Transactional Actors using STM and Eclipse Vert.x

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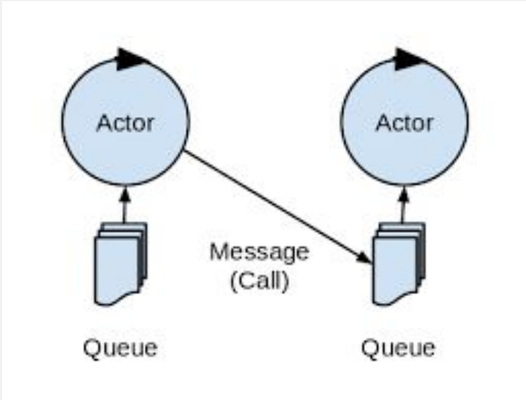
Agenda

- The Actor Model
- Distributed Transactions and Software Transactional Memory (STM)
- Live coding demo

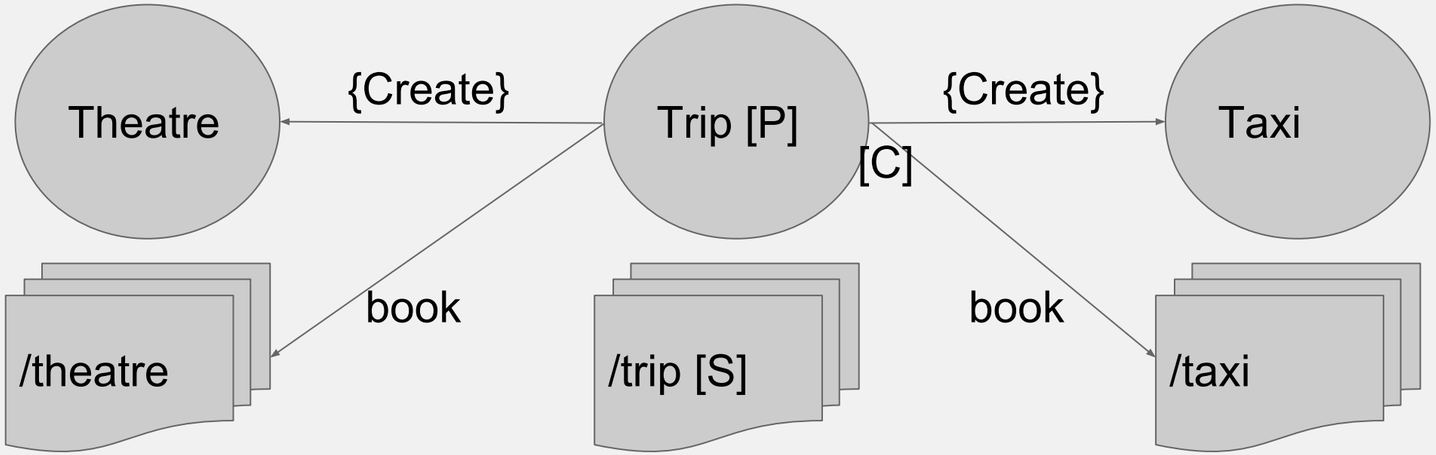
What this talk is NOT

- Not a survey of actors
- Not a survey of transactions
- Not a tutorial on Vert.x
- Not a tutorial on Narayana
- Not a tutorial on OpenShift

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 [P]rocessing, [S]torage and [C]ommunication
- Distributed computations communicate via message passing

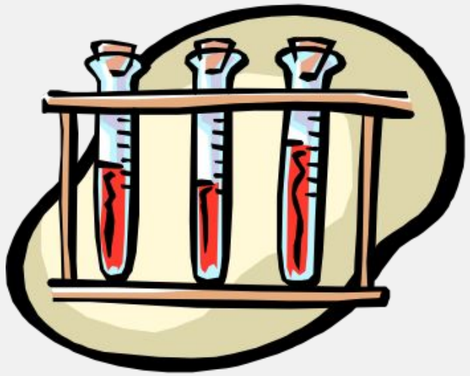


Nice Features of the Actor Model

- Fixed message sets (ie no hidden or unexpected interactions)
- Simplified data management (an actors state is internal to the actor)
- Location transparency (because other actors only see the address)
- Loose coupling
- Asynchronous message passing brings better scalabity and resource utilisation
- Simplicity of the model means that potentially millions of them can be created (cf threads)
- Has much in common with the reactive manifesto (Responsive, Elastic, Asynchronous and, with extensions, Resilience).

Distributed Transactions

- ACID properties
  - Atomicity
  - Consistency
  - Isolation
  - Durability
- 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)



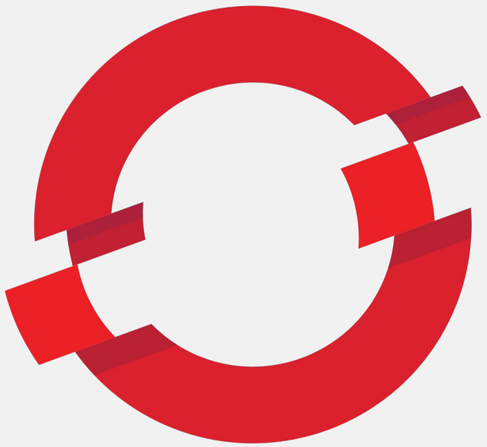
Software Transactional Memory

- Software Transactional Memory (STM) proposed in 1995
  - Still an active area of research
- an approach to developing transactional applications in a highly concurrent environment:
- 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
    - typically though, the Durability property is relaxed;

