FaBRiQ: Fast, Balanced and Reliable Queue

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Outline

- Kafka
- SQS
- Fabriq
  - Motivation
  - Design
  - features
  - Communication cost analysis
- Performance evaluation

Kafka

Motivation

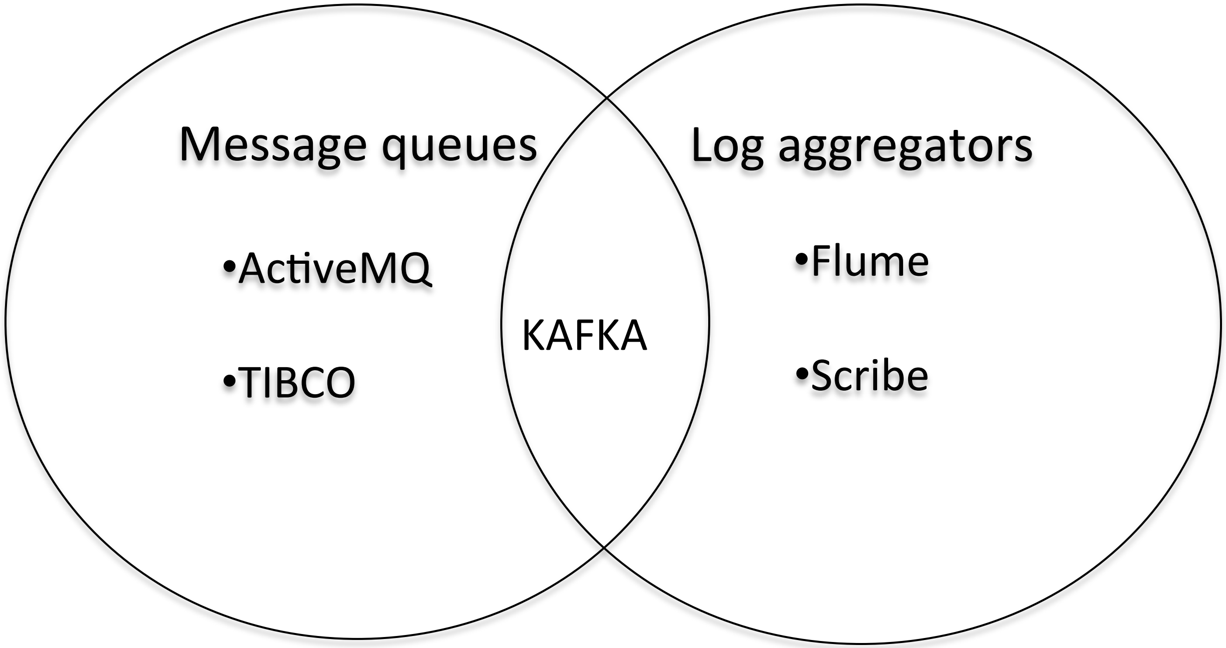
- Log Data
  - Orders of Magnitude larger than the actual data
  - Facebook 5TB daily
  - China Mobile 5-8 TB daily
- Many types of events
  - user activity events: impression, search, ads, etc
  - operational events: call stack, service metrics, etc
- High volume: billions of events per day
- Both online and offline use case
  - reporting, batch analysis
  - security, news feeds, performance dashboard

Solution!

- Traditional Messaging Systems
  - JMS
    - Acknowledge after msg consumption
    - Weak distributed support
    - No batching
  - IBM WebSphere MQ
    - Provides transactional support!
  - ActiveMQ
- Assuming msgs should be consumed real quick
- No offline support
- No focus on throughput

Log Aggregators

- Collect data and load into DWH or Hadoop
  - Facebook Scribe
    - Periodically dumps bunch to HDFS
  - Cloudera Flume
    - Uses push approach
  - Yahoo Data Highway
- Problem
  - All for offline data consumption
  - No online consumption support



- Low throughput
- Secondary indexes
- Tuned for low latency

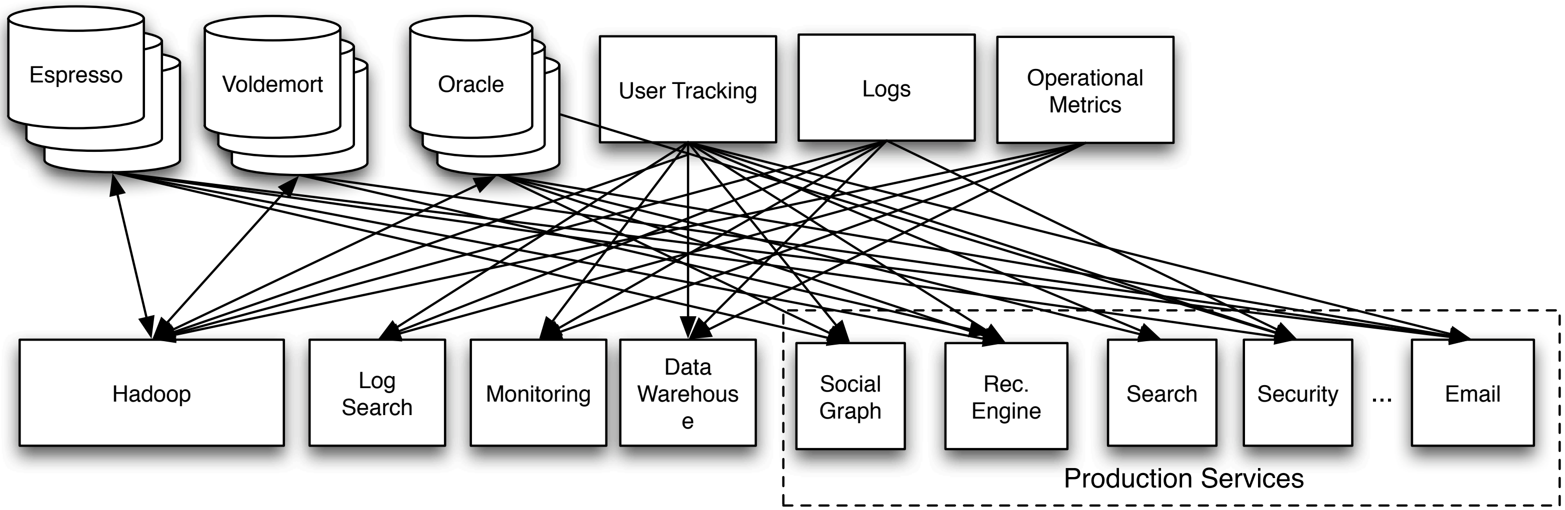
- Focus on HDFS
- Push model
- No rewindable consumption

Kafka

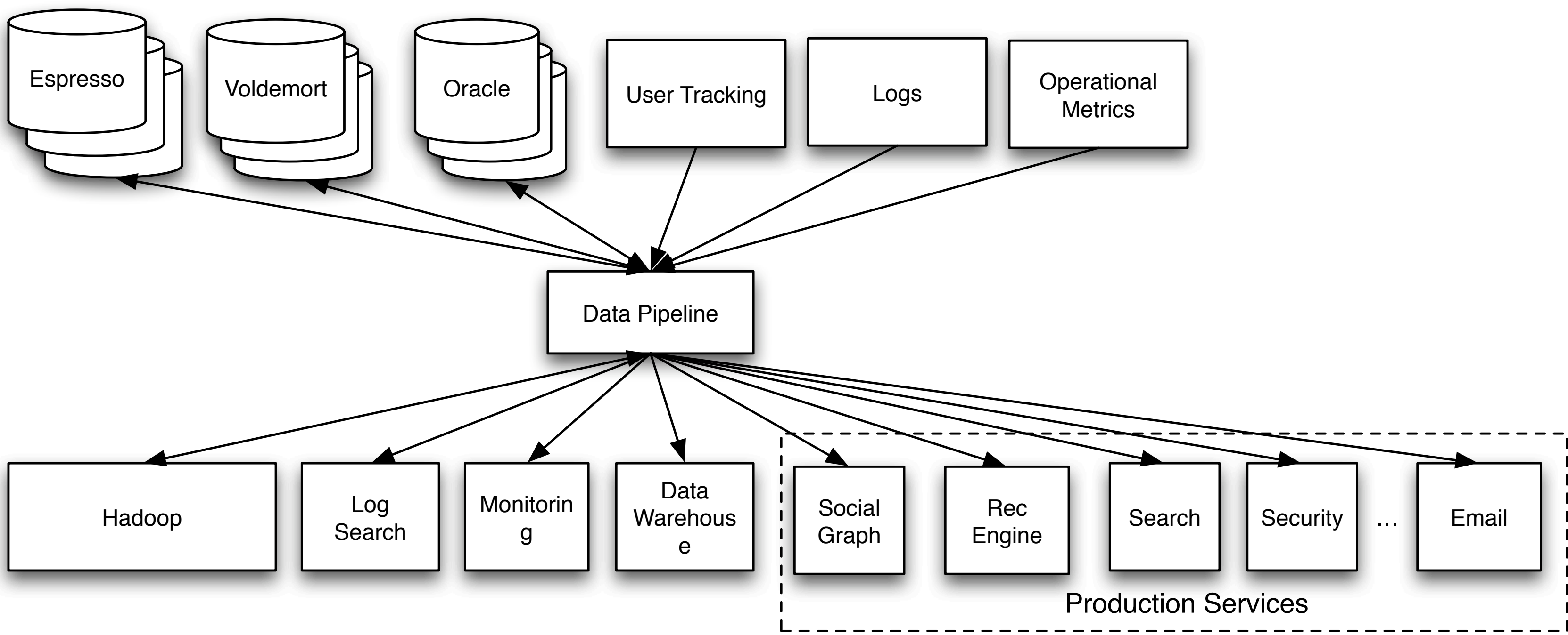
- Collect and deliver high volumes of large data
- Low latency
- Scalable

Design

- Problem: point to point pipelines!!

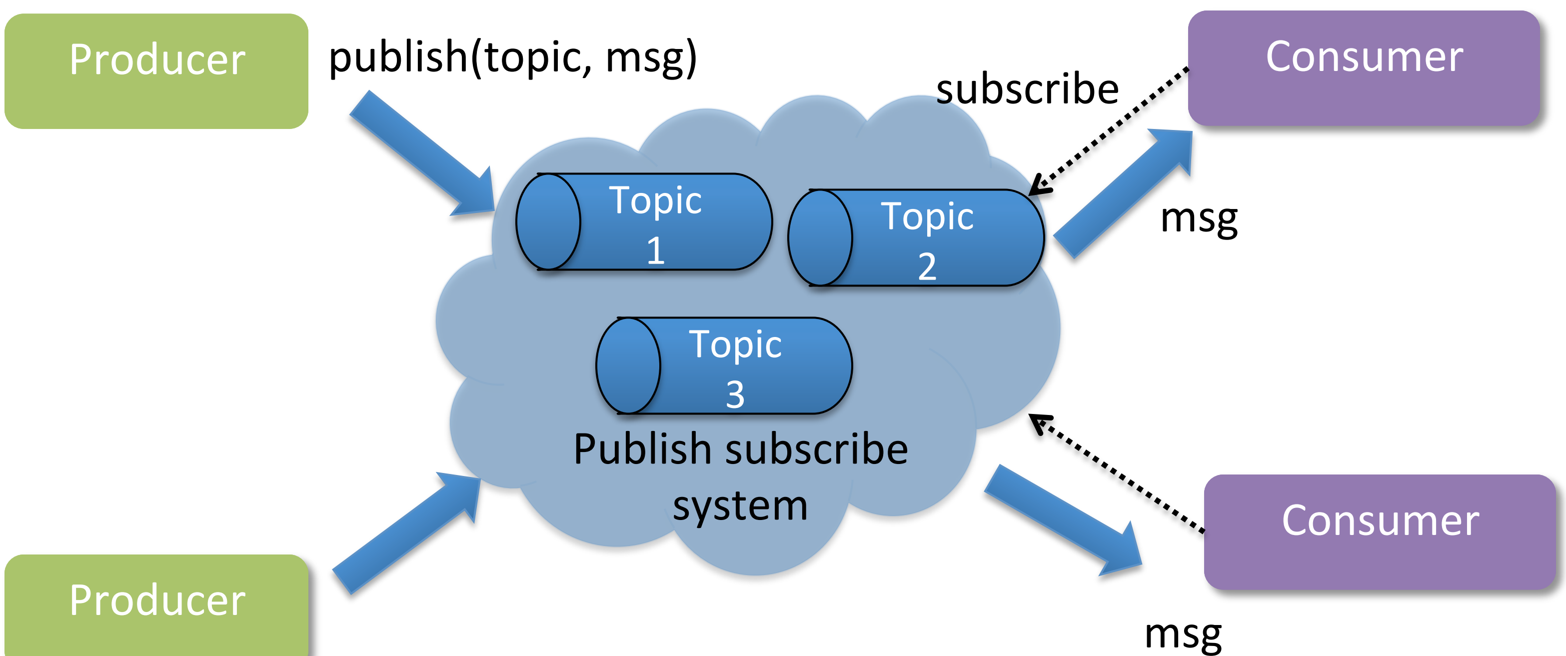


Design



Espresso
Voldemort
Oracle
User Tracking
Logs
Operational Metrics
Data Pipeline
Hadoop
Log Search
Monitorin g
Data Warehous e
Social Graph
Rec Engine
Search
Security
...
Email
Production Services

