Dr Streamlove

or: How I Learned to Stop Worrying and Love the Flow

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Agenda

- What is a Stream?
- Live demo
- What is Reactive?
- Reactive Streams
- Akka Streams
- What's next / Opportunities
- Live demo

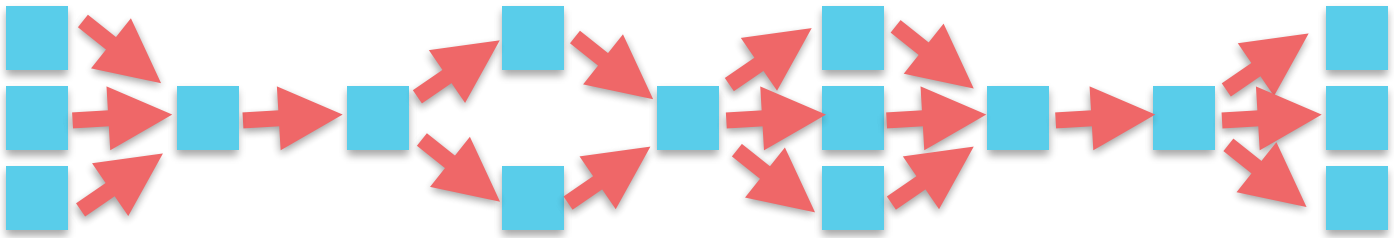
Streams **are not** Collections

“You cannot step twice into the same stream.
For as you are stepping in,
other waters are ever flowing on to you.”

- Heraclitus

What is a Stream?

- Ephemeral flow of data
- Possibly unbounded in length
- Focused on describing transformation
- Can be formed into processing networks



What is a Collection?

- Oxford Dictionary:
  - “a group of things or people”
- wikipedia:
  - “a grouping of some variable number of data items”
- backbone.js:
  - “collections are simply an ordered set of models”
- java.util.Collection:
  - definite size, provides an iterator, query membership

User Expectations

- an Iterator is expected to visit all elements
  (especially with immutable collections)
- `x.head ++ x.tail == x`
- the contents does not depend on who is processing the collection
- the contents does not depend on when the processing happens
  (especially with immutable collections)

Unexpected: observed sequence depends on

- when the subscriber subscribed to the stream
- whether the subscriber can process fast enough
- whether the streams flows fast enough

java.util.stream

- Stream is not *derived* from Collection
  “Streams differ from Collections in several ways”
  - no storage
  - functional in nature
  - laziness seeking
  - possibly unbounded
  - consumable

Streams vs. Collections

- a collection can be streamed
- a stream processor can create a collection
- … but saying that a Stream is a lazy Collection evokes the wrong associations

