Pigeon: an Effective Distributed, Hierarchical Datacenter Job Scheduler

Zhijun Wang, Huiyang Li, Zhongwei Li, Xiaocui Sun, Jia Rao, Hao Che and Hong Jiang

University of Texas at Arlington

Datacenter job scheduling challenges-I

- Large scale

Cluster size is large

Tens of thousands of nodes/workers

The number of tasks in a job can be larger

Tens of thousands of tasks in a job

-- More than 50K tasks in a job in the Cloudera trace

Datacenter job scheduling challenges-II

- Heterogeneous workload

Short jobs (e.g., user facing applications)

---call for short response time

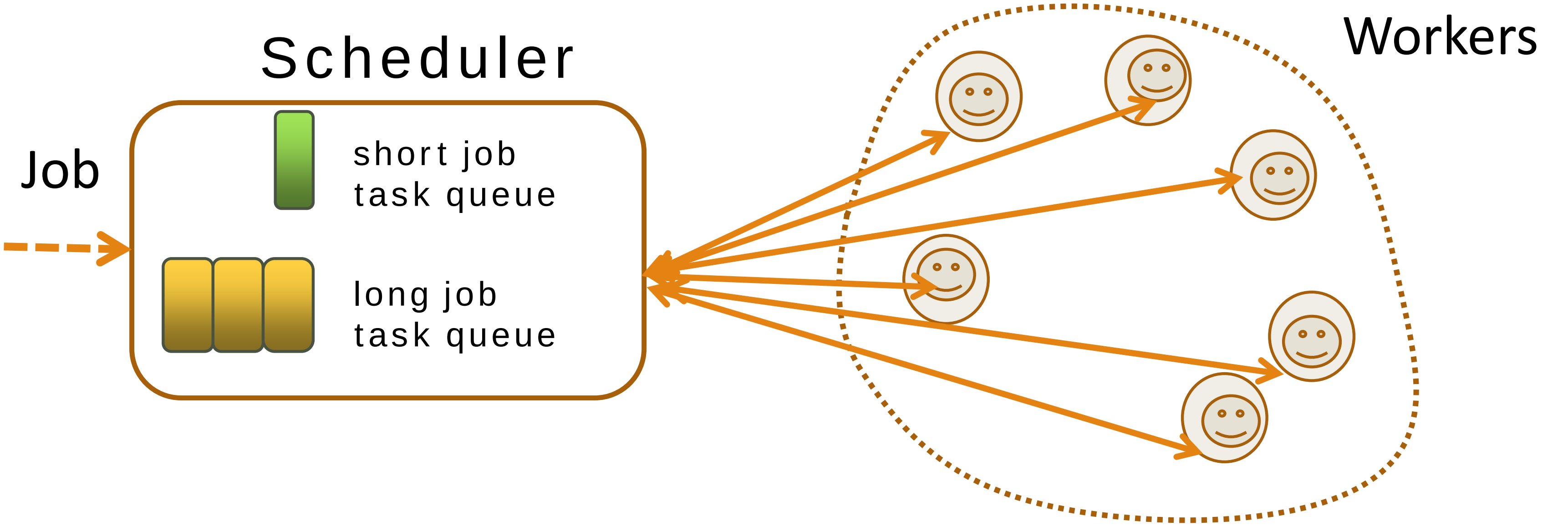
Long jobs (e.g., Data backup)

