redhat.

The Reactive Landscape

http://bit.ly/jfokus-reactive

Clement Escoffier, Vert.x Core Developer, Red Hat

Reactive all the things ???

reactive

ADJECTIVE

1 Showing a response to a stimulus.
'pupils are reactive to light'

1.1 *Physiology* Showing an immune response to a specific antigen.
'lysosomal activity can activate B lymphocytes reactive against self-components'

1.2 (of a disease or illness) caused by a reaction to something.
'reactive arthritis'
'reactive depression'

1.3 Having a tendency to react chemically.
'nitrogen dioxide is a highly reactive gas'

2 Acting in response to a situation rather than creating or controlling it.
'a proactive rather than a reactive approach'

3 *Physics*
Relating to reactance.
'a reactive load'

https://en.oxforddictionaries.com/definition/reactive

reactive

FAKE !

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3 *Software*
A software reacting to stimuli such as messages, requests, metrics, availability....

reactive

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End of the flow of control ?

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reactive

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End of the flow of control ? or just the comeback of asynchrony ?

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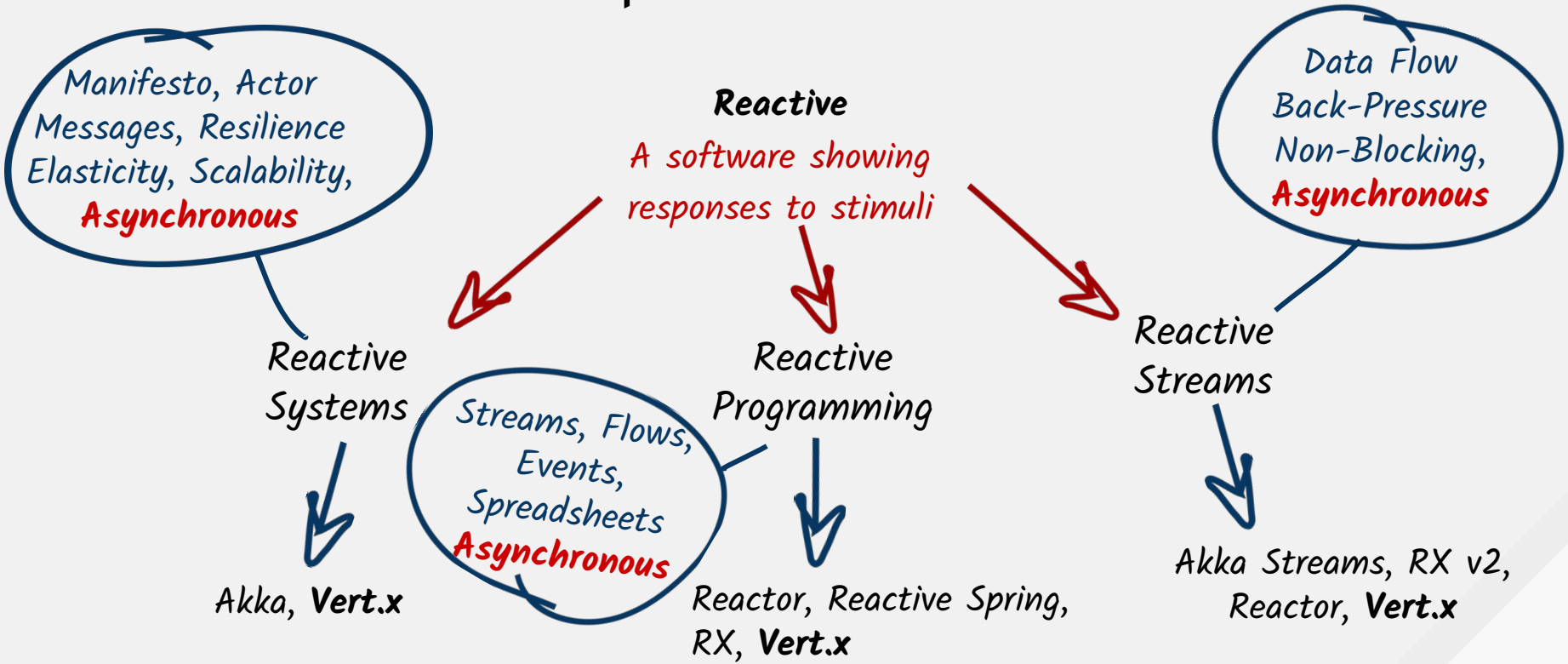
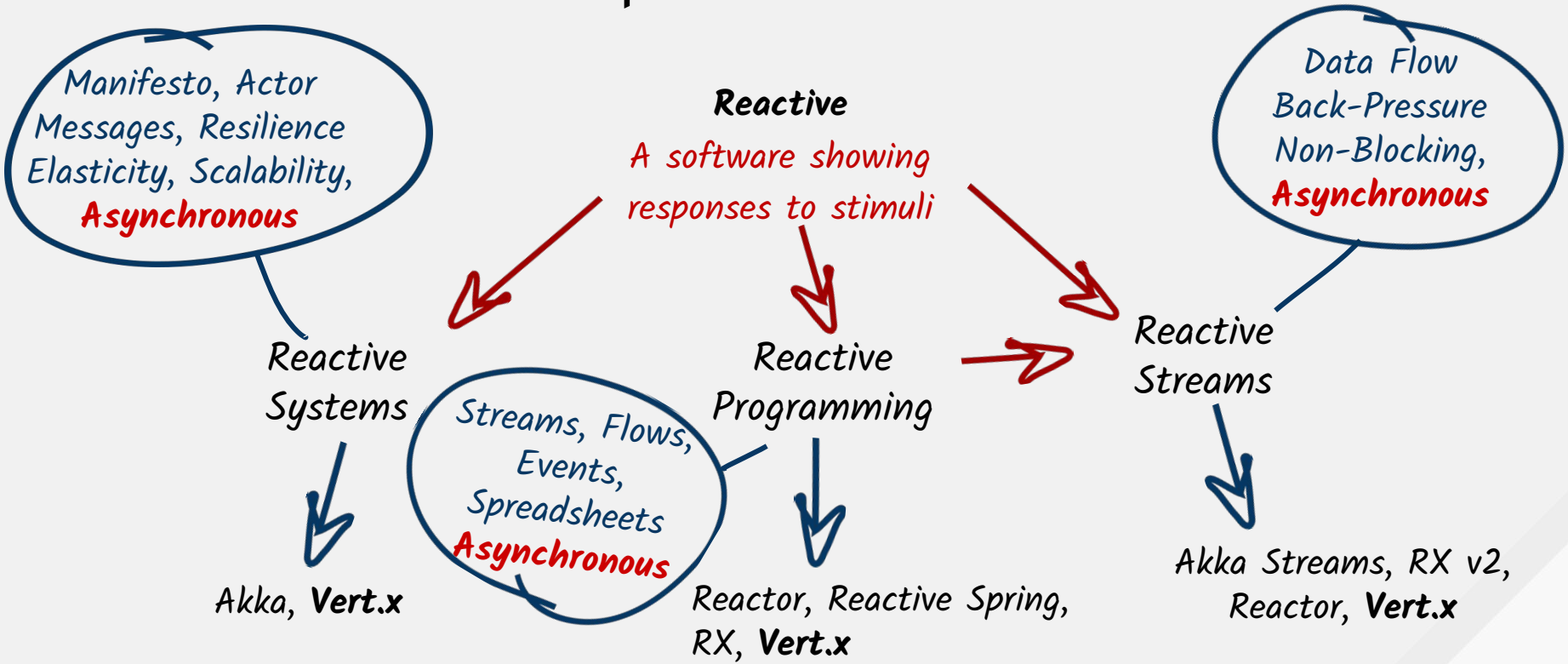
'a proactive rather than a reactive approach'

3 *Software*
A software reacting to stimuli such as messages, requests, metrics, availability....

