Go Reactive

Event-Driven,
Scalable,
Resilient &
Responsive
Systems

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CTO Typesafe

@jboner

New Tools for a New Era

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- The demands and expectations for applications have changed dramatically in recent years
- We need to write applications that manages
  1. Mobile devices
  2. Multicore architectures
  3. Cloud computing environments
- Deliver applications that are
  1. Interactive & Real-time
  2. Responsive
  3. Collaborative

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New Tools for a New Era

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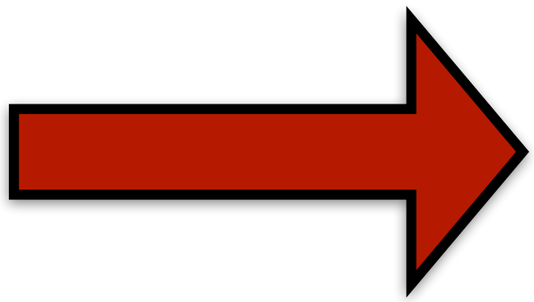

Reactive Applications

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Reactive

"Readily responsive to a stimulus"

- Merriam Webster

The four traits of Reactive

Responsive

Scalable

Resilient

Event-Driven

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Event-Driven

"The flow of the program is determined by events"

- Wikipedia

Shared mutable state

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Together with threads...

Shared mutable state

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...code that is totally non-deterministic

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1. Never block

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1. Never block

- ...unless you really have to
- Blocking kills scalability (& performance)
- Never sit on resources you don't use
- Use non-blocking IO
- Use lock-free concurrency

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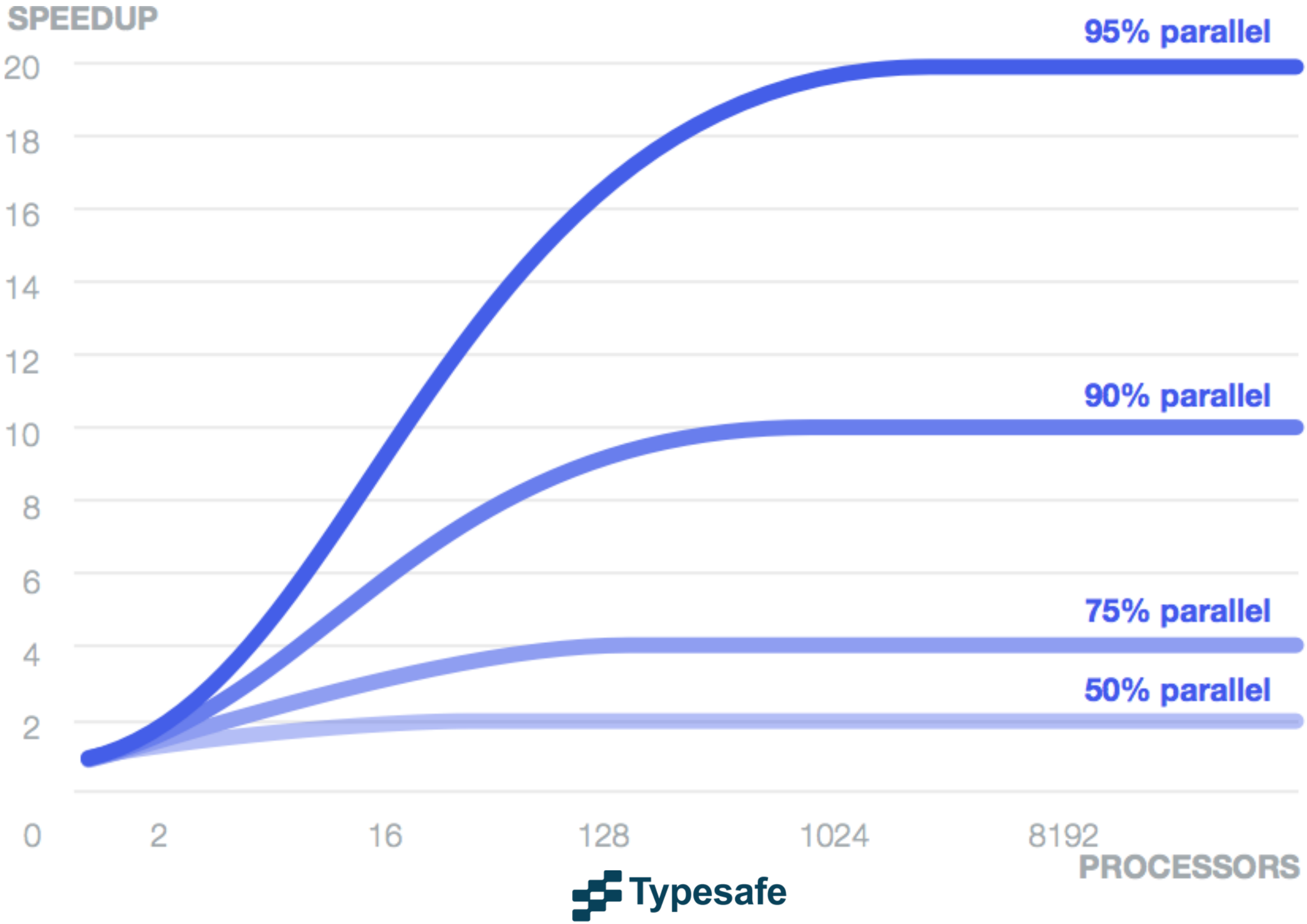
2. Go Async

Design for reactive event-driven systems

- Use asynchronous event/message passing
- Think in workflow, how the events flow in the system
- Gives you
  1. lower latency
  2. better throughput
  3. a more loosely coupled architecture, easier to extend, evolve & maintain

Amdahl's Law



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Amdahl's Law


SPEEDUP
20
18
16
14
12
10
8
6
4
2
0
2
16
128
1024
8192
PROCESSORS
parallel
75% parallel
50% parallel
Needs to be
Reactive from
ToP to BoTToM
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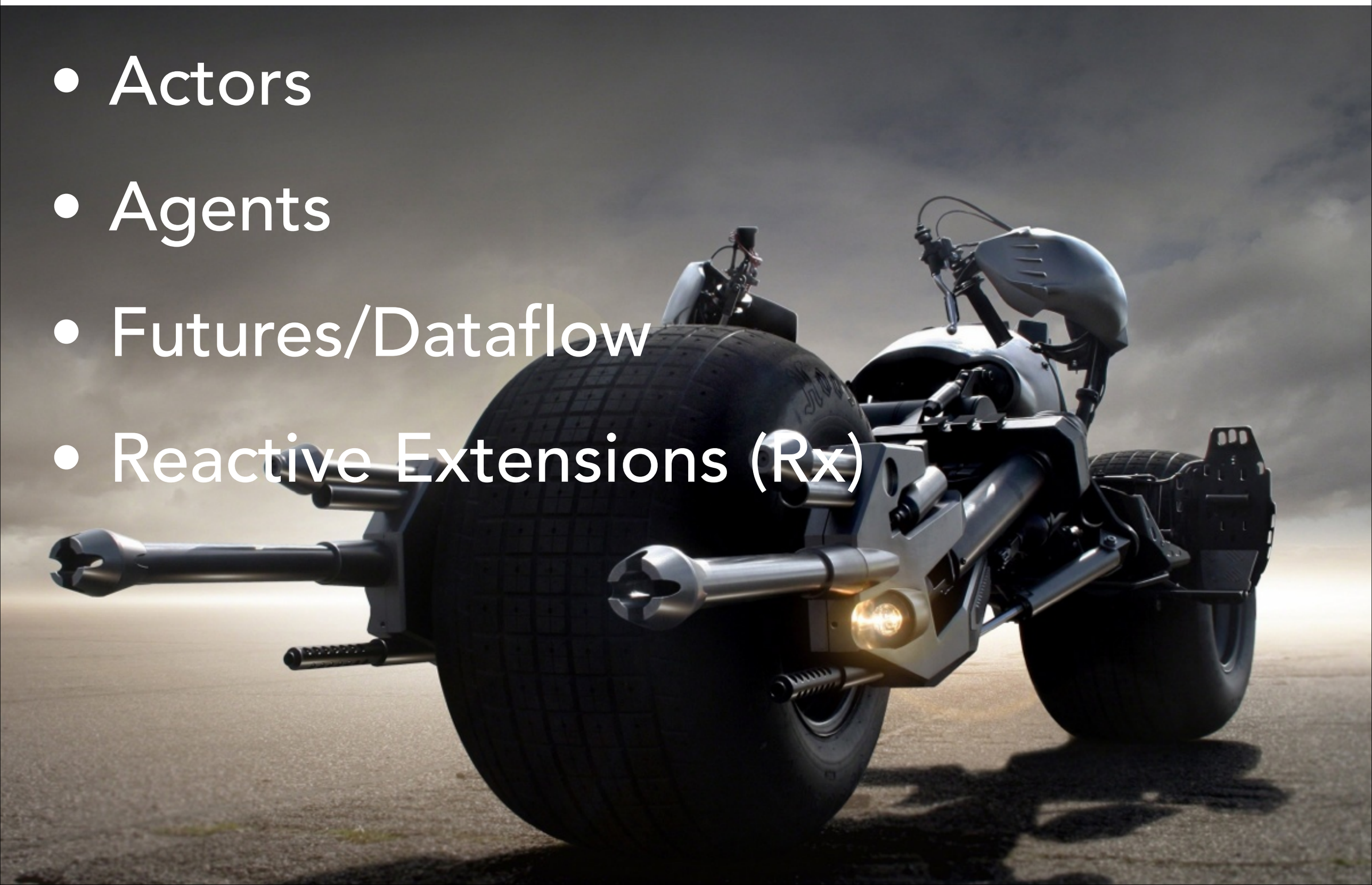
You deserve better tools



