reactive Extensions

The Reactive Extensions (Rx)...

...is a library to compose asynchronous and event-based programs using observable collections and LINQ-style query operators.

REACTIVE EXTENSIONS

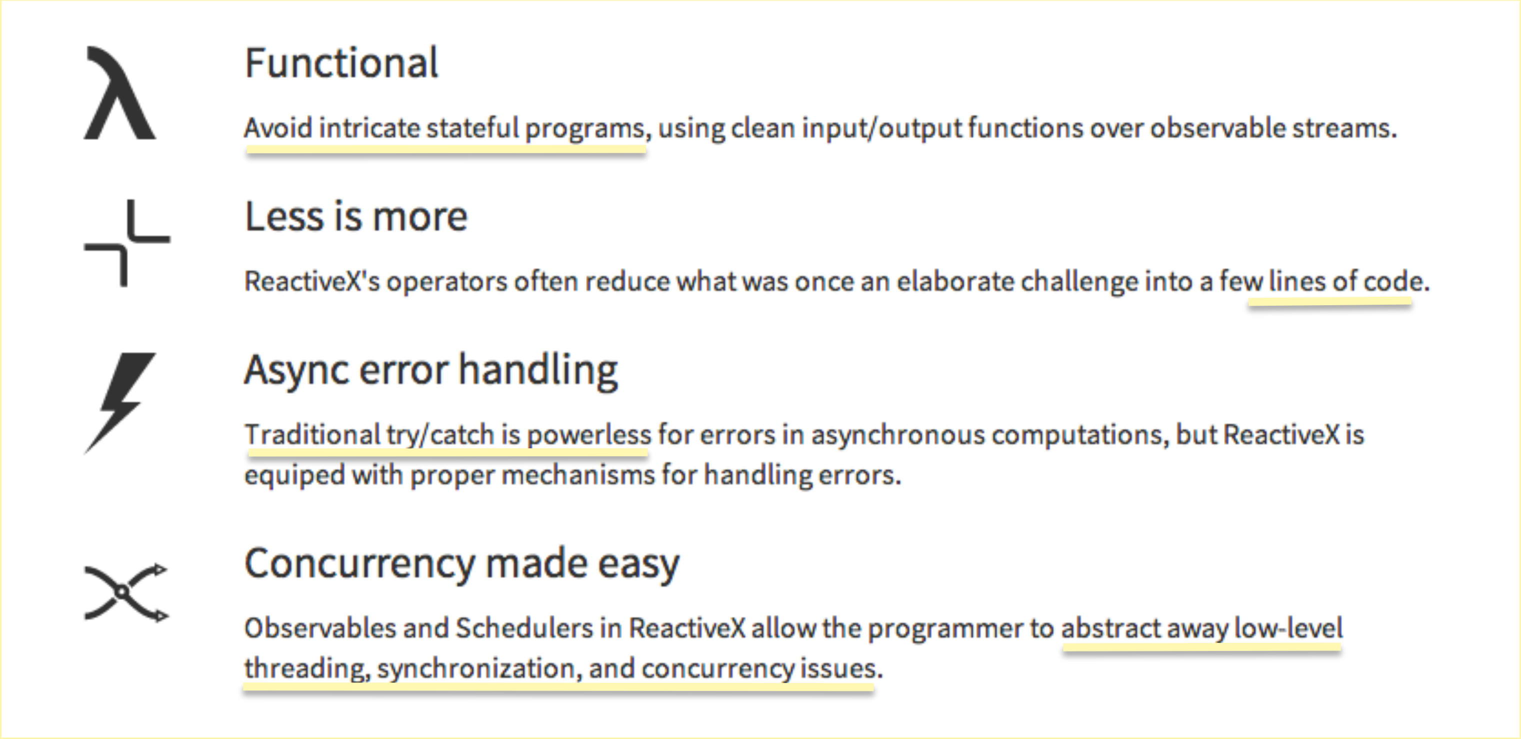
http://reactivex.io/



The Observer pattern done right

ReactiveX is a combination of the best ideas from
the Observer pattern, the Iterator pattern, and functional programming

REACTIVE EXTENSIONS



Functional

Avoid intricate stateful programs, using clean input/output functions over observable streams.

Less is more

ReactiveX's operators often reduce what was once an elaborate challenge into a few lines of code.

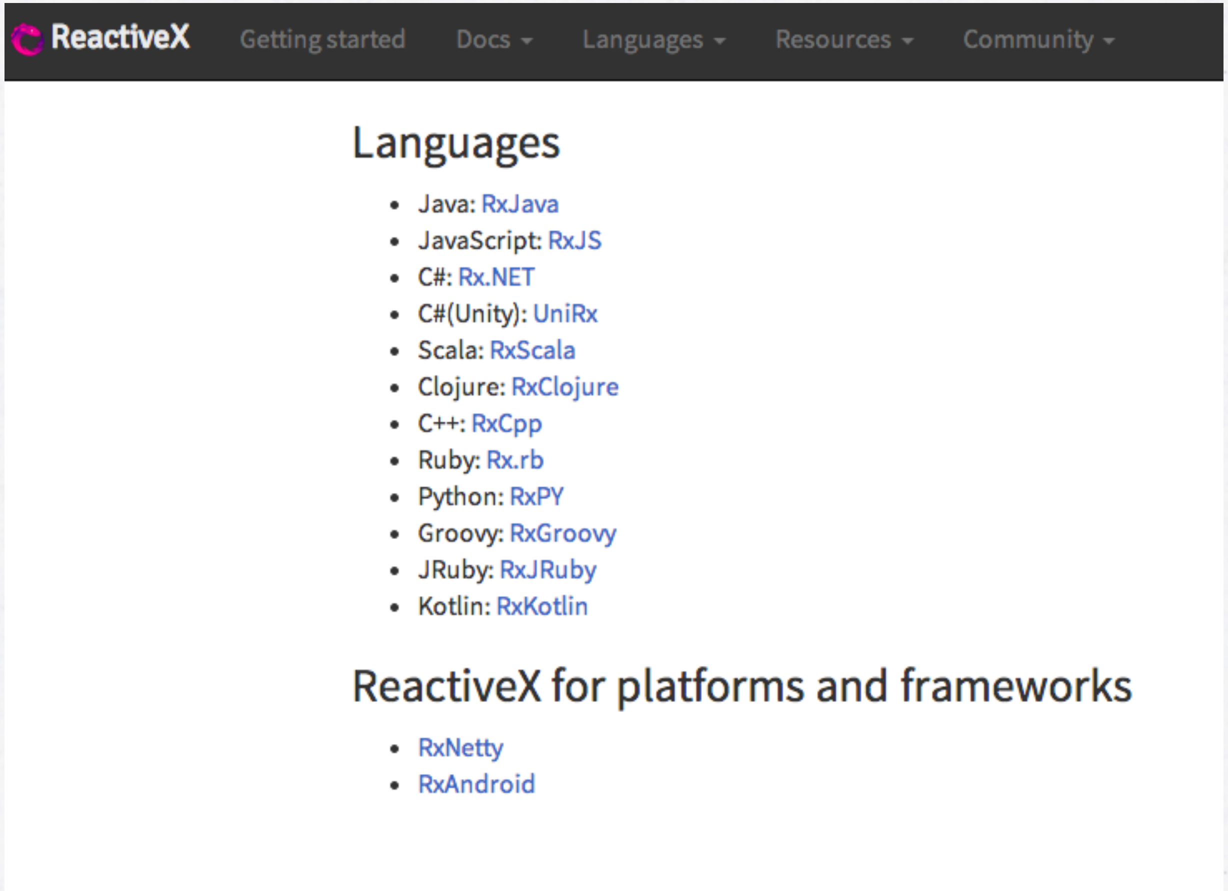
Async error handling

Traditional try/catch is powerless for errors in asynchronous computations, but ReactiveX is equiped with proper mechanisms for handling errors.

Concurrency made easy

Observables and Schedulers in ReactiveX allow the programmer to abstract away low-level threading, synchronization, and concurrency issues.