The reactive landscape

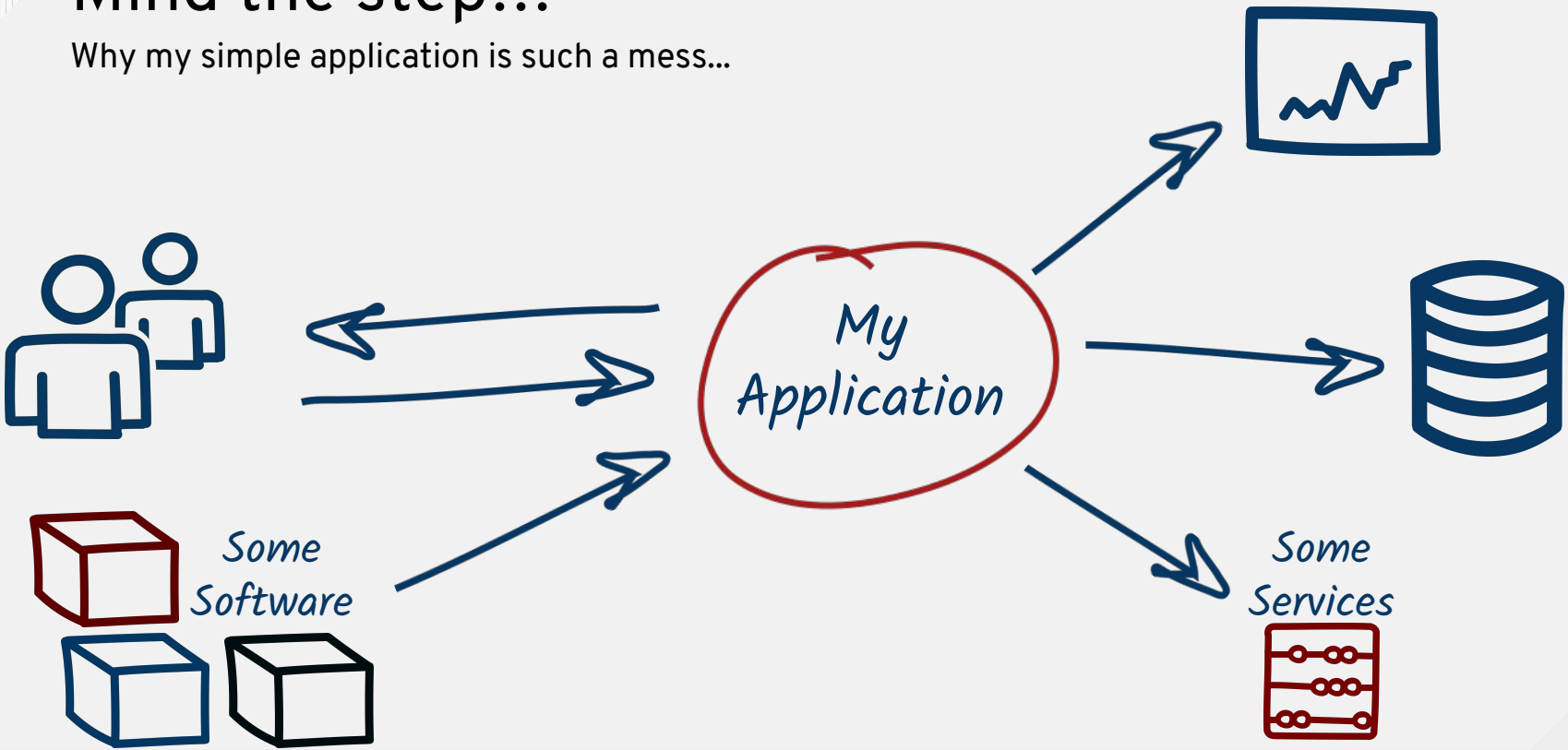


The reactive landscape



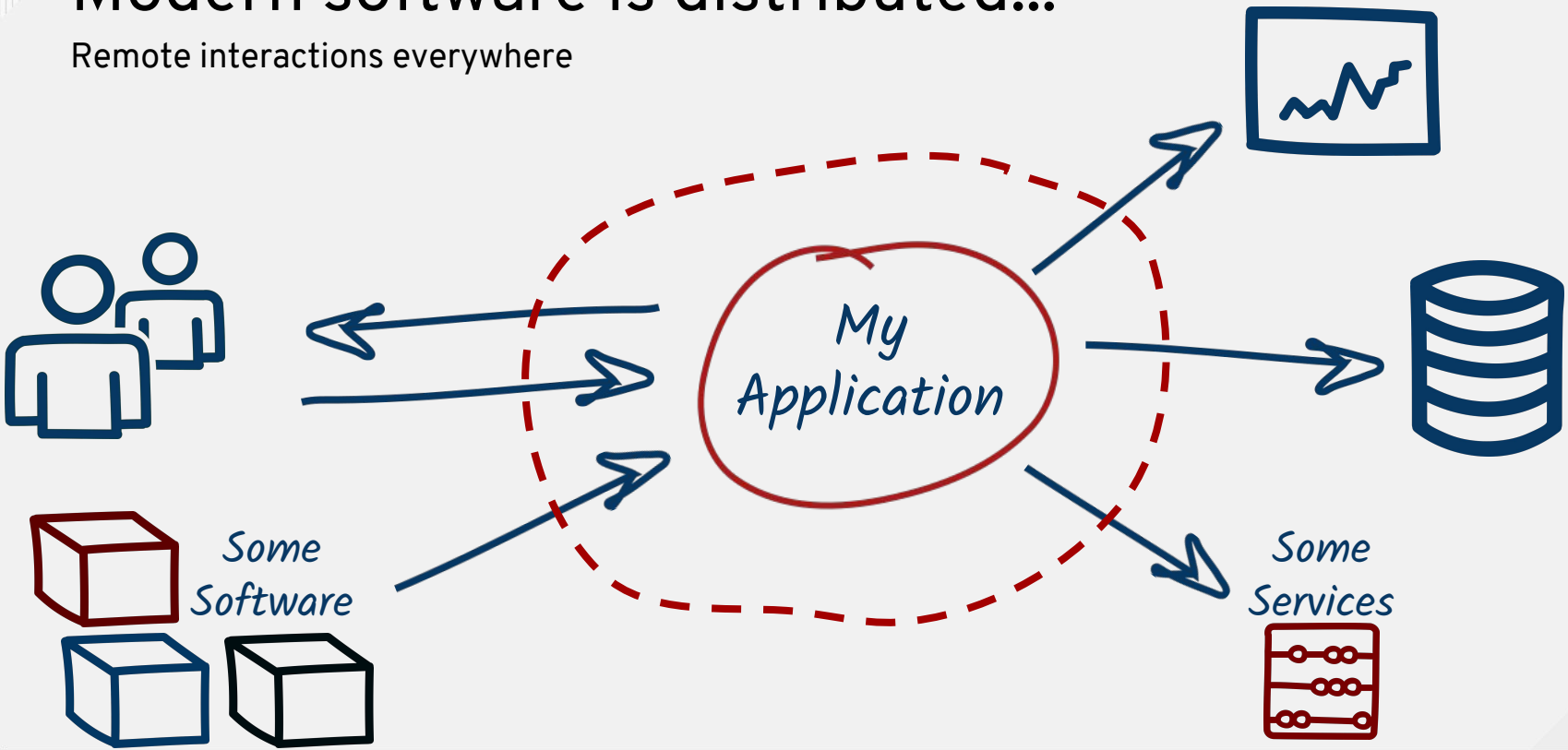
Mind the step...

Why my simple application is such a mess...



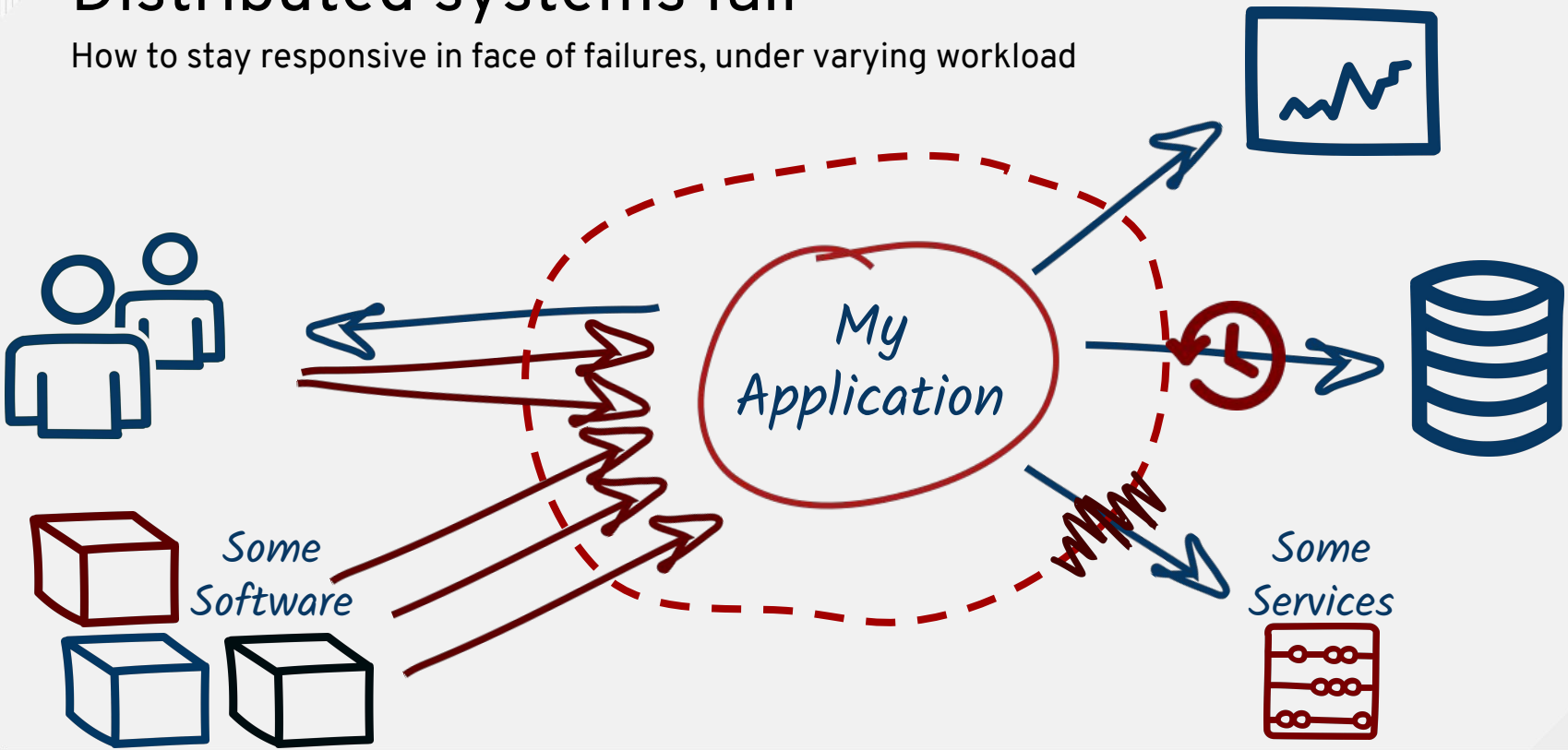
Modern software is distributed...

