CLOUDKON: A CLOUD ENABLED DISTRIBUTED TASK EXECUTION FRAMEWORK

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Introduction

- MTC: Many-Task Computing
  - Bridge the gap between HPC and HTC
  - Many resources over short time periods
  - Loosely coupled apps with HPC orientations
  - Example: MapReduce

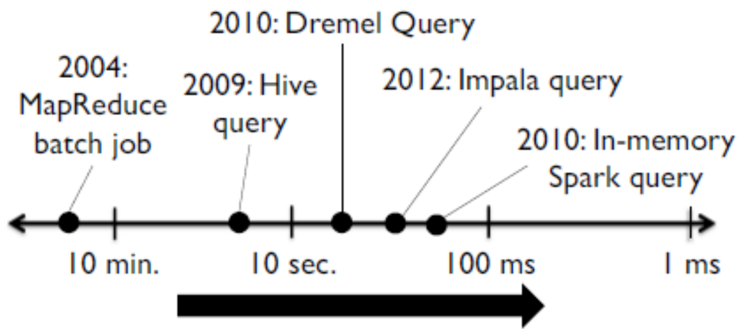
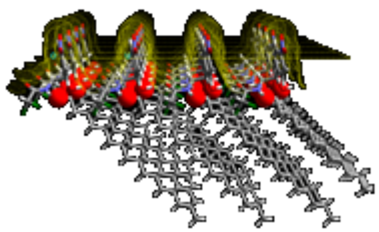
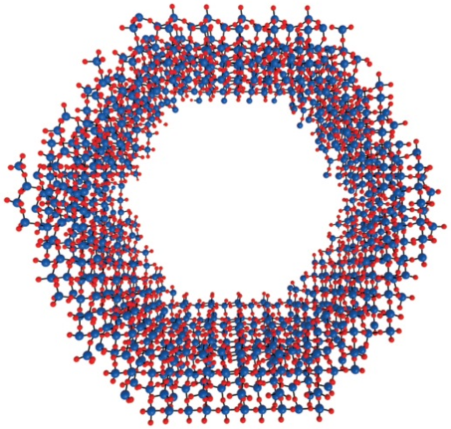


Image taken from: Sparrow: Scalable scheduling for sub-second parallel jobs. Tech. Rep. UCB/EECS-2013-29, University of California, Berkeley,

- Data analytics moving towards fine granular tasks
  - Example: GAMESS(chemistry), TPC-H(industry)

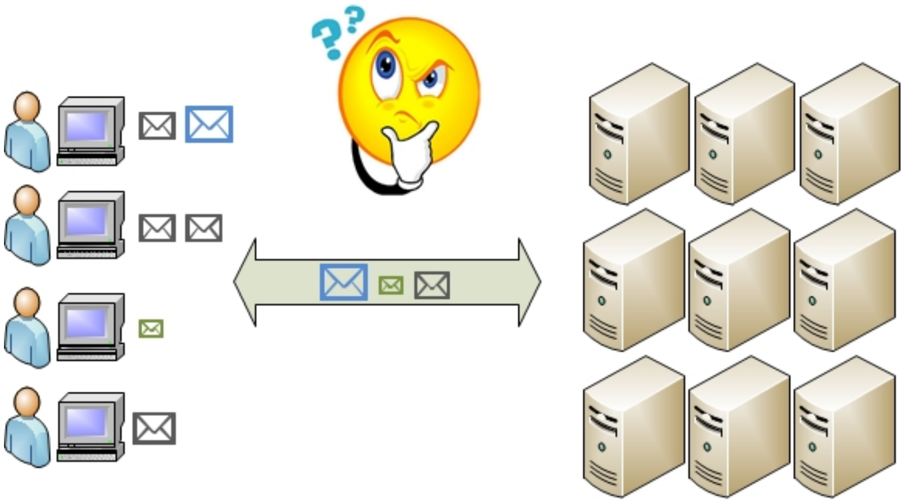




- Traditional Batch Schedulers
  - Heavy weight
  - Cannot scale for the new workloads

Introduction

- Large Scale Task Execution
  - Run on distributed resources
  - Workloads
    - Tasks
      - More in number
      - Shorter in length
  - Requirements for high performance
    - Concurrency
    - Load Balance
    - System Utilization



Motivation

- Current resources
  - Clusters & Super Computers
  - Alternatives?!
- How about Clouds?
  - Large resources
  - Easier access than the other two
  - Scale up as much as you want
  - Customizable
  - Pay-as-you go model, pay only when you use it
  - Perfect for medium size projects with limited budget
    - Use as long as you have budget

State-of-the-art job schedulers

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

- Distributed Architectures
  - Hierarchical
    - several dispatchers in a tree-based topology
    - Example: Distributed Falkon
  - Fully distributed
    - each computing node maintains its own job execution
    - Example: Sparrow
  - Common issues
    - Poor load balancing
    - Poor system utilization

