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Caching, NOSQL & Grids
What the banks can teach us

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John Davies

- An ageing "Über-geek"
  - Hardware, Assembler, C, Objective-C, C++, OCCAM, SmallTalk, Java
  - Worked mostly in trading systems, FX & Derivatives
  - Head of trading systems at Paribas, head of architecture at BNP Paribas, global head of architecture at JP Morgan
  - Author of Learning Trees Enterprise Java courses & co-author of several Java & architecture books
- Co-founder of C24 Solution in 2000
  - Sold to Nasdaq's Iona Technologies in 2007, Iona sold to Progress Software in 2008, Technical Director of both companies
- Co-founded Incept5 in 2008, re-acquired C24 from Progress in April 2011
  - CTO of both Incept5 & C24
  - Original technical architect behind Visa's V.me (pre-public release)

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What we're going to look at today...

- SQL or NoSQL - Good or Bad?
  - If Java better than SQL?
  - What can't SQL do?
- The need to scale
  - Too much data to store on spinning disks of iron
  - Too many calculations
- Virtualisation
  - Distributed computing, grids, private and public cloud
- Look at a few grid technologies

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SQL is just a language

- SQL is a language that allows you to manipulate relational databases - RDBs
- If the data you're storing is relational then SQL is a pretty good fit
- If fact, for dealing with lists (as tables) it's a great language, dynamic and relatively fast
  - Sure it has a few problems but give me a language that doesn't

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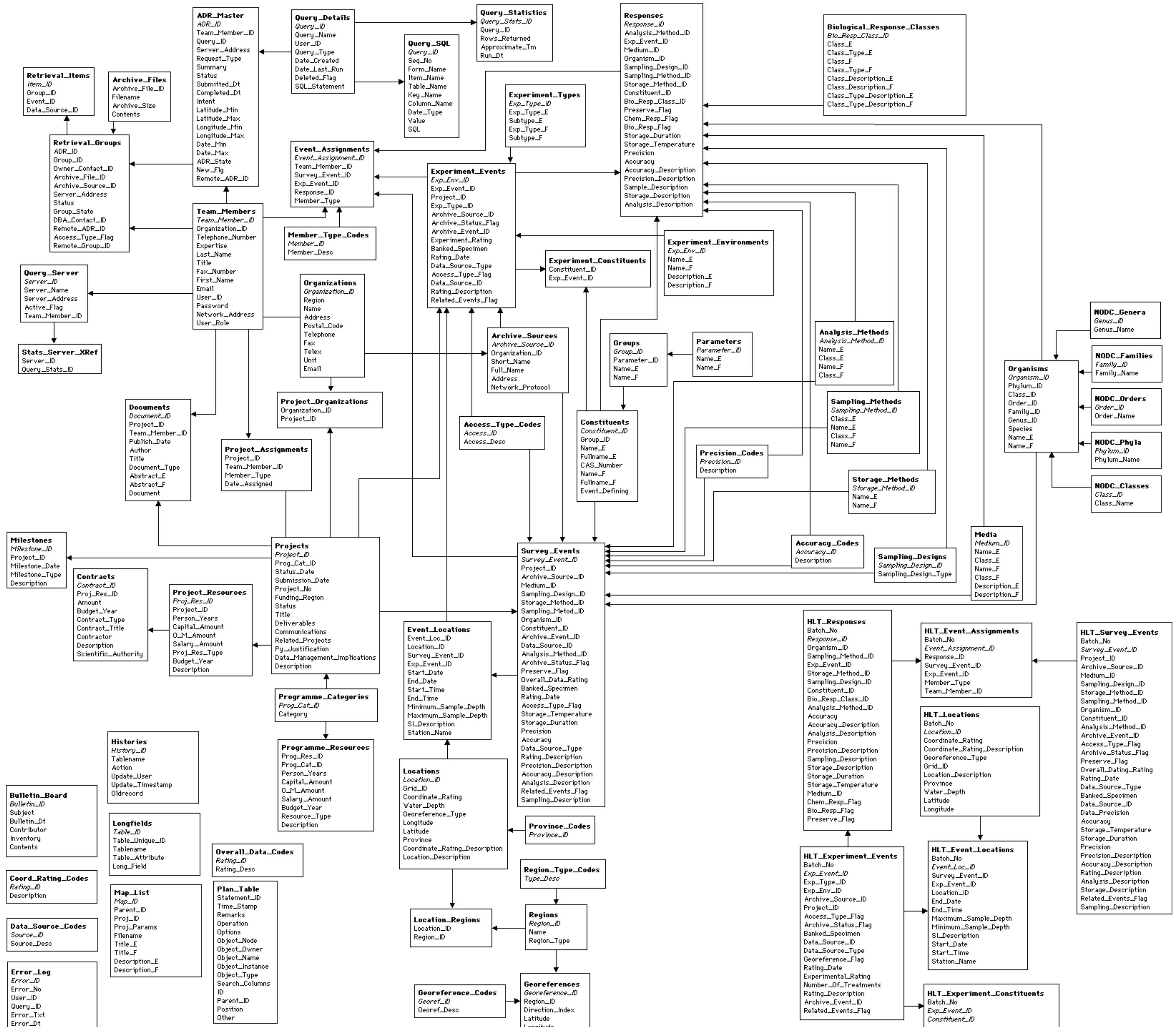
How complex can it be?



