DataStax

Pulsar Introduction Workshop I

Led By Aleks and Zeke

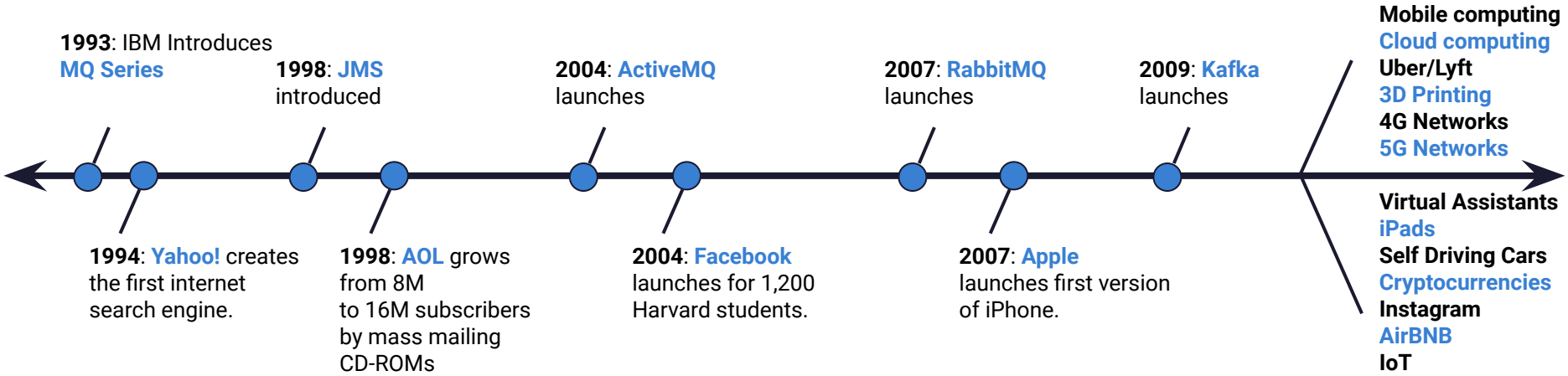
June 7th

Agenda

- History of Messaging
- Introduction to Pulsar
- Hands on

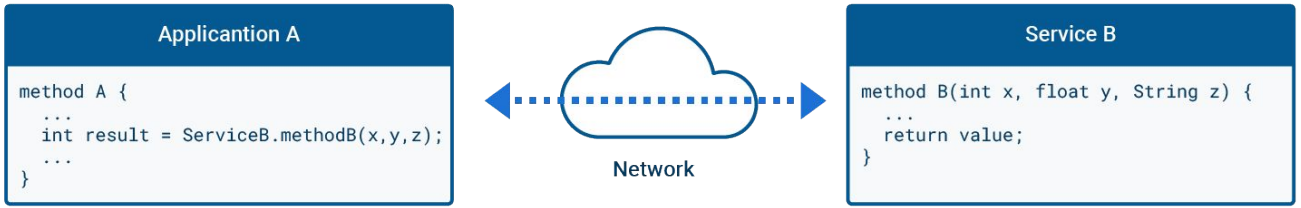
History of Messaging

Most enterprise messaging systems were made to solve yesterday's problems



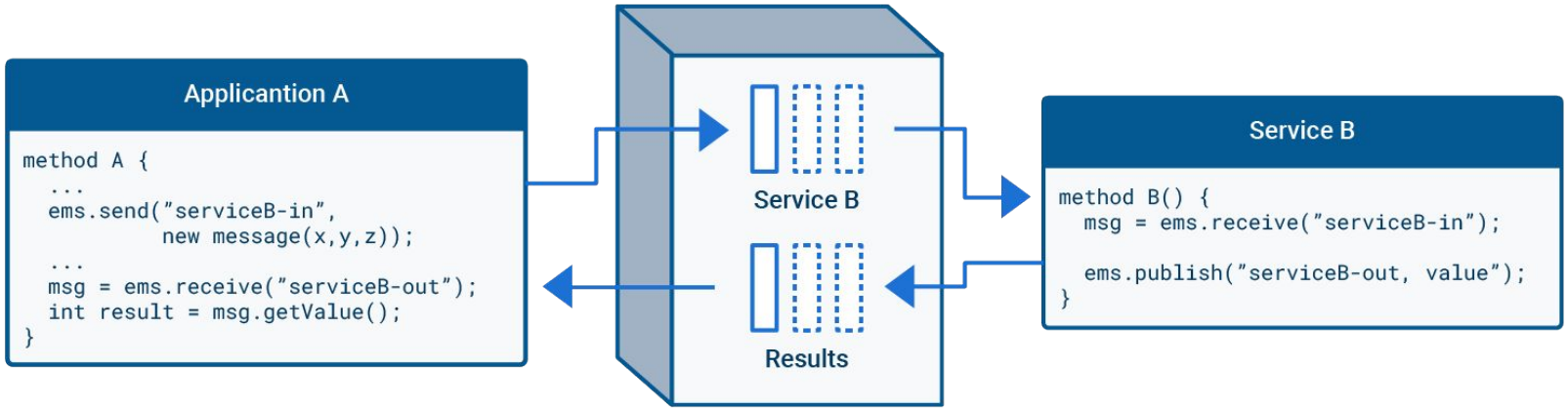
Remote Procedure Calls – Pain before Messaging Sytems

- Remote Procedure Calls
  - Service makes a request from another service
  - Service responds



- Problems
  - Huge risk with networking and service discovery
  - Point to Point communications
  - Slow as you are waiting for one server to respond to another

Enterprise Message Systems solved RPC limits



- Decouple message senders from the receivers by using a **messaging service**
- Persistent buffer to handle requests and data
- Async = no need to wait!