- Actors
- Agents
- Futures/Dataflow
- Reactive Extensions (Rx)

Actors

- Share NOTHING
- Isolated lightweight event-based processes
- Each actor has a mailbox (message queue)
- Communicates through asynchronous & non-blocking message passing
- Location transparent (distributable)
- Supervision-based failure management
- Examples: Akka & Erlang

Actors in Akka

```
public class Greeting implements Serializable {
 public final String who;
 public Greeting(String who) { this.who = who; }
}

public class GreetingActor extends UntypedActor {

  public void onReceive(Object message) {
   if (message instanceof Greeting)
    println("Hello " + ((Greeting) message).who);
 }
}
```

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Actors in Akka

Define the message(s) the Actor should be able to respond to

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      println("Hello " + ((Greeting) message).who);
  }
}
```

Define the Actor class

Define the Actor's behavior

Agents

- Reactive memory cells
- Send a update function to the Agent, which

  1. adds it to an (ordered) queue, to be

  2. applied to the Agent async & non-blocking

- Reads are “free”, just dereferences the Ref
- Composes nicely
- Examples: Clojure & Akka

Agents in Akka

```
val agent = Agent(5)
agent send (x => x + 1)
agent send (x => x * 2)
```

Futures/Dataflow

- Allows you to spawn concurrent computations and work with the not yet computed results
- Write-once, Read-many
- Freely sharable
- Allows non-blocking composition
- Monadic (composes in for-comprehensions)
- Build in model for managing failure

Futures in Scala

```
val result1 = future { ... }
val result2 = future { ... }
val result3 = future { ... }

val sum = for {
   r1 <- result1
   r2 <- result2
   r3 <- result3
} yield { r1 + r2 + r3 }
```

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Reactive Extensions (Rx)

- Extend Futures with the concept of a Stream
- Composable in a type-safe way
- Event-based & asynchronous
- Observable ⇛ Push Collections
  - onNext(T), onError(E), onCompleted()
  - Compared to Iterable ⇛ Pull Collections
- Examples: Rx.NET, RxJava, RxJS etc.

RxJava

```
getDataFromNetwork()
   .skip(10)
   .take(5)
   .map({ s -> return s + " transformed" })
   .subscribe({ println "onNext => " + it })
```

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Scalable

"Capable of being easily expanded or upgraded on demand"

- *Merriam Webster*

Distributed systems is the

new normal

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Distributed systems is the

new normal

You already have a distributed system,

whether you want it or not

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Mobile

SQL Replication

NOSQL DBs

Cloud Services

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What is the essence of distributed computing?

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It's to try to overcome that

1. Information travels at the speed of light
2. Independent things fail independently

Why do we need it?

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Scalability

When you outgrow
the resources of
a single node

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When you outgrow the resources of a single node

Availability

Providing resilience if one node fails

Why do we need it?

Scalability

When you outgrow
the resources of
a single node

Availability

Providing resilience if
one node fails

Rich stateful clients

The problem?

The problem?

It is still

Very Hard

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No difference

Between a

Slow node

and a

Dead node

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The network is

Inherently Unreliable

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Inherently Unreliable

http://aphyr.com/posts/288-the-network-is-reliable

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Fallacies

Peter Deutsch's

8 Fallacies

of Distributed Computing

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Fallacies

Peter Deutsch's

8 Fallacies of Distributed Computing

1. The network is reliable
2. Latency is zero
3. Bandwidth is infinite
4. The network is secure
5. Topology doesn't change
6. There is one administrator
7. Transport cost is zero
8. The network is homogeneous

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Graveyard of distributed systems

- Distributed Shared Mutable State
  - $EVIL^{N}$ (where N is number of nodes)

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- Serializable Distributed Transactions

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Graveyard of distributed systems

- Distributed Shared Mutable State
  - EVIL^{N} (where N is number of nodes)
- Serializable Distributed Transactions
- Synchronous RPC
- Guaranteed Delivery
- Distributed Objects
  - *"Sucks like an inverted hurricane" - Martin Fowler*

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Instead

Instead

Embrace the Network

Use

Asynchronous

Message

Passing

and be done with it

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We need

Location Transparency

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What is

Location Transparency?

```
// send message to local actor
ActorRef localGreeter = system.actorOf(
    new Props(GreetingActor.class), “greeter");

localGreeter.tell(“Jonas”);
```

What is

Location Transparency?

```
// send message to local actor
ActorRef localGreeter = system.actorOf(
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```

