Software Transactional Memory and Microservices: A Match Made in Heaven

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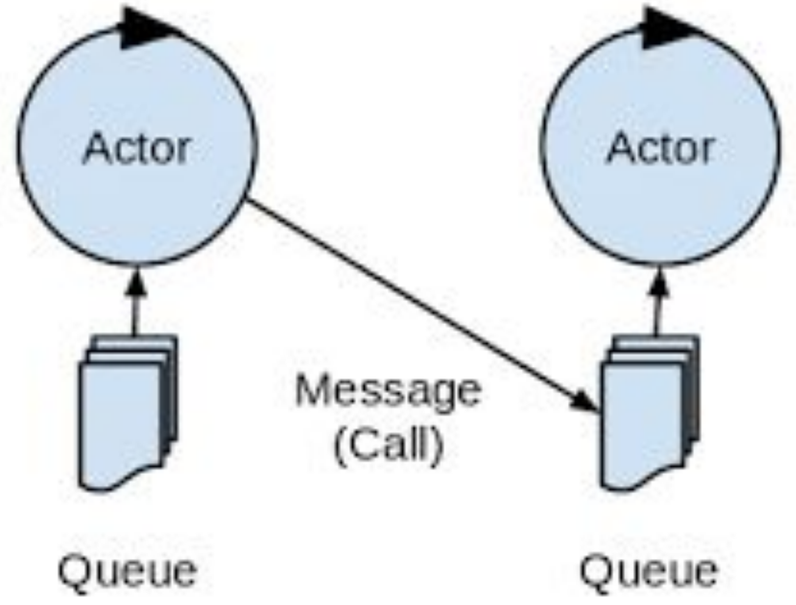
Agenda

- The Actor Model
- Distributed Transactions and Software Transactional Memory (STM)
- Microservices
- Why do these all belong together?
- Technology (Quarkus/Vert.x, Narayana STM, OpenShift)
- Coding demo

The Actor Based Programming Model

- Actors and CSP have been around for decades
  - CSP from Hoare, 1985
  - Actor model from Hewitt et al, 1973
- But popular ways to model primitives for concurrent computations
  - Embodies Processing, Storage and Communication
- Distributed computations communicate via message passing

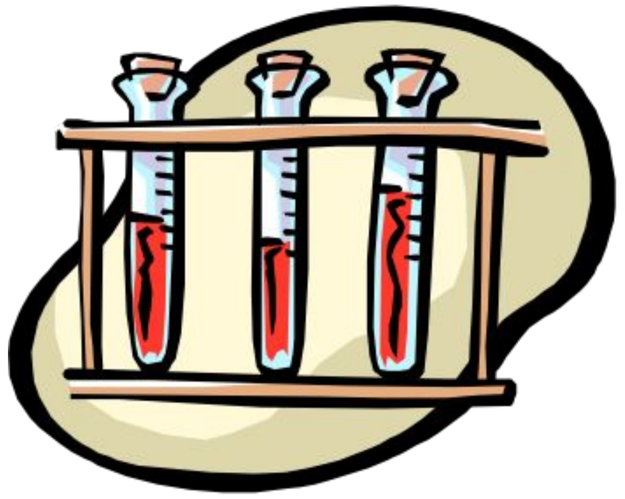


Nice Features of the Actor Model

- Fixed message sets (i.e., no hidden or unexpected interactions)
- Simplified data management (state is internal to the actor)
- Location transparency (because other actors only see the address)
- Loose coupling
- Asynchronous message passing

Transactions

- ACID properties
- Two-phase commit
  - Required when there is more than one resource (RM)
  - Managed by the transaction manager (TM)
  - Uses a familiar two-phase technique (2PC)