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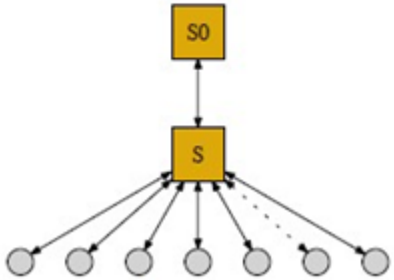

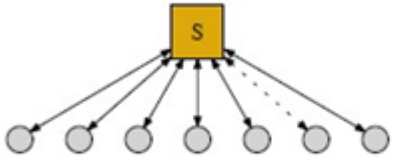

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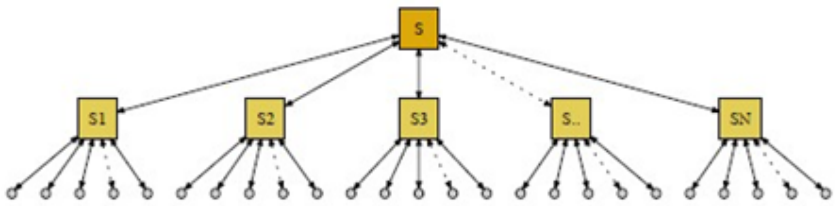

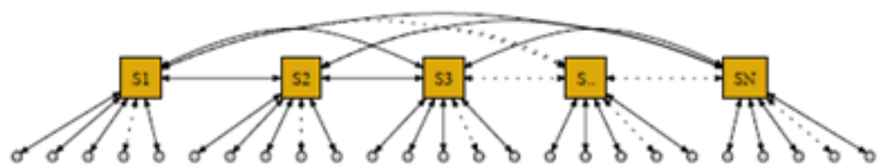

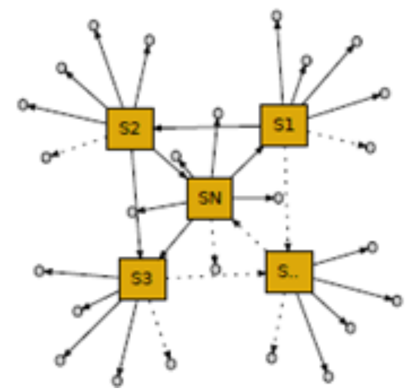

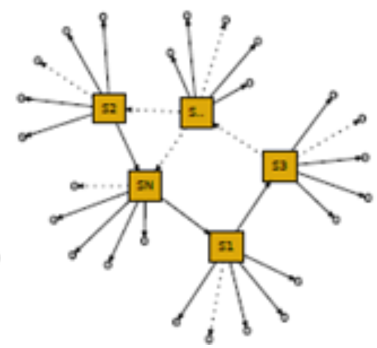

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Agenda

- Background
- Proposed Work
  - CloudKon Architecture
  - Task Consistency
  - Dynamic Provisioning
  - Communication Cost
  - Implementation details
- Performance Evaluation
  - Throughput
  - Latency
  - Consistency effect on throughput and latency
  - Efficiency
  - Consistency effect on efficiency
- Conclusion and Future work

Amazon Simple Queue Service (SQS)

- Distributed message delivery queue
  - Highly scalable
  - Messages sent and read simultaneously
    - Messages sent to multiple servers
  - Reliable
    - Guarantees message delivery
      - <u>At least</u> once delivery
      - Multiple copies may be available and accessed
  - Secure
    - Through authentication

Amazon Dynamo DB

- No-SQL Key Value Store
- Fully distributed
- faster and more scalable than traditional DBs
- Simple query support
- Atomic operations support
  - Atomic read
  - Atomic write

