Hawk: Hybrid Datacenter Scheduling

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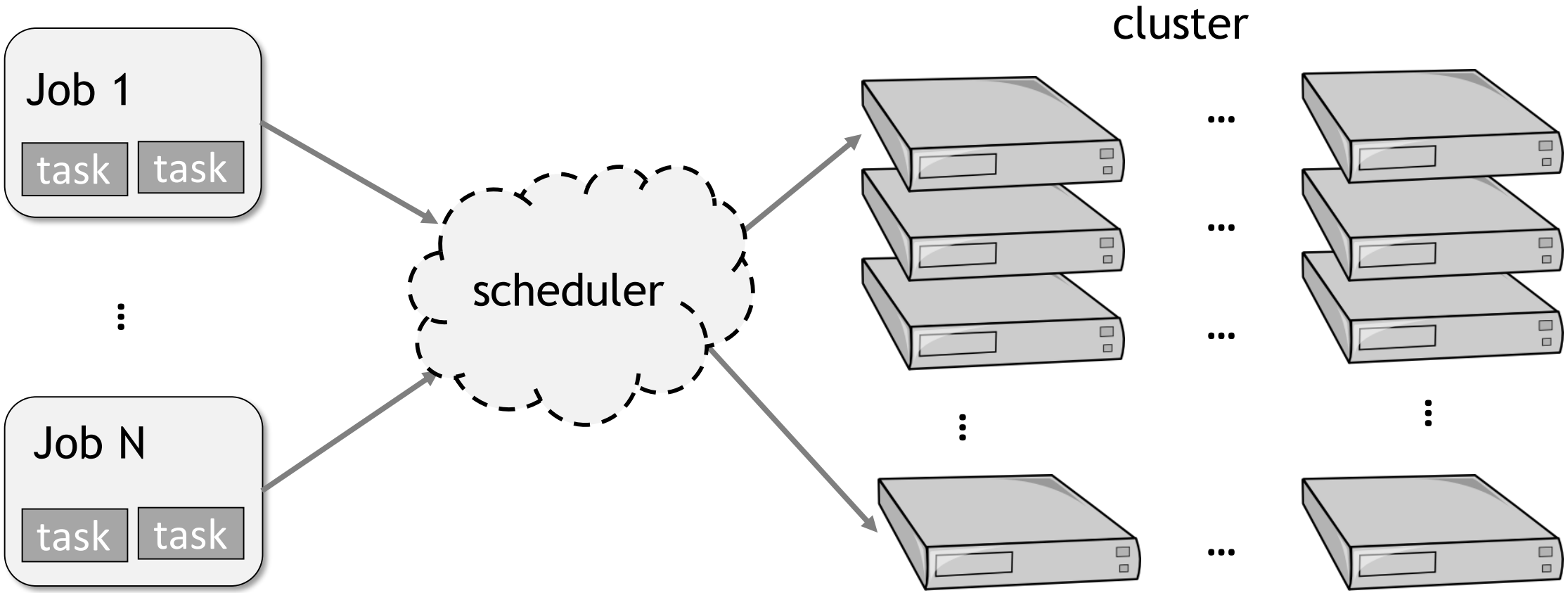
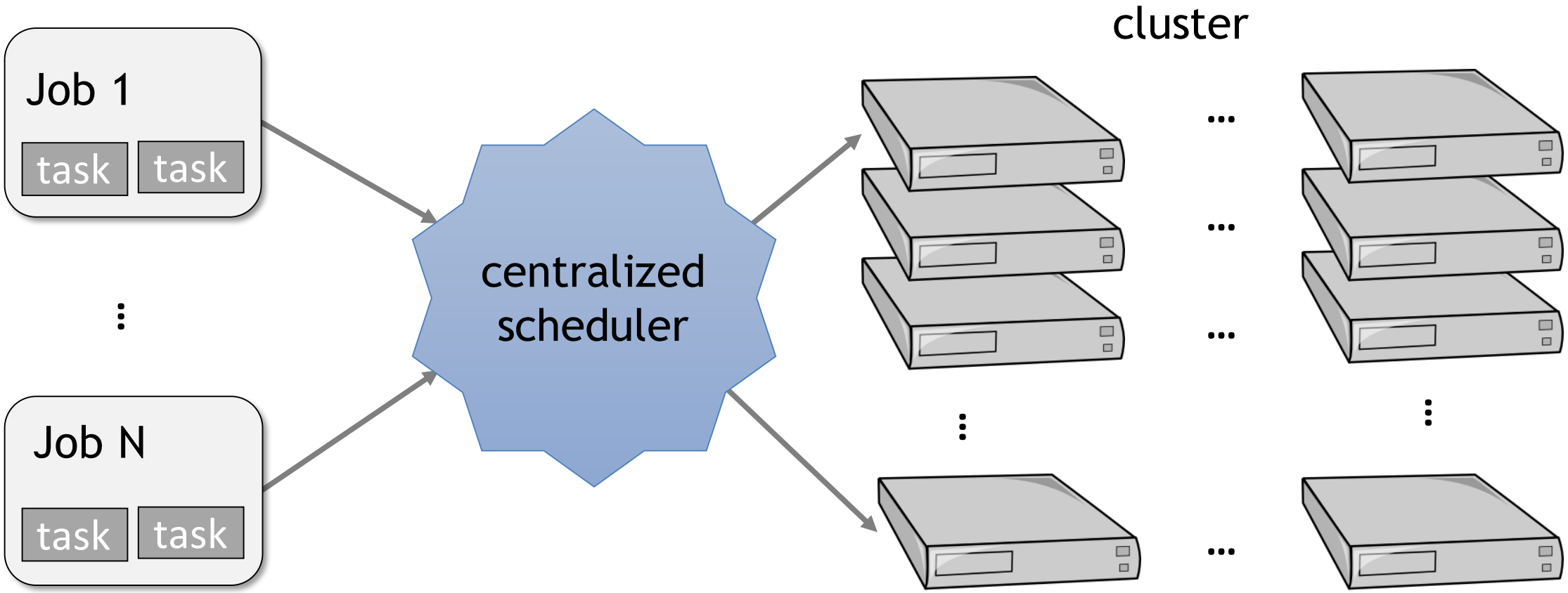
Anne-Marie Kermarrec, Willy Zwaenepoel

Introduction: datacenter scheduling



Introduction: centralized scheduling



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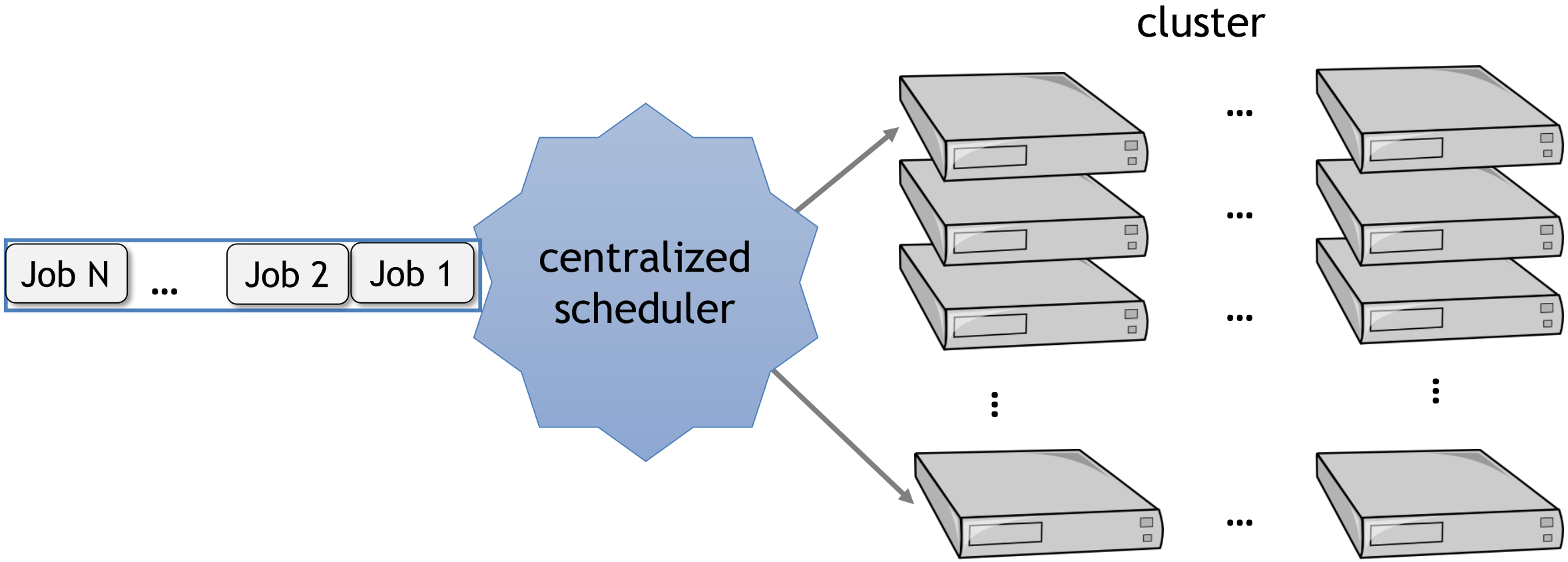
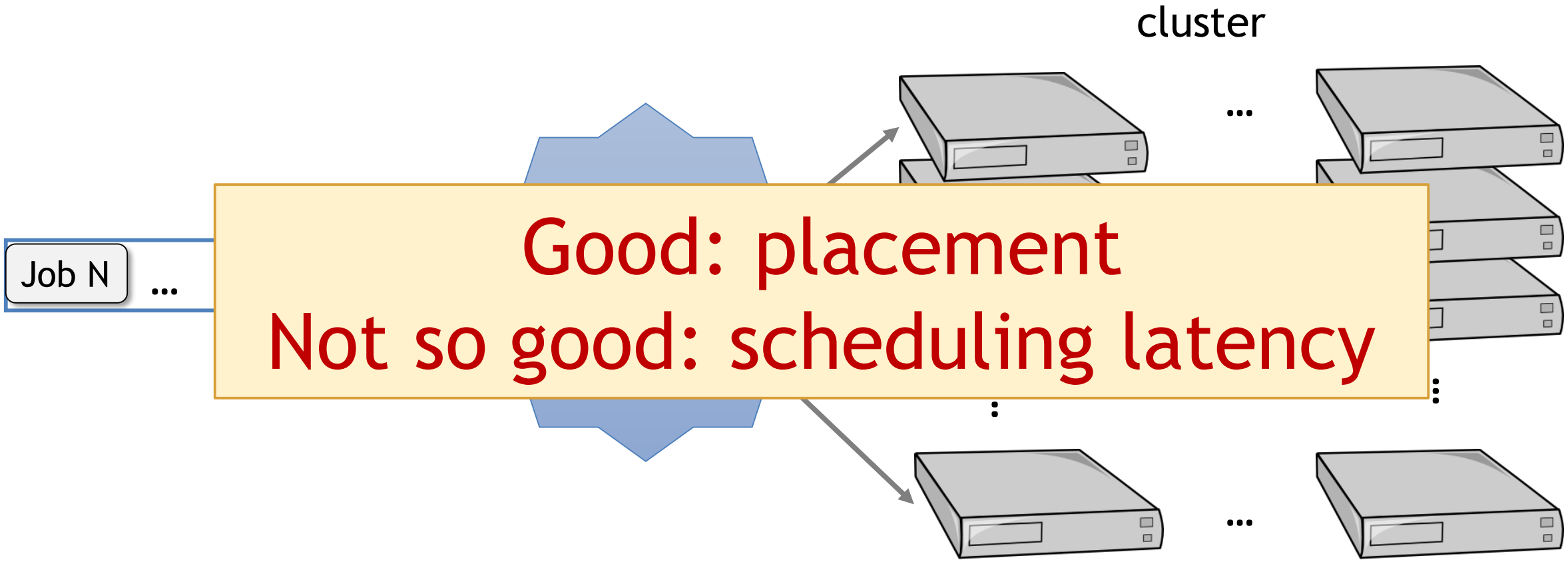
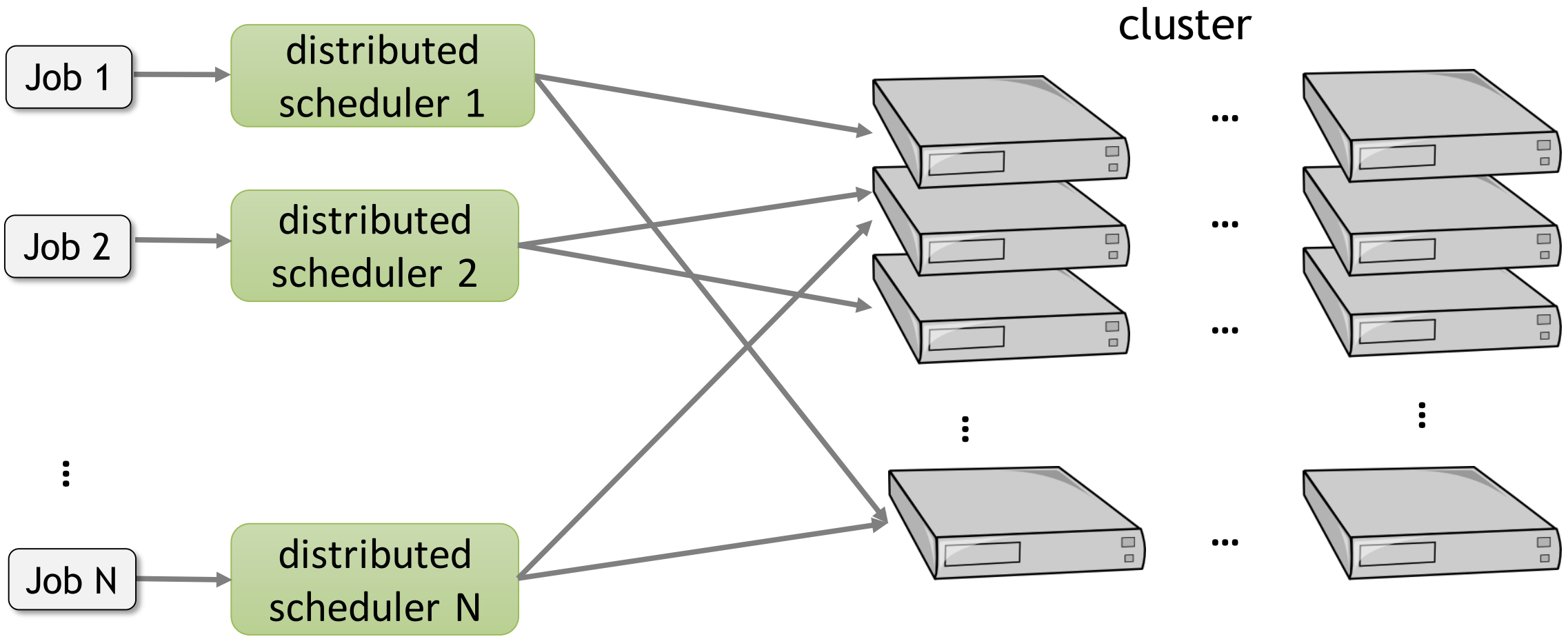