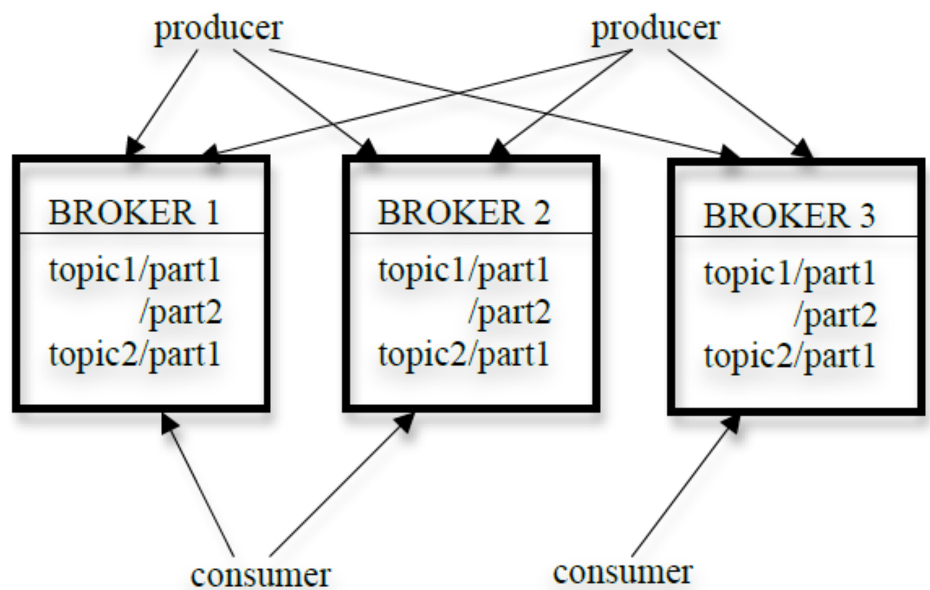
Pub-Sub



Producer
publish(topic, msg)
Producer
Topic
1
Topic
2
Topic
3
Publish subscribe
system
subscribe
Consumer
msg
Consumer
msg

Design

- Producer, Consumer
- Broker
- Topic, Partition
- Load balance



Efficiency

- No message IDs
  - Logical offset
- Consumer consumes msgs from a Partition sequentially (starting on an offset)
- Single partition in a topic
  - Only used by single consumer
- No Master
  - Consumers and brokers coordinate via ZooKeeper

Stateless Broker

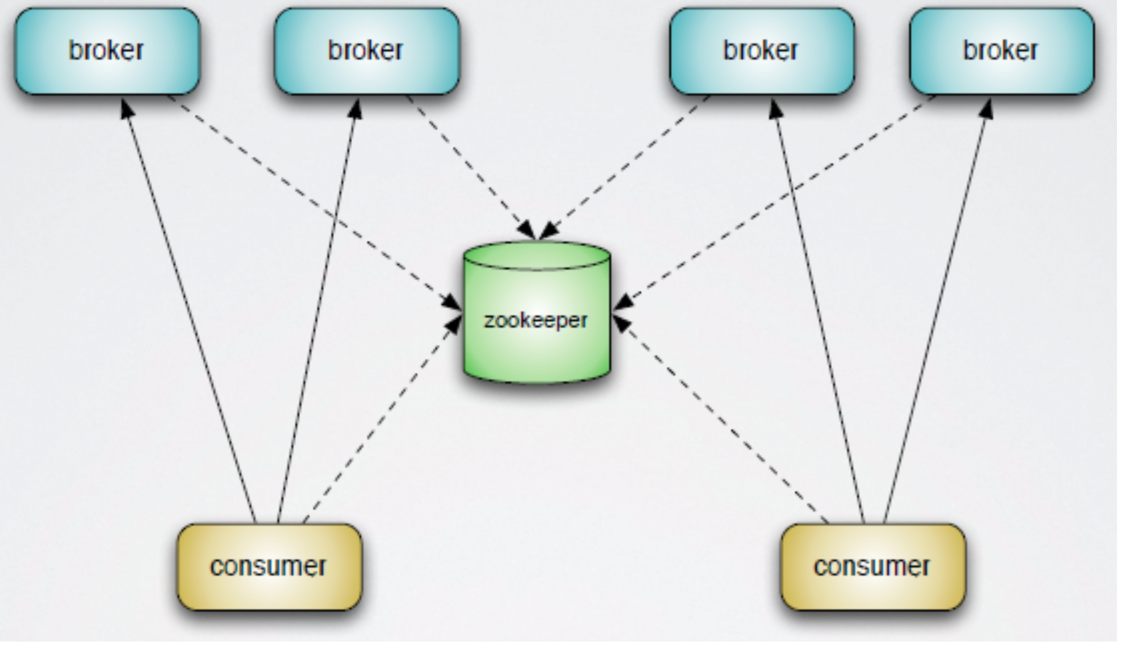
- Broker doesn't keep track of consumption
- Each consumer maintains its own state
- Message deletion driven by retention policy, not by tracking consumption
  - rewindable consumer

ZooKeeper

- Create a path
- Set value to path
- Read value on path
- Delete path
- Get notifications on a path
- Provides replication

Auto Consumer Load Balance

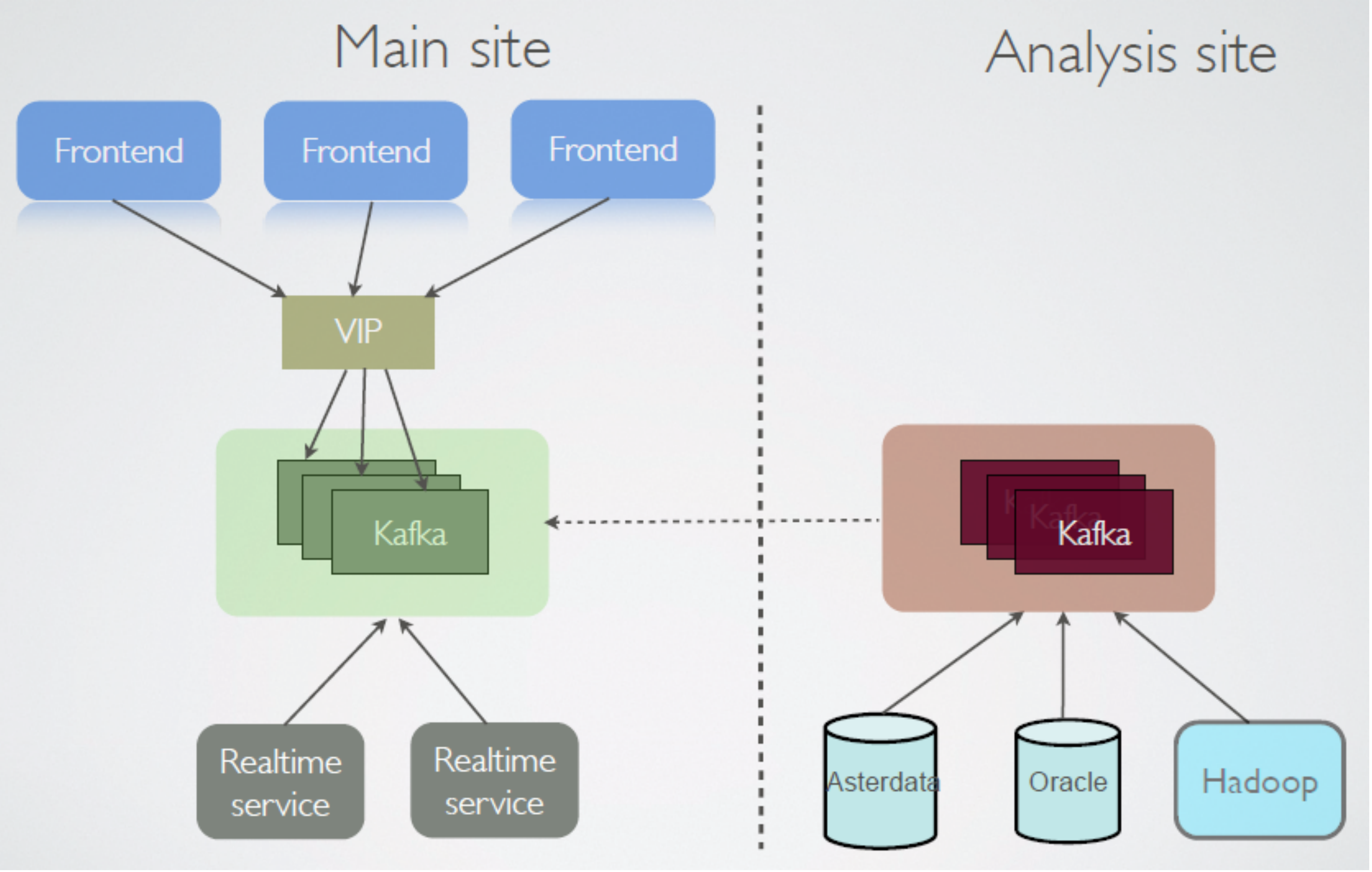
- brokers and consumers register in zookeeper
- consumers listen to broker and consumer changes
- each change triggers consumer rebalancing



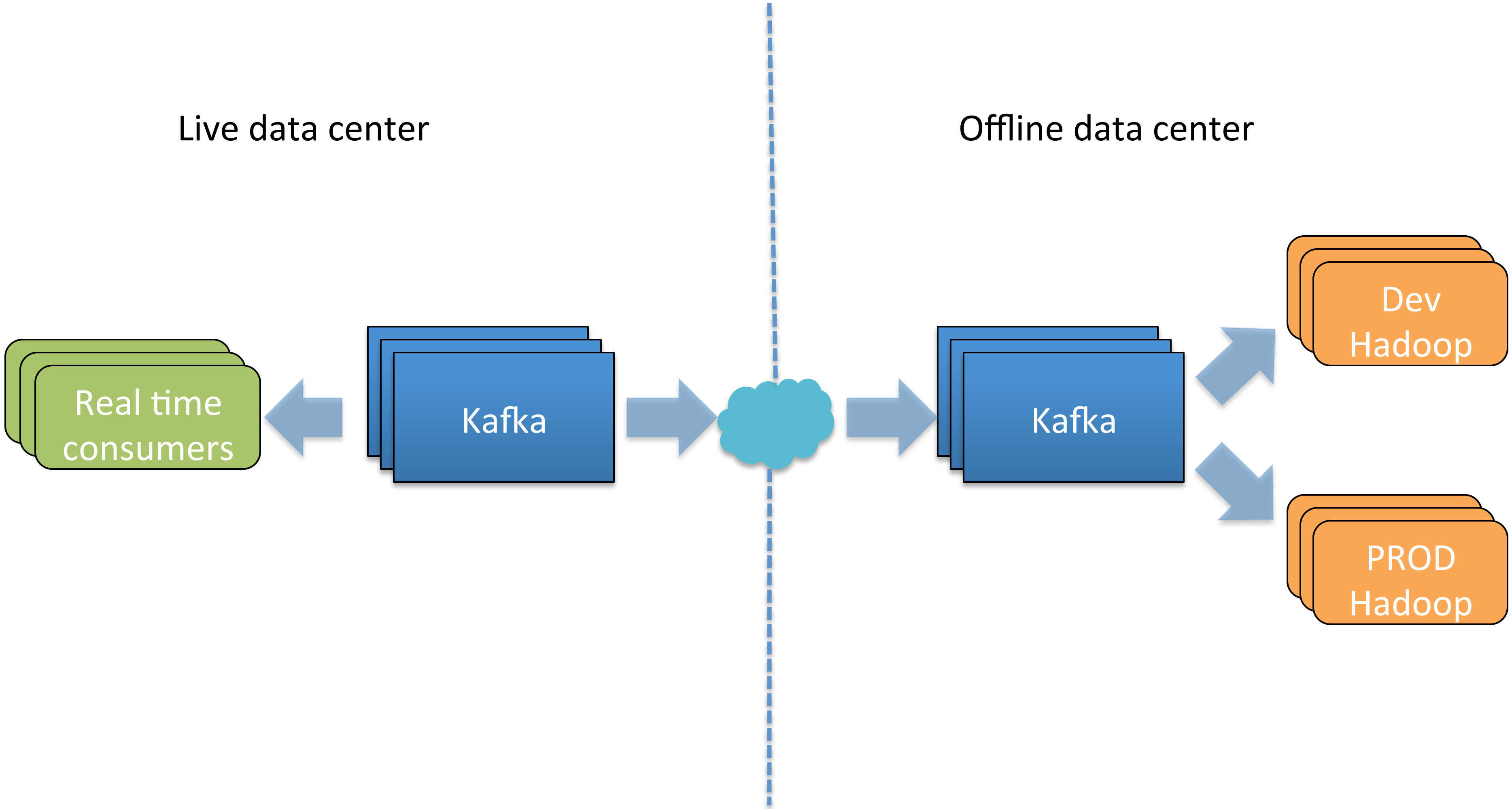
Guarantees

- At least once delivery
- In order delivery, inside a single partition
- No guarantee on order from diff partitions
- No support for duplicated messages
- Persistence
  - If broker goes down
    - msgs temp unavailable
  - If broker disk damaged
    - Msgs lost permanently