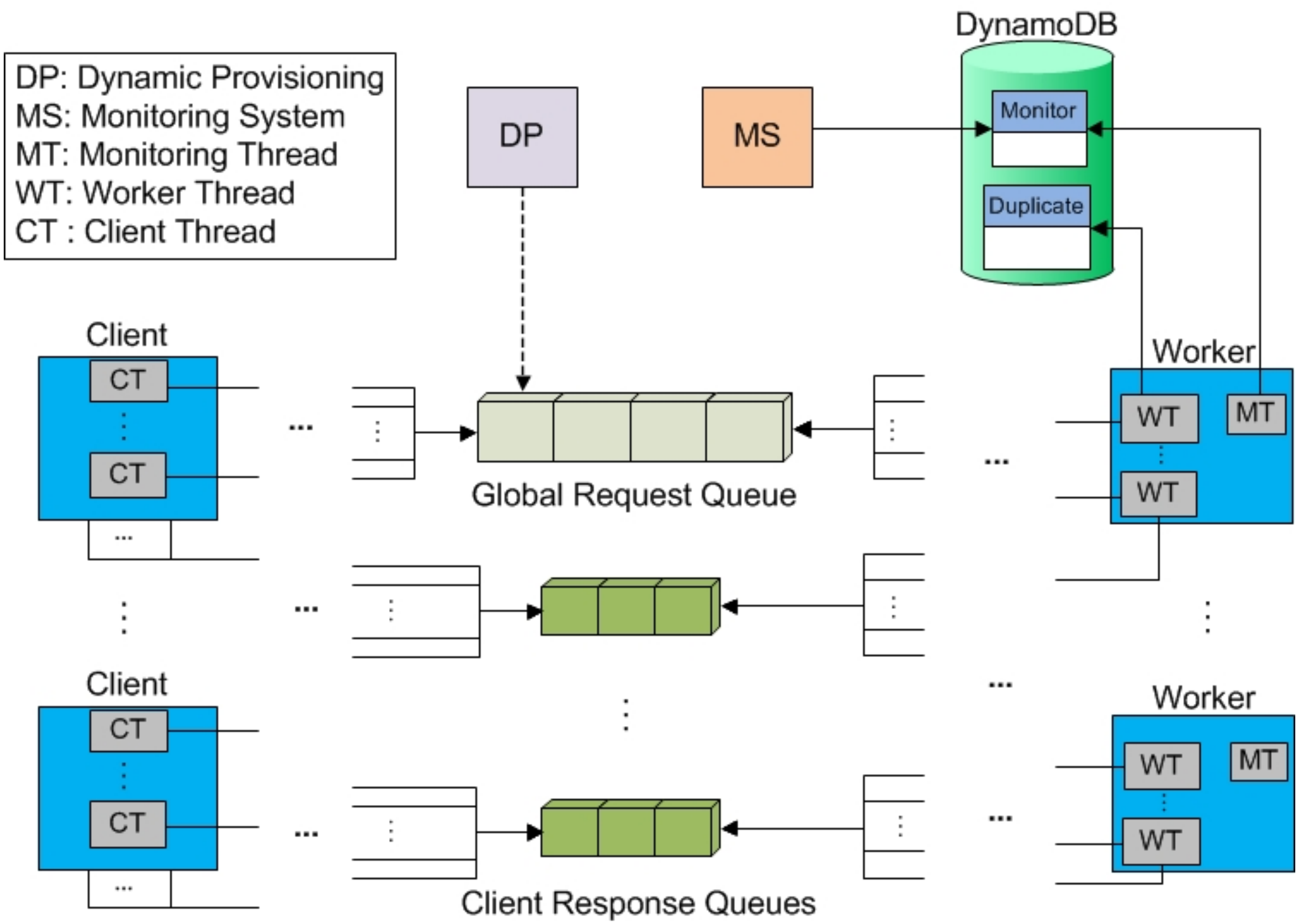
Agenda

- Intro and Motivation (5min)
- Background (2min)
- Proposed Work (6min)
  - CloudKon Architecture
  - Task Consistency
  - Dynamic Provisioning 15s
  - Monitoring15s
  - Communication Cost 15s
  - Implementation details
- Performance Evaluation (5min)
  - Throughput
  - Consistency effect on throughput and latency
  - Efficiency
  - Consistency effect on efficiency
- Conclusion and Future work (2min)

Proposed Work

- Use SQS as a task delivery component
- Decouple Clients and Workers
- Pushing vs. Pulling approach
  - Pushing
    - Local/global manager node needs to predict/decide
      - Randomness
      - Get system information periodically from workers
      - Needs to know about the address of worker nodes.
  - Pulling
    - No need to know about workers
    - Workers decide for themselves
- Load balancing
- System Utilization

CloudKon Architecture



Task consistency

- SQS only guarantees at least 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

Dynamic Provisioning

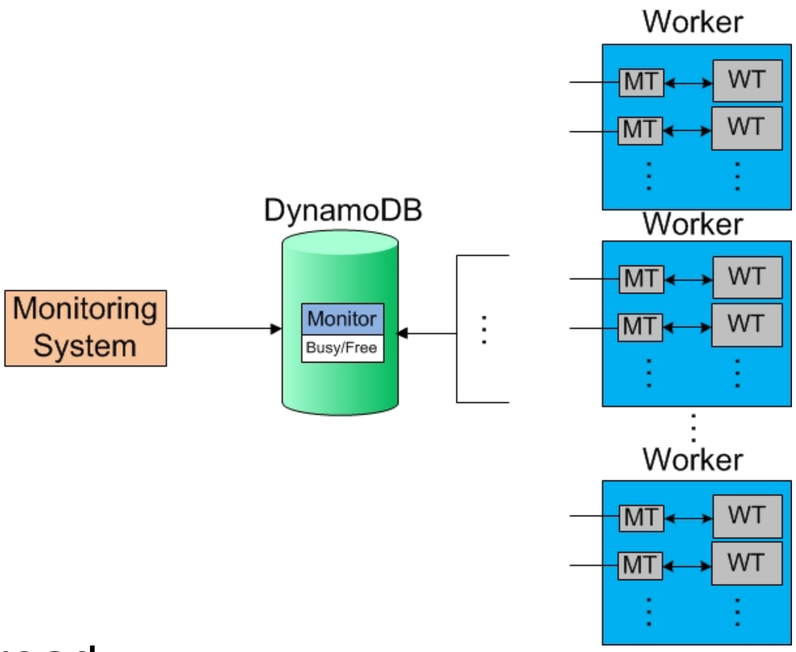
- Dynamically scale up and down the system
- Scale up

