HYDRA

A FEDERATED RESOURCE MANAGER FOR DATA-CENTER SCALE ANALYTICS

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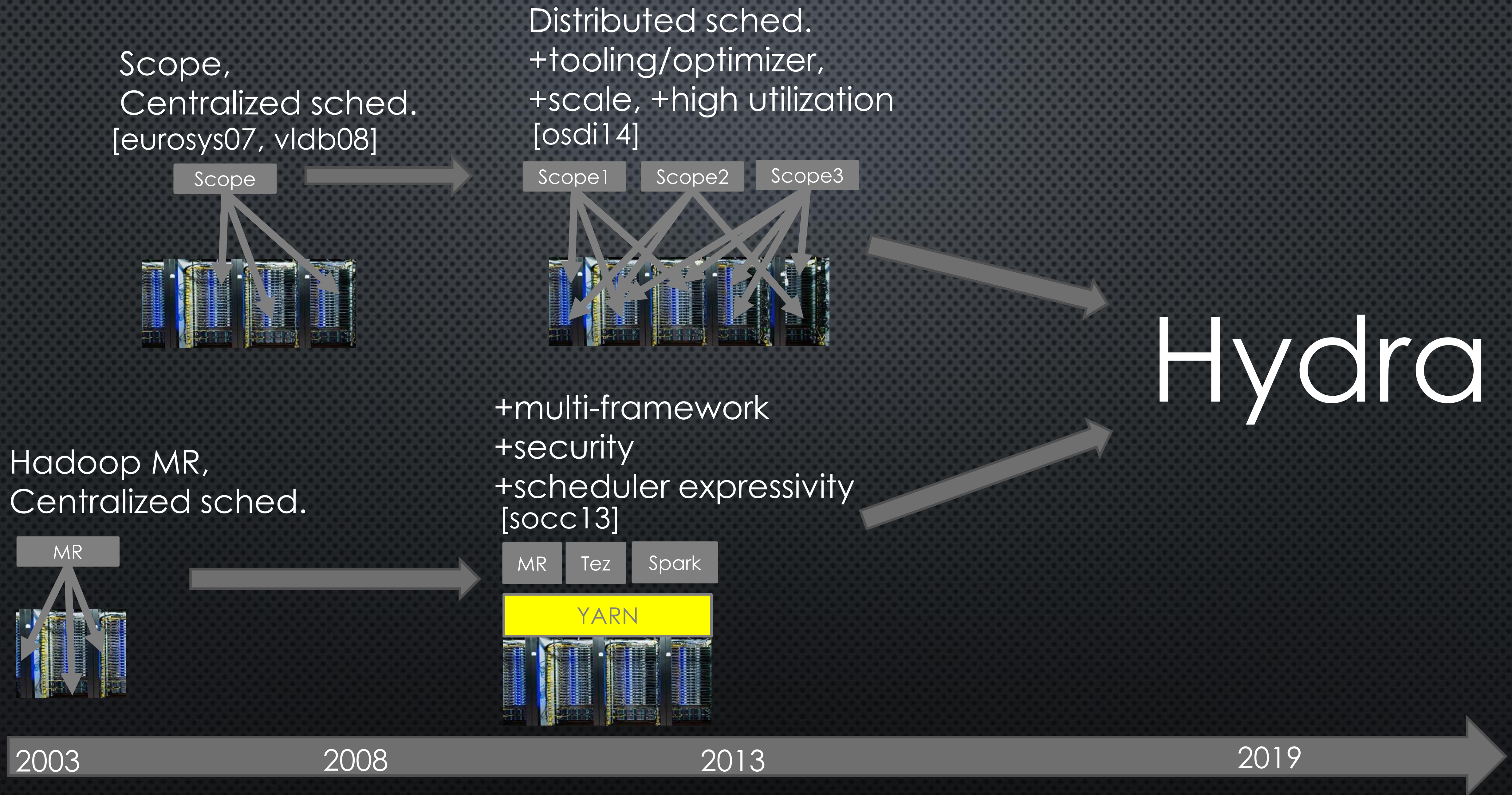
Microsoft

BIGDATA SCHEDULING: A JOURNEY…



Scope,
Centralized sched.
[eurosys07, vldb08]

Distributed sched.
+tooling/optimizer,
+scale, +high utilization
[osdi14]

Hadoop MR,
Centralized sched.

+multi-framework
+security
+scheduler expressivity
[socc13]