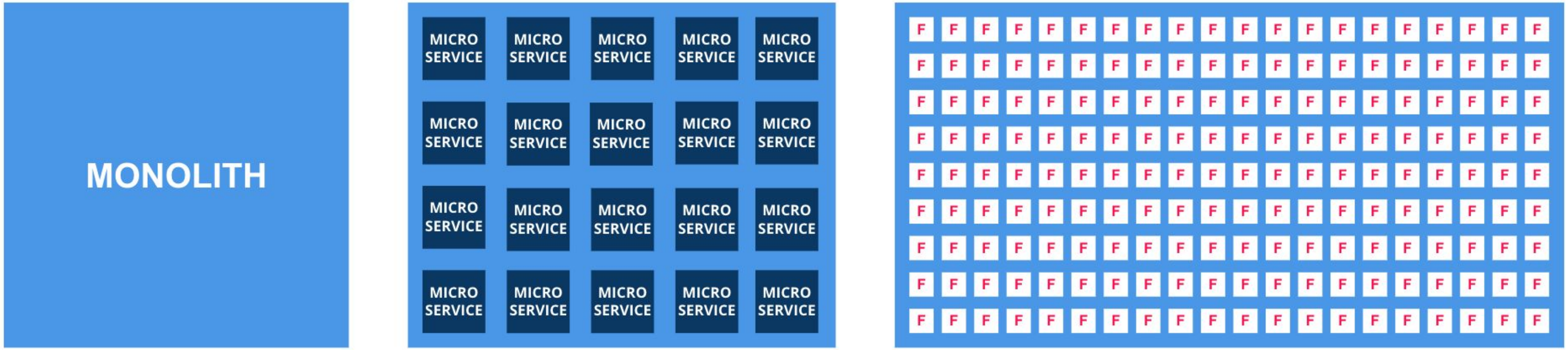
Software Transactional Memory

- Software Transactional Memory (STM) proposed in 1995
- STM is about ease of use and reliability
  - Access shared state, either for reading or writing, occurs within atomic blocks
  - All code inside an atomic block executes as if it were single threaded
  - Less error prone (the atomic block is the protection) than traditional concurrency primitives or placing composite operations behind an API
  - Some implementations can be lock free (optimistic vs pessimistic, timestamp)
  - Has some of the same characteristics of ACID transactions

Transactions and Actors

- An actor may go through multiple state transitions upon receipt of a message
- An actor could be internally implemented using multiple threads
- Computational failures may occur
- Hardware and software failures may occur
- Consistency of state important
- Composition of actors
- The combination of STM and Actors is fairly natural

Microservices 101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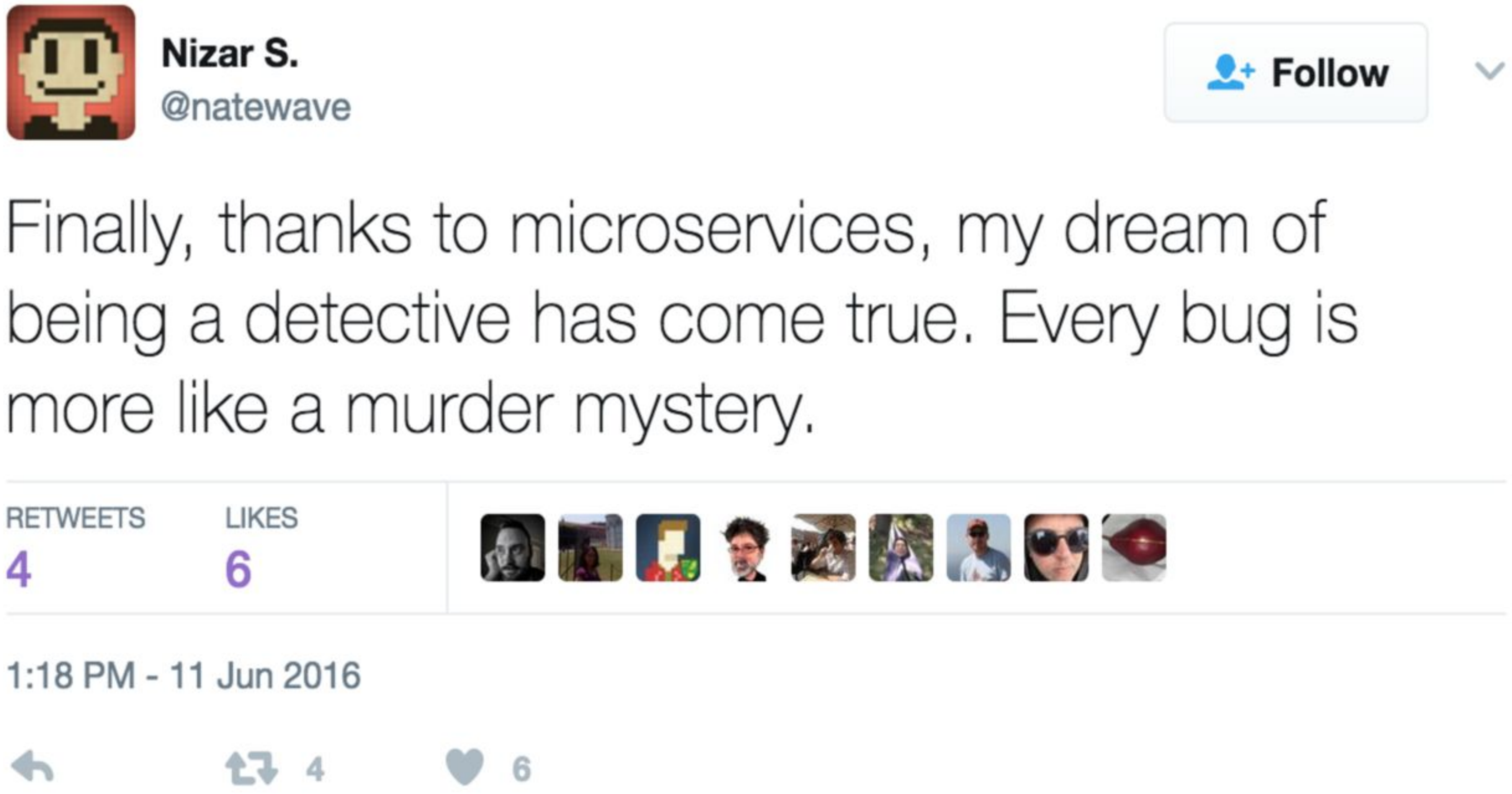


