Designing for Scalability

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bea Think liquid.™

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Agenda

- **Define and discuss scalability**
  - **Vertical**
  - **Horizontal**
- **Examine ways to make software scale**
  - **Code / Algorithms**
  - **Asynchronous Libraries**
  - **Other Languages**

Scalability

- **Ability to increase the total number of operations performed in a unit of time**
- **Vertical Scalability:**
  - **"Make the machine bigger"**
- **Horizontal Scalability**
  - **"Add more machines"**

Bottlenecks

- **Limit the scalability of a system**
- **Intrinsic bottlenecks**
- **Artificial bottlenecks**

Example Problem Domain

- **Financial fund management**
- **Multiple in-house engineering needs**
  - **Trade Execution**
  - **Trade Settlement**
  - **Strategy Definition**
  - **Strategy Simulation**
  - **Portfolio Risk Analysis**

Vertical Scalability

Translated into Java:

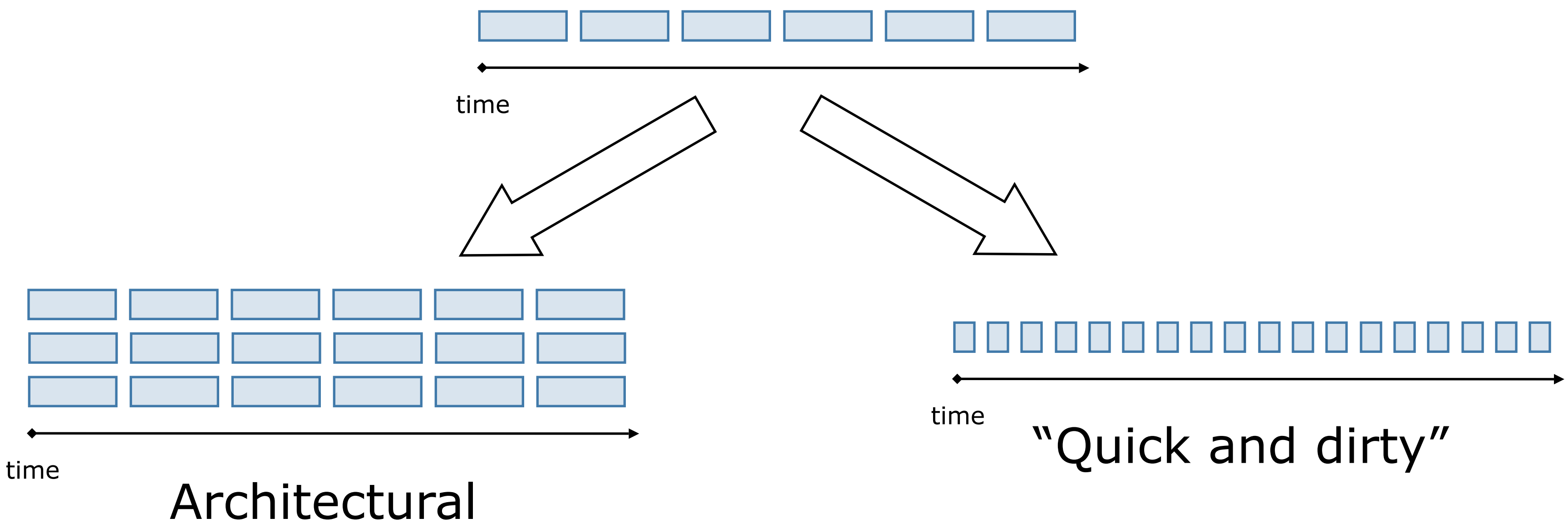
Scaling Within a Machine

Vertical Scale Factors In Your Control

- **Improve code efficiency**
  - **Memory**
  - **CPU**
- **Optimize I/O between physical tiers**
  - **Web 2.0: beware!**
- **Make code scale across multiple cores / CPUs**

Code Optimization Possibilities

- **Performance and scalability are linked**
- **Scalability: more operations per time unit**



“Scale” Vertically via Code Optimization

- Reduce copying, looping, etc.
  - “Write good code”
- SQL statement batching
  - `PreparedStatement.addBatch()`
  - ORM frameworks
- Transaction batching
  - Especially powerful in XA environments
  - JMS message batching

Write-Once Shared Memory

```
class SlowTradeManager {
  private Set types;
  public synchronized Set
    getTradeTypes() {
    if (types == null)
      types = loadTypeData();
    return types;
  }
}
```