Usage in LinkedIn



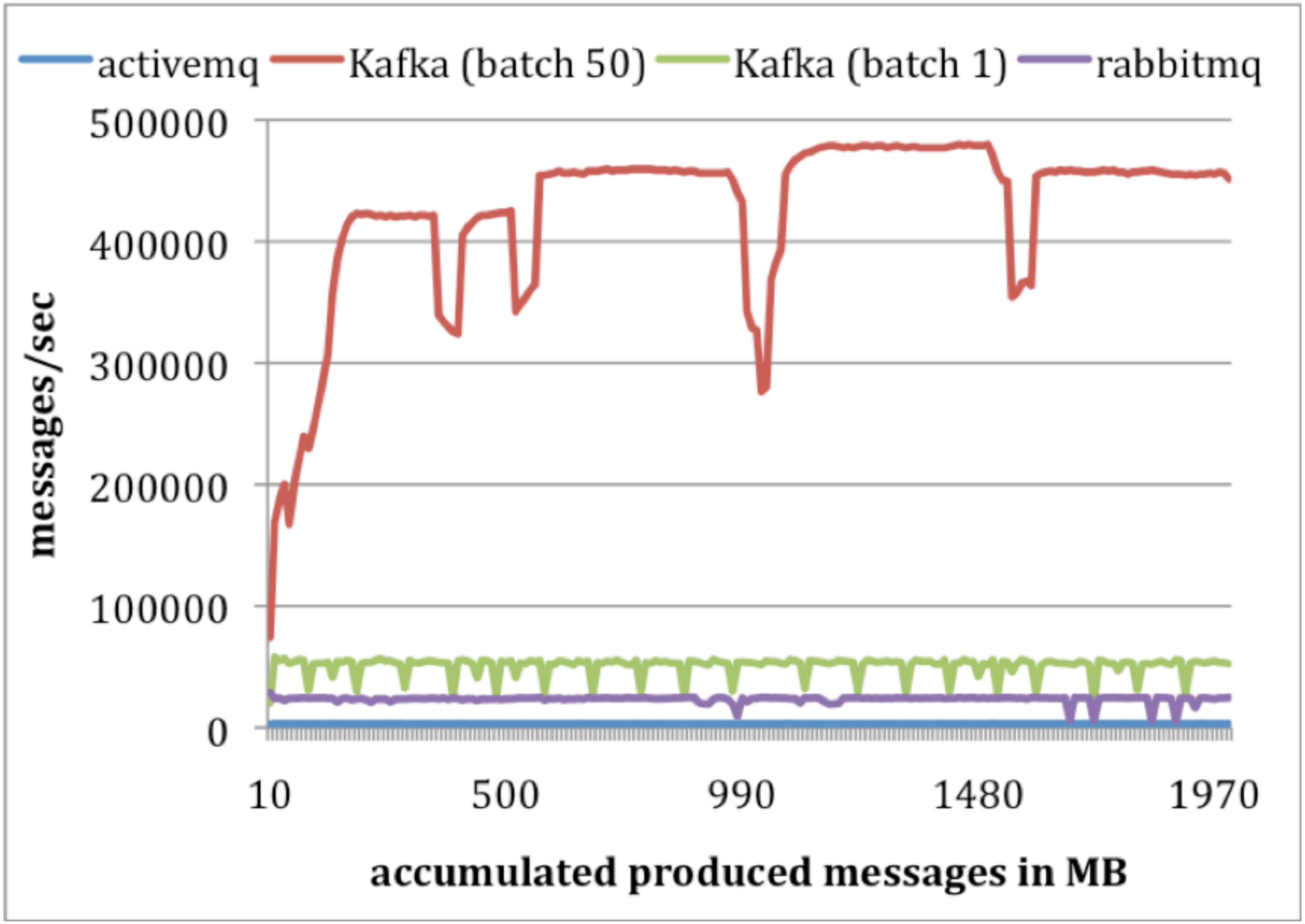
Hadoop Data Load for Kafka



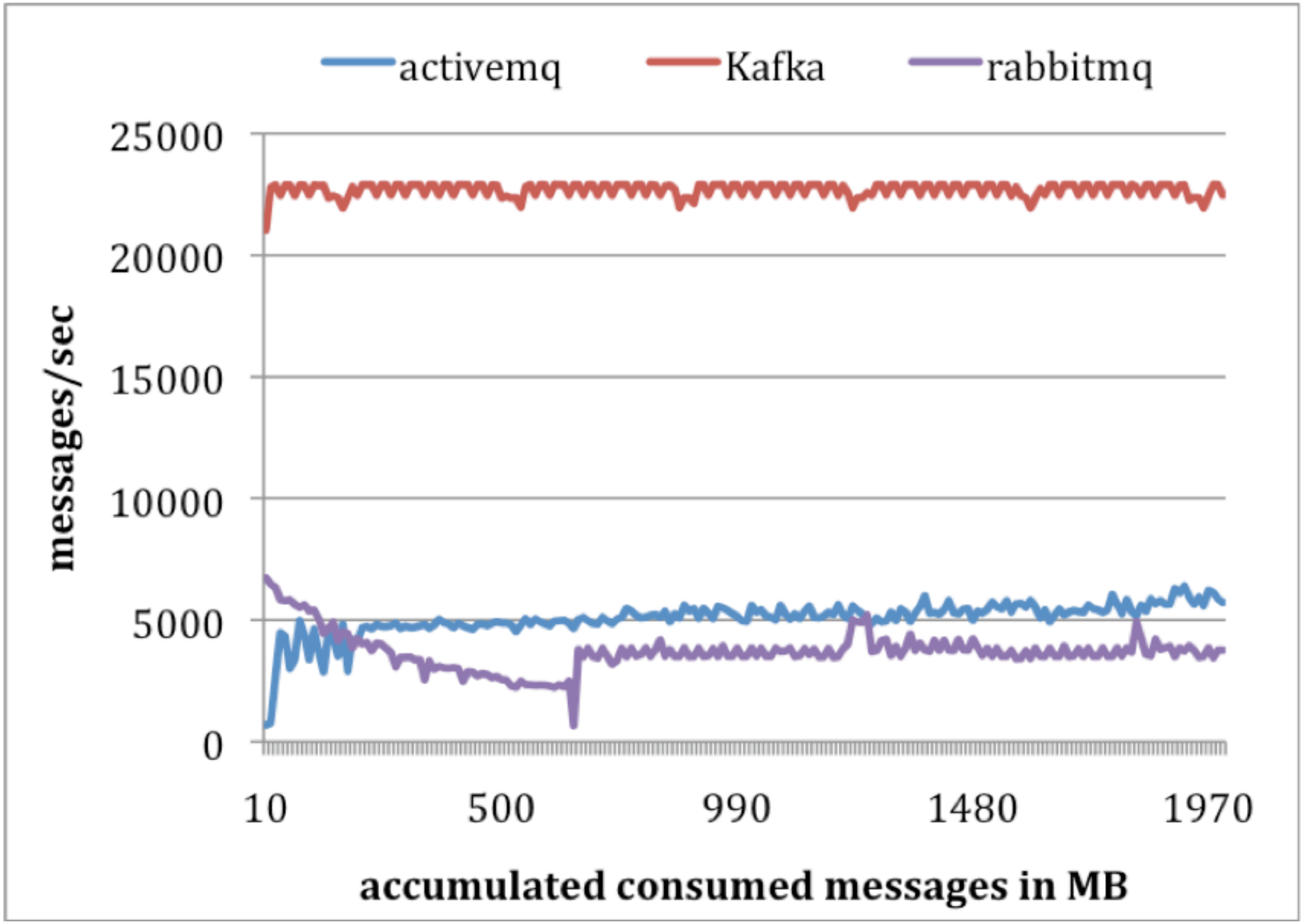
Performance Evaluation

- 2 Linux boxes
  - 16 2.0 GHz cores
  - 6 7200 rpm SATA drive RAID 10
  - 24GB memory
  - 1Gb network link
- 200 byte messages
- 10 million msgs in total
- Batch size:
  - 1: 50K msgs/sec
  - 50: 400K msgs/sec

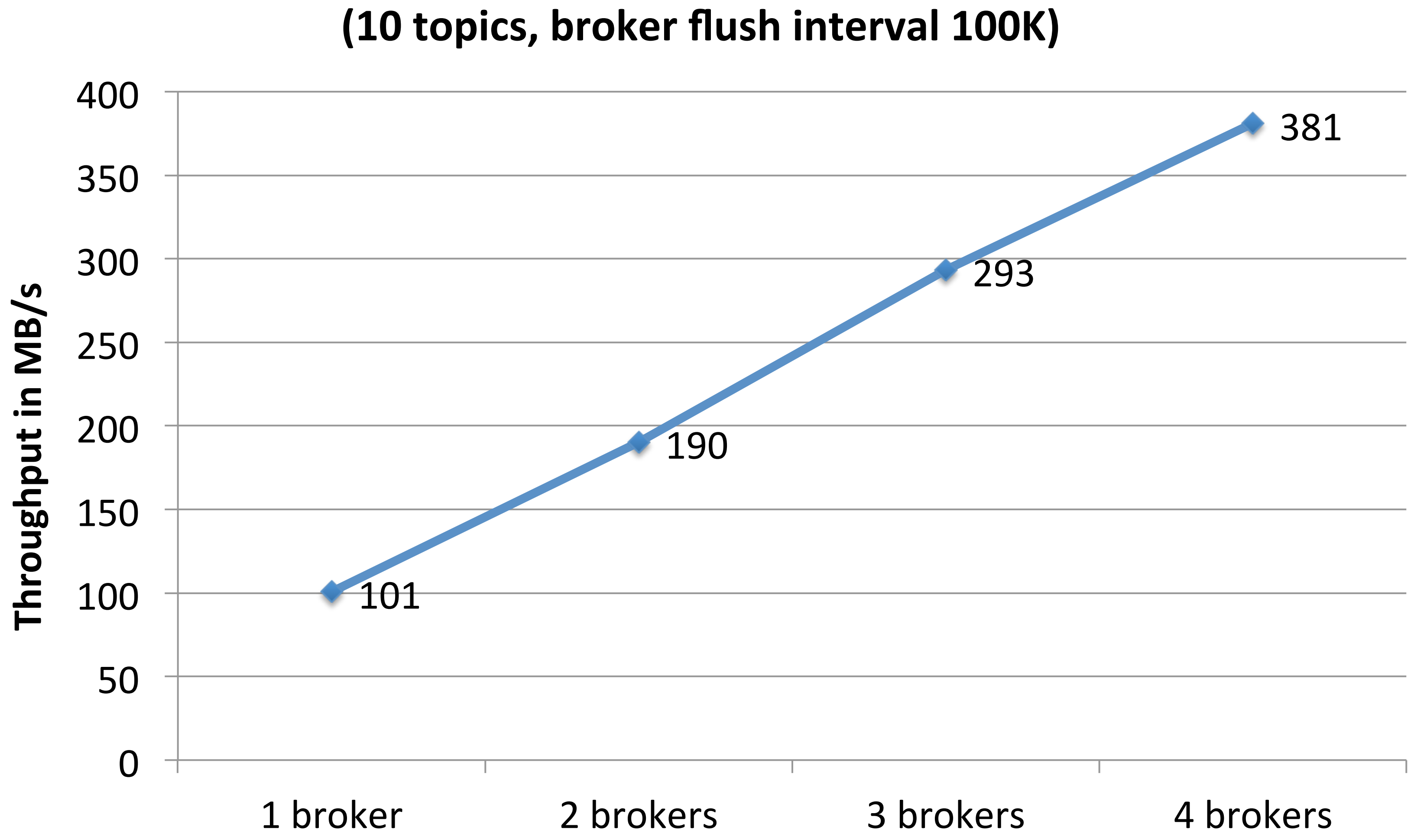
Producer performance



Consumer performance



Scalability



SQS

- Amazon Simple Queue Service (SQS)
  - Distributed message delivery queue
    - Highly scalable
    - Messages sent and read simultaneously
    - Reliable
      - Guarantees message delivery
        - » <u>At least</u> once delivery

Outline

- Kafka
- SQS
- **Fabriq**
  - Motivation
  - Design
  - features
  - Communication cost analysis
- Performance evaluation

Motivation

- More than 2.5 exabytes of data is generated every day
  - more than %70 of it is unstructured
- not possible for the traditional data processing systems to handle needs in Big Data processing.
  - There is a need to reinvent the wheel instead of using the traditional systems
- Traditional data processing middleware being replaced:
  - SQL databases by No-SQL datastores
  - file system by key-value storage systems

Motivation

- A Distributed message queue
- useful in various data movement and communication scenarios
    - monitoring,
    - workflow applications,
    - big data analytics,
    - log processing
- Companies started using queues:
  - Linkedin, Facebook, Cloudera and Yahoo have developed similar queuing solutions
    - to handle gathering and processing of terabytes of log data on their servers
  - Kafka feeds hundreds of gigabytes of data into Hadoop clusters and other servers every day
- Queues can play an important role in Many Task Computing (MTC) and High Performance Computing (HPC)
  - handle data movement on HPC and MTC workloads in larger scales without adding significant overhead to the execution process
  - CloudKon