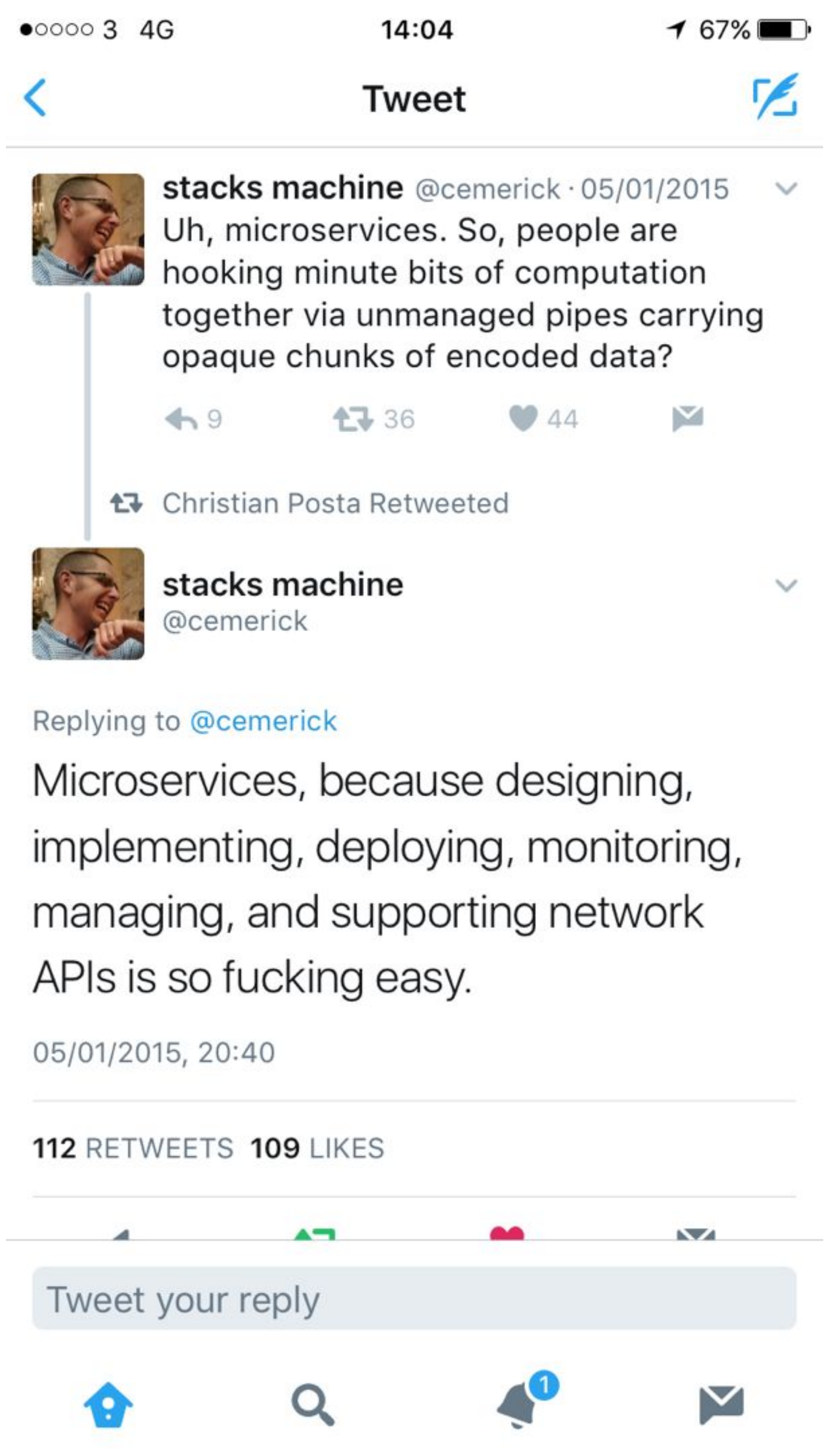
Nizar S.
@natewave

Finally, thanks to microservices, my dream of being a detective has come true. Every bug is more like a murder mystery.

RETWEETS 4 LIKES 6

1:18 PM - 11 Jun 2016

4 6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Tweet

stacks machine @cemerick · 05/01/2015

Uh, microservices. So, people are hooking minute bits of computation together via unmanaged pipes carrying opaque chunks of encoded data?

9 36 44

Christian Posta Retweeted

stacks machine
@cemerick

Replying to @cemerick

Microservices, because designing, implementing, deploying, monitoring, managing, and supporting network APIs is so fucking easy.

05/01/2015, 20:40

112 RETWEETS **109** LIKES

Tweet your reply

OK so WHAT are they then?!

- Microservices pushes us (back) to distributed systems (circa 1996)
  - Services inherently in separate machines (physical or virtual)
  - Communication between distributed systems slower than within same address space
  - Failures can happen independently
  - Cascading failures can happen
  - Consistency concerns become even more of a challenge
  - Throwing developers into distributed systems 101 is not a good way to be agile!

Enterprise microservices

- Microservices distributed systems present challenges
  - The need for transactions, reliable messaging etc. doesn’t go away
  - If anything it becomes more important to developers
  - Application containers breaking into pieces
  - Independently deployable (Linux container based) services
  - Available to different language clients using REST/HTTP