Messaging System Features

01

Asynchronous Communication

02

Message Retention

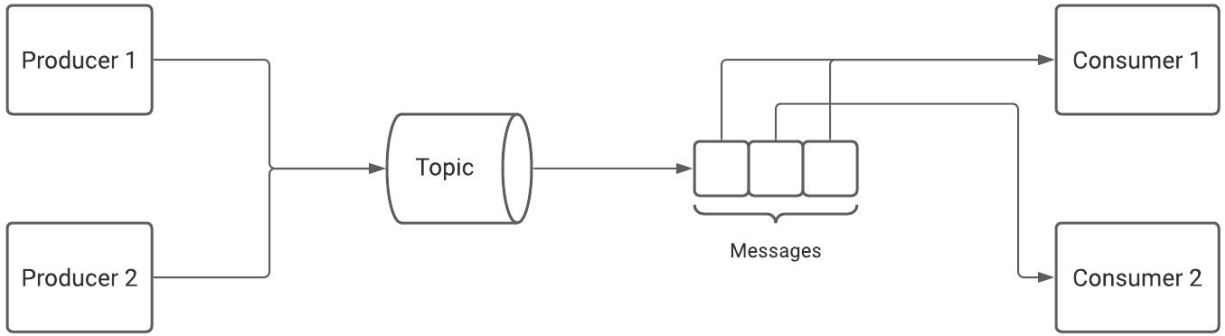
03

Acknowledgement

04

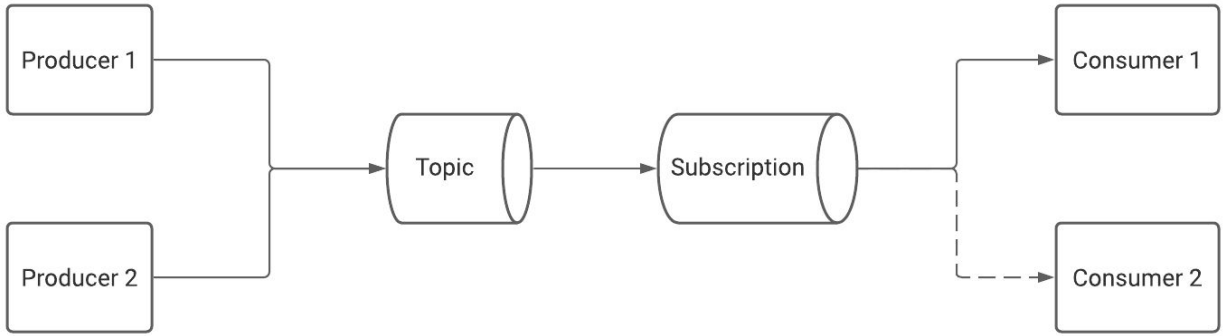
Message Consumption

Message Consumption – Queuing



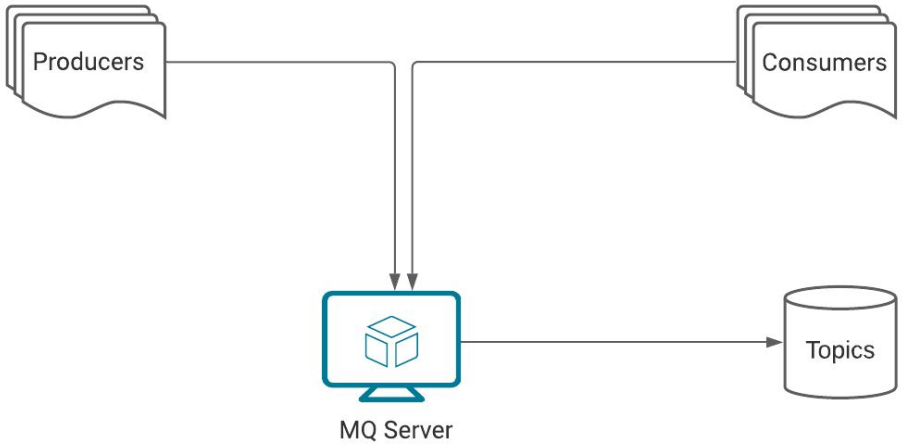
- Exactly One Processing of messages
- Backlog of messages
- Distributed Processing
- Message Failover

Message Consumption – Publish / Subscribe Messaging



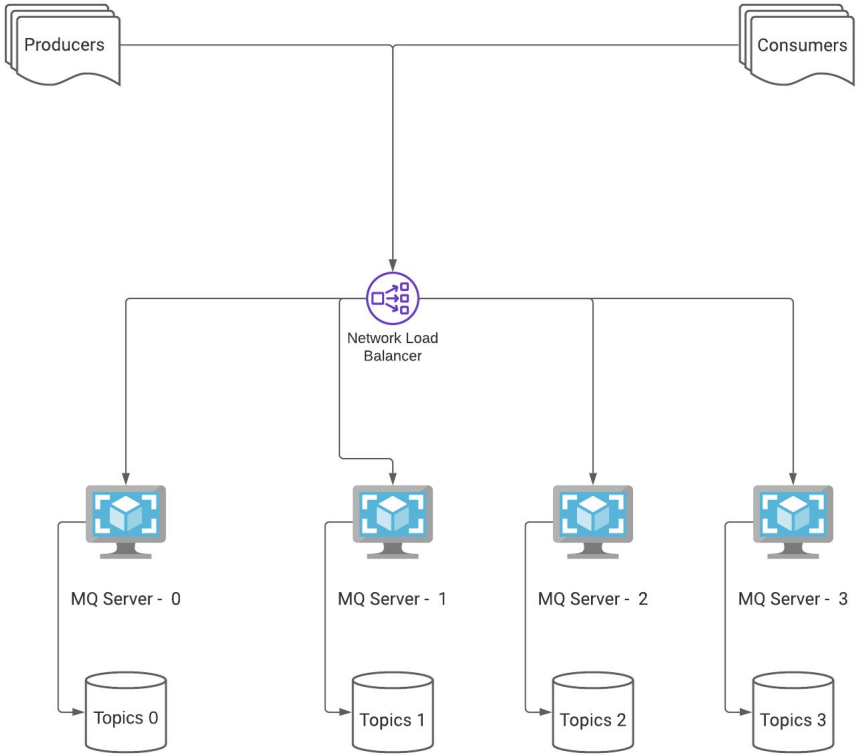
- Producers send to Topic
- Consumers subscribe to Topic
- Multiple consumers

Message Oriented Middleware – MQ – Original Design



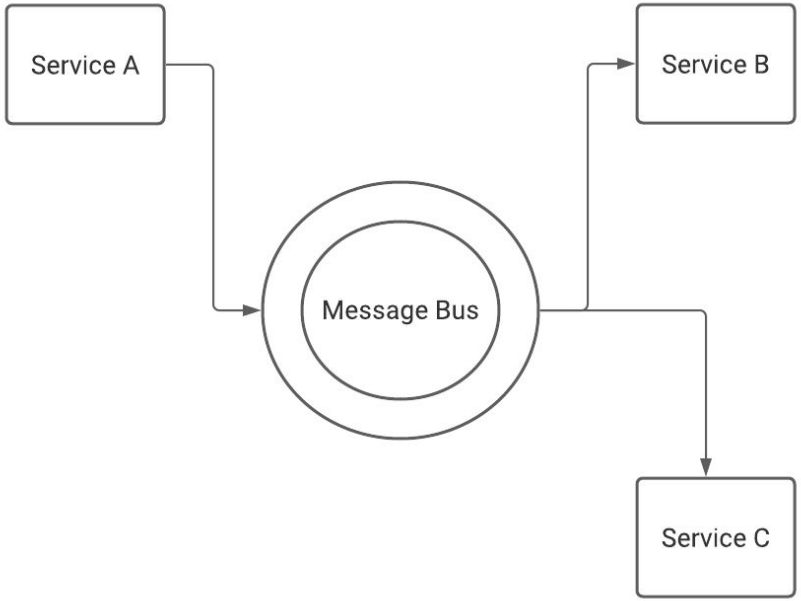
- IBM WebSphere MQ - 1993
- Single Machine Design

Message Oriented Middleware – MQ – Current Design



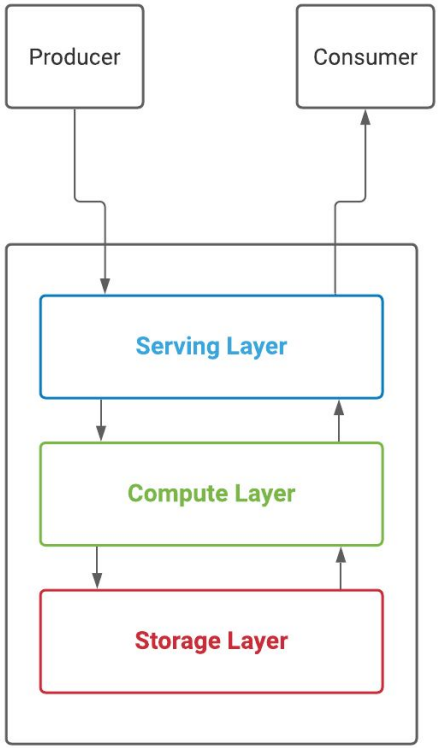
- Clustering allowed the load to be spread across multiple servers instead of just one.
- Each server in the cluster was responsible for handling only a portion of the topics.