Use Provisioner component → Check request queue length (periodically) → Launch new worker if it's getting larger

- Scale down
  - If:
    - The worker goes idle (because of having no job to run!)
    - The rent time is closer than threshold to the rent unit value of time
  - Then:
    - Terminate the worker instance
  - Benefits:
    - No component needs to keep track of workers

Monitoring

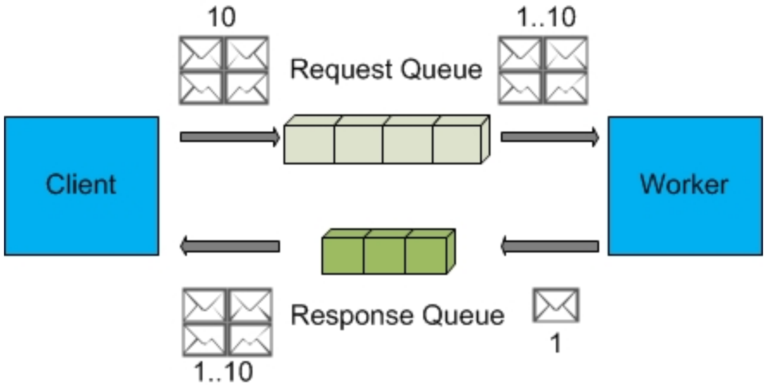
- Monitor workers for:
  - System utilization
  - Debug

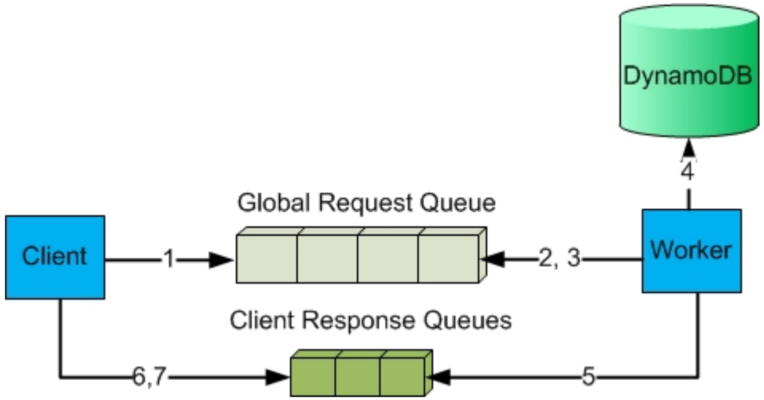


- Monitor Thread
  - Each worker thread has a monitor thread
  - Reports system utilization periodically
  - Able to report other details of each worker
- Monitoring System
  - Reads the aggregate utilization results from store

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





Implementation Details

- Written in Java
- Dependency
  - AWS Java SDK library
  - Apache Commons library
  - Google protocol buffer library
- Serialization
  - Used Google Protocol Buffer
    - More efficient protocol than JSON
- Simple and short code base
  - Only 1052 lines of code
  - Delivers 2X performance with less than 5% code base length