Live Demo

Getting Data across an **Async Boundary**

Possible Solutions

- the Traditional way: blocking calls

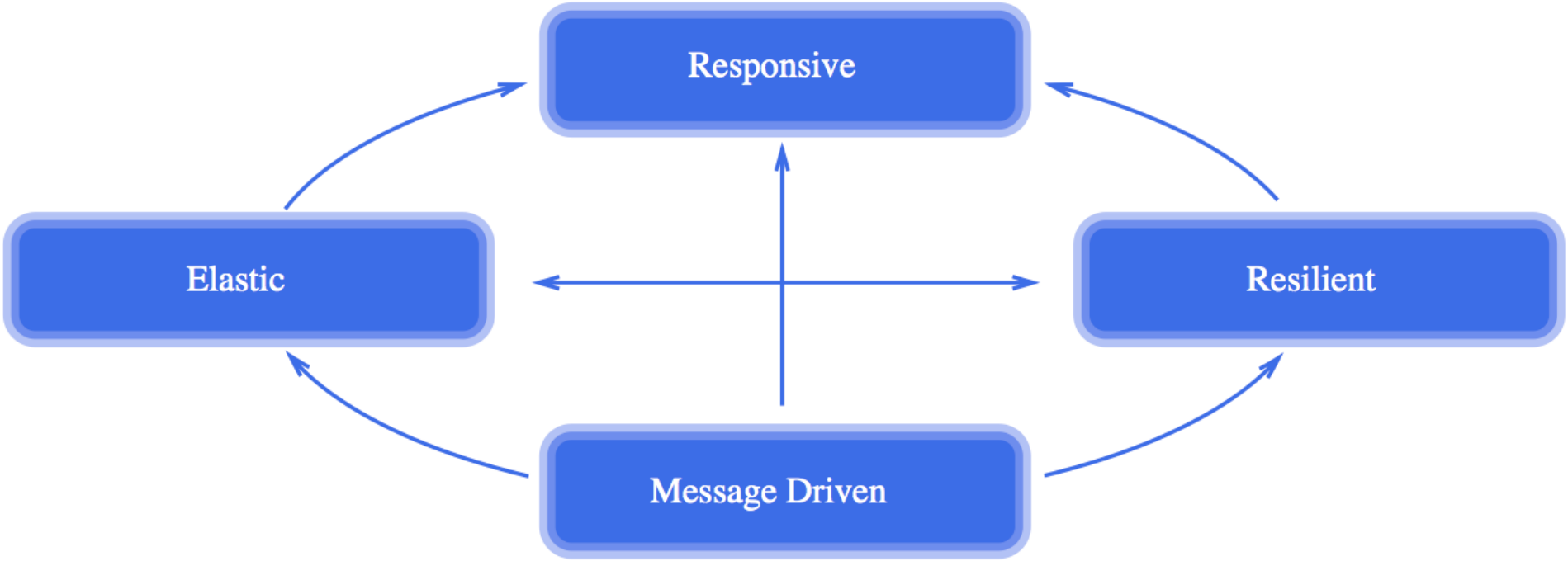
Possible Solutions

- the Push way: buffering and/or dropping

Possible Solutions

- the Reactive way:
  non-blocking & non-dropping & bounded

The Four Horsemen of Reactive



http://reactivemanifesto.org/

Reactive Streams Initiative

Origin and motivation

- all participants face the same basic problem
- all are building tools for their community
- a common solution benefits everybody
- interoperability to make best use of efforts
- propose to include in future JDK

See also: Jon Brisbin's post on "Tribalism as a Force for Good"

Collaboration between Engineers

- Björn Antonsson – Typesafe Inc.
- Gavin Bierman – Oracle Inc.
- Jon Brisbin – Pivotal Software Inc.
- George Campbell – Netflix, Inc
- Ben Christensen – Netflix, Inc
- Mathias Doenitz – spray.io
- Marius Eriksen – Twitter Inc.
- Tim Fox – Red Hat Inc.
- Viktor Klang – Typesafe Inc.
- Dr. Roland Kuhn – Typesafe Inc.
- Doug Lea – SUNY Oswego
- Stephane Maldini – Pivotal Software Inc.
- Norman Maurer – Red Hat Inc.
- Erik Meijer – Applied Duality Inc.
- Todd Montgomery – Kaazing Corp.
- Patrik Nordwall – Typesafe Inc.
- Johannes Rudolph – spray.io
- Endre Varga – Typesafe Inc.

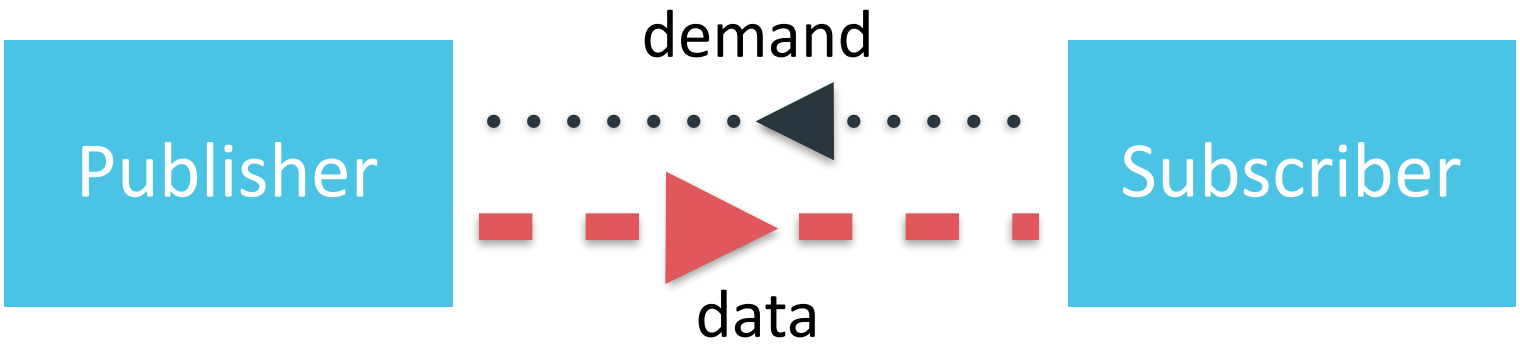
Goals

- minimal interfaces—essentials only
- rigorous specification of semantics
- TCK for verification of implementation
- complete freedom for many idiomatic APIs
- specification should be efficiently implementable