POLYGLOT



Languages

- Java: RxJava
- JavaScript: RxJS
- C#: Rx.NET
- C#(Unity): UniRx
- Scala: RxScala
- Clojure: RxClojure
- C++: RxCpp
- Ruby: Rx.rb
- Python: RxPY
- Groovy: RxGroovy
- JRuby: RxJRuby
- Kotlin: RxKotlin

ReactiveX for platforms and frameworks

- RxNetty
- RxAndroid

REACTIVE EXTENSIONS

We use ReactiveX

Applied Duality
Microsoft
NETFLIX
GitHub
SOUNDCLOUD
Trello
treehouse
SeatGeek
ooVoo
Couchbase
Futurice
welbe

OBSERVABLE

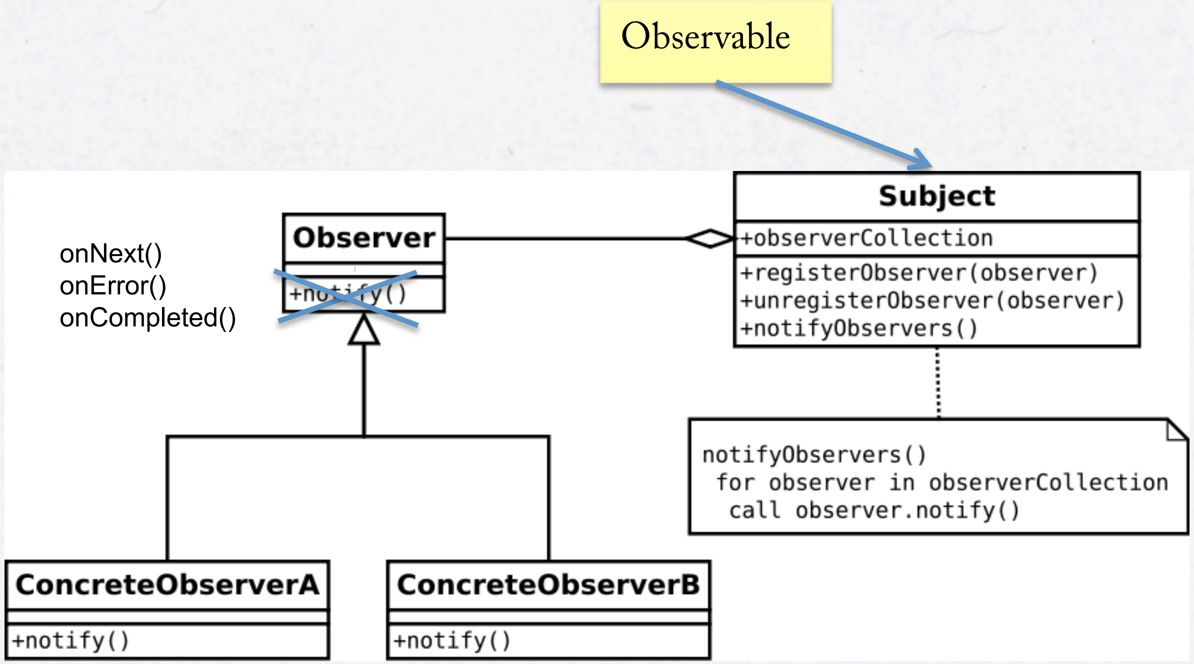
Design Patterns

Elements of Reusable Object-Oriented Software

Erich Gamma
Richard Helm
Ralph Johnson
John Vlissides

Foreword by Grady Booch

ADDISON-WESLEY PROFESSIONAL COMPUTING SERIES



```
notifyObservers()
 for observer in observerCollection
  call observer.notify()
```

ITERABLE VS. OBSERVABLE

event	Iterable (pull)	Observable (push)
retrieve data	T next()	onNext(T)
discover error	throws Exception	onError(Exception)
complete	!hasNext()	onCompleted()

ITERABLE VS. OBSERVABLE

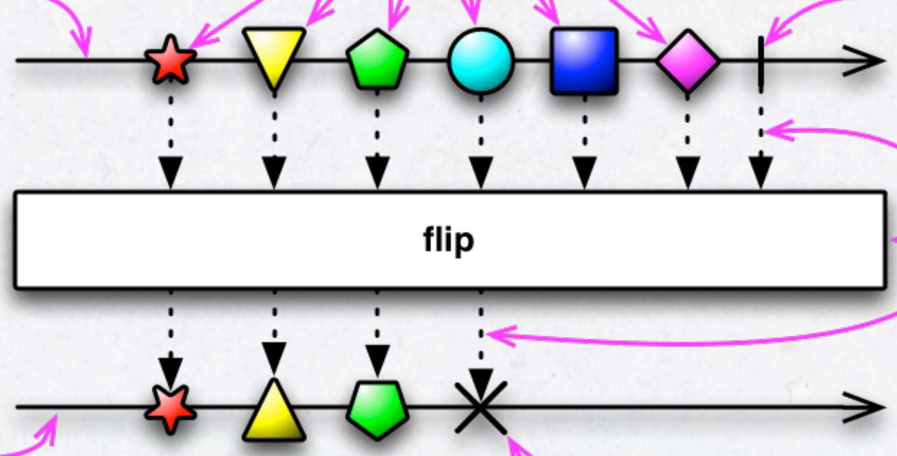
Observable “Push based”	Iterable (Java Stream) “Pull based”

getData()
.skip(10)
.take(5)
.map(s -> s + "transformed")
.forEach(System.out::println);
	getData()
	.skip(10)
	.limit(5)
	.map(s -> s + "transformed")
	.forEach(System.out::println);

REACTIVE EXTENSIONS

- Lightweight (only one jar-file).
- Flexible in implementation of Observables.
- Changing implementation does not break Observers.
- Polyglot

MARBLE DIAGRAMS



This is the timeline of the Observable. Time flows from left to right.

These are items emitted by the Observable.

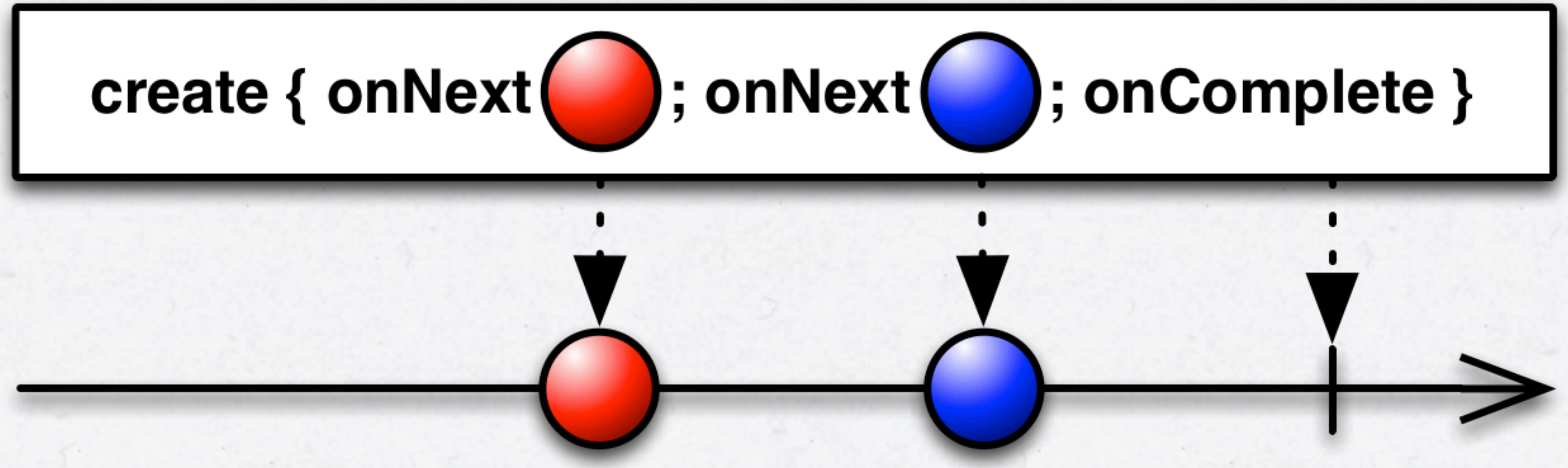
This vertical line indicates that the Observable has completed successfully.

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.

This Observable is the result of the transformation.

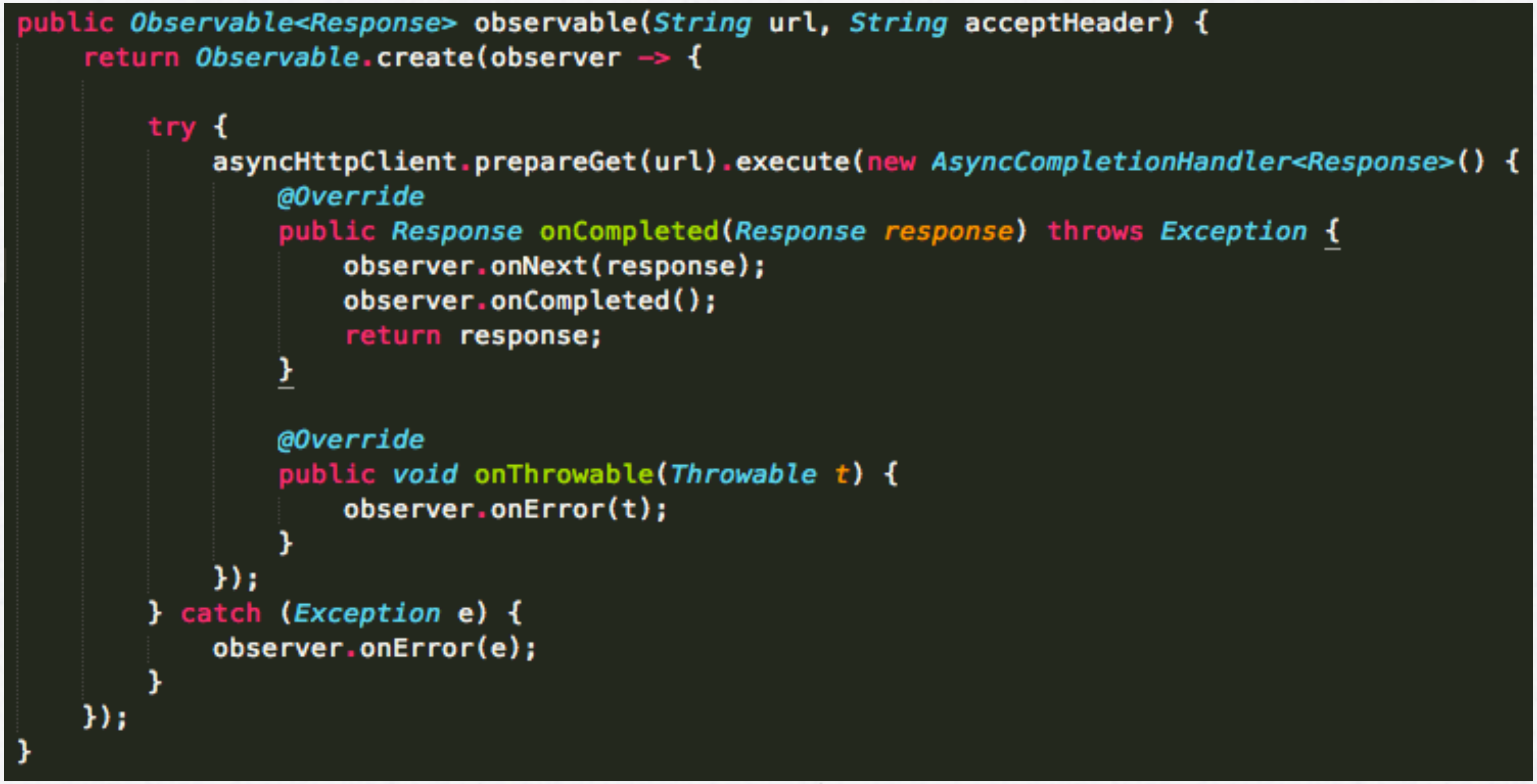
If for some reason the Observable terminates abnormally, with an error, the vertical line is replaced by an X.

