Reactive Programming

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Reactive Programming

Agenda

- The Reactive Manifesto
- Reactive Use Case

Reactive Programming

The Reactive Manifesto

Times have changed

<= Milliseconds of Response time

100% Availability

An exponential increase in Data Volume

Multi-platform Applications

Multi-device Client Applications

Cloud Native Apps with PaaS

https://www.reactivemanifesto.org/

- We believe that a **coherent approach** to systems architecture is needed
- We believe that all necessary **aspects** are already **recognized individually**
- We want systems that are **Responsive, Resilient, Elastic, and Message Driven**
- We call these **Reactive Systems.**
- Systems built as Reactive Systems are more **flexible, loosely coupled, and scalable**
- They meet it with **elegance** rather than **disaster**.

Reactive Programming

Why Reactive?

1. Gaining an understanding of the **central principles** of designing robust systems

2. It should be **reactive to any changes** that may affect the system's ability to respond to user requests

3. One of the first ways to achieve the primary goal is through **elasticity**

4. Building a scalable distributed system **without the ability to stay responsive** regardless of failures is a **challenge**

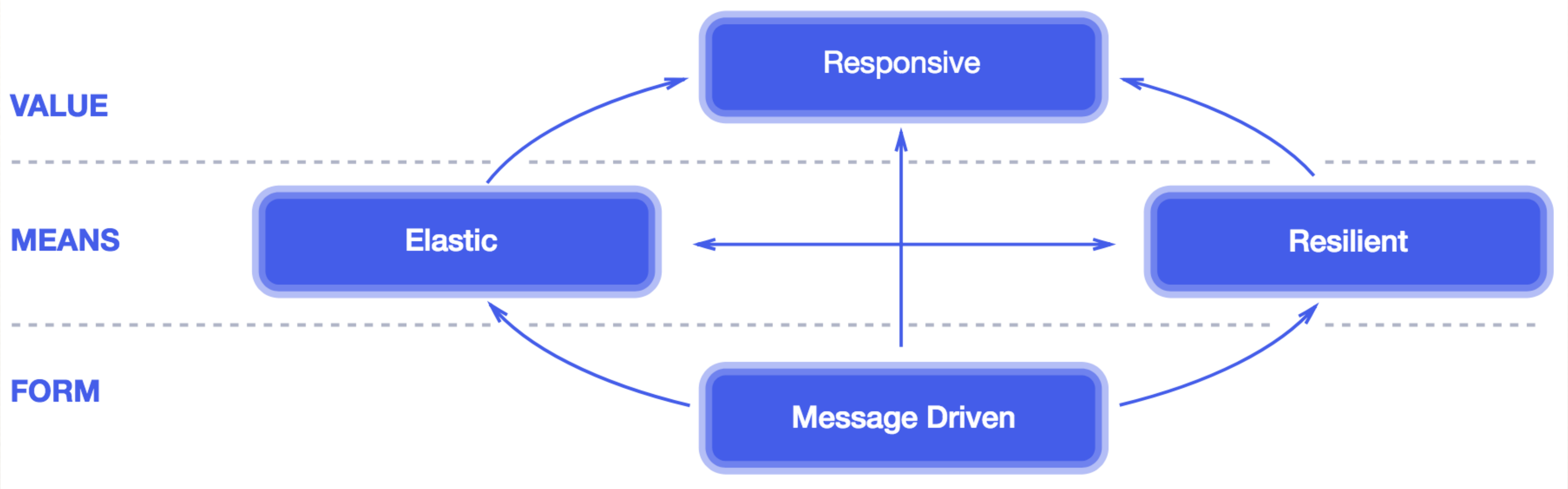
5. The acceptance criteria for the system are the ability to stay responsive under failures, or, in other words, to be **resilient**

6. Resilience can be achieved by **Isolation**

7. ONLY a combination of **Elasticity & Resilience** can make a System as **Responsive**

Reactive Programming

Why Reactive?