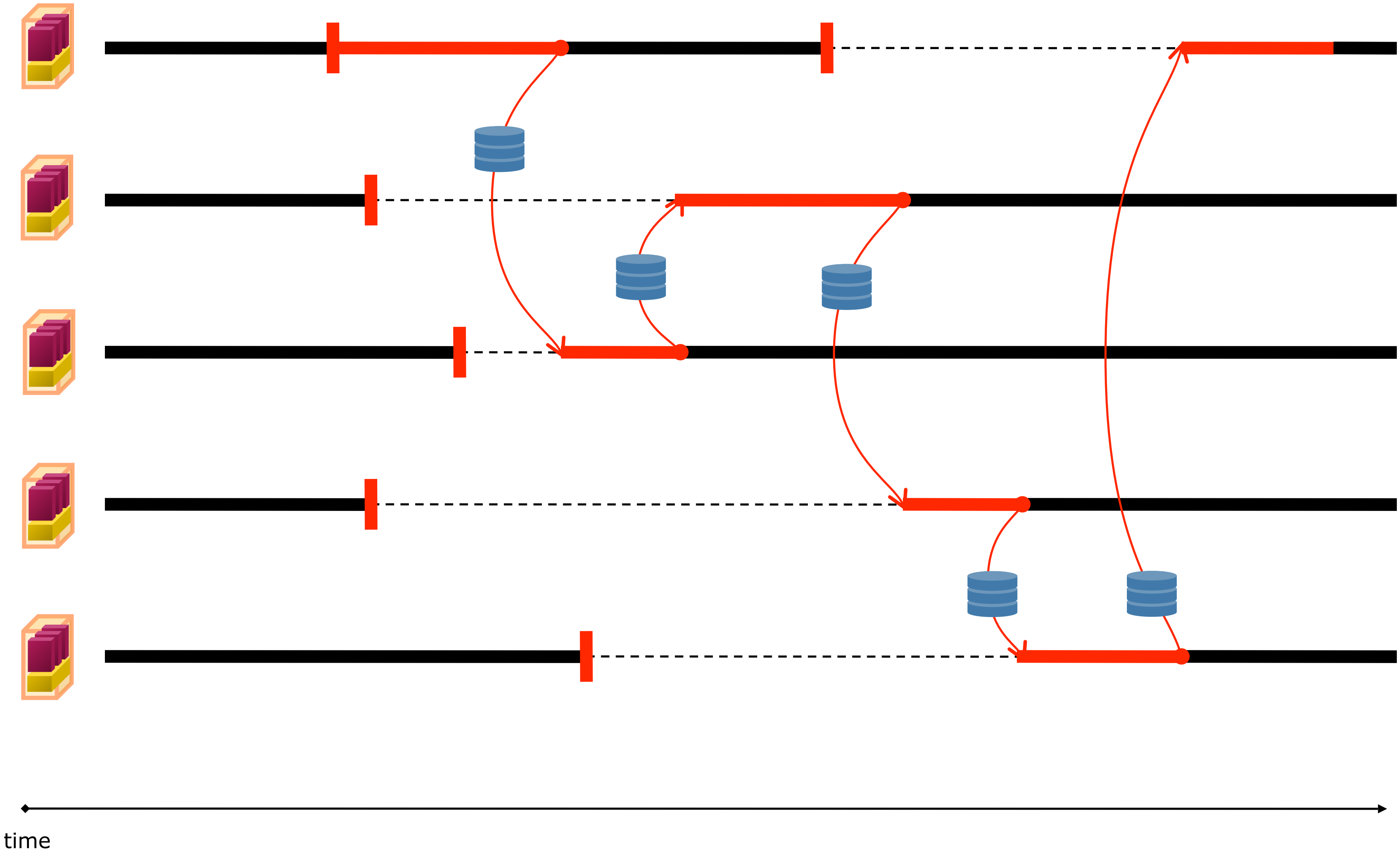
```
class FastTradeManager {
  private Set types;
  public Set getTradeTypes() {
    if (types == null)
      types = loadTypeData();
    return types;
  }
}
```

loadTypeData() might be called more than once

Fund Risk Balancing

- **Problem**
  - **Multiple traders act on the same security**
- **Solution**
  - **Maintain fund-global position data**
  - **Mutable shared state!**