CREATE OBSERVABLE



BORING…

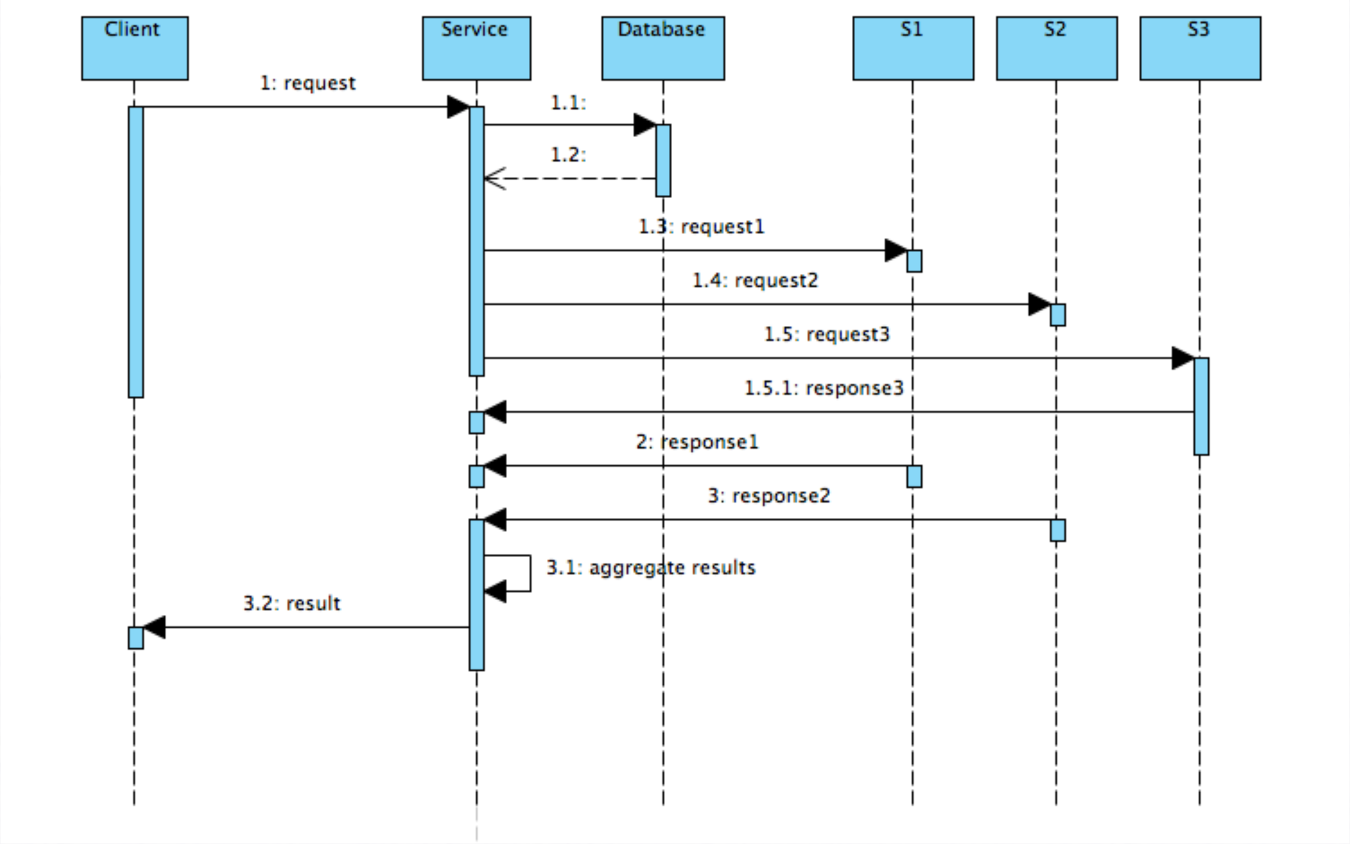
CREATE AN OBSERVABLE



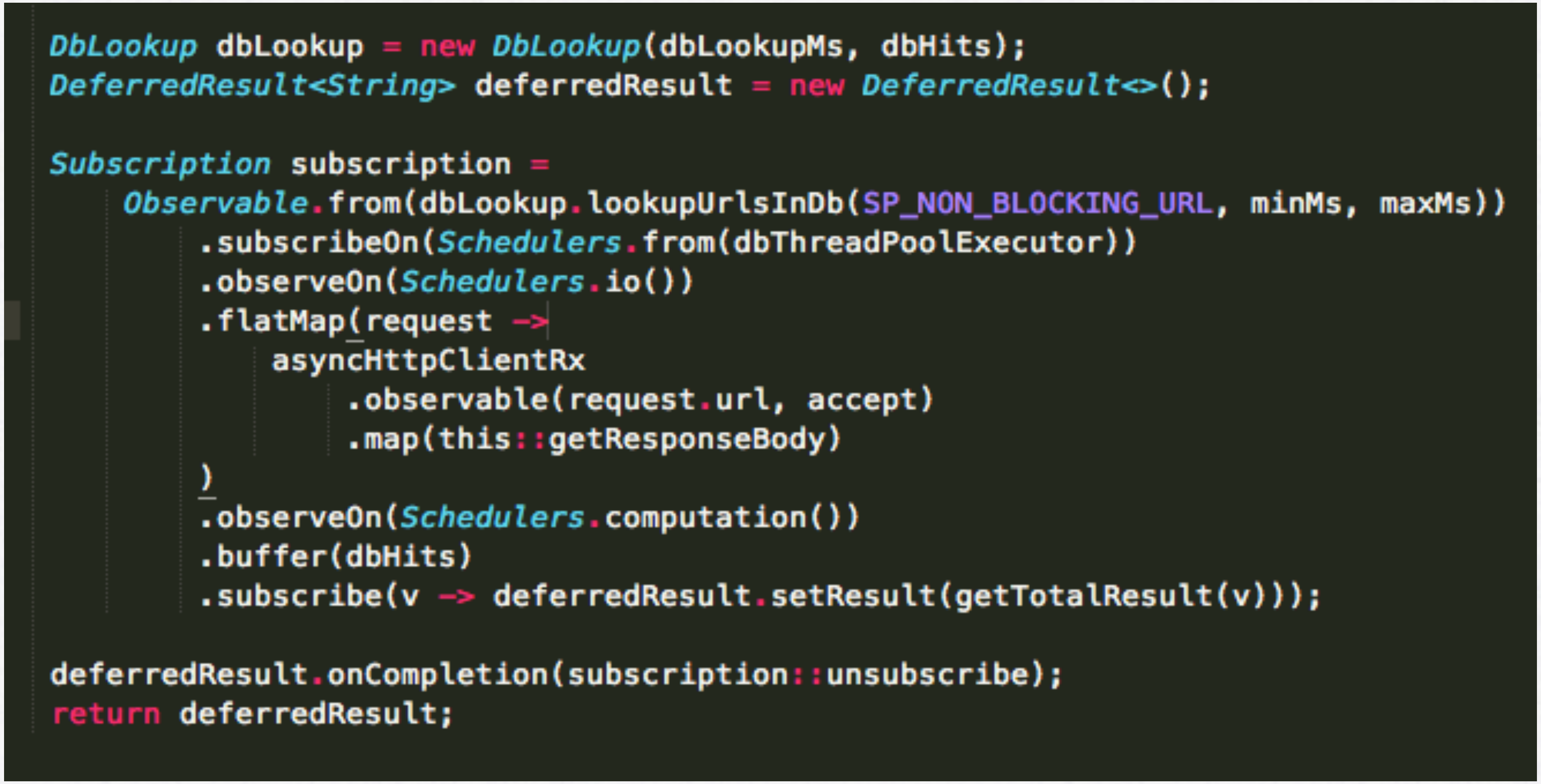
```
public Observable<Response> observable(String url, String acceptHeader) {
    return Observable.create(observer -> {

        try {
            asyncHttpClient.prepareGet(url).execute(new AsyncCompletionHandler<Response>() {
                @Override
                public Response onCompleted(Response response) throws Exception {
                    observer.onNext(response);
                    observer.onCompleted();
                    return response;
                }

                @Override
                public void onThrowable(Throwable t) {
                    observer.onError(t);
                }
            });
        } catch (Exception e) {
            observer.onError(e);
        }
    });
}
```