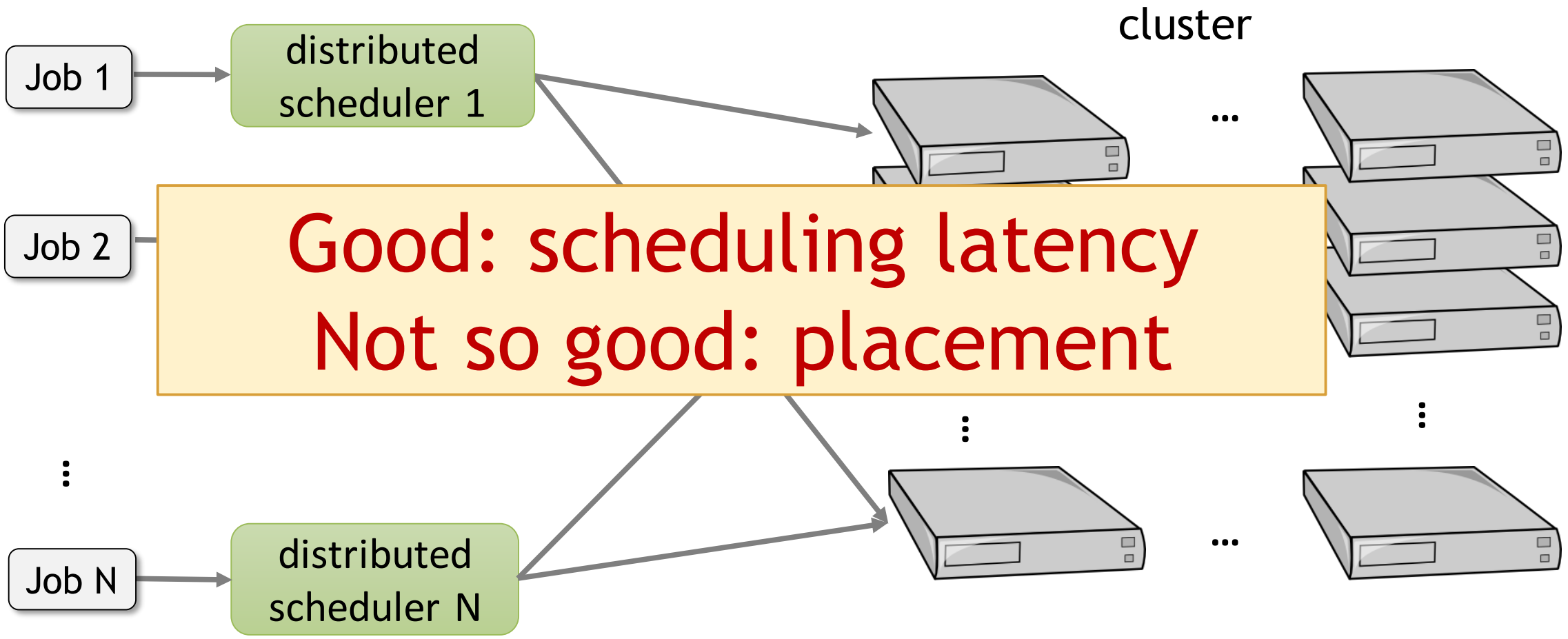
Introduction: centralized scheduling



Introduction: distributed scheduling



Introduction: distributed scheduling



Outline

1) Introduction

2) HAWK hybrid scheduling

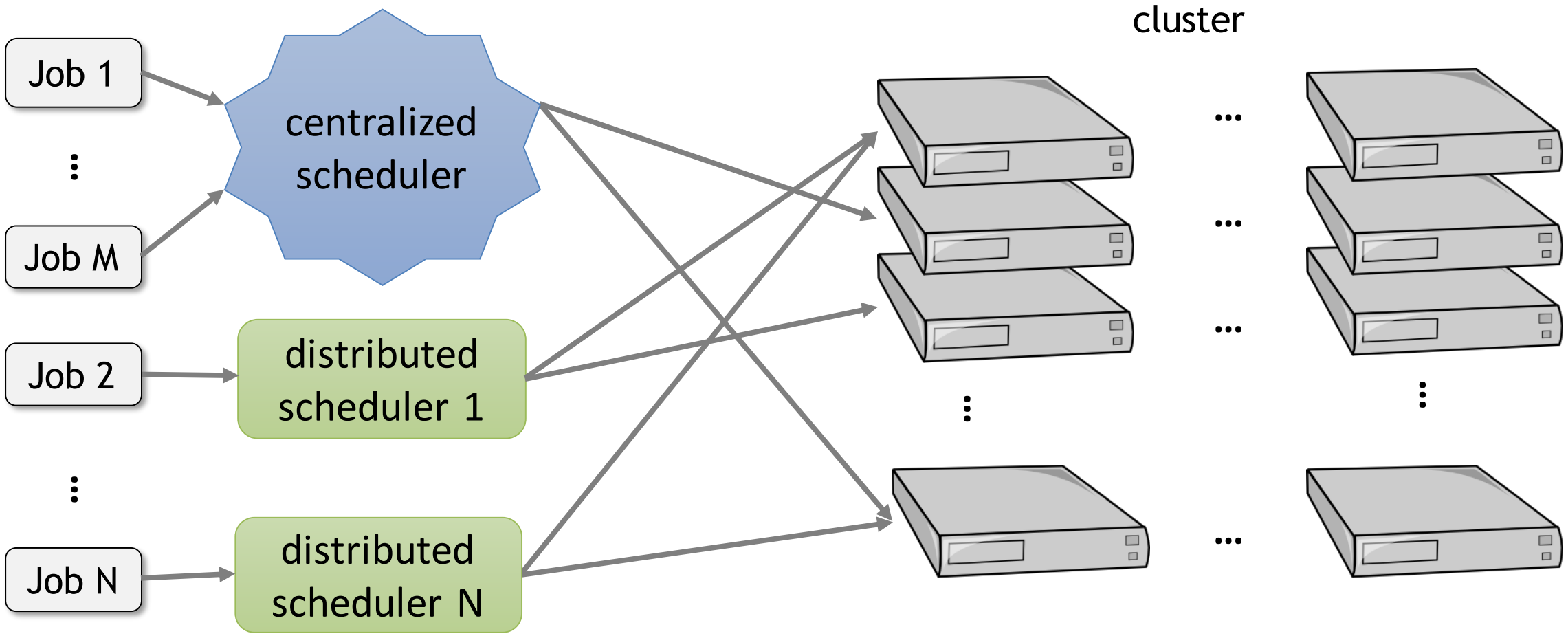
- Rationale
- Design

3) Evaluation

- Simulation
- Real cluster implementation

4) Conclusion

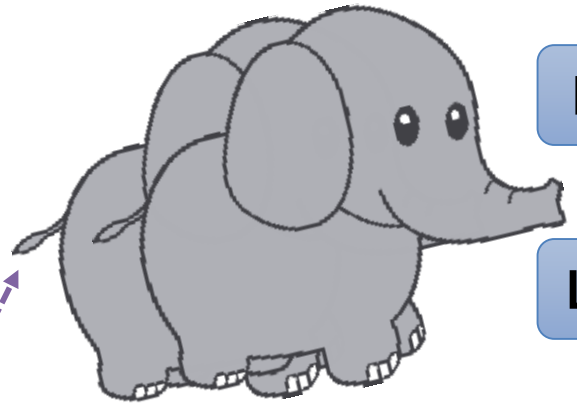
Hybrid scheduling



Hawk: hybrid scheduling

- ✓ Long jobs → centralized
- ✓ Short jobs → distributed

Hawk: hybrid scheduling

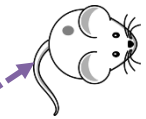


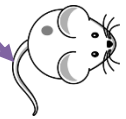
Long/short:
estimated execution time vs cut-off