Remote interactions everywhere



Distributed systems fail

How to stay responsive in face of failures, under varying workload



Distributed systems fail

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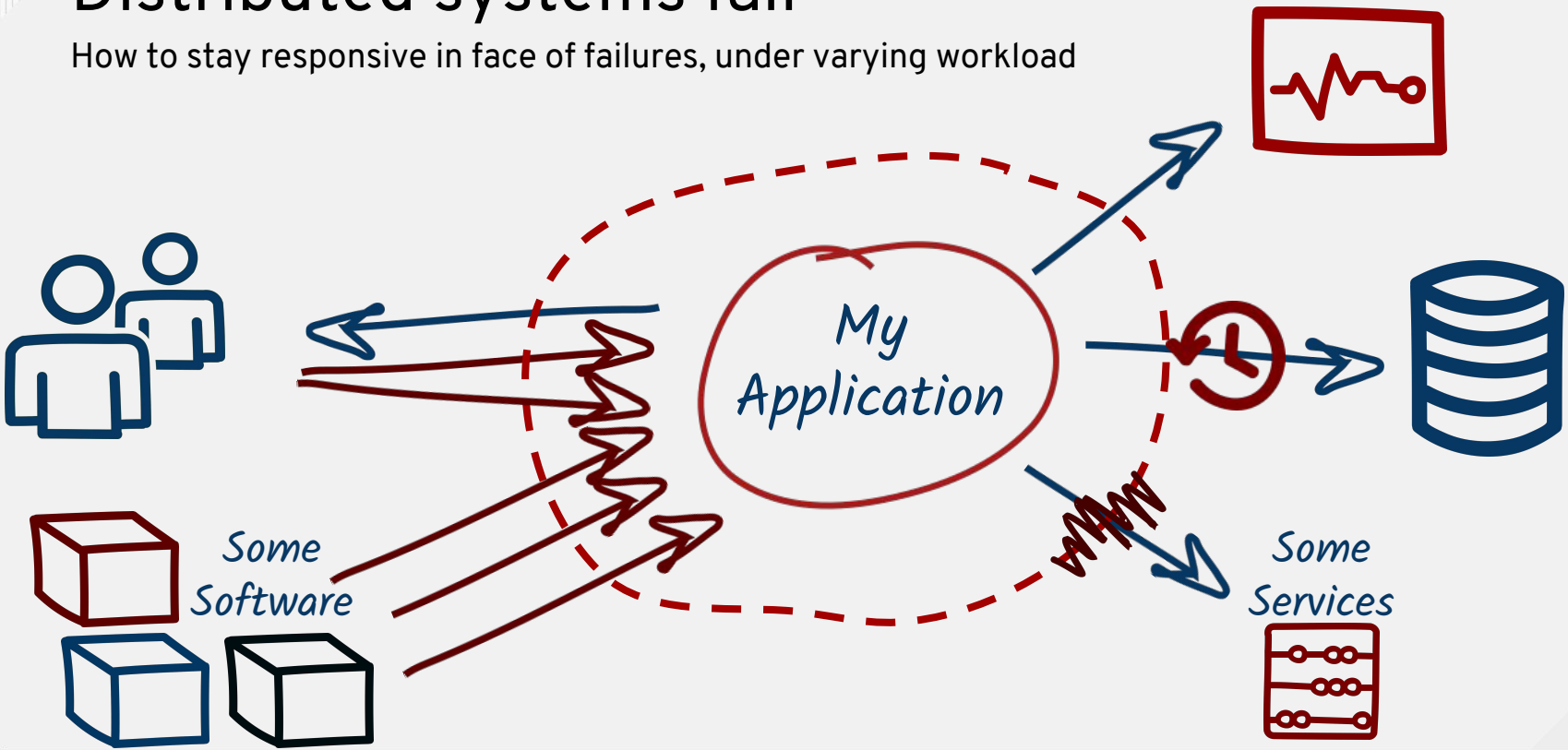
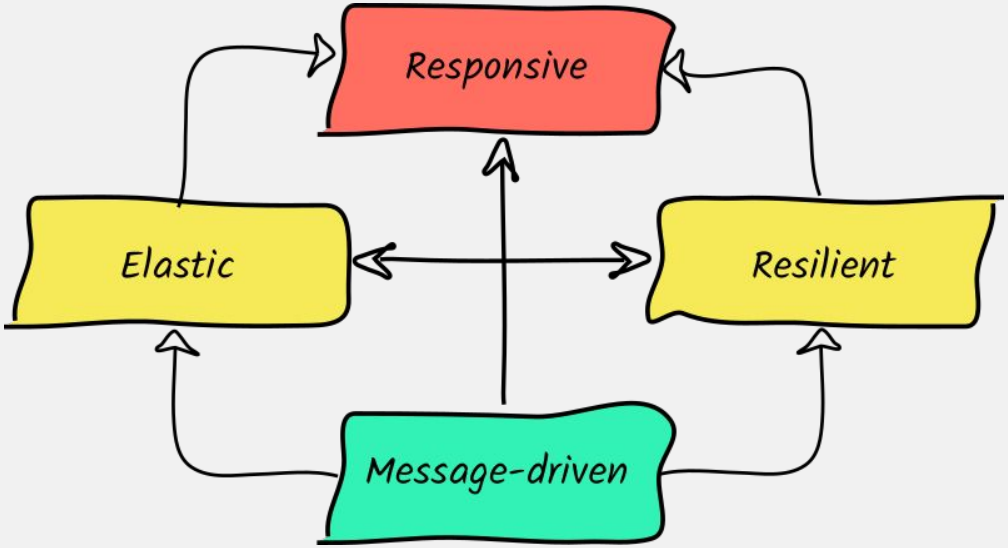