Reactive Streams

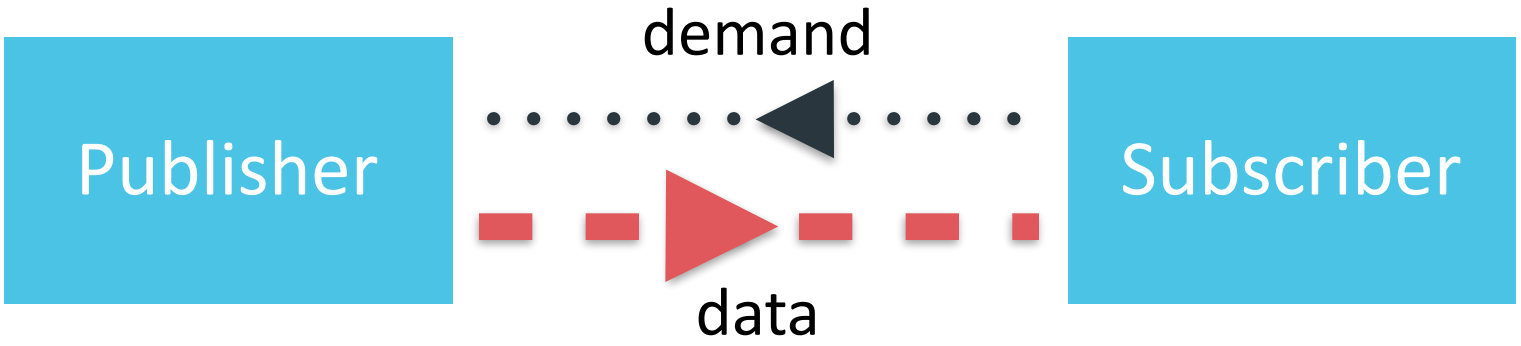
- asynchronous & non-blocking
  - flow of data
  - flow of demand
- minimal coordination and contention
- message passing allows for distribution across
  - applications, nodes, CPUs, threads, actors

A Data Market using Supply & Demand



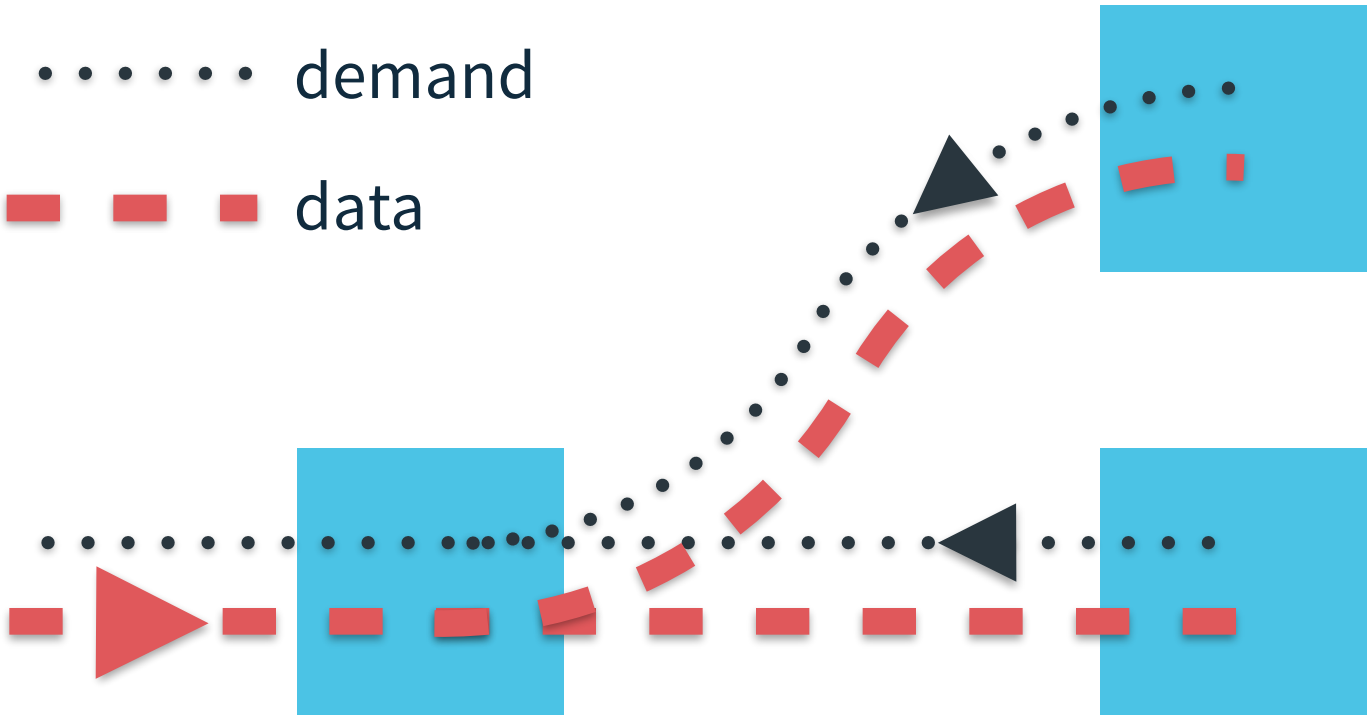
- data elements flow downstream
- demand flows upstream
- data elements flow only when there is demand
  - data in flight is bounded by signaled demand
  - recipient is in control of maximal incoming data rate