Long job 1

Long job M

centralized scheduler





Short job 1

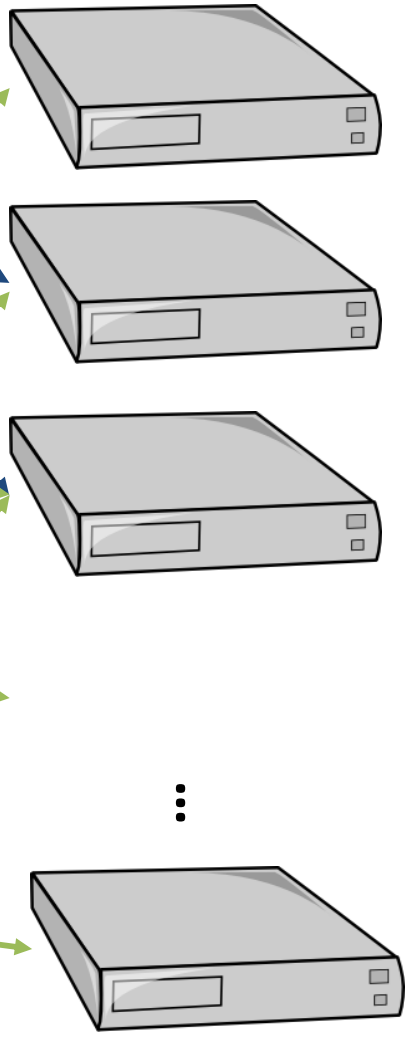
Short job 2

Short job N

distributed scheduler 1

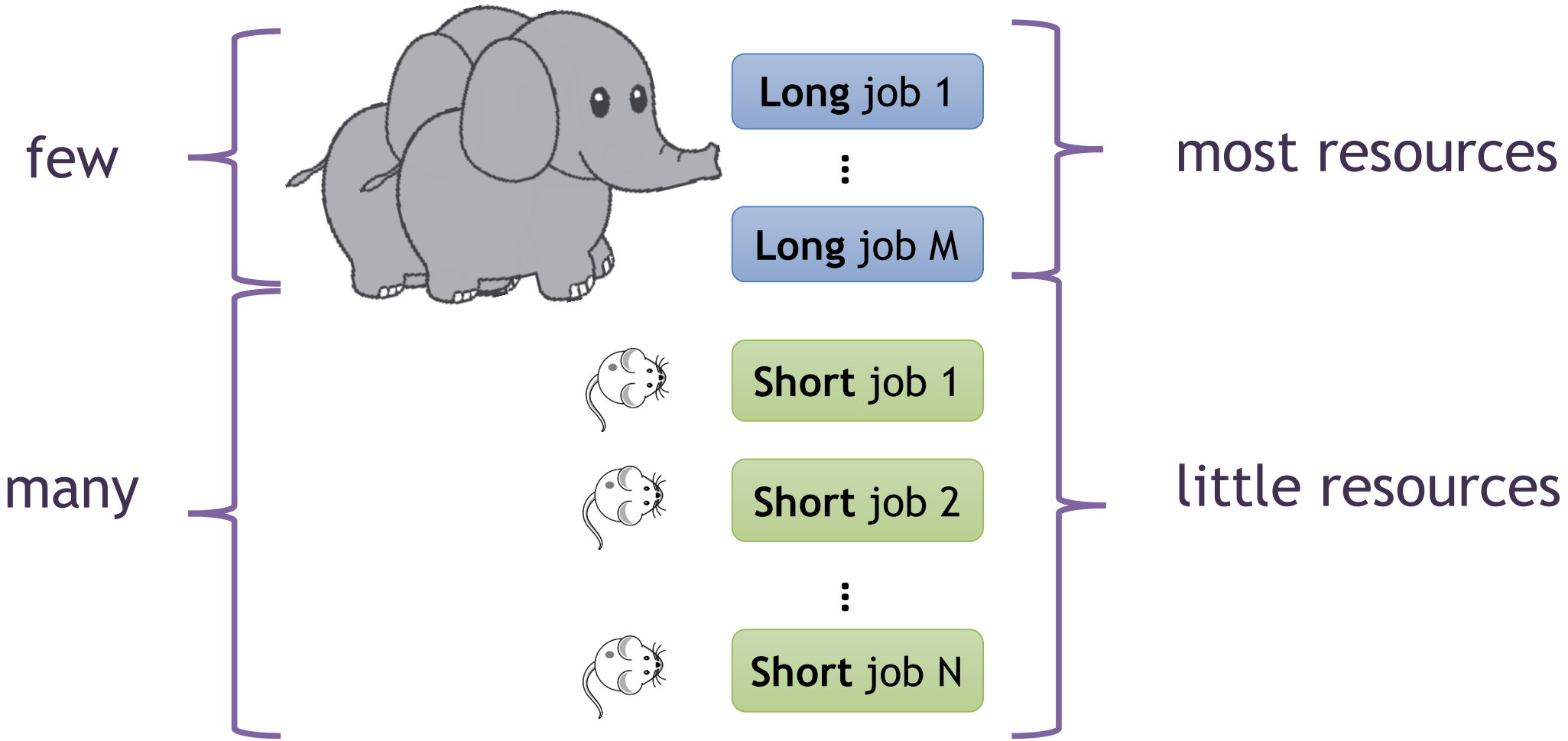
distributed scheduler 2

distributed scheduler N

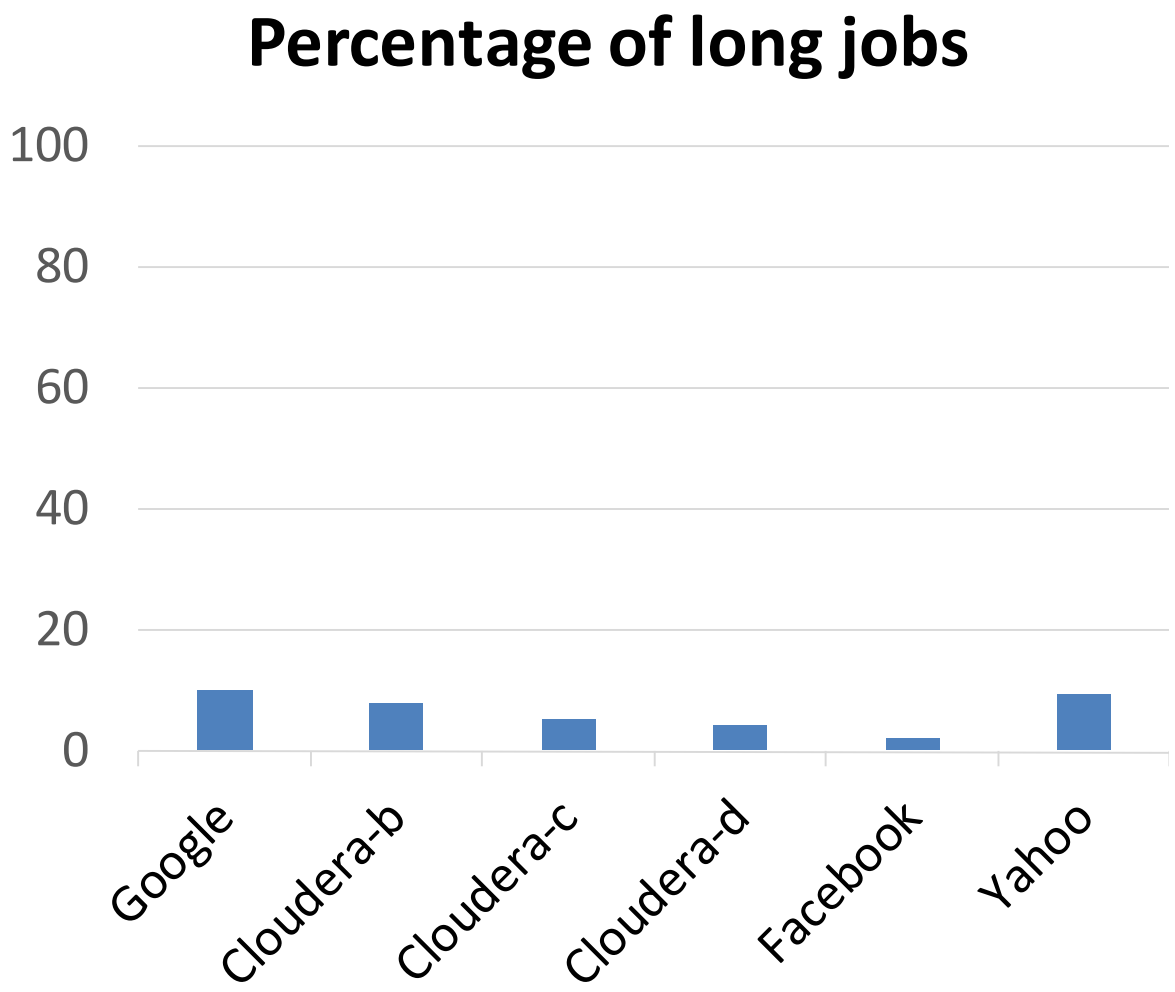


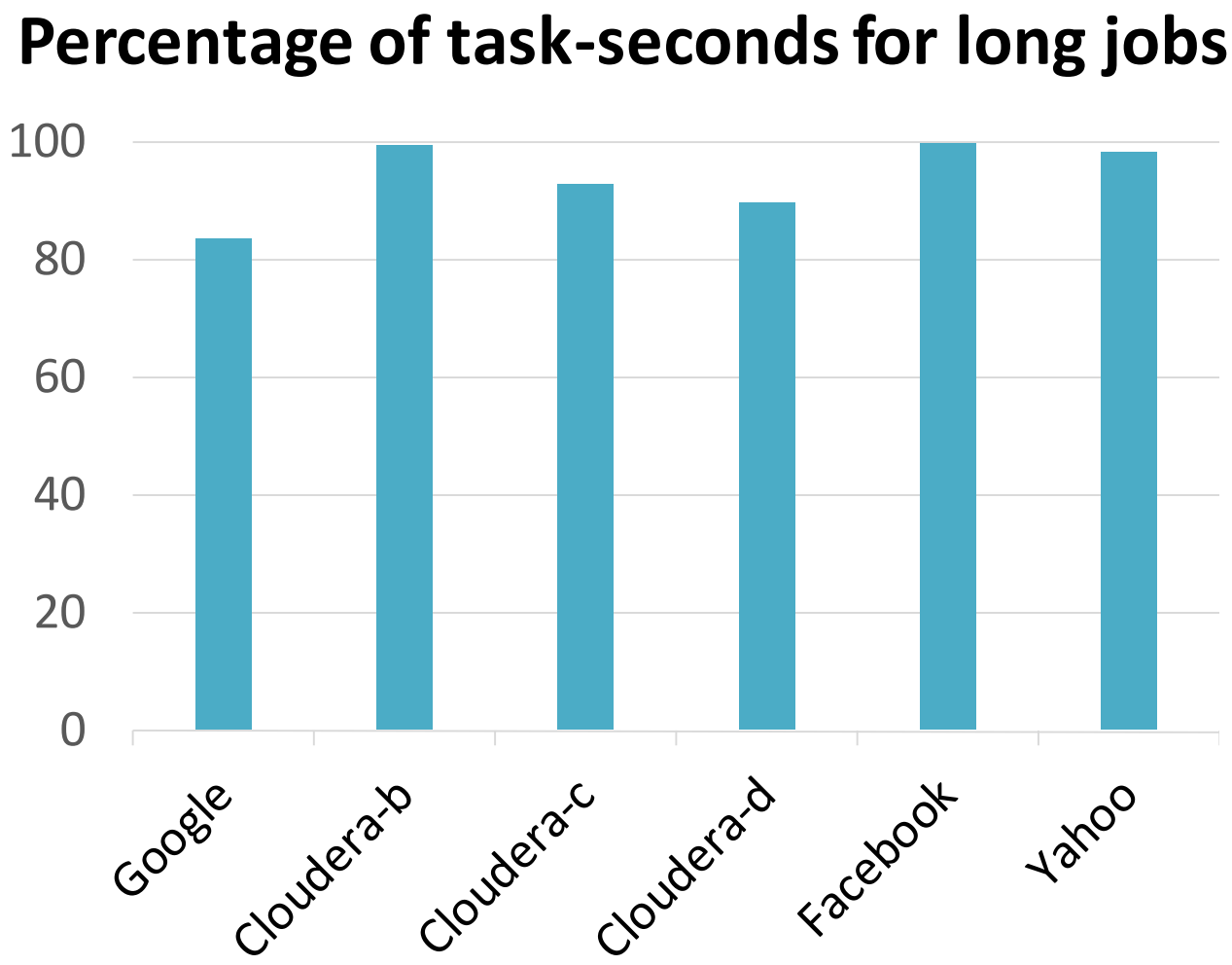
Rationale for Hawk

Typical production workloads



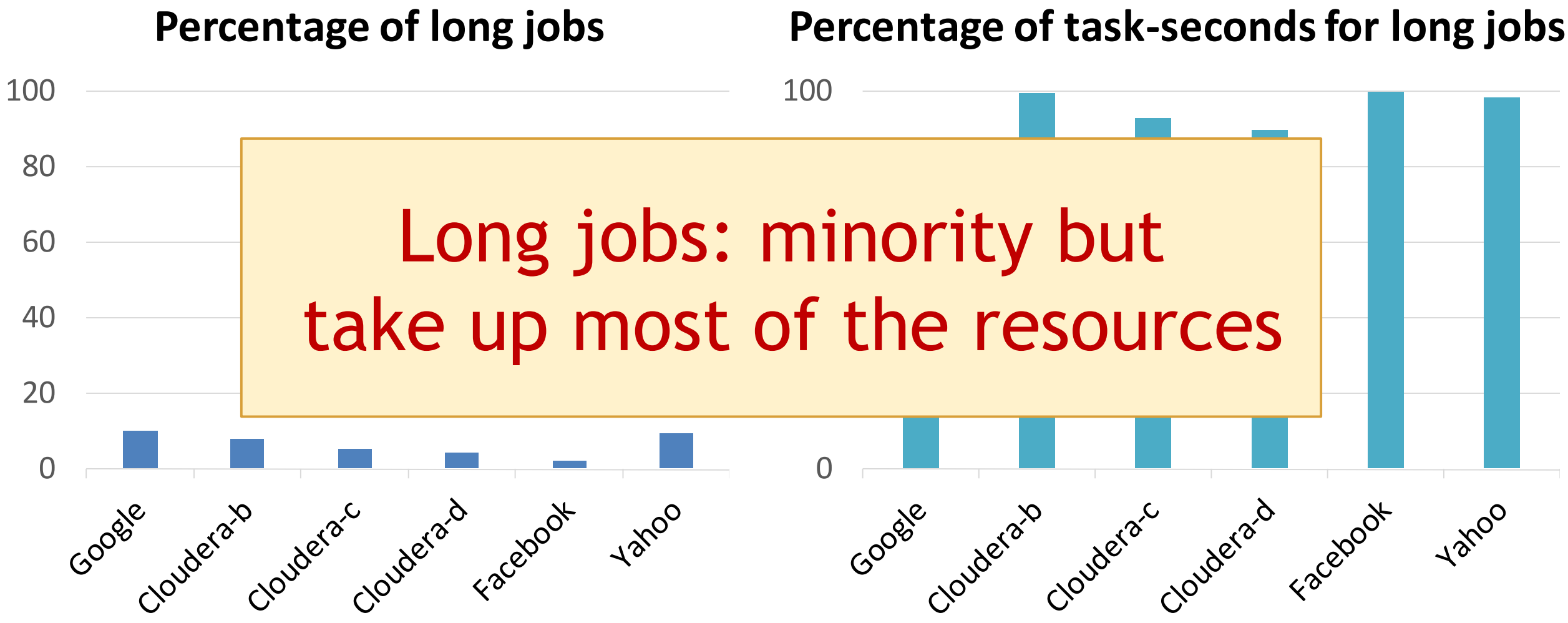
Rationale for Hawk (continued)





Source: Design Insights for MapReduce from Diverse Production Workloads, Chen et al 2012

Rationale for Hawk (continued)



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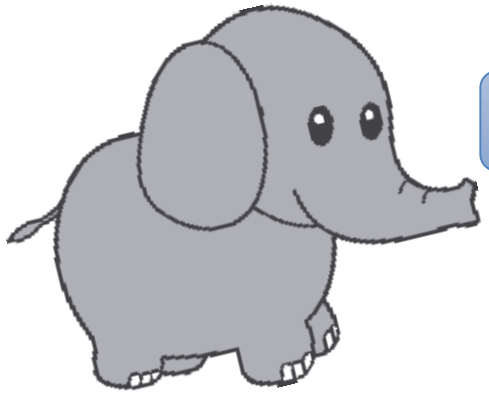
Hawk: hybrid scheduling

Bulk of resources → good placement



Long job 1

⋮

centralized

Few jobs → reasonable scheduling latency

Short job 1 → distributed 1

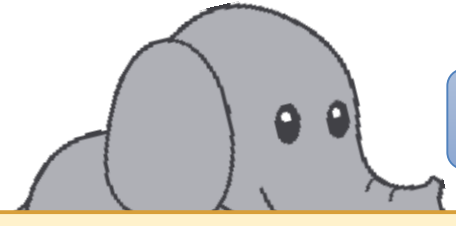
Latency sensitive → Fast scheduling

⋮ ⋮

Short job N → distributed N

Few resources → can trade not-so-good placement

Hawk: hybrid scheduling



Long job 1

centralized

Few jobs →

Bulk of

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Short job N

distributed N

BEST OF BOTH WORLDS

Good: scheduling latency for short jobs

Good: placement for long jobs

Hawk: distributed scheduling

- Sparrow

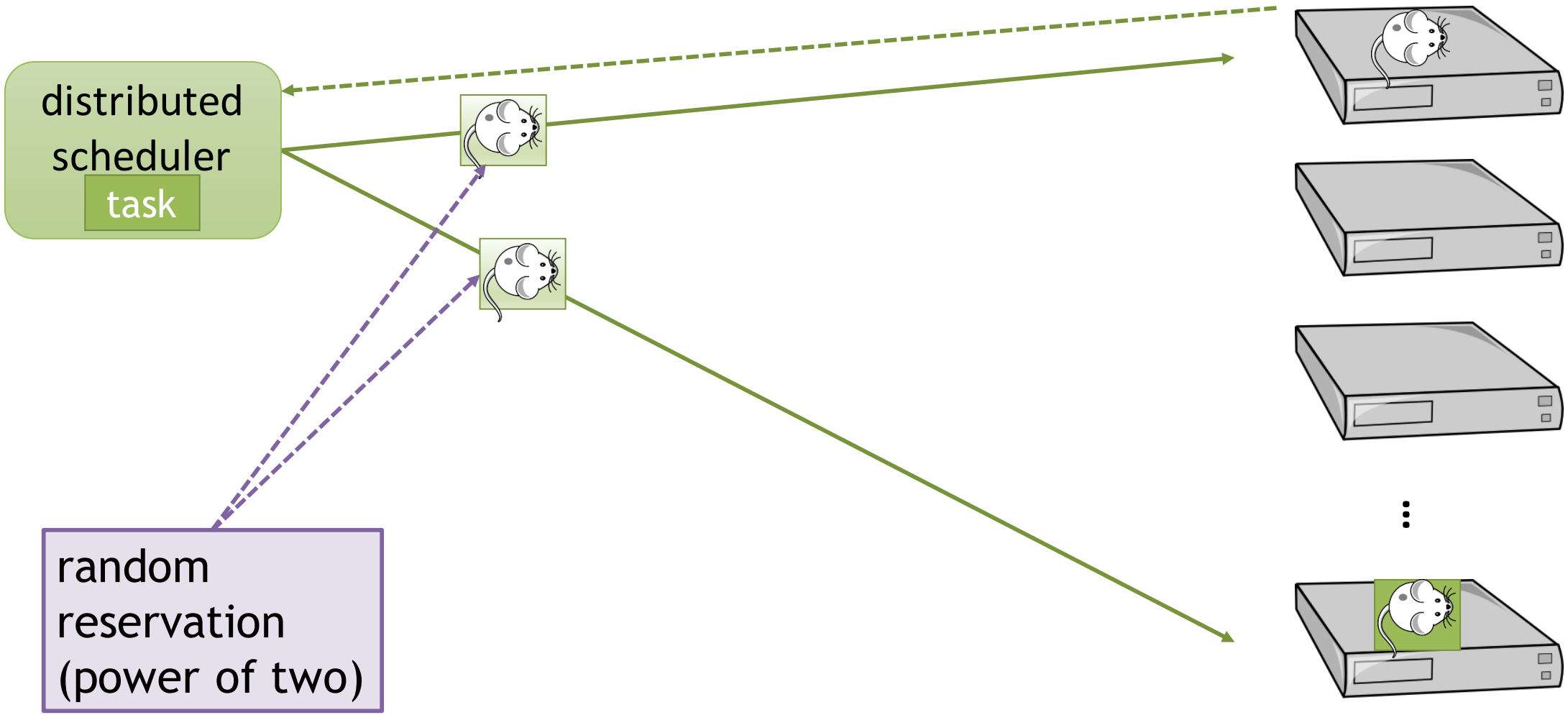
- Work-stealing

Hawk: distributed scheduling

- Sparrow

- Work-stealing

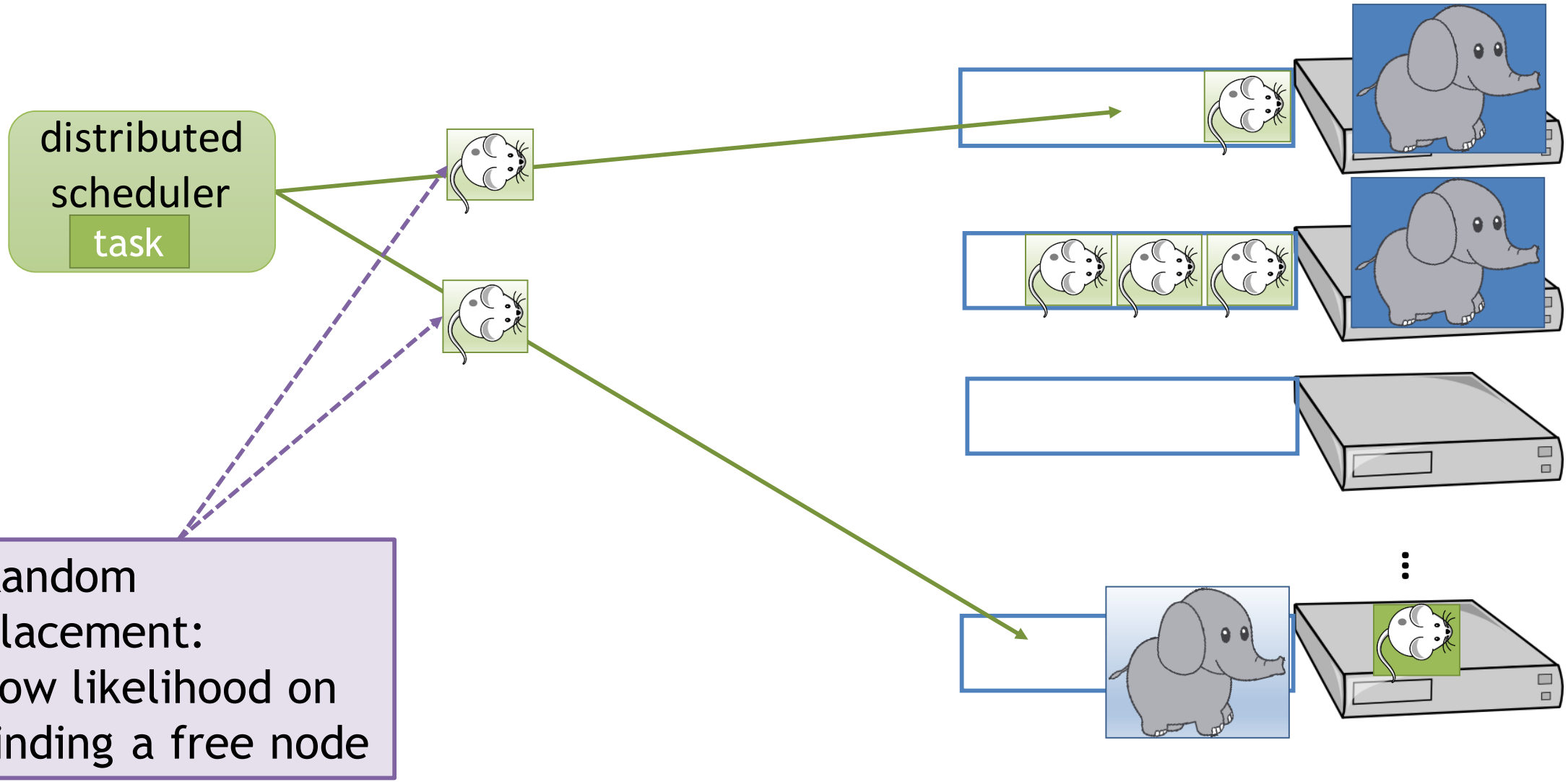
Sparrow


distributed scheduler
task
random reservation (power of two)