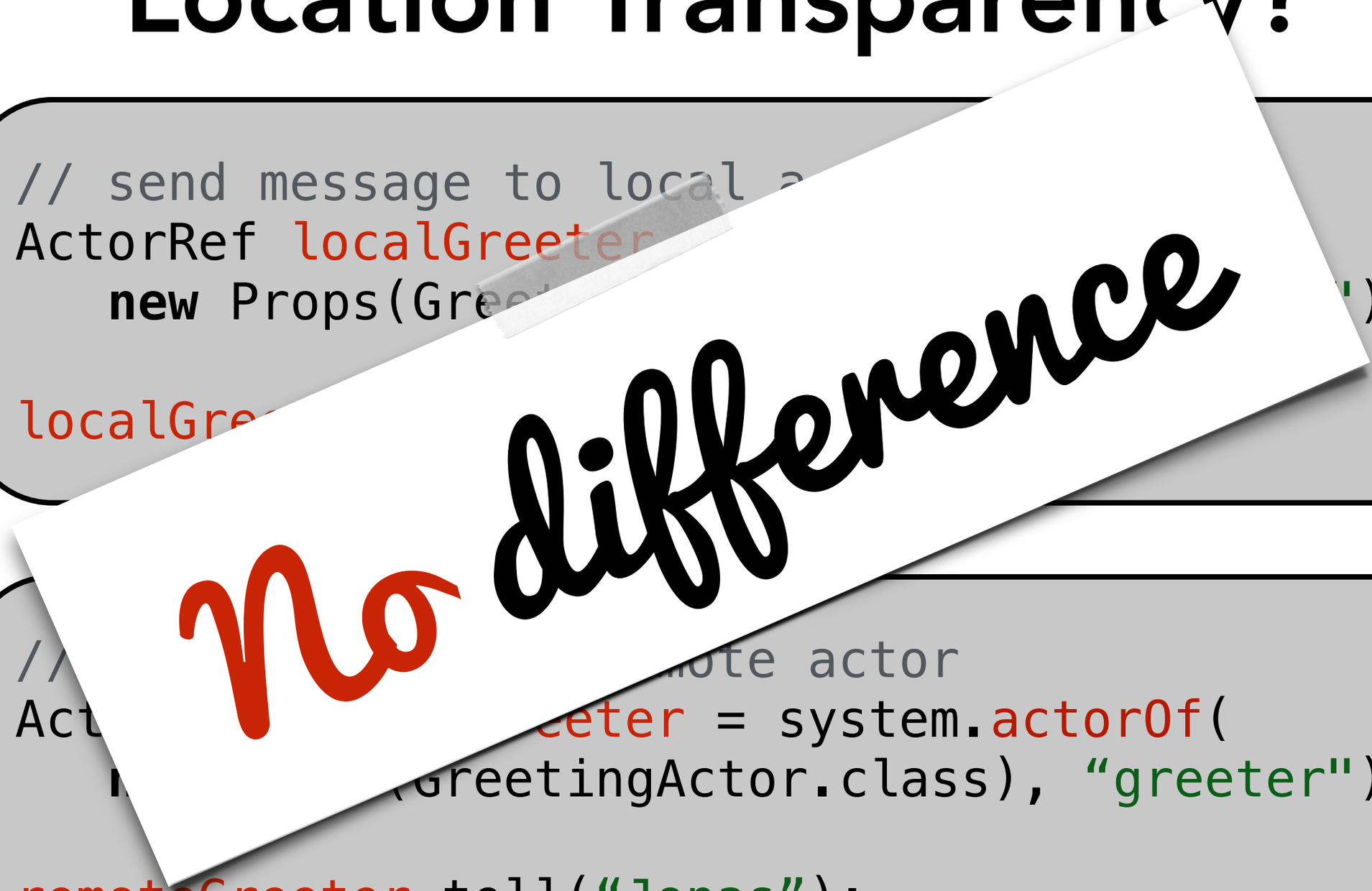
```
// send message to remote actor
ActorRef remoteGreeter = system.actorOf(
    new Props(GreetingActor.class), “greeter");

remoteGreeter.tell(“Jonas”);
```

What is Location Transparency?

```
// send message to local a
ActorRef localGreeter
    new Props(Gre                    ");

localGre
```




```
//                    mote actor
Act          eeter = system.actorOf(
    n          (GreetingActor.class), “greeter");

remoteGreeter.tell(“Jonas”);
```

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Divide & Conquer

Partition

for scale

Replicate

for resilience

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Share
Nothing

Share

Nothing

Asynchronous

Communication

Share
Nothing

Loose
Coupling

Asynchronous
Communication

Typesafe

Share
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Loose
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Location
Transparency

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No limit to scalability

Typesafe

Share
Nothing

Loose
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Location
Transparency

close to at least

No limit to scalability

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Resilience

"The ability of a substance or object to spring back into shape."

"The capacity to recover quickly from difficulties."

- *Merriam Webster*

Failure Recovery in Java/C/C# etc.

Failure Recovery in Java/C/C# etc.

- You are given a SINGLE thread of control
- If this thread blows up you are screwed
- So you need to do all explicit error handling WITHIN this single thread
- To make things worse - errors do not propagate between threads so there is NO WAY OF EVEN FINDING OUT that something have failed
- This leads to DEFENSIVE programming with:
  - Error handling TANGLED with business logic
  - SCATTERED all over the code base

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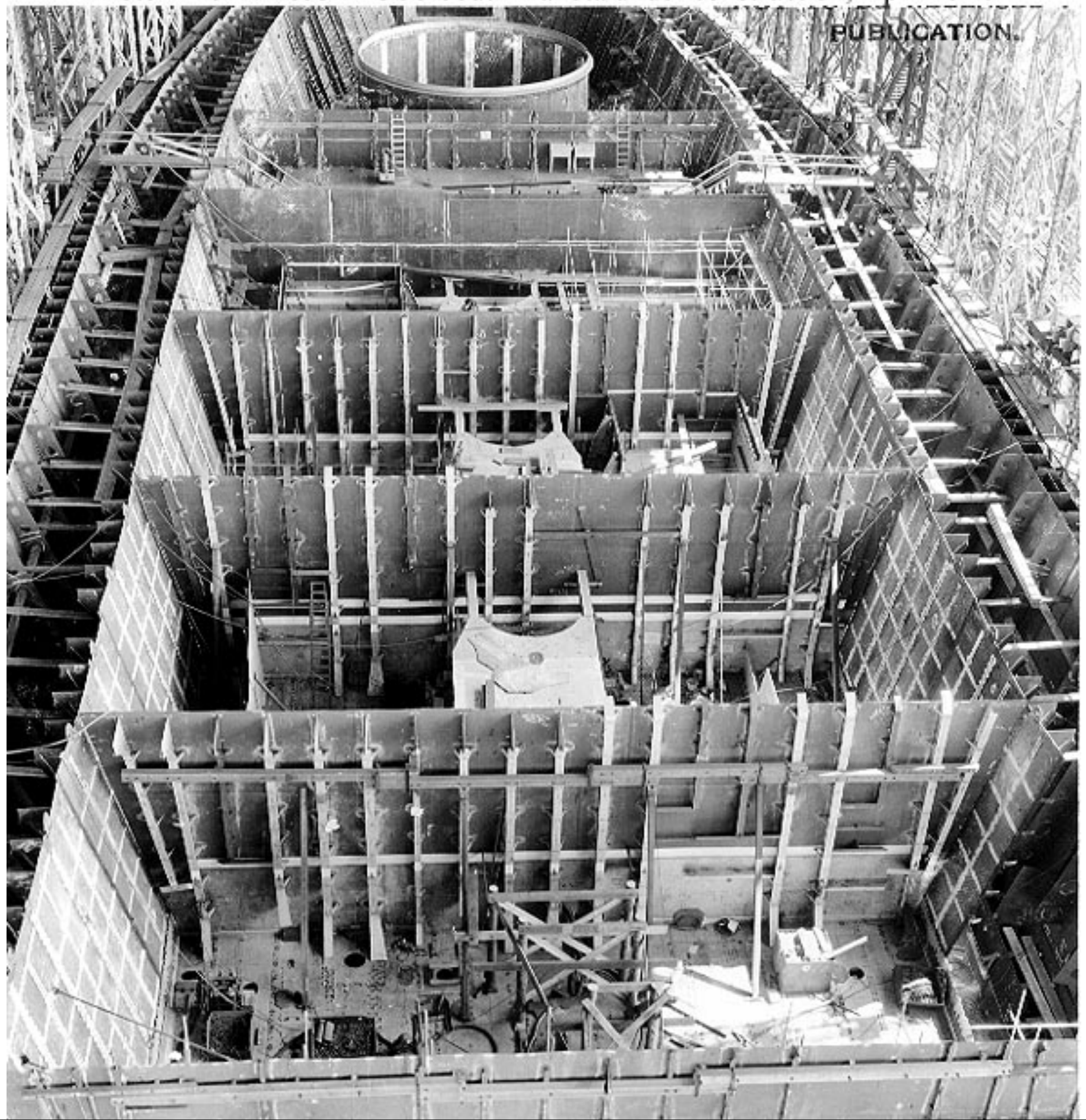
Photo # 19-N-28532 USS South Dakota under construction, April 1940



The Right Way

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- Isolate the failure
- Compartmentalize
- Manage failure locally
- Avoid cascading failures