Enterprise Message Bus – Message Routing



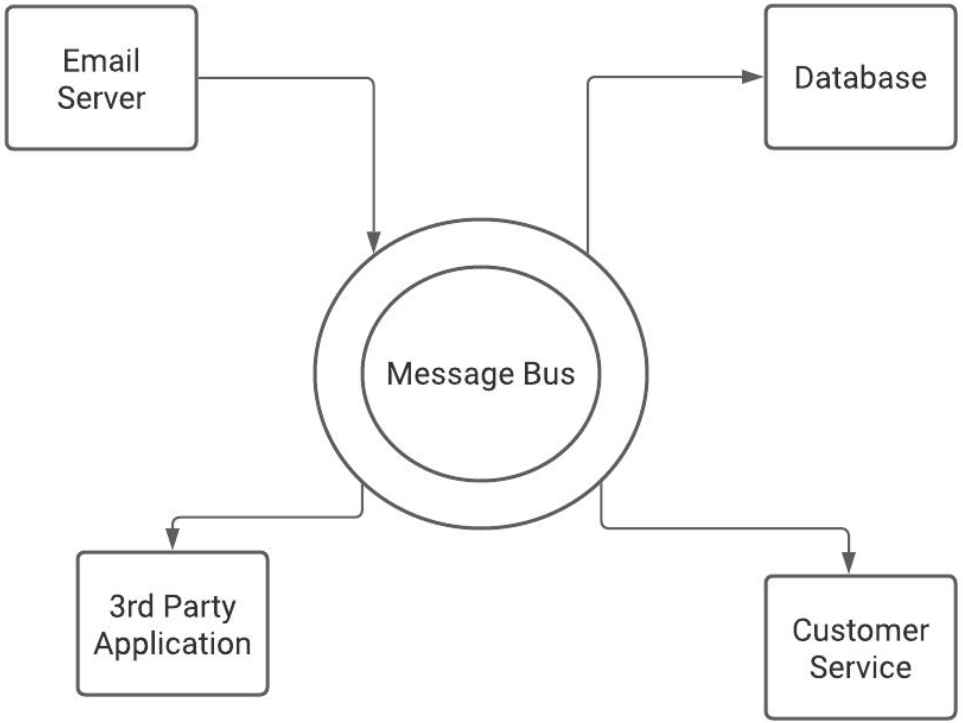
- Designed to eliminate the need for point-to-point communication.
- Service A merely publishes its message to the bus
- Message routed to applications B and C
- Data enrichment and transformations

Enterprise Message Bus – Message Enrichment

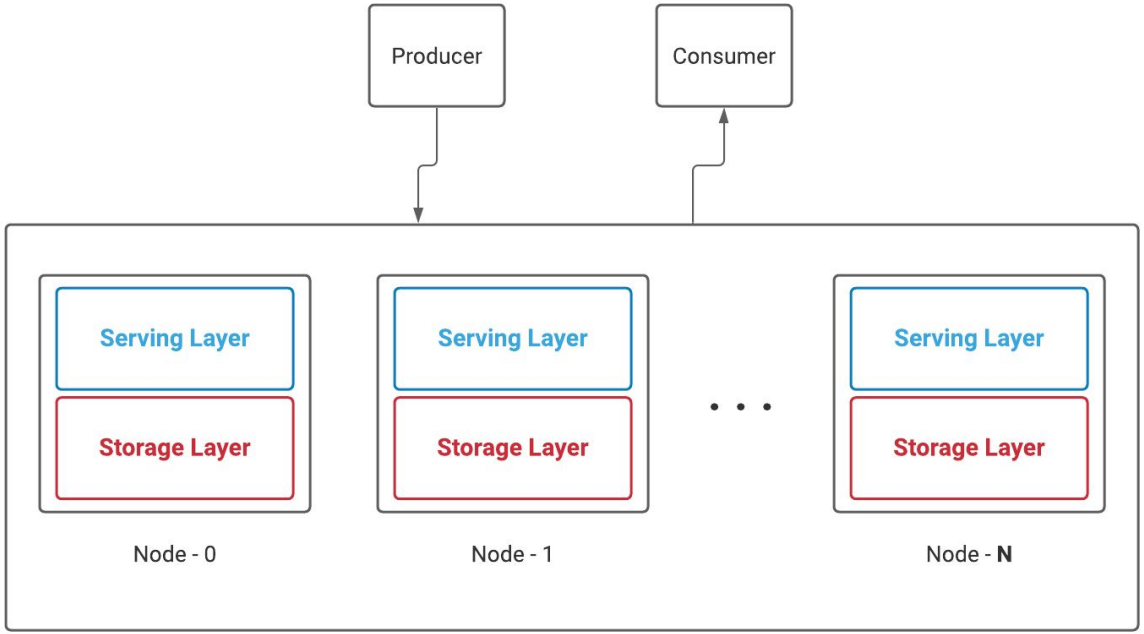


- Dynamic Routing
- Transformation (often via XSLT or XQuery)
- Message Enrichment from other sources
- Message-processing

Enterprise Message Bus – 3rd Party Integration



Distributed Messaging Systems – Kafka

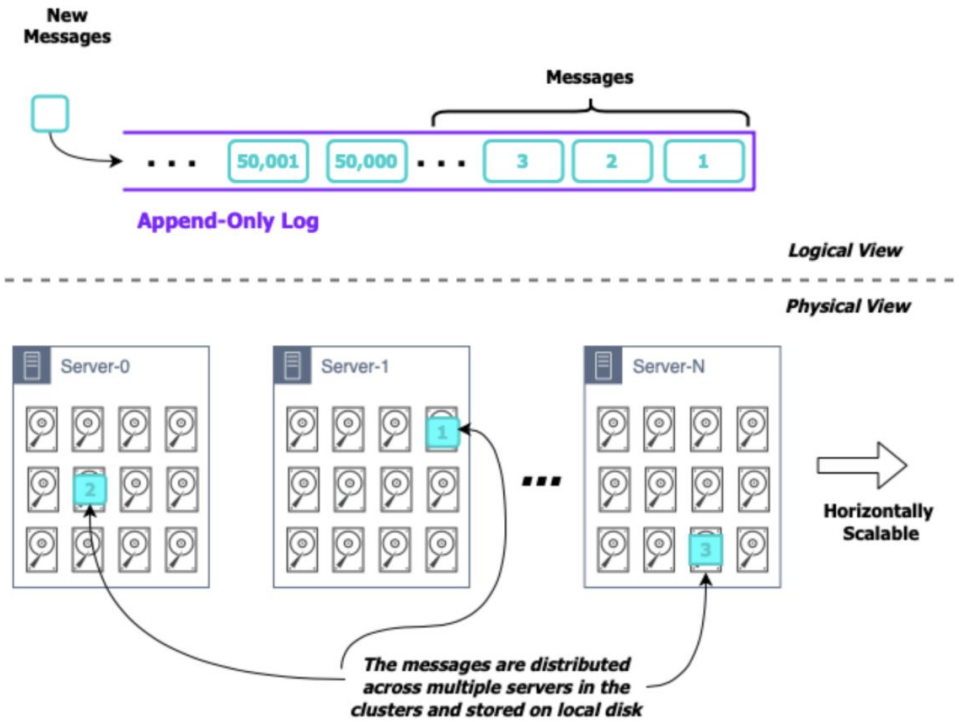


- Each machine should share the messaging load and scale
- Horizontally scalable on commodity hardware
- A single topic is distributed across multiple machines

What is Kafka great for?

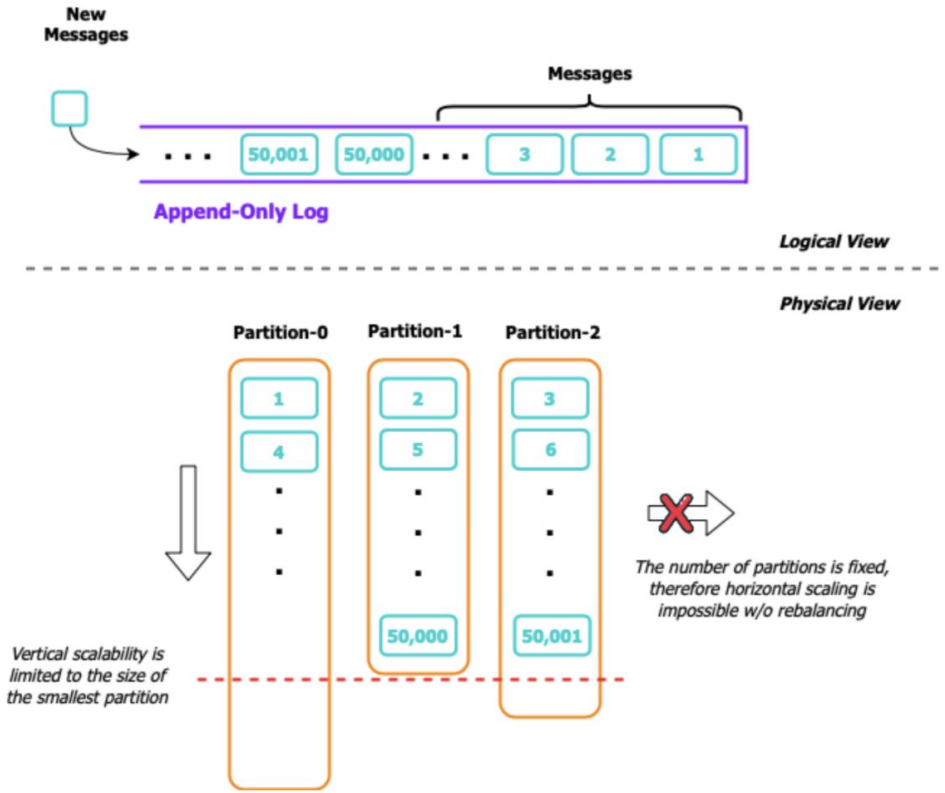
- Streaming
- Distributed commit log
- Huge Scale
- Fast