Hydra

BIGDATA SCHEDULING: A JOURNEY…

Scope
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[eurosys

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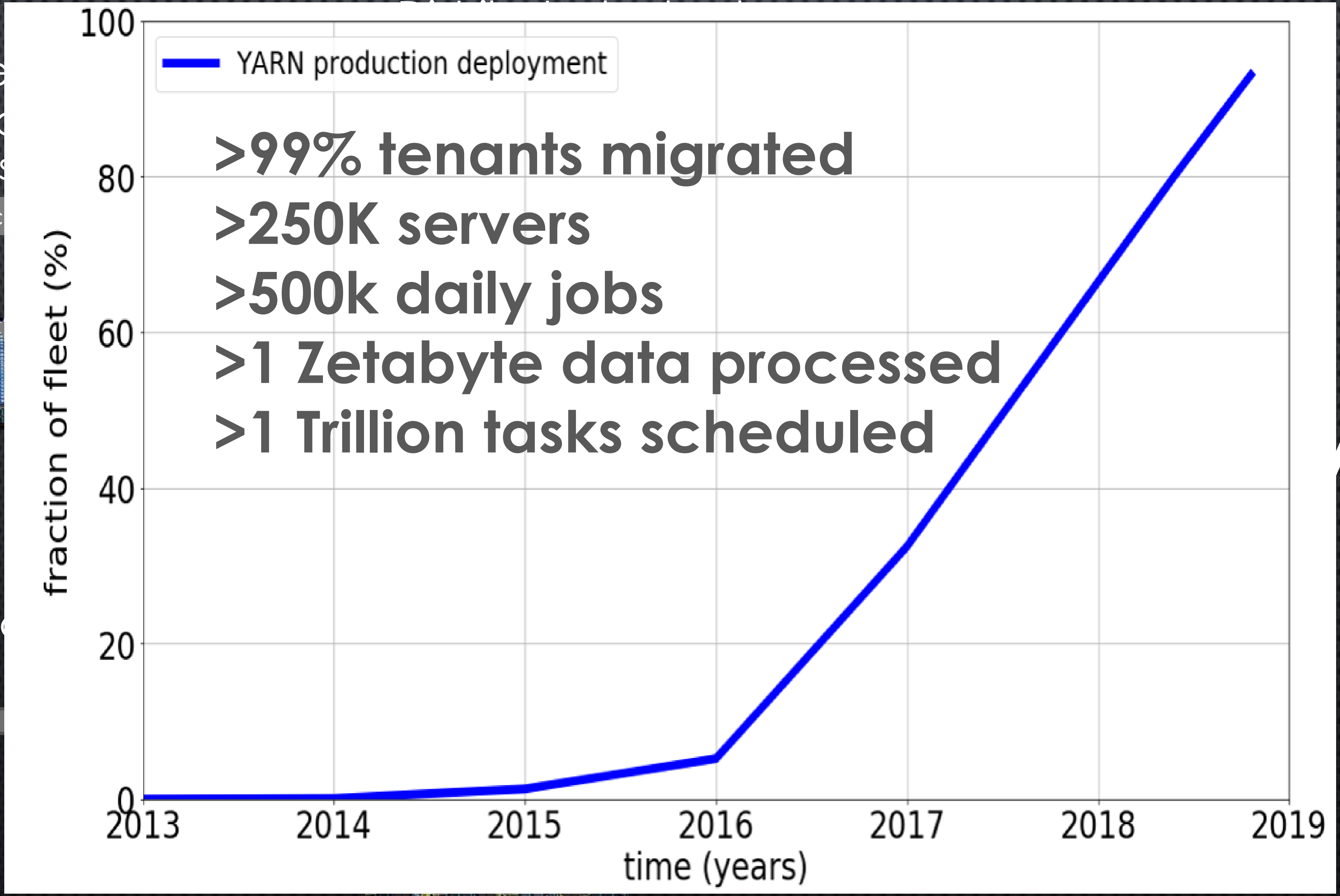
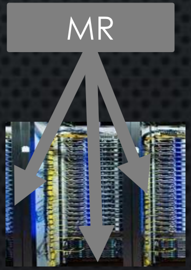


>99% tenants migrated
>250K servers
>500k daily jobs
>1 Zetabyte data processed
>1 Trillion tasks scheduled

ydra

Hadoop MR,
Centralized s



2003 2008 2013 2019

HYDRA CHALLENGES

1. Support multiple application frameworks **[socc13]**
2. Simplify writing new app frameworks **[vldb14,sigmod15,tocs17]**
3. Achieve good ROI, i.e., high CPU utilization **[atc15, eurosys16]**
4. Scale to large clusters, many jobs, large jobs **[nsdi19]**

OSS + production!