The primary **value** for any business implemented with a distributed system is responsiveness.

Achieving a responsive system **means** following fundamental techniques such as elasticity and resilience.

Finally, one of the fundamental **ways (form)** to attain a responsive, elastic, and resilient system is by employing message-driven communication.

In addition, systems built following such principles are highly maintainable and extensible, since all components in the system are independent and properly isolated.

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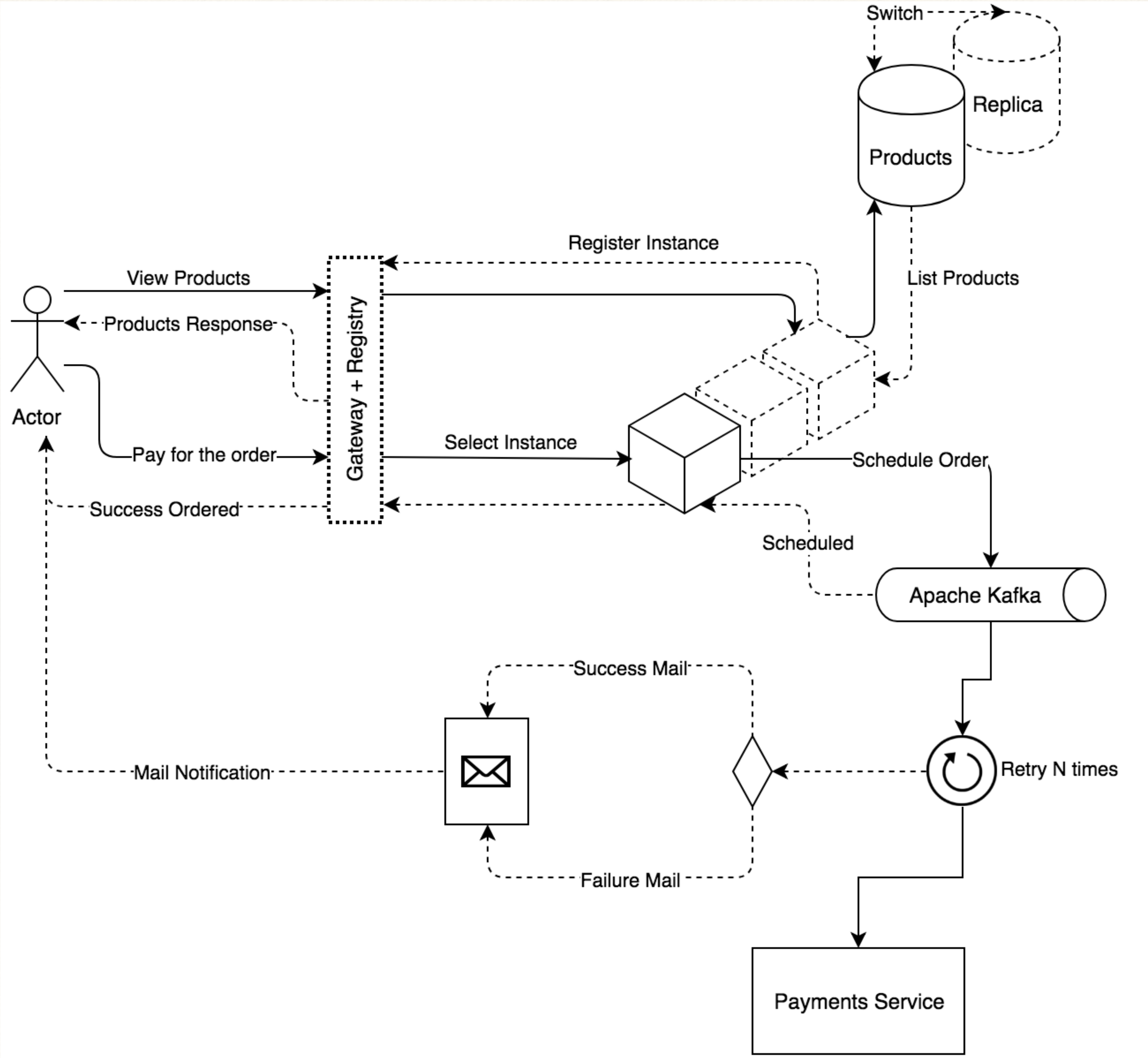
Reactivity Real-time Use Case - Web Store