Challenges

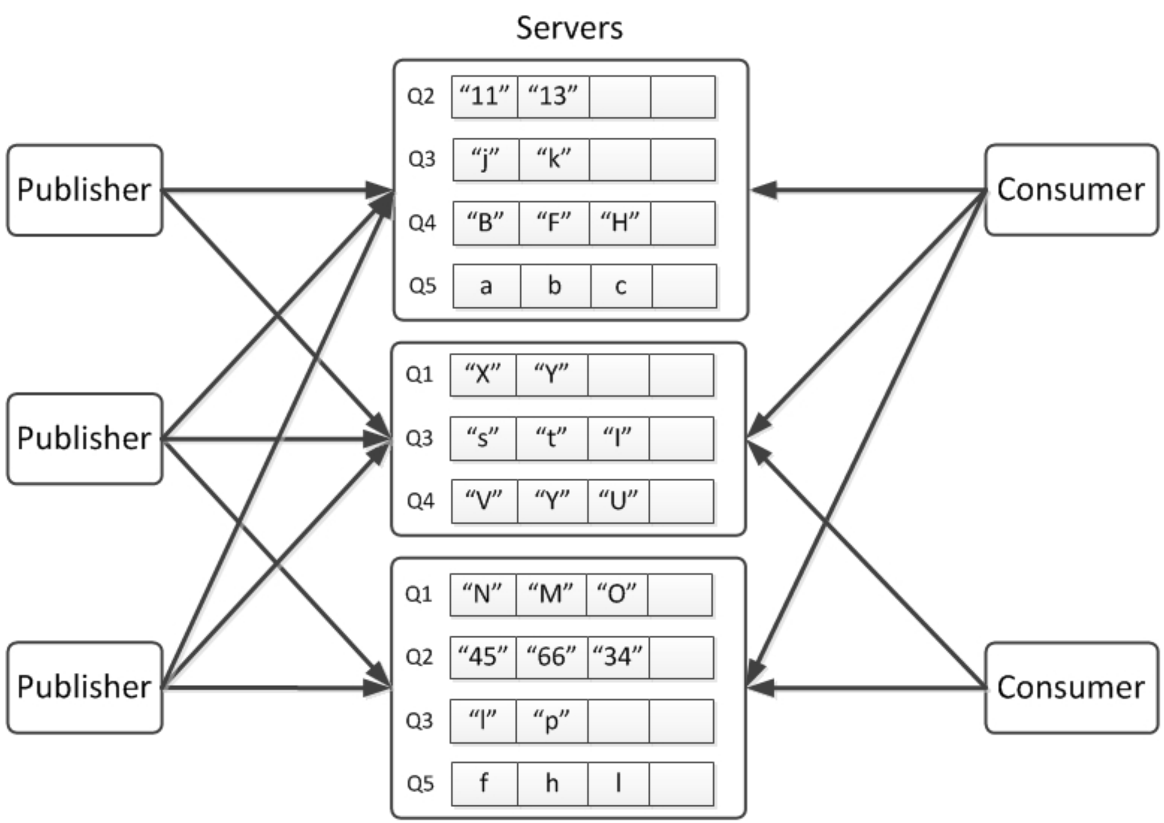
- Traditional queue services
  - usually have centralized architecture
  - cannot scale well to handle today's big data requirements
  - Providing transactional support
  - Providing consumption acknowledgement
  - Persistence: Many are in memory queues.
  - Delivery guarantee!

Introducing FaBRiQ

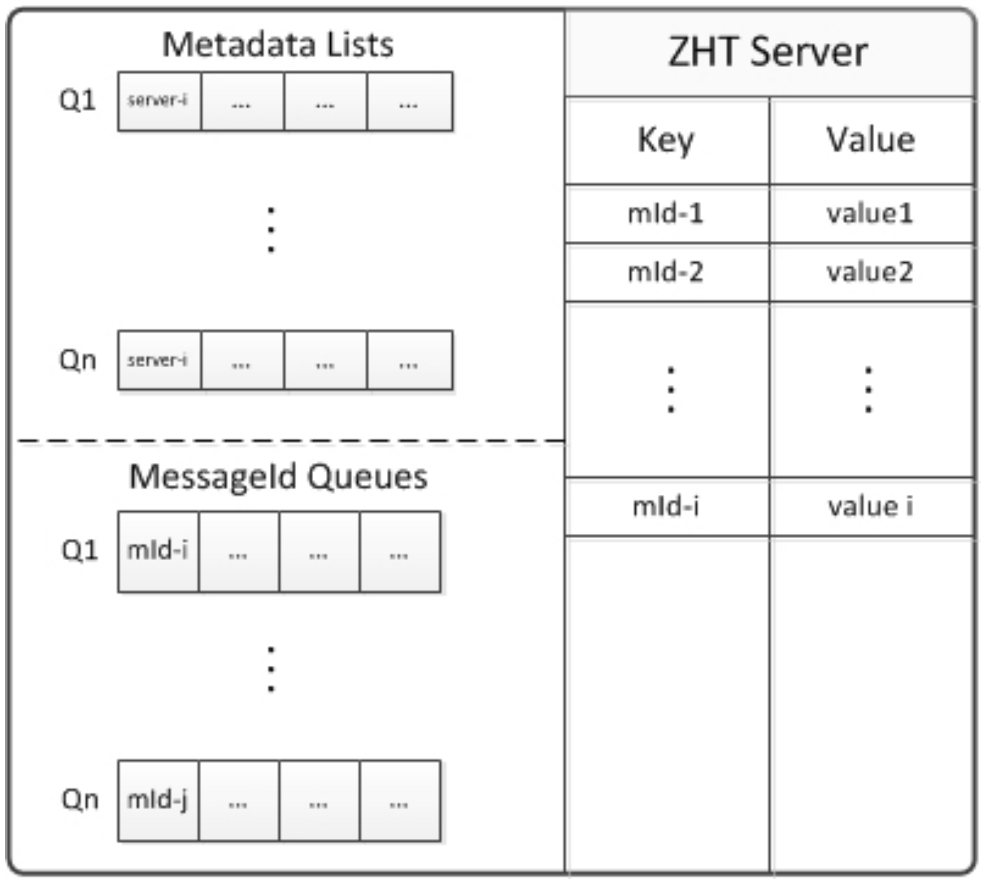
- FaBRiQ (Fast, Balanced and Reliable Queue):
  - a persistent message queue that aims to achieve high throughput and
  - low latency
  - while keeping the near perfect load balance and high utilization on large scales
  - Uses ZHT as its building block
    - Communications
    - Storing data

Design

- Distributing queues among servers



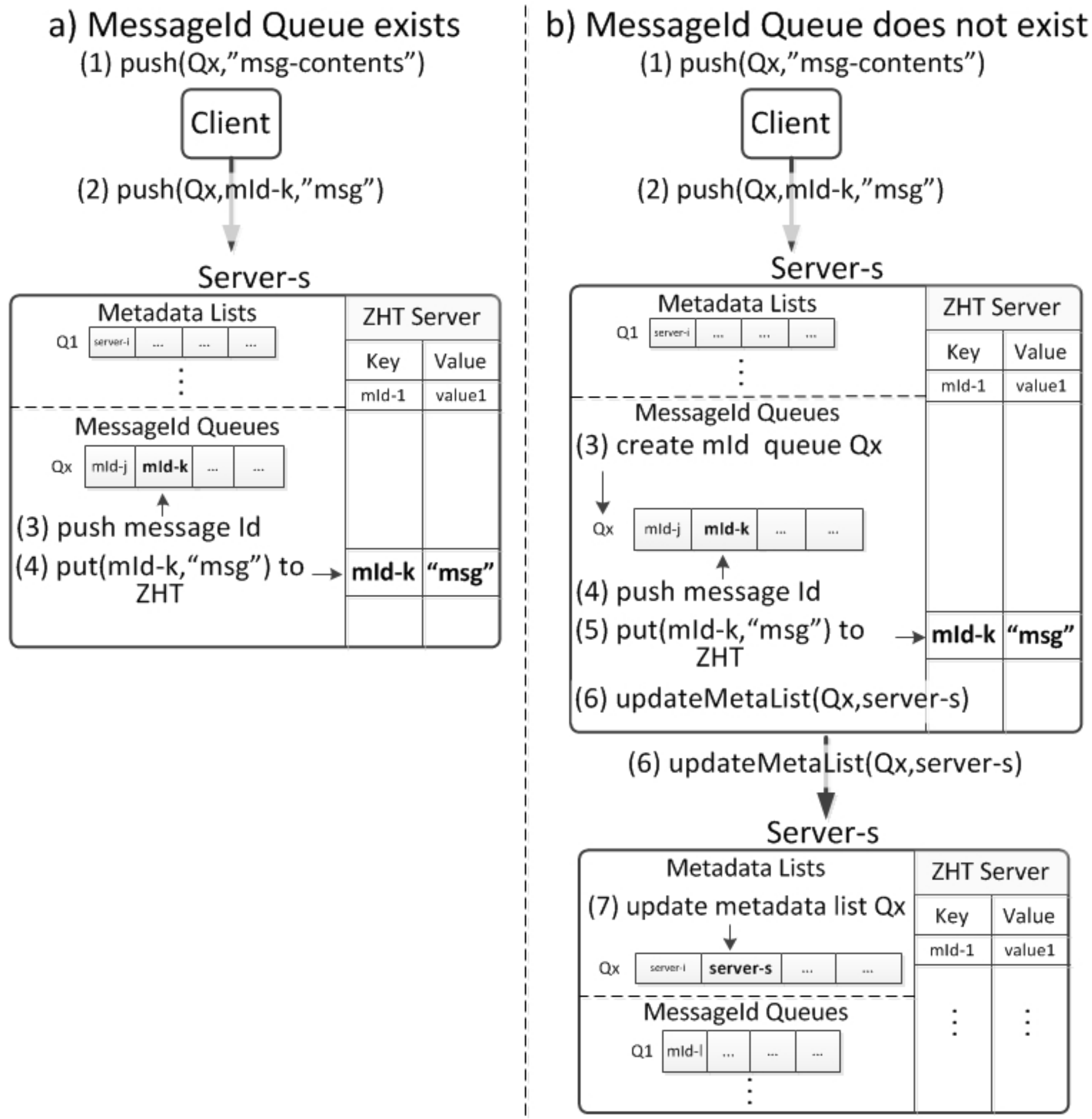
FaBRiQ Server



Operations

- CreateQueue
- Push
- Pop
- Remove

Push

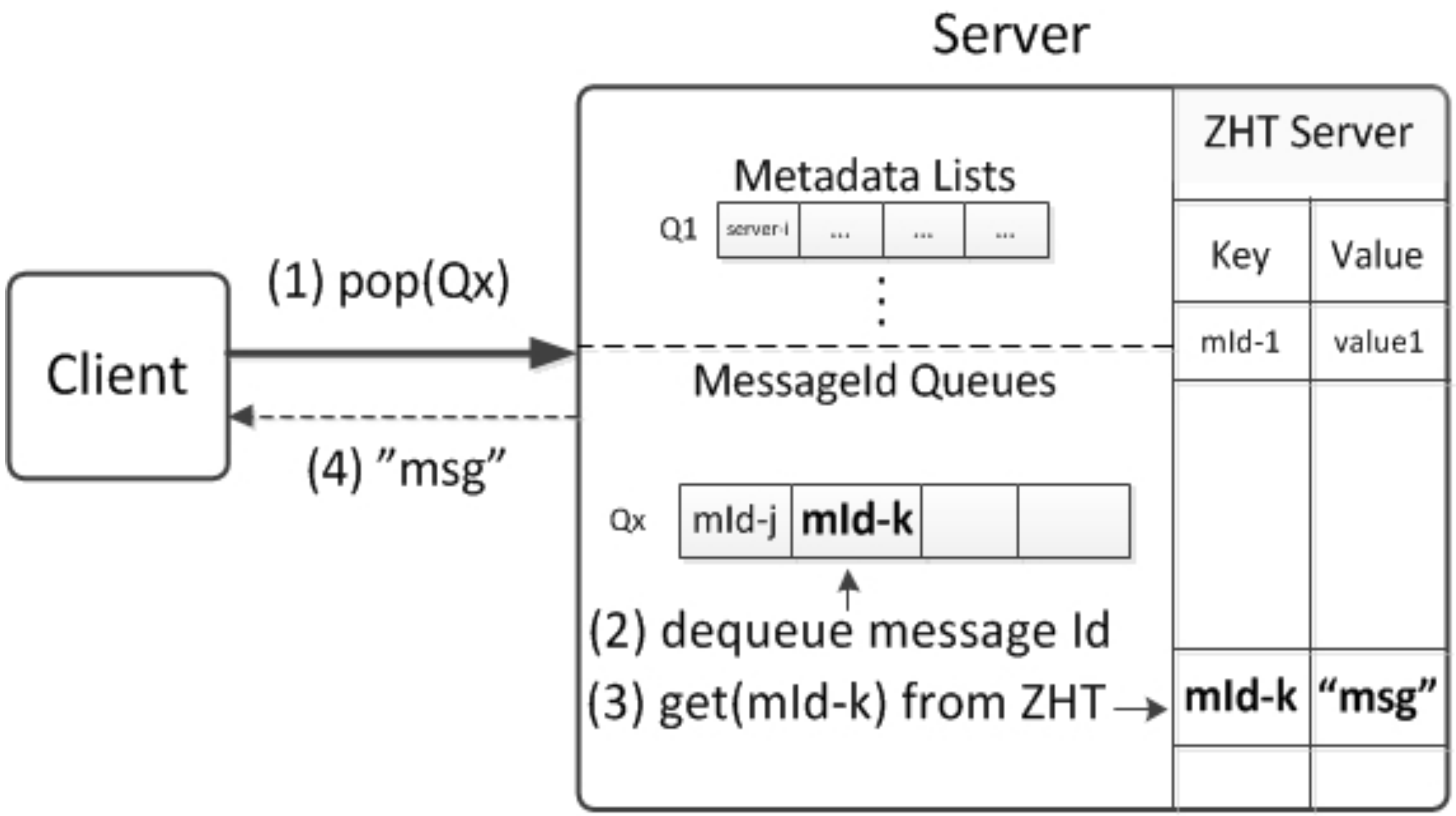


a) MessageId Queue exists
(1) push(Qx,"msg-contents")
Client
(2) push(Qx,mId-k,"msg")
Server-s
Metadata Lists
Q1
server-i
...
ZHT Server
Key
Value
mId-1
value1
MessageId Queues
Qx
mId-j
mId-k
(3) push message Id
(4) put(mId-k,"msg") to ZHT
mId-k
"msg"
b) MessageId Queue does not exist
(1) push(Qx,"msg-contents")
Client
(2) push(Qx,mId-k,"msg")
Server-s
Metadata Lists
Q1
server-i
ZHT Server
Key
Value
mId-1
value1
MessageId Queues
(3) create mId queue Qx
Qx
mId-j
mId-k
(4) push message Id
(5) put(mId-k,"msg") to ZHT
mId-k
"msg"
(6) updateMetaList(Qx,server-s)
(6) updateMetaList(Qx,server-s)
Server-s
Metadata Lists
(7) update metadata list Qx
Qx
server-i
server-s
ZHT Server
Key
Value
mId-1
value1
MessageId Queues
Q1
mId-l