Notable Technology Used in the Demonstration

OPENSHIFT

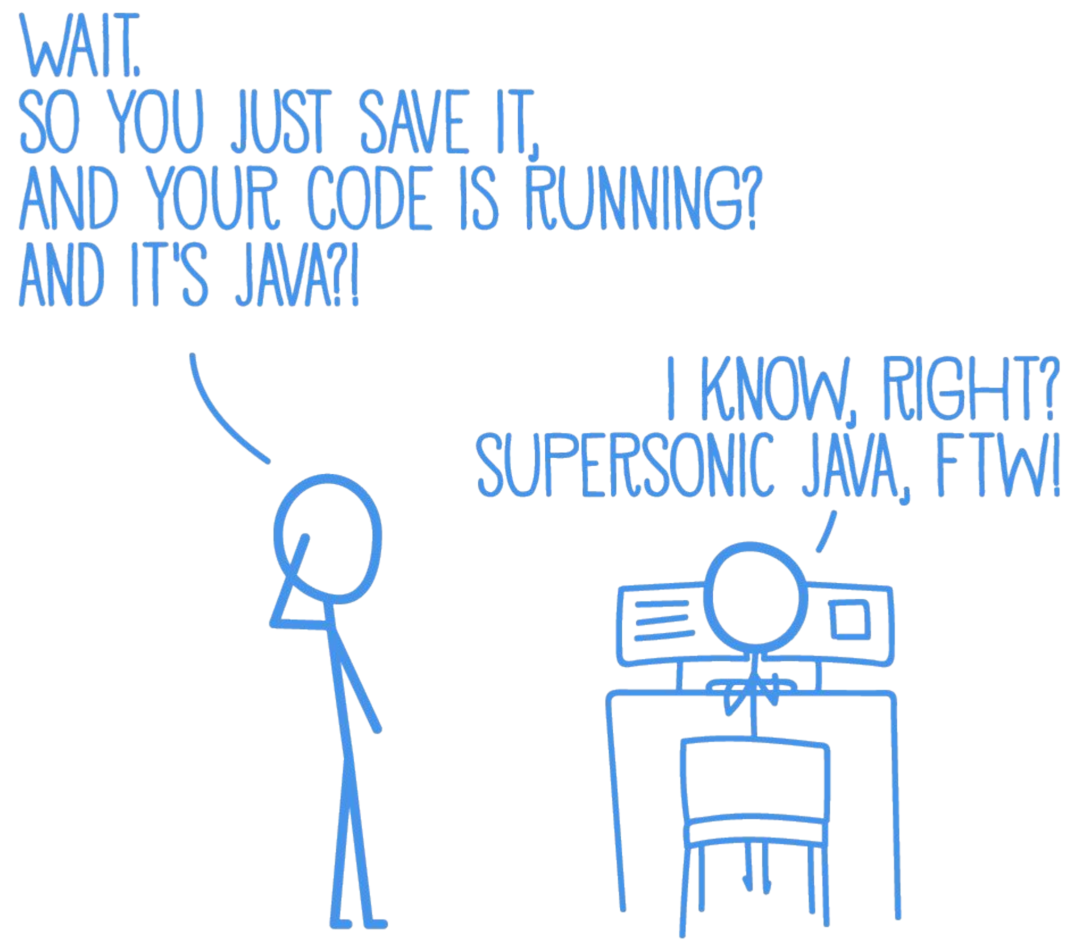
narayana

VERT.X

Quarkus

A cohesive platform for optimized developer joy:

- Based on standards, but not limited
- Unified configuration