--call for mean response time guarantee

Centralized job scheduling

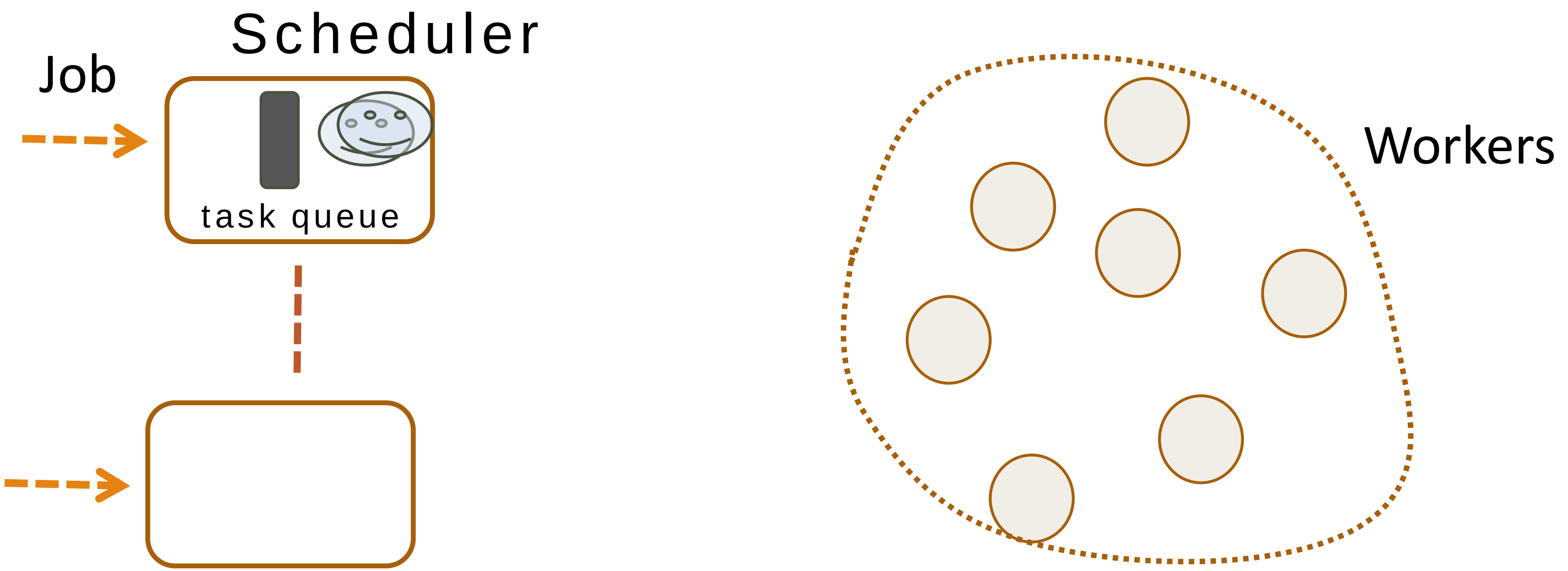
Scalability problem

A scheduler manages all the workers' resources in a cluster



