Reactive for the Impatient
(Java Edition)

IBM Developer

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A Gentle Intro to Reactive Programming and Reactive Systems with a survey of

4 popular Reactive Java tools and libraries:

RxJava
Spring Reactor
Akka
Eclipse Vert.x

Why Reactive?

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Evolving changes/demands in the Computing Ecosystem

- Hardware level
- * Virtualization and cloud strategies
- Software System Level
- Software Application Level
- The impatient human beings!

What is Reactive?

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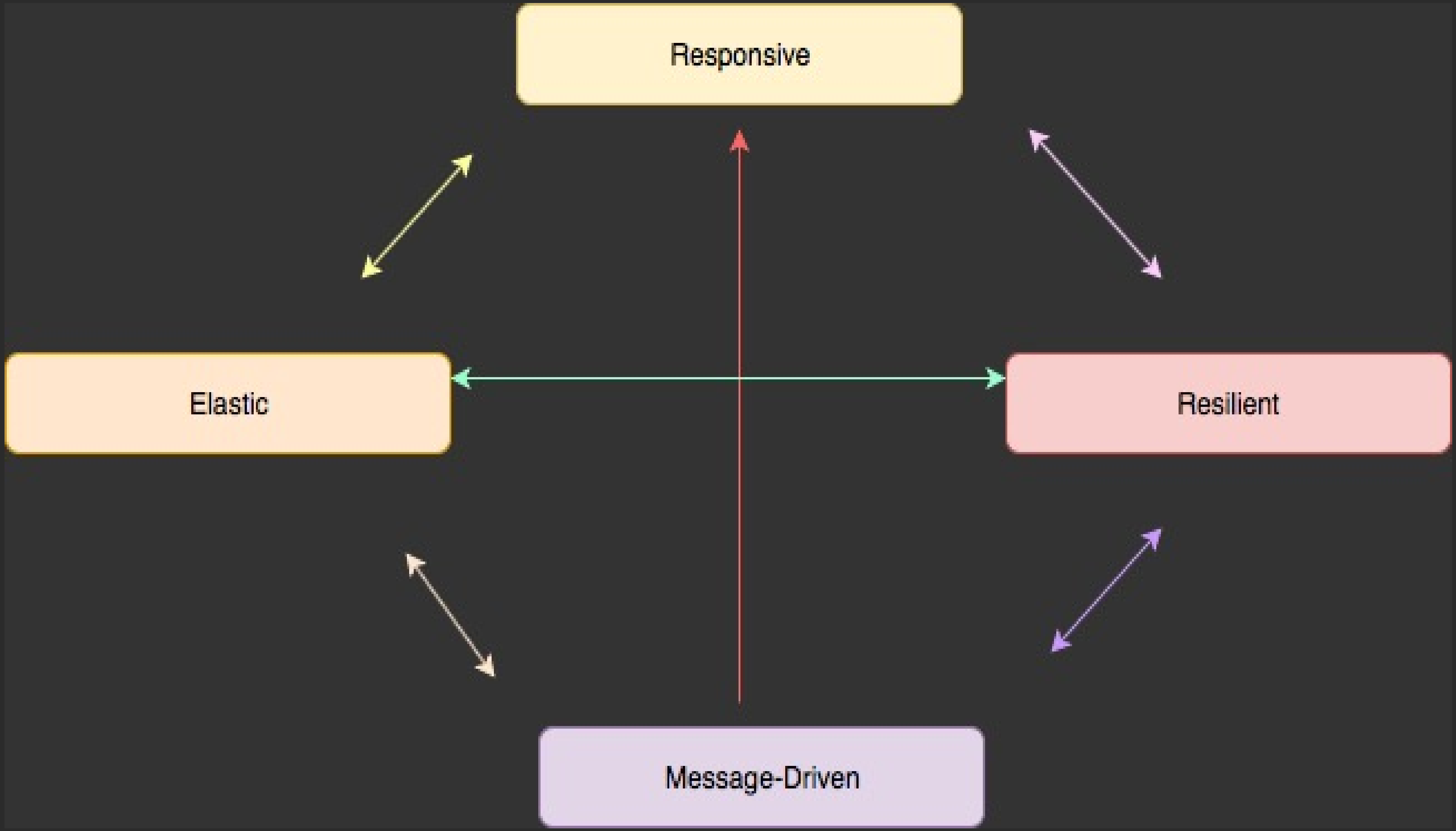
Reactive Manifesto

https://www.reactivemanifesto.org

Version 2.0 (September 2014)