THE SCALE/UTILIZATION CHALLENGE…

Cluster(s):
> 50K nodes

Job(s):
>2M tasks, >5PB input

Scheduler:
>70K QPS

Utilization:
~60% avg CPU util

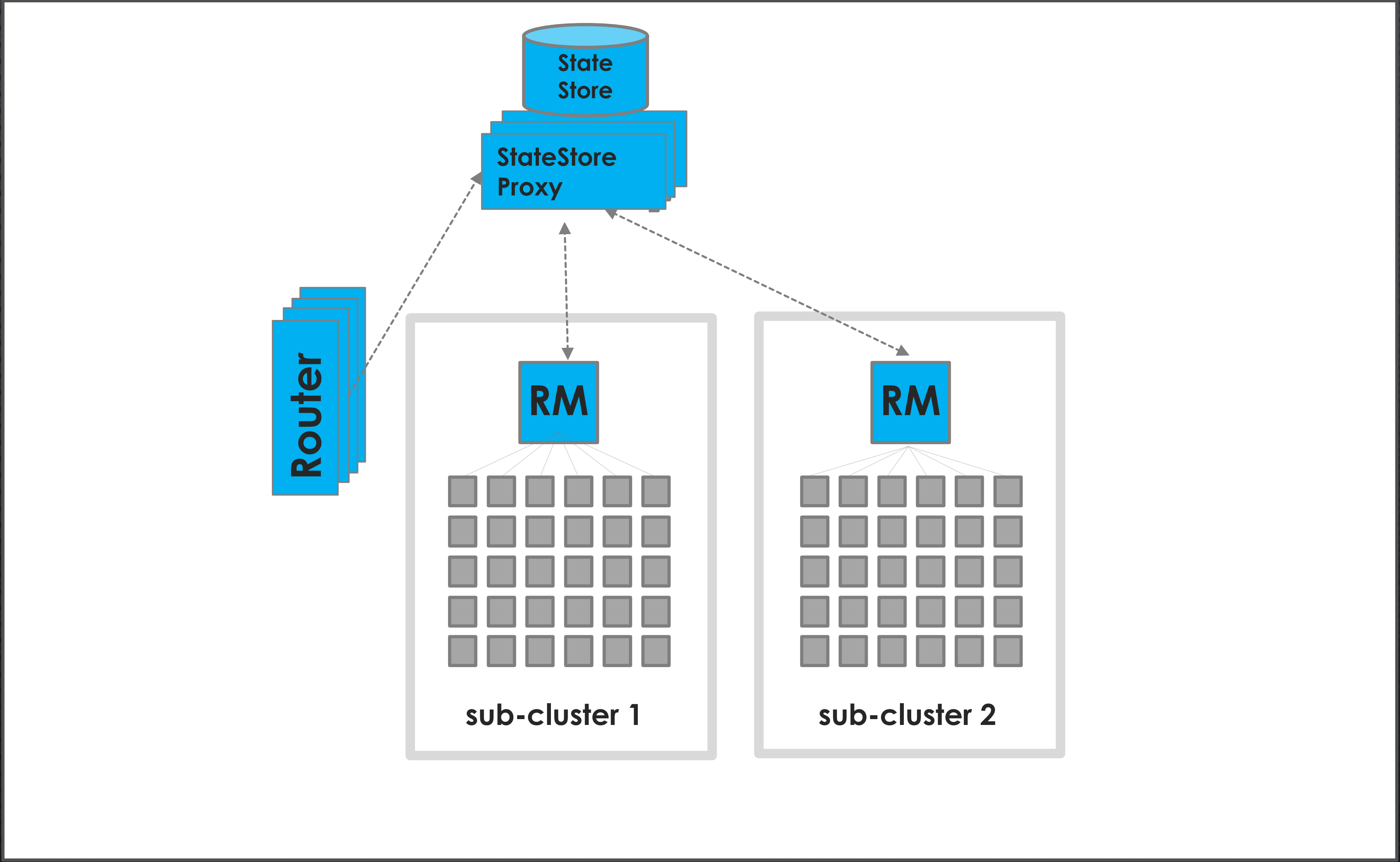
Tasks:
10 sec 50th %ile

NEED SCALE, UTILIZATION?
GO DISTRIBUTED!
NEED SCHEDULING CONTROL AND MULTI-FRAMEWORK
GO CENTRALIZED!

WANT IT ALL?

YOU GOTTA FEDERATE!

HYDRA ARCHITECTURE



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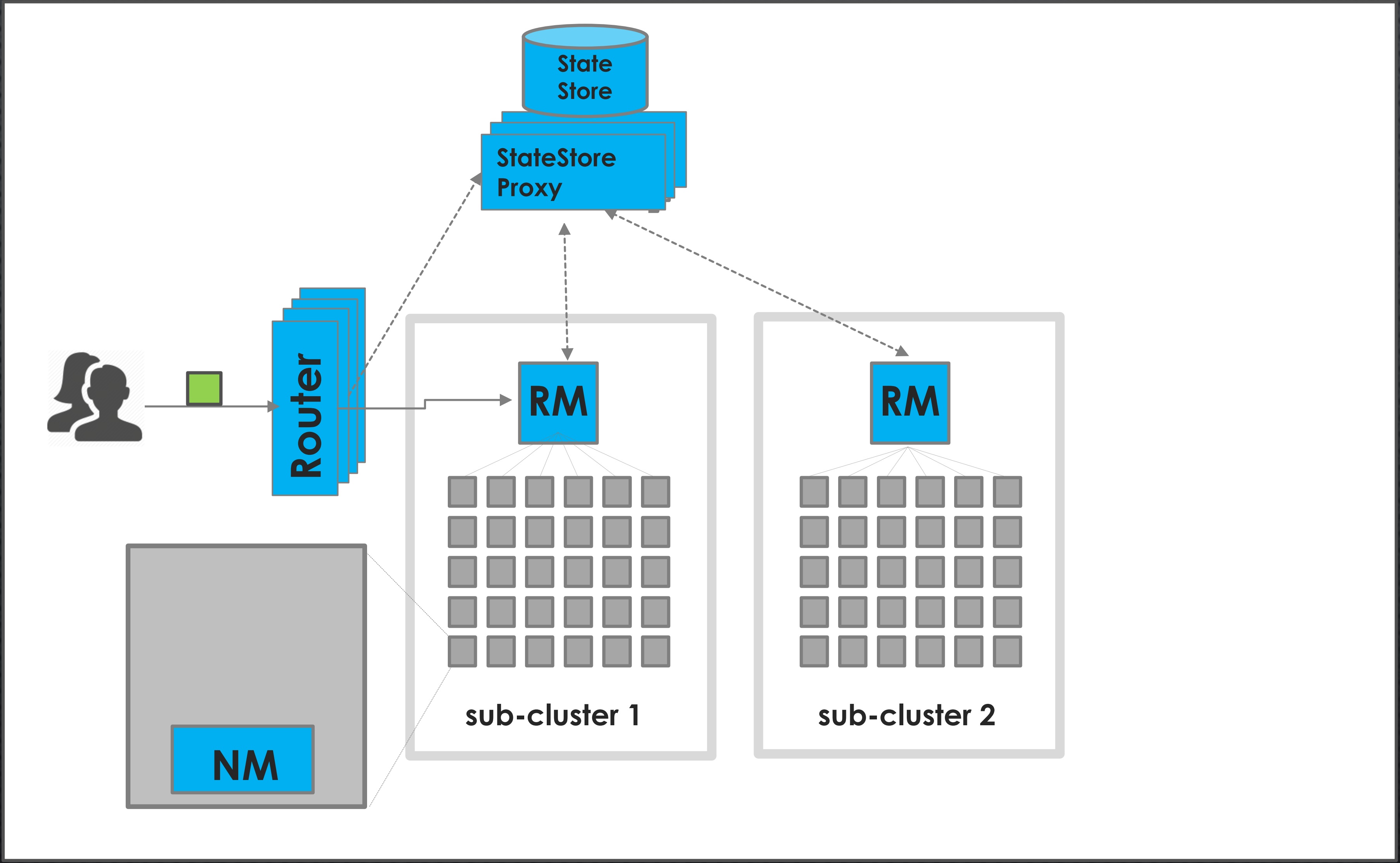