Distributed Messaging Systems – Kafka



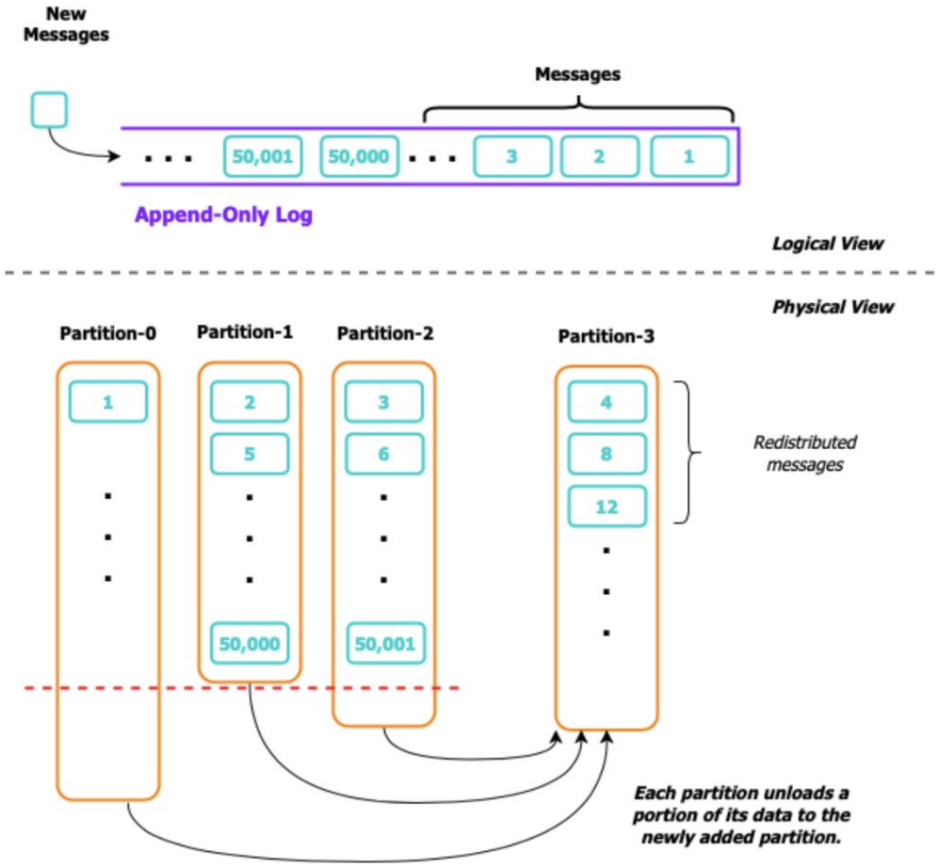
- Append only log
- Messages in a topic stored sequentially
- Distributed Storage

Fixed Partition Size



- Partitions are how Kafka Scales
- By Adding more partitions you can

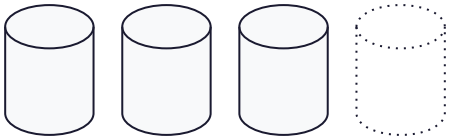
Challenges with Scale



- Adding Partitions to new brokers is an operational nightmare
- A portion of the data from the existing partitions is copied over to the newly added partition(s) in order to free up disk space on the existing nodes.

Problems I ran into with Kafka

Scale



Application Development

- Steep Learning Curve
- Hard to Debug

DataStax

Introduction to Apache Pulsar

Agenda

- Intro and Architecture
- Deployment and Development
- Pulsar Components and Ecosystem
- Message Processing - Core Concepts and Processing Model
- Multi-Tenancy in Pulsar
- Geo-replication In-depth
- Summary and Q&A

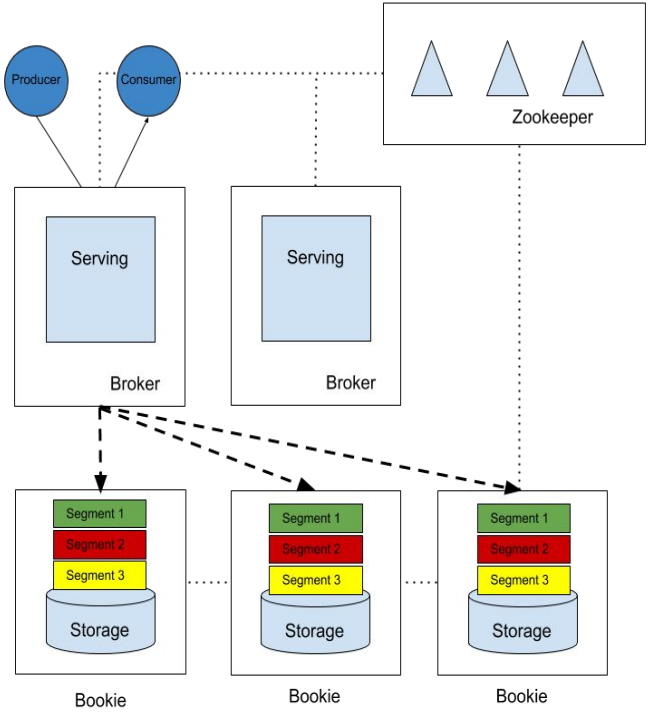
What is Apache Pulsar

- Distributed pub-sub messaging system
  - High throughput, low latency
  - Separates compute from storage
  - Horizontally scalable
  - Streaming and queuing

- Open source
  - Originally developed at Yahoo!
  - Contributed to the Apache Software Foundation (ASF) in 2016
  - Top-level project (2018)
  - 7.2K GitHub stars, over 300 contributors

Architecture

- Distributed, tiered architecture
- Separates compute from storage
- ZooKeeper holds metadata for the cluster
- Stateless Broker handles producers and consumers
- Storage is handled by Apache BookKeeper
  - BookKeeper distributed, append-only log
  - Data is broken into segments written to multiple bookies



Why Apache Pulsar

Four Reasons Why Apache Pulsar is Essential to the Modern Data Stack

- Geo-replication
- Scaling
- Multitenancy
- Queuing (as well as Streaming)

- Cloud Native
  - K8s
  - Multi-cloud, hybrid-cloud

- Performance
  - High throughput
  - Consistent low latency

Deployment and Development

Deployment

- On-prem
- Ansible script
- Docker image
  - OSS image: JDK8
  - DataStax image: JDK11 (more performing)
    - Bug fix + improvements (e.g. enhanced C* sink connector)
- K8s Helm chart
  - OSS and DataStax
- Replicated K8s (DataStax)
- Pulsar-as-a-service
  - Kesque
  - Astra Streaming (future)

Development

- Client APIs
  - Java
  - Python
  - C++
  - Go (C++ wrapper)
  - Native Go
  - Node.js
  - C#
  - WebSocket
- Pulsar Rest API
- Pulsar Admin Rest API
- Community clients
  - .NET
  - Scala
  - Rust
  - HTTP
  - Haskell