Dynamic Push–Pull



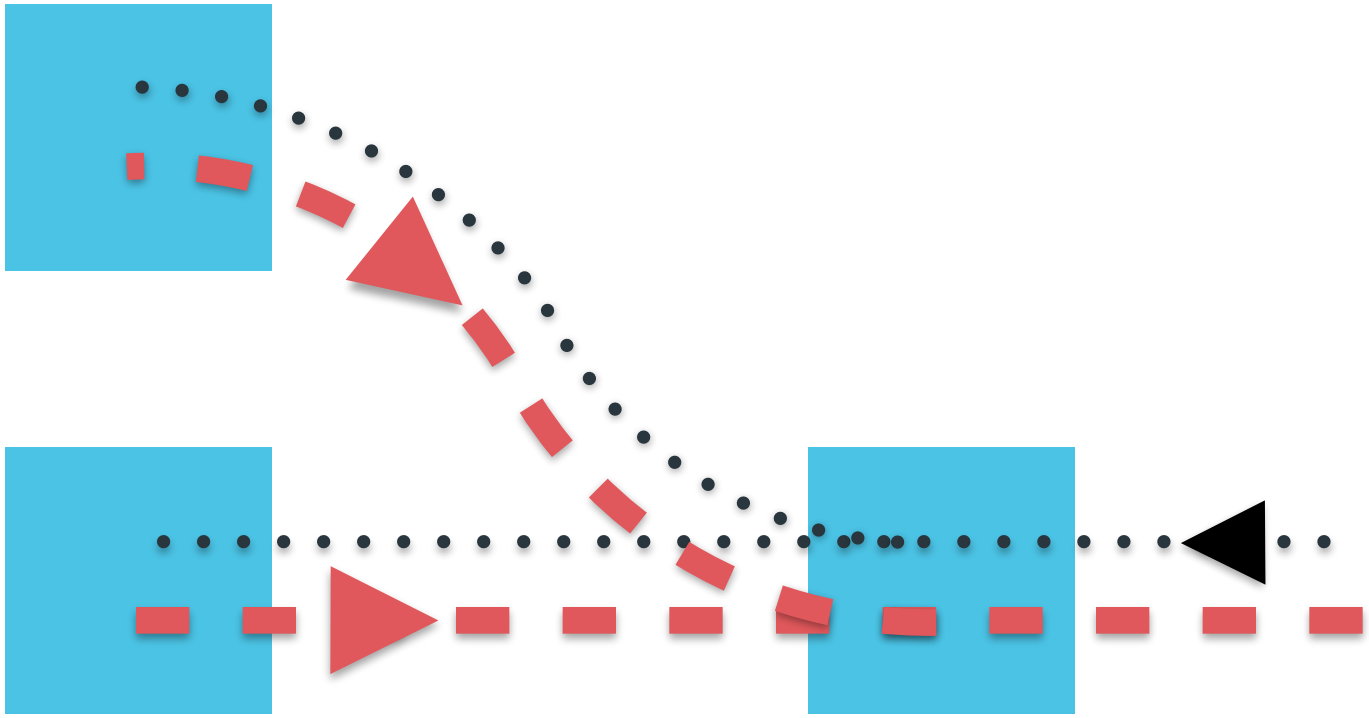
- “push”—when consumer is faster
- “pull”—when producer is faster
- switches automatically between these
- batching demand allows batching data