Reactive Systems => Responsive Systems

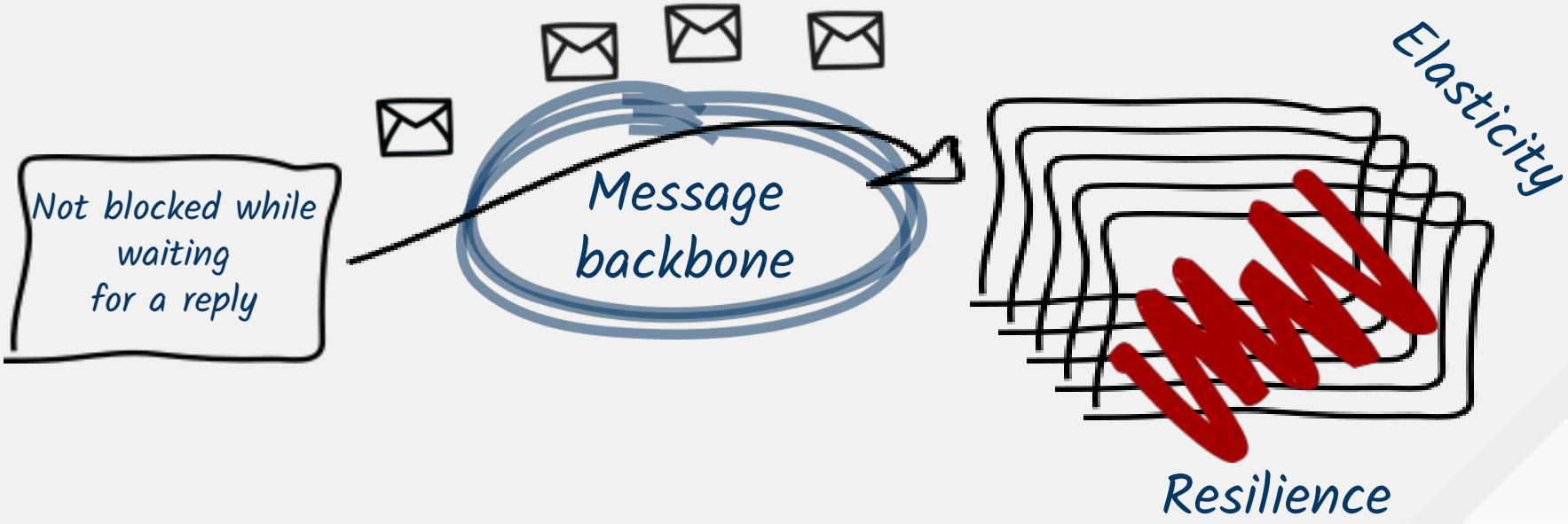
Reactive Manifesto

http://www.reactivemanifesto.org/

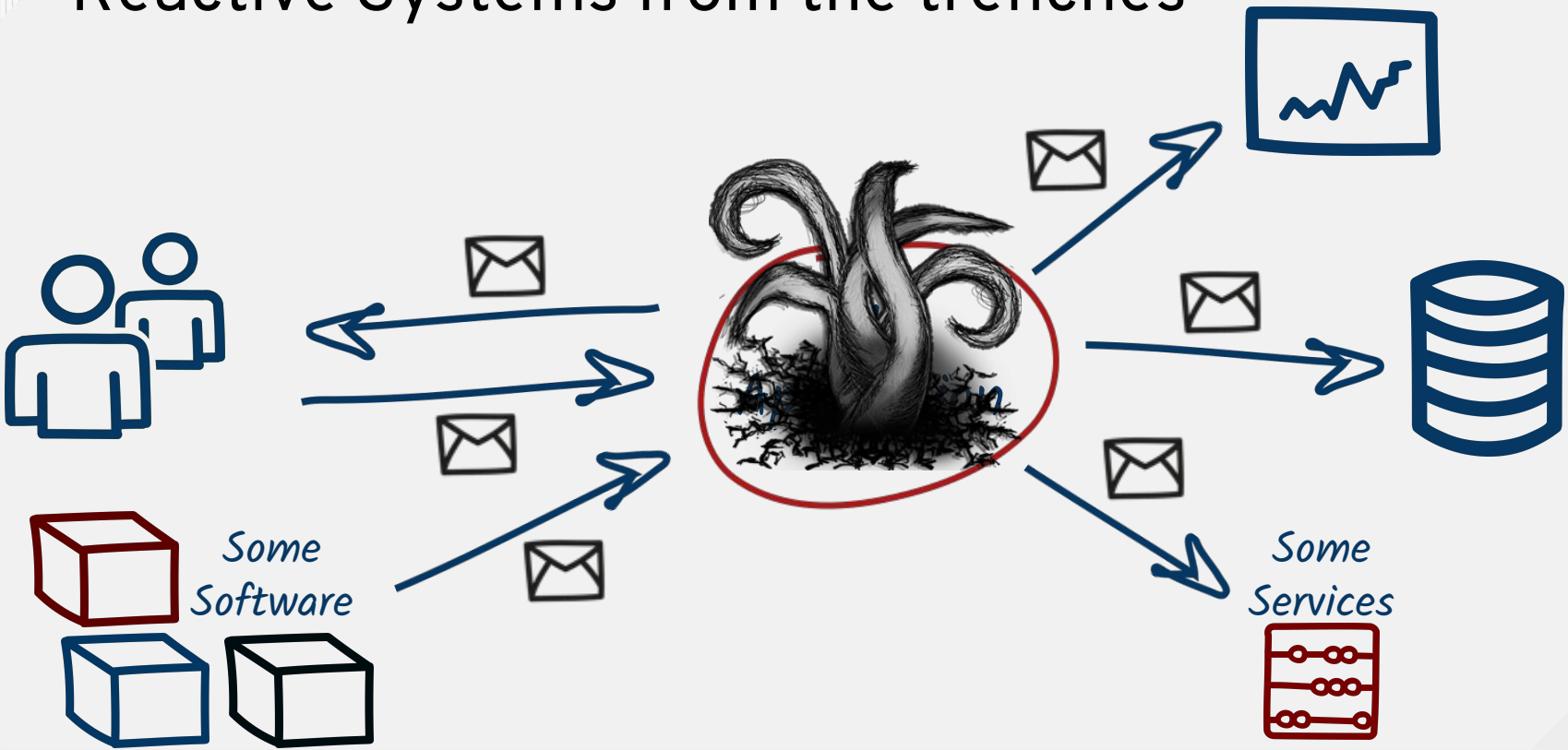


Asynchronous message passing

Asynchronous message passing

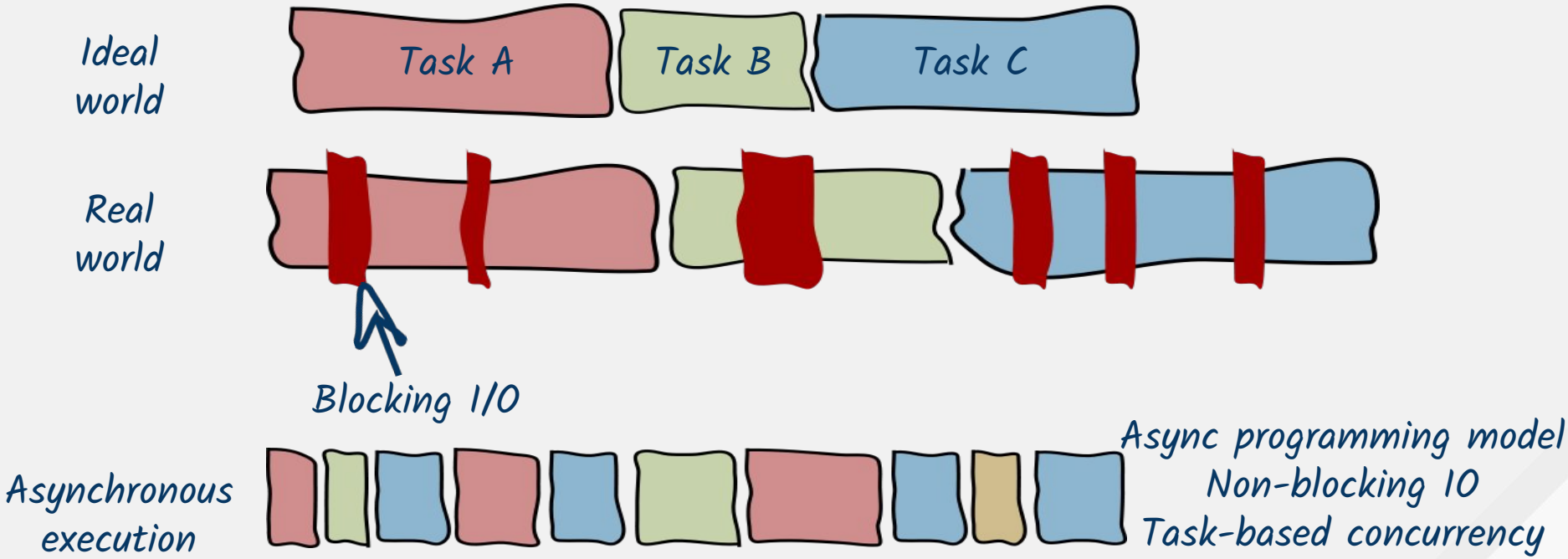


Reactive Systems from the trenches



Asynchronous development model

Asynchronous execution



Asynchronous, welcome to Hollywood

Don't wait, we will call you...

Synchronous

```
public int compute(int a, int b) {
    return ...;
}
```

```
int res = compute(1, 2);
```

Asynchronous

```
public void compute(int a, int b,
  Handler<AsyncResult<Integer>> h){
    // ...
    handler.handle(i);
}
```

```
compute(1, 2, res -> {
    // Called with the
    // async result
});
```

Callbacks for notifications and async actions

Web server example

```
vertx.createHttpServer()
    .requestHandler(req ->  // Async reaction
        req.response().end("Reactive greetings")
    )
    .listen(8080, ar -> { // Async operation
        //...
    });
```

Callbacks lead to...

Reality check

```
client.getConnection(conn -> {
   if (conn.failed()) {/* failure handling */}
   else {
       SQLConnection connection = conn.result();
       connection.query("SELECT * from PRODUCTS",
           rs -> {
               if (rs.failed()) {/* failure handling */}
               else {
                   List<JsonArray> lines =    rs.result().getResults();
                   for (JsonArray l : lines) {  System.out.println(new Product(l)); }
                   connection.close(
                      done -> {
                       if (done.failed()) {/* failure handling */}
                   });
               }
       });
   }
});
```

Reactive Programming...

