European Organization for Particle Physics

The coolest place on earth
Large Scale Messaging with ActiveMQ for Particle Accelerators at CERN
Overview

- Examples
- Operation
- Introduction to CERN
- Usage of ActiveMQ

30min
About the Speaker

Member of CERN Beams Controls Group:
Responsible for JMS Service Middleware
Developer for Alarm and Monitoring System

Previous Activities:
Large Storage Systems
Grid Environment

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What is CERN?

A European Organization for Nuclear Research
originally: Conseil Européen pour la Recherche Nucléaire

- Founded in 1954
- Based in Geneva, Switzerland
- 3’000 staff members
- 8’000 visiting scientists
- Financed by its member states
Large Machines for High Energy Physics

Particle colliders for tracing “fragments”
The CERN Campus

Geneva Lake

27km Tunnel
100m under ground

CERN Main Campus

Airport
The Large Hadron Collider
But the LHC is not the only accelerator
A lot of systems to control

- Controls
- Computers
- Electricity
- Cryogenics
- Magnets

85’000 Devices
> 2 Million I/O Endpoints

Much more when including subsystems!

- Safety
- Cooling
- Ventilation
- Vacuum
Everything from one central point: The CERN Control Centre
USING ACTIVEMQ FOR ACCELERATOR CONTROLS
Controls Architecture

JMS Purpose: Reliable and scalable transport of data between Java processes
History

• Early use of ActiveMQ already in 2005
  – We were looking for a free JMS solution
  – Apache? Can’t be bad!

• Why OpenSource?
  – Low Costs
  – We can **read and check** the code
  – We can add / fix code
History – First Setup

- Clients
  - Java middle-tier servers and GUIs

- Data access for Clients via Middleware API

- Two interconnected Brokers

Simple Setup, few projects, little data, easy to use. Did the job!
History - Evolution

• But: Service suffered by its own success
  – More users and more data was sent around
  – Higher QoS was requested
    • Redundancy
    • Queues, persistent messaging and global transactions (XA)
  – Support for non Java clients

• We needed to adapt the infrastructure
  and needed to SCALE
Deployment Today

- 20 Production Brokers
  - 10 single Brokers
  - 5 HA Clusters
- No one large cluster but manageable entities
- Vital part of beam instrumentation and operation

No JMS – No Particle Physics!
Deployment Today - Setup

• HA Clusters
  – 2 equivalent broker members, no master-slave
  – Two (real) machines with separate network links

• Single Broker
  – For projects which do not require HA
  – Deployed on same (real) machine as middle-tier server

• Local secured network together with Producers and Consumers

• Fuse ActiveMQ Distribution since 2010
  – Issues solved faster in service packs
Deployment Today

Some numbers:

- 300 Applications
- 4,400 Connections
- 40,000 Subscriptions
- 85,000 Topics
- 68,000 Consumers
- 8 Million msg/h IN, 3.5M msg/h OUT

Archived Uptime in 2011: 99.98%

Not all data which is produced is consumed.
Example of Data Handling during LHC Startup 2010

Output Data Handling for 1 Broker of the General Broker Cluster

1TB/day

150% unpredicted increase in data demand

2.5TB/day

LHC Startup March 2010
Usage Cases

Usage Case 1
- Payload 2MByte
- 1 msg/sec
- 1 Topic
- 20-30 Java Clients

Usage Case 2
- Payload 500Bytes-1KBytes
- 30-200 msg/sec
- 120 Queues
- 4 Million XAS/day
- 2 Clients

Usage Case 3
- Payload 200Byte - 10KByte
- 50-4500 msg/sec
- 10'000 Topics
- 2-5 Clients

Usage Case 4
- Payload <200 Bytes
- <10 msg/hour
- 1 Queue
- < 10 STOMP Clients

Scalability  Reliability  Versatility  Flexibility
OPERATION
Management of Brokers

• Monitoring
  – via JMX
  – Submission of test message
  – Host machine monitoring

• Deployment
  – Rollout scripts for deploying/rollback
  – Configuration changes tracked in SVN
Diagnostic Tools

Dump JMX information into SQLite database for fast, easy and intuitive access.

“Give me all clients which have outstanding acknowledgements.”

```
select name, awaitack, clientid
from subscriptions
where awaitack > 0;
```
Diagnostic Tools

Traffic Monitoring Tool

- Collecting information by **listening** on Topic
  - Message size & speed

- Allows **history view** on
  - Average Message throughput
  - Average Message size
Lessons learnt - Operation

• Separate usage cases from each other
  – Easier than implementing per destination policies
  – Broker restart does not affect others

• More clients, more memory

• Broker does not die when hitting memory limits

• Check if you need all features
  – Maintenance overhead vs. failure probability & effect
Lessons learnt - Configuration

- Disable DedicatedTaskRunner: takes many threads
- Reduce the PrefetchLimit on clients side
- Couldn’t get Broker discarding messages
  - ConstantPrefetchLimit unset + brain-dead client
    = Out of Memory

- Memory is important
  - But GC takes longer
  - New Java GC options help

-XX:+UseConcMarkSweepGC
-XX:+CMSIncrementalMode
-XX:+CMSIncrementalPacing
-XX:CMSIncrementalDutyCycleMin=0
-XX:CMSIncrementalDutyCycle=10
-XX:+HeapDumpOnOutOfMemoryError
EXAMPLES
LHC Status Displays

PROTON PHYSICS: INJECTION PROBE BEAM

BCT T12: 0.00e+00  I(B1): 1.39e+10  BCT T18: 0.00e+00  I(B2): 1.94e+10

TED T12 position: BEAM  TDI P2 gaps/mm up: 9.00  down: 8.93
TED T18 position: BEAM  TDI P8 gaps/mm up: 8.76  down: 8.77

TBCT Intensity

Comments 25-04-2010 20:50:54 :

injected one bunch per beam correcting machine

BIS status and SMP flags

Link Status of Beam Permits true false
Global Beam Permit true true
Setup Beam true true
Beam Presence true true
Moveable Devices Allowed In Orbit false true

http://lmgtfy.com/?q=cern+vistars
Remote Control for Video Viewer

Access Request

Business Logic

“Show Cam 1”

Button Panel

Video Viewer

Powered by VLC
“Bamboo” for Accelerators

Run Tests for Hardware Commissioning
Animate Synoptic Displays

Technical Infrastructure (Power, Cooling, Water, Doors,...)
Camel for Unifying Log Events

Finding/Debugging a problem becomes cumbersome!

Collecting and unifying log messages in one central place

Easy correlation of events among many services
Finally

A great thanks to all developers!
European Organization for Particle Physics

Take part!