Pulsar Components and Ecosystem

Zookeeper

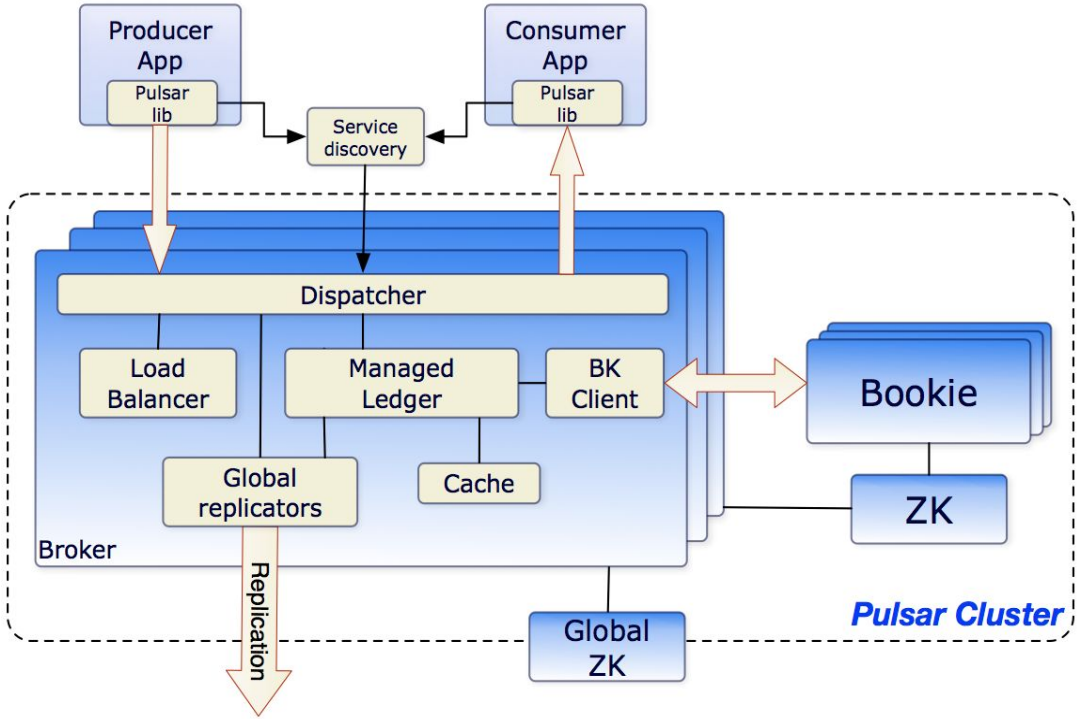
- For metadata storage, cluster configuration, and coordination

- Instance/Global level Zookeeper
  - Geo-replication
  - Configuration for tenants, namespaces, and other entities that need to be globally consistent
  - Optional

- Cluster level Zookeeper
  - Ownership metadata
  - Broker load reports
  - BookKeeper ledger metadata
  - … …

Broker

- Stateless
- Topic ownership
- Load Balancing
- Pulsar's "Brain"
  - HTTP Rest APIs for Admin tasks and topic lookup
  - TCP binary protocol for data transfers



Broker (Topic Ownership), cont'd

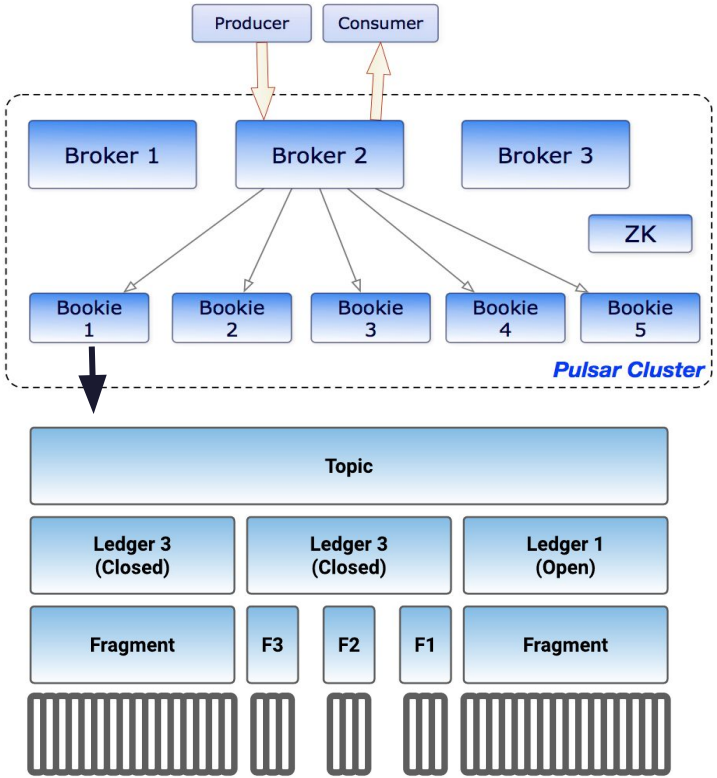
- Stateless broker makes possible of **dynamic assignment**
  - Topic ownership can change on the fly
  - Broker crash
  - Overloaded broker
- Ownership assignment granularity
  - Namespace **bundle** (subset of a namespace)
    - defaultNumberOfNamespaceBundles=4
  - Consistent hashing
    - C* ring

Broker (Load Balancing), cont'd

- Unload topics and bundles
  - Triggers topic re-assignment based on the current workload
  - Automatic or manual
- Bundle Split
  - Tunable thresholds
  - Automatically triggers topics unloading
- Automatic Load Shedding
  - Forces topics unloading from overloaded brokers
  - Enabled by default and can be disabled

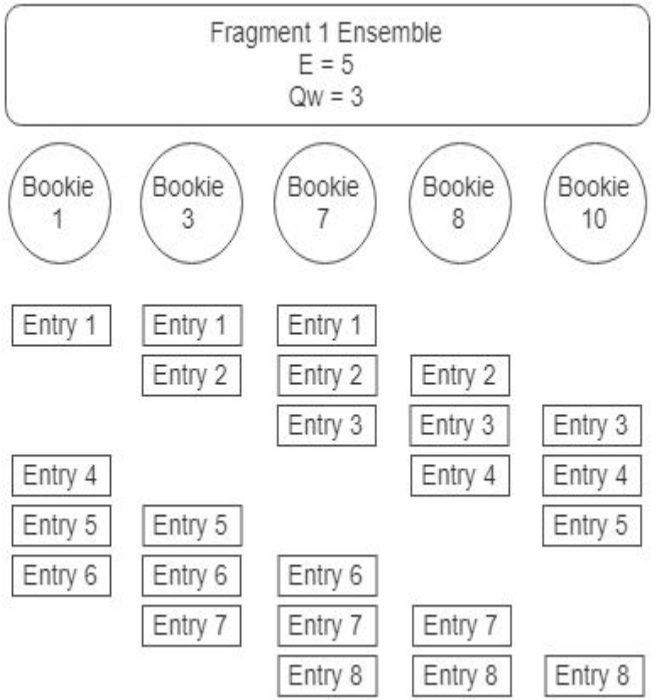
Bookkeeper (Bookie)

- Managed ledger (Topic)
  - Logical abstraction
  - A stream of ledgers
- A Ledger is created when:
  - A new topic is created, or
  - Roll-over occurs (size/time limit, ownership change)
- Append only
  - Read only after closed
- Fragments and Entries



