MODERN MESSAGING FOR DISTRIBUTED SYSTEMS

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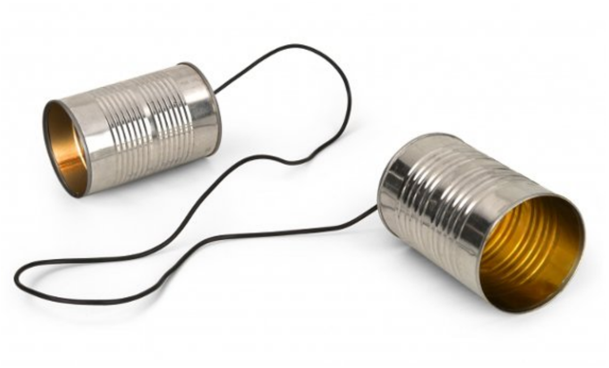
Outline

- Why Messaging
  - *what's wrong with socket?*
- Principles
  - *a bit of theory*
- Technology
  - *messaging software*
- Stories
  - *messaging at work*
- Summary

TIGHTLY-COUPLED COMMUNICATION



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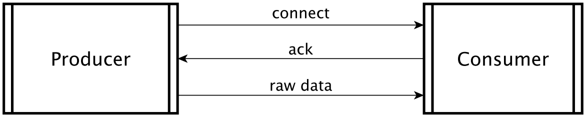

Information exchange based on several assumptions

- Temporal dependency
- Location
- Data structure
- Platform technology (internal data representation)

A LOOSELY-COUPLED SOLUTION: MESSAGING

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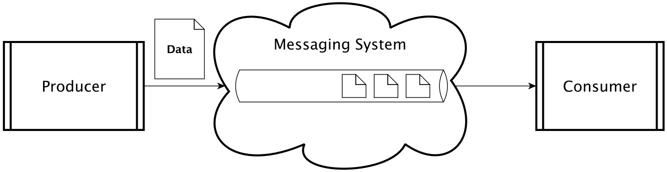
A LOOSELY-COUPLED SOLUTION: MESSAGING



To minimize producer and consumer dependencies

- **Data sent via an intermediate channel**
- **Channel enhaced with functionality (e.g. queuing)**
- **Message** as the information building block
  - body: immutable, structured data (e.g. JSON, Protobuffer)
  - header: key/value pairs, used for routing

TYPICAL MESSAGING USE CASES

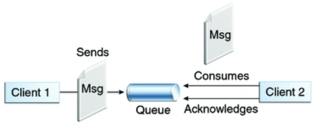
- Information Publishing
  - An entity publishes volatile information with no a-priori knowledge about who is interested
  - e.g. sensor
- Information Storing
  - An entity collects information from multiple sources
  - e.g. log collector
- Remote Procedure Call
  - An entity sends request to one or more remote entity and expect reply
  - e.g. command distribution

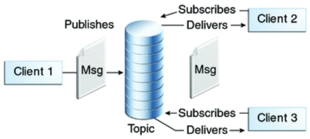
MESSAGING TODAY

- Rich ecosystem of tools and services with years of development
  - message brokers & libraries
  - based on well-defined communication and integration patterns
- New technology recently appeared with focus on low-latency/high-performance
- Not the *silver-bullet*
  - important benefits in flexibility and scalability
  - more complex programming model and architecture

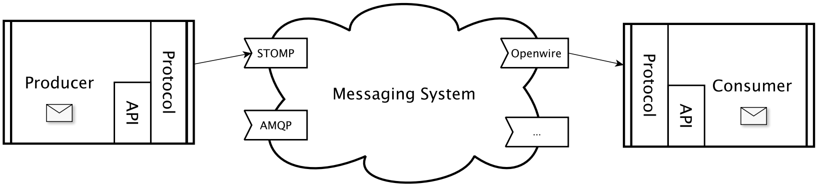
MAIN COMMUNICATION MODELS

- Point to Point (Queue)
  - no consumers: message is kept in the channel
  - multiple consumers: message is delivered only once
- Publish/Subscribe (Topic)
  - no consumers: message is discarded
  - multiple consumers: message is delivered multiple times
- More complex delivery semantics exist





Protocols & API



- No standard way to interact with message brokers (yet)
  - Many protocols, with different capabilities and QoS
- Protocol is bound in the application
- Messaging system can be polyglot
- AMQP *may* eventually unify

MESSAGING PROTOCOLS

- AMQP = Advanced Message Queuing Protocol
  - major contributors: Cisco, Microsoft, Red Hat, banks
  - designed for interoperability between different messaging systems
  - feature complete but complex (wire protocol + semantic definition)
  - binary protocol, in theory faster and compact
  - major transition: from AMQP 0.x to AMQP 1.0, no backward compatibility
  - brokers support still incomplete
- STOMP = Streaming Text Orientated Messaging Protocol
  - text-based, meant to be simple and widely-interoperable
  - extensive set of clients
  - supporting basic messaging features (e.g. transaction)
  - supported by many brokers

MESSAGING PROTOCOLS (II)