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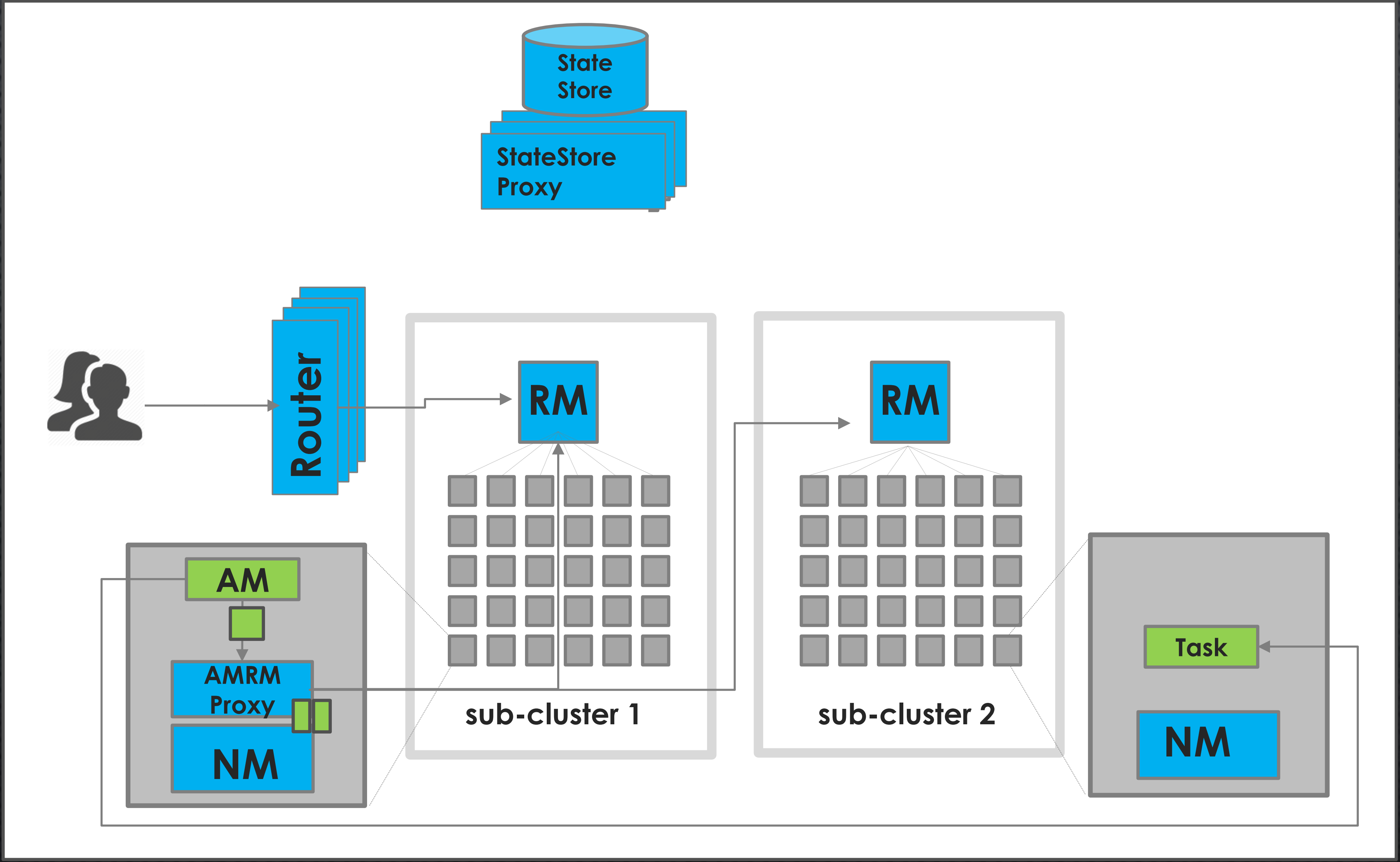