Explicit Demand: One-to-many



Splitting the data means *merging the demand*

Explicit Demand: Many-to-one



Merging the data means *splitting the demand*

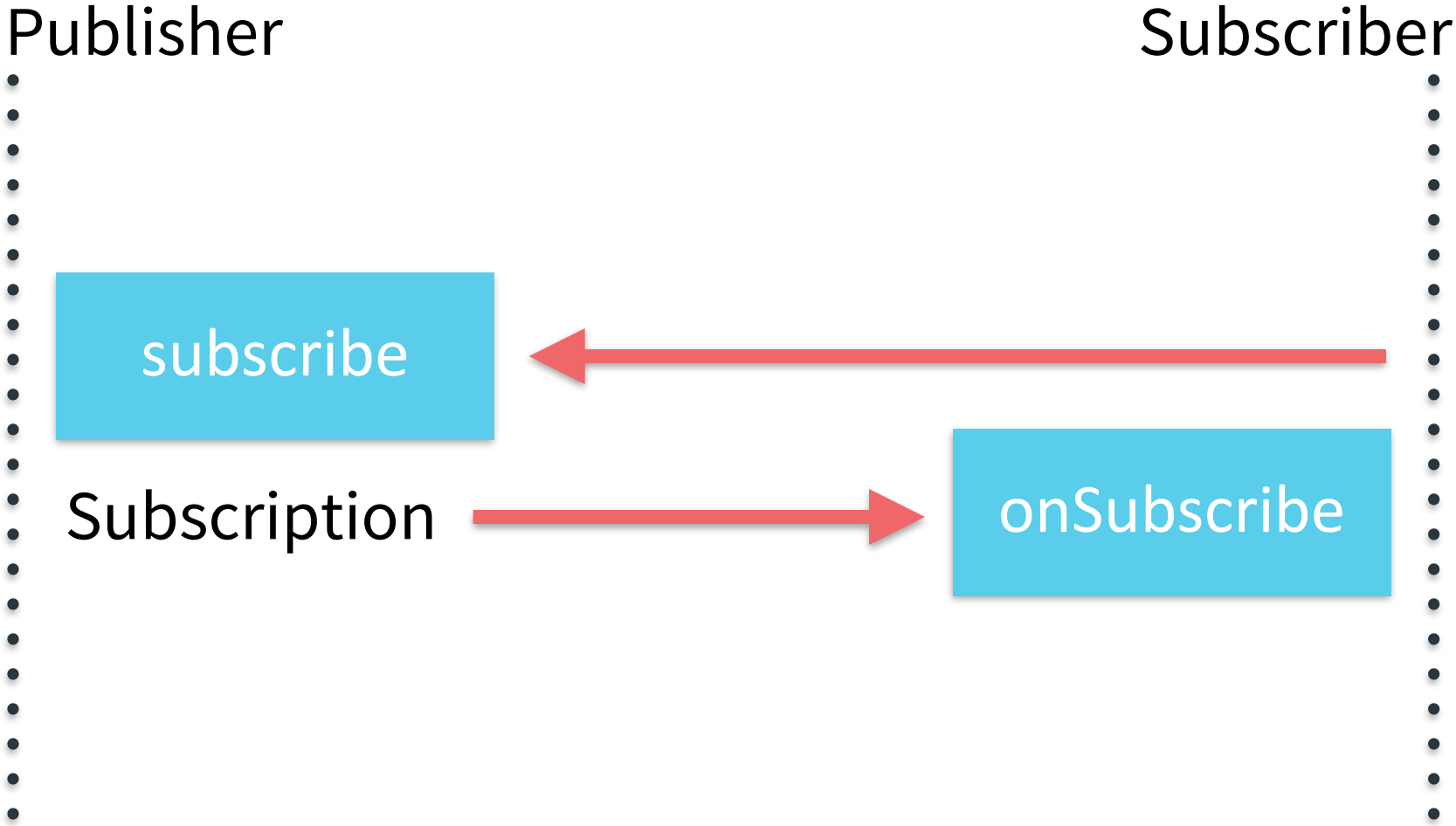
The Meat: Java

```
public interface Publisher<T> {
  public void subscribe(Subscriber<T> s);
}
public void Subscription {
  public void request(long n);
  public void cancel();
}
public interface Subscriber<T> {
  public void onSubscribe(Subscription s);
  public void onNext(T t);
  public void onError(Throwable t);
  public void onComplete();
}
```