- Zero config, live reload in the blink of an eye
- Streamlined code for the 80% common usages, flexible for the 20%
- No hassle native executable generation



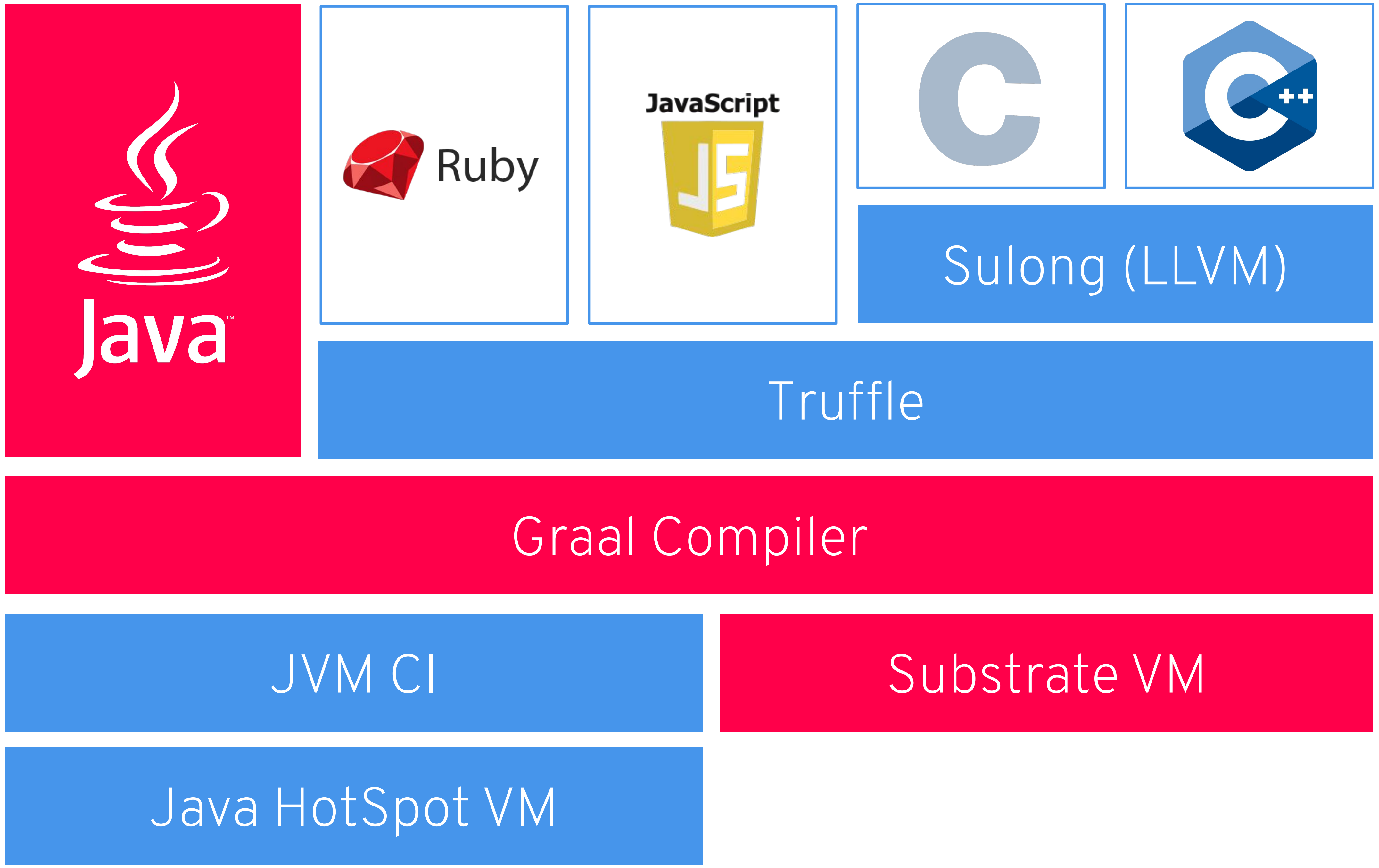
Boot time to compile time

What does a framework do at startup time?