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NoSQL - No What?

- Did we really need a name for it?
  - We'd worked for years without needing a name for it

- Later No SQL became Not Only SQL
  - The vendors chickened out :-)
  - NoSQL vendors support NoSQL because they can't support SQL

- NOJ - No Java
- NOSS - No Shell Scripts
- NOW! - No Windows!

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SQL works

- SQL might be the wrong language for hierarchical data but it's superb for tables
- Imagine the telephone directory - in a single table
  - Tell me how many "Davies's"
  - select count(*) from directory where surname="Davies"
- Now in XPath (for example)
  - count(/directory[surname='Davies'])

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SQL is useful - when things are flat

- Easy, so now I'd like to see the 10 most popular names and order them by popularity...
  - Select surname,count(*) from directory group by surname order by count(*) desc limit 10

- If you had the list as a CSV then you could do the same with a little shell magic - assuming you're on a decent OS of course
  - cut -d "," -f 1 | sort | uniq -c | sort -r | head -10

- Both will execute, even on a million rows in around a second

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Java instead of SQL?

- A few years back we needed a cache for 1TB of data
  - Coherence was perfect so I called Cameron Purdy for a price
  - It would have been over $500k!
- So we used MySQL distributed over 20 machines with a query aggregator
  - Data was stored in a columnar format with everything indexed in memory
- It worked incredibly well but...
- Joins and aggregate functions took another year to write
  - avg, max, min, count etc.

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A question for you...

- I have 1 million rows of CSV (Comma-Separated-Values), each row roughly 1k in size and some 50 columns
  - So 1GB of data, 50 million fields

- I now want to count the number of rows where the 7th column contains the word "Think"

- How long SHOULD it take to return the answer?
  - A - Around 30 seconds to a minute
  - B - Around 20-30 seconds
  - C - Around 10-15 seconds
  - D - Sub 10 seconds

Java NIO

- Using ~~Sun's~~ Oracle's NIO Grep example it threw OOM with -Xms4G -Xmx4G
  - The 100m version took 1.2 seconds so let's estimate 1GB will take 12 seconds as it's a linear search

- The following however took under a second...

```
grep -c Think BigFile.csv | cut -d "," -f 7
```

- Java is not the silver bullet

ORM - OMG!

- Probably the biggest waste of programming time, lines of code and source of bugs and latency is ORM
- The effort of trying to convert something inherently hierarchical into something relational
- It's probably the main source of complaints about SQL
  - People start with a nice XML document, map it with ORM into a RDBMS and then end up writing custom SQL because the ORM layer is too slow
- GOOD LUCK!