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Reactivity Real-time Use Case - Web Store

- Here, we improved our small web store by applying modern **microservice patterns**.
- In that case, we use an **API Gateway pattern** for achieving location transparency.
- It provides the identification of a specific resource with **no knowledge about particular services** that are responsible for handling requests.
- In turn, the responsibility for keeping information about available services up to date is implemented using the **service registry pattern** and achieved with the support of the client-side discovery pattern.
- Additionally, the **high responsiveness** of the system is achieved by applying **replication to the service**.
- On the other hand, **failure tolerance** is attained by properly employed **message-driven communication** using **Apache Kafka** and the independent **Payment Proxy Service** which is responsible for **redelivering payment** in the case of **unavailability of the external system**.
- Also, we use **database replication** to stay **resilient** in the case of the **outage of one of the replicas**.
- To stay responsive, we return a **response about an accepted order immediately** and **asynchronously** process and send the user payment to the **payments service**.
- A **final notification** will be delivered later by one of the supported **channels**, for example, via **email**.

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Reactivity Real-time Use Case - Analytics

- Suppose we are designing a system for monitoring a telecommunication network based on cell site data.
- Due to the latest statistic report of the number of cell towers, in 2016 there were 308,334 active sites in the USA.
- To design this system, we may follow one of the efficient architectural techniques called streaming.

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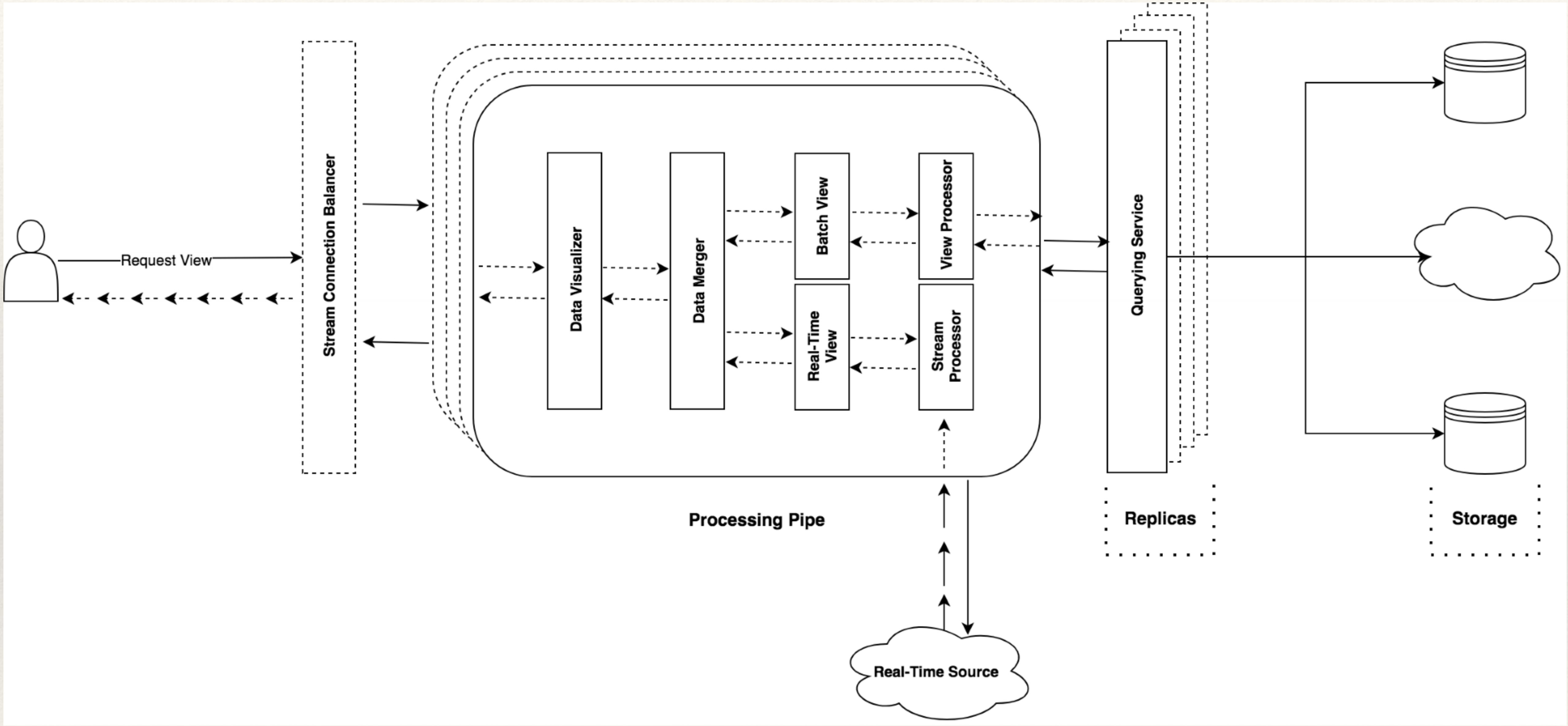
Reactivity Real-time Use Case - Analytics