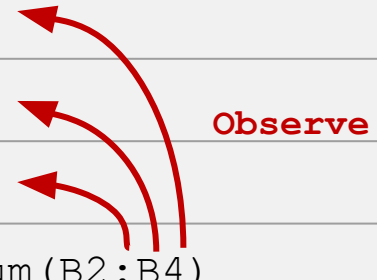
Tame the asynchronous

Are you an “Excel” user?

My Expense Report	
Lunch	15€
Coffee	25€
Drinks	45€
Total	85€

Are you an “Excel” user?

My Expense Report	
Lunch	15€
Coffee	25€
Drinks	45€
Total	=sum(B2:B4)



Streams (a.k.a Observables, Flowables, Publishers)

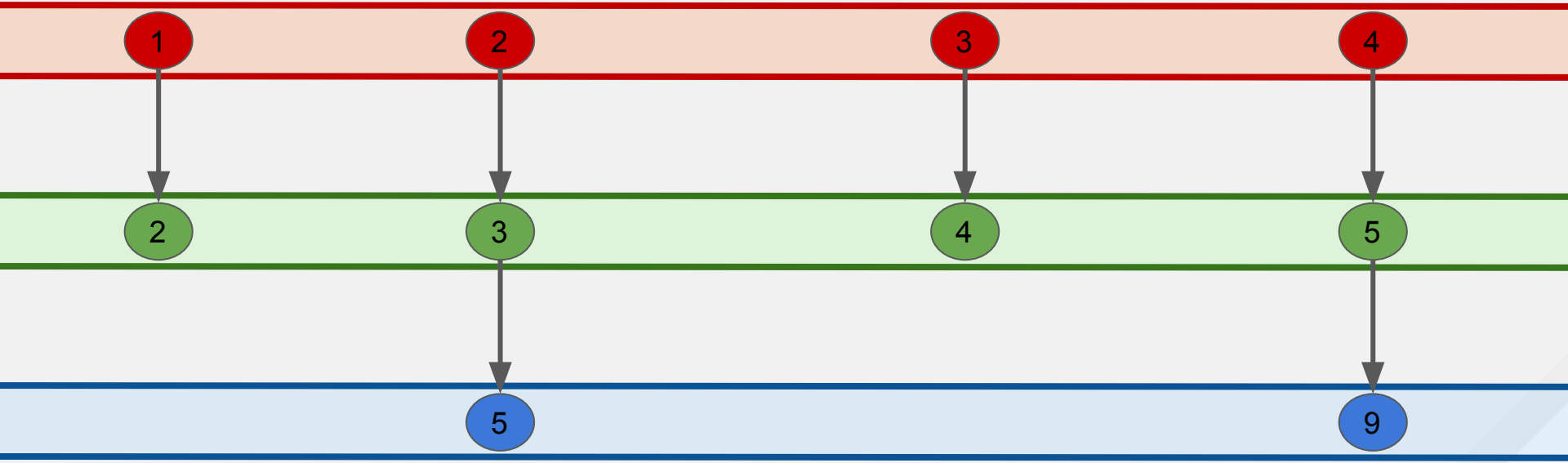
My Expense Report	
Lunch	15€
Coffee	0€
Drinks	0€
Total	15€

My Expense Report	
Lunch	15€
Coffee	25€
Drinks	0€
Total	40€

My Expense Report	
Lunch	15€
Coffee	25€
Drinks	45€
Total	85€

Reactive Programming

Publisher and Subscriber



Reactive Extension - RX Java 2

```
Flowable<Integer> obs1 = Flowable.range(1, 10);

Flowable<Integer> obs2 = obs1.map(i -> i + 1);

Flowable<Integer> obs3 = obs2.window(2)
   .flatMap(MathFlowable::sumInt);

obs3.subscribe(
   i -> System.out.println("Computed " + i)
);
```

Reactive types & Asynchronous

Flowable / Observable - Stream of data, Async reaction

- Bounded or unbounded stream of values
- Data, Error, End of Stream

Singles / Maybe - Async operation

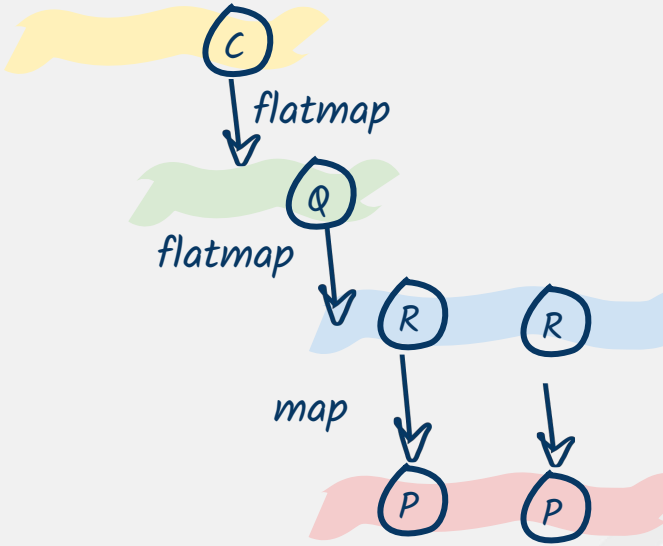
- Stream of one value
- Data, Error, Completion (maybe)

Completables - Async operation (no return)

- Stream without a value
- Completion, Error

Reactive types & Asynchronous

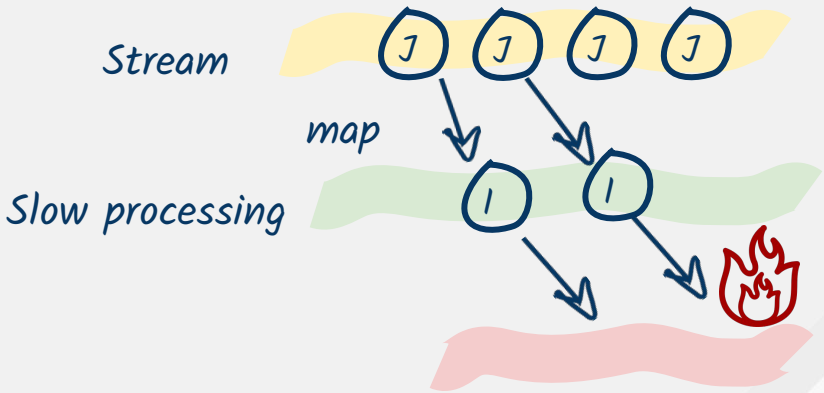
```
client.rxGetConnection()   // Single(async op)
 .flatMapPublisher(conn ->
   conn
     .rxQueryStream("SELECT * from PRODUCTS")
     .flatMapPublisher(SQLRowStream::toFlowable)
     .doAfterTerminate(conn::close)
 ) // Flowable of Rows
 .map(Product::new) // Flowable of Products
 .subscribe(System.out::println);
```



Back pressure & Reactive streams

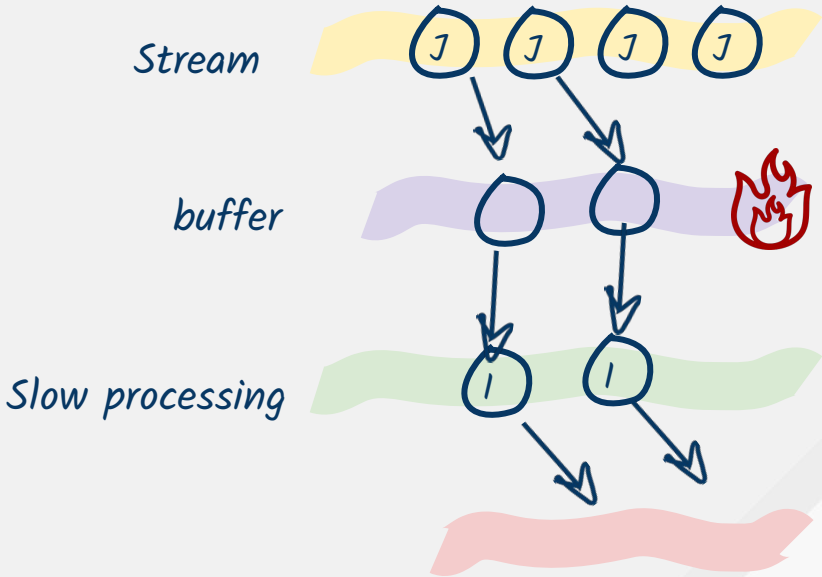
What if … the processing can't keep up

```
Streams.getStream()
   .observeOn(Schedulers.computation())

   .map(i -> {
      Thread.sleep(100); // I'm slow...
      return i.getLong("id");
   })
   .blockingSubscribe(
      x -> System.out.println("Processed:" + x),
      Throwable::printStackTrace,
      () -> System.out.println("Completed !")
   );
```