STILL BORING

AGGREGATOR EXAMPLE

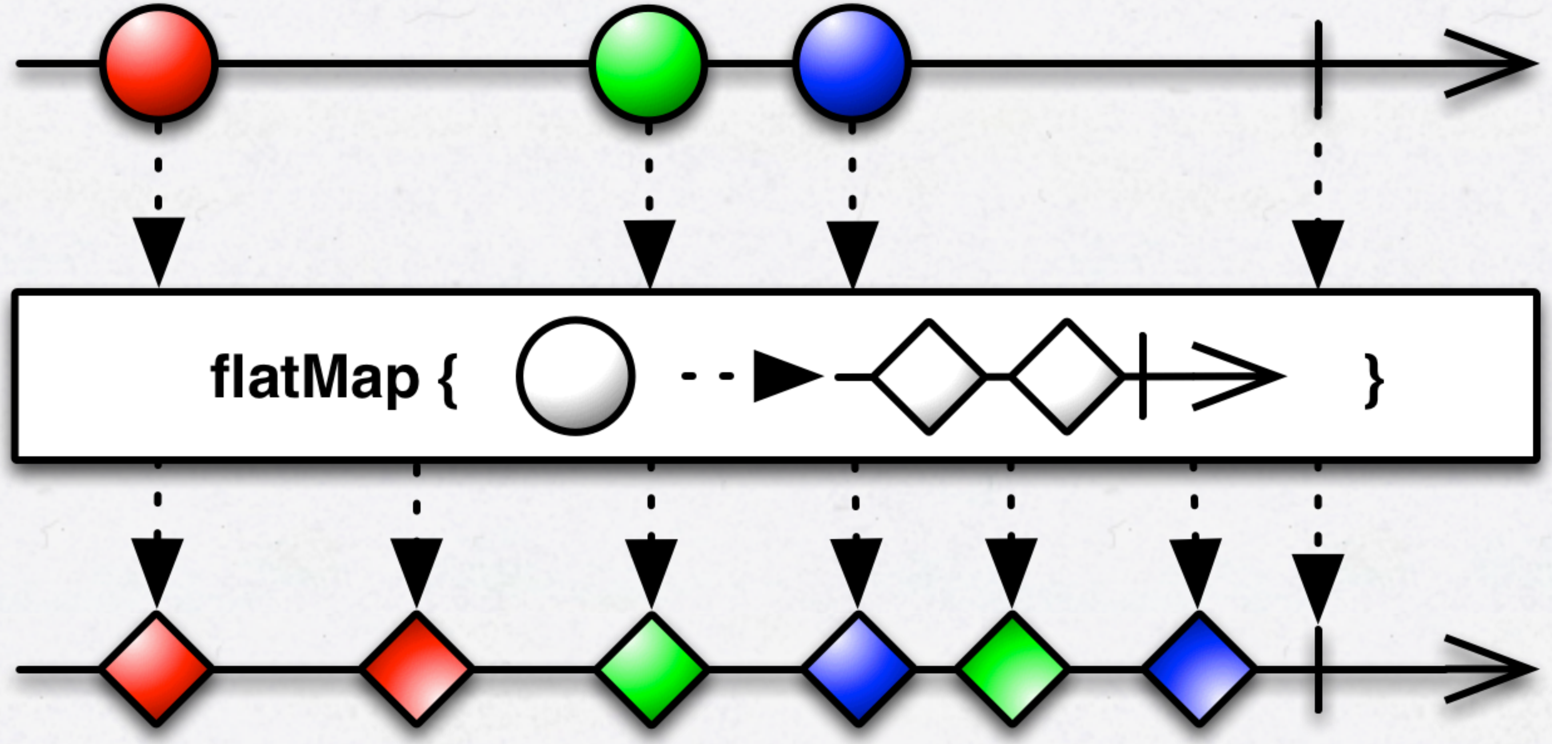


AGGREGATOR EXAMPLE

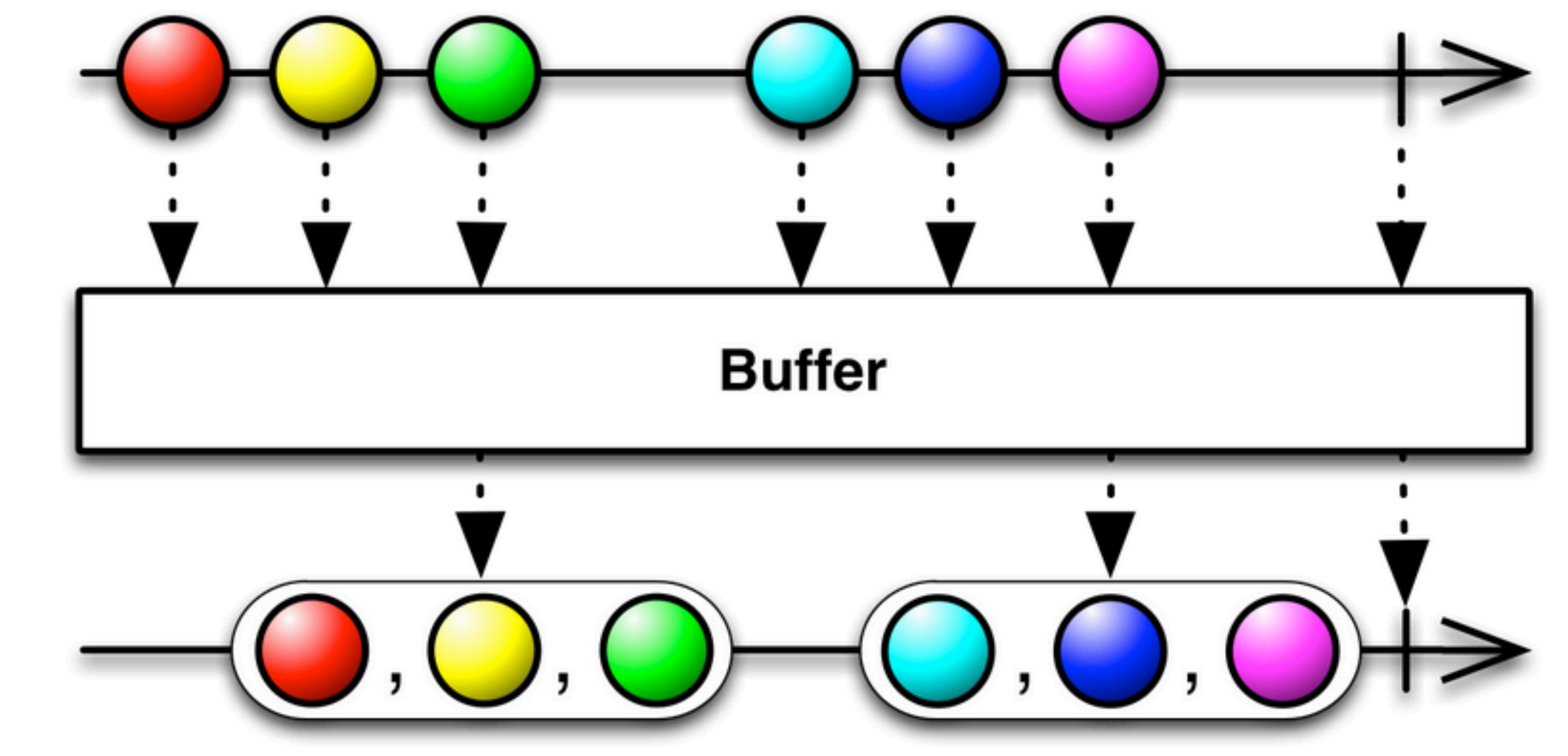


```
DbLookup dbLookup = new DbLookup(dbLookupMs, dbHits);
DeferredResult<String> deferredResult = new DeferredResult<>();

Subscription subscription =
    Observable.from(dbLookup.lookupUrlsInDb(SP_NON_BLOCKING_URL, minMs, maxMs))
        .subscribeOn(Schedulers.from(dbThreadPoolExecutor))
        .observeOn(Schedulers.io())
        .flatMap(request ->
            asyncHttpClientRx
                .observable(request.url, accept)
                .map(this::getResponseBody)
        )
        .observeOn(Schedulers.computation())
        .buffer(dbHits)
        .subscribe(v -> deferredResult.setResult(getTotalResult(v)));

deferredResult.onCompletion(subscription::unsubscribe);
return deferredResult;
```