pop

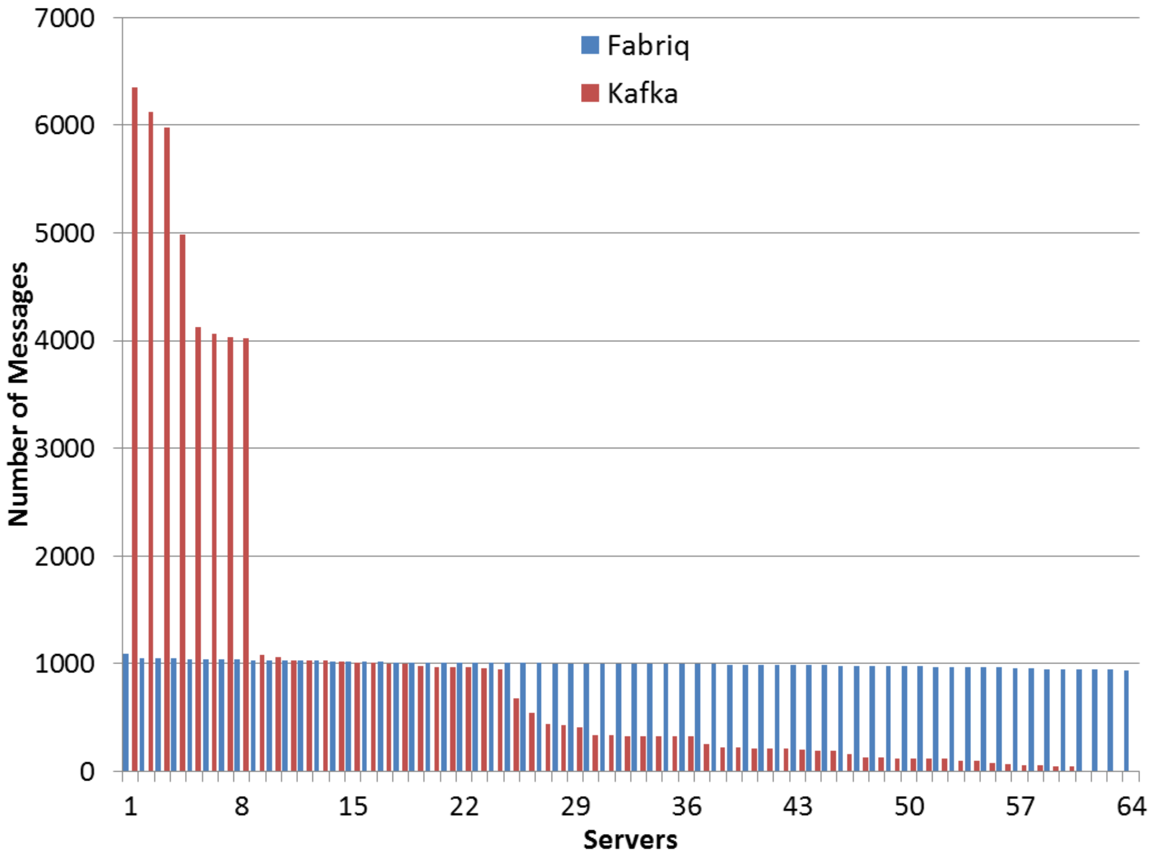
- Keep the latency low
- steps to follow
  - Local Access
  - Random server
  - Last known server
  - Metadata list owner
    - Redirect to a message keeper

Pop


Server
ZHT Server
Metadata Lists
Q1
server-i
...
...
...
Key
Value
mId-1
value1
Client
(1) pop(Qx)
MessageId Queues
(4) "msg"
Qx
mId-j
mId-k
(2) dequeue message Id
(3) get(mId-k) from ZHT
mId-k
"msg"

Load Balancing

- Load Balancing
  - Using a uniformly distributed hash function.

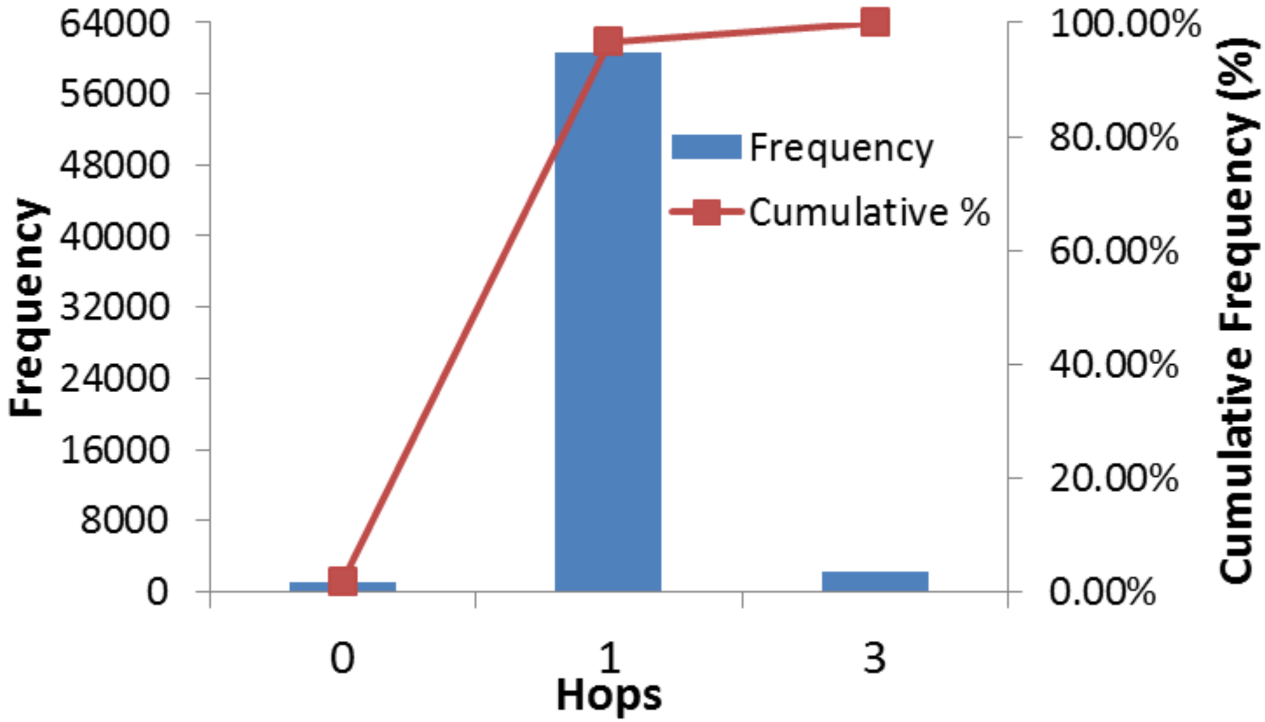


Features

- Order of messages
- Message delivery guarantee
- Persistence
- consistency and fault tolerance
- Multithreading

Communication cost analysis

- Push: 1 hop
- Pop: 0 – 3 hops



Comparison

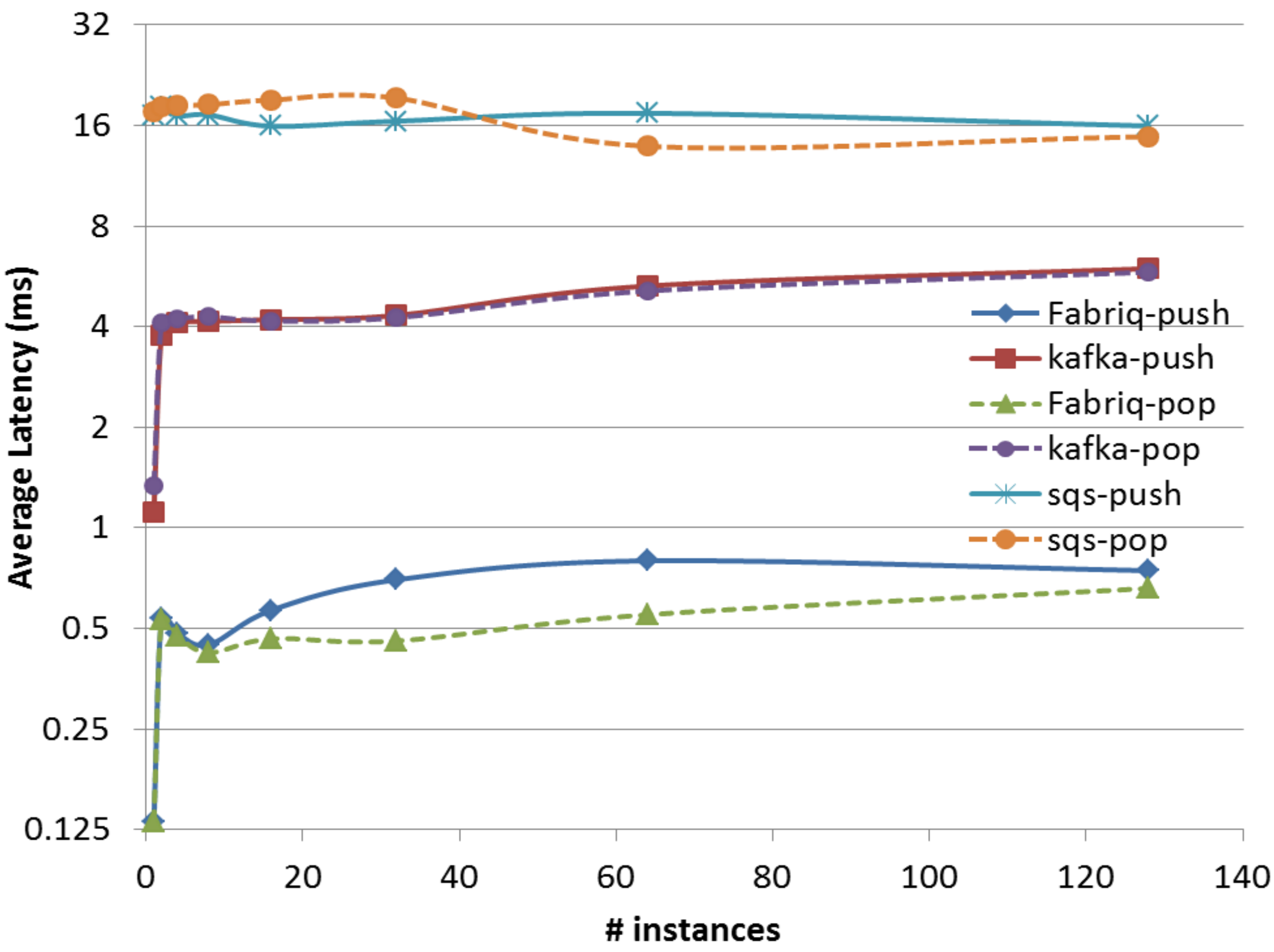
Feature	Fabriq	Kafka	SQS
Persistence	Yes	Yes	Yes
Delivery Guarantee	Exactly Once	At least Once	At least Once
Message Order	Inside Node	Inside Node	-
Replication	Customizable	Mirroring	3x
Shared Pool	Yes	No	Yes
Batching	No (Future work)	Yes	Yes

Performance Evaluation

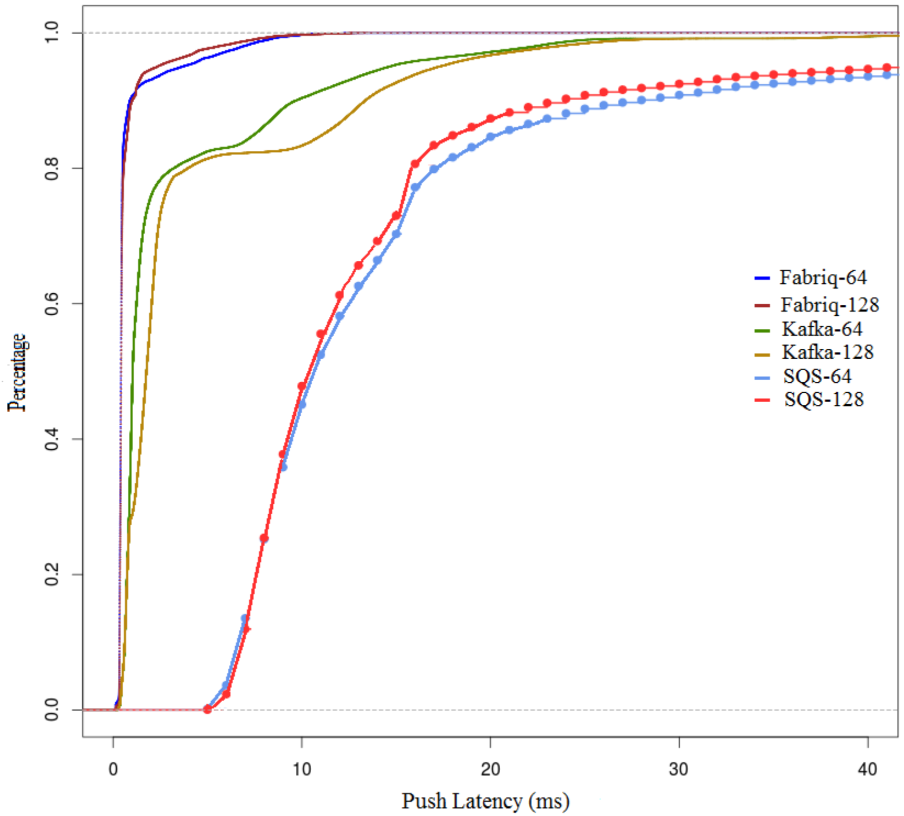
- FaBRiQ, Kafka, SQS
  - Latency
  - Throughput