- MQTT (Message Queue Telemetry Transport)
  - originally from IBM, recently open sourced
  - low footprint: designed for low bandwidth , high-latency networks
  - *Internet of Things* style applications (mobile phones, etc.)
  - strength: simplicity, compact binary format, good fit for simple push scenario
- Many other broker-specific protocols exist (e.g. Openwire)

No clear *best* protocol, but the protocol choice is an important decision in respect to the messaging system coupling within the application

JAVA MESSAGE SERVICE (JMS) API

- Messaging standard that allows application components to create, send, receive, and read messages
- Define messaging main concepts
- Mature (1.1 spec. in 2002, 2.0 in 2013) and part of Java EE
  - It is (mainly) an API
  - Supports (mainly) two models:
    - Point-to-point
    - Publish/subscribe
- Many JMS frameworks/implementations available: commercial application servers, Spring, ActiveMQ, etc.

Messaging Functionality

- Common features
  - *Persistence, Fail-over, Guaranteed delivery, Ordering, Transaction, High-availability, Clustering*
  - shared by main brokers, with different interpretation
- Many *unique* broker-specific features
  - *e.g. Virtual Queues, Last Value Queues*
- Suggestion: focus on real requirements

Message Brokers (*MQ)

Apollo ActiveMQ RabbitMQ Open Source Enterprise Messaging

Qpid HornetQ ...

- Many exist
- Most feature rich
- Different in features, protocols, implementation languages, platform support
- Focus here on open-source solutions

NON-EXHAUSTIVE COMPARISON

Broker	***Qpid***	***MRG***	***HornetQ***	***ActiveMQ***	***Apollo***	***RabbitMQ***
Language	Java	C++	Java	Java	Scala	Erlang
Main Protocols	AMQP	AMQP	proprietary STOMP	OpenWire STOMP AMQP MQTT	OpenWire STOMP AMQP MQTT	AMQP STOMP (MQTT)
Owner (*)		Red Hat	Red Hat	FuseSource (Progress)		VMware

- 2012 RedHat completed FuseSource acquisition

Apache ActiveMQ

- *The most widely adopted open-source message broker*
- Written in Java
- Commercially supported by RedHat
- Solid and mature
- Many features (e.g. JDBC message stores, advanced clustering configuration)
- Weak point: complexity
- Future:
  - Apollo seemed the designed successor
  - RedHat may evolve ActiveMQ as unified messaging solution

RABBITMQ

- Open source
- Written in Erlang
- Modular design (e.g. AMQP, MQTT plugins)
- Development effort comes from SpringSource (a division of VMware)
- Embedded in several projects (e.g. Logstash, Sensu)

CONSIDERATIONS ON PERFORMANCE

- Beware of numbers!
  - msg/s has little value without context
  - in realistic scenario performance vary across 100K msg/s and few K msg/s (Broker comparison over STOMP)
- To *handle with care*:
  - message $>$ 1KB payload
  - rate $>$ 10K msg/s LAN & binary protocol
  - persistent message (at least x10 slower)
  - $>$ 100 new sessions per second (in particular with security)
  - number of subscribers
  - slow subscribers!!!

CONSIDERATIONS ON PERFORMANCE (II)

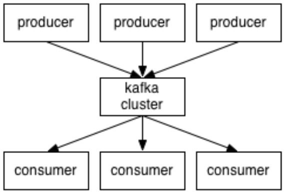
- Messages go through intermediaries
  - multiple hops, delays, retries, failures
  - not a good fit for low-latency / high-throughput
- New projects tackled the problem from different perspective...

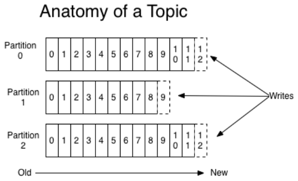
Kind of broker: APACHE KAFKA

- From LinkedIn, now Apache
- Written in Scala
- Focus on data movement
- Meant for *real-time* activity stream analytics (e.g. user data, metrics)
- Designed as distributed system easy to scale out (based on Zookeeper)
- Limited messaging features
  - (Mainly) Topic semantic
  - Filesystem based Persistence
  - Guranted ordering
  - Automatic balancing of consumer/producer/broker

APACHE KAFKA - DESIGN

- Kafka broker is stateless
  - consumer maintains its own state and pools data from the broker
- Messages are persisted independently from consumers
  - not removed on consumption, but by retention period
  - allow for re-consumption in case of problem
- Fast writes and batch-reads (zero-copy)
- # consumers is not relevant
- Used as *pipe* to different processing systems (e.g. Hadoop, Storm)



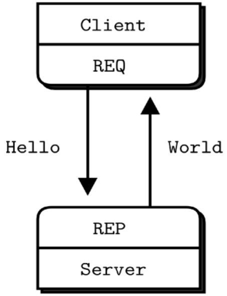


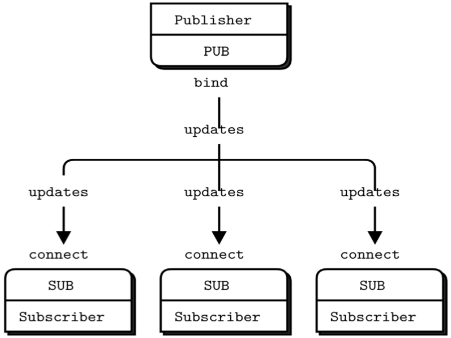
Not a broker: ZEROMQ (ZMQ, 0MQ)