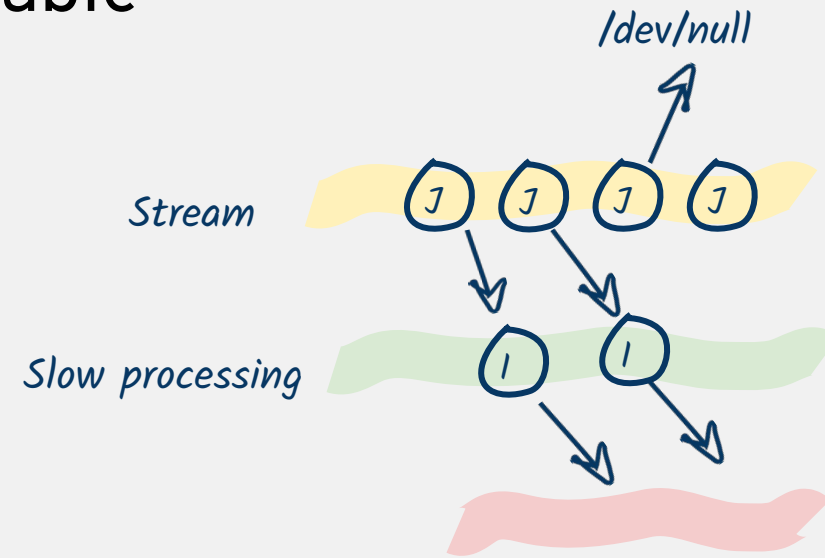
Buffer to handle small bumps

```
Streams.getStream()
  .onBackPressureBuffer(10000)
  .observeOn(Schedulers.computation())

  .map(i -> {
     Thread.sleep(100); // I'm slow...
     return i.getLong("id");
  })
  .blockingSubscribe(
     x -> System.out.println("Processed:" + x),
     Throwable::printStackTrace,
     () -> System.out.println("Completed !")
  );
```



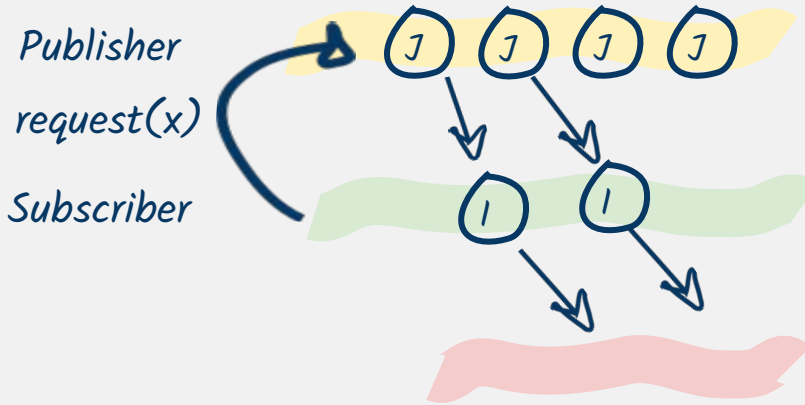
Drop when data loss is acceptable

```
Streams.getStream()
   .onBackPressureDrop()
   .observeOn(Schedulers.computation())

   .map(i -> {
      Thread.sleep(100); // I'm slow...
      return i.getLong("id");
   })
   .blockingSubscribe(
      x -> System.out.println("Processed:" + x),
      Throwable::printStackTrace,
      () -> System.out.println("Completed !")
   );
```



Control Flow and Reactive Streams

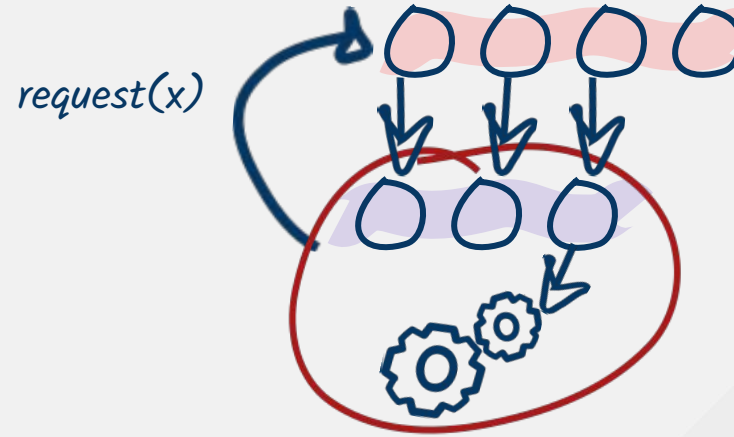
```
Streams.getStreamWithBackPressure()
   .observeOn(Schedulers.computation())

   .map(i -> {
      Thread.sleep(100); // I'm slow...
      return i.getLong("id");
   })
   .blockingSubscribe(
      x -> System.out.println("Processed:" + x),
      Throwable::printStackTrace,
      () -> System.out.println("Completed !")
   );
```



Reactive Stream API - http://www.reactive-streams.org
Java 9 Flow - http://download.java.net/java/jdk9/docs/api/java/util/concurrent/Flow.html

Back to our database access

```
client.rxGetConnection()   // Single(async op)
 .flatMapPublisher(conn ->
   conn
     .rxQueryStream("SELECT * from PRODUCTS")
     .flatMapPublisher(SQLRowStream:: toFlowable)
     .doAfterTerminate(conn::close)
 ) // Flowable of Rows
 .map(Product::new) // Flowable of Products
.subscribe(p -> {
    // do something slow, but it's fine
  });
```