- Measuring:
  - Push / produce
  - Pop / consume

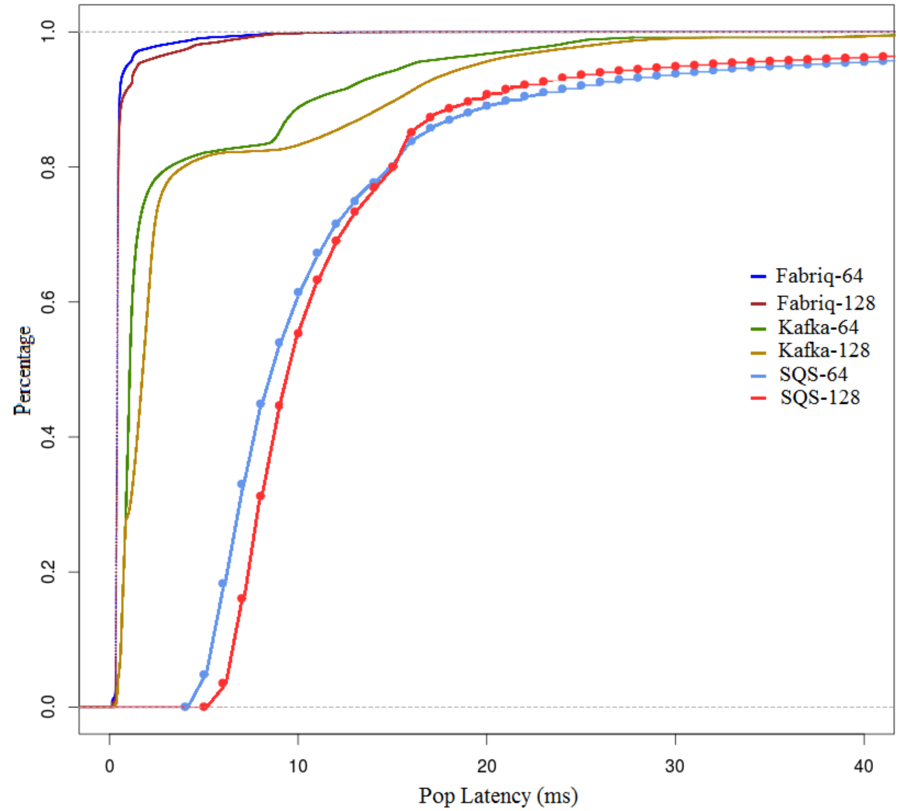
Latency (short messages)



Latency (CDF)

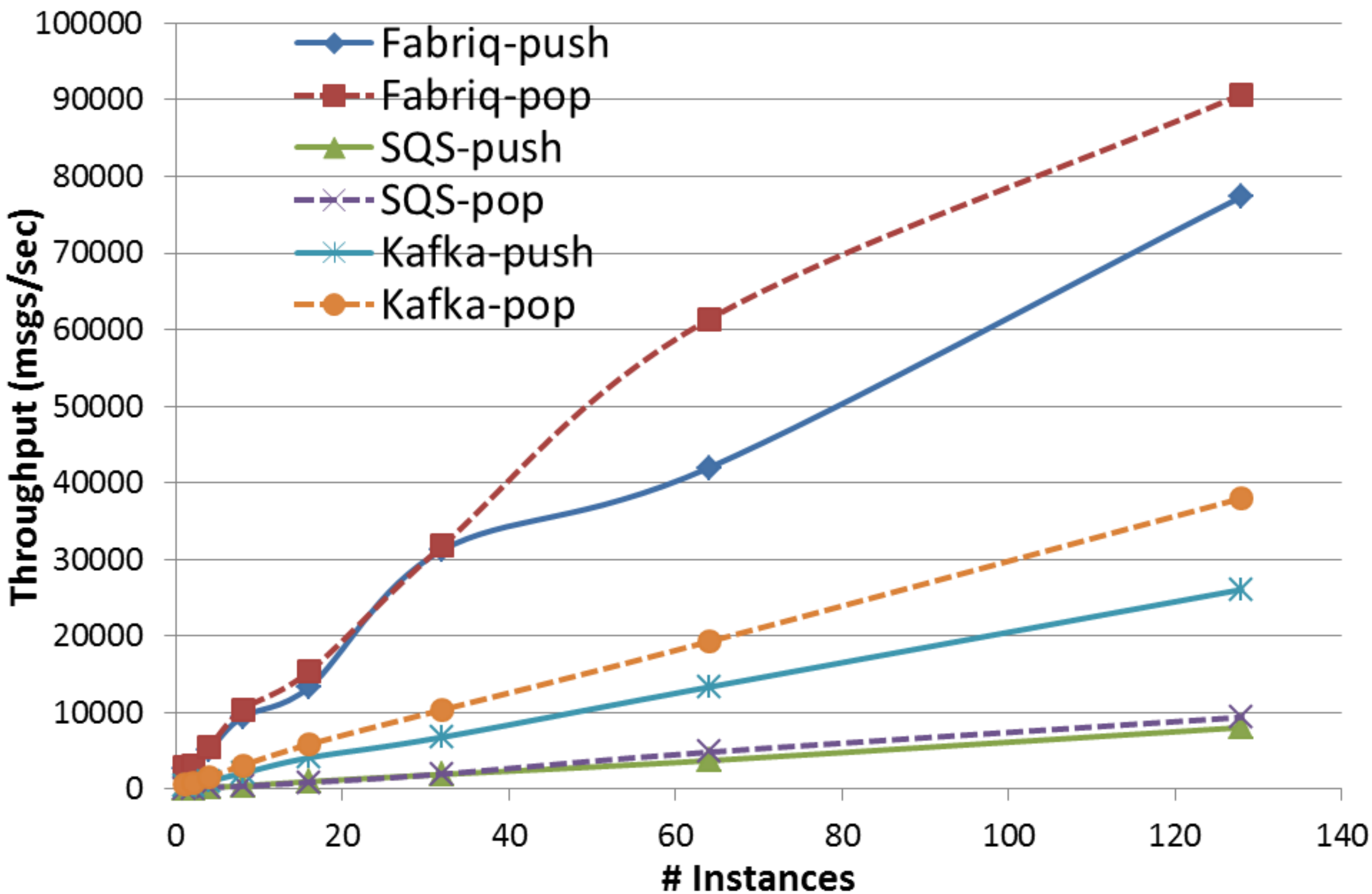


Fabriq-64
Fabriq-128
Kafka-64
Kafka-128
SQS-64
SQS-128
Percentage
Push Latency (ms)
0.0
0.2
0.4
0.6
0.8
1.0
0
10
20
30
40

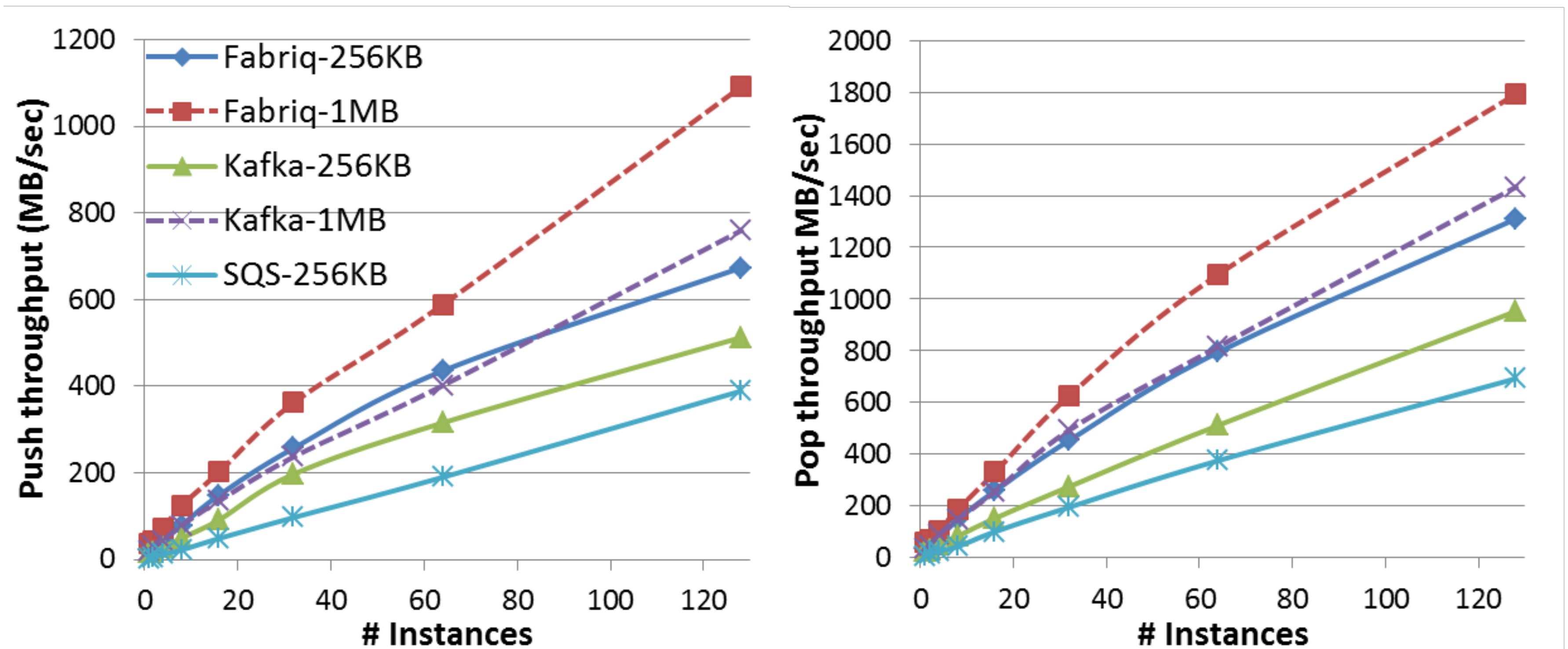


Fabriq-64
Fabriq-128
Kafka-64
Kafka-128
SQS-64
SQS-128
Percentage
Pop Latency (ms)
0.0
0.2
0.4
0.6
0.8
1.0
0
10
20
30
40

Throughput (short messages)



Throughput (large messages)



Duplicate messages

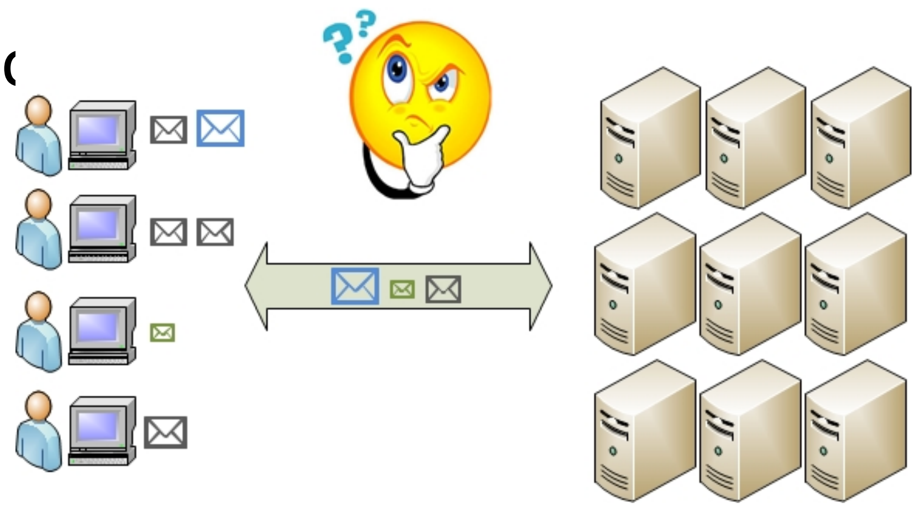
Scale - #msgs	Kafka	SQS
1 - 1000	0	0
2 -2000	0	1
4 - 4000	0	5
8 - 8000	1	5
16 - 16000	2	8-11
32 - 32000	4	8-15
64 - 64000	4	20-25

Future work

- Batching

Introduction

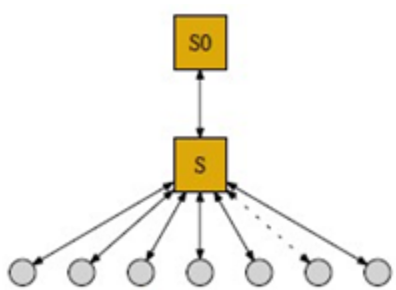
- Large Scale Task Execution
  - Run on distributed res