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Reactivity Real-time Use Case - Analytics

- Streaming architecture is about the construction of the **flow of data processing and transformation**.
- In general, such a system is characterized by **low latency and high throughput**.
- In turn, the **ability to respond** or simply **deliver analyzed updates** of the telecommunication network state is therefore crucial.
- Thus, to build such a highly-available system, we have to rely on **fundamental principles**.
- For example, achieving **resilience** might be done by enabling **backpressure support**.
- **Backpressure** refers to a sophisticated mechanism of **workload management between processing stages** in such a way that ensures we do not overwhelm another.
- **Efficient workload management** may be achieved by using **message-driven communication** over a **reliable message broker**, which may persist messages internally and send messages on demand.
- Alternatively, the stream of data may be **processed in a batch** in the databases, or partially processed in real-time by applying **windowing or machine-learning techniques**.
- Anyways, all **fundamental principles** offered by the **Reactive Manifesto** are valid here, regardless of the overall domain or business idea.

Reactive Programming

Why Reactive Spring?

- In the JVM world, the most commonly known frameworks for building a reactive system has been **Akka and Vert.x ecosystems**.
- On one hand, **Akka** is a popular framework with a **huge list of features and a big community**.
- However, at the very beginning, **Akka was built as part of the Scala ecosystem** and for a long time, it **showed its power only within solutions written in Scala**.
- Despite the fact that **Scala is** a JVM-based language, it is **noticeably different from Java**.
- A few years ago, **Akka provided direct support for Java**, but for some reason, it was not as popular in the Java world as it was in Scala.
- On the other hand, there is the **Vert.x framework** which is also a powerful solution for building an efficient reactive system.
- **Vert.x** was designed as a **non-blocking, event-driven** alternative to **Node.js** that runs on the **JVM**.
- However, **Vert.x started being competitive only a few years ago** and during the last 15 years, the market for frameworks for **flexible robust application development has been held by the Spring Framework.**
- The **Spring Framework** provides wide possibilities for building a web application using a **developer-friendly programming model**.
- **However, for a long time, Spring had some limitations in building a robust reactive system.**

Reactive Programming

Reactive Programming in Spring

- Java 8 does not support Reactive Programming
- We will use **Reactive Streams, Reactor & Spring WebFlux**

"Reactive Streams is an initiative to provide a standard for asynchronous stream processing with non-blocking back pressure. This encompasses efforts aimed at runtime environments (JVM and JavaScript) as well as network protocols."	Reactive streams aim to define a **minimal set of interfaces**, methods, and protocols to enable reactive programming.
	Reactive streams aim to be a **language-neutral approach** with implementation in the Java (JVM-based) and JavaScript languages.
	Multiple transport streams (TCP, UDP, HTTP, and WebSockets) are supported.