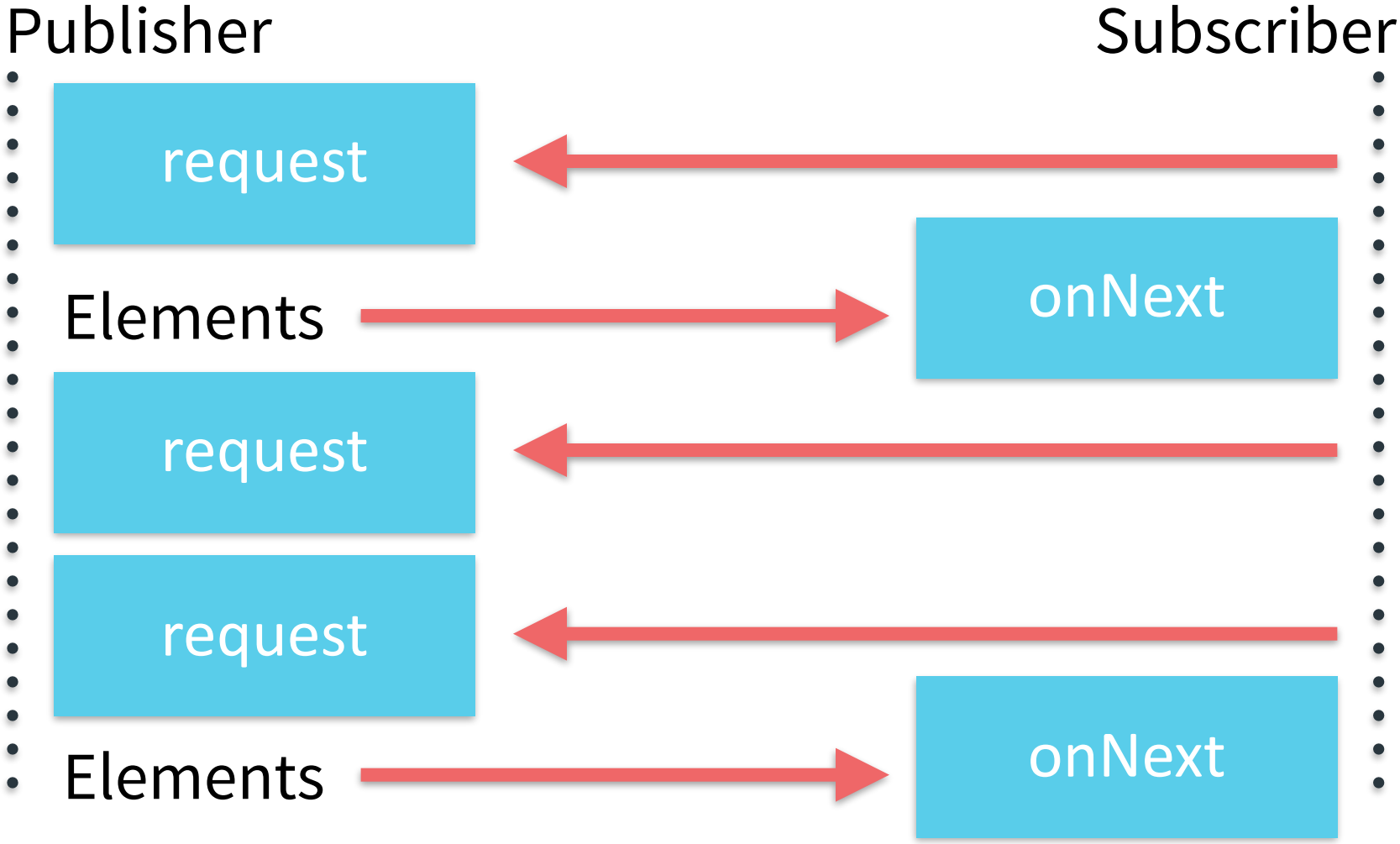
The dessert: Java

```
public interface Processor<T, R>
  extends Subscriber<T>, Publisher<R> {
}
```