Transactions and Actors

- A stateful actor may go through multiple state transitions upon receipt of a message
- An actor could be internally implemented using multiple threads (as we show in the demo later)
- 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

Notable technology used in the demo



OPENSHIFT

VERT.X

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
- Adding transactions and STM
- Large user base and community of contributors

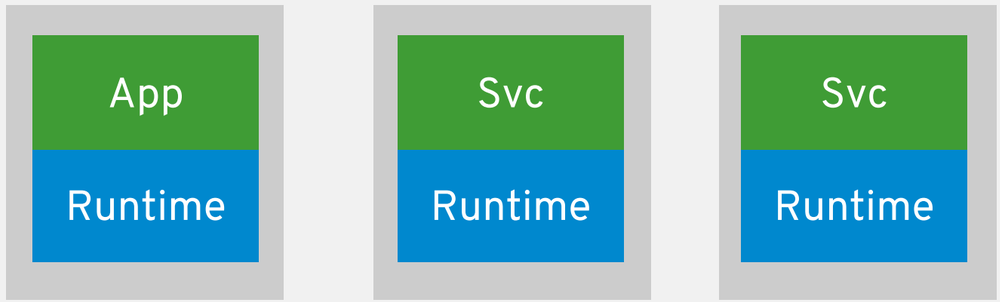
Narayana STM

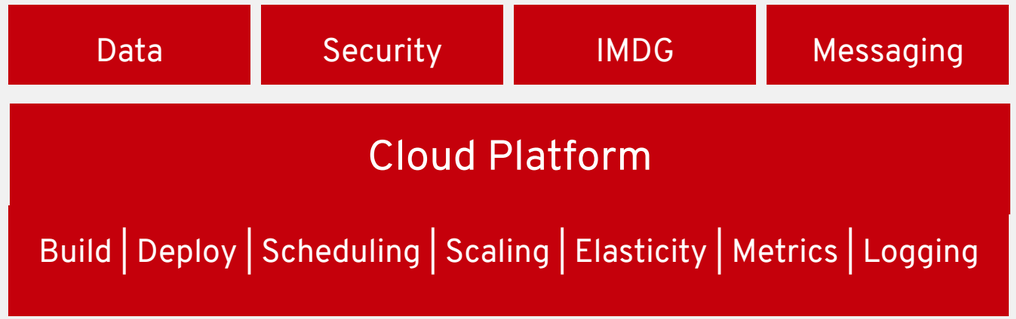
- Provides an STM implementation
- Define state (objects) which can be manipulated within transactions
  - Volatile (recoverable) and persistent (durable)
- Pessimistic and Optimistic models
- Different variants of transactions
  - Top level
  - Nested
  - Nested top level
- Modularity
  - Transaction context on threads
- Annotations

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





Live coding demo

An STM Example: Create a new Vert.x Project

- Use the vertx plugin to create a new maven project

```
mvn io.fabric8:vertx-maven-plugin:1.0.7:setup -DvertxVersion=3.4.2 -Ddependencies=web
Enter the GAV coordinates + verticle class name
```

- Fill in the verticle's start method
- Start the verticle: mvn compile vertx:run
- Test it: curl -X POST http://localhost:8080/api
- Add a service interface and implementation and main to deploy the verticle
- Stress test the service
- Make the service interface a volatile STM object and restress
- Turn it into a shared persistent STM object and deploy to OpenShift
- Test and then scale up and down via the OpenShift console to show persistency

Running on OpenShift

> minishift start --vm-driver=virtualbox # or whatever hypervisor you are using

> minishift console # opens the OpenShift web console

> oc login -u developer -p developer

> oc new-project stmdemo

Create a PVC via the OpenShift console ("stm-vertx-demo-flight-logs", RWX access)

> mvn fabric8:deploy -Popenshift -f flight/pom.xml # use S2I to build and deploy the image

> oc get routes # to find the host/port

> curl -X POST http://stm-vertx-demo-flight-stmdemo.192.168.99.100.nip.io/api/flight/BA123

> scale up and notice the hostId field change. Scale to zero and back up to show persistence

Composing STM objects

```
ServiceResult bookTrip(String serviceName, TheatreService theatreService, TaxiService ...) throws Exception {
  AtomicAction A = new AtomicAction();
  A.begin();
  try {
    boolean commitTrip = theatreService.bookShow(showName); // book the theatre seats inside a top level transaction
     AtomicAction B = new AtomicAction();
     B.begin();       // book the transport inside a nested transaction since we want to keep the theatre booking
     if (!taxiService.bookTaxi(taxiName)) {
        B.abort(); // the taxi booking  failed so unwind any transaction state changes made by the bookTaxi call
        if (trainName == null || !trainService.bookTrain(trainName))  // if train is set then attempt to book it in the context of the outer transaction A:
           commitTrip = false; // cannot get any transport so abort everything
     } else {
        B.commit();
     }
     if (commitTrip)  A.commit();  else  A.abort(); // since the taxi or train booking was nested they too will be aborted (even though they committed)
      ...
```

Where can I find out more?

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

THANK YOU
- any questions?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