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- Compartmentalize
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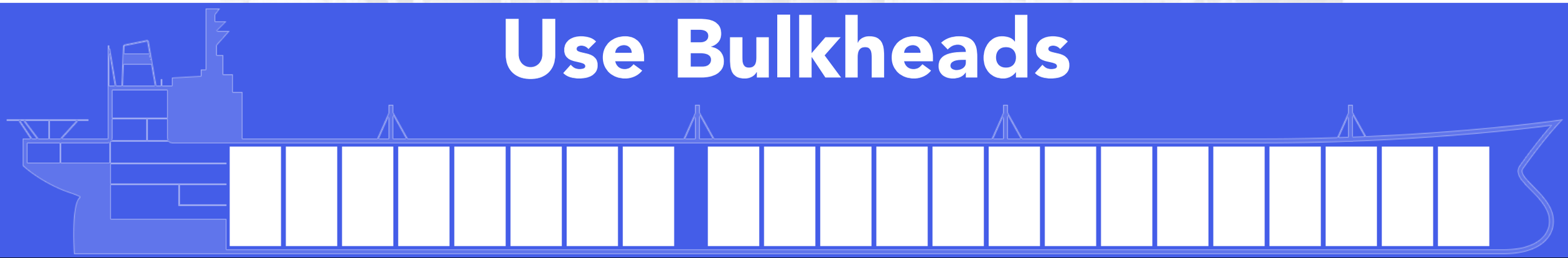
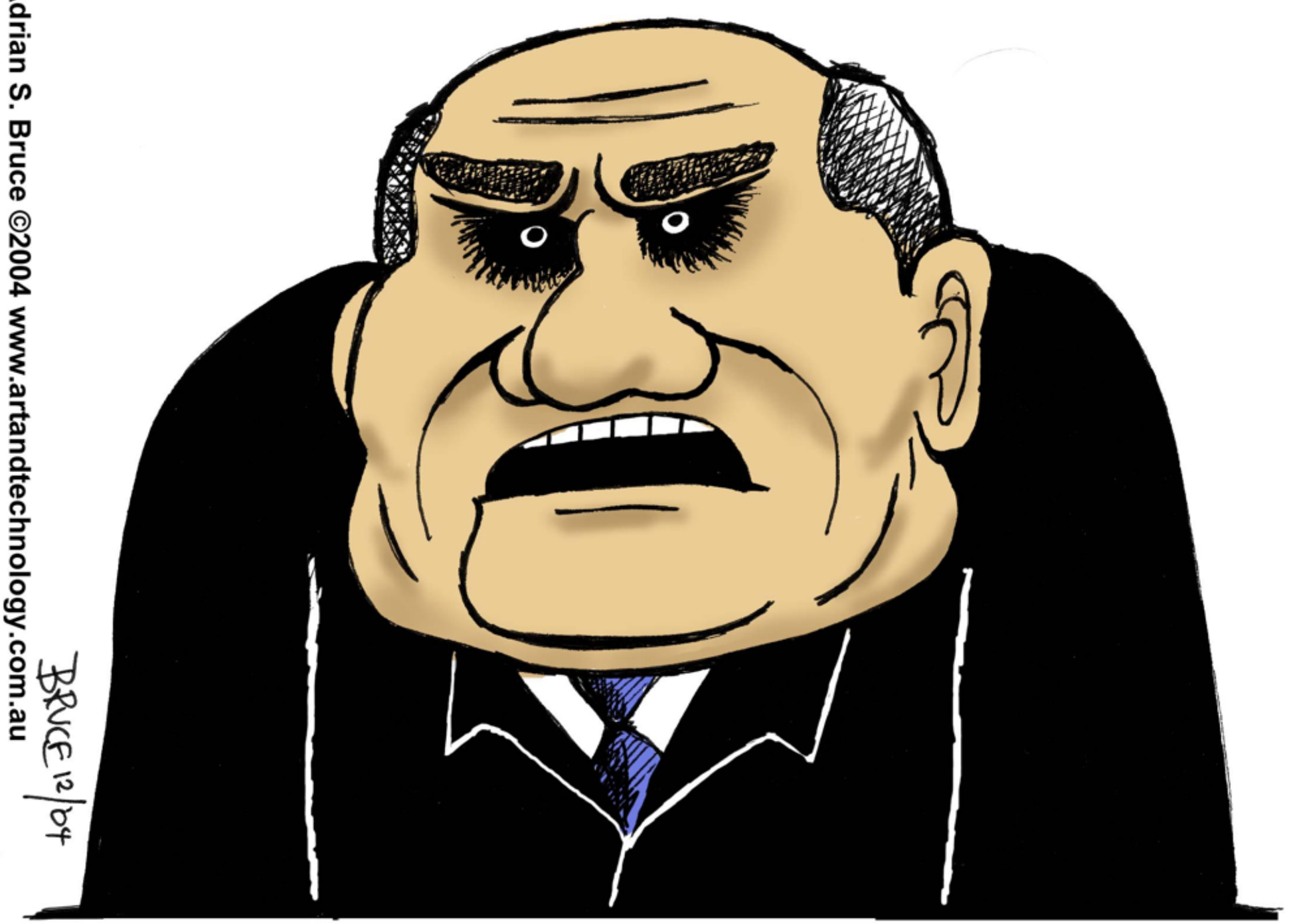
Use Bulkheads



...together with supervision



THE BEATINGS WILL CONTINUE UNTIL MORALE IMPROVES

...together with supervision

1. Use Isolated lightweight processes (compartments)
2. Supervise these processes
    1. Each process has a supervising parent process
    2. Errors are reified and sent as (async) events to the supervisor
    3. Supervisor manages the failure - can kill, restart, suspend/resume

- Same semantics local as remote
- Full decoupling between business logic & error handling
- Build into the Actor model

Supervision in Akka

Every single actor has a
default supervisor strategy.
Which is usually sufficient.
But it can be overridden.

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```
class Supervisor extends UntypedActor {
  private SupervisorStrategy strategy = new OneForOneStrategy(
    10,
    Duration.parse("1 minute"),
    new Function<Throwable, Directive>() {
      @Override public Directive apply(Throwable t) {
        if (t instanceof ArithmeticException)       return resume();
        else if (t instanceof NullPointerException) return restart();
        else                                        return escalate();
    }
  });

  @Override public SupervisorStrategy supervisorStrategy() {
```

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akka

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    }
  });

  @Override public SupervisorStrategy supervisorStrategy() {
    return strategy;
  }

  ActorRef worker = context.actorOf(new Props(Worker.class));

  public void onReceive(Object message) throws Exception {
    if (message instanceof Integer) worker.forward(message);
  }
}
```

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Responsive

"Quick to respond or react appropriately"

- Merriam Webster

Keep

latency consistent

1. Blue sky scenarios
2. Traffic bursts
3. Failures

Keep

latency consistent

1. Blue sky scenarios
2. Traffic bursts
3. Failures

The system should

always be responsive

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Use Back Pressure

Bounded queues with backoff strategies

Use Back Pressure

Bounded queues with backoff strategies

Respect Little's Law:

$$L = \lambda W$$

Queue Length = Arrival Rate * Response Time

Use Back Pressure

Bounded queues with backoff strategies

Respect Little's Law:

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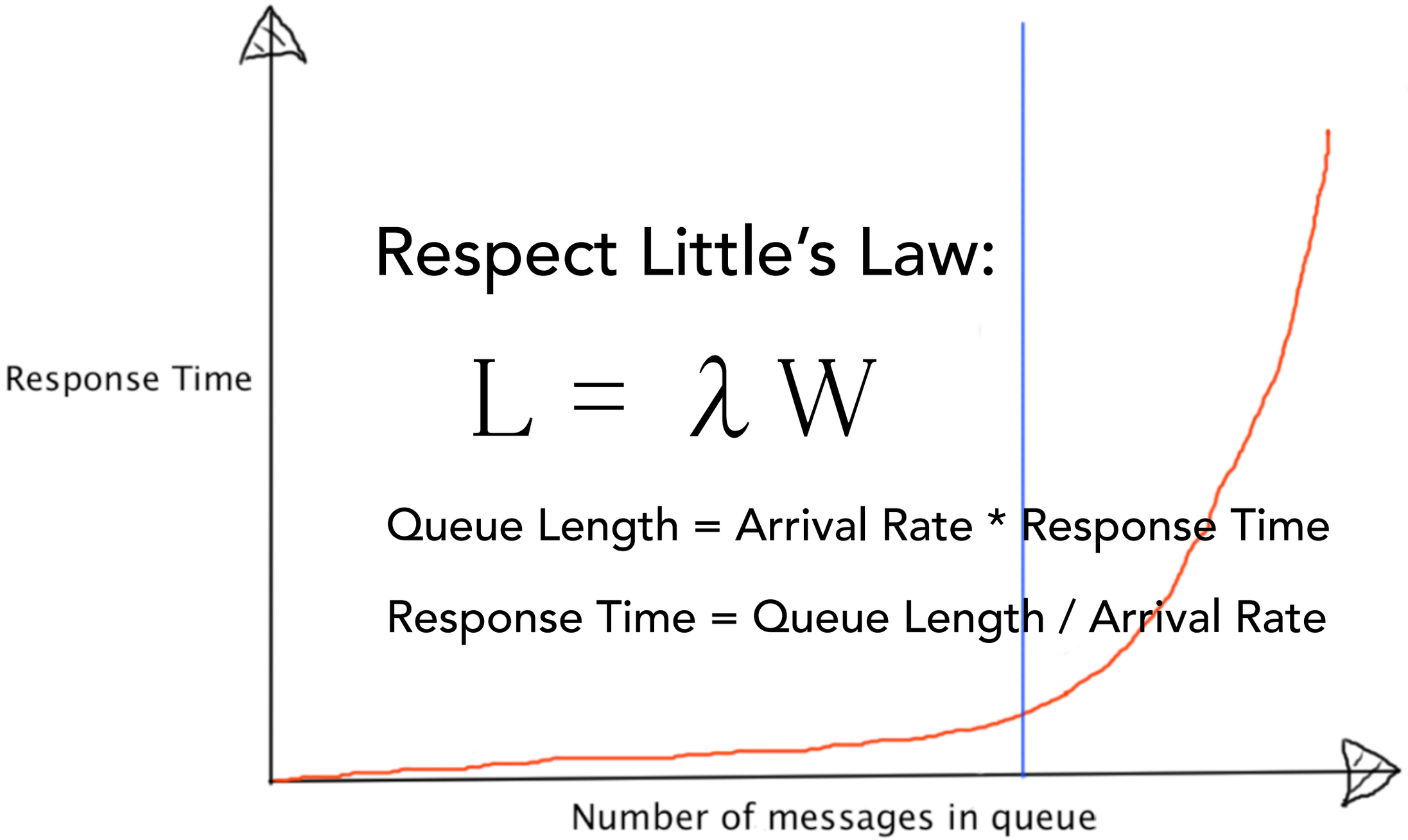
Queue Length = Arrival Rate * Response Time

Response Time = Queue Length / Arrival Rate

Use Back Pressure

Bounded queues with backoff strategies



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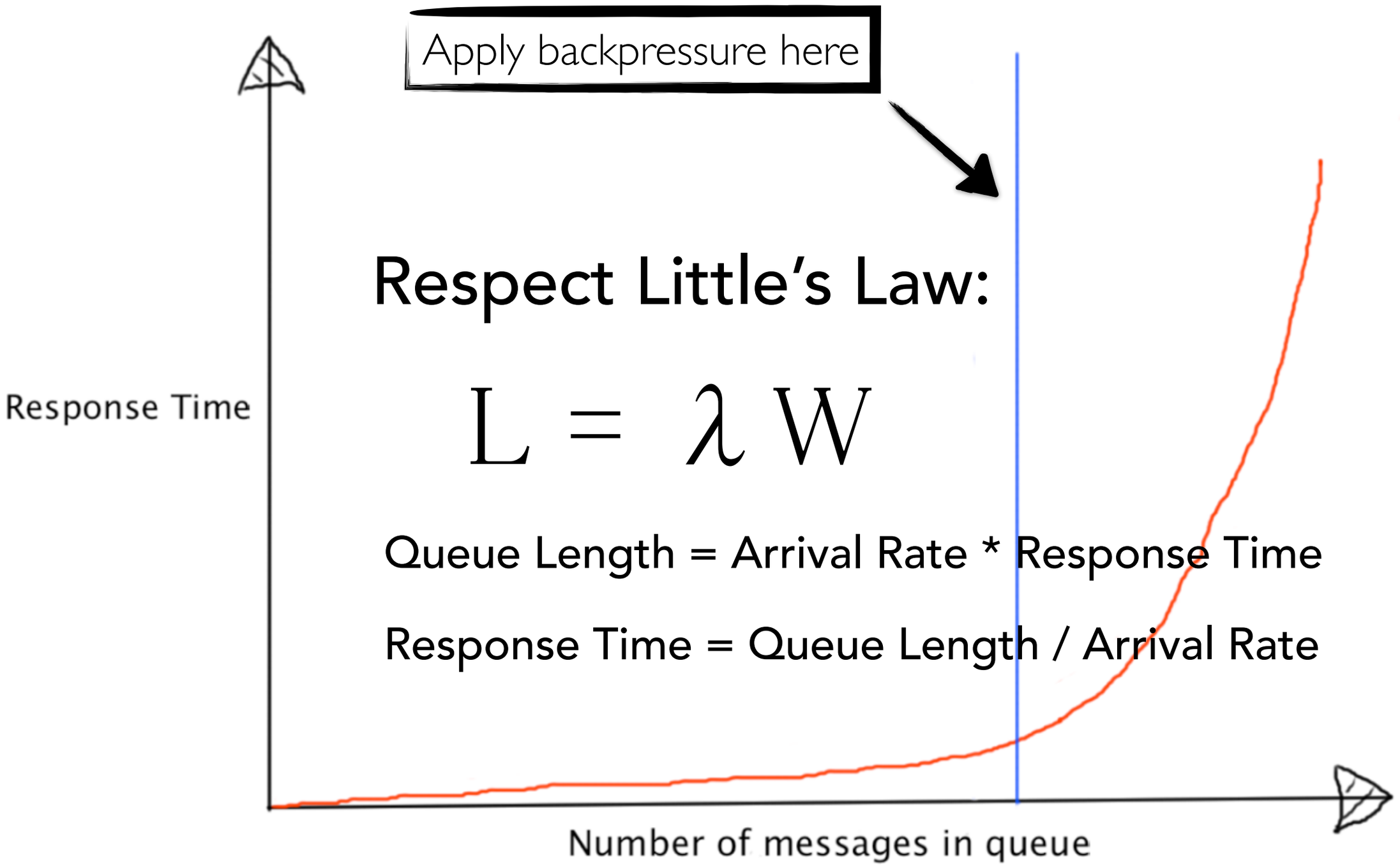