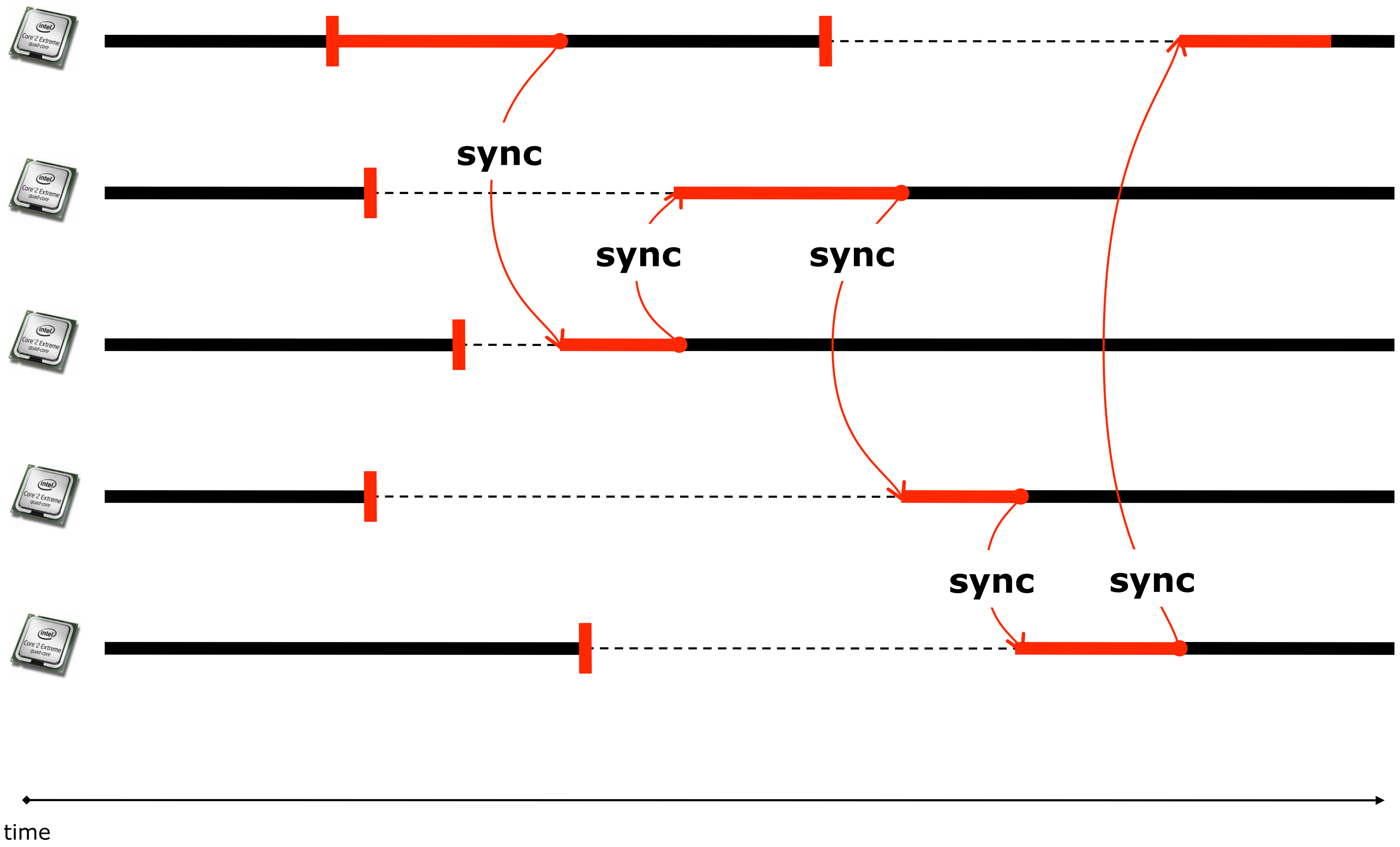
Multi-machine solution (circa 1998)



Synchronization

- `synchronized` **is for *asynchronous execution***
  - **“Execute this block of code in its entirety before others that share this lock”**
- **Modern computers handle high* concurrency**
  - `synchronized` **is often a bottleneck**
  - **Avoid synchronization at runtime *at all costs***
    - **uncontended synchronization is cheap**