Distributed scheduling-Sparrow

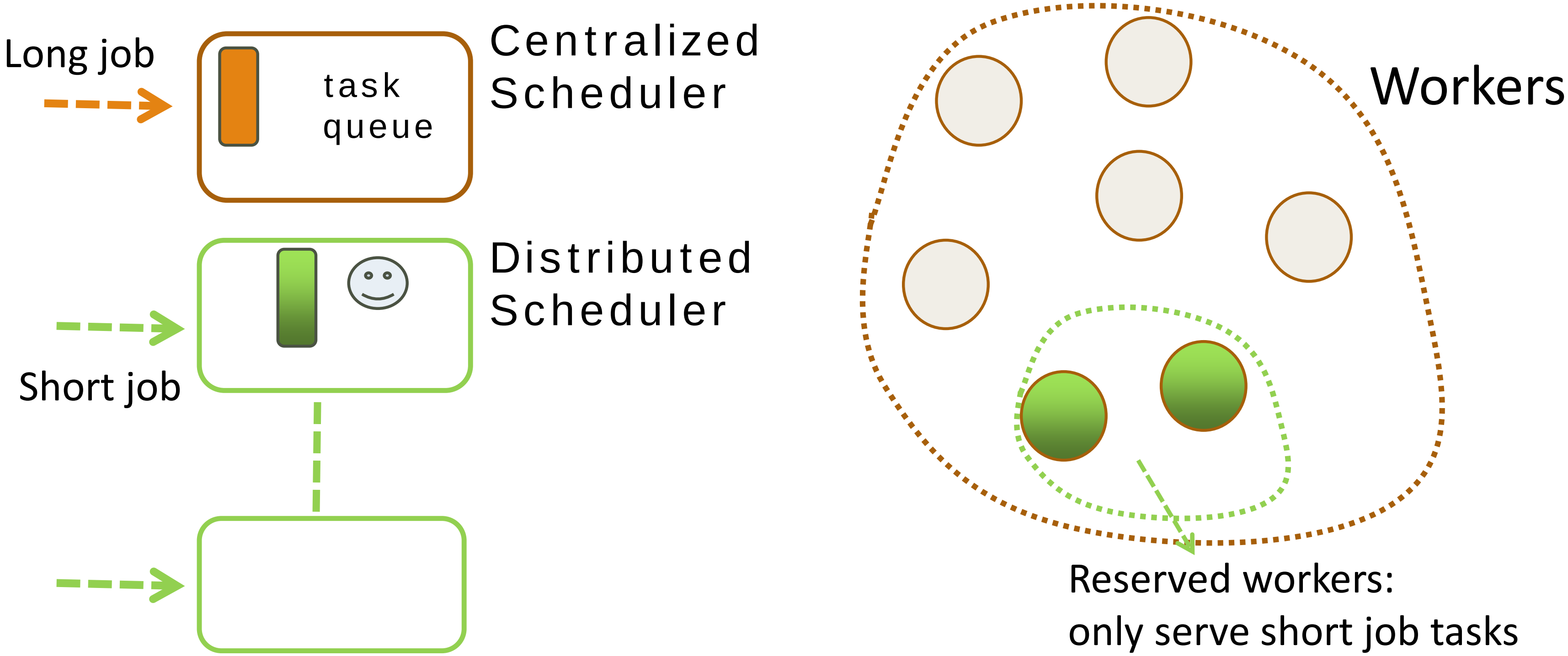
- Low efficinecy: unbalanced probing



A scheduler needs to maintain all probes.