RX FLATMAP

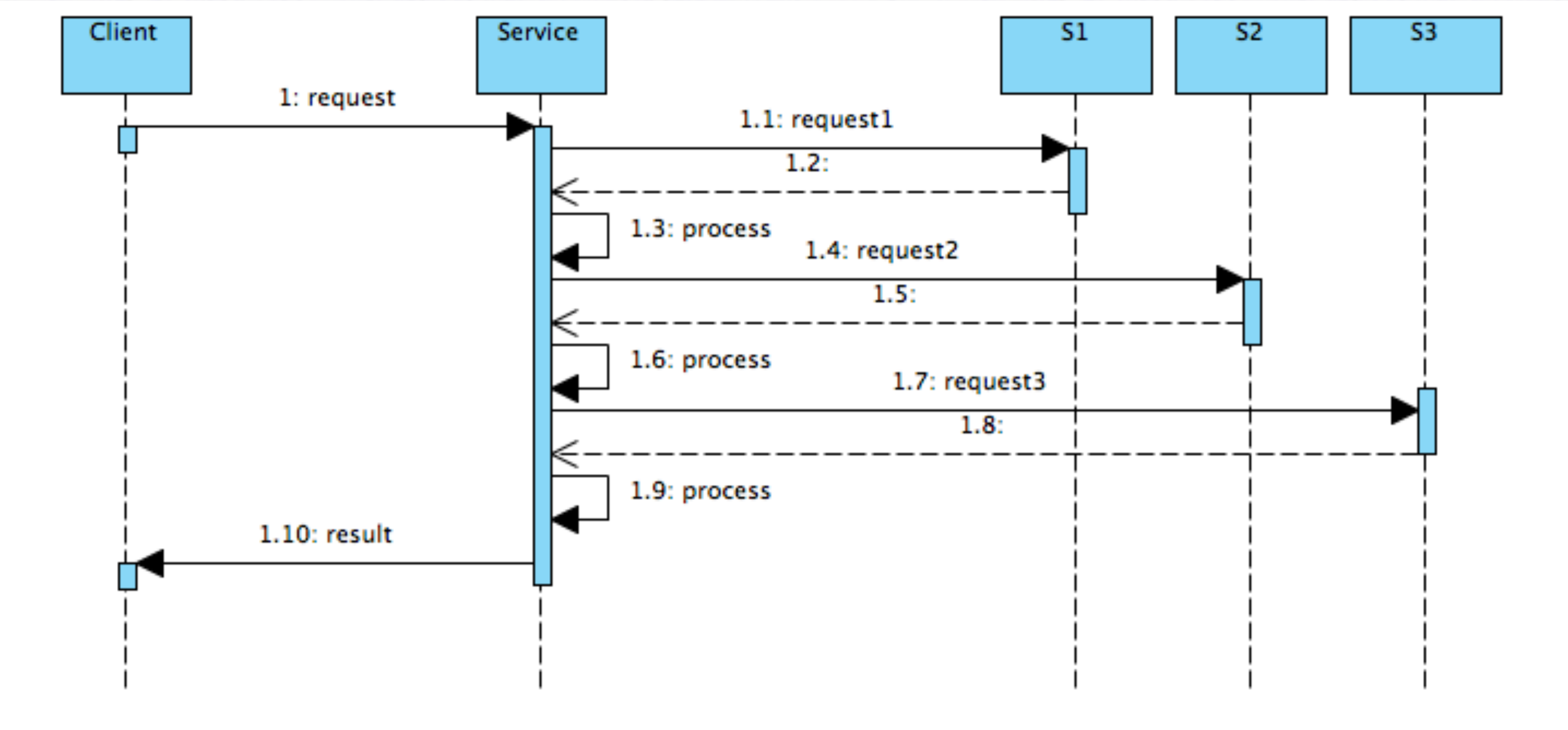


RX BUFFER

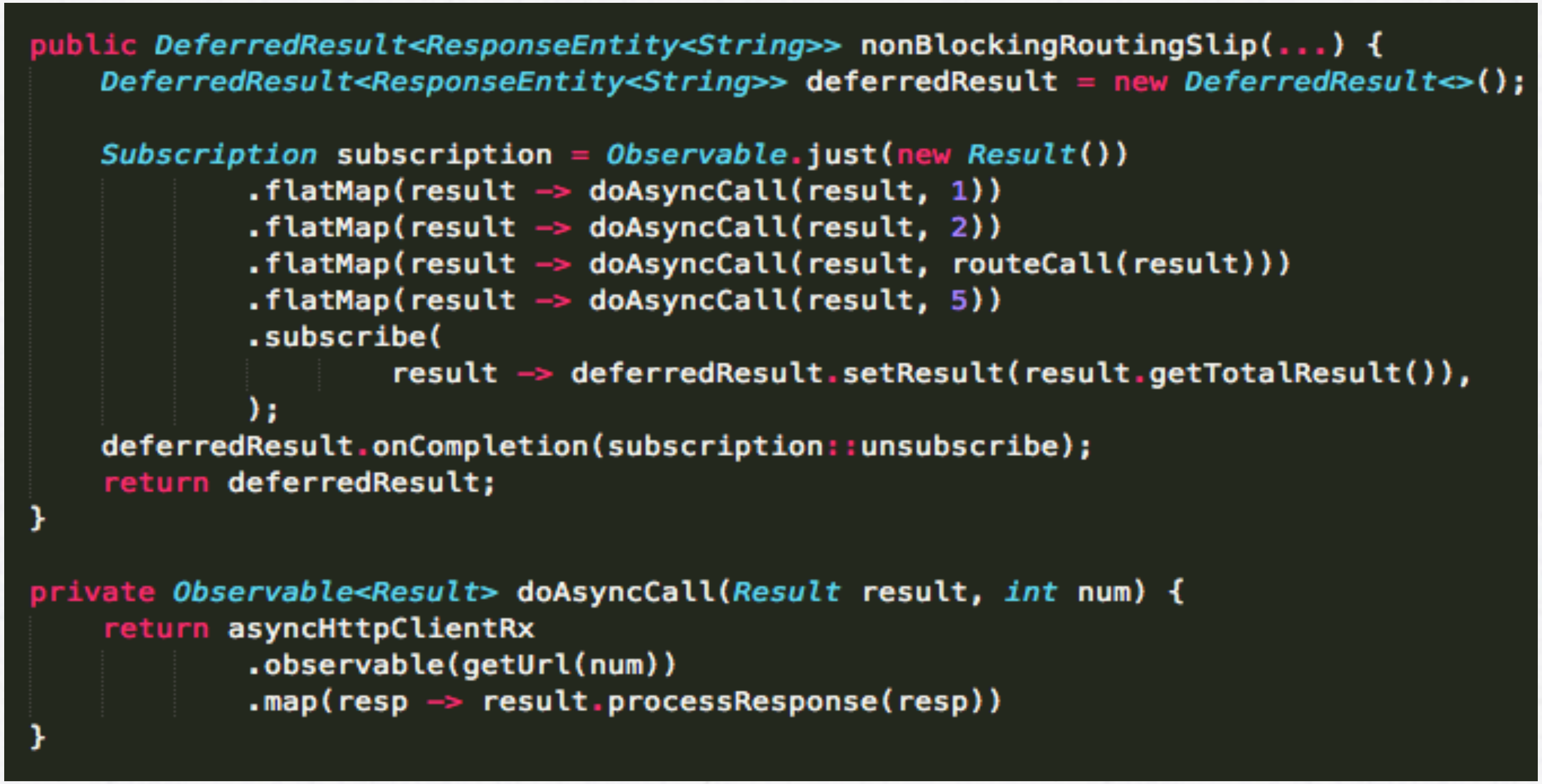


JUST AWESOME

ROUTING SLIP EXAMPLE



ROUTING SLIP EXAMPLE

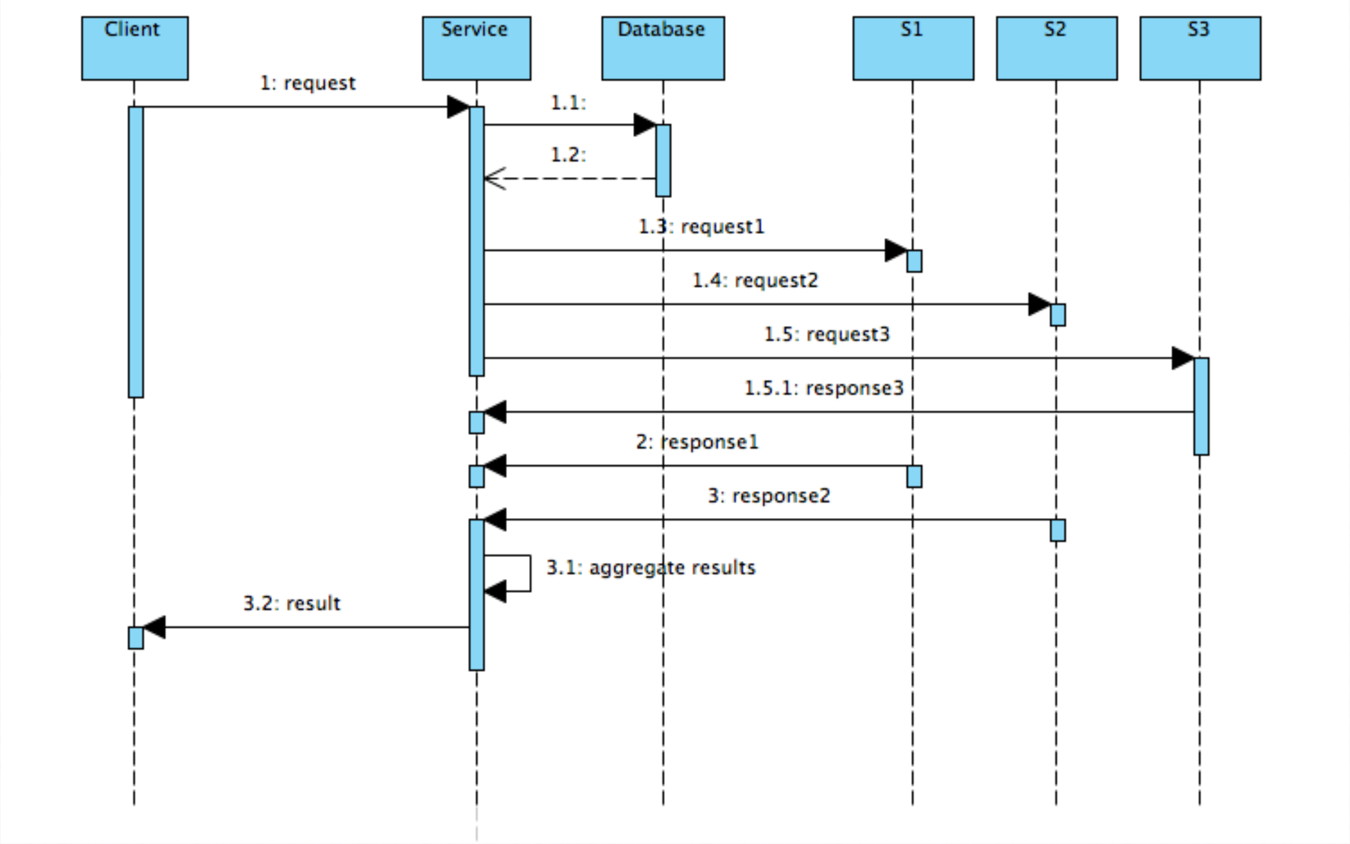


```
public DeferredResult<ResponseEntity<String>> nonBlockingRoutingSlip(...) {
    DeferredResult<ResponseEntity<String>> deferredResult = new DeferredResult<>();

    Subscription subscription = Observable.just(new Result())
            .flatMap(result -> doAsyncCall(result, 1))
            .flatMap(result -> doAsyncCall(result, 2))
            .flatMap(result -> doAsyncCall(result, routeCall(result)))
            .flatMap(result -> doAsyncCall(result, 5))
            .subscribe(
                    result -> deferredResult.setResult(result.getTotalResult()),
            );
    deferredResult.onCompletion(subscription::unsubscribe);
    return deferredResult;
}

private Observable<Result> doAsyncCall(Result result, int num) {
    return asyncHttpClientRx
            .observable(getUrl(num))
            .map(resp -> result.processResponse(resp))
}
```