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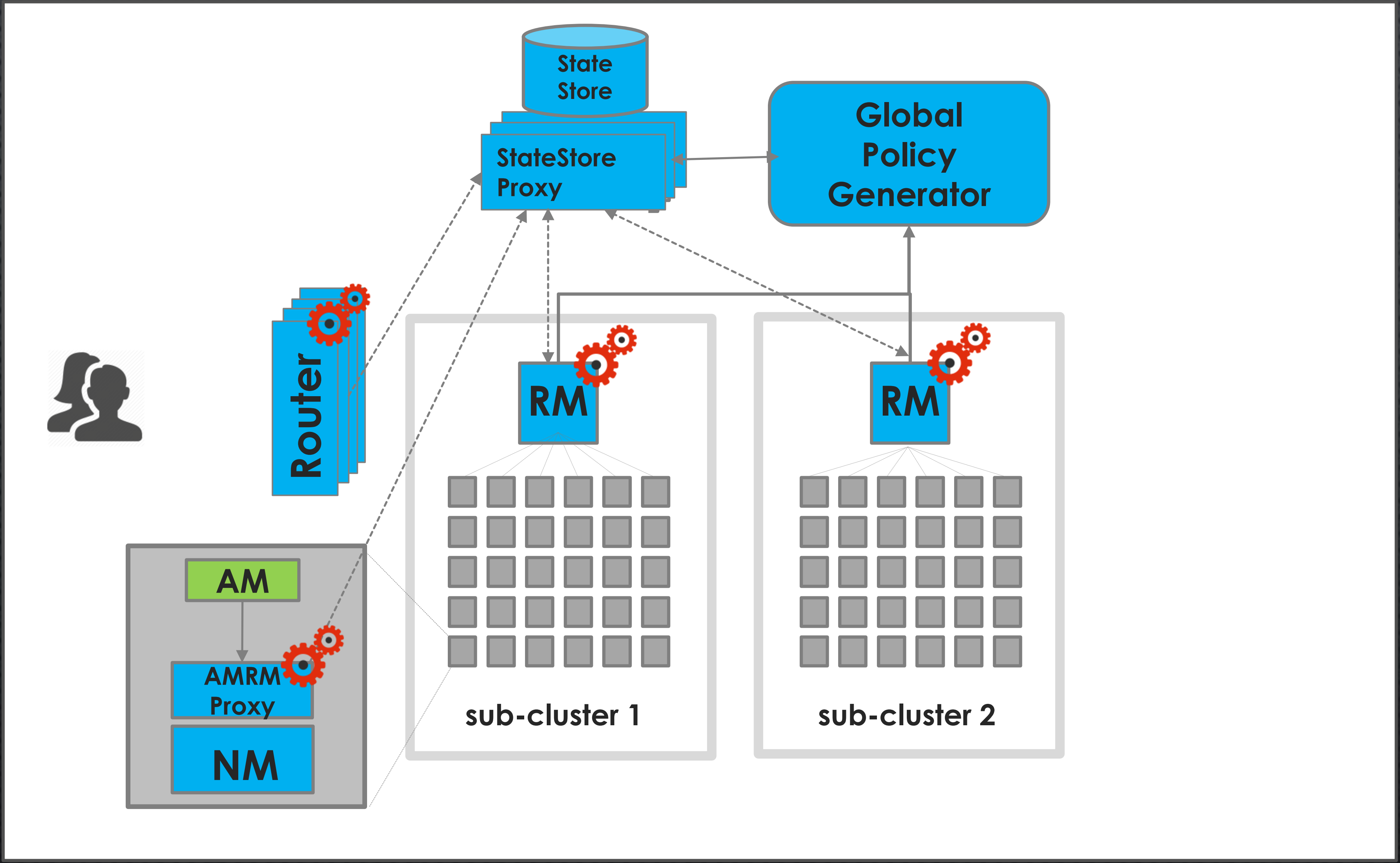


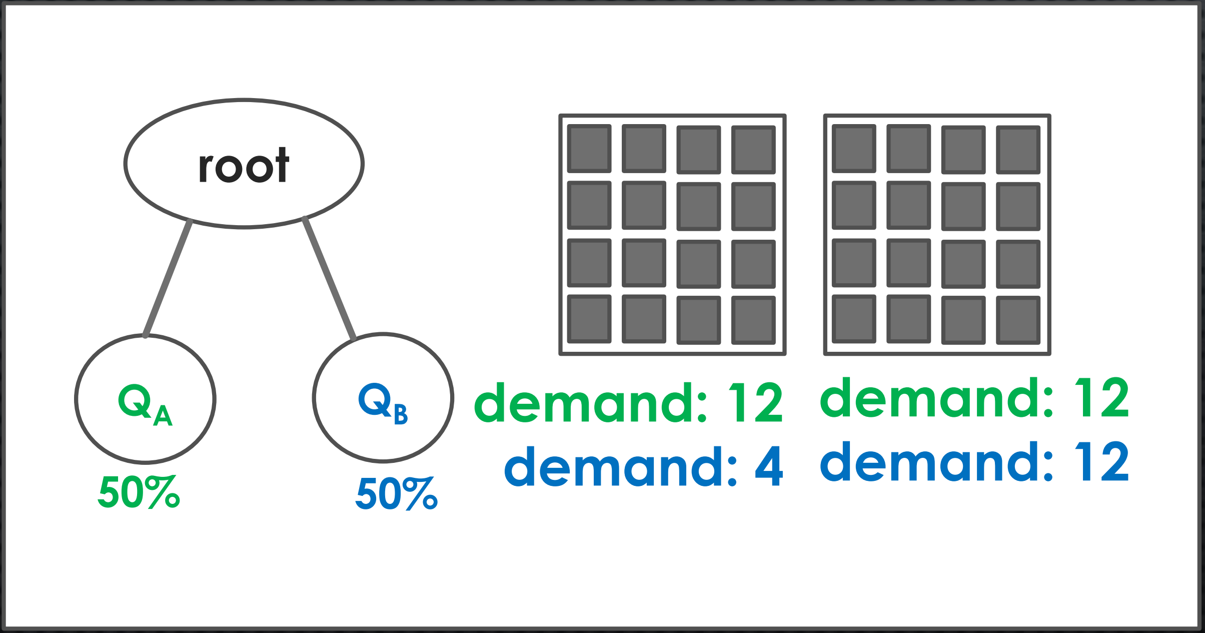
POLICIES

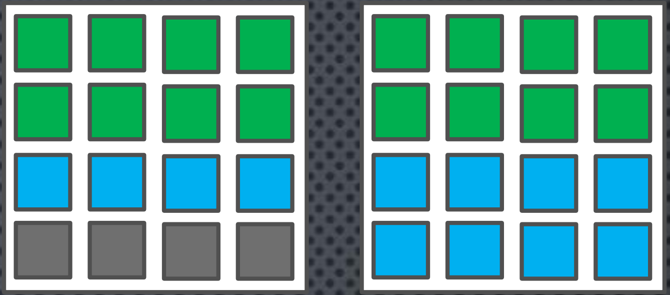
SCHEDULING DESIDERATA

- Global goals:
  - High Utilization
  - Scheduling invariants *(e.g., fairness)*
  - Locality *(e.g., machine preferences)*