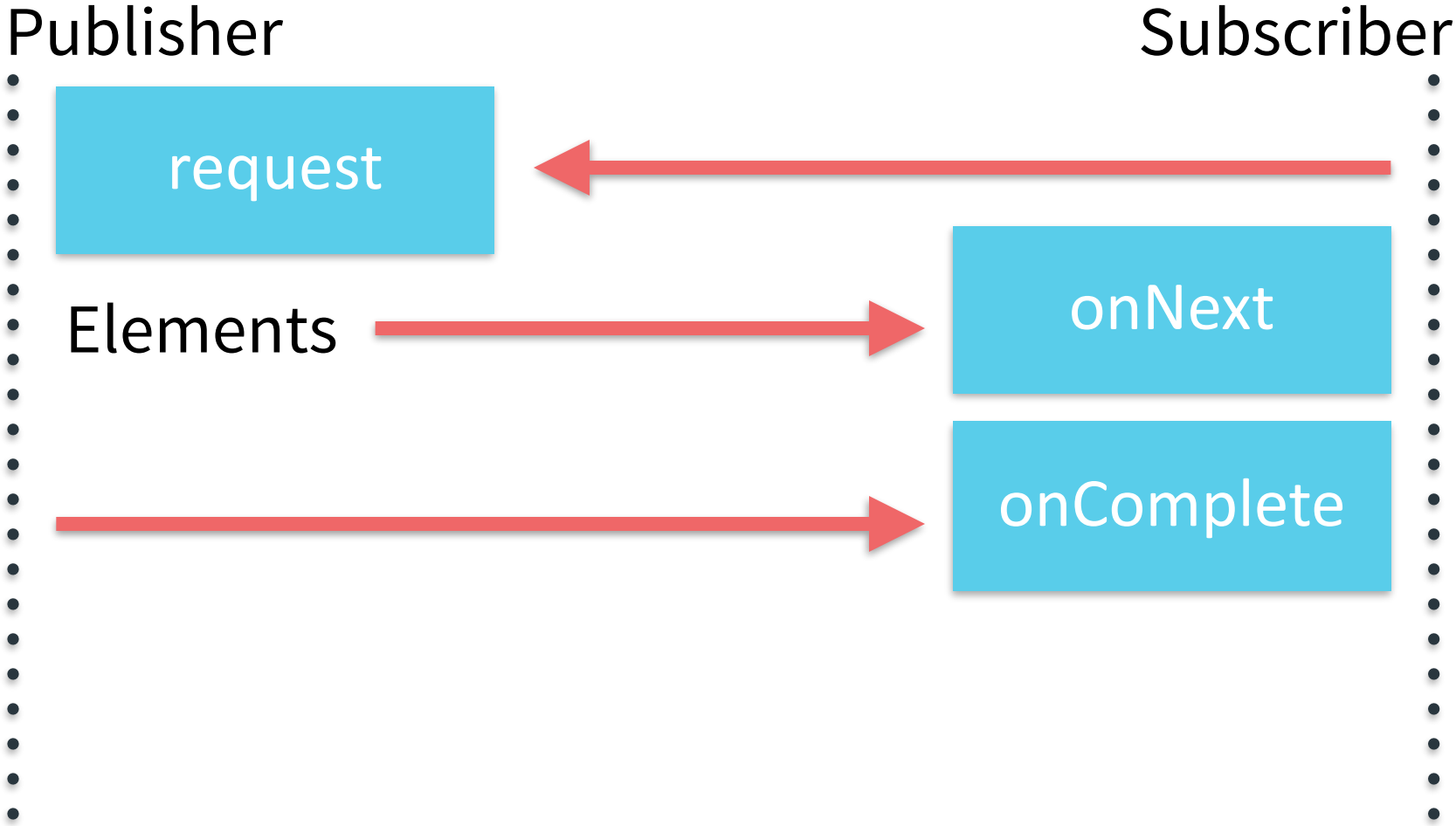
How does it Connect?



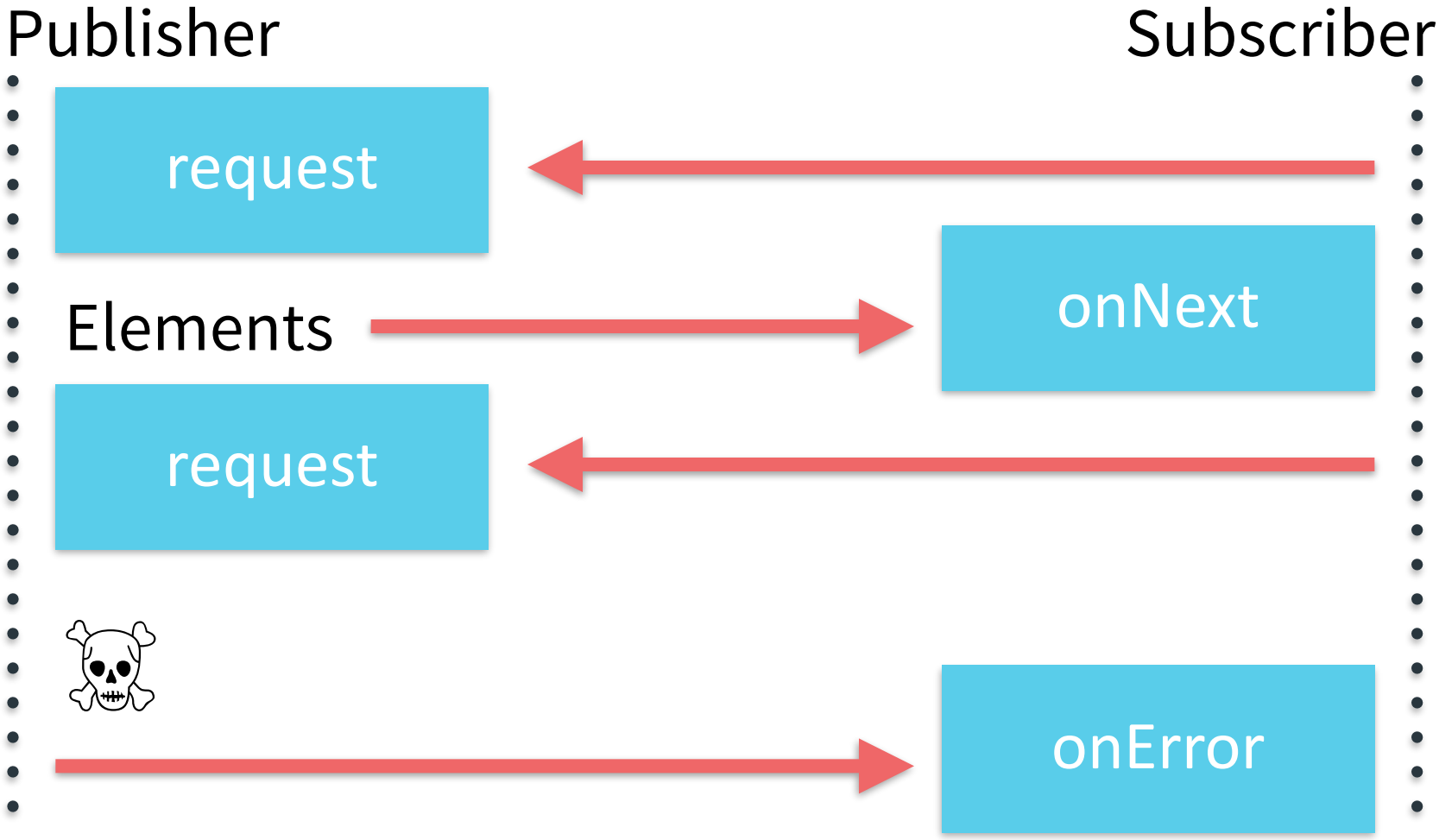
How does it Flow?