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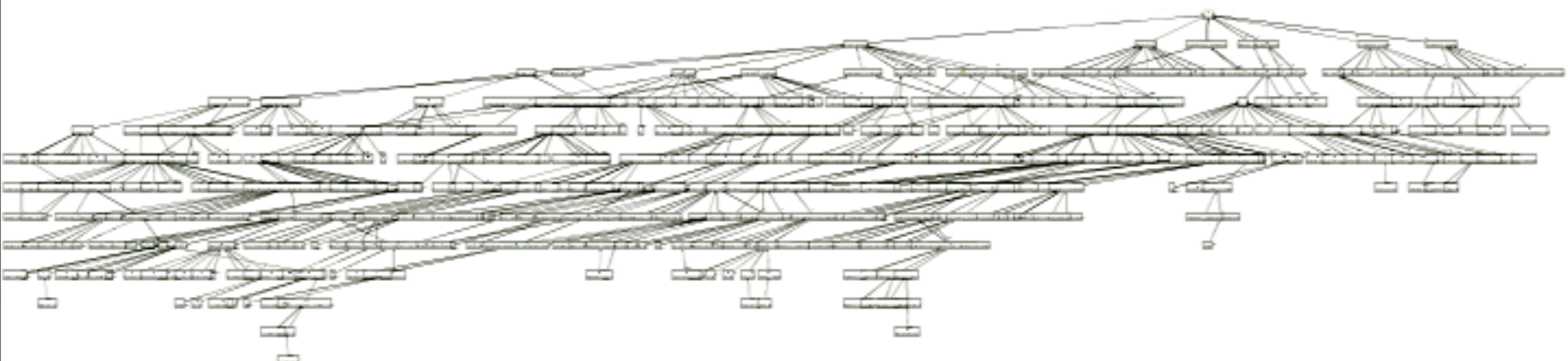
FpML into a classic database?

- The fuzzy patch below is the complete model of and FpML Swap from the IRD (Interest Rate Derivative) schema

- It's one of several dozen financial models in FpML



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FpML has to be persisted

- **This still needs to be stored...**

```xml
<?xml version="1.0" encoding="UTF-8"?><!--
  == Copyright (c) 2002-2007. All rights reserved.
  == Financial Products Markup Language is subject to the FpML public license.
  == A copy of this license is available at http://www.fpml.org/license/license.html
  -->
<FpML xmlns="http://www.fpml.org/2007/FpML-4-4" xmlns:fpml="http://www.fpml.org/2007/FpML-4-4" xmlns:xsi="http://www.w3.org/2001/
XMLSchema-instance" version="4-4" xsi:schemaLocation="http://www.fpml.org/2007/FpML-4-4 ../fpml-main-4-4.xsd http://www.w3.org/
2000/09/xmldsig# ../xmldsig-core-schema.xsd" xsi:type="DataDocument">
   <trade>
      <tradeHeader>
         <partyTradeIdentifier>
            <partyReference href="party1"/>
            <tradeId tradeIdScheme="http://www.chase.com/swaps/trade-id">TW9235</tradeId>
         </partyTradeIdentifier>
         <partyTradeIdentifier>
            <partyReference href="party2"/>
            <tradeId tradeIdScheme="http://www.barclays.com/swaps/trade-id">SW2000</tradeId>
         </partyTradeIdentifier>
         <tradeDate>1994-12-12</tradeDate>
      </tradeHeader>
      <swap><!-- Chase pays the floating rate every 6 months, based on 6M USD-LIBOR-BBA,
            on an ACT/360 basis -->
         <swapStream>
            <payerPartyReference href="party1"/>
            <receiverPartyReference href="party2"/>
            <calculationPeriodDates id="floatingCalcPeriodDates">
               <effectiveDate>
                  <unadjustedDate>1994-12-14Z</unadjustedDate>
                  <dateAdjustments>
                     <businessDayConvention>NONE</businessDayConvention>
                  </dateAdjustments>
               </effectiveDate>
               <terminationDate>
                  <unadjustedDate>1999-12-14Z</unadjustedDate>
                  <dateAdjustments>
                     <businessDayConvention>MODFOLLOWING</businessDayConvention>
                     <businessCenters id="primaryBusinessCenters">
                        <businessCenter>GBLO</businessCenter>
                        <businessCenter>JPTO</businessCenter>
                        <businessCenter>USNY</businessCenter>
                     </businessCenters>
                  </dateAdjustments>
               </terminationDate>
```

NoSQL?

- No RDBMS or NoSQL?
- We can still store the XML or hierarchical data in a RDBMS but SQL is pretty useless
- Now we need something like XQuery
- We have however found a good reason to move away from SQL

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Enough of SQL

OK, so SQL has its uses

Hierarchical data is not one of them

Let’s look at another problem...