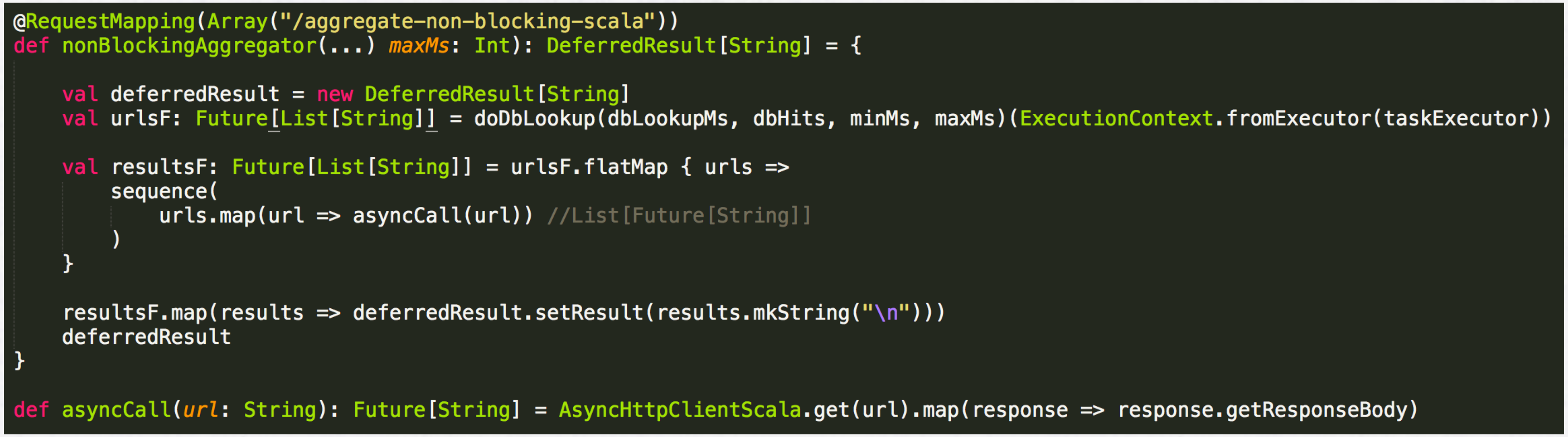
CONCLUSIONS

SCALA

AGGREGATOR EXAMPLE

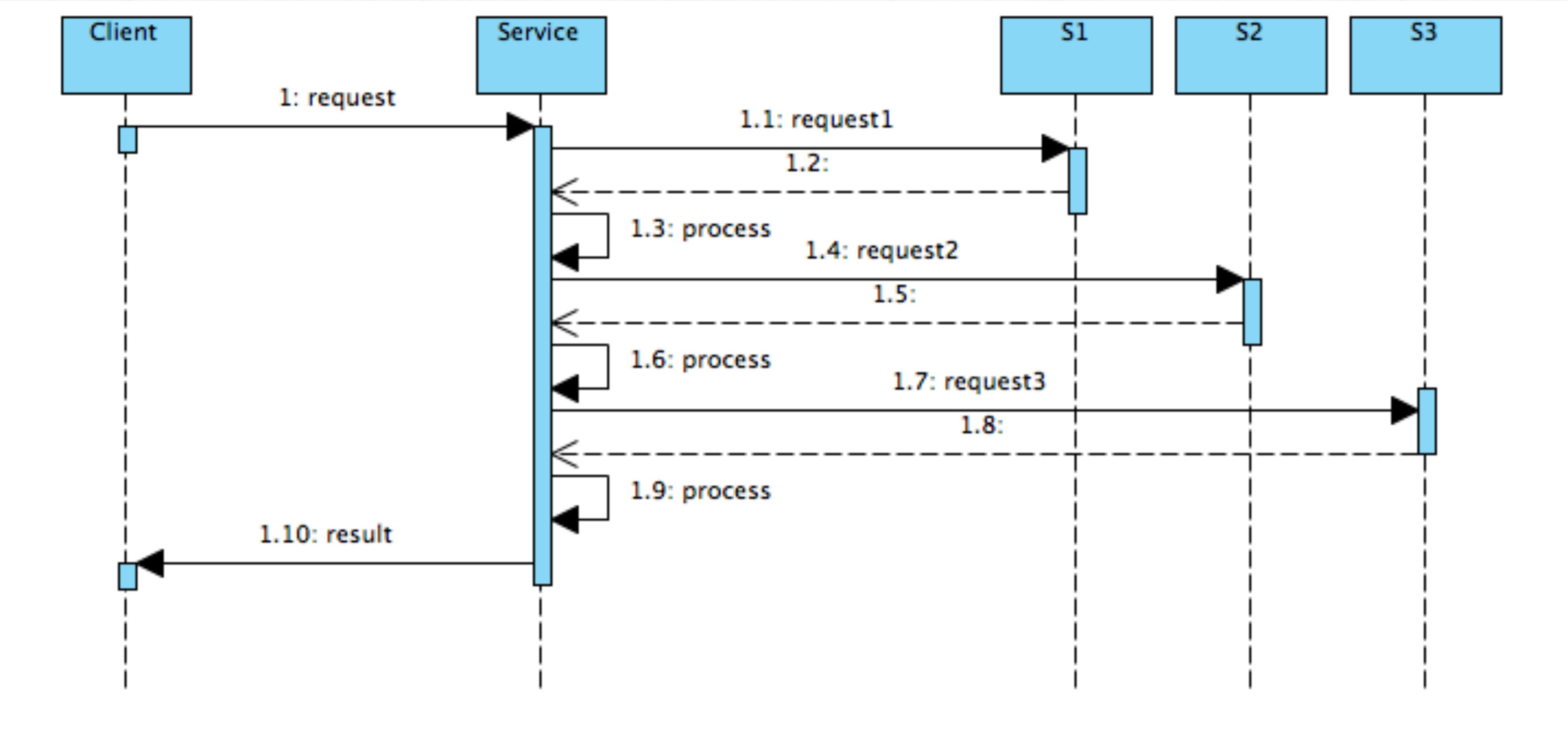


AGGREGATOR - SCALA

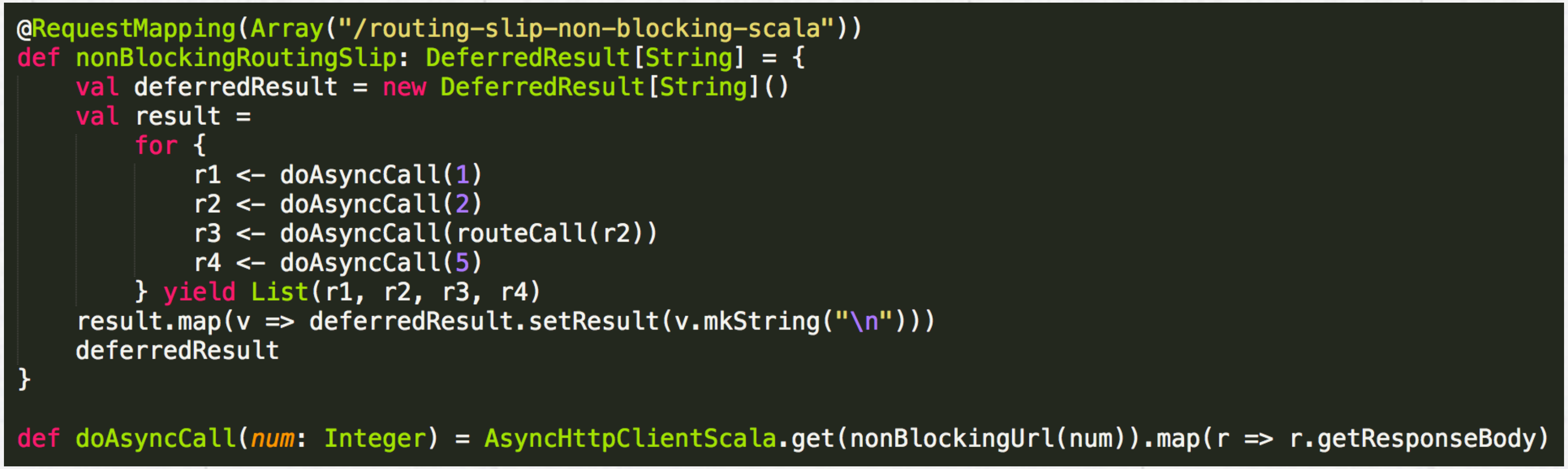


```scala
@RequestMapping(Array("/aggregate-non-blocking-scala"))
def nonBlockingAggregator(...) maxMs: Int): DeferredResult[String] = {

    val deferredResult = new DeferredResult[String]
    val urlsF: Future[List[String]] = doDbLookup(dbLookupMs, dbHits, minMs, maxMs)(ExecutionContext.fromExecutor(taskExecutor))

    val resultsF: Future[List[String]] = urlsF.flatMap { urls =>
        sequence(
            urls.map(url => asyncCall(url)) //List[Future[String]]
        )
    }

    resultsF.map(results => deferredResult.setResult(results.mkString("\n")))
    deferredResult
}

def asyncCall(url: String): Future[String] = AsyncHttpClientScala.get(url).map(response => response.getResponseBody)
```

ROUTING SLIP EXAMPLE



ROUTING SLIP - SCALA



```scala
@RequestMapping(Array("/routing-slip-non-blocking-scala"))
def nonBlockingRoutingSlip: DeferredResult[String] = {
    val deferredResult = new DeferredResult[String]()
    val result =
        for {
            r1 <- doAsyncCall(1)
            r2 <- doAsyncCall(2)
            r3 <- doAsyncCall(routeCall(r2))
            r4 <- doAsyncCall(5)
        } yield List(r1, r2, r3, r4)
    result.map(v => deferredResult.setResult(v.mkString("\n")))
    deferredResult
}

def doAsyncCall(num: Integer) = AsyncHttpClientScala.get(nonBlockingUrl(num)).map(r => r.getResponseBody)
```

PLAY FRAMEWORK

PLAY FRAMEWORK

- Developer friendly
- Stateless web tier
- Non-blocking I/O
- Build on Akka
- Real-time enabled
- Restful by default
- Websockets, Comet, EventSource