Multi-core / CPU synchronization

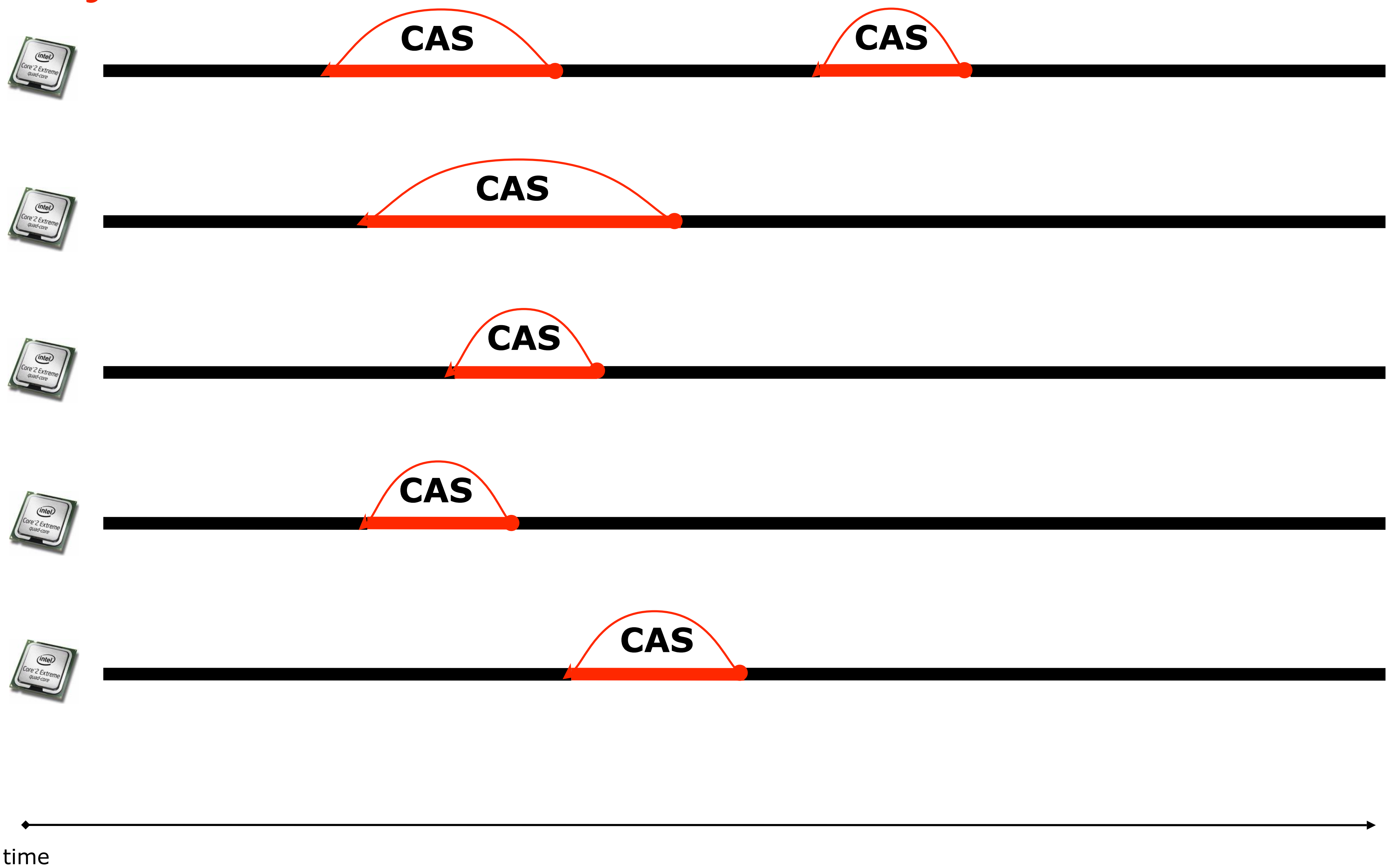


Mutable Shared Memory

```
import java.util.concurrent.atomic.AtomicDouble;

class AggregateFundPosition {
    private AtomicDouble totalExposure = new AtomicDouble(0);
    public double incrementBy(double amount) {
        while (true) {
            double old = totalExposure.get();
            double next = old + amount;
            if (counter.compareAndSet(old, next))
                return next;
        }
    }
}
```

Synchronization-free shared state



Horizontal Scalability

Translated into Java:

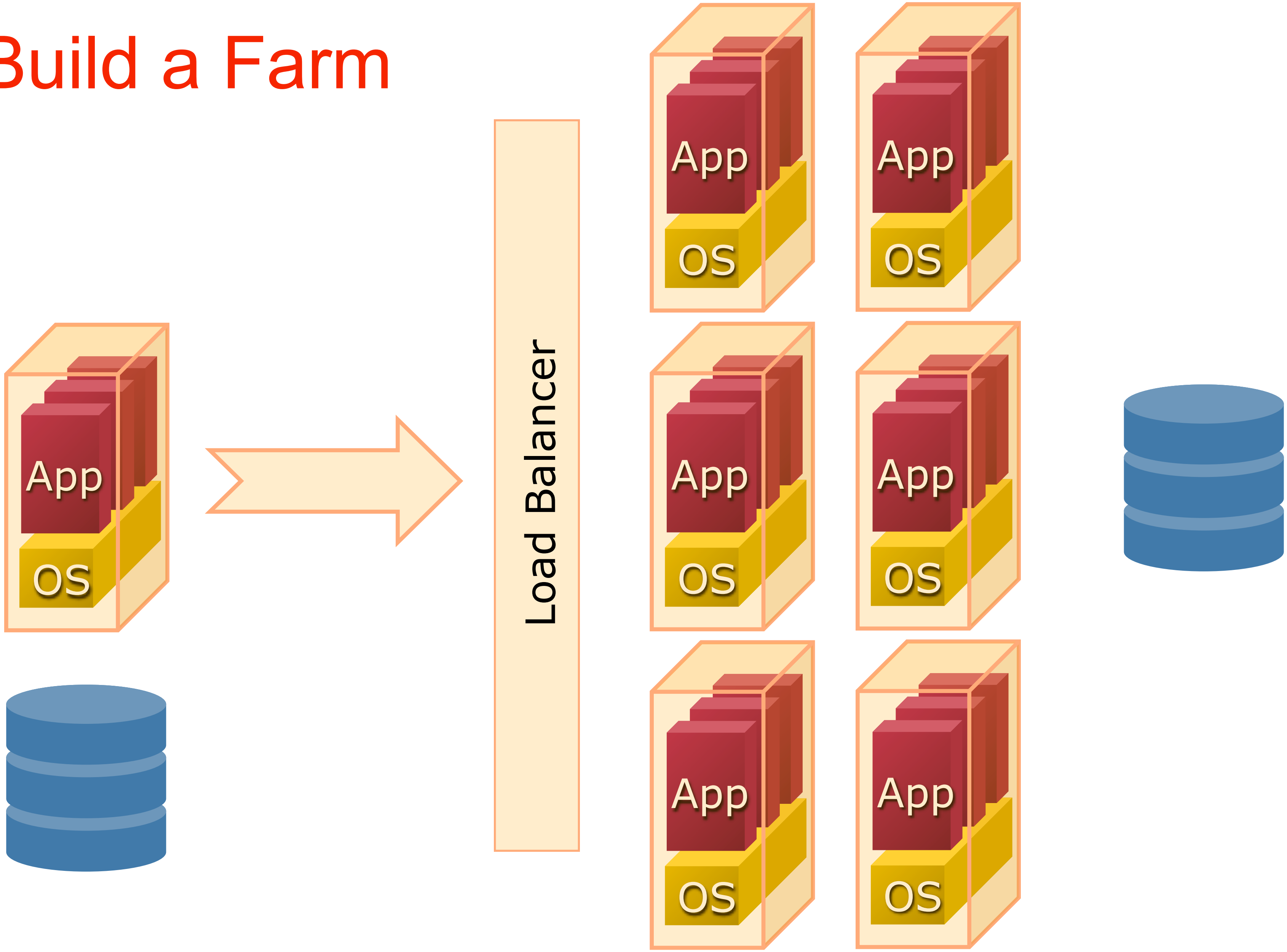
Scaling Across Machines

Think liquid.