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Lots of data

- In the banking world we have a lot of data
- Today 50-100,000 quotes a second isn't unusual
  - We recently hit 350,000/sec from just one source (CME)
- Writing this to a database is possible but not usually practical or necessary
  - Storing 100,000 objects is pretty simple, the data is relatively flat
  - But the problem is rarely so simple
- It gets more complex...

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Adding complexity

- 10,000 portfolios, each with 1,000 buy/sell orders at specific prices
  - For example one portfolio might contain someone's investment, partly held in Hong Kong equity, one of those equities might have a sell order (for the 500 shares) at HKD $85
- We now have 100,000 prices coming in every second and 10 million orders to watch
  - Technically 1 trillion (10^{12}) but there are optimisations that can be made
- Then repeat this across 20 exchanges
  - Oh yes and if you get a match we need sub milli-second triggers

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Time is critical

- I've simplified the use-case but you should get the idea
- In the world of trading only the first one gets the deal, there is no second place
  - This drives performance - mainly around latency
- While being first to have the order is what makes the money banks now have a "new" problem
  - To be honest it's not new, they're finally being forced to manage it
- Risk

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Risk management

- Especially after recent events it's critical that financial institutions monitor their exposure to risk
  - How much they owe or how much they are owed
  - Or how much they **might** owe etc.

- A 100 years ago teams, often hundreds of people, would calculate the figures every day
  - It could take days or weeks to know if you were bankrupt or rich

- Today we need to know by the second
  - Every single trade has a risk associated with it

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Risk

- Everything presents a risk...
  - The equity / asset could de-value
  - The seller could go under (bankrupt)
  - The currency of the asset could de-value
  - The political regime of the seller could change
  - The political regime or currency of the parent bank could change
  - The broker or counter-party who brokered the deal could go under
- All these may appear small risks but they are very real
  - Remember Sub-prime, Enron, Northern Rock?
- It's like a Tokyo or San Francisco earthquake, a very small chance it will happen tomorrow but it will happen one day

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Lots of data, lots of calculations

- There are two main flavours of distributed computing
  - Data
  - Computation

- Often they are closely related but not always

- To achieve either we usually need lots of memory and CPUs

- We don’t stack them or put them in clusters these days, we distribute them
  - Usually in a rack - but you don’t need to know that

We need to scale

Huge amounts of data
Vast amounts of computations

We need scaleability

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Distributed Computing - Ideal case

- In an ideal world we code without having to know about the deployment architecture
  - We assume a machine powerful enough and with enough memory to perform our task(s)
  - For a long time this was the case
- Sadly this doesn't usually work so we need to code with a view to scaling, scaling both memory and CPU power
- We code for a distributed environment, we hand out tasks to be distributed and data through and API to be stored

Change the programming model

- Probably the hardest thing to drill into programmers and worse, their managers, is to program for a distributed architecture
  - It all seems like an overhead at first
  - Abstraction of location
  - Storage though APIs
- The EJB model was a start but scalability was limited to the server or cluster of servers
  - JNDI lookup
  - Object life-cycle manage by the container
  - Spring extended this

Virtualisation

- If we just had 4 machines we might be mistaken into thinking it's a cluster
- Ideally we need to imagine an infinite amount
  - We code it, someone else pays for and adds computing resources
- Today's machines are a little large, we need finer granularity
  - This is where Virtualisation comes in
- We can split a large server into half a dozen smaller processing units (sometimes more)

Virtualisation is good

- Each virtual machine is independent from the other
  - Almost - VMs on the same physical machine rely on the same hardware
  - This needs to be understood by the provisioning software
- In many cases the Java VM is good enough but today's OS VMs usually leave us with more control
  - The Java VM runs on top of the OS Virtual Machine - usually Linux
  - We still rely on a lot of the OS - logging, network etc.
- Usually the same VM is as easy to run locally as remotely
  - This makes it easy to configure, code, test and deploy

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Local vs Grid vs Cloud

- If we can distribute to local VMs we're most of the way there
- Move the VMs to other machines on the network and we have "Grid"
  - Also known today as "private cloud", these can be physically local or remote but usually on your network or VPN
  - Today's investment banks and hedge-funds have anything from 200 to 20,000 CPUs in their grids
- Use someone else's hardware and you have "Cloud"
  - Amazon's EC2 is a perfect example