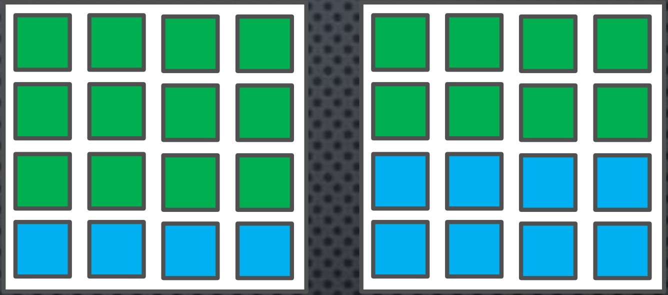
POLICIES

- AMRMProxy routing of requests
  - Enforce locality?
- Per-cluster RM scheduling decisions
  - Enforce quotas?

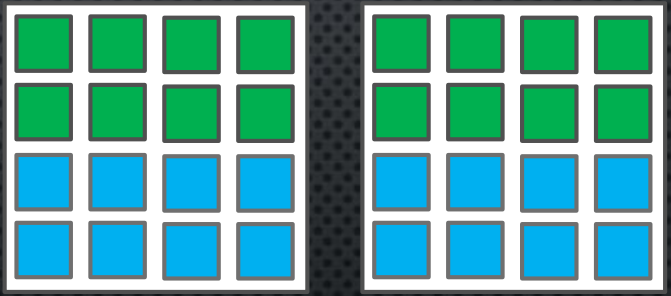




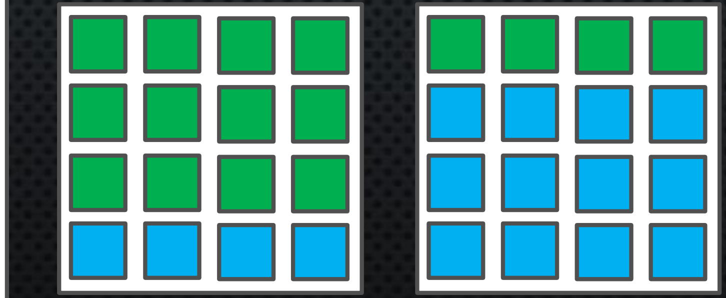
✓ Locality, Fairness
✗ Utilization



✓ Utilization, locality
✗ Fairness



✓ Utilization, Fairness
✗ Locality



✓ Utilization,
✓ Fairness,
✓ Locality.

KEY IDEA

DECOUPLE:

- Share determination
  - How many resources should a queue get?
- Placement
  - On which machine should each task run?

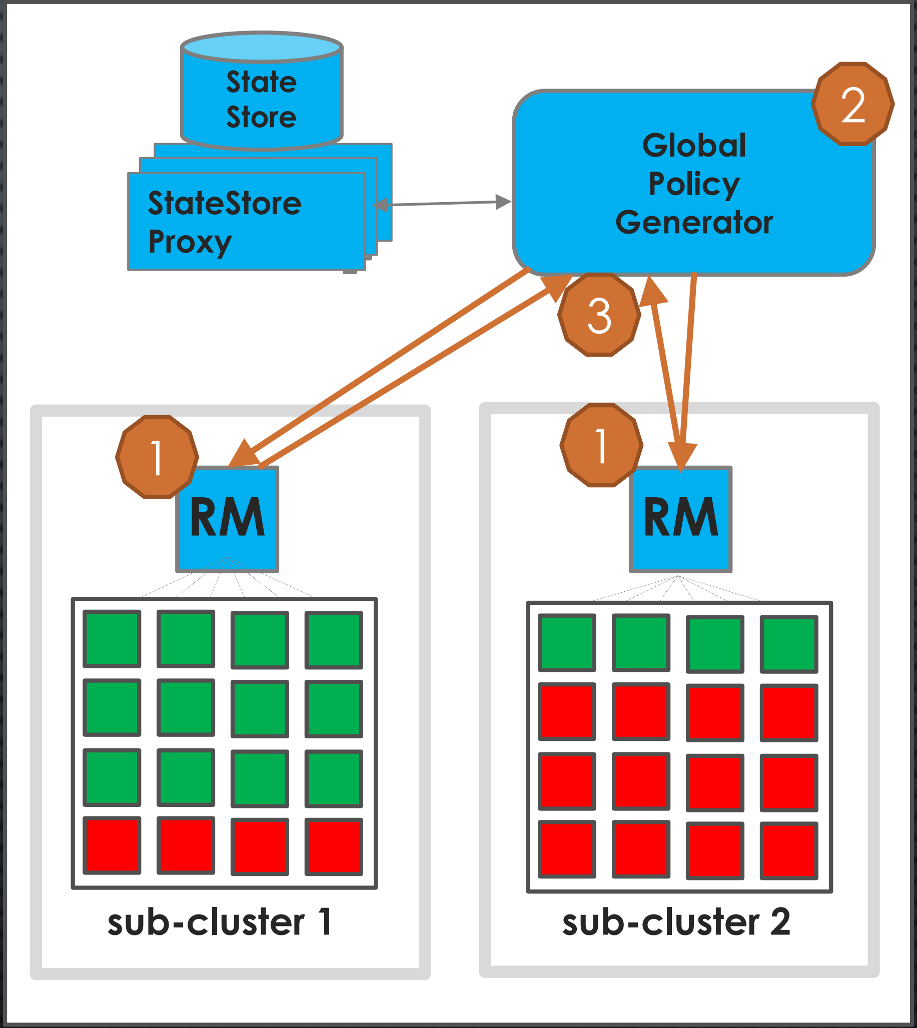
PROPOSED SOLUTION*

1 Periodically gather queue information at GPG

2 Determine resources for each queue at each sub-cluster centrally

- Logically reassign all resources, accounting for demand skew (and already assigned resources)