- Parse config files
- Classpath & classes scanning
  - for annotations, getters or other metadata
- Build framework metamodel objects
- Prepare reflection and build proxies
- *Start and open IO, threads etc*

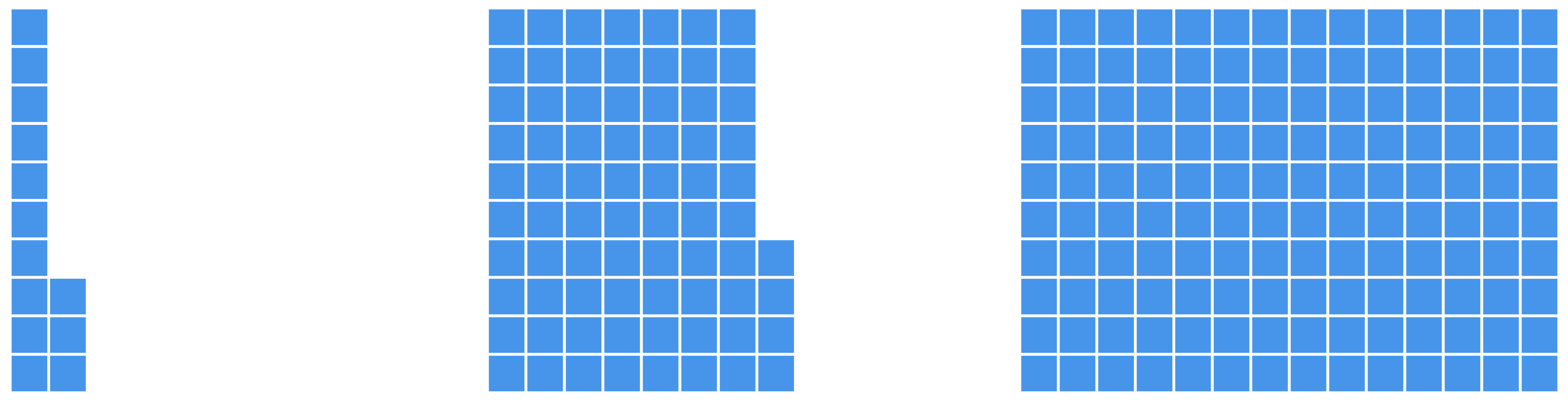
Framework Optimizations

- Moved as much as possible to build phase
- Minimized runtime dependencies
- Maximize dead code elimination
- Introduced clear metadata contracts
- Spectrum of optimization levels (all → some → no runtime reflection)


Java
Ruby
JavaScript
JS
C
C++
Sulong (LLVM)
Truffle
Graal Compiler
JVM CI
Substrate VM
Java HotSpot VM