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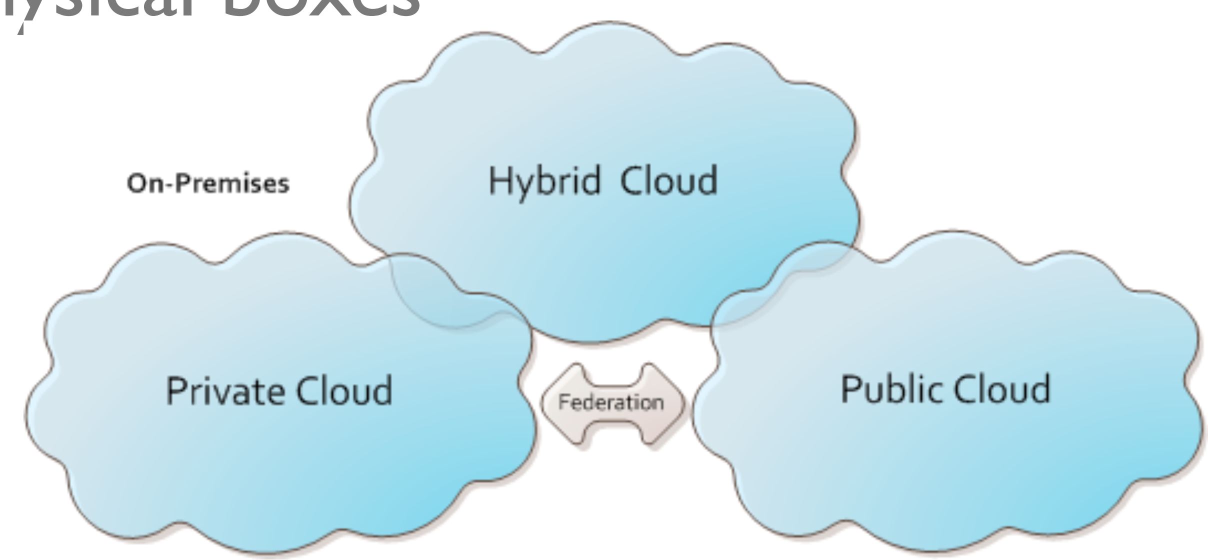
Local vs Grid vs Cloud

- Local
  - Very fast but limited by the physical size/power of your box
  - Perfect for developing and testing
- Private Cloud / Grid
  - Very secure - perfect for banks & governments
  - Very scalable but slight latency
  - Costly - as you have to buy the physical boxes
- Cloud
  - Pay for what you eat
  - Extremely scalable
  - Latency and security can be an issue



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Grid technologies

- Let's look at some of the Grid technologies, there are dozens but we'll take a slightly closer look at a few...
  - GemFire
  - Terracotta (BigMemory)
  - GigaSpaces
  - Coherence
  - Neo4J

- Many other technologies overlap in areas, predominately the caching side, these too are viable alternatives
  - EHCache, Memcached, JCache (JSR-107) etc.

- It would be wrong not to mention NoSQL DBs...

The list goes on...

- Many of the following are appearing on the scenes
  - MongoDB
  - HBase
  - Cassandra
  - Riak
  - CouchDB
  - Redis

- MongoDB is pretty popular
  - HBase with Hadoop and Cassandra occasionally too
  - Others I've not seen but that doesn't mean they're not being used, many of them have extremely powerful features with considering

How to compare?

- I could write a book and talk to you for days
  - But I still can not tell you which is best
- I've seen a lot of money spent on comparing them
  - Each one of them will give you examples where they've excelled
- Most of them will do the job and most of them will tell you bad things about the others
- All I can do is point out a few major differences
  - Anything claim I make would be disproven as things evolve

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Grid technologies

- GemFire
  - Originally an OOD, now has a pure Java implementation
  - Recently acquired by VMWare
- Terracotta
  - Uses Java VM replication,
  - Recently acquired by Software AG
- GigaSpaces
  - Originally the only viable implementation of Sun's JavaSpaces
- Coherene
  - Formally "Tangosol", now owned by Oracle
- Neo4J
  - The wild-card, a graph database

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GemFire

- Connect to the distributed system and get the Cache ref

```
// Create / Find a cache (using the map interface)
DistributedSystem ds = DistributedSystem.connect();

// Get the Singleton instance of the cache
Cache cache =  CacheFactory.create(system);
```