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Reactive Streams

Interfaces in reactive-streams

```
public interface Subscriber<T> {
      public void onSubscribe(Subscription s);
      public void onNext(T t);
      public void onError(Throwable t);
      public void onComplete();
    }

   public interface Publisher<T> {
     public void subscribe(Subscriber<? super T> s);
   }

   public interface Subscription {
     public void request(long n);
     public void cancel();
  }
```

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Reactive Streams

Interface Publisher	• Publisher provides a **stream of elements** in response to the demand received from its subscribers. • A publisher can serve **any number of subscribers**. The subscriber count might vary with time.
Interface Subscriber	• **Subscriber registers** to listen to the stream of events. • Subscribing is a **two-step process**. • The first step is calling **Publisher.subscribe (Subscriber)**. • The second step involves making a call to **Subscription.request (long)**. • Once these steps are completed, the subscriber can start processing notifications using the **onNext(T t)** method. • The **onComplete()** method signals the end of the notifications.
Interface Subscription	• Subscription represents the **link between one Subscriber and its Publisher**. • A subscriber can request **more data using request(long n).** • It can cancel the subscription to notifications using the **cancel() method.**

Reactive Programming

Reactive Programming in Spring

Exploring Reactor Framework

```xml
<dependency>
    <groupId>io.projectreactor</groupId>
    <artifactId>reactor-core</artifactId>
</dependency>

<dependency>
<groupId>io.projectreactor.addons</groupId>
    <artifactId>reactor-test</artifactId>
    <version>3.0.6.RELEASE</version>
</dependency>
```

- Reactor is a Reactive Framework from **Spring Pivotal** Team
- Spring 5 uses Reactive Framework to enable Reactive Web features
- Reactor adds important APIs on top of Reactive Streams - **Flux & Mono**

Flux	Flux represents a Reactive stream that **emits 0 to n elements**.
Mono	Mono represents a Reactive stream that emits either **no elements or one element**.

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Observer Use Case - Stock Price change

The use case we want to build is a stock price page that notifies all the subscribers about the price change.

There are 2 Observers – Trader & Trading Agent

Each Observer must register with the Subject to get change notification.

Both of these observers make different decisions based on the stock price change.

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Reactive Use Case - A Stock Price Page

The use case we want to build is a stock price page that displays the price of a specific stock.

As long as the page remains open, we want to update the latest price of the stock on the page.