Hybrid scheduling-Eagle, Hawk

- All short jobs are put to reserved workers
- Scalability problem



Pigeon

- Contributions

1. Introduce a master level for task distribution

   New architecture, hierarchical job scheduler

2. Fully solve scalability problem

3. High efficiency

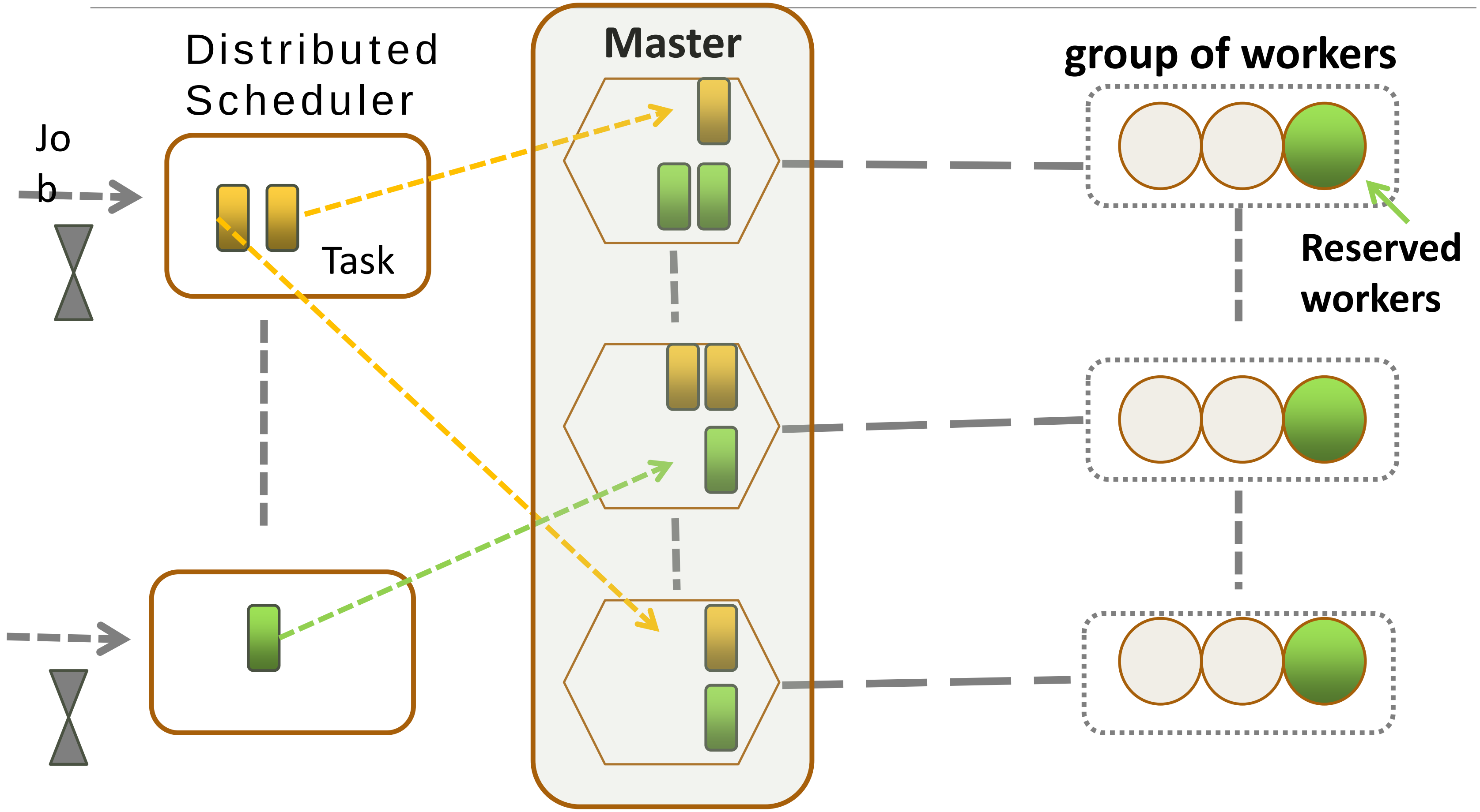
Centrally manage a group of workers

Receive tasks from job schedulers