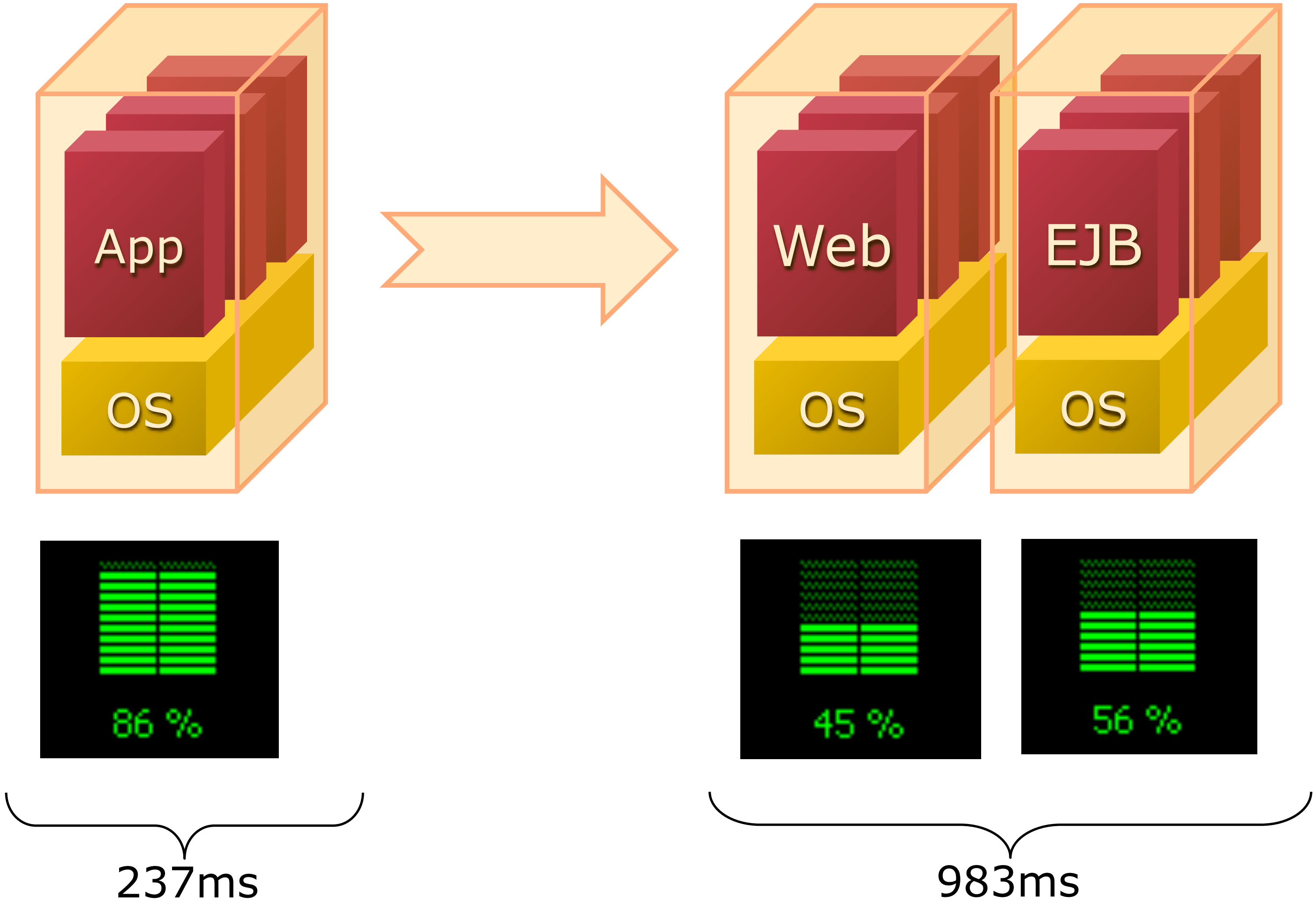
Horizontal Scaling: Add More Servers

- **All doing the same thing**
- **Partitioned by infrastructure layer**
- **Partitioned by application role**
- **Partitioned along data graph boundaries**