*** More flexible systems**
***Highly responsive**
***More tolerant of failures**
***Handling of failures**

Reactive Principles



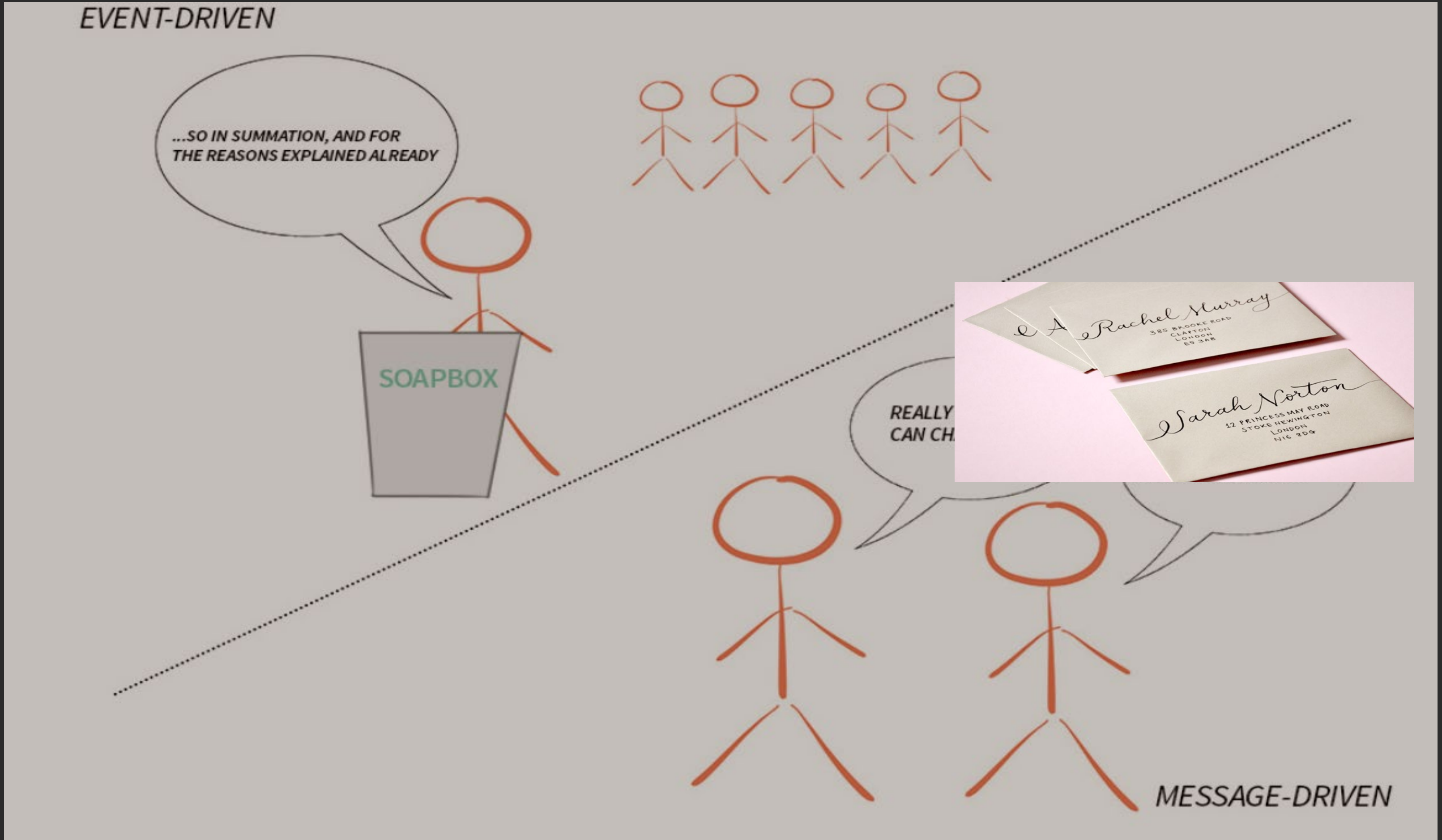
Important distinctions…

Reactive Programming

Functional Reactive Programming

Reactive Systems and Architecture

Event-Driven vs Message-Driven



While event-driven communication takes a "soapbox" approach, broadcasting facts (events) for others to observe (if they are listening), message-driven communication has an addressable recipient and a single purpose.

An Interesting "Reactive" Use Case:

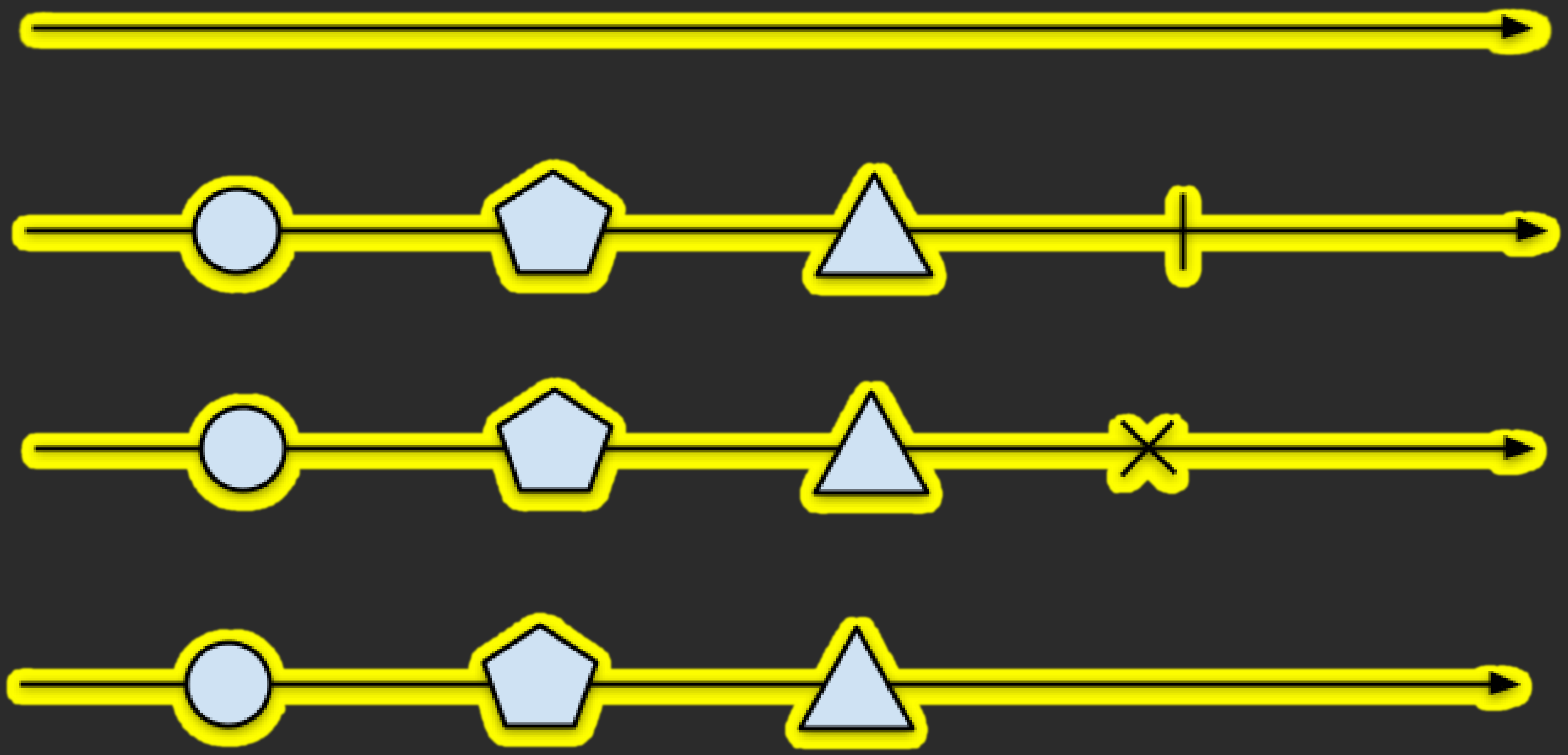
Menya Musashi Ramen Shop in Tokyo

Reactive Programming: Patterns, Terminologies

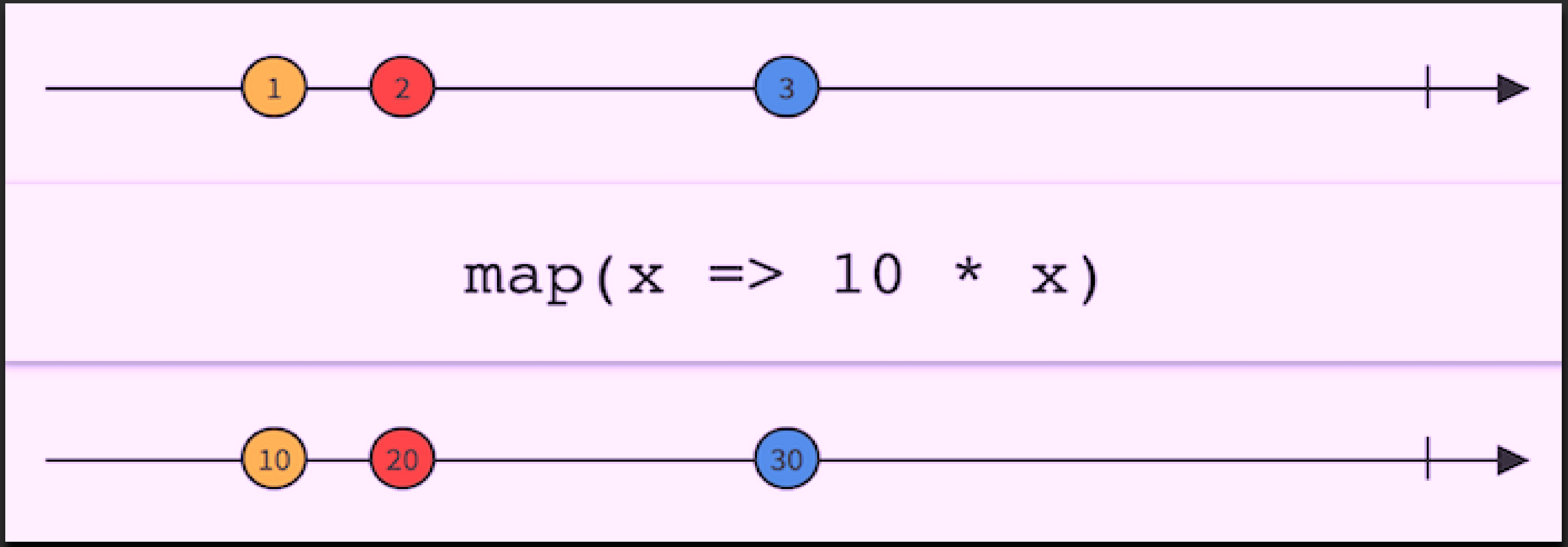
- Reactivity
- Events
- Streams
- Observables