How does it Complete?



How does it Fail?



Akka Streams

Akka

- Akka's unit of computation is called an Actor
- Akka Actors are purely reactive components:
  - an address
  - a mailbox
  - a current behavior
  - local storage
- Scheduled to run when sent a message
- Each actor has a parent, handling its failures
- Each actor can have 0..N “child” actors

Akka Actors

- An actor processes a message at a time
  - Multiple-producers & Single-consumer
- The overhead per actor is about ~450bytes
  - Run millions of actors on commodity hardware
- Akka Cluster currently handles ~2500 nodes
  - 2500 nodes × millions of actors
    =
    “ought to be enough for anybody”

Canonical papers

- Carl Hewitt; Peter Bishop; Richard Steiger (1973). A Universal Modular Actor Formalism for Artificial Intelligence. IJCAI.
- Gul Agha (1986). Actors: A Model of Concurrent Computation in Distributed Systems. Doctoral Dissertation. MIT Press.

What’s next for Akka Streams?

Opportunity: API

- Current API is minimal
  - Establish core functionality and take it from there
- Naming: Use established terminology or simplified?
- New APIs on the way
  - FlowGraph
- Both Scala and Java APIs
  - Allows for use by other JVM-hosted languages

Opportunity: Self-tuning back pressure

- Each processing stage can know
  - Latency between requesting more and getting more
  - Latency for internal processing
  - Behavior of downstream demand
    - Latency between satisfying and receiving more
    - Trends in requested demand (patterns)
      - Lock-step
      - N-buffered
      - N + X-buffered
      - “chaotic”

Opportunity: Operation Fusion

- Compile-time, using Scala Macros
  - filter ++ map == collect
  - map ++ filter == collect?
- Run-time, using intra-stage simplification
  - Rule: <any> ++ identity == <any>
    Rule: identity ++ <any> == <any>
  - filter ++ dropUntil(cond) ++ map
  - filter ++ identity ++ map == collect

Opportunity: Operation Elision

- Compile-time, using Scala Macros
  - fold ++ take(n where n > 0) == fold
  - drop(0) == identity
  - <any> concat identity == <any>
- Run-time, using intra-stage simplification
  - map ++ dropUntil(cond) ++ take(N)
  - map ++ identity ++ take(N)
  - map ++ take(N)

Opportunity: Execution optimizations

- synchronous intra-stage execution N steps then trampoline and/or give control to other Thread / Flow

Opportunity: Distributed Streams

- Encode Reactive Streams as a transport protocol
  - Possibility to run over
    - TCP
    - UDP
    - … essentially any bidirectional channel
  - MUX-ing streams
- Materialize a Flow on a cluster of Akka nodes

Advanced Live Demo

Outro: How do I get my hands on this?

- http://reactive-streams.org/
- https://github.com/reactive-streams
- Preview is available:

```
"org.reactivestreams" % "reactive-streams" % “0.4.0”
"com.typesafe.akka" %% "akka-stream-experimental" % "0.8"
```

- check out the Activator template "Akka Streams with Scala!" (https://github.com/typesafehub/activator-akka-stream-scala)