3 Propagate capacity decisions to each sub-cluster's RM, which perform local task allocation



* More advanced than what in prod. (details in paper)

HANDLING GPG DOWNTIME

- If GPG is down, we would fallback to local decisions
  - Problematic if they “diverge” too much from global one

- Leverage LP-based “tuning” of local queue allocation
  - Historical demand as a predictor of future demand

PRODUCTION EXPERIENCE

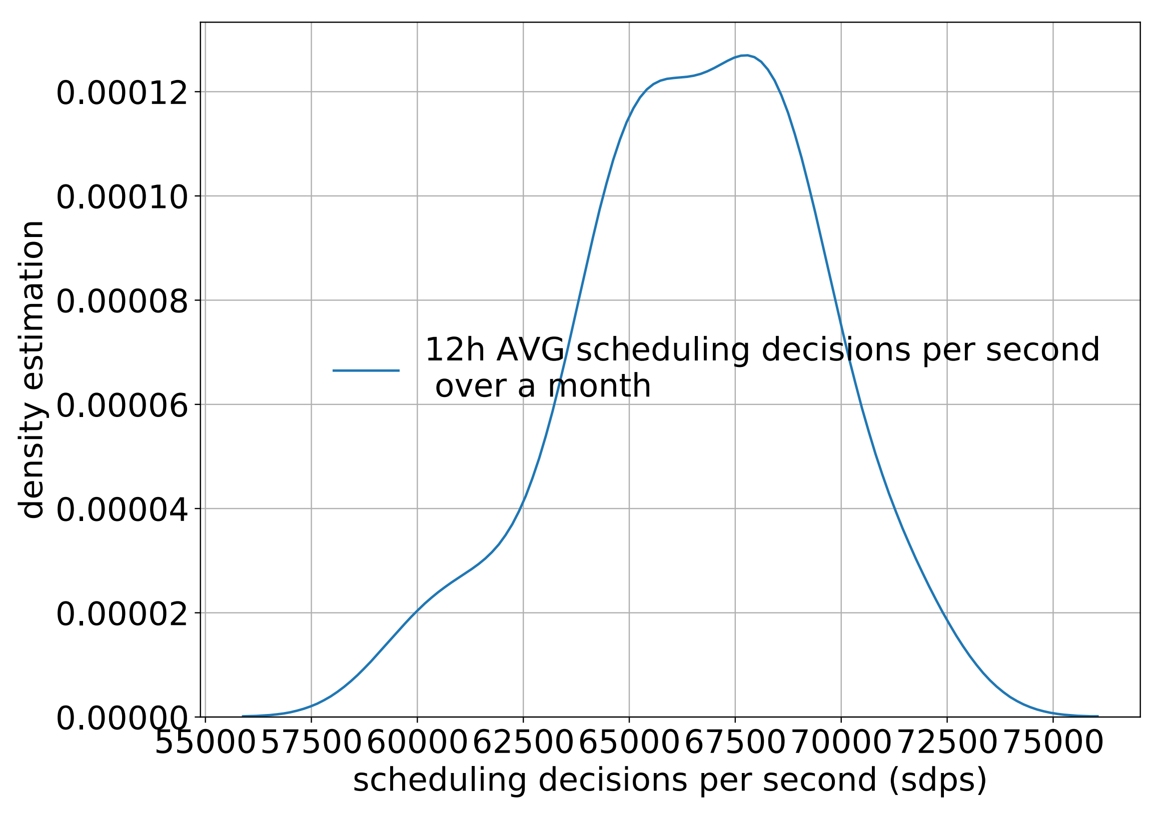
MATCHING A DISTRIBUTED SCHEDULER VIA FEDERATION