LinkedIn

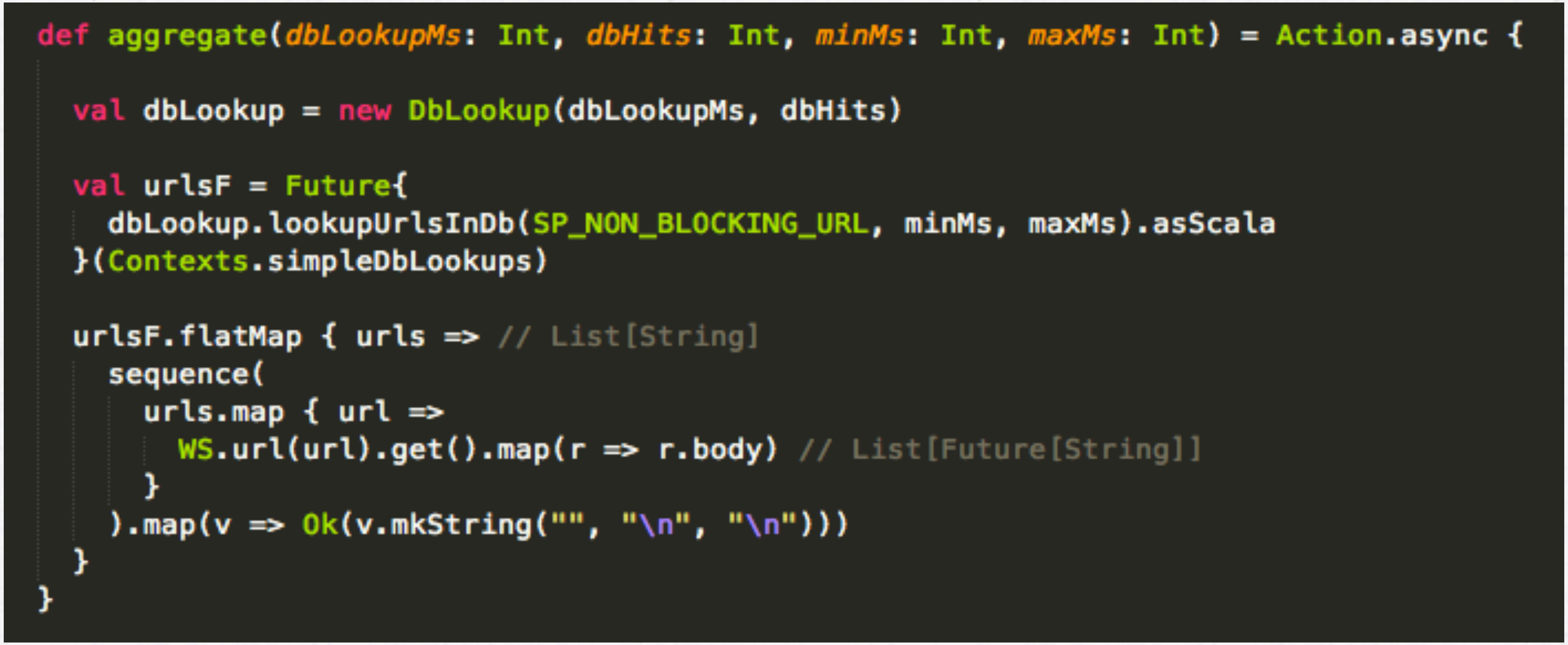
KLOUT

GILT

theguardian

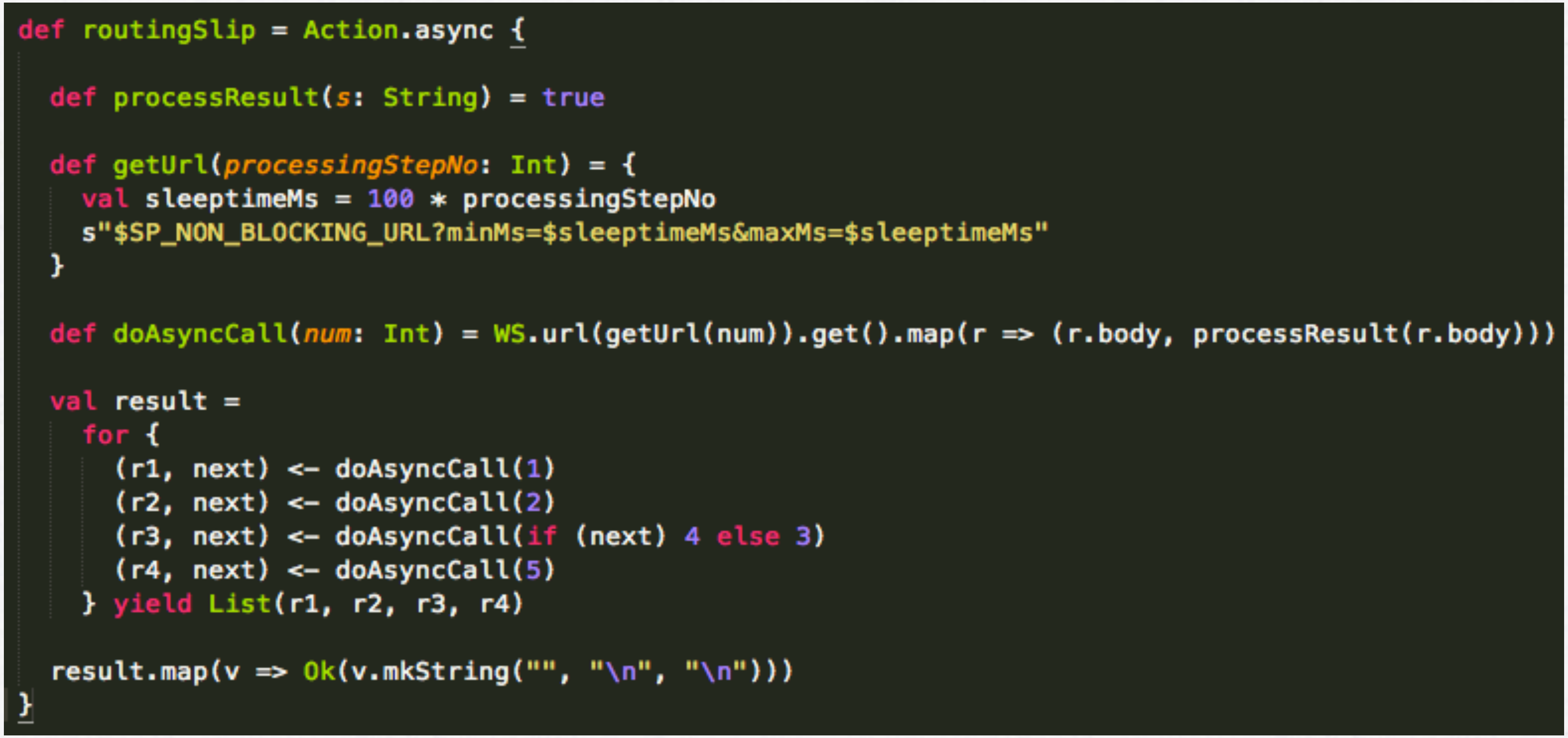
ZapTravel

PLAY AGGREGATE



```scala
def aggregate(dbLookupMs: Int, dbHits: Int, minMs: Int, maxMs: Int) = Action.async {

  val dbLookup = new DbLookup(dbLookupMs, dbHits)

  val urlsF = Future{
    dbLookup.lookupUrlsInDb(SP_NON_BLOCKING_URL, minMs, maxMs).asScala
  }(Contexts.simpleDbLookups)

  urlsF.flatMap { urls => // List[String]
    sequence(
      urls.map { url =>
        WS.url(url).get().map(r => r.body) // List[Future[String]]
      }
    ).map(v => Ok(v.mkString("", "\n", "\n")))
  }
}
```

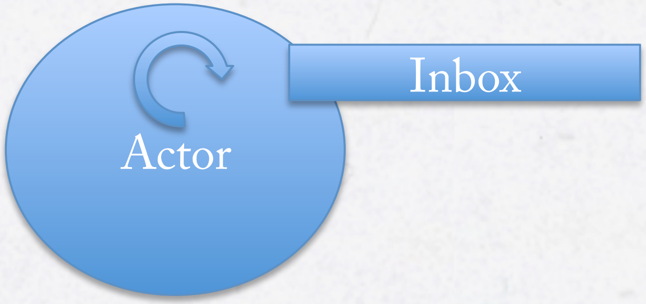
PLAY ROUTING SLIP



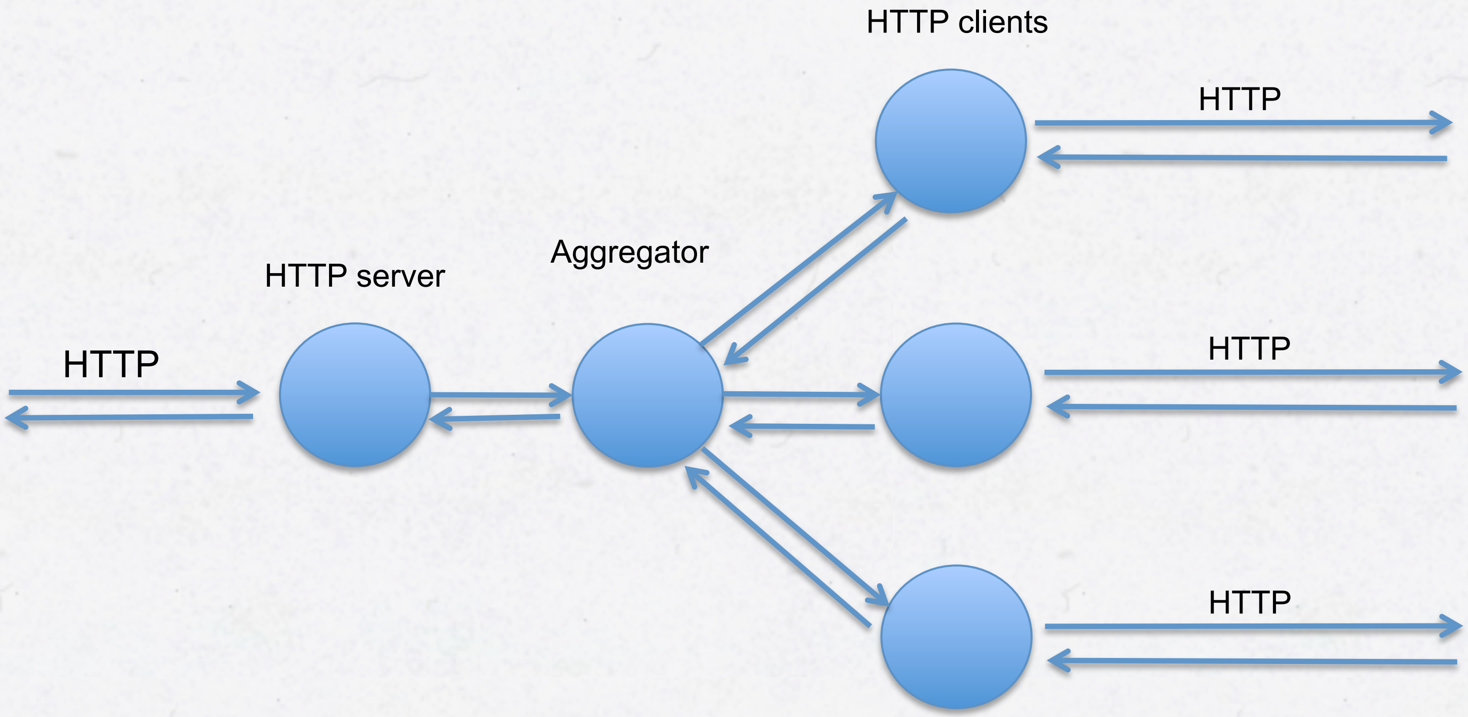
```scala
def routingSlip = Action.async {

  def processResult(s: String) = true

  def getUrl(processingStepNo: Int) = {
    val sleeptimeMs = 100 * processingStepNo
    s"$SP_NON_BLOCKING_URL?minMs=$sleeptimeMs&maxMs=$sleeptimeMs"
  }

  def doAsyncCall(num: Int) = WS.url(getUrl(num)).get().map(r => (r.body, processResult(r.body)))

  val result =
    for {
      (r1, next) <- doAsyncCall(1)
      (r2, next) <- doAsyncCall(2)
      (r3, next) <- doAsyncCall(if (next) 4 else 3)
      (r4, next) <- doAsyncCall(5)