Bookkeeper (Bookie), cont'd

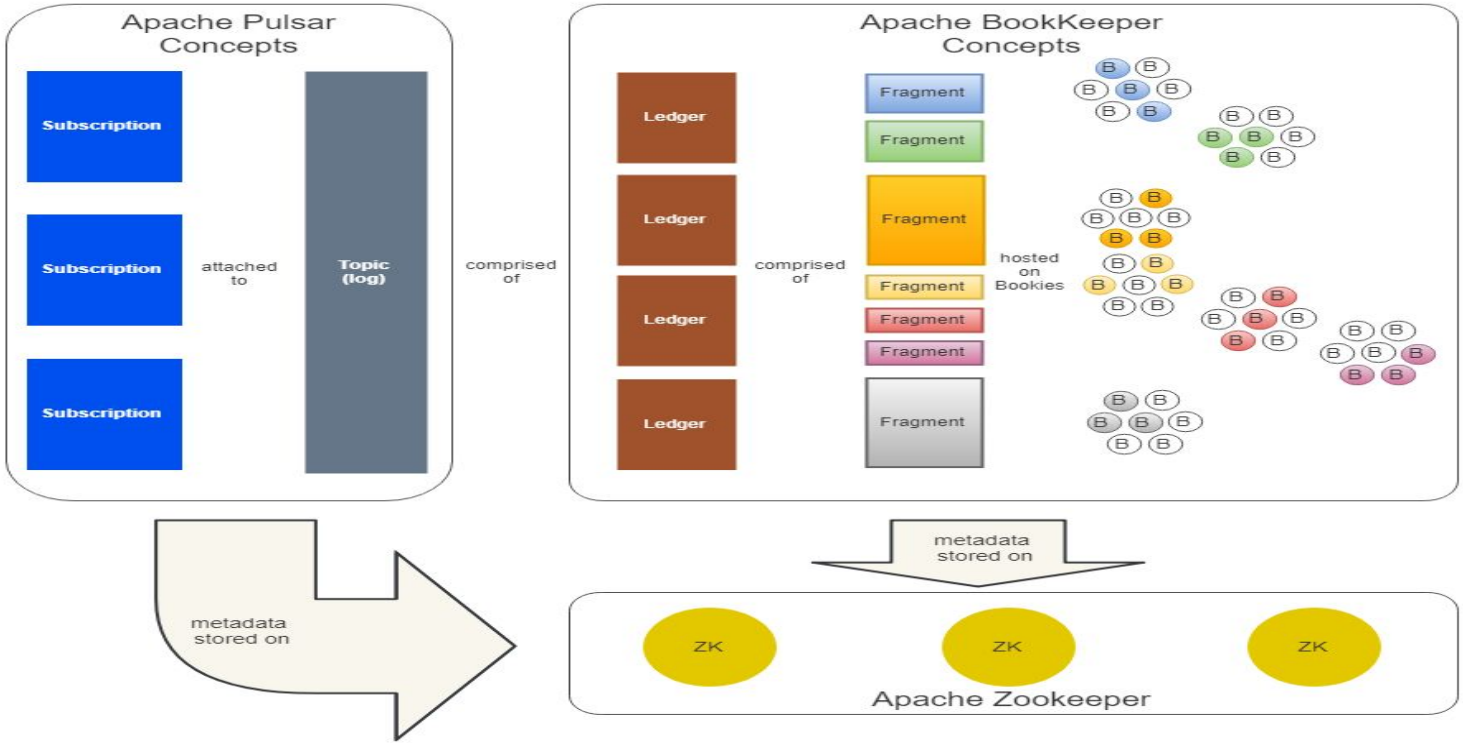
- Key Configuration
  - Ensemble Size (E)
    - The size of the pool of Bookies available for writes
  - Write Quorum Size (Qw)
    - The number of actual Bookies that Pulsar will write an entry to
  - Ack Quorum Size (Qa)
    - The number of Bookies that must acknowledge the write
- Rack-awareness
- WAL Journal
  - Seperate Journal and Ledger disks



Bookkeeper (Bookie), cont'd

- Bookie Recovery
  - The process of "replicating" fragments to ensure the replication factor (Qw) is maintained for each ledger.
  - Manual recovery
    - bin/bookkeeper shell recover <failed_bookie_ip_port>
  - Automatic recovery
    - Detects failed bookie automatically
    - Replicates all the ledgers that were stored on that bookie.
  - Dedicated recovery hosts or sharing the same bookie hosts

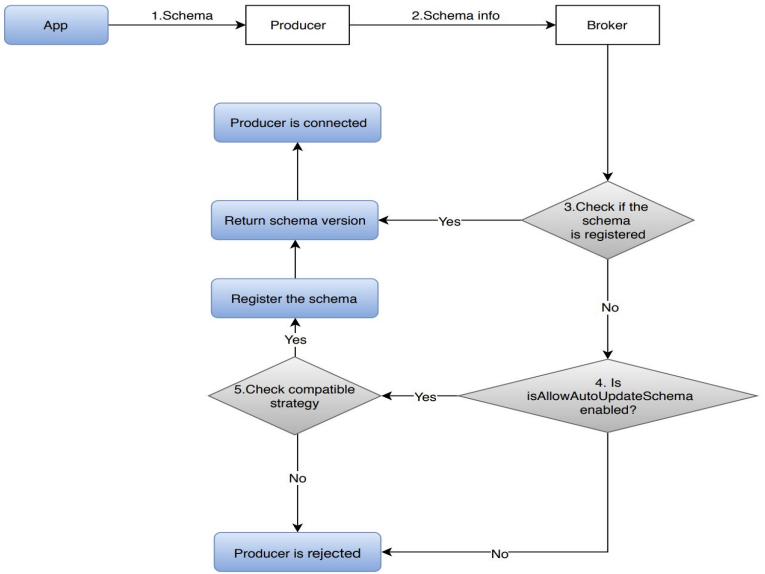
Put all Together



Other Components and Ecosystem

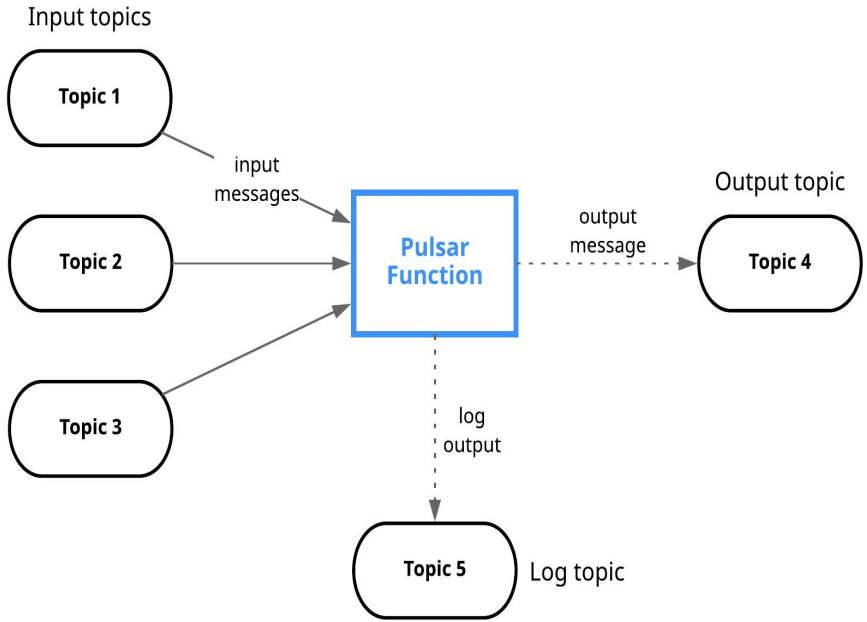
- Pulsar Proxy
  - Internal “gateway” to brokers
  - No direct connection to broker
  - K8s deployment

- Pulsar Schema
  - Built-in schema registry
  - Schema type
    - Primitive
    - Key/value pair
    - Avro, JSON, Protobuf
  - Schema evolution
    - Version
    - Compatibility
  - Schema Management
    - Automatic
    - Manual



Other Components and Ecosystem, cont'd

- Pulsar Function
  - Allows complex streaming processing
  - Light-weight
  - Function-as-a-service (AWS Lambda, Google Function, …)
  - Main languages:
    - Java
    - Python
    - Go