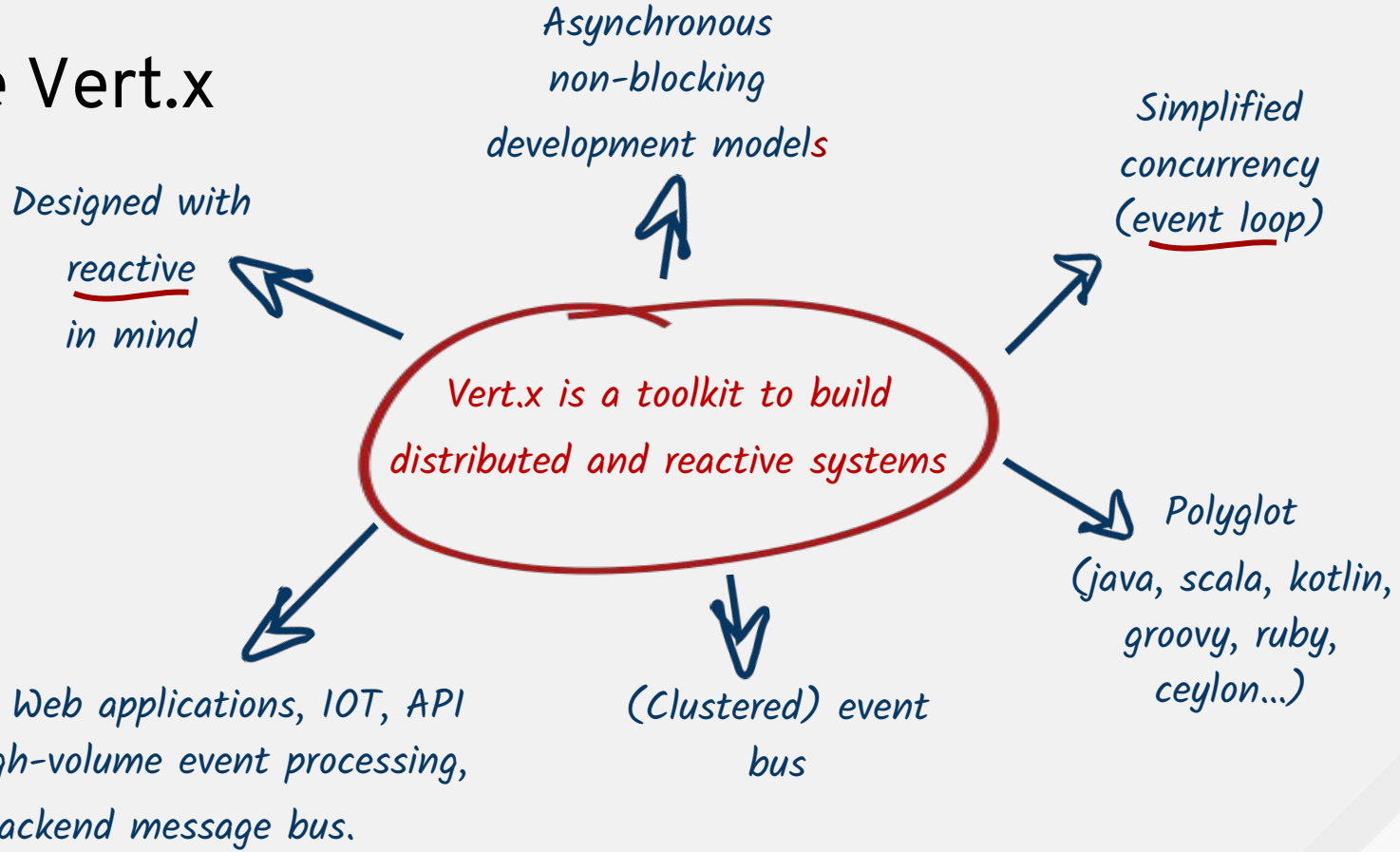


Eclipse Vert.x

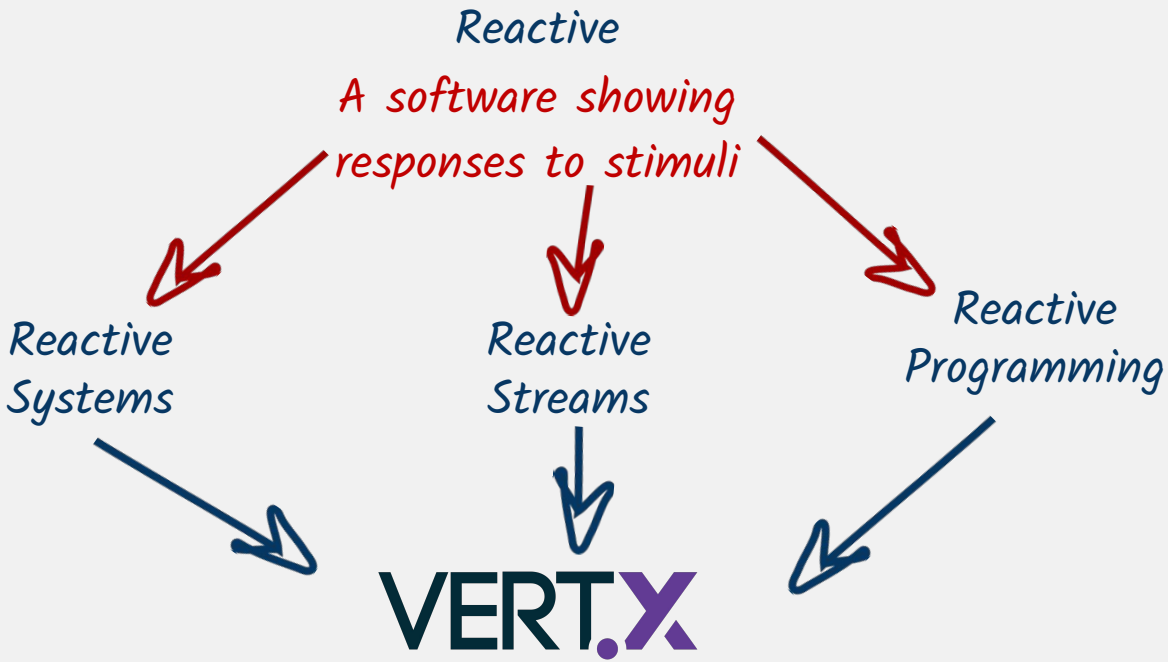
Unleash your reactive superpowers

redhat.

Eclipse Vert.x

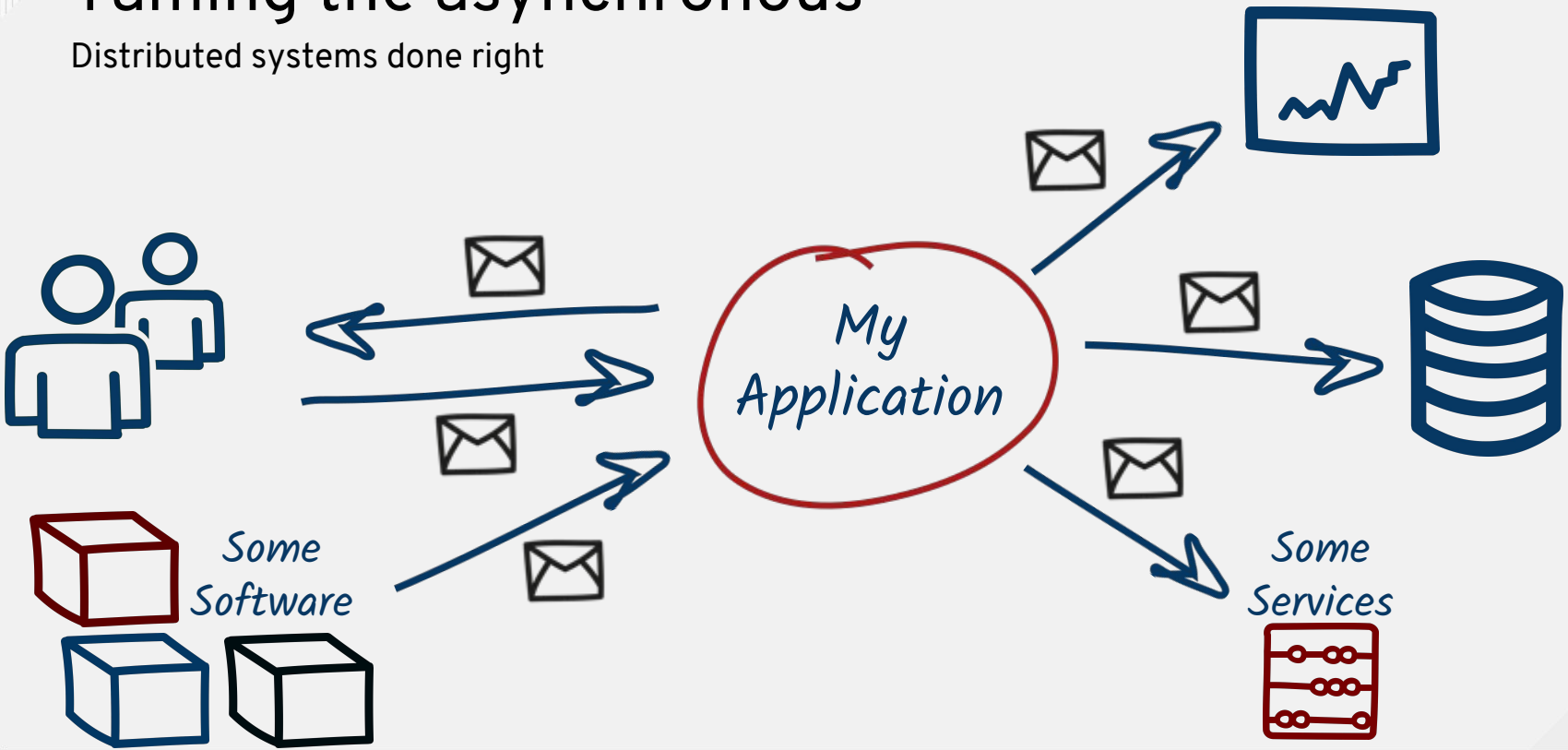


Vert.x - the all-in-one toolkit



Taming the asynchronous

Distributed systems done right



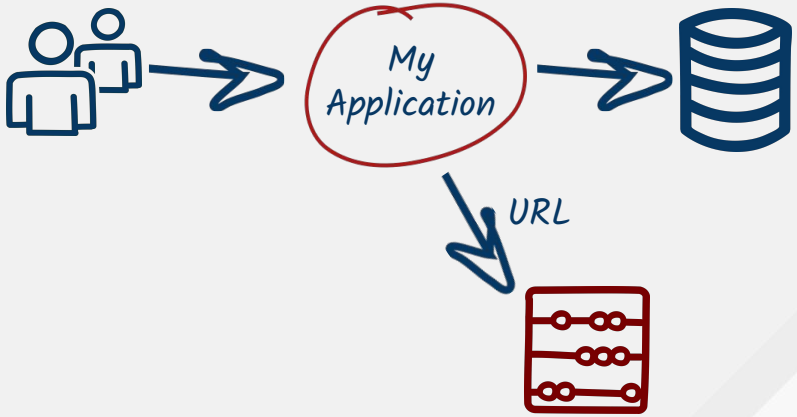
Reactive Web Application

```
private void add(RoutingContext rc) {
  String name = rc.getBodyAsString();
  database.insert(name) // Single (async)
    .subscribe(
      () -> rc.response().setStatusCode(201).end(),
      rc::fail
    );
}

private void list(RoutingContext rc) {
  HttpServerResponse response = rc.response().setChunked(true);
  database.retrieve() // Flowable<Product> (async)
    .subscribe(
      p -> response.write(Json.encode(p) +" \n\n"),
      rc::fail,
      response::end);
}
```