- Instantiate your object and simply put into a Map

```
// Create / Find Data Region "Prices" in the cache
Map prices = (Map ) cache.getRegion("Prices");

// Write the Price to the cache...
prices.put( price.getKey(), price );
```

- As you can see this couldn't be easier

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Reading a Price from GemFire

```
// Get Access to the Data Region "Prices" and cast as a java.util.Map
Map map = (Map)cache.getRegion("Prices");

// Retrieve the latest spot price for GBP/NOK
Price myPrice = (Price ) map.get("GBP/NOK-SPOT" );
```

- All GemFire Data Regions are indexes on the key used in Put

```
// Get Access to the Data Region "Prices"
Region prices = cache.getRegion("Prices");

// If the retrieval is not based on primary key, you can use OQL
// Retrieve the latest spot price for GBP/NOK
SelectResults results = prices.query("getKey() = 'GBP/NOK-SPOT'");
for (Iterator iter = results.iterator(); iter.hasNext(); ){
    Price myPrice = (Price) iter.next();
}
```

- All GemFire Data Regions can be indexed on fields or and/or methods

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Spring work equally well

- With most of these you can use Spring Integration to insert complex data into our Grids...

```
< gfe:cache/>
 <gfe:replicated-region id="swift-etc">
        <gfe:cache-listener>
            <bean class="biz.c24.io.swift.etc.data.CacheListener"/>
        </gfe:cache-listener>
 </gfe:replicated-region>

 <file:inbound-channel-adapter
        id="filesIn" directory="file:/Users/jdavies/dev/Spring_C24/spring-integration-samples/input"
        filename-pattern="*.txt">
      <int:poller id="poller" fixed-delay="0"/>
  </file:inbound-channel-adapter>

 <int-gfe:outbound-channel-adapter id="channel2" region="swift-etc">
     <int-gfe:cache-entries>
        <entry key="payload.Block4.SeqA.Field20aReference.C.Reference" value="payload"/>
     </int-gfe:cache-entries>
 </int-gfe:outbound-channel-adapter>
```

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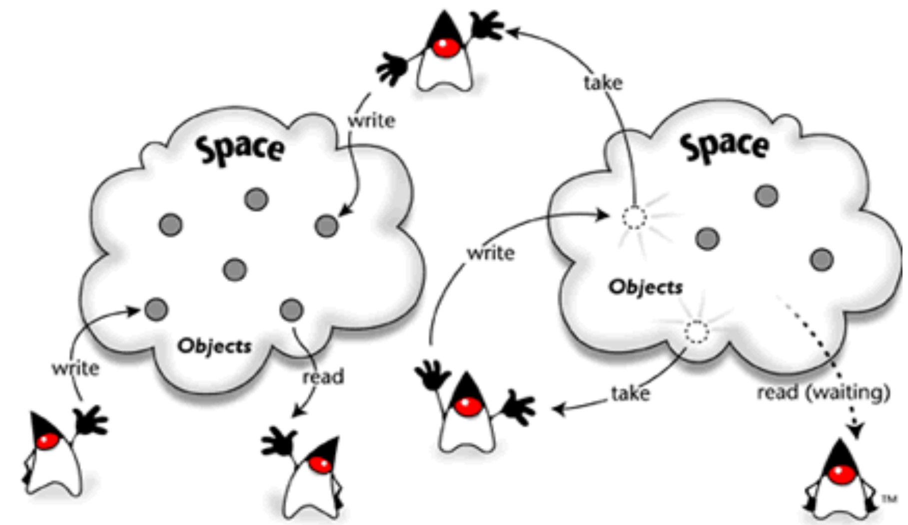
GigaSpaces

- GigaSpaces is the perfect implementation of a Master/Worker pattern
  - But they don't really push this sadly

```
public String url = "jini://*/*/C24Space";
space = new GigaSpaceConfigurer(new UrlSpaceConfigurer(url)).clustered(true).gigaSpace();

// CacheItem is our own POJO to host an ID & SWIFT POJO from C24's Integration Objects
ci = new CacheItem();
MT513Element mt513Element = new MT513Element();
MT513Message mt513 = ci.parseMT513FromString(rawSwiftMT513);
id = extractID(mt513);

ci.setId(id);
ci.setMessageData(mt513);
space.write(ci);
```