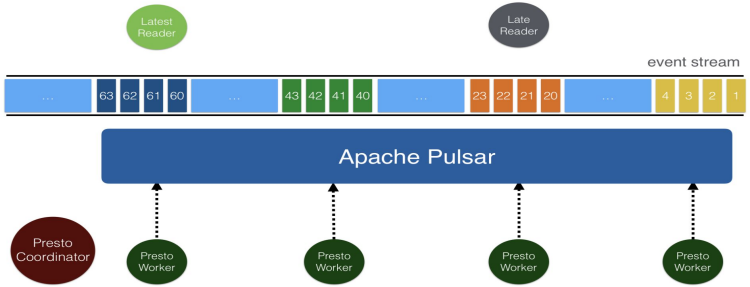


Other Components and Ecosystem, cont'd

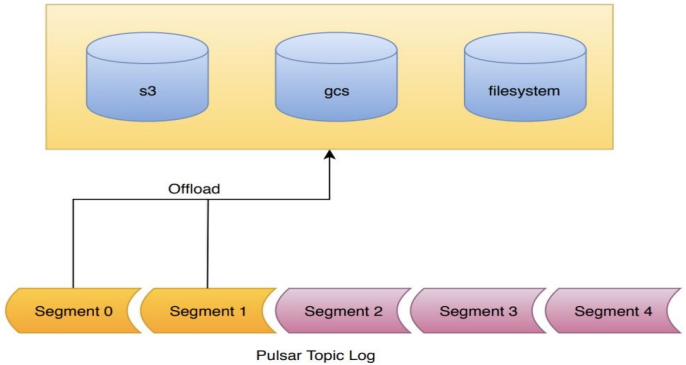
- Pulsar I/O
  - Source Connectors
  - Sink Connectors
- Built-in Source Connector
  - RDBMS
  - Kafka (**DataStax Enhanced version**)
  - Kinesis
  - … …
- Built-in Sink Connector
  - ElasticSearch
  - Cassandra (**DataStax Enhanced Version**)
  - MongoDB
  - RDBMS
  - … …
- CDC Connector
  - Canal
  - Debezium (MySQL, PostgreSQL, MongoDB)
- Custom I/O Connector through API

Other Components and Ecosystem, cont'd

- Pulsar SQL
  - Through Presto (now called Trino)
  - Presto Pulsar Connector
    - ${project.root}/conf/presto/catalog/pulsar.properties



- Tiered Storage
  - Pulsar is tiered (compute and storage)
  - Further tier in storage
    - AWS S3 offloader
    - GCS offloader
    - File system offloader
    - Azure blob offloader
  - Transparent to client
  - Can be configured to run automatically or manually

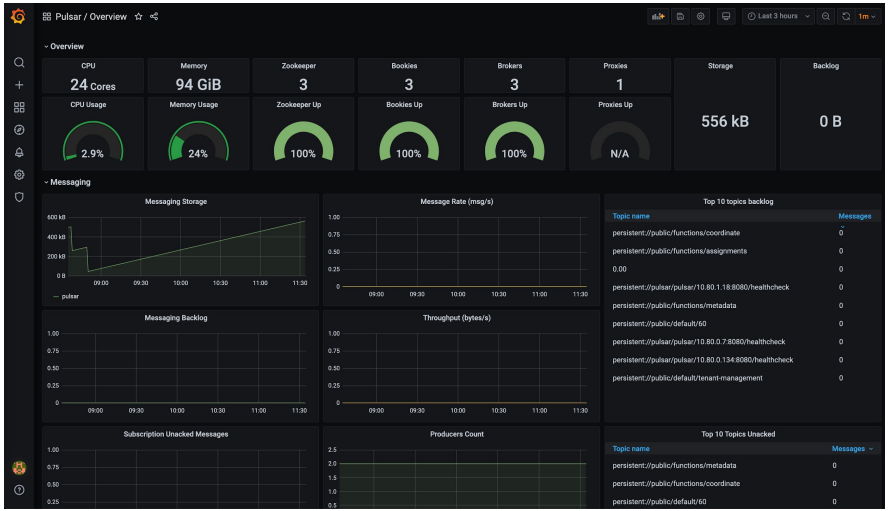


Other Components and Ecosystem, cont'd

- Security
  - Pluggable Authentication
    - Certificate based authentication
    - JWT token based authentication
    - Authenz
    - Kerberos
    - OAuth 2.0
  - Pluggable Authorization
    - Role based ("role token")
    - Authenz
    - Internal
  - TLS encryption
    - Traffic encryption
      - Between clients (producers/consumers) and Pulsar
      - Among Pulsar components
    - Message encryption (outside Pulsar)
      - End-to-end encryption
      - Volume based encryption

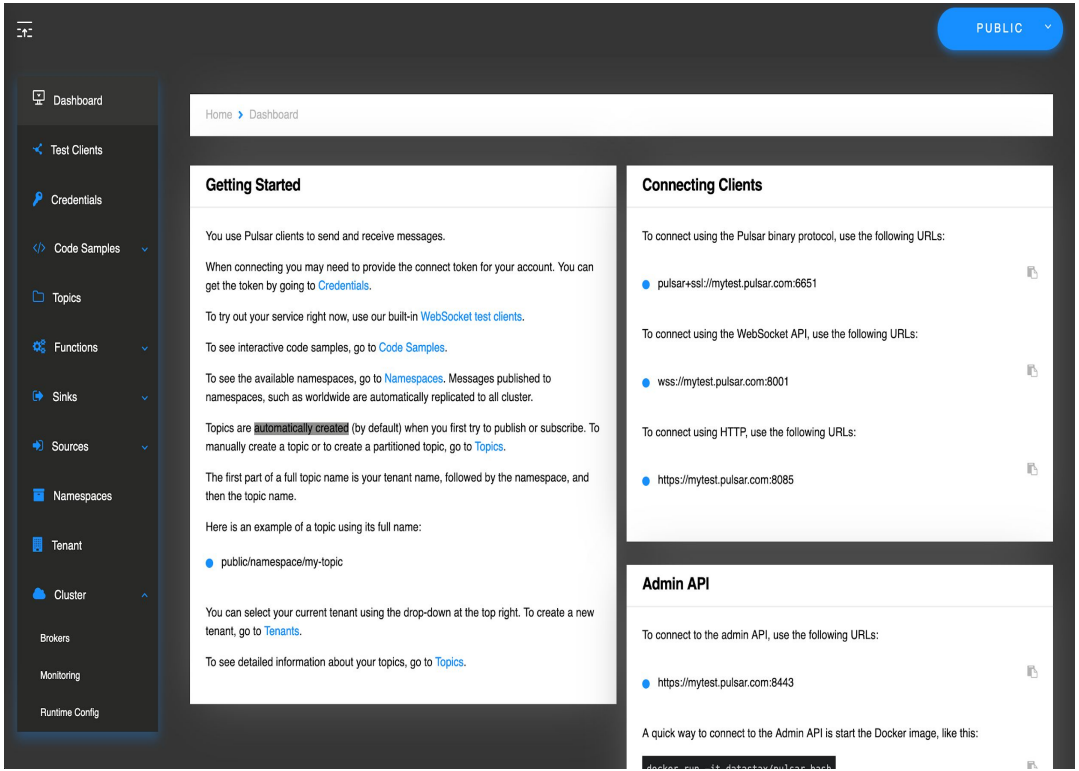
Other Components and Ecosystem, cont'd

- Metrics Monitoring
  - Expose metrics in **prometheus** format
    - "/metrics" at different ports (e.g. 8080 for broker, 8000 for zookeeper, etc.)
  - Pulsar Helm chart (for K8s) has embedded Prometheus and Grafana components
    - Built-in dashboards
  - Prometheus Alert-manager