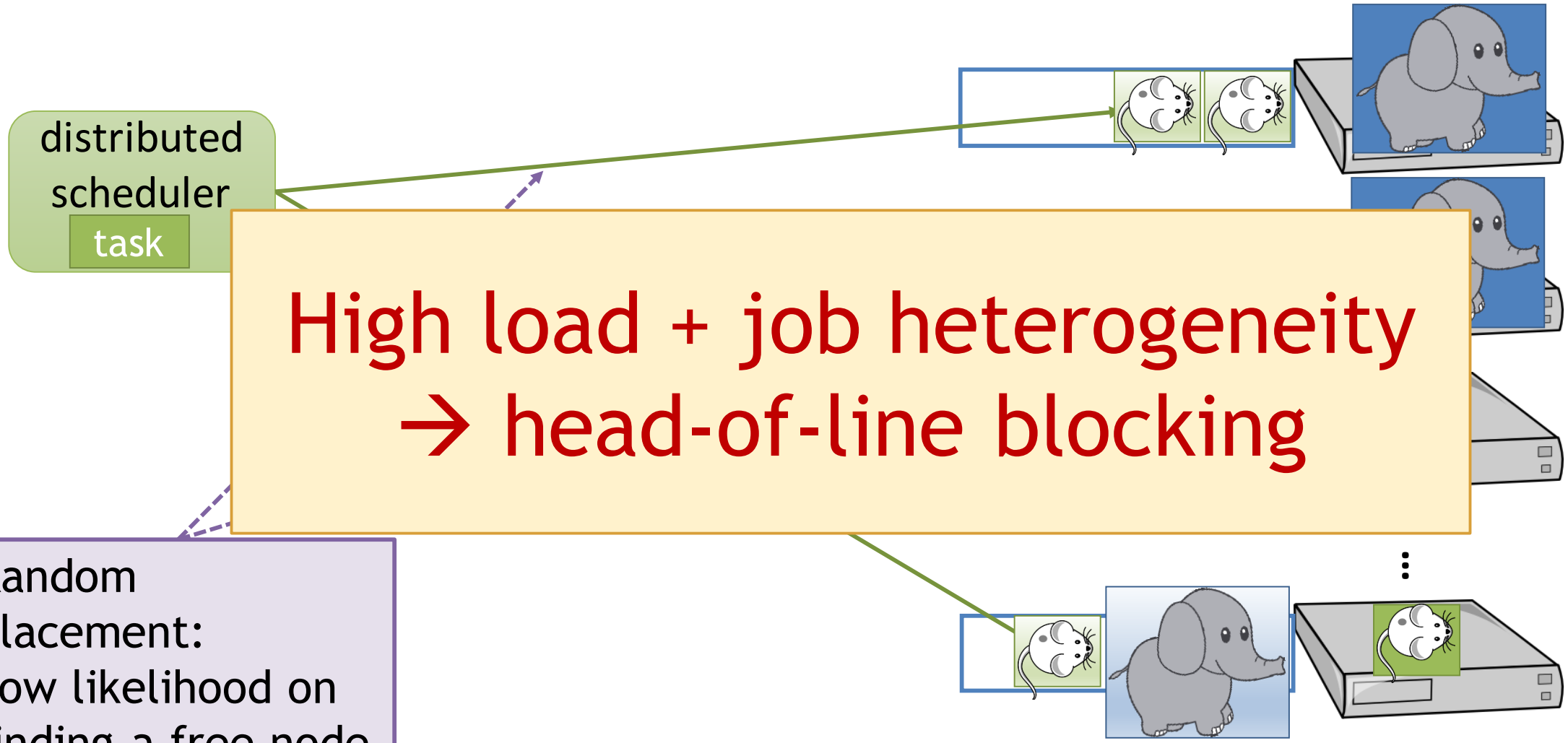
Hawk: distributed scheduling

- Sparrow
- Work-stealing

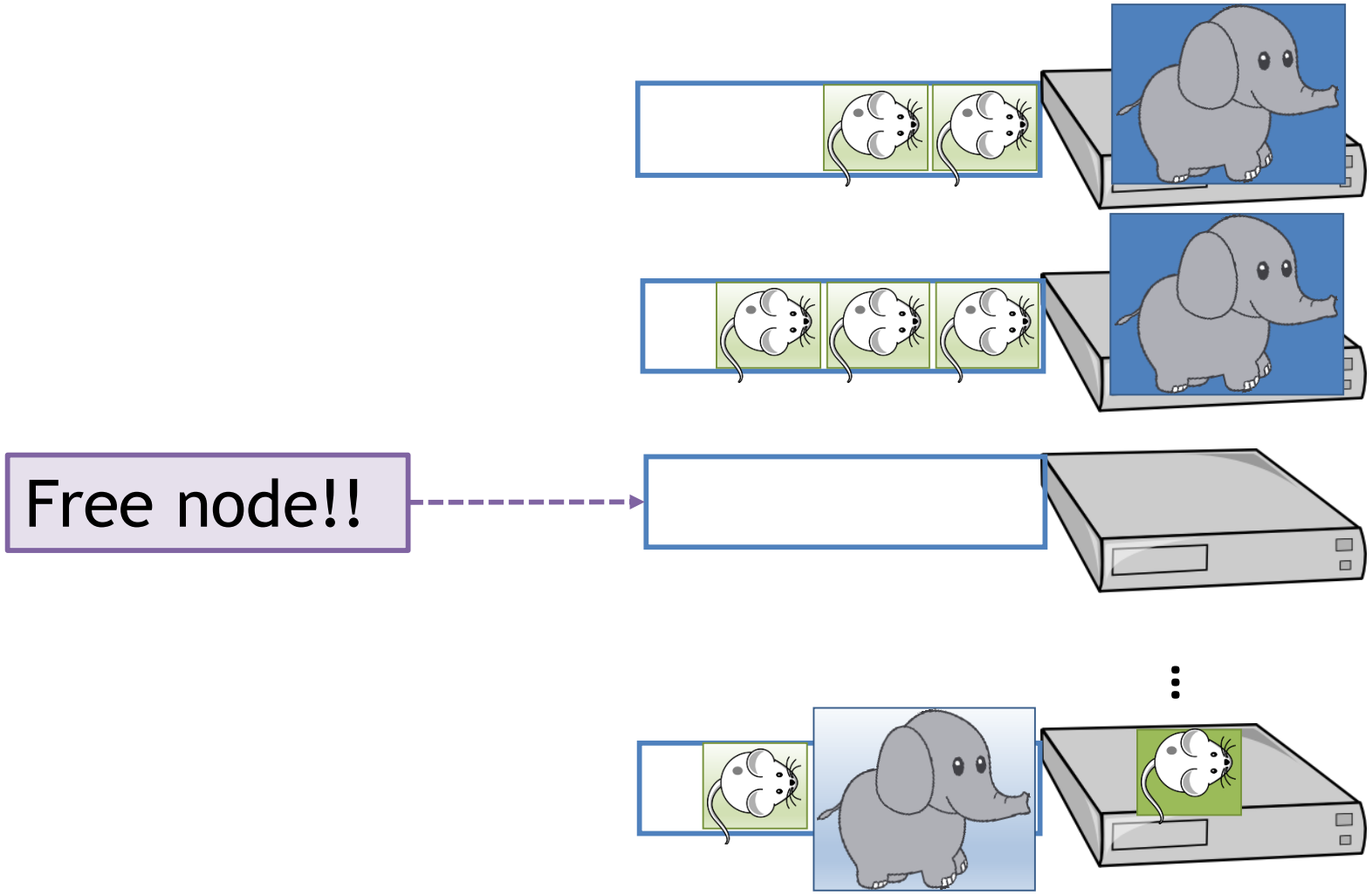
Sparrow and high load



Sparrow and high load



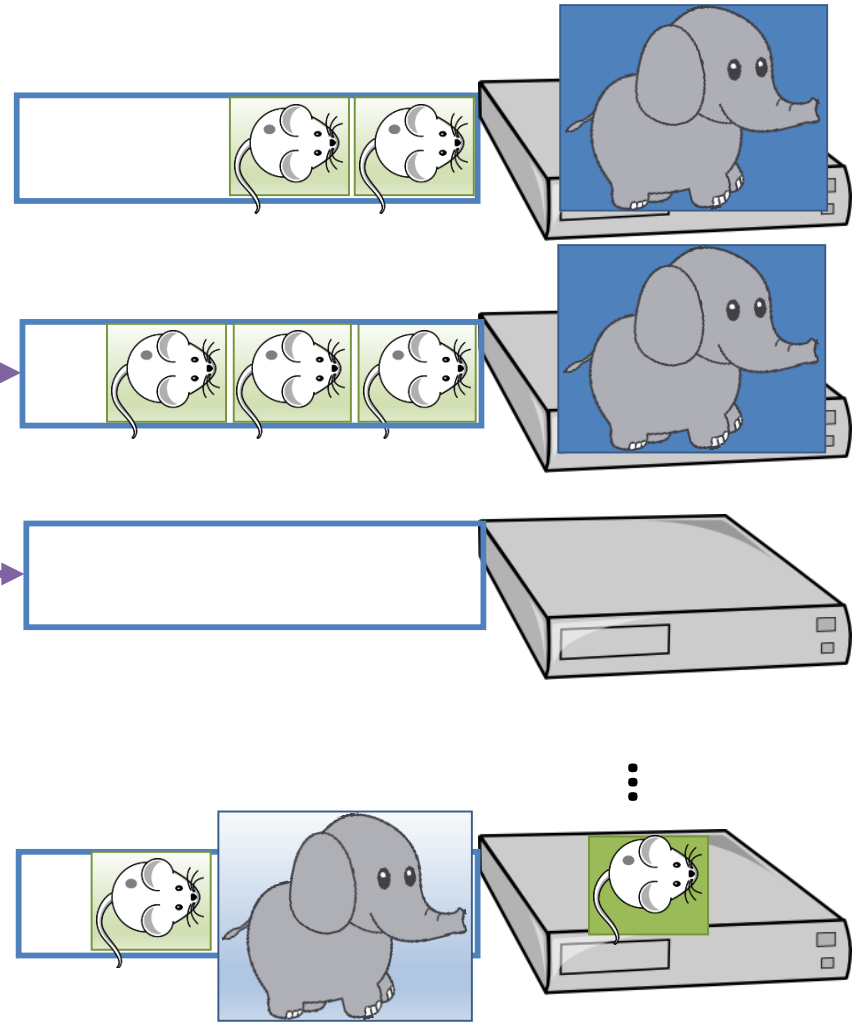
Hawk work-stealing



Hawk work-stealing

2. Random node: send **short tasks** reservation in queue

1. Free node: contact random node for probes!



Hawk work-stealing

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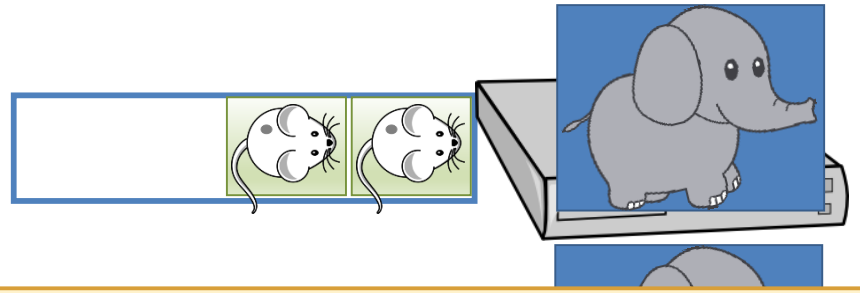
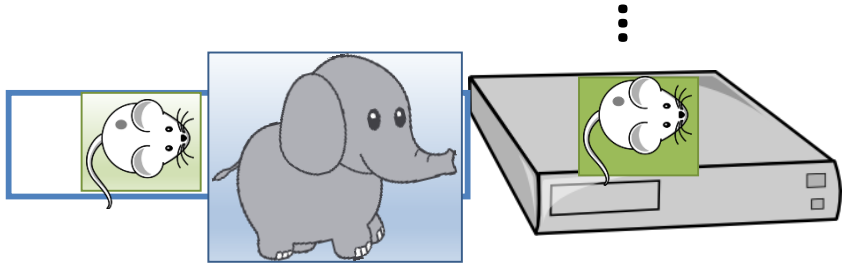
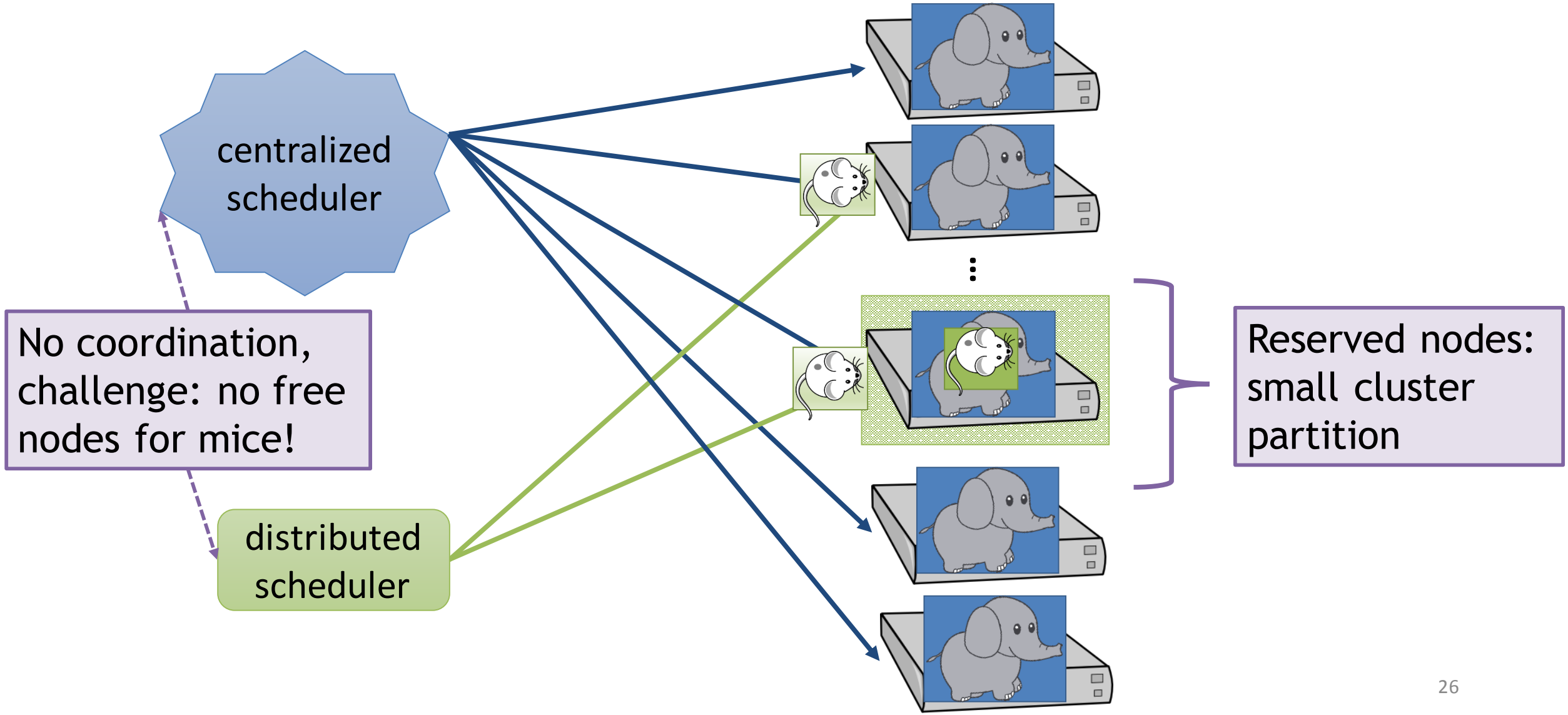