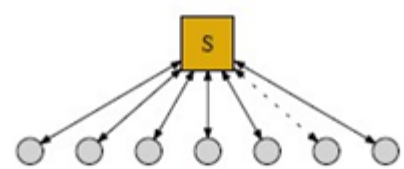


  - Workloads
    - Tasks
      - More in number
      - Shorter in length
  - Requirements for high performance
    - Concurrency
    - Load Balance
    - System Utilization

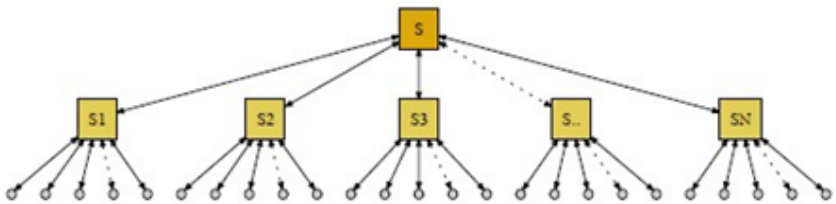
State-of-the-art job schedulers

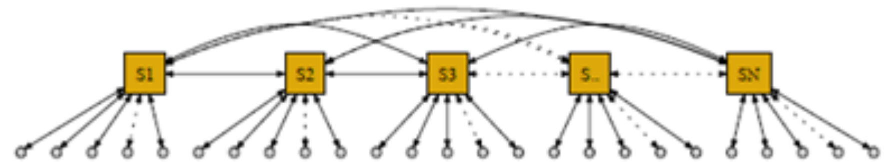
- Centralized Master/Slaves architecture
  - Scalability issues at petascale and beyond
  - Single point of failure
  - Example: SLURM, CONDOR, Falkon



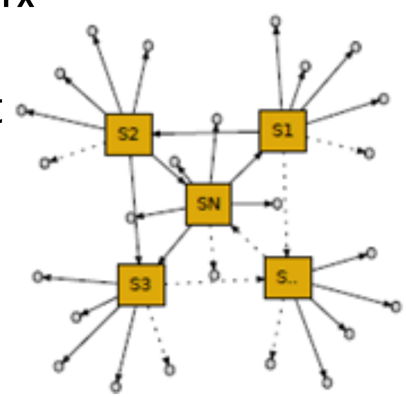


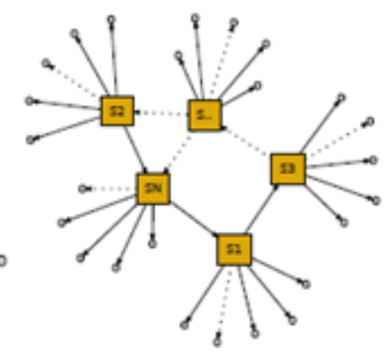
State-of-the-art job schedulers





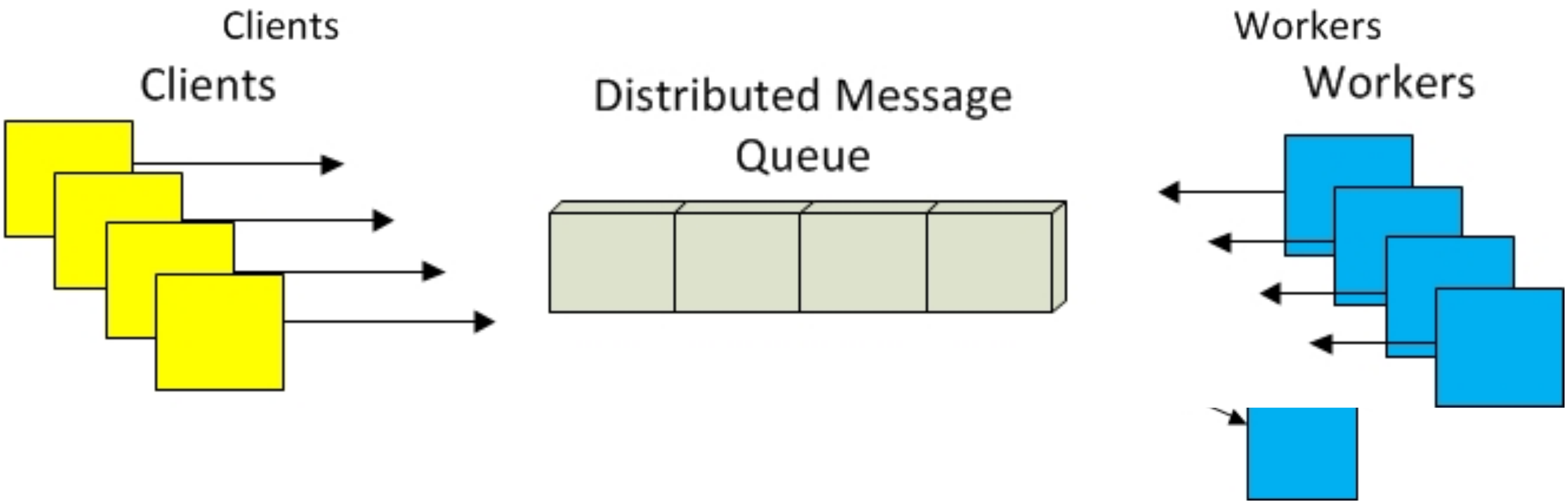
- Distributed Architectures
  - Hierarchical
    - several dispatchers in a tree-based topology
    - Example: Distributed Falkon, Dremel
  - Fully distributed
    - each computing node maintains its own job execution
    - Example: Sparrow, Omega, MATRIX
- Common challenges
  - Complex Design and Implementat
  - Load balancing
  - System utilization





Idea: Scheduling with Message Queues

- Idea: leverage Distributed Message Queues!
  - Mapping between Job Schedulers and Message Queues



Amazon AWS Cloud

- Amazon EC2
  - IaaS Cloud Service
    - Launch VMs and access remotely
  - Ability to launch more than 1000 instances

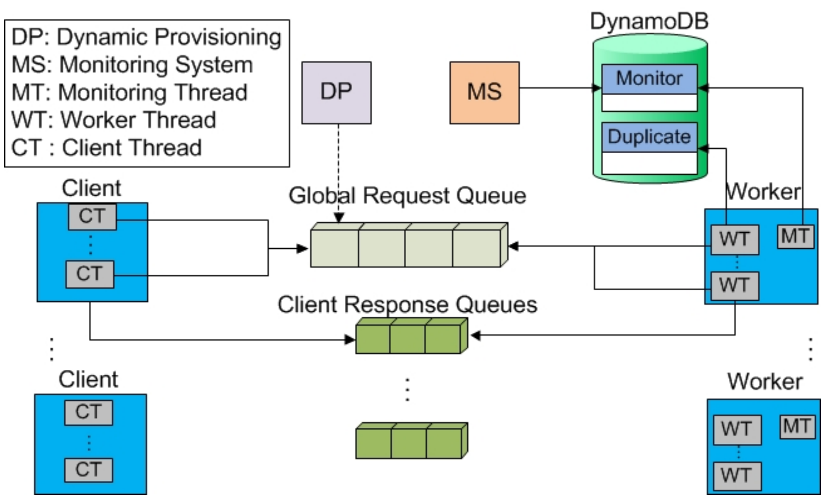
- Amazon Simple Queue Service (SQS)
  - Distributed message delivery queue
    - Highly scalable
    - Messages sent and read simultaneously
    - Reliable
      - Guarantees message delivery
        - <u>At least</u> once delivery

Proposed Work

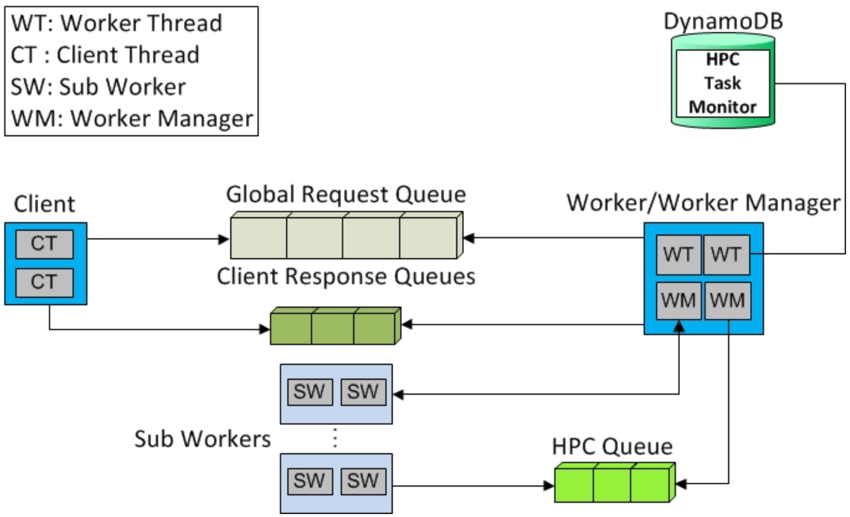
- Use SQS as a task delivery component / task pool
- Decouple Clients and Workers
- Pushing vs. Pulling approach
  - Pushing
    - Local/global manager node needs to predict/decide
      - About the address of worker nodes
      - Underlying network topology
  - Pulling
    - No need to know about workers
    - Workers decide for themselves
- Load balancing
- System Utilization

CloudKon Architecture

- MTC



- HPC



- General format, running MTC tasks
- Benefits:
  - Dynamic workforce
  - Non-blocking task submission

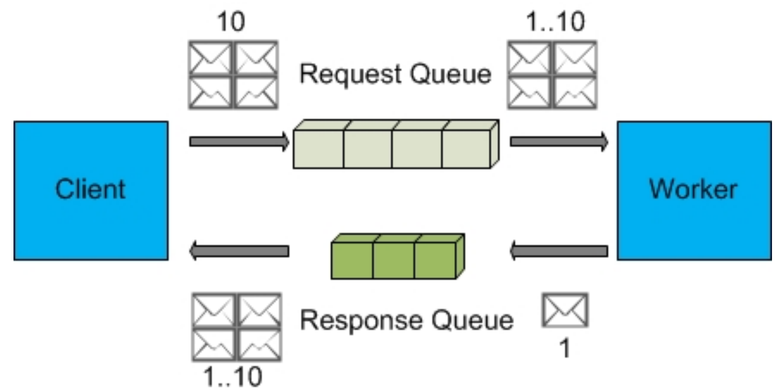
- Running HPC jobs with multiple tasks

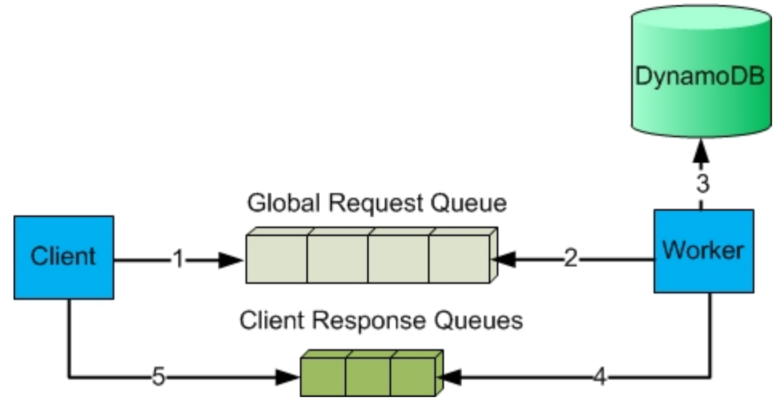
Task consistency

- SQS only guarantees <u>at least</u> once delivery
- Some workloads require exactly once execution of tasks!
- Use DynamoDB to verify
- Use conditional write
    - ➢ Write if the task does not exist
    - ➢ Throw exception if exists
  - Atomic operation
- Using a single operation, the checking is done
  - Minimize the communication overhead