	CloudKon	Sparrow	Falkon
Lines of code	1052	24500	33000

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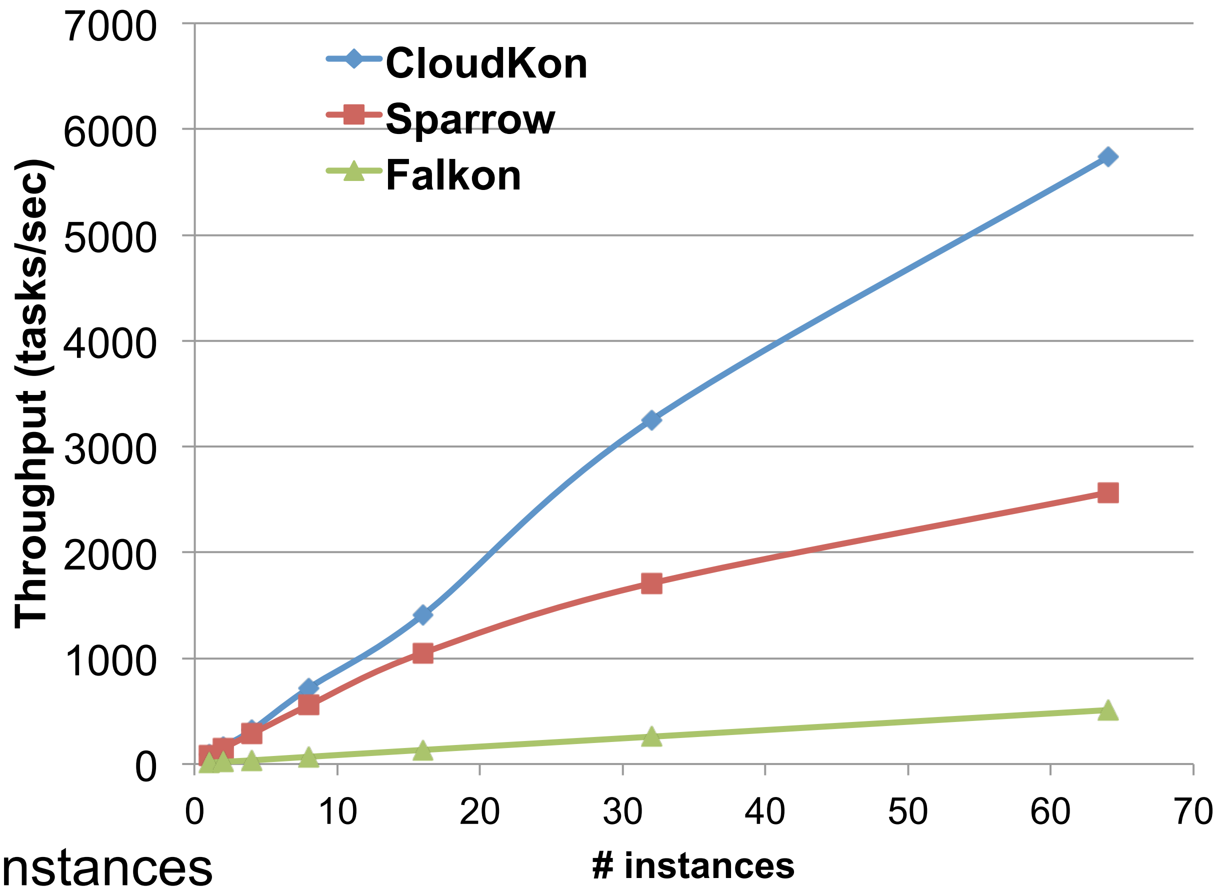
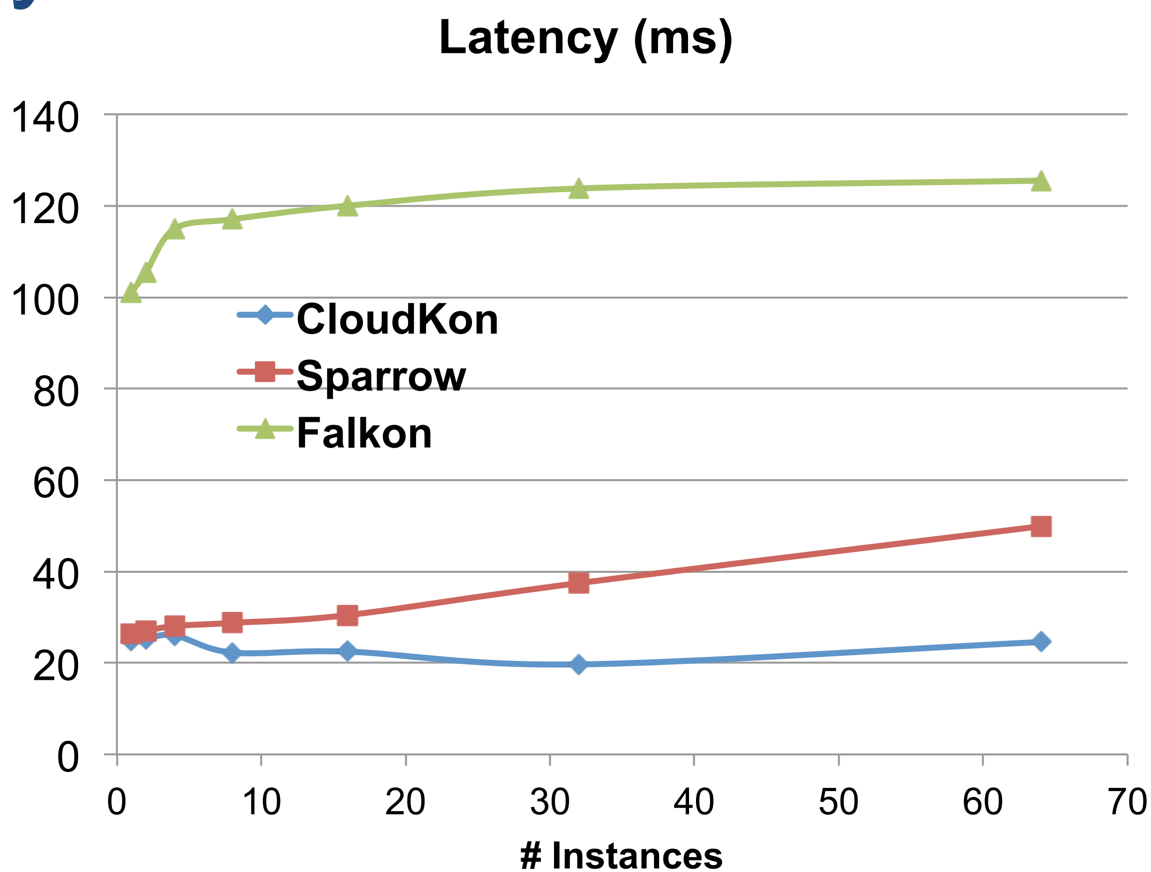
Throughput