Design Patterns:
Observer, Composite, Iterator

Rx Marble Diagram



Rx Marble Diagram: Map()



```
Observable.just(1, 2, 3)
        .map(x -> 10 * x)
        .subscribe(x -> Timber.d("item: " + x)));
```

Output:

```
item: 10
item: 20
item: 30
```

Source: ***https://rxmarbles.com***

Reactive Systems Design: Patterns

- State Management and Persistence Patterns
- Flow Control Patterns
- Message Flow Patterns
- Fault Tolerance and Recovery Patterns
- Replication Patterns
- Resource Management Patterns

Reactive Systems Design: Terminologies

- Reactive Microservices vs Monoliths
- Isolation of State, Space, Time, Failure
- Circuit Breakers
- Back –Pressure
- High Availability
- Eventual Consistency

- *CAP Theorem

Reactive Streams

- Specifications 1.0
- Working groups started in 2013: Netflix, Pivotal, LightBend – later joined by Oracle, Twitter, Red Hat, spray.io
- Standard for asynchronous stream processing with non-blocking back pressure
- Initial release: May 2015
- Latest release: August 2017

What about Microservices?

How are Microservices related to Reactive Programming, and also Reactive Systems?

Lagom – A Reactive Microservices Framework

- From LightBend
- Built on the Play Framework and Akka Cluster
- RPC-style programming style
- Message Broker API implemented in Akka Streams and Kafka
- Persistence based on the concept of Entities – Domain-Driven Design
  - Event-sourcing
  - CQRS

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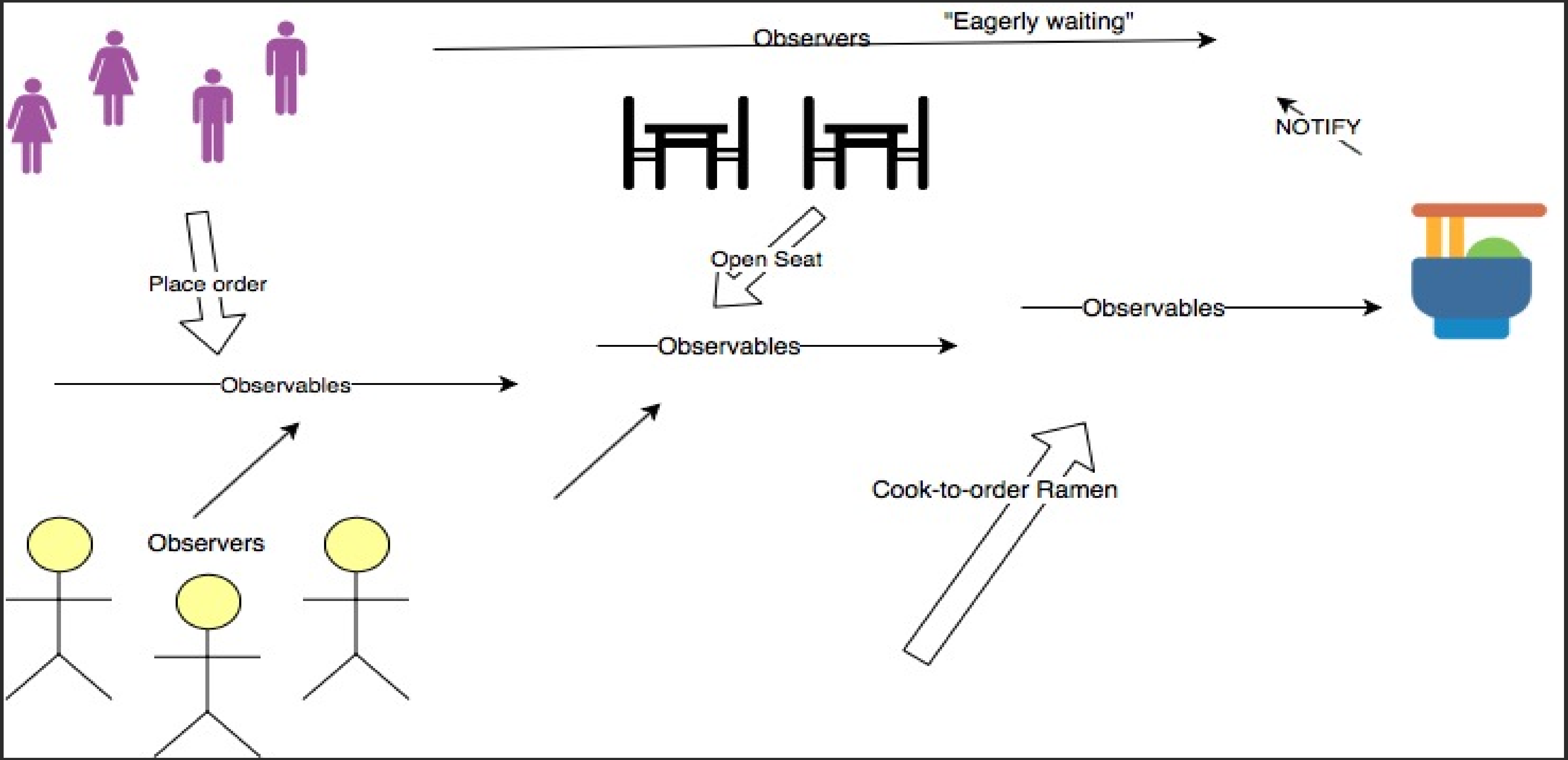
"Reactive" Design Thinking