Build a Farm



Slow Down

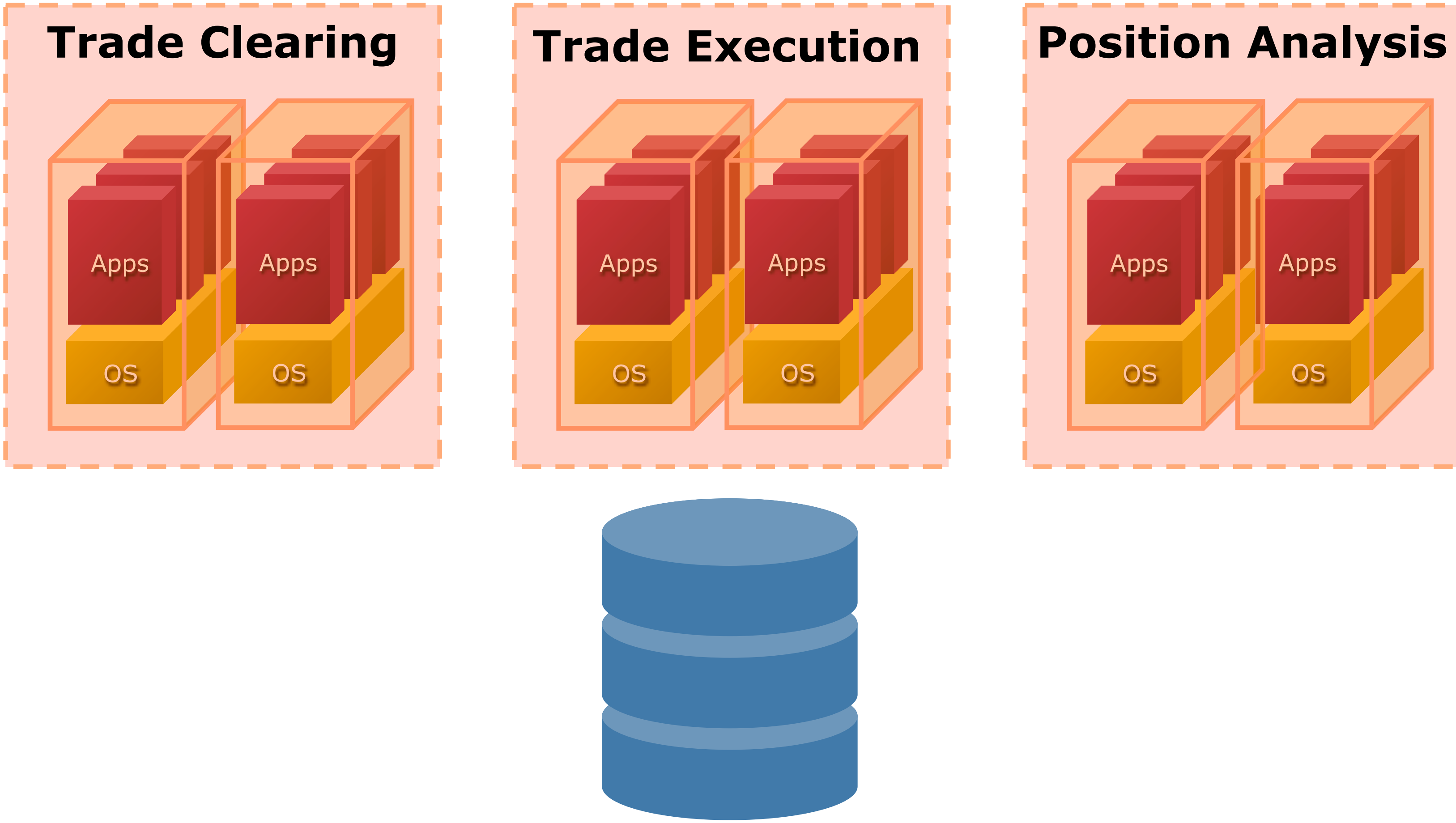


Divide and Conquer

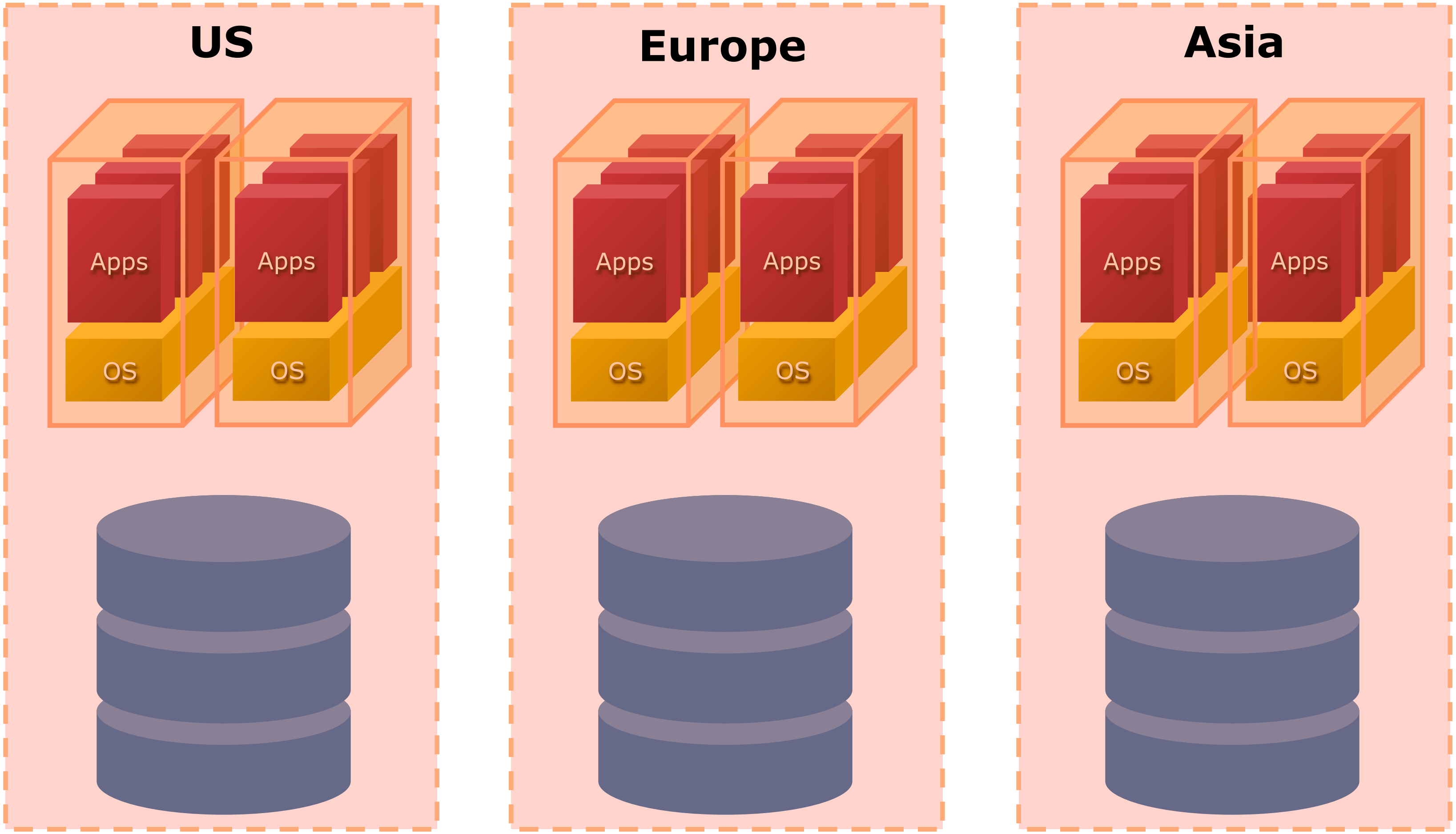
- **Old as `time` itself**
  - **mail, news, telnet all on different servers**
- **You use partitioning every day**
  - **Telephone call routing**
  - **ATM card transactions**
  - **Stock markets**
  - **Elevator banks**

Break Up Stateful Services

Partition Along Application Boundaries



Partition along data set “fault lines”