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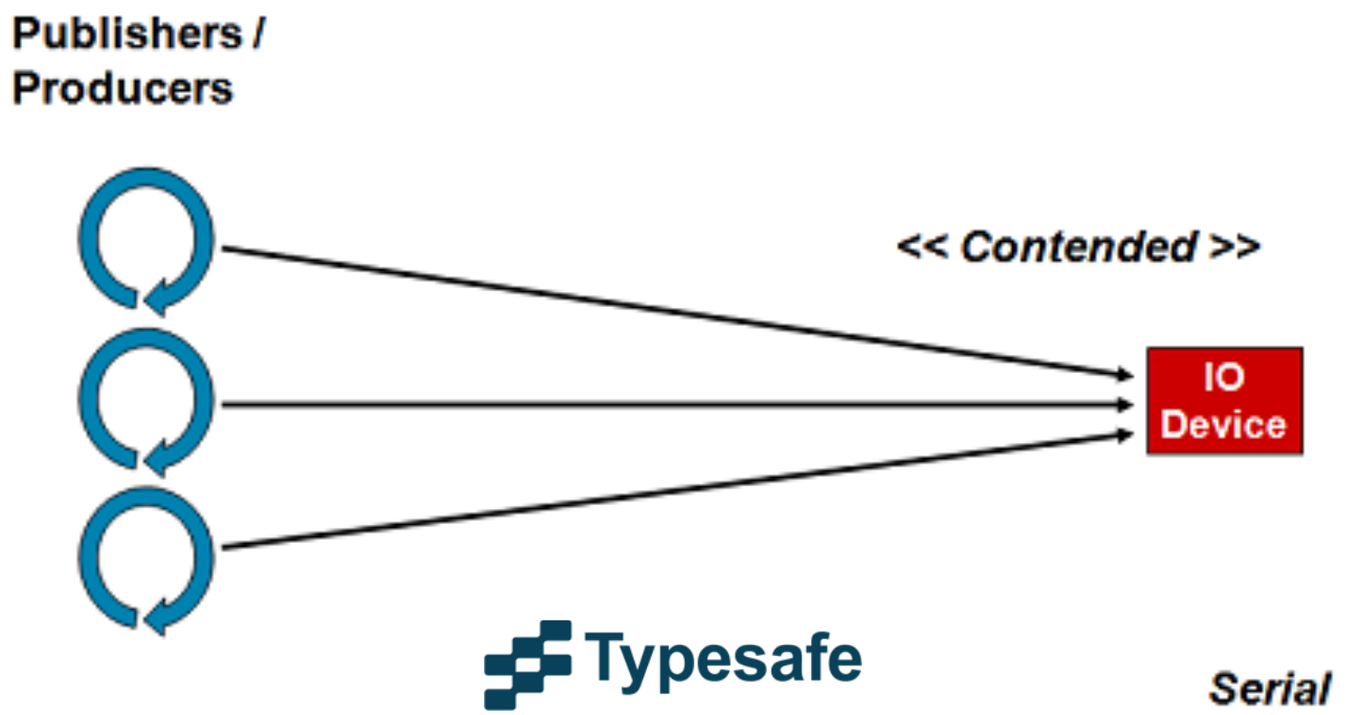
Smart Batching



Smart Batching
http://bit.ly/smartbatching
By Martin Thompson

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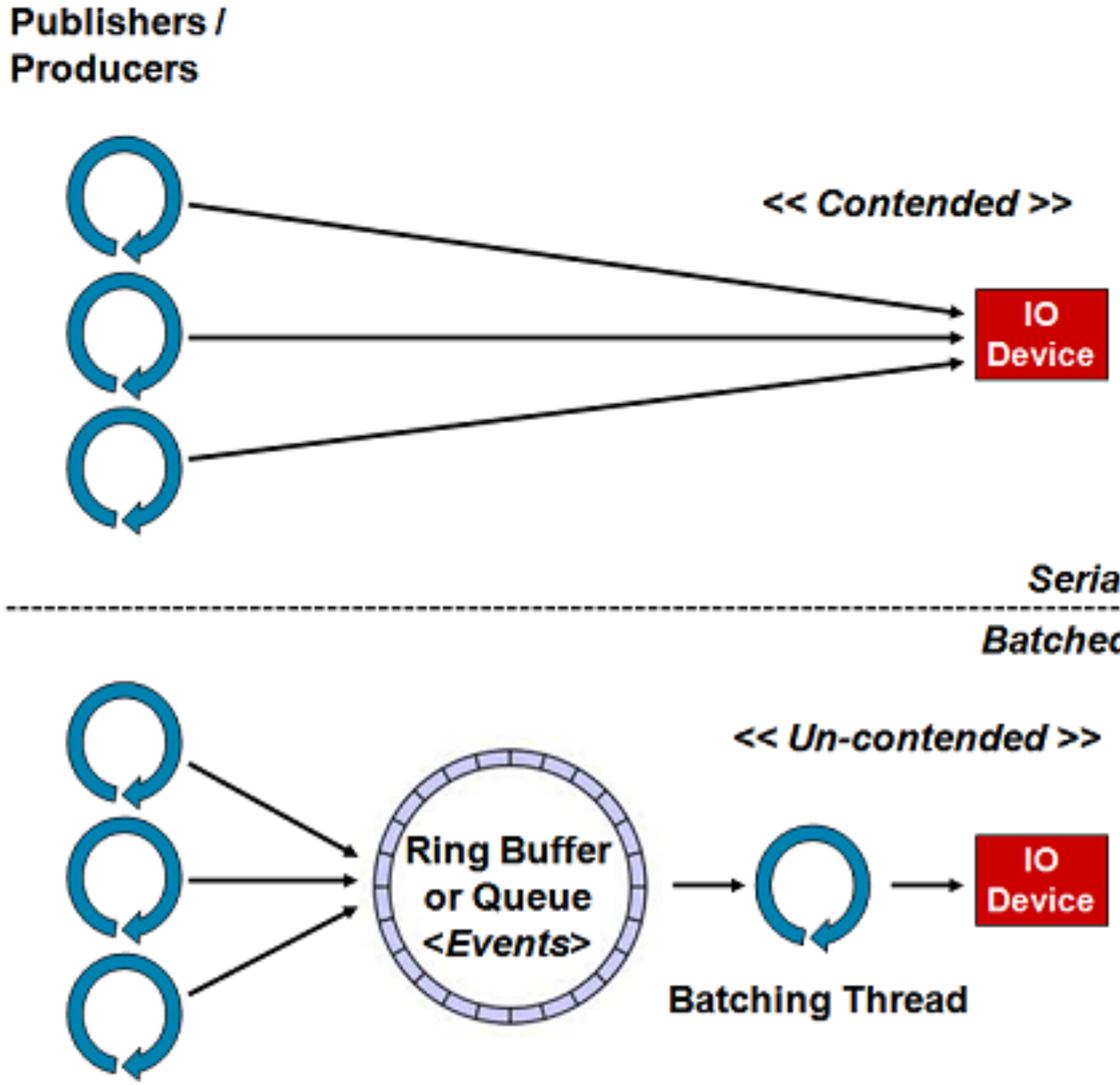

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Reactive Web & Mobile Apps

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Reactive Web & Mobile Apps

1. Reactive Request

Async & Non-blocking Request & Response

Reactive Web & Mobile Apps

1. Reactive Request

Async & Non-blocking Request & Response

2. Reactive Composition

Reactive Request + Reactive Request + ...

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Reactive Web & Mobile Apps

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   Reactive Request + Reactive Request + ...

3. Reactive Push

   Stream Producer

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4. 2-way Reactive (Bi-Directional Reactive Push)

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Reactive Web & Mobile Apps

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Async & Non-blocking Request & Response

2. Reactive Composition

Reactive Request + Reactive Request + ...