    } yield List(r1, r2, r3, r4)

  result.map(v => Ok(v.mkString("", "\n", "\n")))
}
```

AKKA

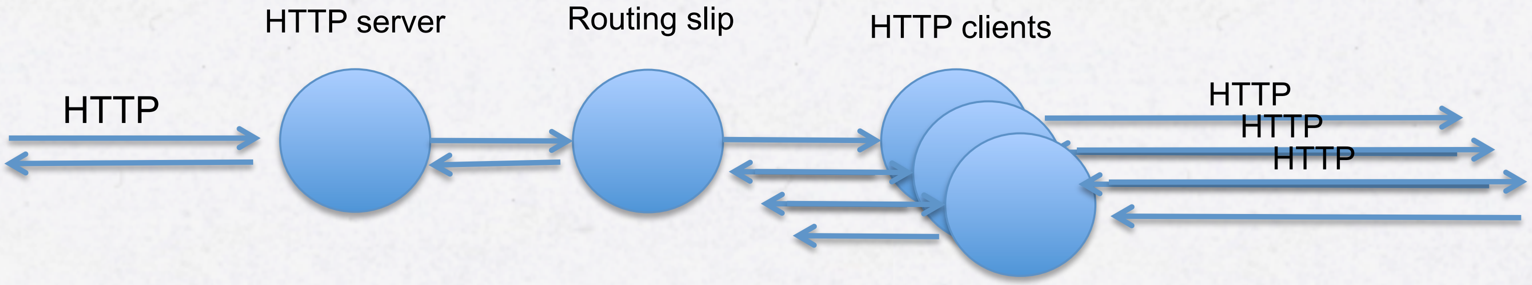
AKKA



AKKA



AKKA ROUTING SLIP



Summary and next step

SUMMARY

- We have seen…
  - If you need scalability and resilience its time to say goodbye to Blocking I/O!
  - The callback model is simple to get started with
    - …but gets easily very complex…
  - Reactive and Functional programming to the rescue!
  - Makes it possible to program asynchronous logic in a sequential way
    - Composable Futures is a key feature!
  - A lot of alternatives exists…
    - We have looked at Java 8, RX Java and Scala/Akka (more exists…)
    - What to choose?

SUMMARY

- What to choose?
  - Start with simple cases and the *callback* model to warm up…
  - When you need it and are ready for *reactive* and *functional* programming:
    - » Choose Java 8 and Completable Futures if
      - ▸ You must/want to avoid 3’rd party libraries
      - ▸ Watch out for the bloated API!
    - » Choose RX Java otherwise
      - ▸ Clean abstraction and API
      - ▸ Supports several languages (JS, .Net et al)
      - ▸ Runs on Java 7 (but you have to live without lambdas then ☺)
    - » If you are ready to switch language take a look at Scala…