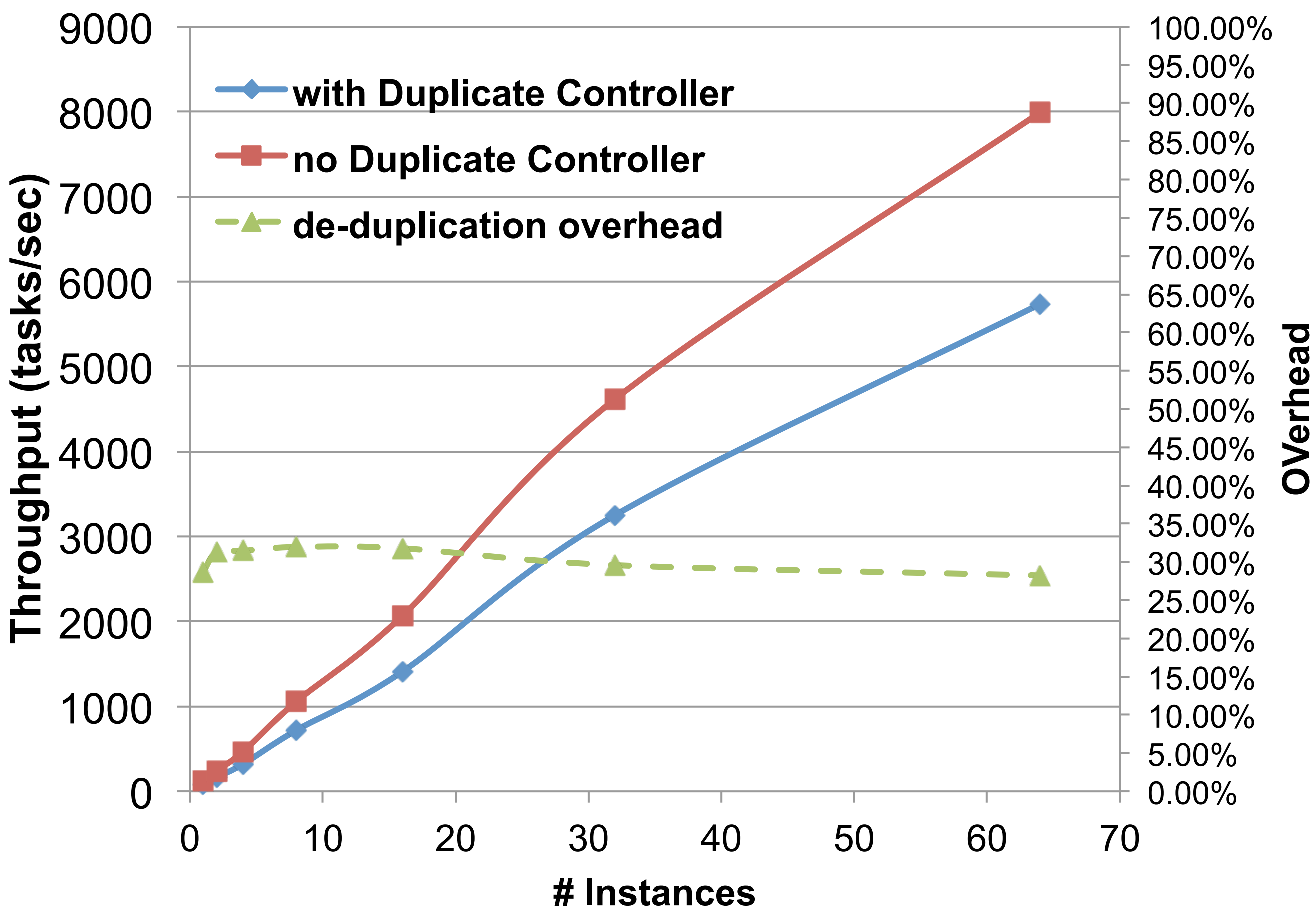
- 1 to 64 instances
- 16000 to 1024000 tasks
- 5735 msgs/sec on the largest scale (64)