High load → high probability of contacting node with backlog

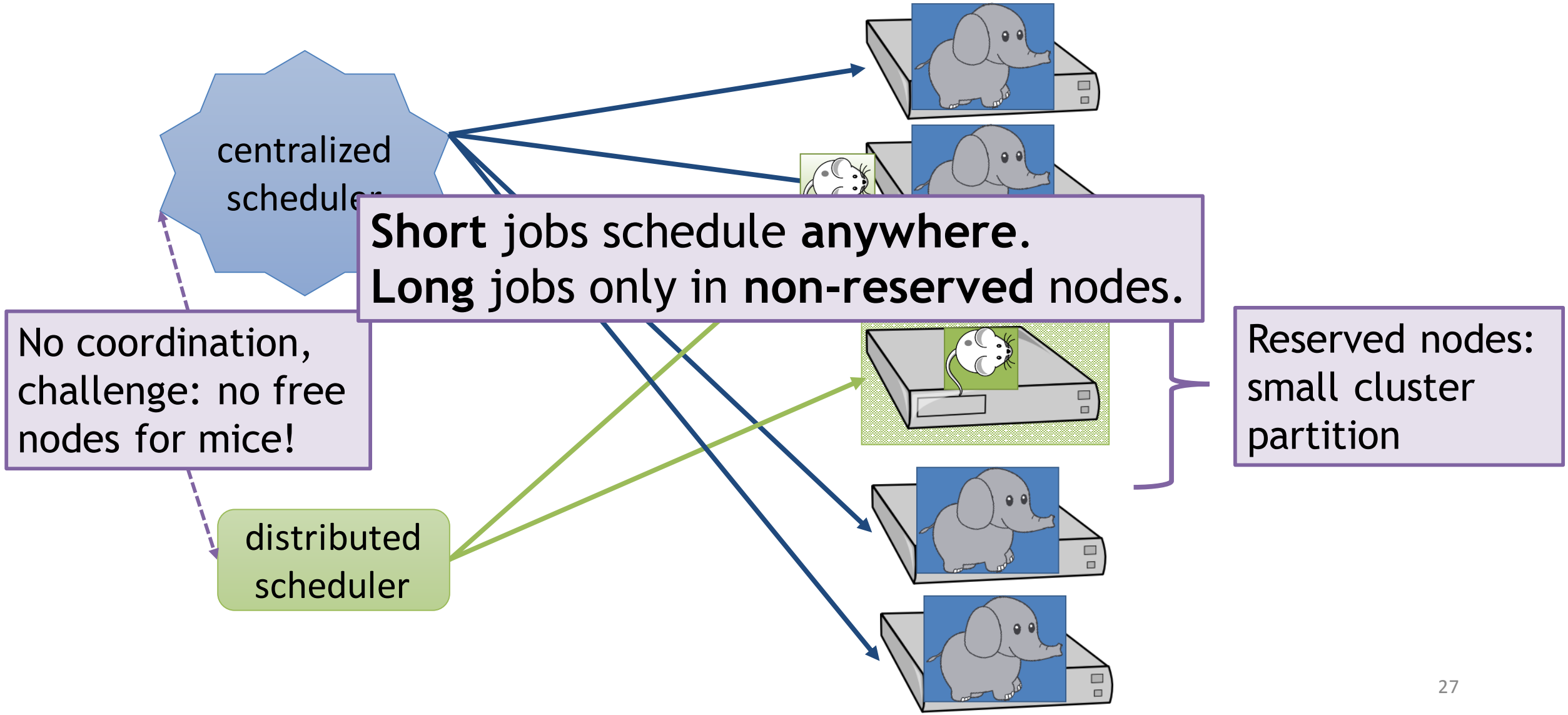
1. Free node: contact random node for probes!



Hawk cluster partitioning



Hawk cluster partitioning



Hawk design summary

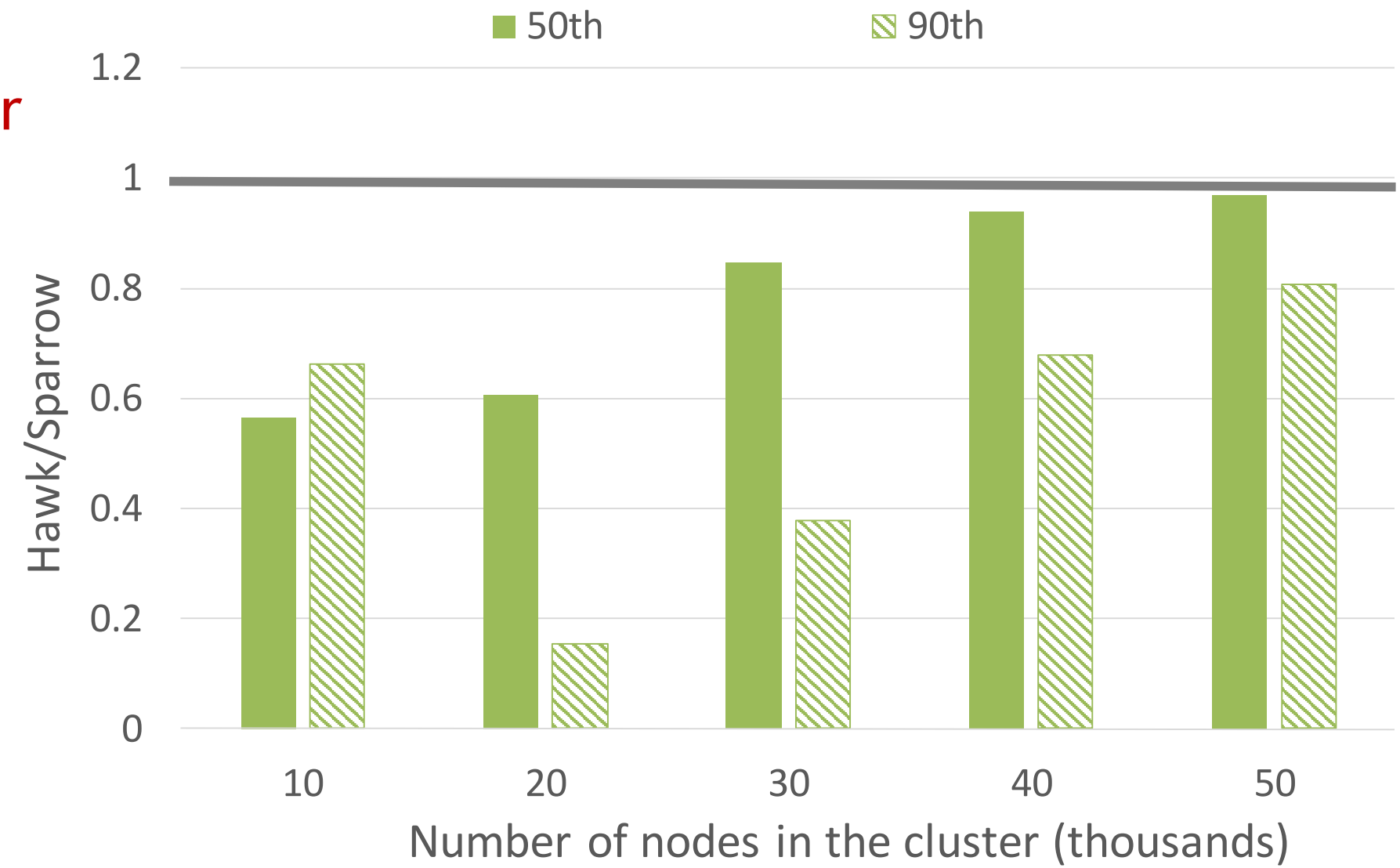
- ✓ Hybrid scheduler:
  long → centralized, short → distributed
- ✓ Work-stealing
- ✓ Cluster partitioning

Evaluation: 1. Simulation

- Sparrow simulator
- Google trace
- Vary number of nodes to vary cluster utilization
- Measure: Job running time
- Report 50^{th} and 90^{th} percentiles for short and long jobs
- Normalized to Sparrow