Orchestrating remote interactions

Sequential composition

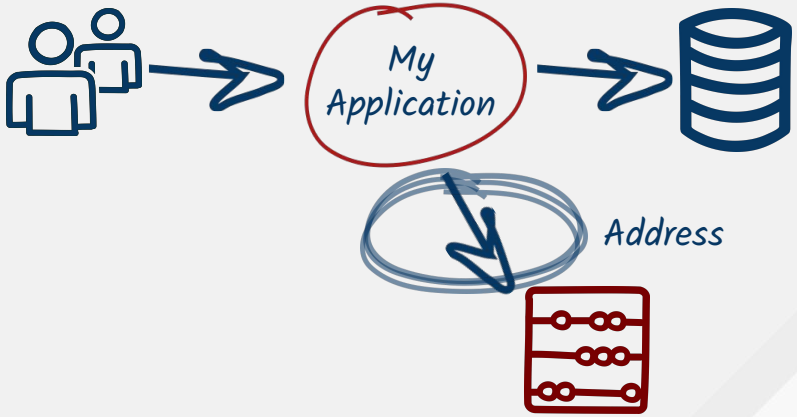
```
WebClient pricer = ...
HttpServerResponse response = rc.response().setChunked(true);
database.retrieve()
  // For each row call...
  .flatMapSingle(p ->
     webClient
        .get("/prices/" + p.getName())
        .rxSend()
        .map(HttpResponse::bodyAsJsonObject)
        .map(json -> p.setPrice(json.getDouble("price")))
  )
  .subscribe(
     p -> response.write(Json.encode(p) + " \n\n"),
     rc::fail,
     response::end);
```



Orchestrating remote interactions

Event Bus

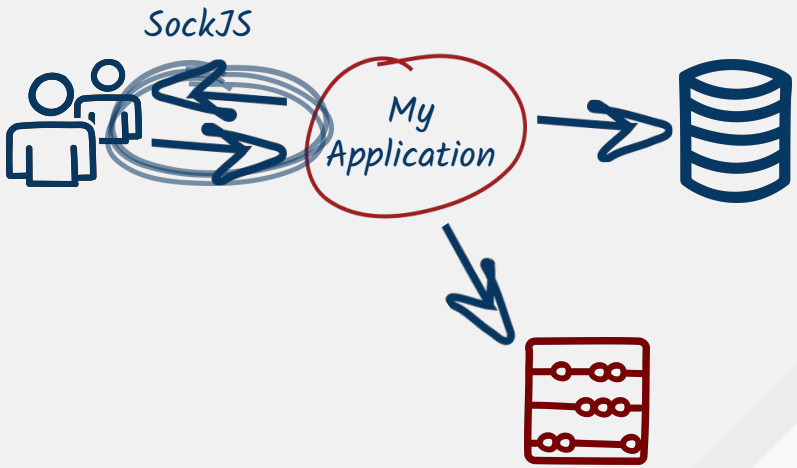
```
WebClient pricer = ...
HttpServerResponse response = rc.response().setChunked(true);
database.retrieve()
  // For each row call...
  .flatMapSingle(p ->
    vertx.eventBus()
        .<JsonObject>rxSend("pricer", p.getName())
        .map(Message::body)
        .map(json -> p.setPrice(json.getDouble("price")))
  )
  .subscribe(
      p -> response.write(Json.encode(p) + " \n\n"),
      rc::fail,
      response::end);
```



Push data using **event bus** bridges

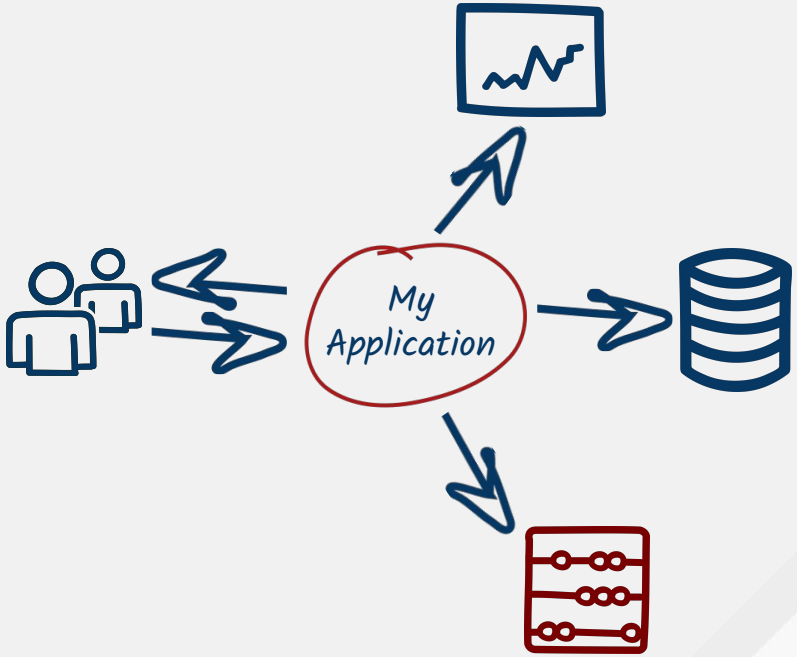
Web Socket, SSE...

```
String name = rc.getBodyAsString().trim();
database.insert(name)
   .flatMap(...)
   .subscribe(
      p -> {
         String json = Json.encode(p);
         rc.response().setStatusCode(201).end(json);
         vertx.eventBus().publish("products", json);
      },
      rc::fail);
```



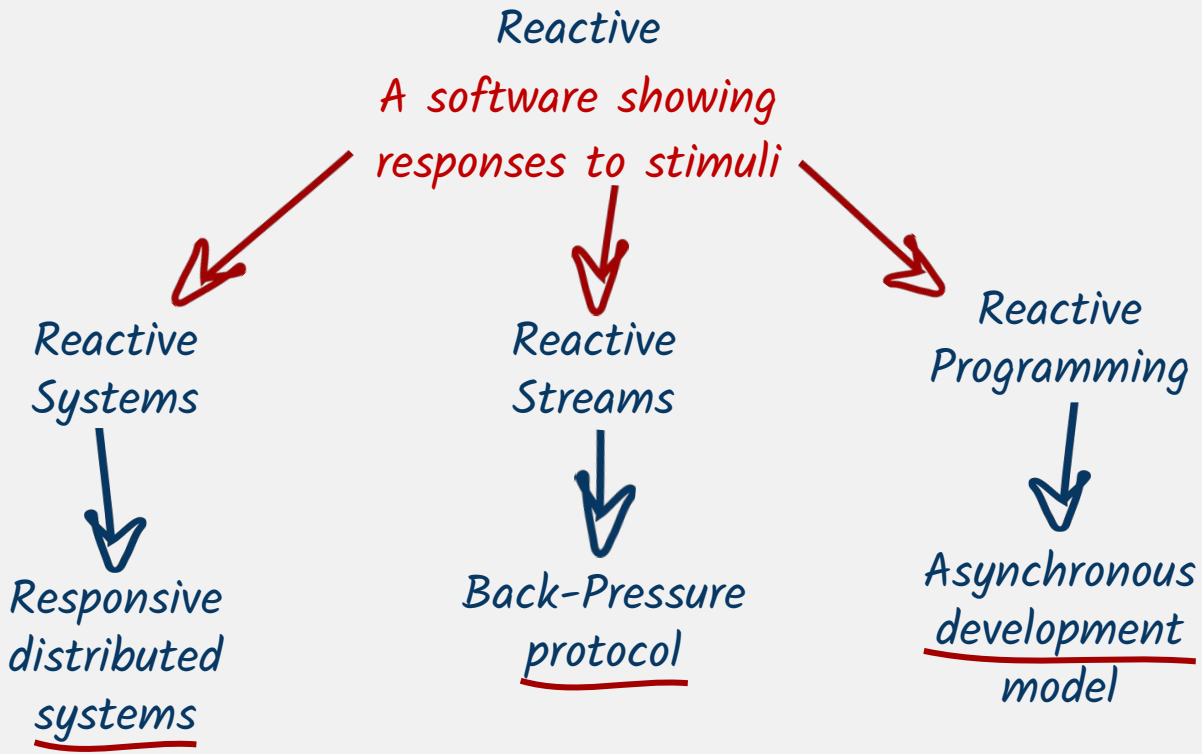
Executing several operations concurrently

```
database.insert(name)
  .flatMap(p -> {
    Single<Product> price = getPriceForProduct(p);
    Single<Integer> audit = sendActionToAudit(p);
    return Single.zip(price, audit, (pr, a) -> pr);
  })
  .subscribe(
    p -> {
      String json = Json.encode(p);
      rc.response().setStatusCode(201).end(json);
      vertx.eventBus().publish("products", json);
    },
    rc::fail);
```



Reactive => Build better systems

Welcome to an asynchronous world



Building Reactive Microservices in Java

Use Eclipse Vert.x to build reactive microservices:

- Explore the elements of reactive microservices and learn how Vert.x works.
- Build and consume a single microservice to understand how messaging improves its reactiveness.
- Create an entire microservices system, using stability and resilience patterns to manage failures.

Download the book from: http://bit.ly/vertx-reactive

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