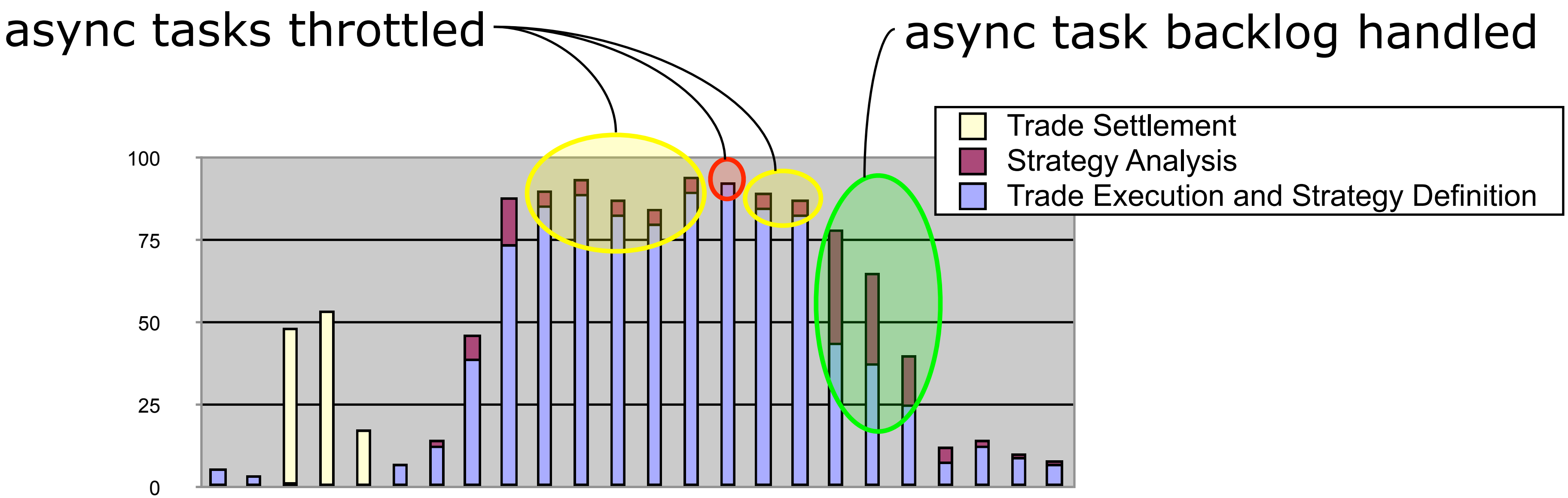


Asynchrony in Java

- **Java is a mostly synchronous environment**
- **Business algorithms often aren't**
- **Take advantage of this where possible**
  - **JMS message queues**
  - **java.util.concurrent.ExecutorService**
  - **commonj.work.WorkManager**
  - **Scheduled jobs**

Async Tasks and Resource Utilization

- **Good JMS servers / ExecutorServices / WorkManagers do resource tuning and optimization**
  - **Limit threads allocated to async processing**
  - **Configure priority of async vs. sync (i.e., HTTP request)**



Adapt Requirements to Concurrency

- Identify slow-running / expensive parts of the user experience
- Work with requirements team to replace these with asynchronous processes
  - Website usage statistics generated nightly instead of on-demand
  - Dynamic PDF delivery via email instead of embedded web content

Starting from Scratch

Choose Your Toolset

- **Java makes synchronization easy**
  - **... but synchronization != scalability**
- **Other languages avoid shared state**
  - **Rely on message-passing instead**

Erlang: Functional, Asynchronous, Mature

- **Designed for concurrency *in the language***
  - **Parallel execution**
  - **Intrinsic hot-redeploy**
  - **State can only be assigned once**
- **Communication happens via message-passing between actors**
  - **No threads ➞ no shared state!**
  - **JMS-like behavior; language-native syntax**

Scala: Functional Programming for the JVM

- **Java-integrated**
  - **Designed by Java stalwart Martin Odersky**
- **JVM-optimized**
- **Supports Erlang-style concurrency**

Compute Grids

- **Federate your data around a cluster**
- **Decompose your algorithm into serializable work items**
- **Let the compute grid send your work items to the data**

Decision Factors

- **What are your application requirements?**
  - **How many concurrent operations?**
  - **How big of a workload?**
  - **What sorts of SLAs?**
- **Tolerance of deployment complexity?**
  - **How about your operations, QA teams?**

Recap

- Concepts
  - Scalability
  - Bottlenecks
  - Synchronization
  - Asynchrony vs. concurrency
  - Compare-and-set
  - Application Partitioning
  - Synchronous tasks vs. asynchronous tasks
- Technology
  - java.util.concurrent
  - j.u.concurrent.atomic
  - Operation batching
    - Transactions
    - SQL
  - JMS; Executor; WorkManager
  - Scala and Erlang
  - Hibernate Shards
  - OpenJPA Slice

Questions

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