- Despite the name, it's **not a broker, but a library**
- *Socket on steroids*: expand the concept of socket
- 0MQ Socket built-in messaging patterns:
  - Request-Reply
  - Pub/Sub
  - Pipeline
  - Exclusive Pair
- Each socket's connection has its own *queue*

ZeroMQ - Examples

- Inter-thread, inter-process or inter-node communication
- Work seaminglessy with single or multiple clients
- Work with server started after the client





ZEROMQ - OVERALL

- Ligthweight but powerful
- Focus on high-performance low-latency communication
- Price to pay in application complexity
  - comes with basic messaging features
- Good if you can invest sufficient effort to build a messaging solution on top of 0MQ as library

CERN BEAM CONTROL

- *"No messaging, no beam"*
  - Felix Ehm, CamelOne 2012
- Messaging for highly reliable control/monitoring/alarm applications for LHC
  - since 2005

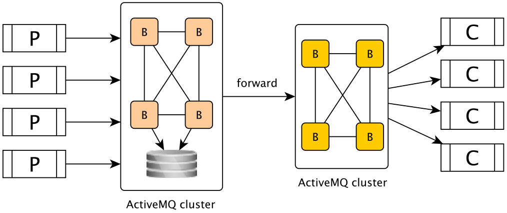
CamelOne 2012 - Felix Ehm Video

Large Scale Messaging with ActiveMQ for Particle Accelerators at CERN
Felix Nikolaus Ehm, CERN

CERN, the international organization for nuclear research based in Geneva runs one of the largest particle accelerator infrastructure in the world including the youngest and most known Large Hadron Collider (LHC). This presentation will be on how ActiveMQ is used since 2005 for the accelerator Controls System to transport mission critical data reliably to high-level control/monitoring/alarm applications enabling a 24×7×365 operation for these machines. Currently single and clustered brokers are deployed to satisfy the very broad diversity of messaging patterns, e.g. large messages low rate (2MBytes/sec) to small messages high frequency (345M messages/day).

CERN Beam Control - Technology

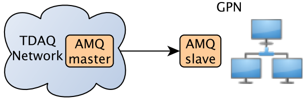
- Clusters of ActiveMQ brokers
  - safety system: 30 producers, 2MB/s each
  - 4.5 K msg/s, many consumers
  - store & forward

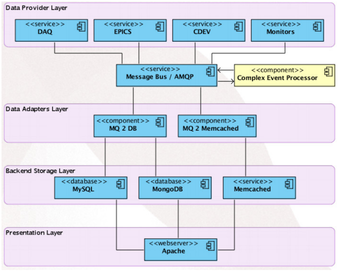


- Corba to 0MQ migration for control middleware
  - *[Middleware Trends and Market Leaders 2011]*
  - [The new CERN Controls Middleware 2012]

MESSAGING & ONLINE MONITORING

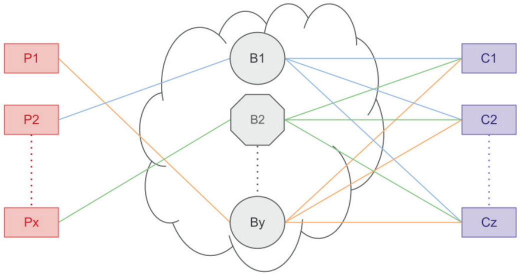
- ATLAS TDAQ
  - distribute operational alarms
  - from private TDAQ network to GPN
  - master/slave configuration
  - single outbound connection
- STAR Online framework
  - detector state processing, storage and monitoring
  - AMQP-based framework for flexible, loosely-coupled stream processing
  - investigation on MQTT for control framework
  - Dmitry Arkhipkin, ACAT 2014





WLCG MESSAGING SERVICE

- Monitoring WLCG sites and services:
  - 50k clients all around the world
  - 100k msg/s or more



- STOMP on ActiveMQ, (RabbitMQ, Apollo)
- Messaging cluster made of independent brokers
  - produce to any, consume from all

SUMMARY

- *Messaging is fundamentally a pragmatic reaction to the problems of distributed systems*
  - asynchronous architecture
  - loose coupling
- It can bring many benefits in distributed applications flexibility and scalability
  - with implications in application and infrastructure complexity
- Messaging technology is still evolving
  - AMQP standardization effort in the good direction, but not yet mature
- New generation of systems promote messaging for low-latency / high-throughput communication
  - narrowing use cases and relaxing assumptions

References

- CERN Messaging service:
  - [http://mig.web.cern.ch]
- *Enterprise Integration Patterns*, G.Hohpe and B.Woolf
  - [http://www.eaipatterns.com]
- Brokers comparison over STOMP
  - [http://hiramchirino.com/stomp-benchmark/ec2-c1.xlarge]

THANK YOU! ANY QUESTION?