Supersonic Subatomic Java

REST

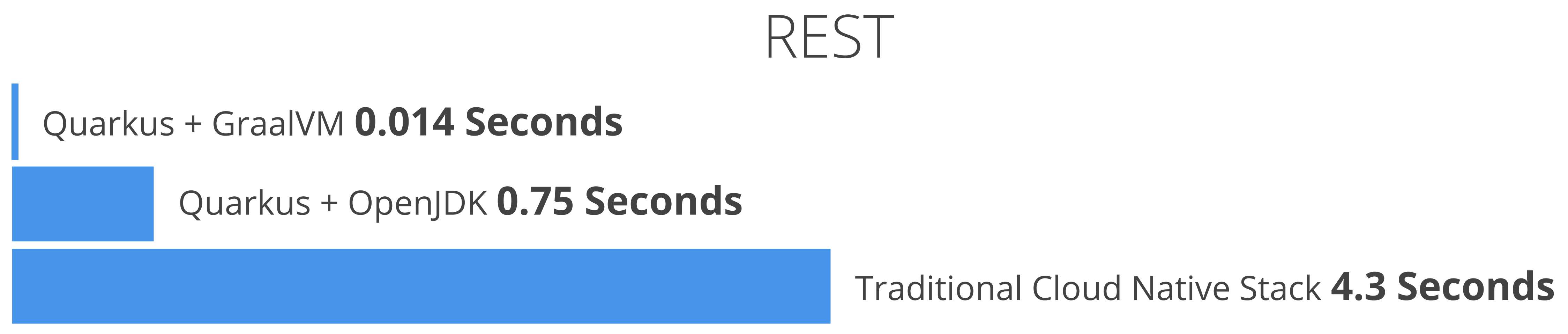


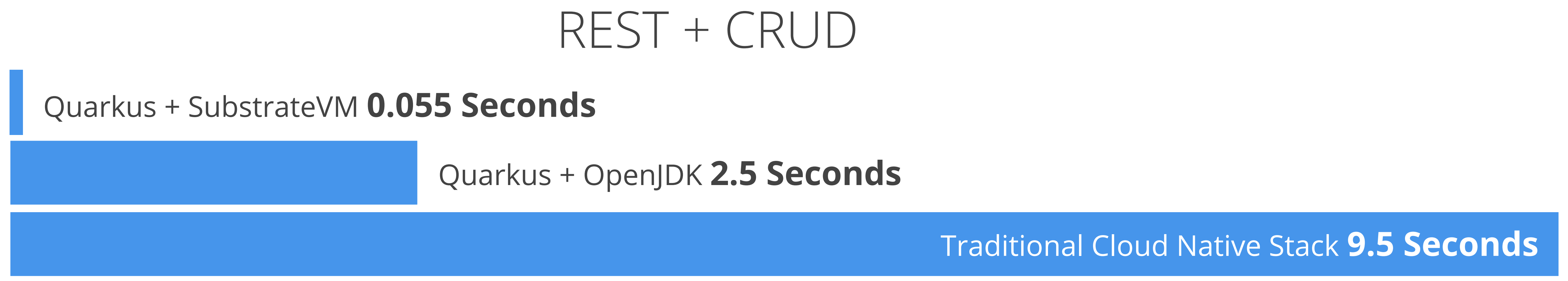
Quarkus + SubstrateVM
13 MB

Quarkus + OpenJDK Hotspot
74 MB

Traditional Cloud Native Stack
140 MB

Supersonic Subatomic Java





Time to first response

Eclipse Vert.x

- Non-blocking (asynchronous) and non locking (concurrency is natural)
- Event bus (reactor pattern)
- Load balancing, failover, circuit breaker
- Clustering and Service Discovery
- Polyglot JVM
- Infinispan/JDG and Spring Boot
- Added AMQ and Qpid Dispatch Router
- TCP, UDP, HTTP 1 & 2 servers and clients (non-blocking), gRPC