RxJava

* Java implementation of ReactiveX (reactivex.io)
* Very popular, especially on Android.
* Also available in Javascript, .NET, Scala, Clojure, Swift (and more!) with equivalent api.
* v1 (pre reactive streams specification) 2014
* v2 2016 (Flowable, with backpressure)

Simple example: Hello World

```
public static void hello(String... args) {
        Flowable.fromArray(args).subscribe(s -> System.out.println("Hello " + s + "!"));
}
```

```java
package com.ibm.reactive.samples;

import io.reactivex.Observable;
import io.reactivex.functions.Consumer;

public class RxJava2Example
{
    public static void main(String[] args)
    {
        //producer
        Observable<String> observable = Observable.just("how", "to", "do", "in", "java");

        //consumer
        Consumer<? super String> consumer = System.out::println;

        //Attaching producer to consumer
        observable.subscribe(consumer);
    }
}
```

Spring Reactor

* Based on Project Reactor from Pivotal
* Very similar api to RxJava2
* Built for Java 8+ allowing for cleaner interface.
* David Karnok (project lead of RxJava, engine contributor to Reactor)

David Karnok@akarnokd
Use Reactor 3 if you are allowed to use Java 8+, use RxJava 2 if you are stuck on Java 6+ or need your functions to throw checked exceptions
(Twitter: Sep 10th, 2016)

* Reactor Core
* Reactor Test
* Reactor Extra
* Reactor Netty
* Reactor Adapter
* Reactor Kafka
* Reactor RabbitMQ
* Incubating reactive streams foundation for .Net, Javascript

Spring 5: Spring Web Reactive (non-blocking web stack)