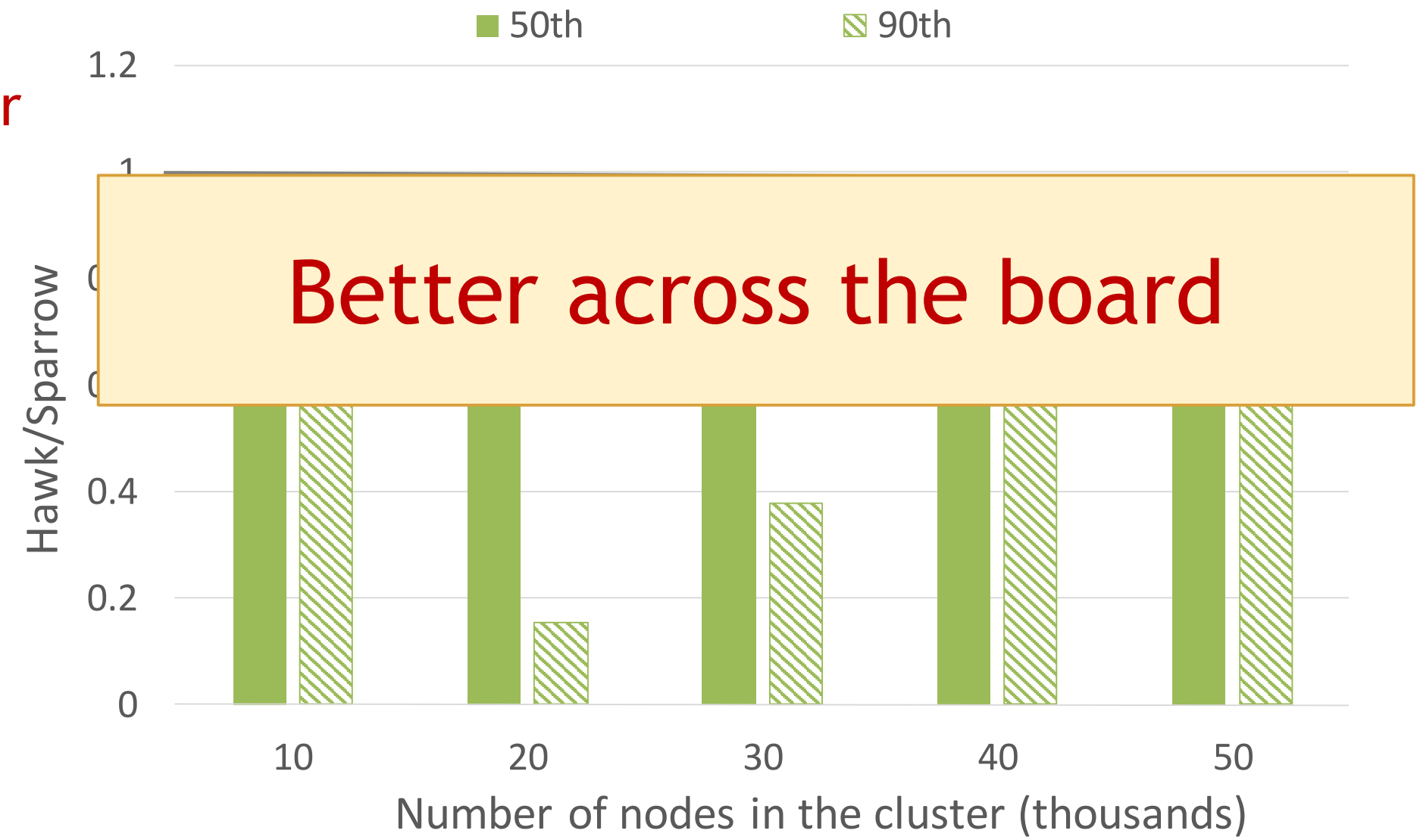
Simulated results: short jobs

lower better



Simulated results: short jobs

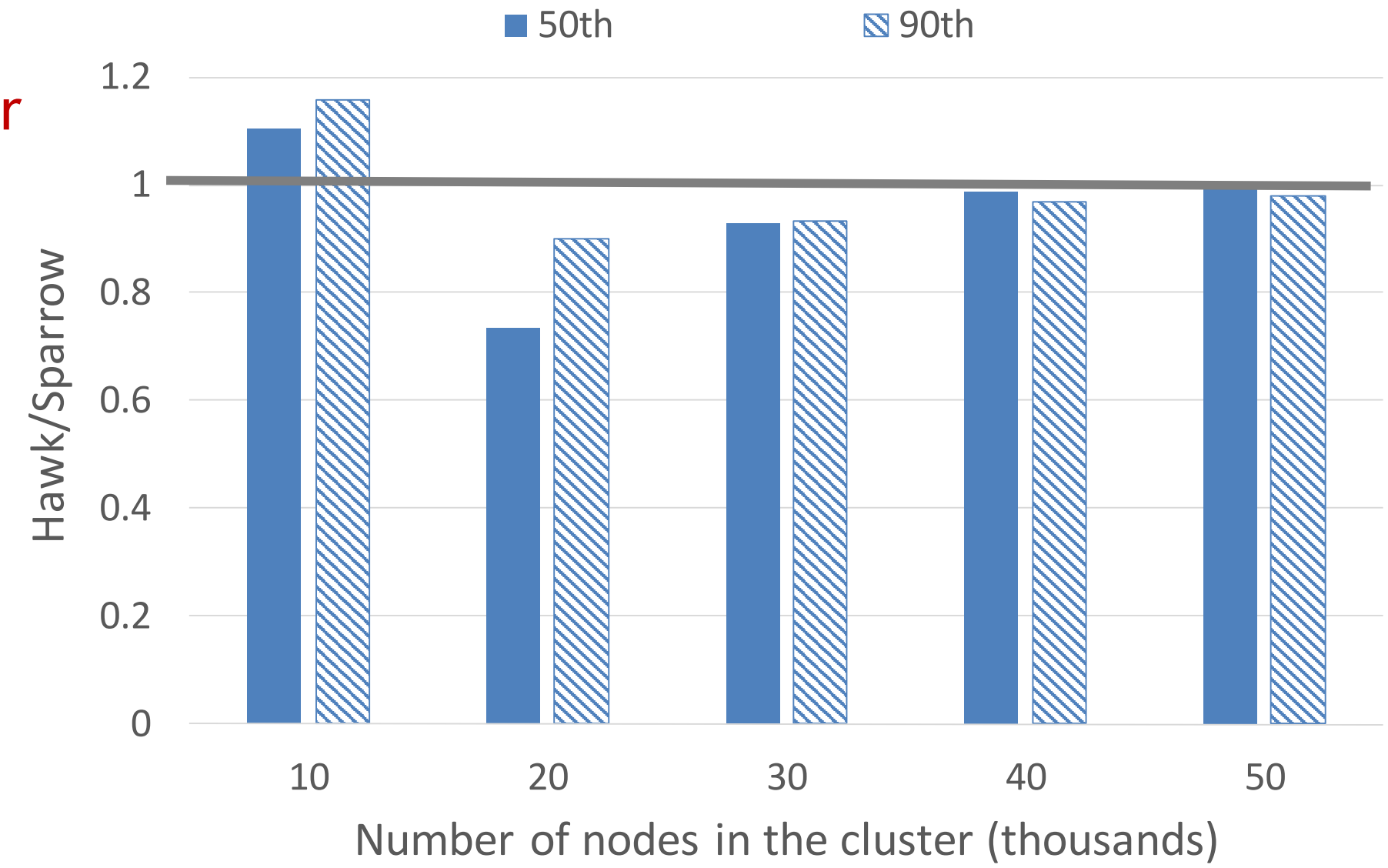
lower better



Better across the board

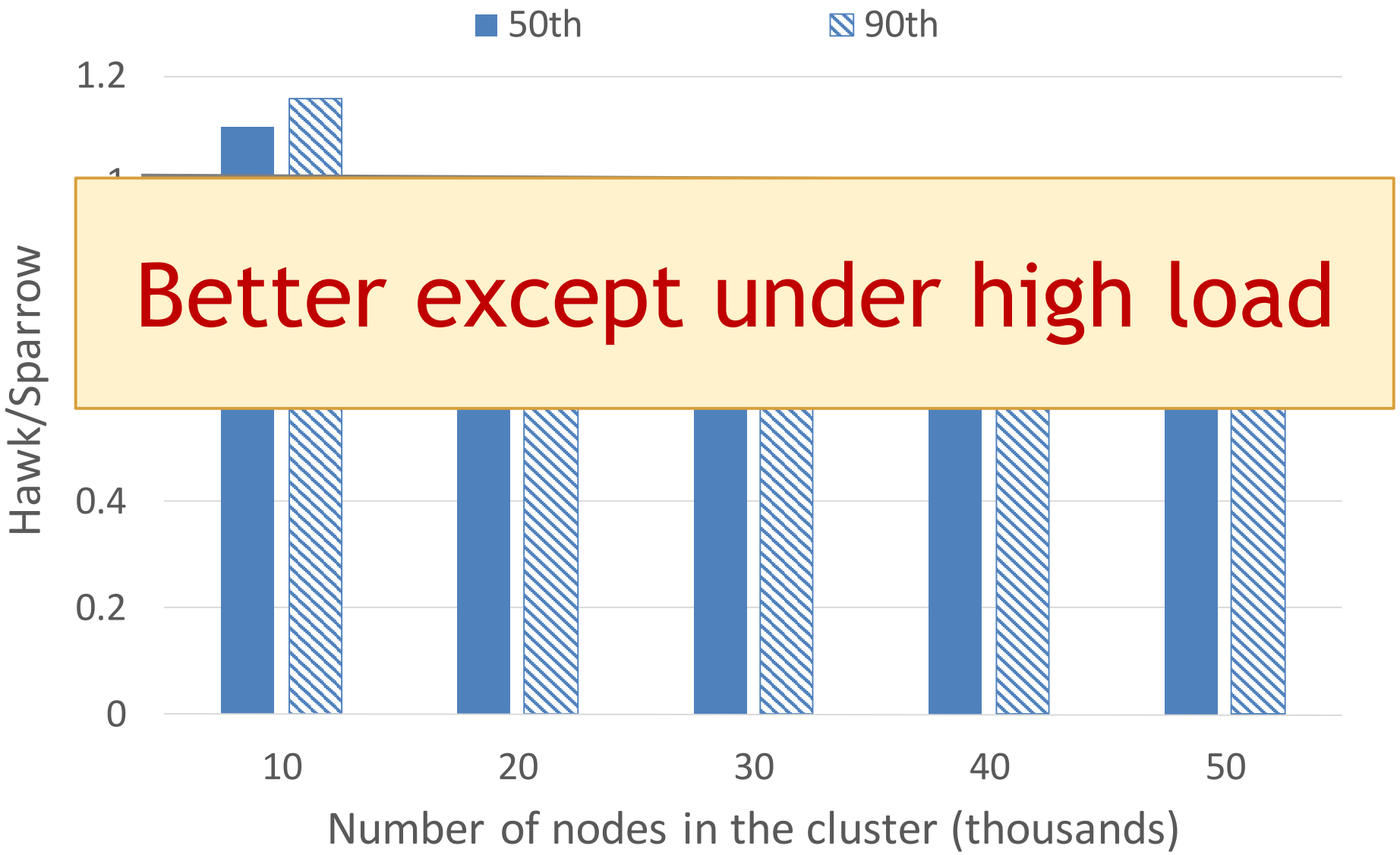
Simulated results: long jobs

lower better



Simulated results: long jobs

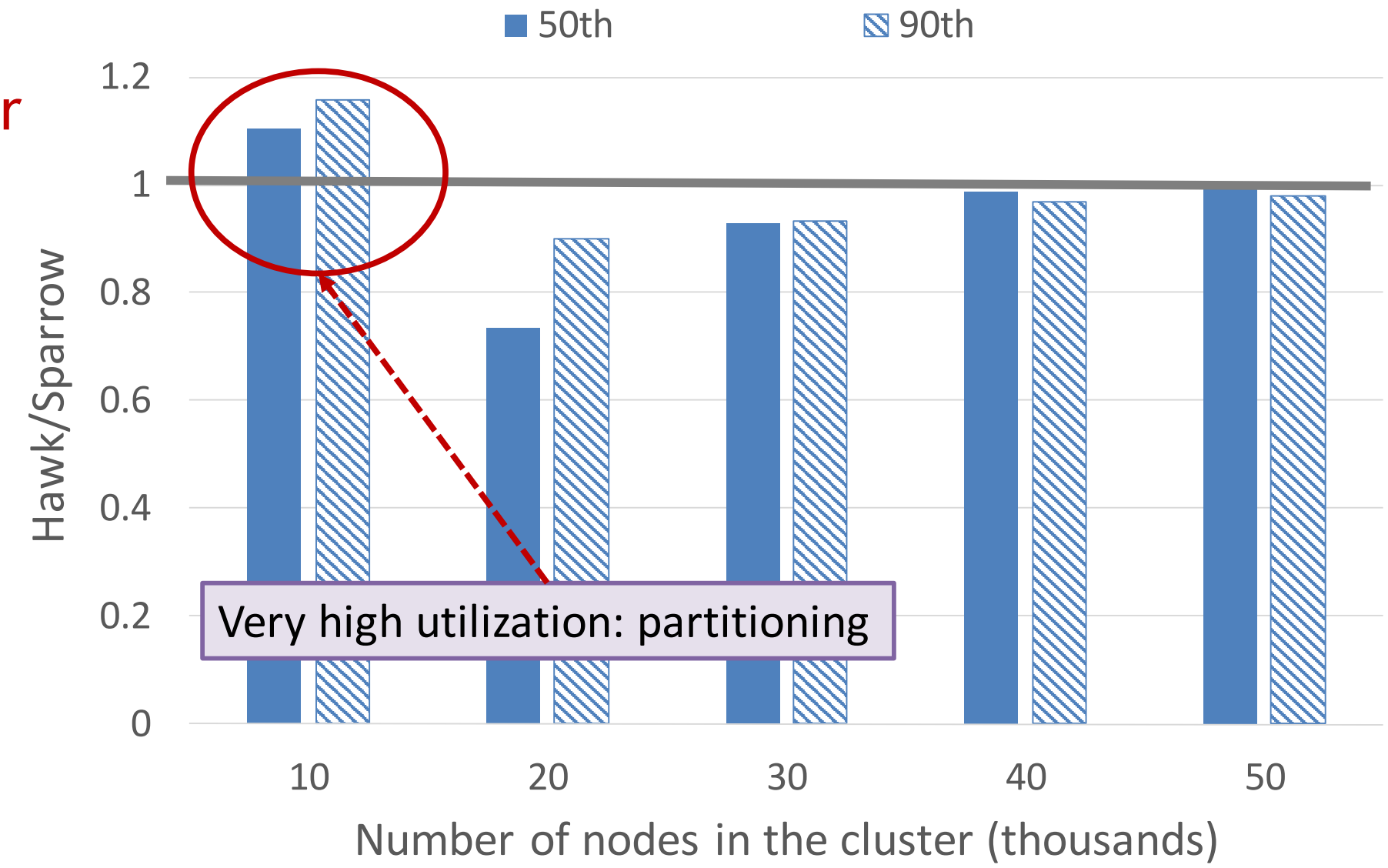
lower better



Better except under high load

Simulated results: long jobs

lower better



Decomposing Hawk

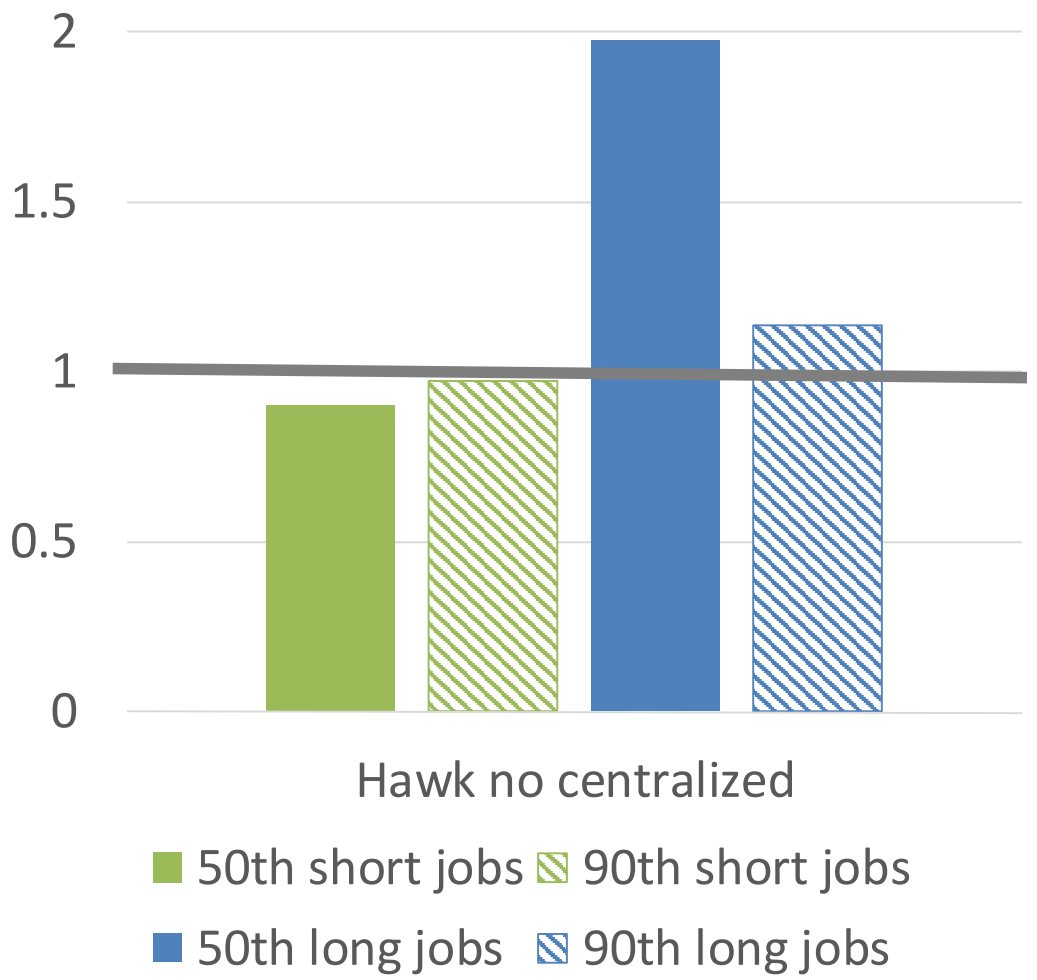
1. Hawk minus centralized
2. Hawk minus stealing
3. Hawk minus partitioning

(normalized to Hawk)