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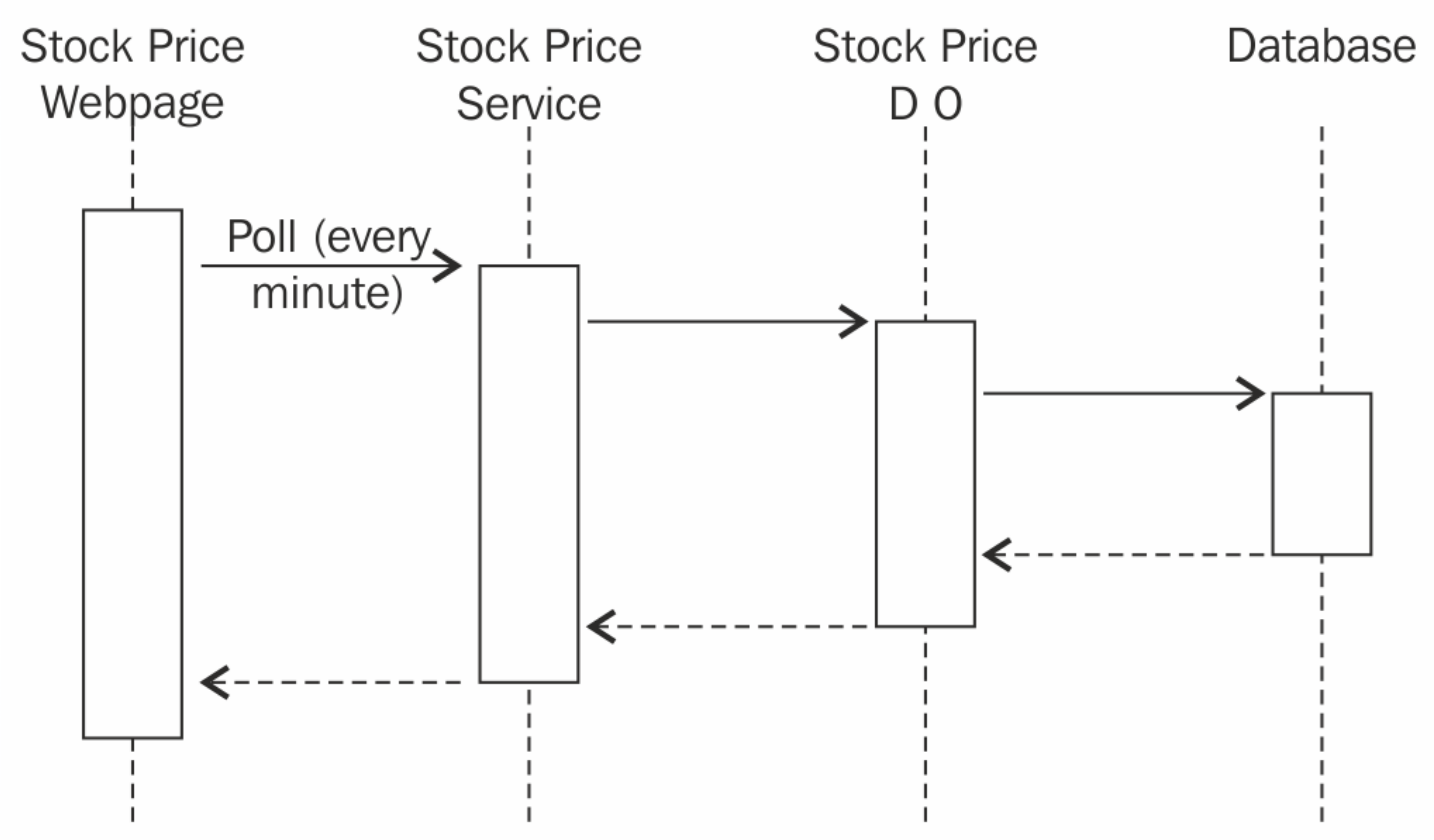
Reactive Use Case - A Stock Price Page