Latency



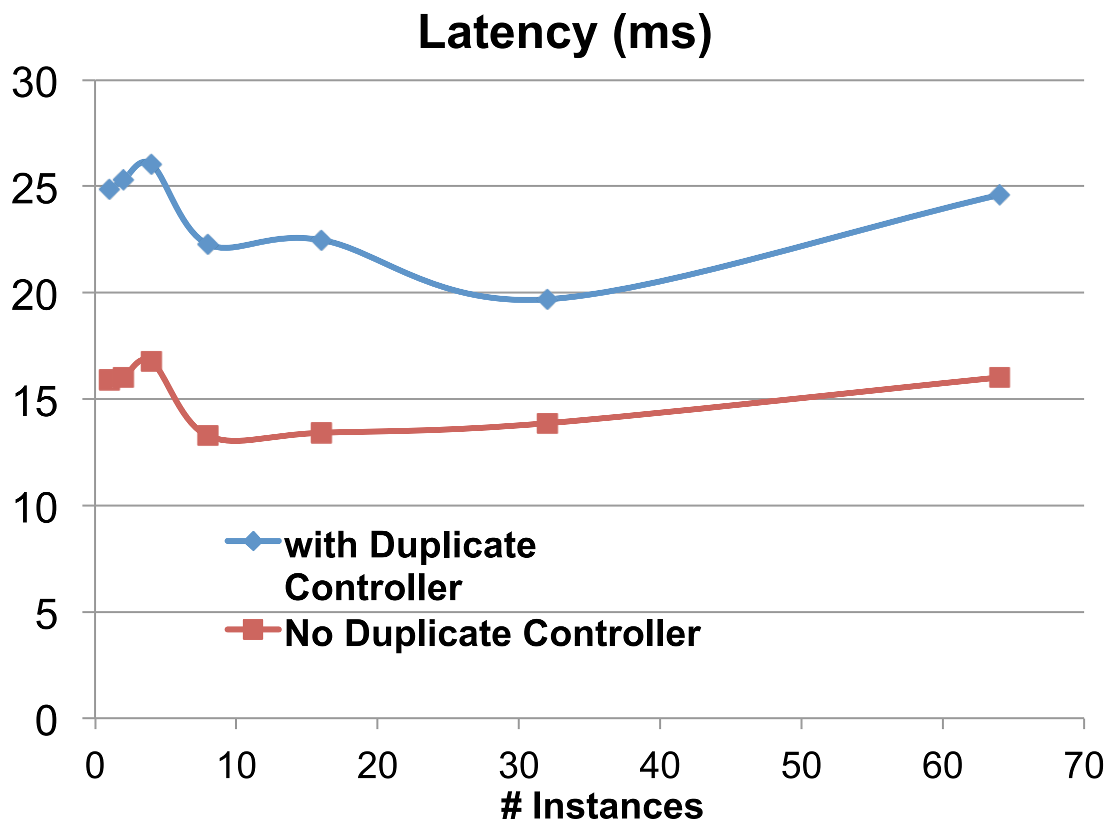
- 24.6 ms latency on 64 scale
  - Compared to 49.9 ms and 125.5 ms

Consistency effect on throughput



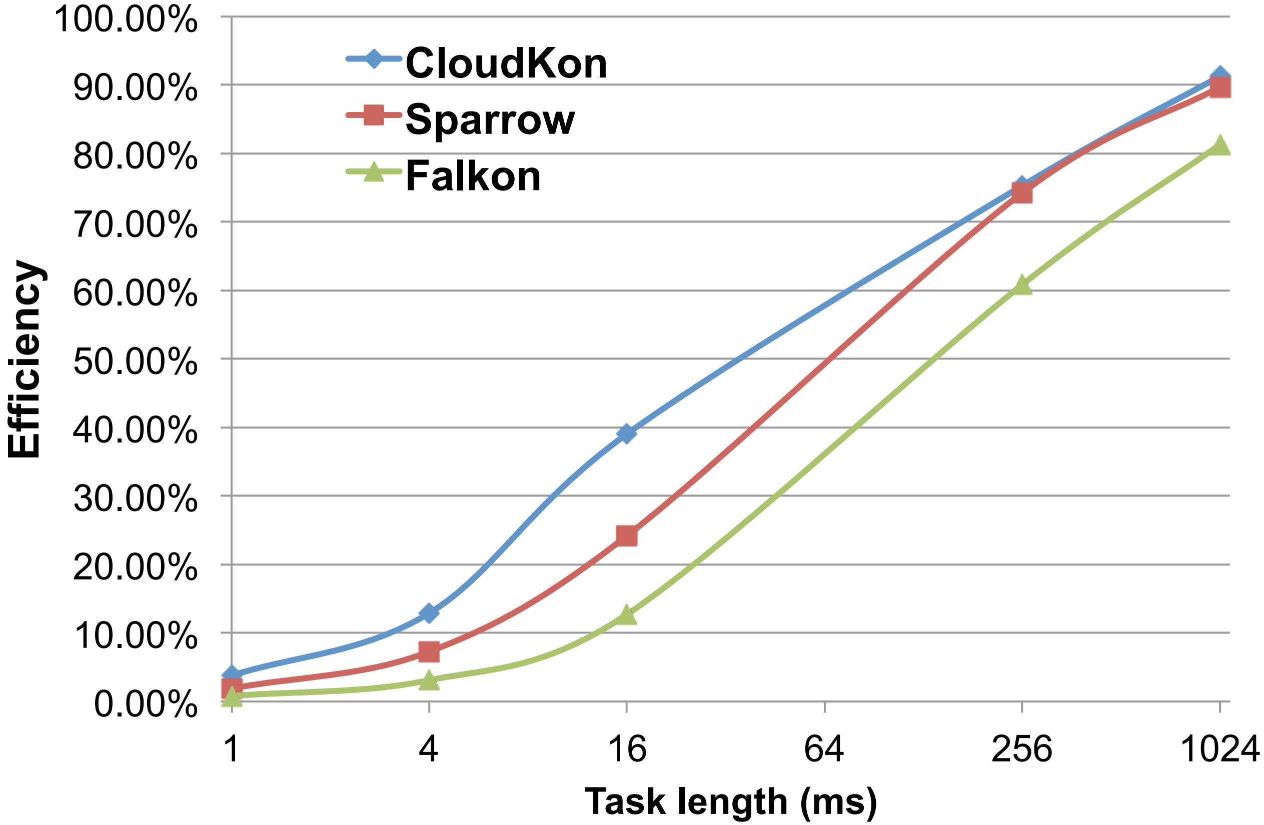
- Duplicate task controller enabled/disabled
- 30% overhead on average
- Overhead decreasing on larger scales