3. Reactive Push

Stream Producer

4. 2-way Reactive (Bi-Directional Reactive Push)

Enables Reactive UIs

1. Interactive
2. Data Synchronization
3. “Real-time” Collaboration

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Reactive Composition in Play

```
public class Application extends Controller {
  public static Result index() {
    return ok(index.render("Your new application is ready."));
  }
}
```

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```
 def get(symbol: String): Action[AnyContent] = Action.async {
   for {
     tweets     <- getTweets(symbol)
     sentiments <- Future.sequence(loadSentiments(tweets.json))
   } yield Ok(toJson(sentiments))
}
```

Reactive Composition in Play

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fully reactive non-blocking request composition

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Get Started – Typesafe Platform – Typesafe

typesafe.com/platform/getstarted

Reader

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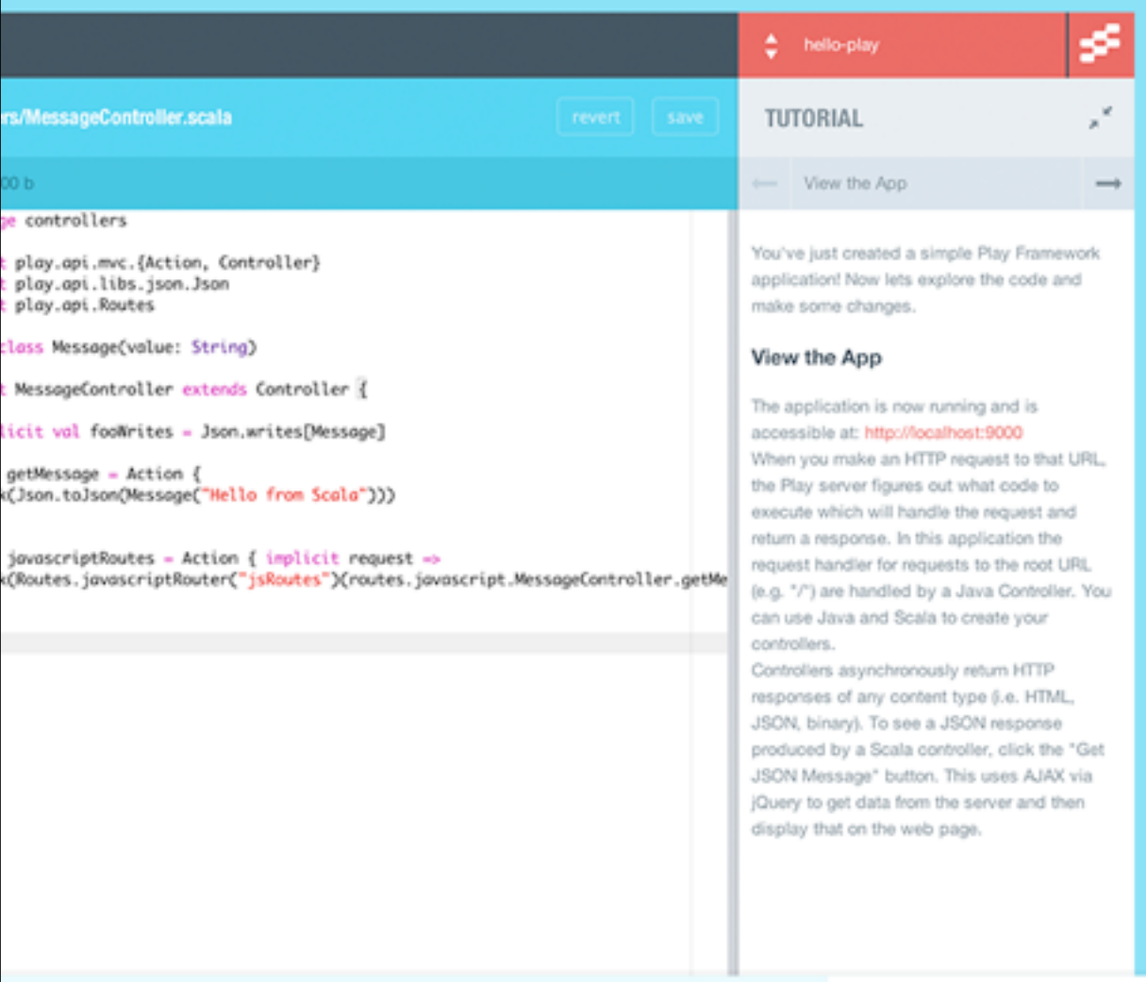