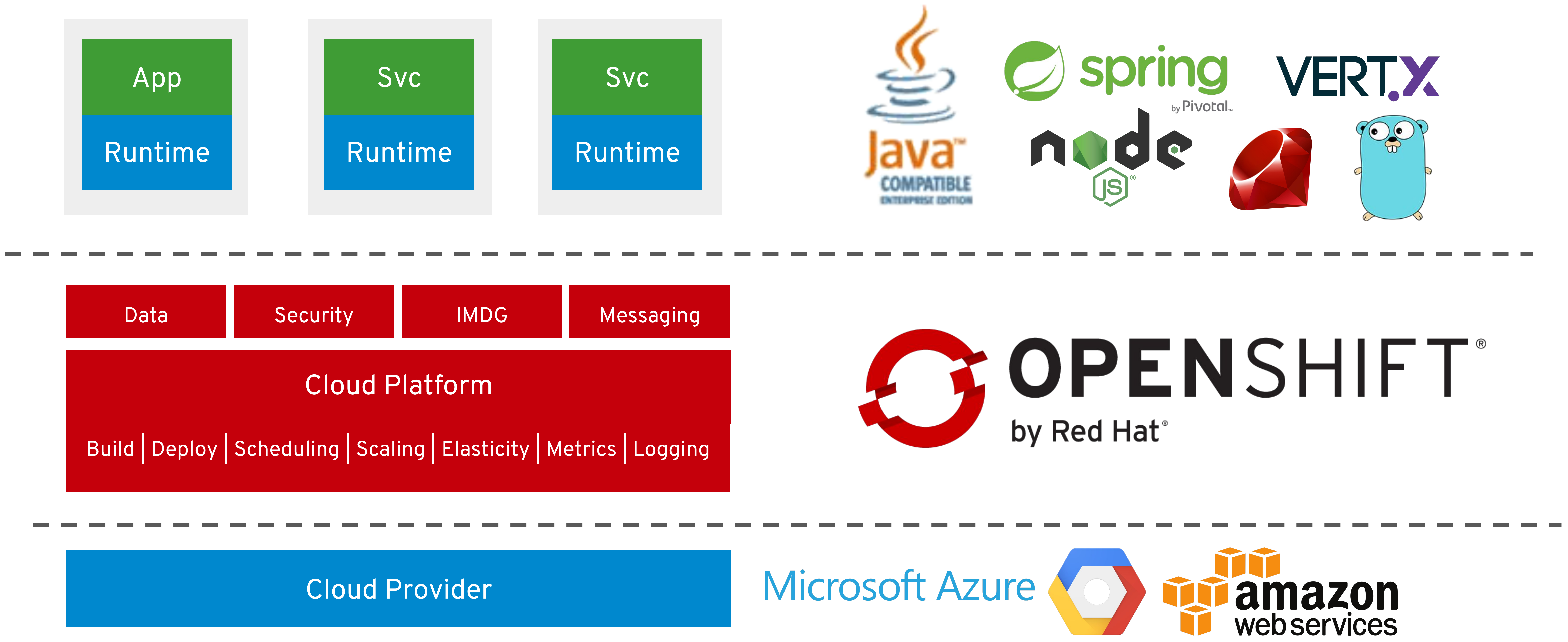
Narayana STM

- Provides an STM implementation
- Java annotation based (more on these in the coding demo)
- Define state (objects) which can be manipulated within transactions
    - Volatile (recoverable) and persistent (durable)
- Pessimistic and Optimistic models
- Different variants of transactions
    - Top level
    - Nested
    - Nested top level
- Modularity

STM Object Annotations

- @Transactional
  - Implementations of the interface then become container managed
- @Nested & @NestedTopLevel
  - The container will create a new transaction for each method
- @Optimistic & @Pessimistic (with @Timeout and @Retry options)
- @ReadLock & @WriteLock
- @State & @NotState
- @TransactionFree

OpenShift


App
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Data
Security
IMDG
Messaging
Cloud Platform
Build | Deploy | Scheduling | Scaling | Elasticity | Metrics | Logging
Cloud Provider
Java COMPATIBLE ENTERPRISE EDITION
spring by Pivotal
VERT.X
node JS
OPENSHIFT by Red Hat
Microsoft Azure
amazon web services

Code demonstration

An STM example running on Quarkus

Three versions of an application running on Quarkus:

1. A standard async JAX-RS app
   a. Reactive/async support via Vert.x
   b. No concurrency control
   c. Stress test to show concurrency issues
2. Same app using volatile STM for concurrency control
   a. Make the service interface a volatile STM object and re-stress
3. Deploy onto Openshift
   a. Turn it into a shared persistent STM object and deploy to OpenShift
   b. Create a shared persistent volume for the STM logs
   c. Test and then scale up and down via the OpenShift console to show persistency
4. Composing STM operations (time permitting)

STM Object Annotations

- **@Transactional** (mark interface as being transactional)
- Which state is shared
  - **@State**
  - **@NotState** (use with care to avoid dirty data leaking between txns)
- Managing conflicts
  - **@ReadLock**
  - **@WriteLock**, or
  - **@LockFree** (runs with a context but no locking)
  - **@Optimistic** & **@Pessimistic** (with **@Timeout** and **@Retry** options)
- **@TransactionFree** (runs without any context)
- Transaction Boundaries (an alternative to tx.begin(); …; tx.commit()) :
  - **@Nested** & **@NestedTopLevel** (create a new transaction for each method call)

Define the STM container and transaction boundary

```
// create a (volatile) transactional memory container
Container<FlightService> container = new Container<>();
// default is Container.TYPE.RECOVERABLE, Container.MODEL.EXCLUSIVE);

FlightService proxy = container.create(new FlightServiceImpl());

// define the transaction boundary (cf BMT versus CMT):
AtomicAction A = new AtomicAction();
A.begin();
proxy.bookFlight(“flight details”);
A.commit();
```

Or use an annotation: **@Nested** or **@NestedTopLevel**

Where can I find out more?

- More information available from https://narayana.io:
  - Forums
  - Blogs
  - IRC
- Demo source
  - https://github.com/mmusgrov/conferences/tree/codeone2019/codeone2019
- STM source
  - https://github.com/jbosstm/narayana/tree/master/STM

THANK YOU - any questions?

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