A quick look at the traditional approach



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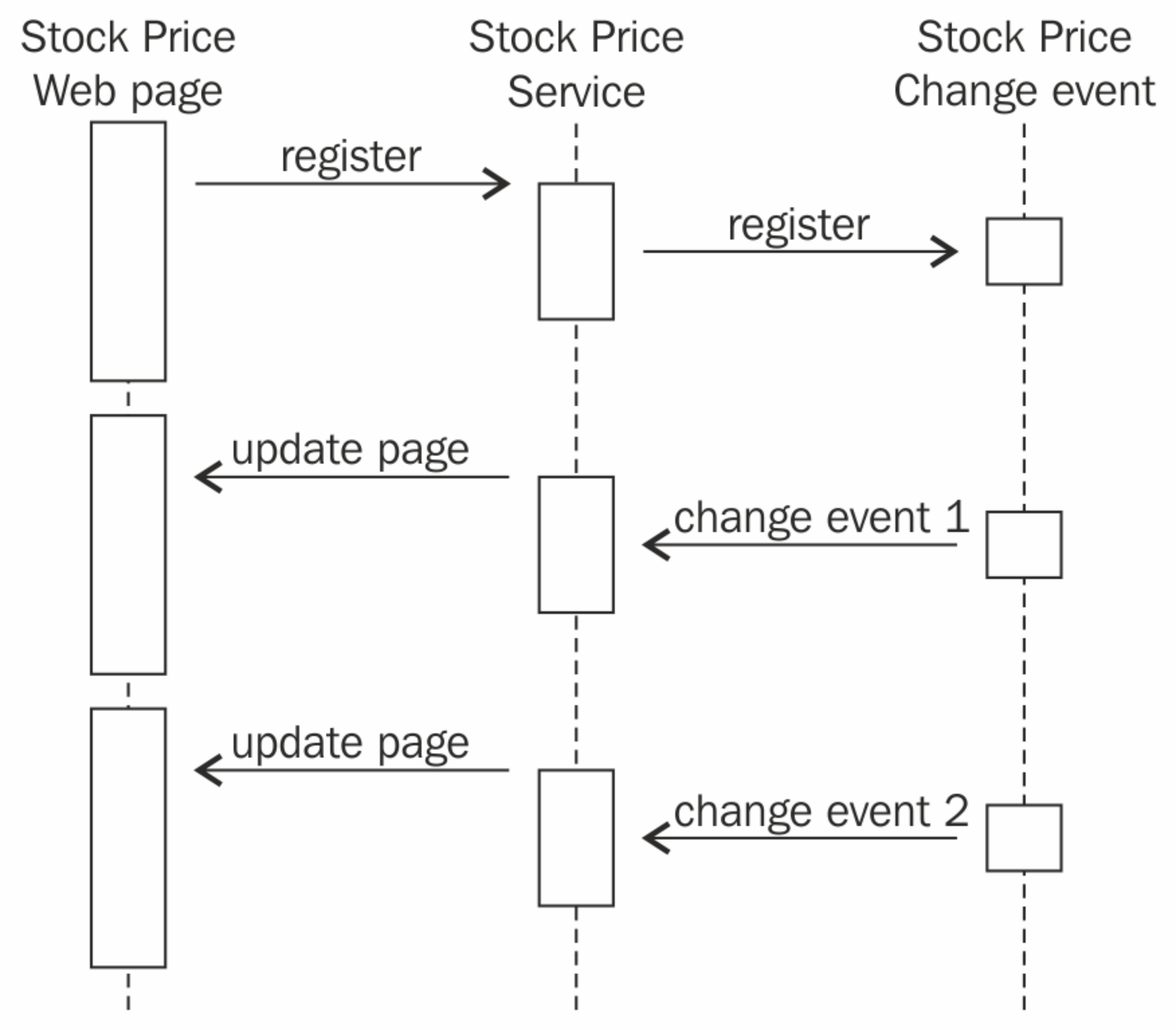
Reactive Use Case - A Stock Price Page

How is the Reactive approach different?



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Reactive Use Case - A Stock Price Page

Steps for Reactive Approach

- Subscribing to Events
- The occurrence of Events
- Unregistering

How Stock Price Page works?

- **Subscribe** to Stock price change **event** on load of webpage
- The way you subscribe is different based on reactive framework
- When the stock price change **event occurs** for a stock, the event is triggered for all the subscribers
- The **listener** within web page updates the latest data
- Unregister request is sent once the browser is closed – Invokes **cancel()** method

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Reactive Use Case - A Stock Price Page

Traditional Approach

- **POLL** for changes
- Polling is irrespective of change
- The lifetime of threads is longer
- All resources used by threads are locked
- High chances of resource contention
- Scaling up is inevitable

Reactive Approach

- Implements Reactive Subscribe & Event Chain
- More complex if Event Chain involves Message Broker
- The sequence is triggered only when the stock price changes
- Threads live for a short time and hence less resource contention
- Reactive infrastructure can handle more users