Decomposing Hawk: no centralized

1. Hawk minus centralized
2. Hawk minus stealing
3. Hawk minus partitioning

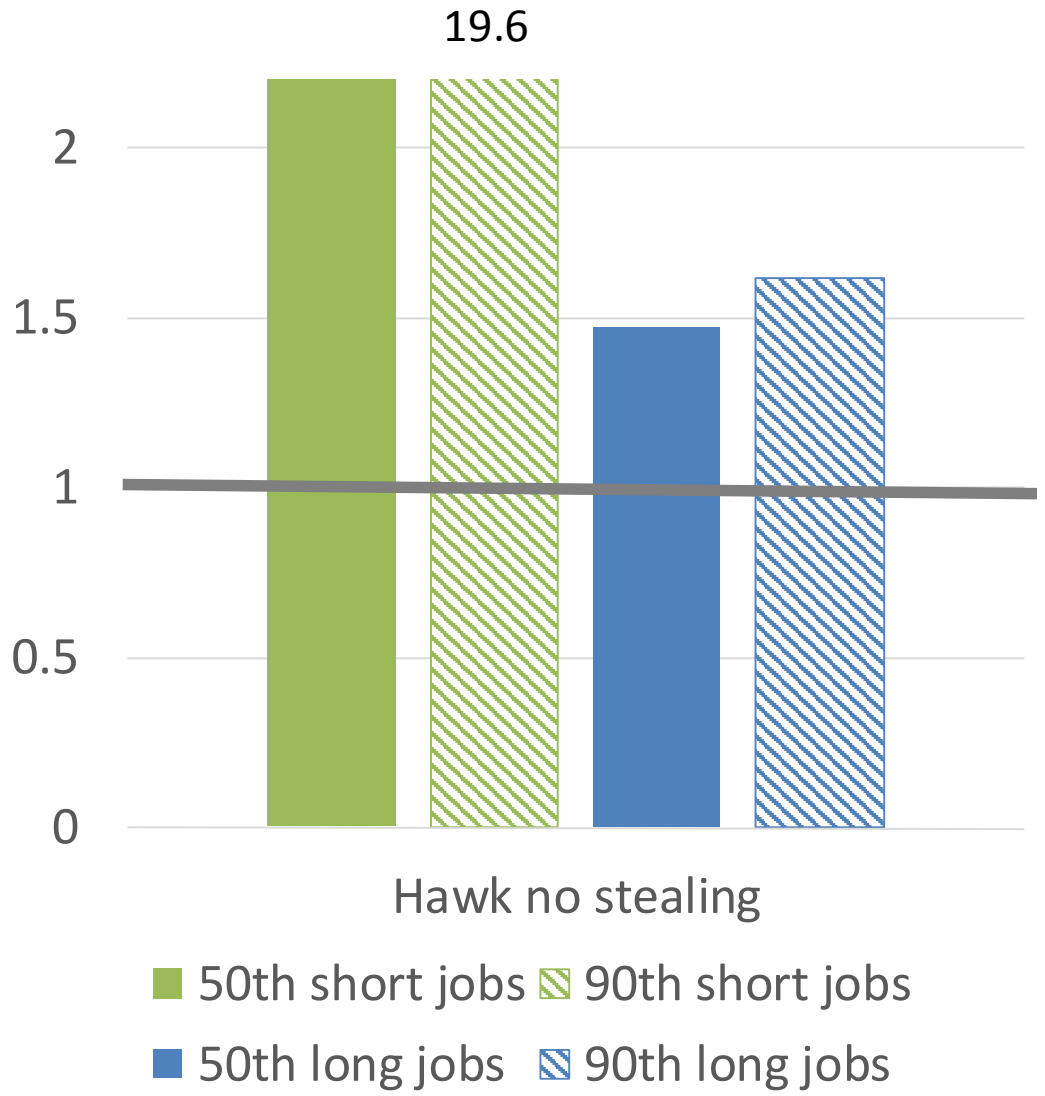
(normalized to Hawk)



Decomposing Hawk: no stealing

1. Hawk minus centralized
2. Hawk minus stealing
3. Hawk minus partitioning

(normalized to Hawk)



Decomposing Hawk: no partitioning

1. Hawk minus centralized
2. Hawk minus stealing
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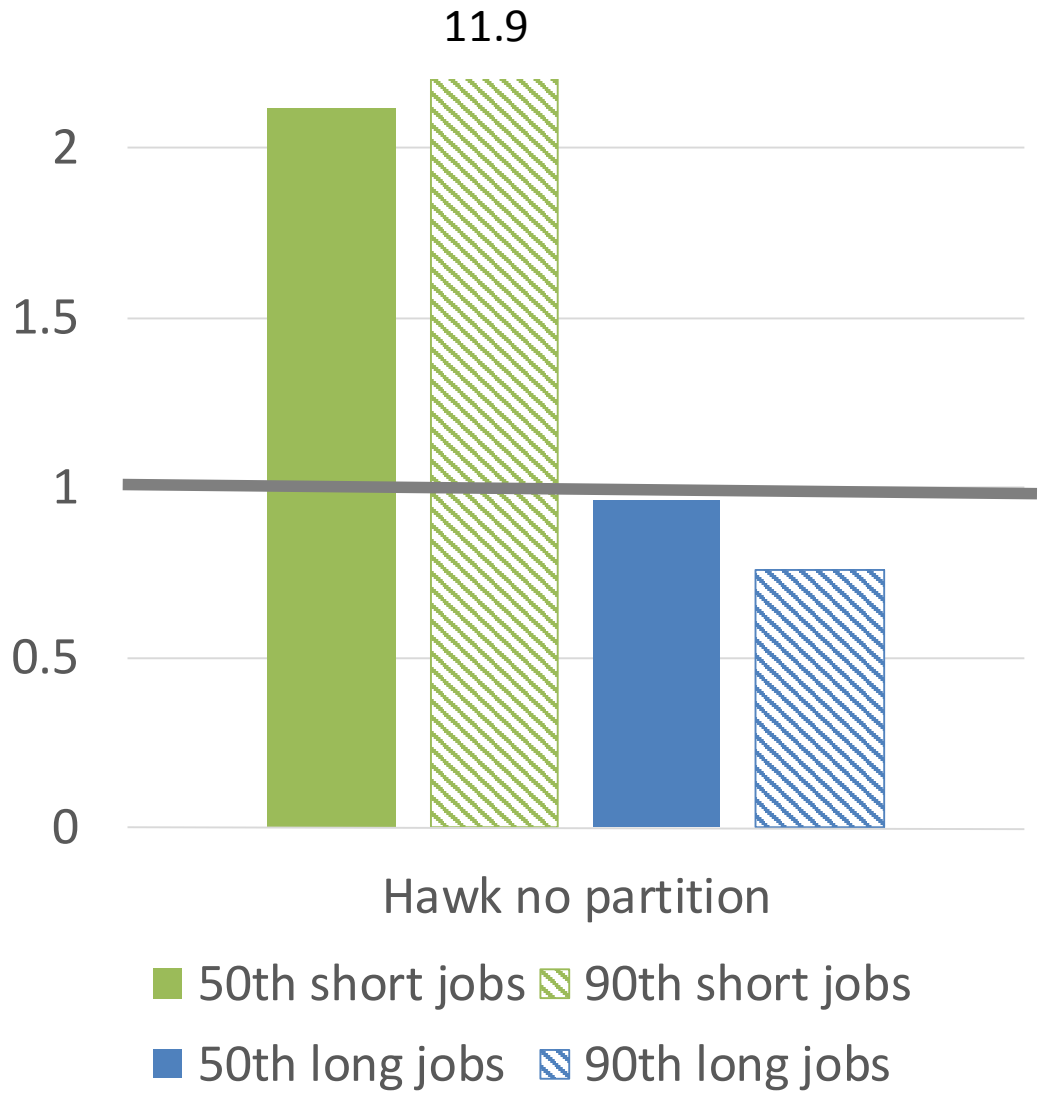
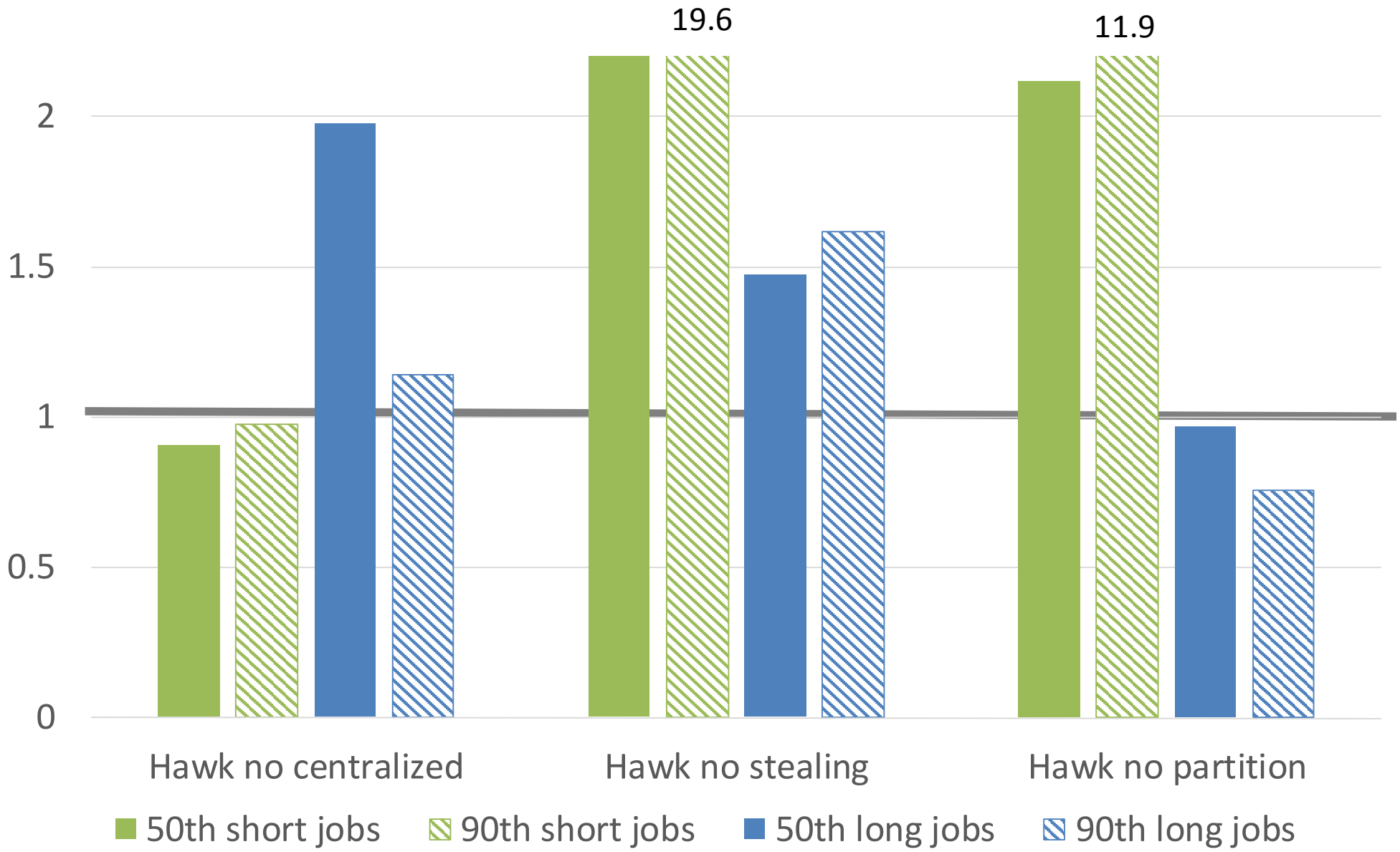
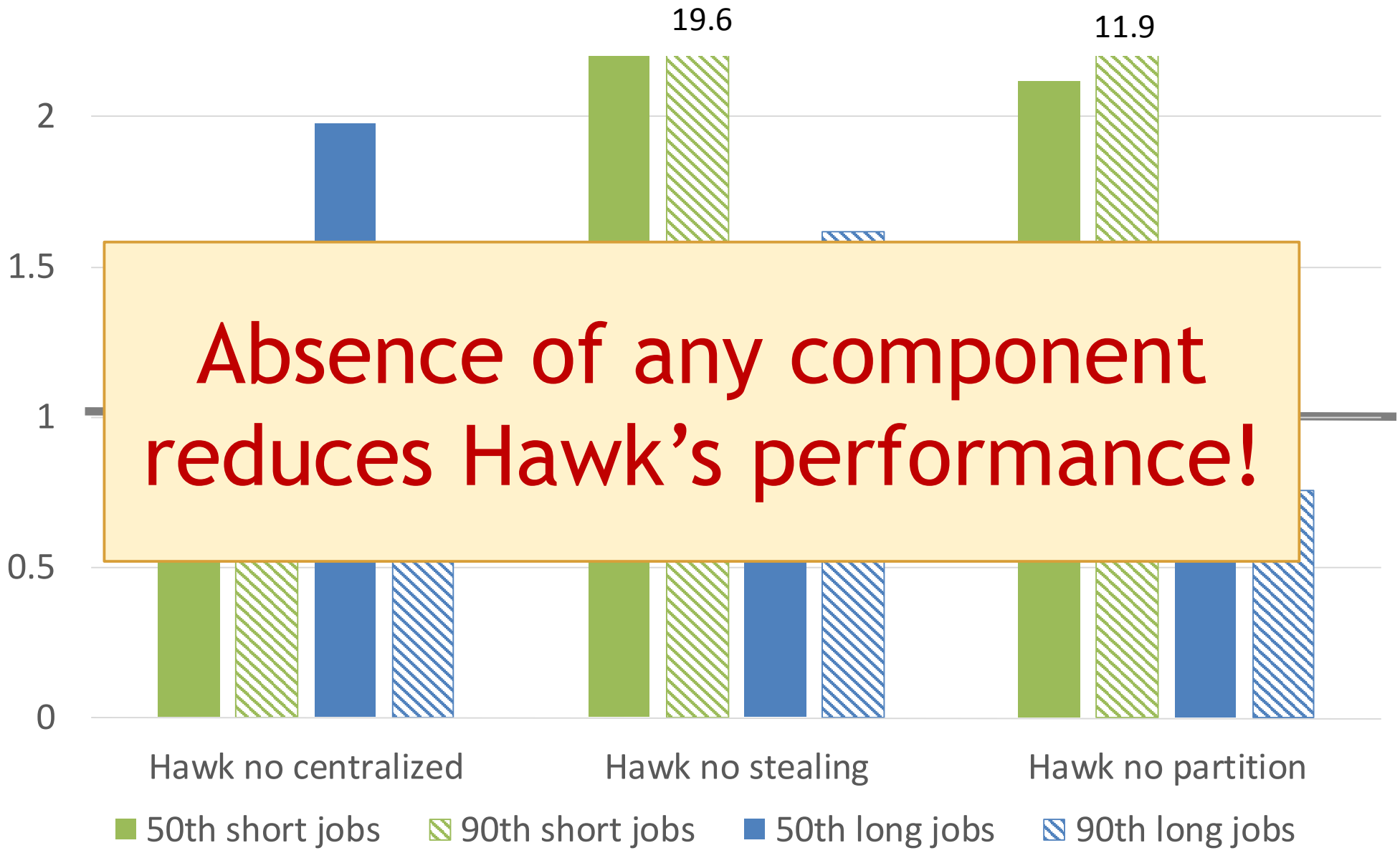
(normalized to Hawk)



Decomposing Hawk summary



Decomposing Hawk summary



Absence of any component reduces Hawk's performance!