Consistency effect on latency



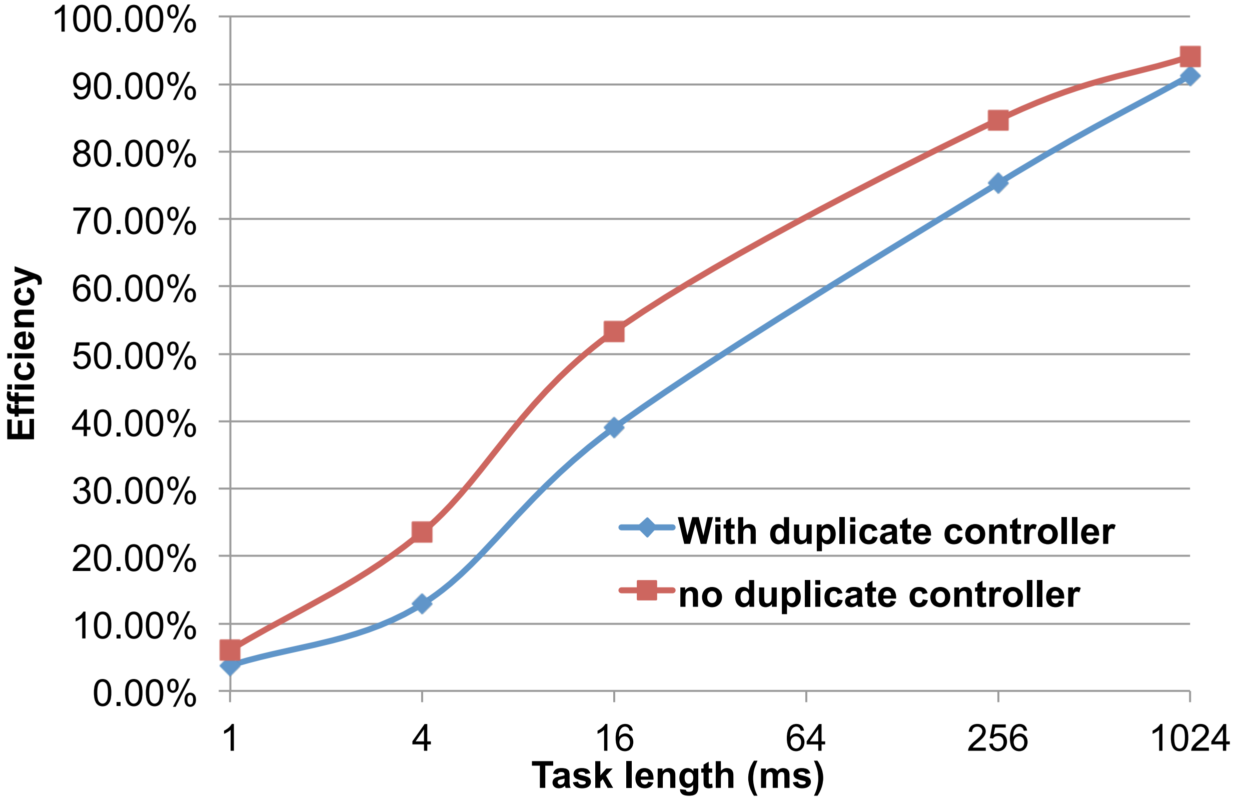
- 37% overhead on average

Efficiency



- 64 instances scale
- High efficiency on 1 sec tasks (91.26%)
- Moderate efficiency on tasks with 100s of ms length.

Consistency effect on efficiency



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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
  - Sparrow 2013
  - Falkon 2007
    - High throughput and efficiency

Future work

- On Cloud Environment
  - Extend the evaluation scale to 1024 instances
  - Run real applications on CloudKon
    - Industrial benchmarks: TPC-H
    - Data Analytics: MapReduce applications (Hadoop workloads)
  - Implement a SQS like service
    - Using ZHT distributed hash table as a building block
    - Make CloudKon infrastructure independent
    - Test CloudKon on private clouds (e. g. OpenStack)
- On HPC environment
  - Create a tightly coupled system using our own Distributed Queue implementation
    - Deliver lower latency
  - Evaluate the performance on HPC Clusters and super computers
    - Run real applications

Thank you

- Questions?!