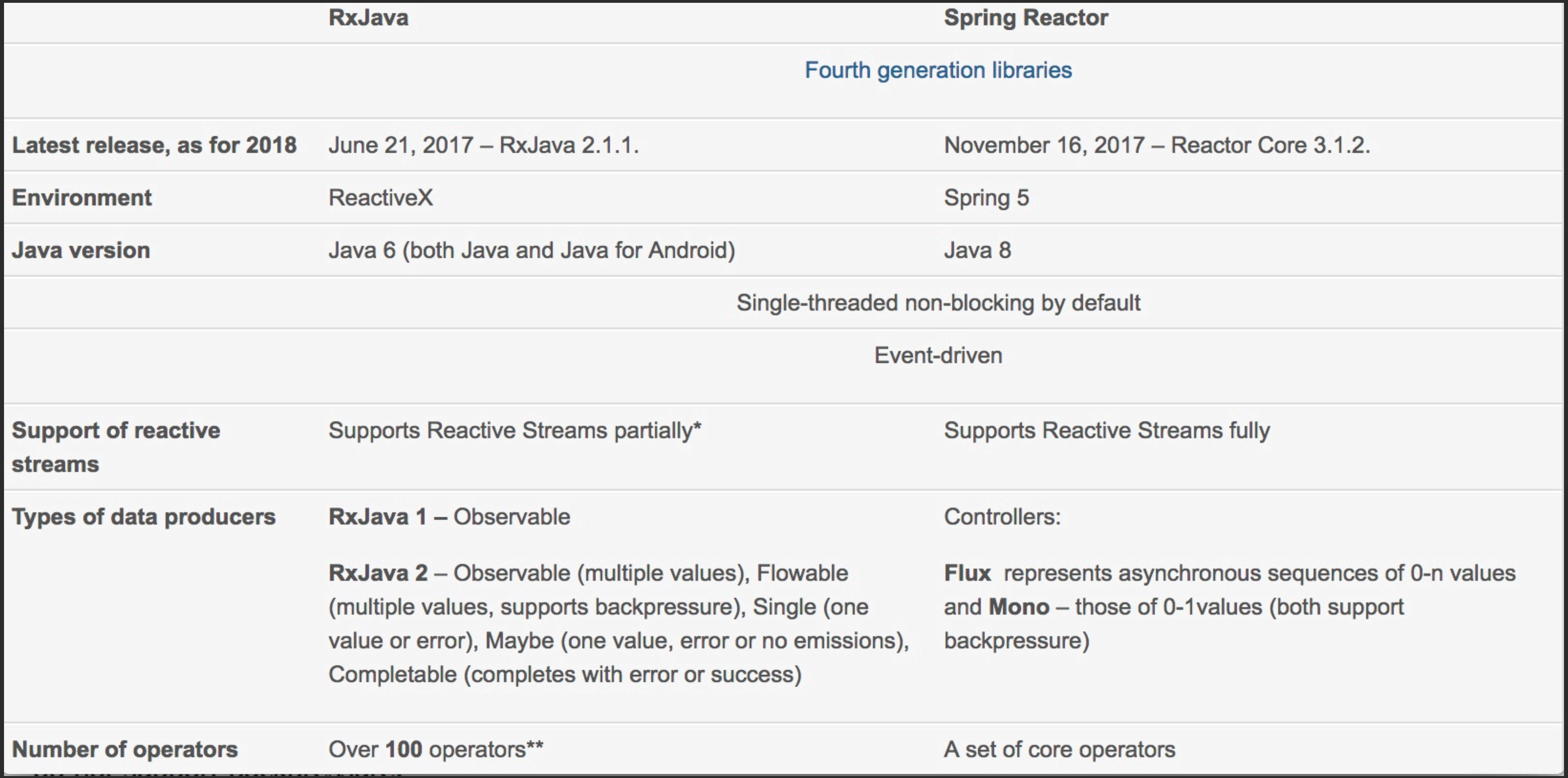
Traditional Approach (Spring MVC):

```
@GetMapping("/traditional")
public List < Product > getAllProducts() {
        System.out.println("Traditional way started");
        List < Product > products = prodService.getProducts("traditional");
        System.out.println("Traditional way completed");
        return products;
}
```

Reactive Approach (Spring Web Reactive – Web Flux):

```
@GetMapping(value = "/reactive", .TEXT_EVENT_STREAM_VALUE)
public Flux < Product > getAll() {
        System.out.println("Reactive way using Flux started");
        Flux < Product > fluxProducts = prodService.getProductsStream("Flux");
        System.out.println("Reactive way using Flux completed");
        return fluxProducts;
}
```

Quick comparison: RxJava vs Spring Reactor



	RxJava	Spring Reactor
	Fourth generation libraries	
Latest release, as for 2018	June 21, 2017 – RxJava 2.1.1.	November 16, 2017 – Reactor Core 3.1.2.
Environment	ReactiveX	Spring 5
Java version	Java 6 (both Java and Java for Android)	Java 8
	Single-threaded non-blocking by default	
	Event-driven	
Support of reactive streams	Supports Reactive Streams partially*	Supports Reactive Streams fully
Types of data producers	**RxJava 1 –** Observable **RxJava 2** – Observable (multiple values), Flowable (multiple values, supports backpressure), Single (one value or error), Maybe (one value, error or no emissions), Completable (completes with error or success)	Controllers: **Flux** represents asynchronous sequences of 0-n values and **Mono** – those of 0-1values (both support backpressure)
Number of operators	Over **100** operators**	A set of core operators

Akka

* From LightBend. - IBM Partnership (June 2017)
    https://www.lightbend.com/ibm-alliance
* Actor Model (from Erlang – Actor Programming Model in the 1980’s)
* Event-Driven
* Location Transparency
* Lightweight

* Resiliency/Recoverability – Supervisor capability

```
package sample.hello;

public class Main {

  public static void main(String[] args) {
    akka.Main.main(new String[] { HelloWorld.class.getName() });
  }
}
```

```
package sample.hello;

import akka.actor.AbstractActor;
import akka.actor.ActorRef;
import akka.actor.Props;

import static sample.hello.Greeter.Msg;

public class HelloWorld extends AbstractActor {

  @Override
  public Receive createReceive() {
    return receiveBuilder()
      .matchEquals(Msg.DONE, m -> {
        // when the greeter is done, stop this actor and with it the application
        getContext().stop(self());
      })
      .build();
  }

  @Override
  public void preStart() {
    // create the greeter actor
    final ActorRef greeter = getContext().actorOf(Props.create(Greeter.class), "greeter");
    // tell it to perform the greeting
    greeter.tell(Msg.GREET, self());
  }
}
```

```java
package sample.hello;

import akka.actor.AbstractActor;

public class Greeter extends AbstractActor {

  public static enum Msg {
    GREET, DONE;
  }

  @Override
  public Receive createReceive() {
    return receiveBuilder()
      .matchEquals(Msg.GREET, m -> {
        System.out.println("Hello World!");
        sender().tell(Msg.DONE, self());
      })
      .build();
  }
}
```

```
import akka.actor.{Actor, ActorSystem, Props}

        //greet message
        case class Greet(name: String)
        //greeter Actor

         class Greeter extends Actor {
             def receive = {
                 case Greet(name) => println(s"Hello $name")
             }

}

object HelloAkka extends App {
        val system=ActorSystem("Intro-Akka")
        val greeter=system.actorOf(Props[Greeter],"greeter")
        greeter ! Greet("Akka")
}
```