TYPESAFE PLATFORM HOW WE HELP COMPANY BLOG

TYPESAFE PLATFORM / **GET STARTED**



Typesafe Activator helps you get started with the Typesafe Platform, Play Framework, Akka & Scala

Download Activator

JDK6+ | 203MB
Activator is in Developer Preview

JVM - Based Runtime

Akka

Play

Typesafe Console

① Download Activator, and unzip the file

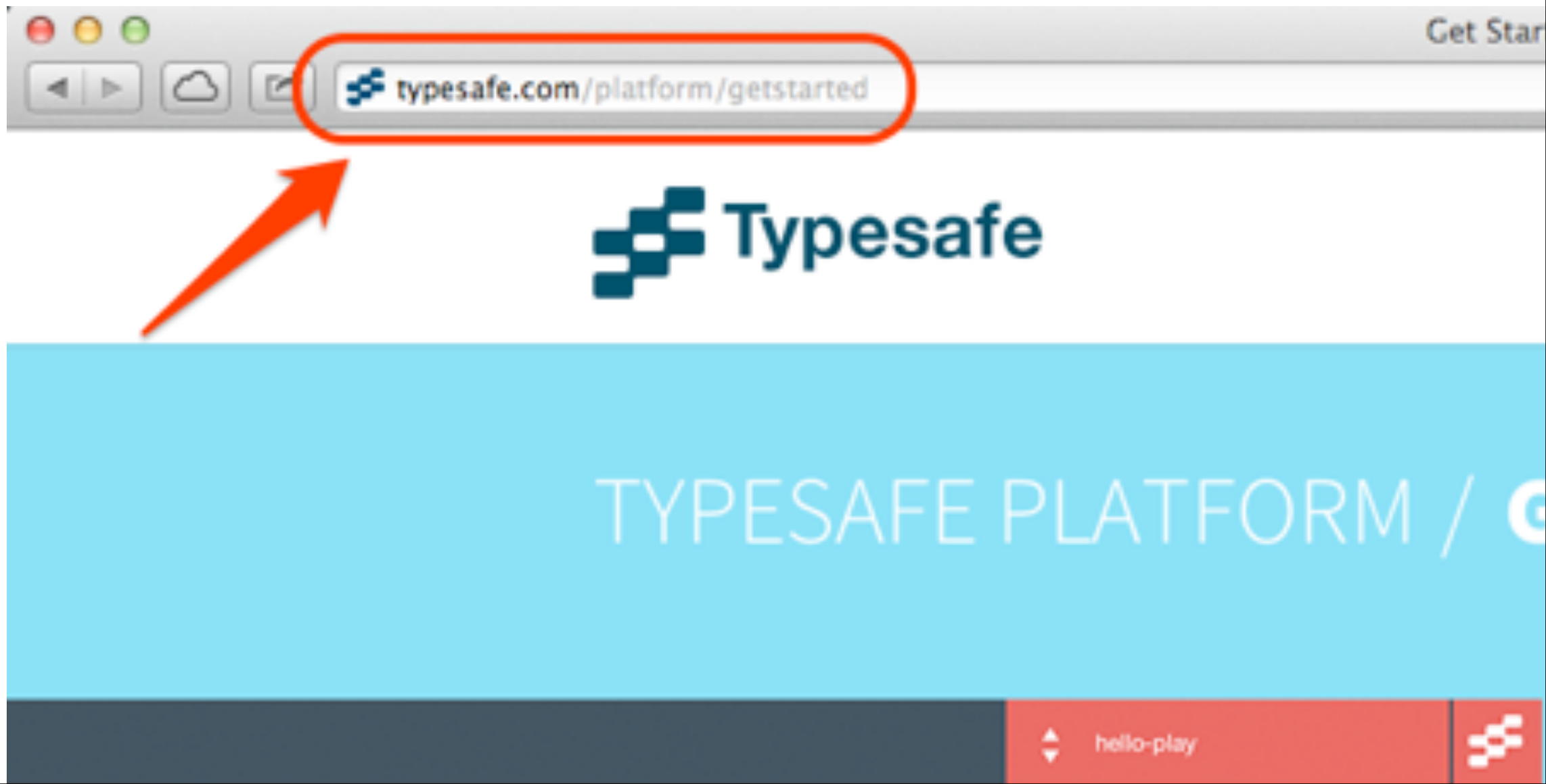
Download Developer Preview 0.1.1 (203MB).

Extract the downloaded zip file to your system.

② Start Activator's UI

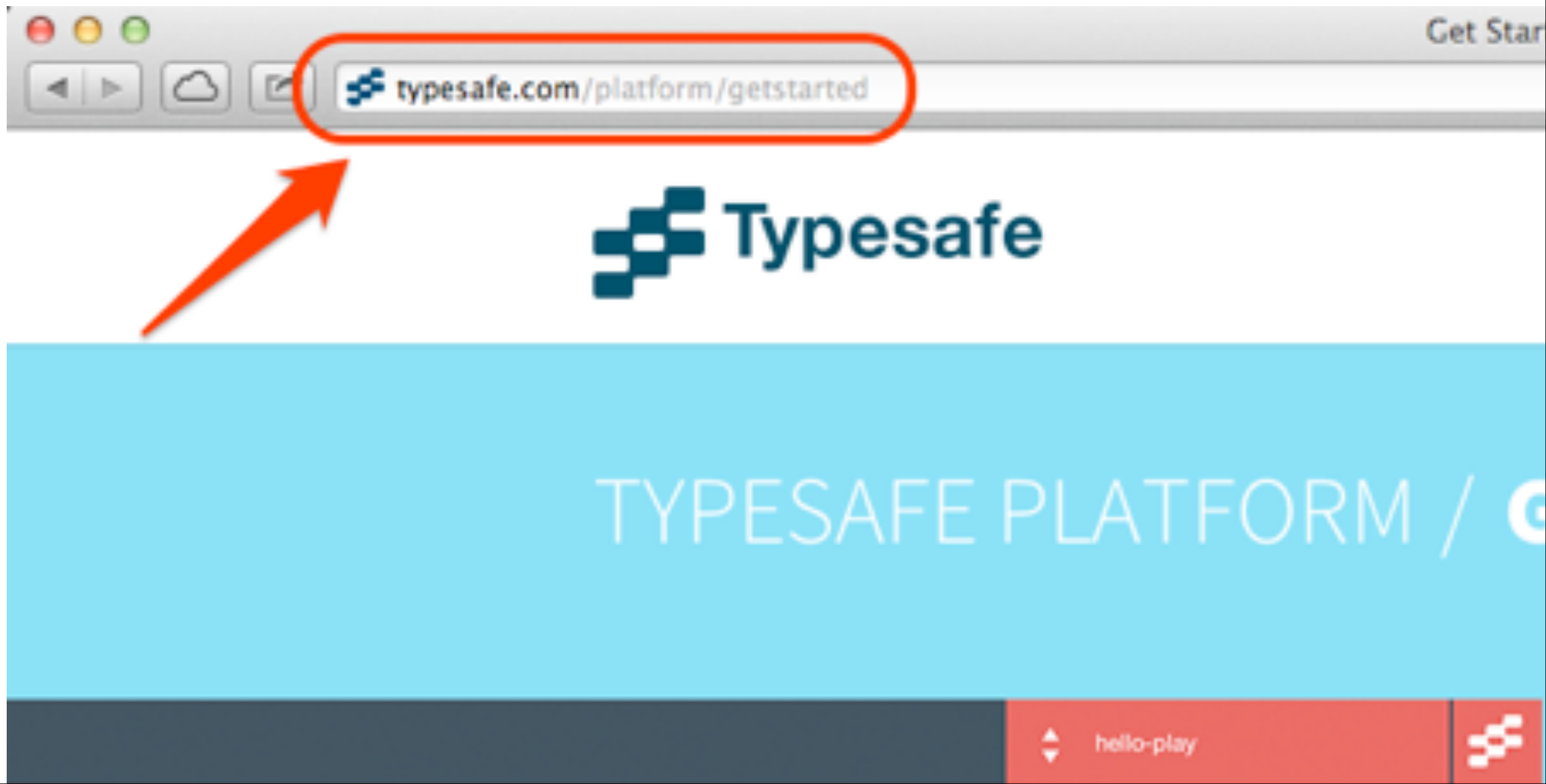
In Finder, navigate to the directory that Activator was extracted to, right-

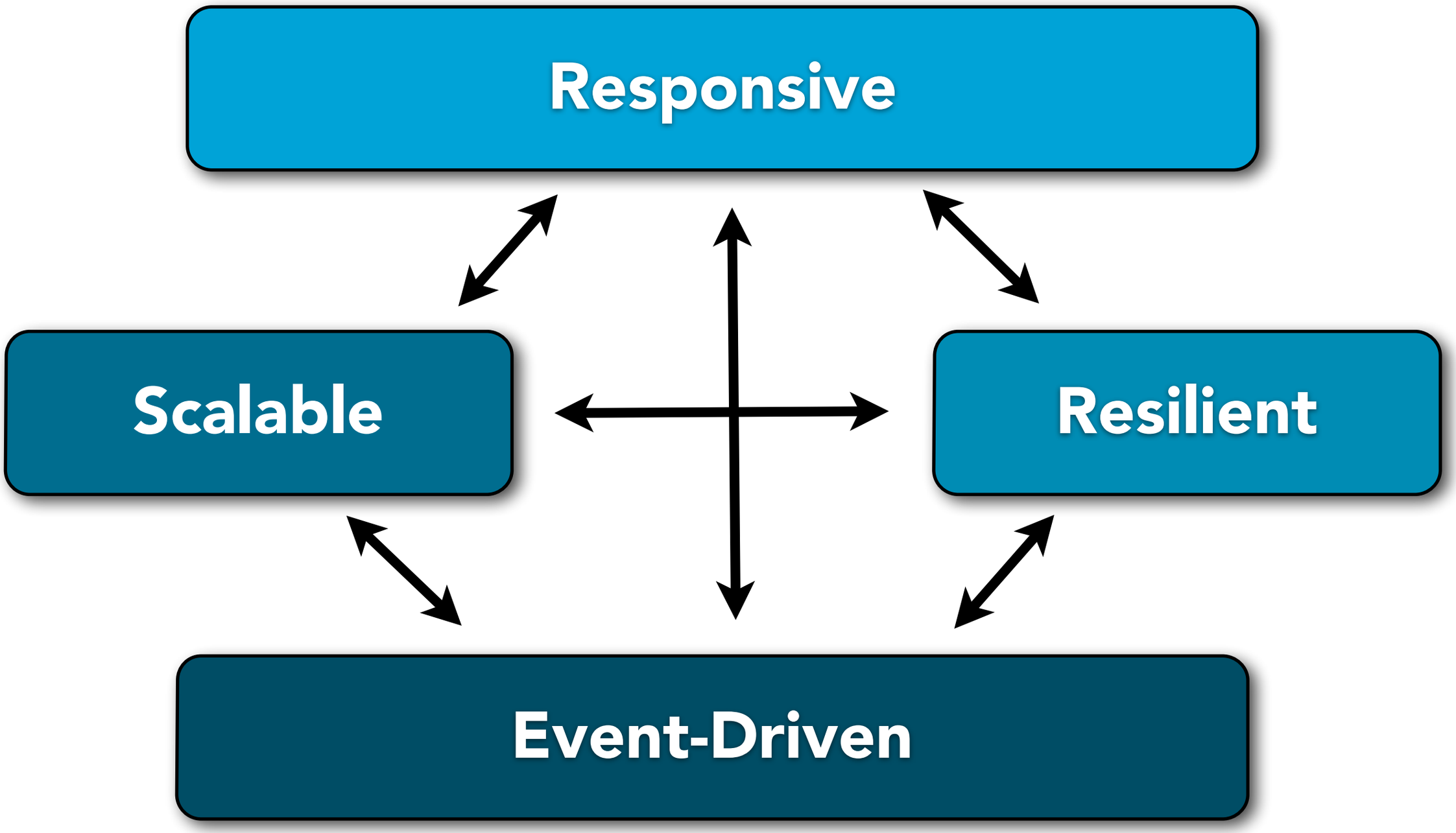
http://typesafe.com/platform/getstarted



Demo time

http://typesafe.com/platform/getstarted




Responsive
Scalable
Resilient
Event-Driven

http://reactivemanifesto.org

The Reactive Manifesto

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Suggest improvements

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Go Reactive

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