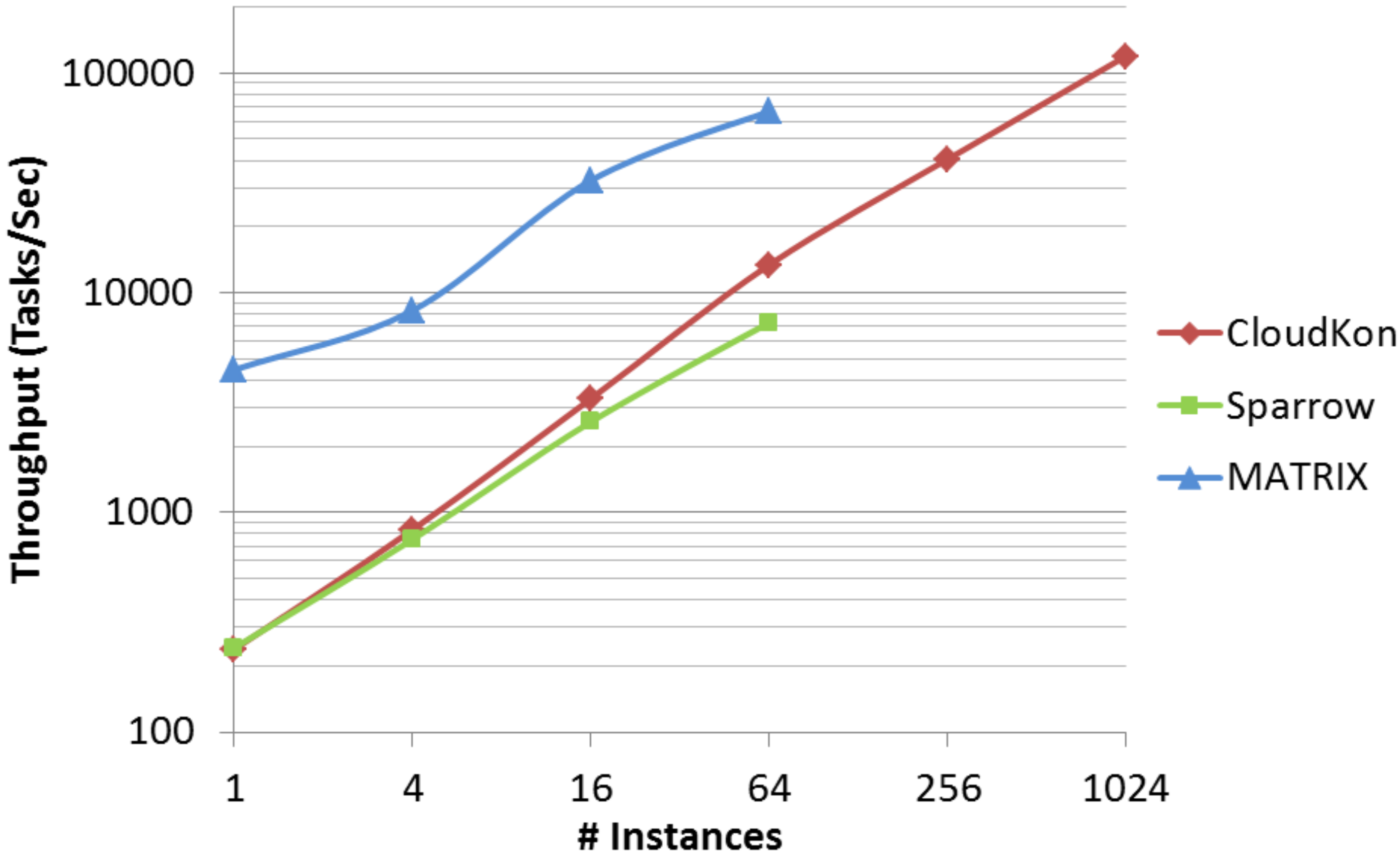
Communication Cost

- Communication overhead is high on Cloud
  - Need to minimize the communication
- Message batching
  - Bundle tasks together to send
- Number of communications
  - Minimum possible number



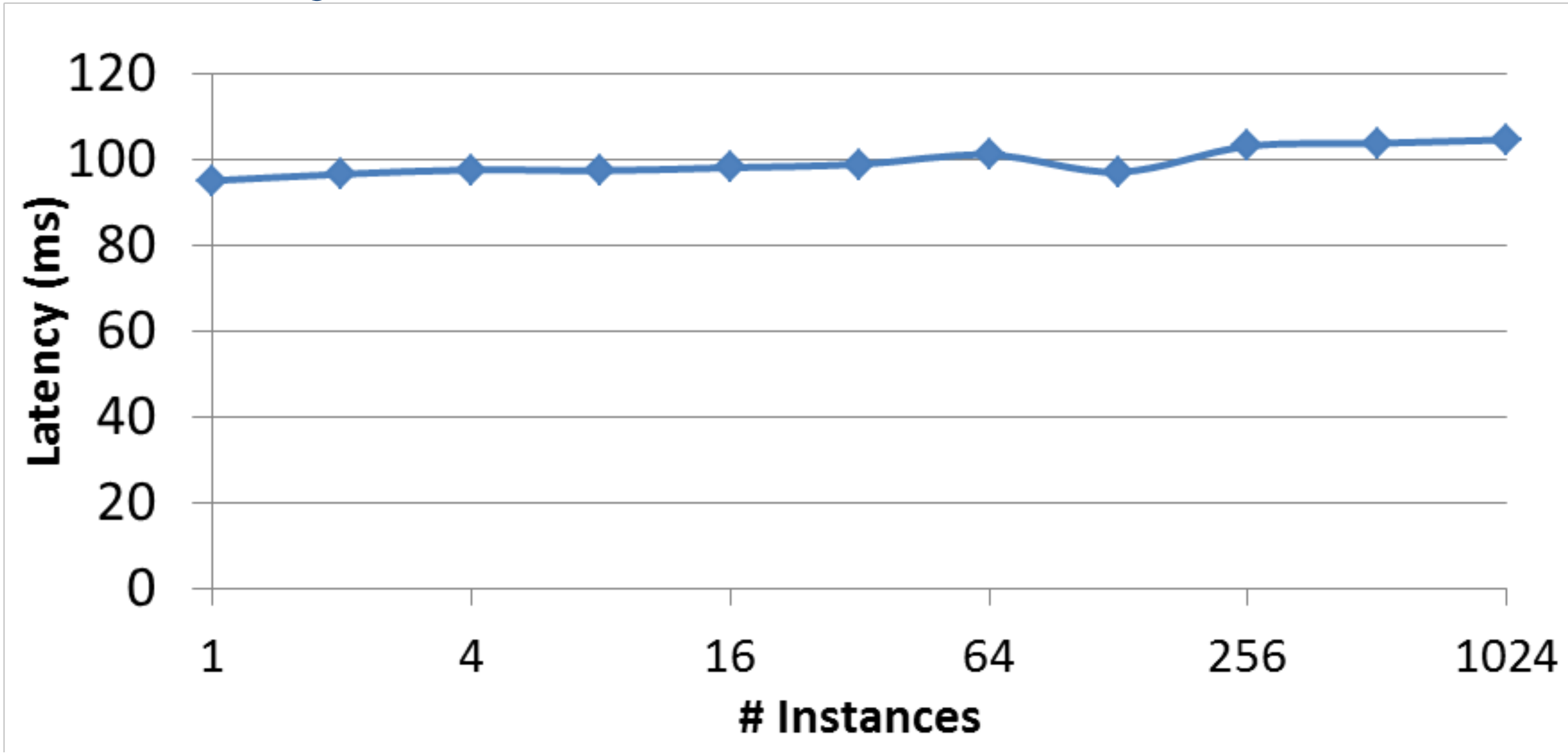


Throughput (MTC)



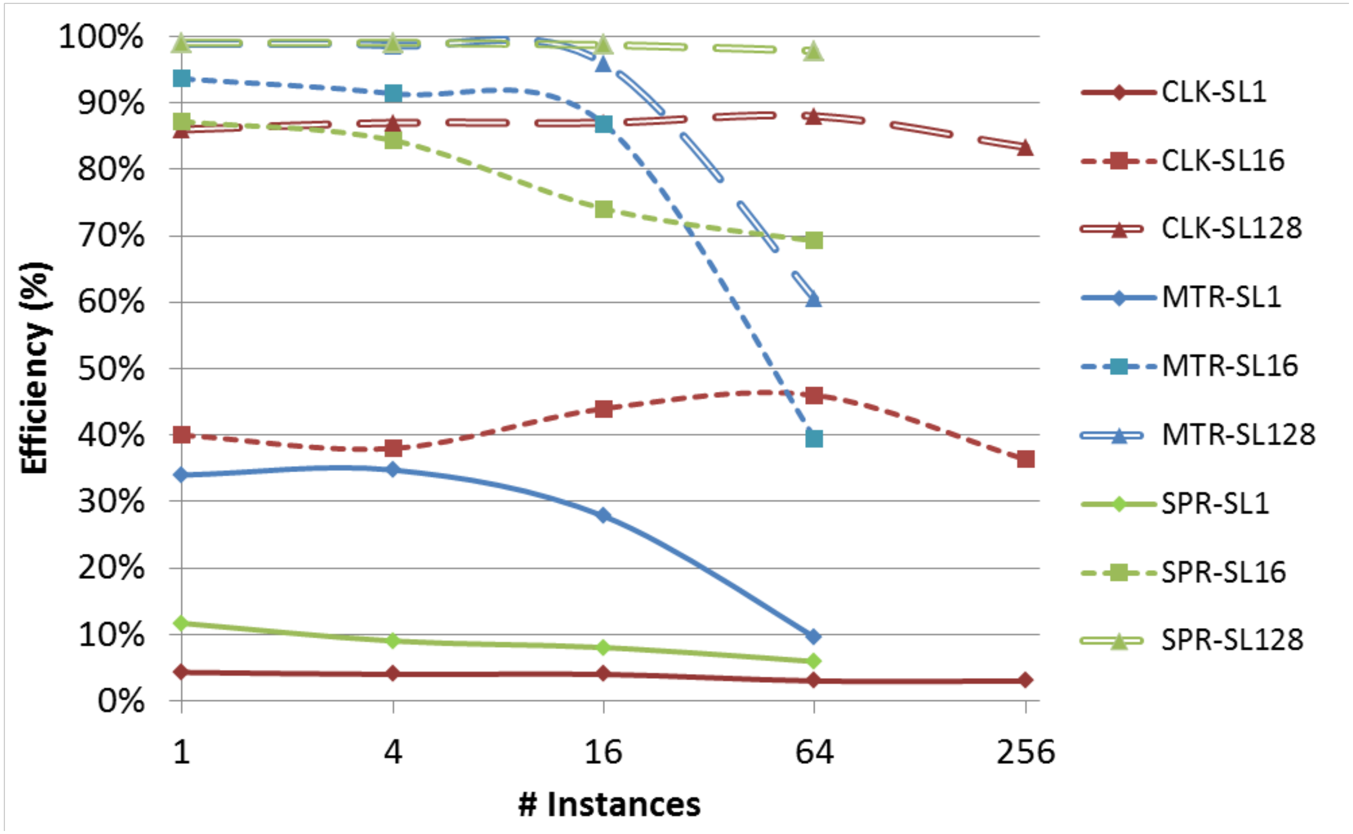
- 1 to 1024 instances,16K to 16.38M tasks
- MATRIX and Sparrow crashing on 256 instances
  - Too many sockets open on TCP connection

Latency



- Stable latency on different scales
  - Ranging from 90 ms to 104 ms

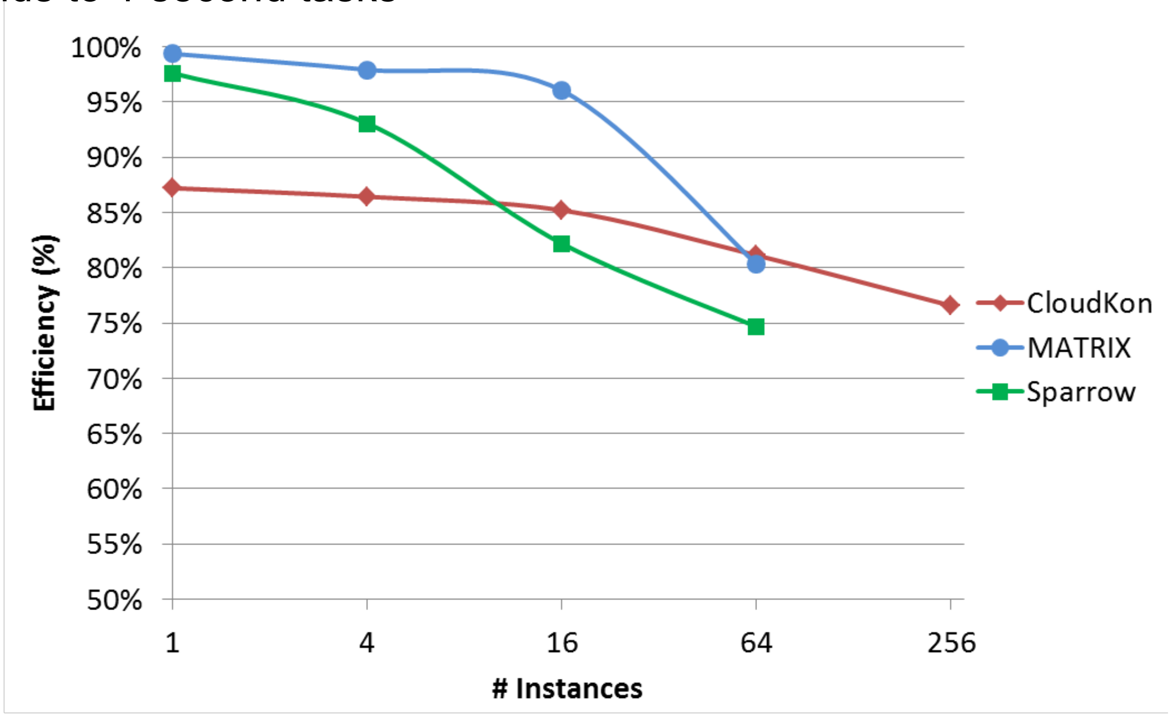
Efficiency – Homogenous Tasks



- MATRIX achieved better efficiency on shorter tasks
- Efficiency of MATRIX drops lower than CloudKon on 64 instances
- CloudKon is stable and scalable

Efficiency – Heterogenous Tasks

- Trace of a real MTC workload
- 2.07M tasks at the largest scale
- 1 milliseconds to 1 second tasks



- CloudKon is more stable and scalable compared to the other two.
- Efficiency of MATRIX and Sparrow drop lower than CloudKon on 64 instances

Conclusion

- Design and implement simple yet effective distributed task execution framework
  - Using cloud services like SQS, DynamoDB
- Run on Public Cloud environment as an alternate resource
  - Optimum usage of cloud resources
- Outperforming other state of the art systems on larger scales
  - Sparrow 2013
  - MATRIX 2013