- Once again really easy to use
  - Notice the interface is not a Map here
  - In "classic" JavaSpaces we use a template to retrieve data
  - But GigaSpaces have added new search APIs now

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Finally my "wild-card"

- Neo4J is interesting but I've yet to find a problem where it's the obvious solution
  - If I had to re-implement Twitter or Facebook I'd use Neo4J
- I've come across a few trading systems that would benefit from the graph-database traversal
  - However the graphs were not deep so the use-case was not obvious
- It is however pretty cool and very fast
  - I encourage you to take a look as it just need someone with a fresh mind to come up with the "killer use-case" other than social groups

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Neo4J

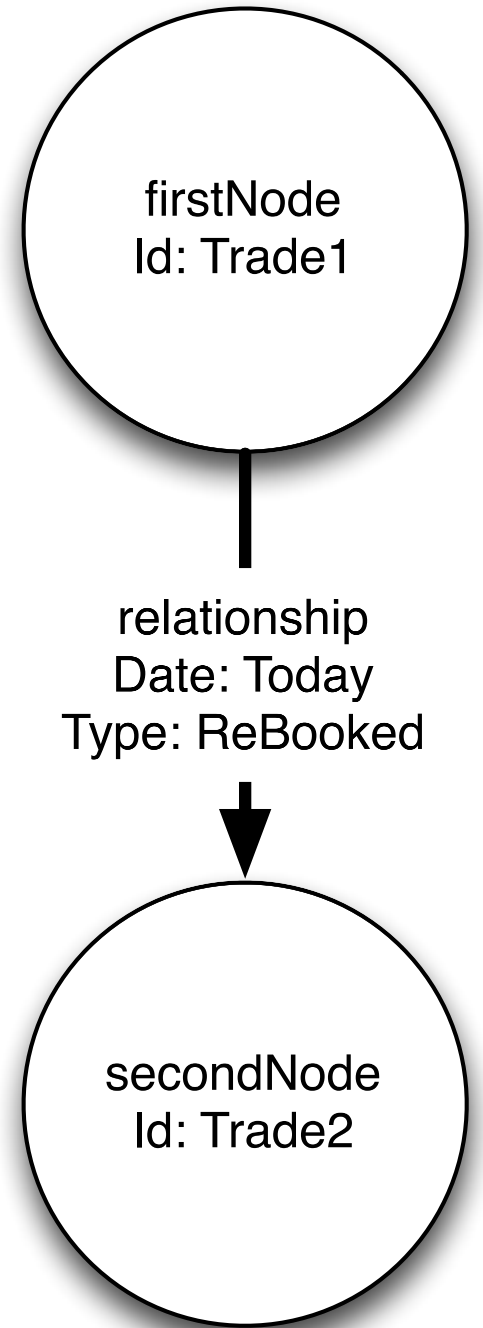
- Some code snippet for Neo4J...

```
private static enum RelType implements RelationshipType {
    ReBooked
}

GraphDatabaseService graphDb = new EmbeddedGraphDatabase( "./" );
registerShutdownHook( graphDb );

Node firstNode;
Node secondNode;
Relationship relationship;

Transaction tx = graphDb.beginTx();
try {
    firstNode = graphDb.createNode();
    firstNode.setProperty( Trade1.getId(), Trade1 );
    secondNode = graphDb.createNode();
    secondNode.setProperty( Trade2.getId(), Trade2 );
    relationship = firstNode.createRelationshipTo( secondNode, RelType.ReBooked );
    relationship.setProperty( “Date”, new java.lang.Date() );
    tx.success();
}
finally {
    tx.finish();
}
```



Grids & Complex Data

- Going back to the FpML
  - And adding ISO-20022, Fix, SWIFT, etc. into the mix
- We're extracting data from the model (usually with XPath) and using it as an index (or indices) into the POJO in the grid
- At one large broker (for example) we're storing Fix messages from dozens of exchanges into distributed memory
  - Over 10,000 per node per second
- Parse the message, read the key data and insert into the grid as key-value pair

It's question time...

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Thank you

- We are looking for talented Spring/Java programmers and architects in London, Chicago, New York & San Francisco

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