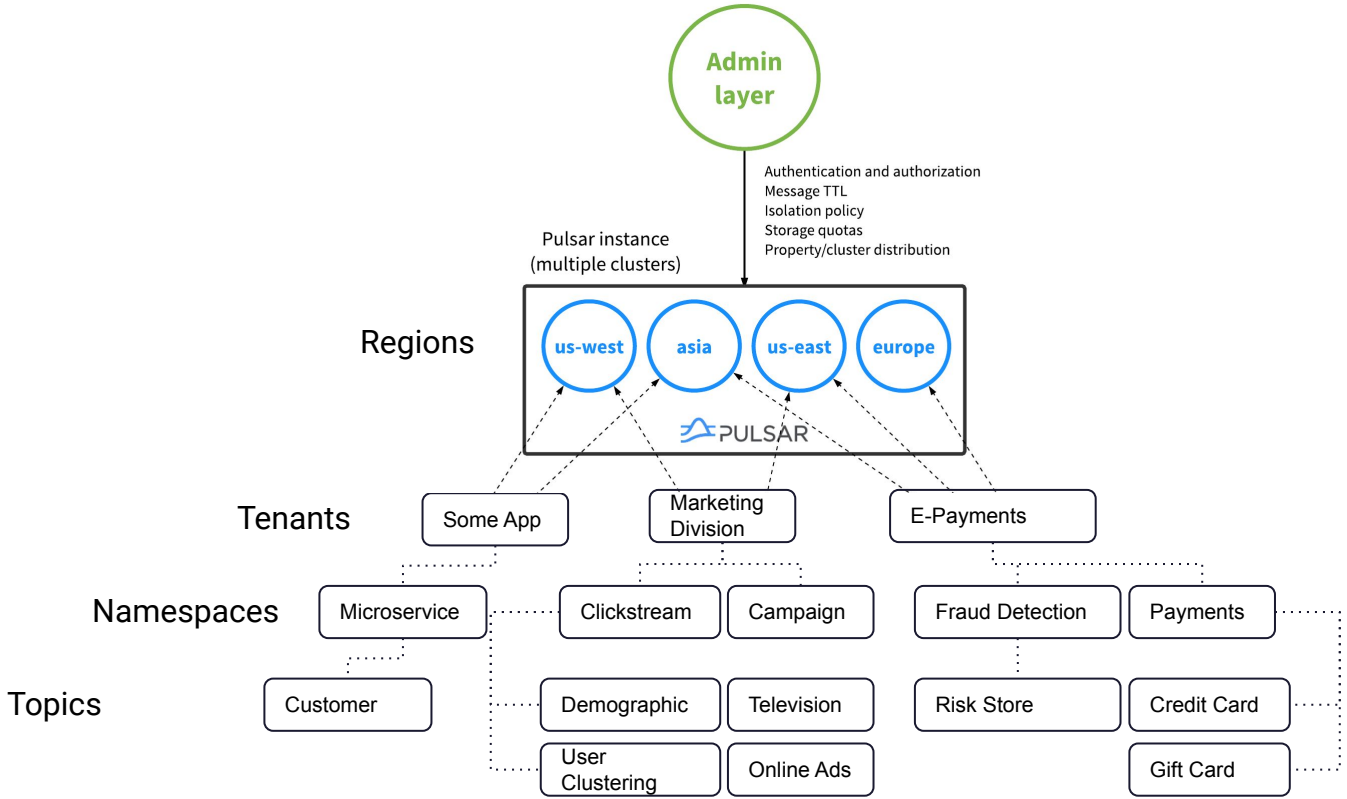
Other Components and Ecosystem, cont'd

- Pulsar Admin Console (DataStax)
- Pulsar Manager
  - Web based Pulsar cluster management tool
  - Able to manage multiple environments
- Admin CLI tools
  - Pulsar-admin
  - Pulsar-client
  - Pulsar-perf
  - … …



Multi-Tenancy in Pulsar

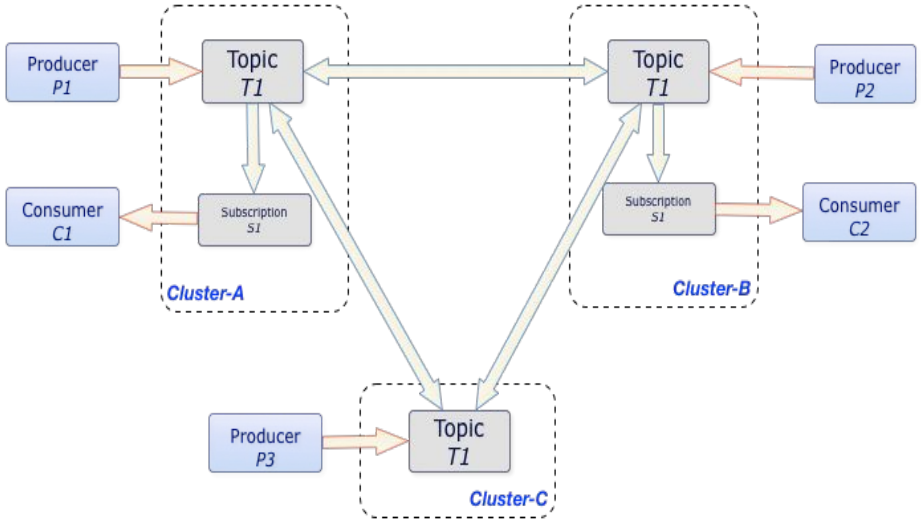
Multi-Tenancy



Geo-replication in Depth

Geo-Replication

- Per-tenant basis
  - Only when a tenant has access to both clusters
- Enabled at namespace-level
  - Assign clusters to namespace
- Replicated Subscription
  - Keep subscription state in sync
  - Consumer failover to another cluster and resume from the failure point
  - Sub-second delay and possible duplicates



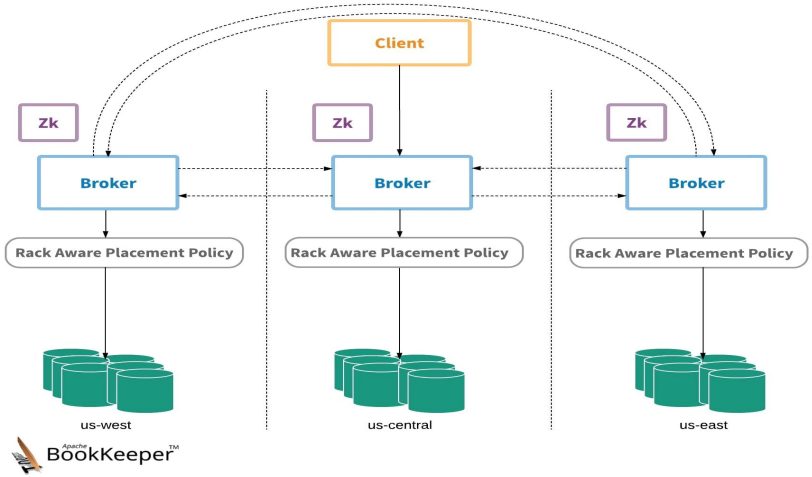
Geo-Replication, cont'd

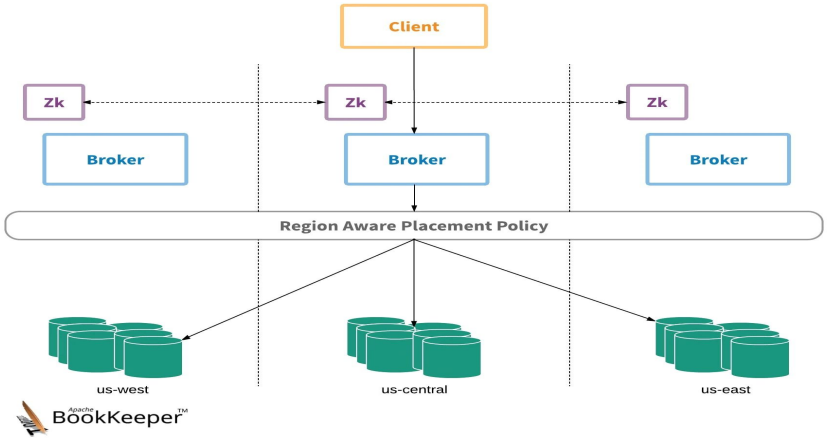
- Geo-replication
  - Local acknowledgement
- Synchronous Geo-replication
  - Global acknowledgement
  - Rack-awareness Policy
- Selective Geo-replication per message

```
List<String> restrictDatacenters =
Lists.newArrayList("apac-australia");

Message message = MessageBuilder.create()
        …
        .setReplicationClusters(restrictDatacenters)
        .build();

producer.send(message);
```





Geo-Replication, cont'd

- Asynchronous Geo-replication pattern
  - Active-active
  - Active-standby
  - Aggregated replication
    - Edge computing
- Monitor replication statistics
  - Replication backlog
- Throttle replication