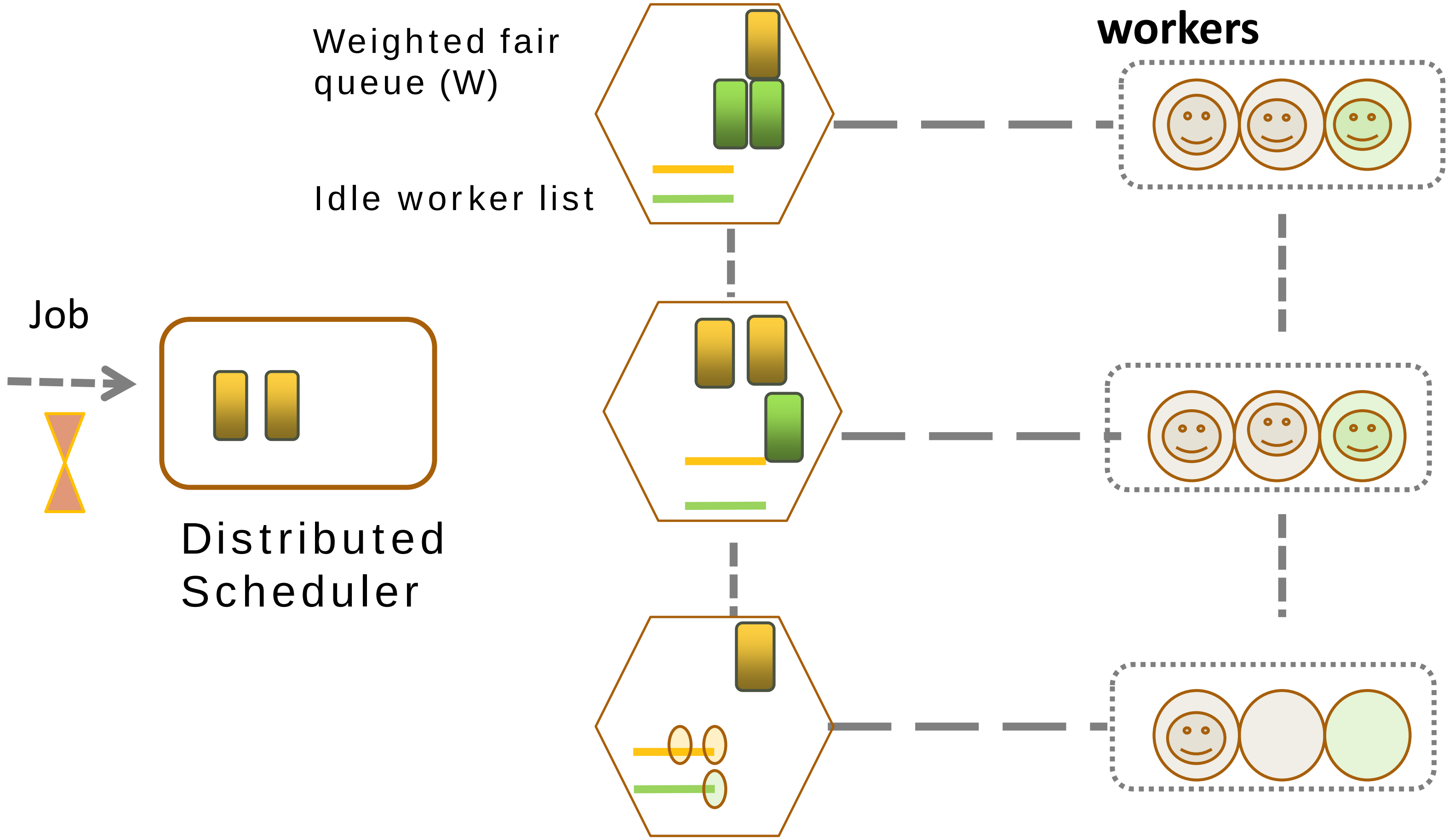
Dispatch tasks to workers

Overview of Pigeon

Master is job agnostic



Job scheduling in Pigeon



Why is Pigeon better?

Solve key challenges in existing schedulers

Scalable: greatly reduce status maintenance costs in job schedulers

Group size 100: # of master is 1% # of workers, reduce 99% status maintenance cost

Efficiency:

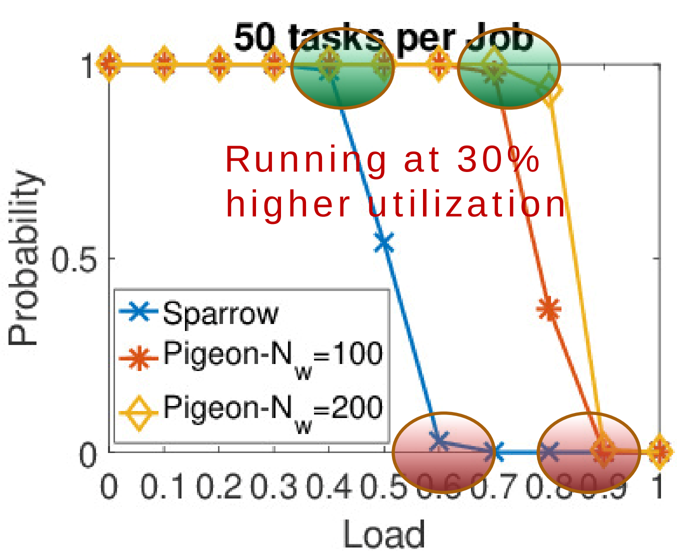
Remove head-of-line blocking

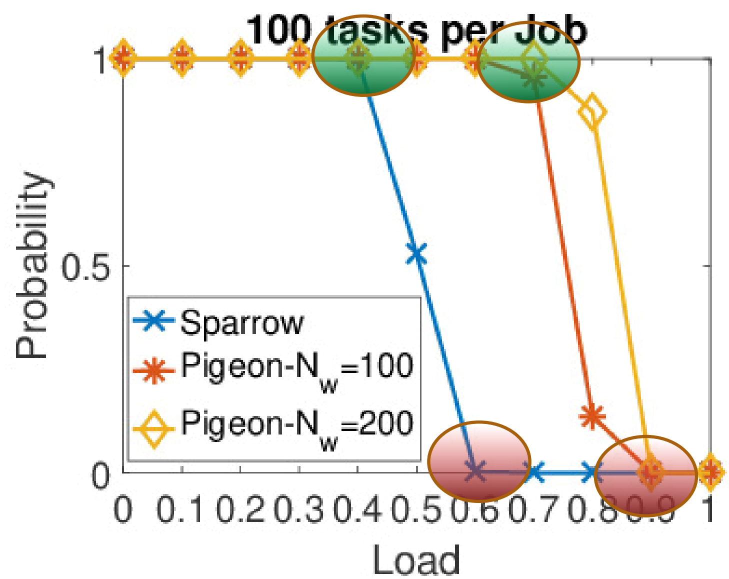
Have statistical multiplexing gain within a group

Group size 100: run at 90% load, the probability of a task finding an idle worker in a group is $1\text{-}0.9^{100}$ =99.99734!!

Modeling and Analysis

Consider a single type of jobs, the fanout degree in a job is less than the number of masters. The task queuing time in a master is a M/M/K queue (K is the group size)



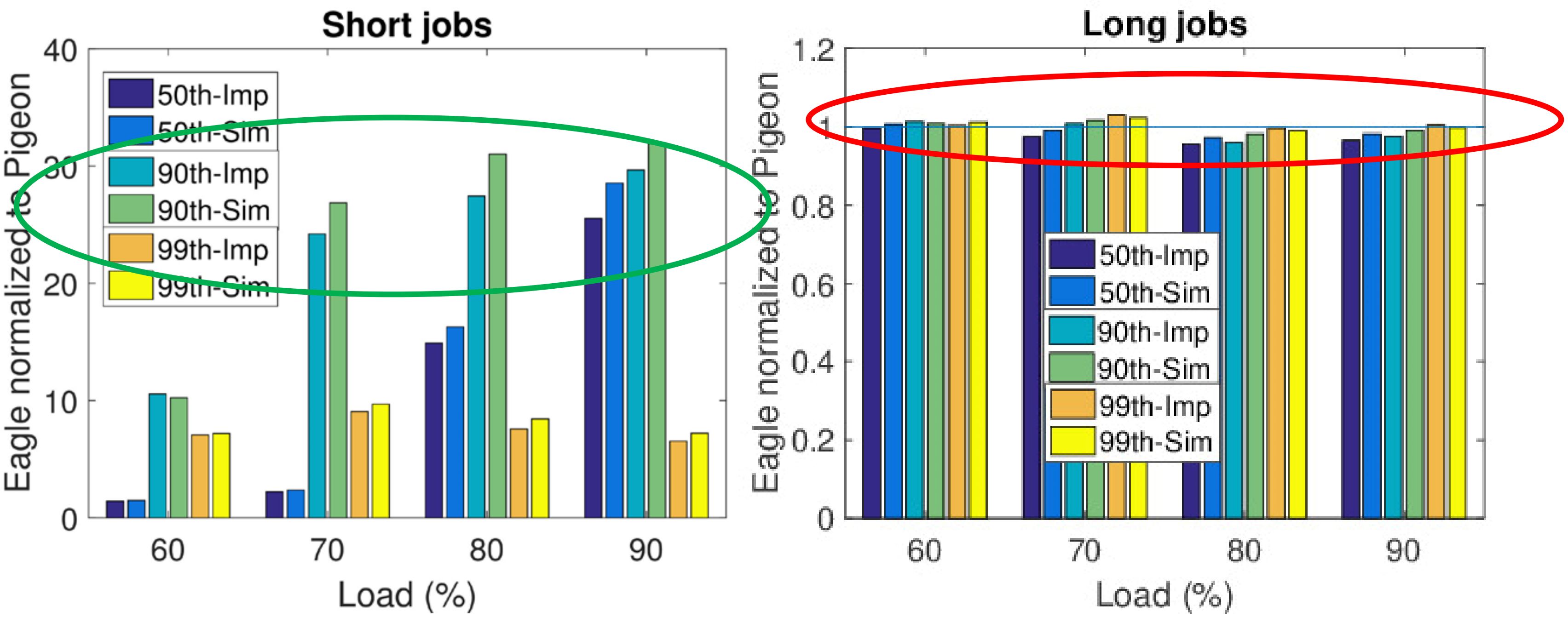


Zero queueing time: job without queuing time,
The task execution time in a job is the same