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Vert.x

* From Eclipse
* A very flexible “polyglot” framework that interoperates with other frameworks and tools.
  - -> RxJava
  - -> Spring Reactor
  - -> Akka
  - -> not to mention the other non-Java frameworks and tools as well (JS, .Net…)
* Verticles – components that are being deployed and executed by Vert.x
  - -> event-driven
  - -> run only when they receive a message
* Vert.x event bus

* Not restrictively tied to any container – Vert.x libraries can be used with other libraries

```
package io.vertx.example;

import io.vertx.core.Vertx;


public class HelloWorldEmbedded {

  public static void main(String[] args) {

        // Create an HTTP server which simply returns "Hello World!" to each request.
        Vertx.vertx().createHttpServer().requestHandler(req -> req.response().end("Hello
        World!")).listen(8080);

  }
```

Recap & Takeaways

* Reactive is an overloaded word in today’s market
* Not for the ”faint of heart” but for the determined
* Reactive programming is not the same as Functional Reactive programming or Reactive systems
* Benefits of being “Reactive” on the programming level
* Reactive systems and architecture bring “reactivity” to another level
* Reactivity to this day has not been fully ready on the database level, despite some significant efforts on the database connectivity level

Thank you

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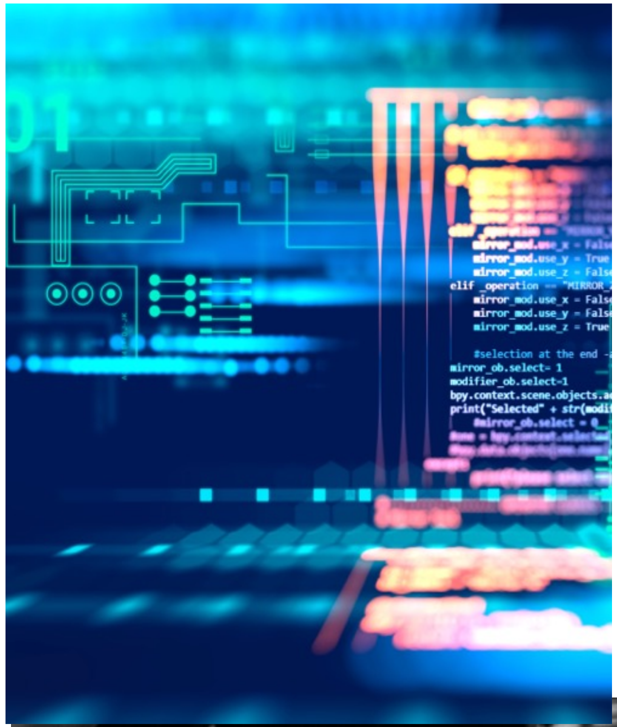
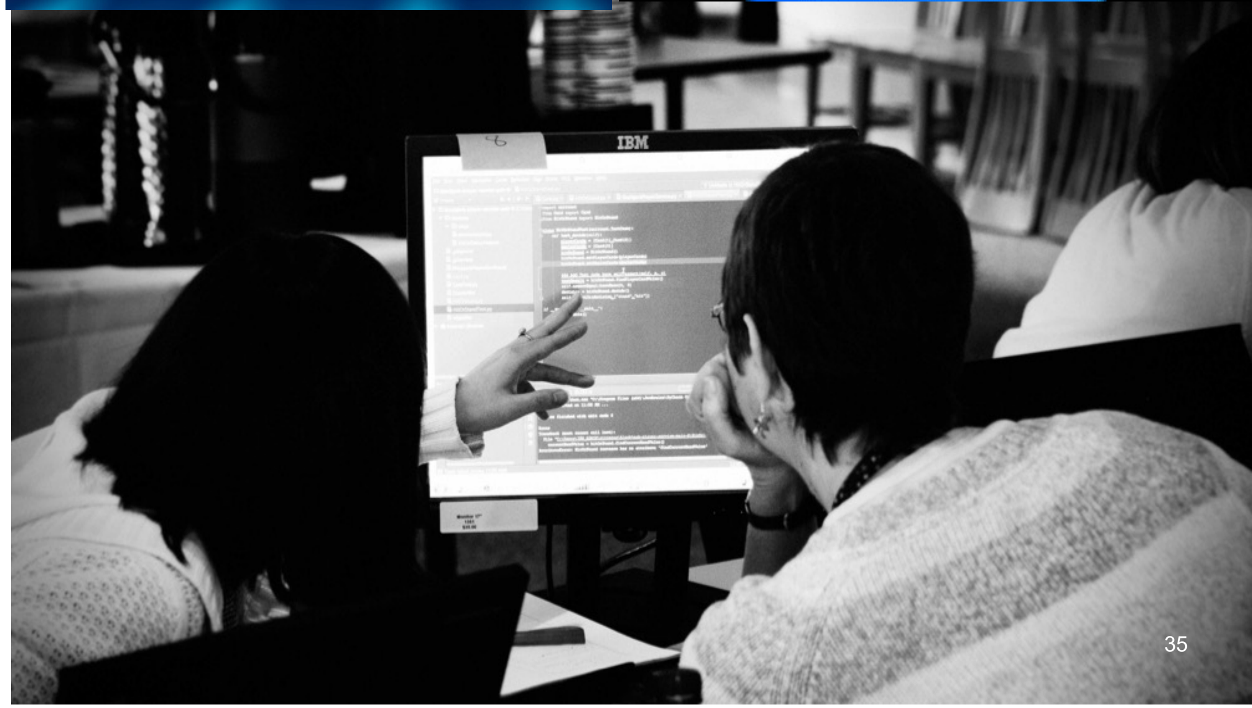
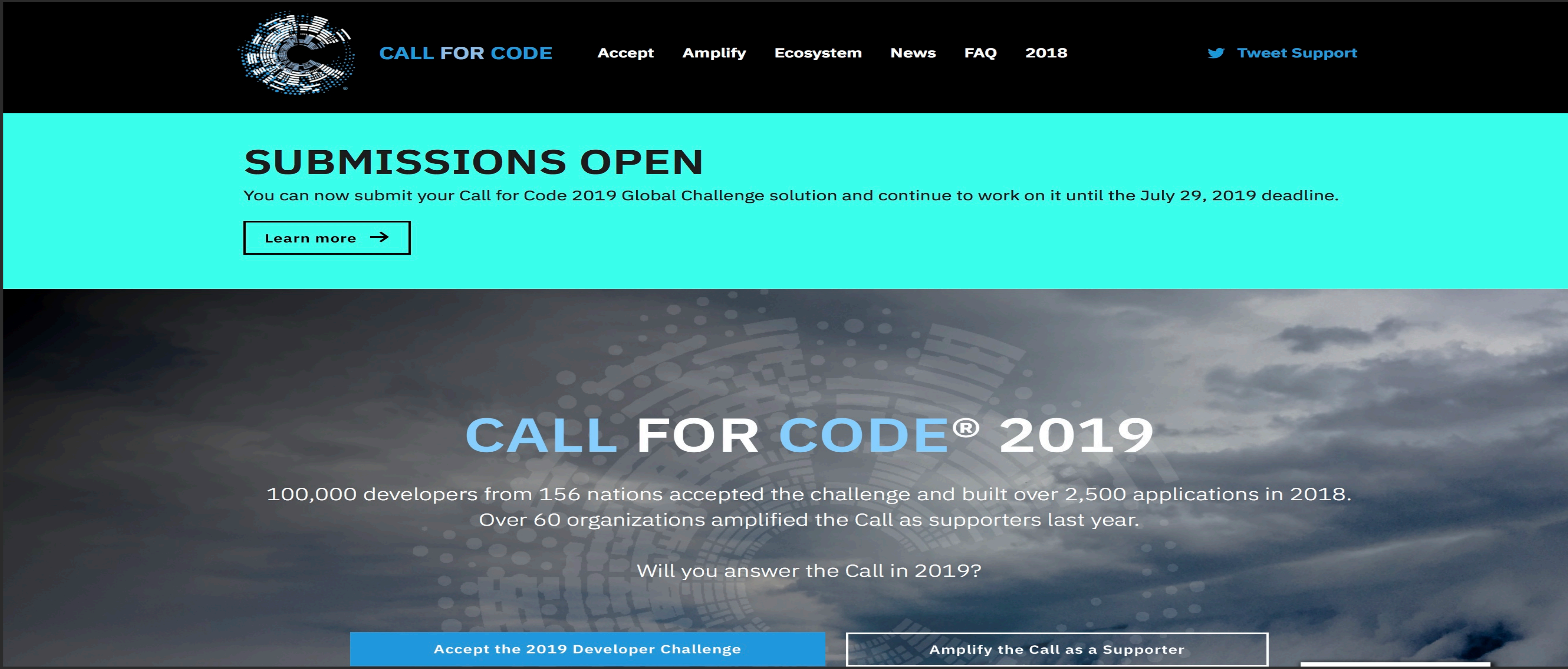
IBM Cloud:
https://ibm.biz/BdzBiQ
https://developer.ibm.com/technologies/reactive-systems/
https://www.lightbend.com/ibm-alliance
https://www.reactivemanifesto.org
https://www.reactivedesignpatterns.com





IBM's Multi-Year Initiative for a Good Cause
http://callforcode.org



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