Sensitivity analysis

1. Incorrect estimates of runtime
2. Cut off long/short
3. Details of stealing

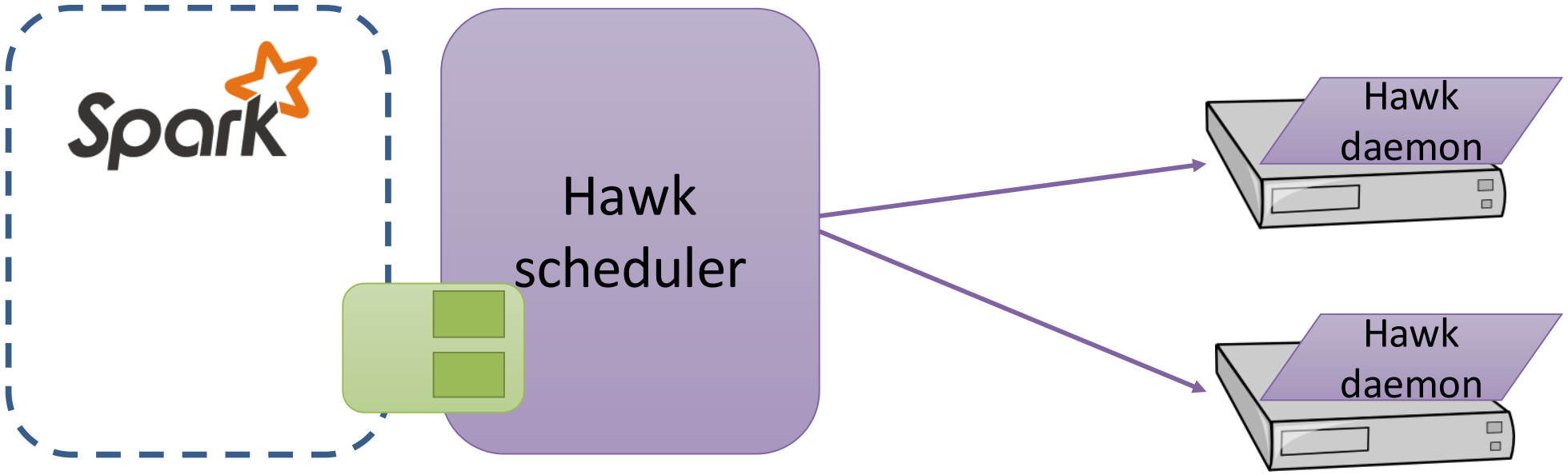
Sensitivity analysis

1. Incorrect estimates of runtime
2. Cut off long/short
3. Details of stealing

Bottom line: benefits of Hawk remain despite variation

See paper for details

Evaluation: 2. Implementation

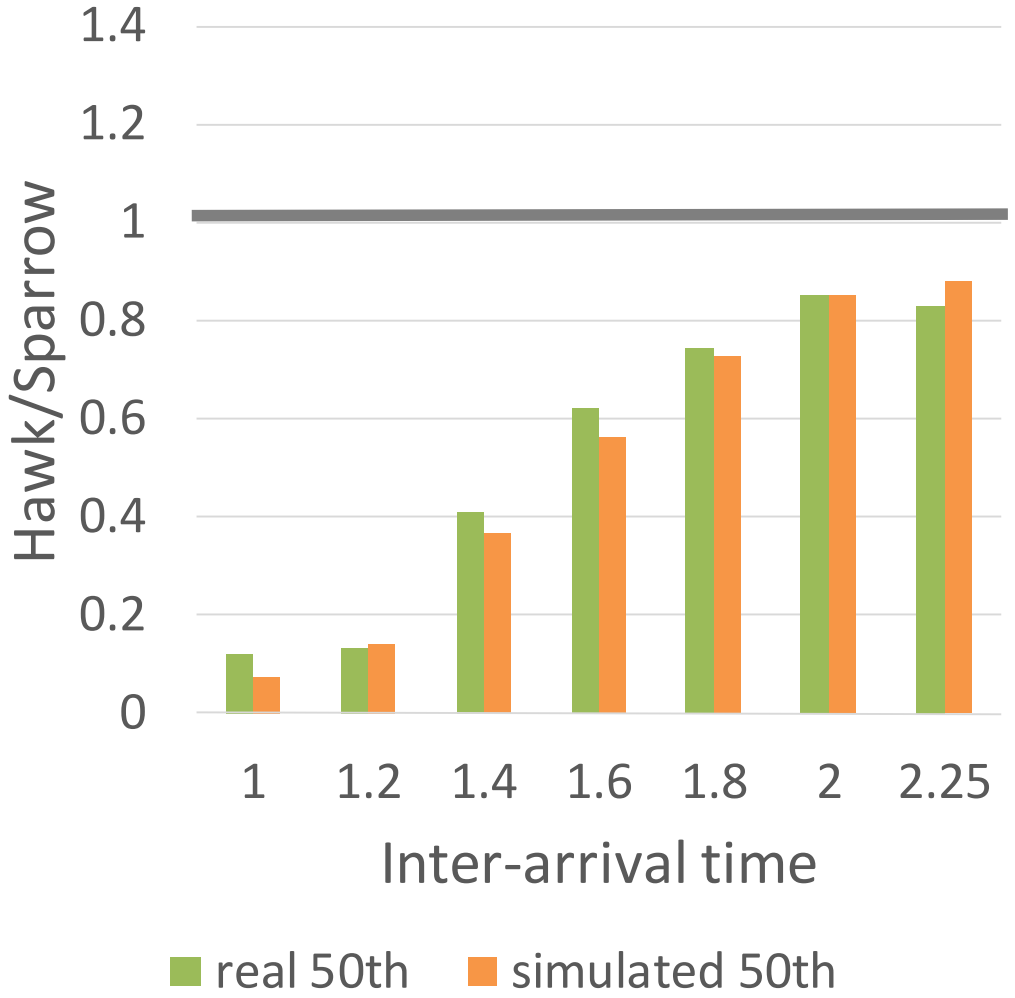


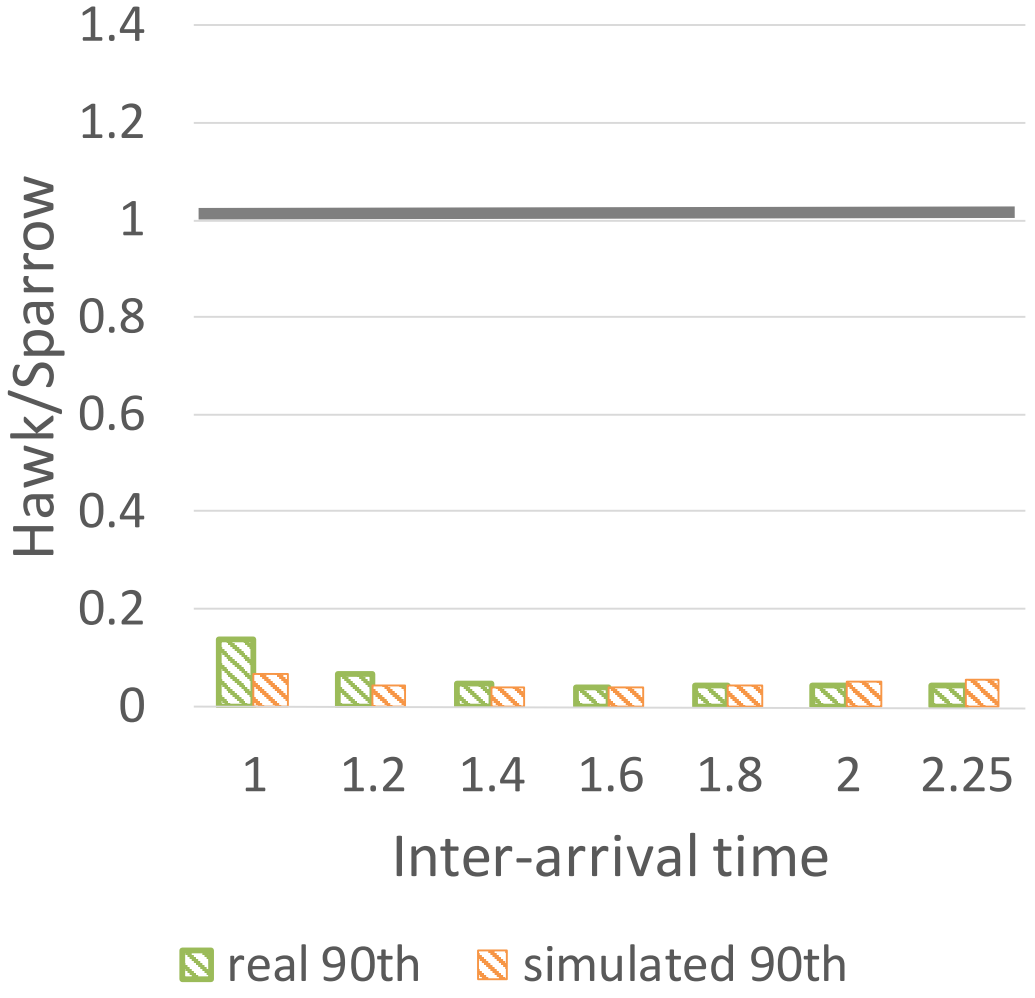
Experiment

- 100-node cluster
- Subset of Google trace
- Vary inter-arrival time to vary cluster utilization
- Measure: Job running time
- Report 50^{th} and 90^{th} percentile for short and long jobs
- Normalized to Sparrow

Short jobs

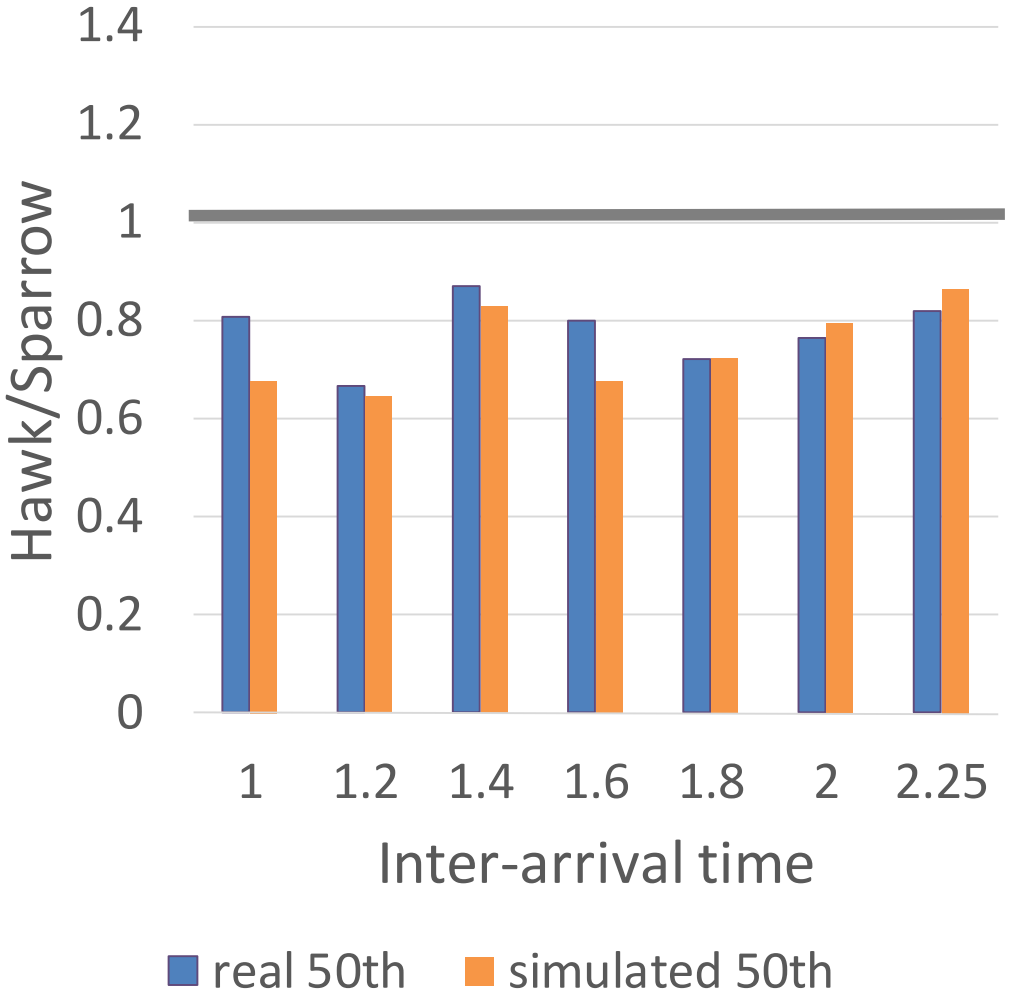
lower better

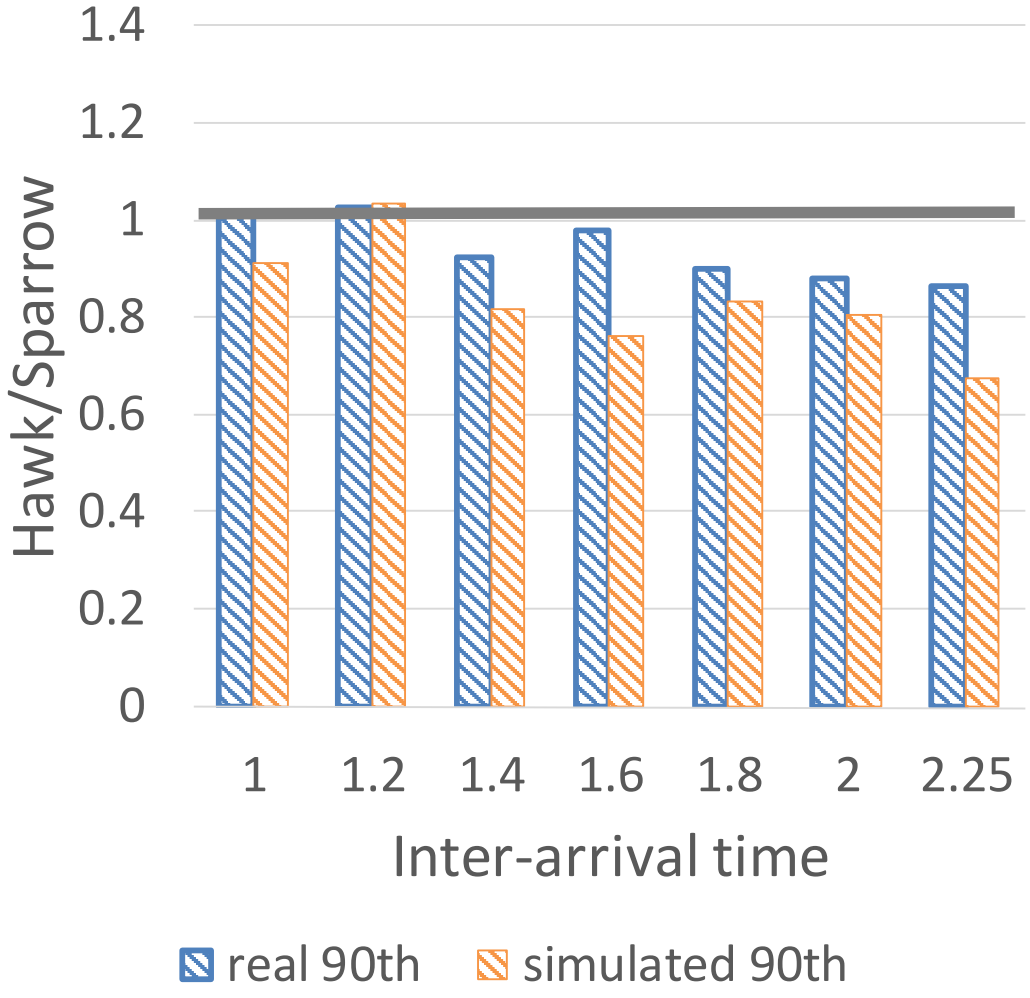




Long jobs

lower better





Implementation

1. Hawk works well in real cluster
2. Good correspondence implementation/simulation

Related work

Centralized: Hadoop Fair Scheduler, Quincy
Eurosys'10, SOSP'09

Two level: Yarn, Mesos
SoCC'12, NSDI'11

Distributed schedulers: Omega, Sparrow
Eurosys'12,SOSP'13

Hybrid schedulers: Mercury

Conclusion

- Hawk: hybrid scheduler

  ✓ long: centralized, short: distributed
  ✓ work-stealing
  ✓ cluster partitioning

- Hawk provides good results for short and long jobs

- Even under high cluster utilization