Evaluation--Implementation

- Spark plug-in, Amazon EC2 cloud
- 120-worker cluster (3 groups in Pigeon)
- Measurement metrics:
  50th, 90th and 99th percentile short and long job completion time
- Compare with state-of-the-art schedulers: Eagle and Sparrow
- Source codes: https://github.com/ruby-/pigeon/

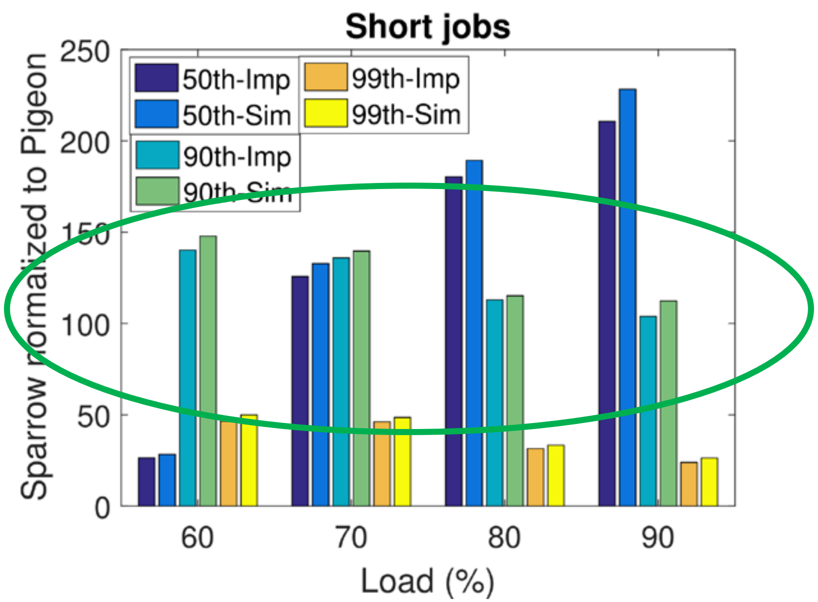
Pigeon vs Eagle--Implementation

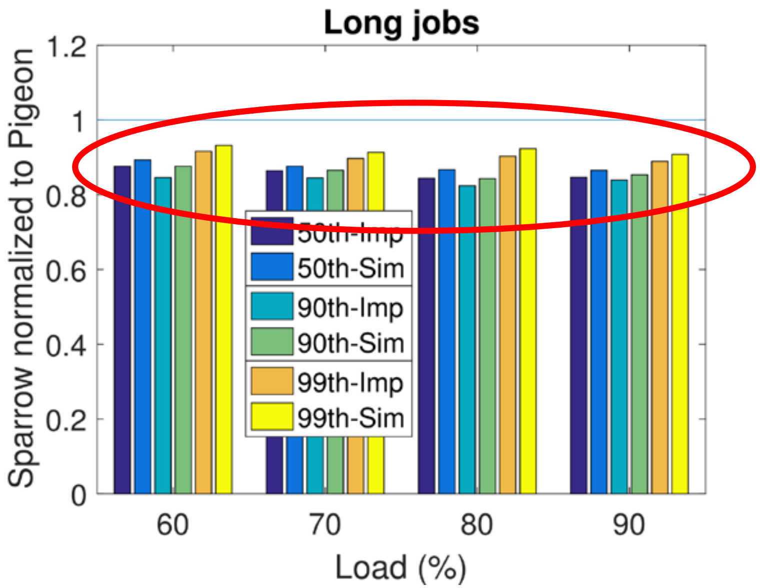


Eagle normalized to Pigeon

20x~30x short job performance gains

Pigeon vs Sparrow--Implementation





Sparrow normalized to Pigeon

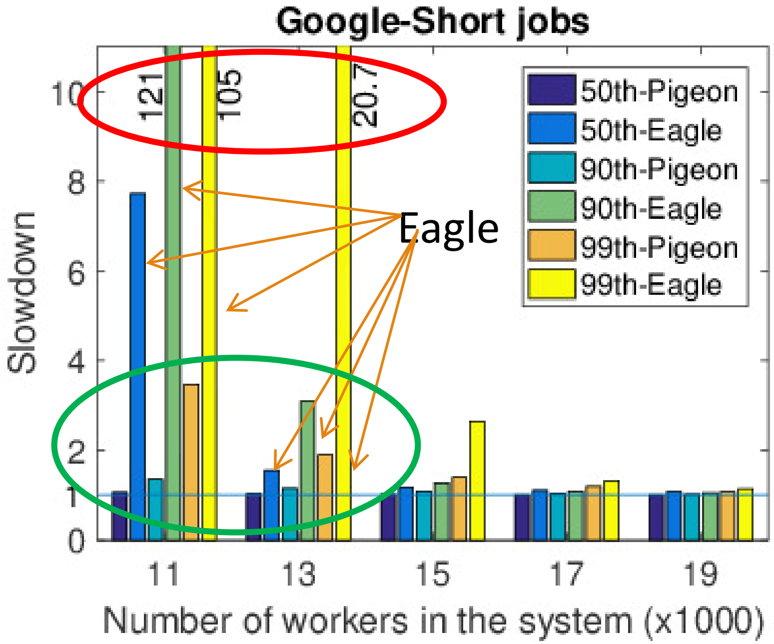
Pigeon works in a real cluster

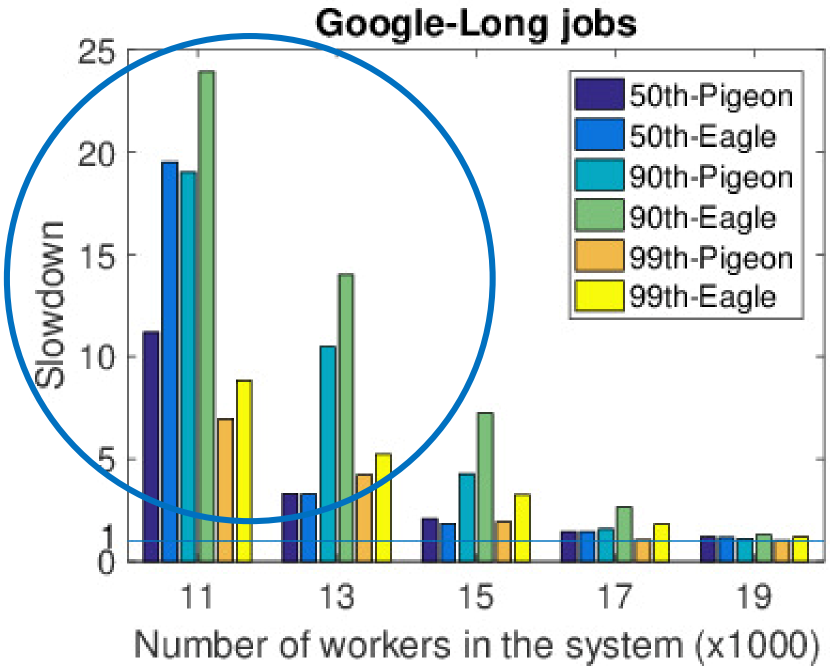
Evaluation—Large Scale Simulation

- Event-driven simulator
- Google, Yahoo and Cloudera traces
- Cluster size 3000--19000 workers
- Measurement metrics:
  50th, 90th and 99th percentile short and long job completion time
- Compare with state-of-the-art hybrid scheduler: Eagle

Pigeon is really scalable and efficient

Google trace





Slowdown=job completion time / job execution time

Big performance gains for short job at high loads
Slightly better performance gains for long jobs

Conclusion

Pigeon: a new distributed and hierarchical job scheduler, new scheduling architecture

1. Excellent scalability
   better than existing schedulers

2. High efficiency with multiplexing

Thank you!
Questions ??