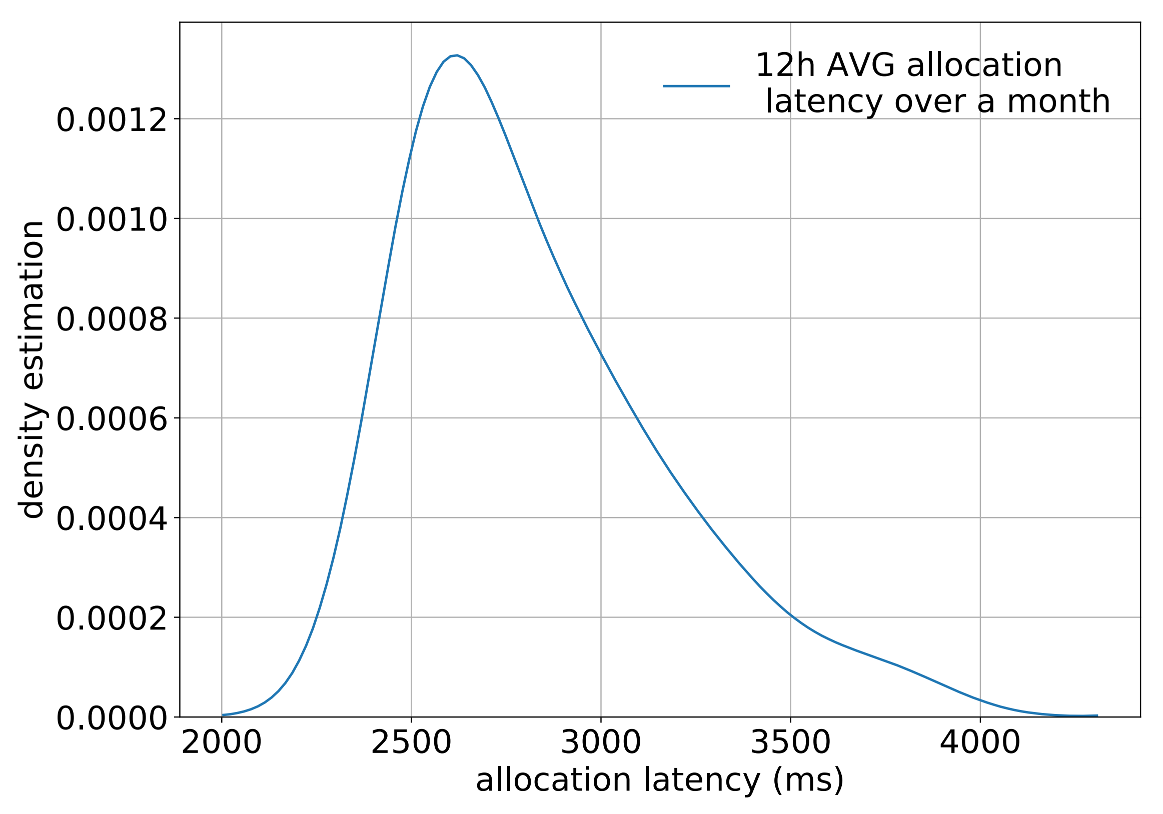
WORKLOAD

- Microsoft-wide production workload
  - 5 clusters with over >250k total servers
  - >500k daily jobs
  - ~2B daily tasks
  - Highly skewed in job and task size/duration

SCALE

HIGH SCHEDULING RATE AT LOW ALLOCATION LATENCY!

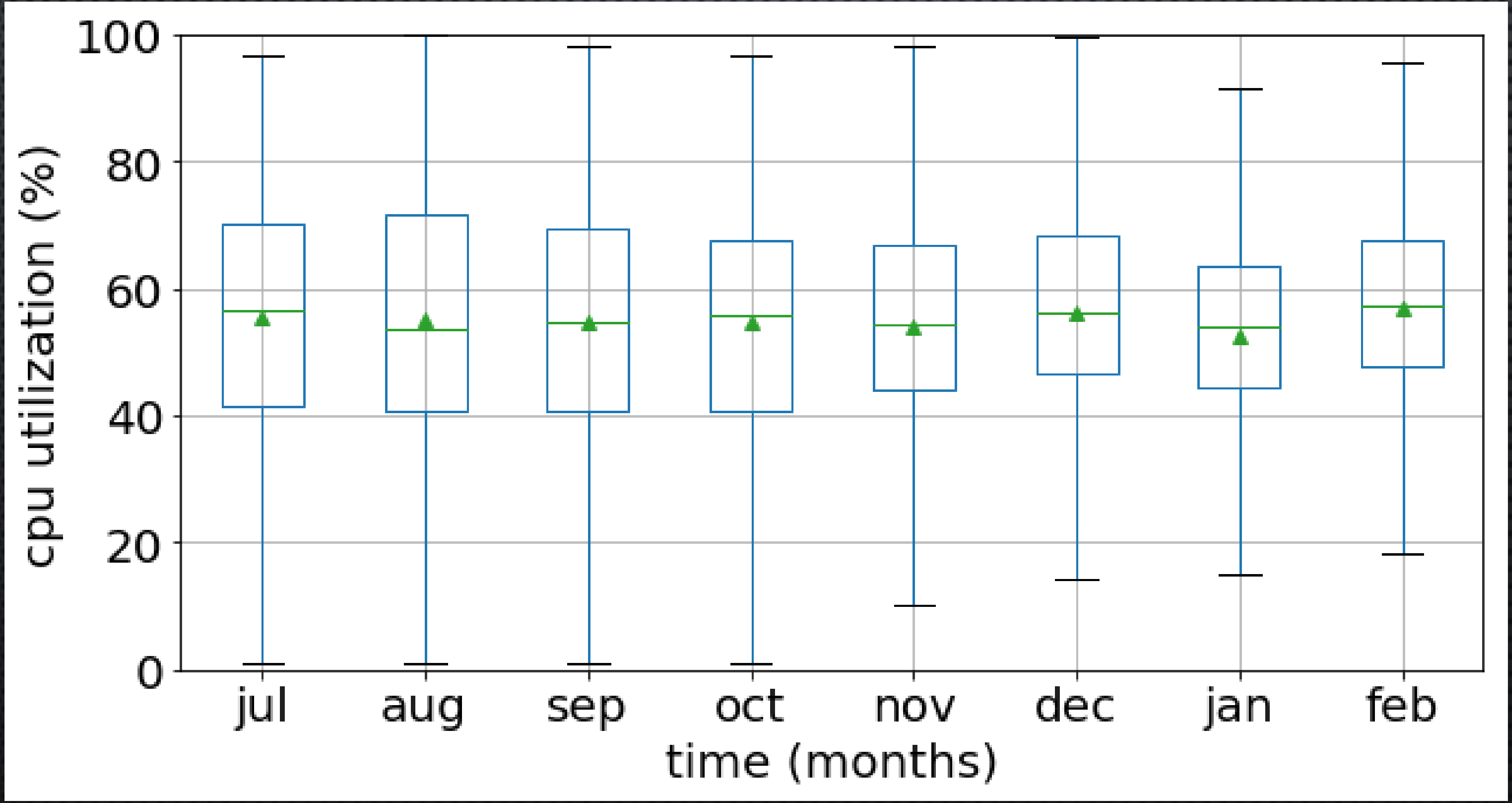




*not in the paper, updated as of jan/feb 2019

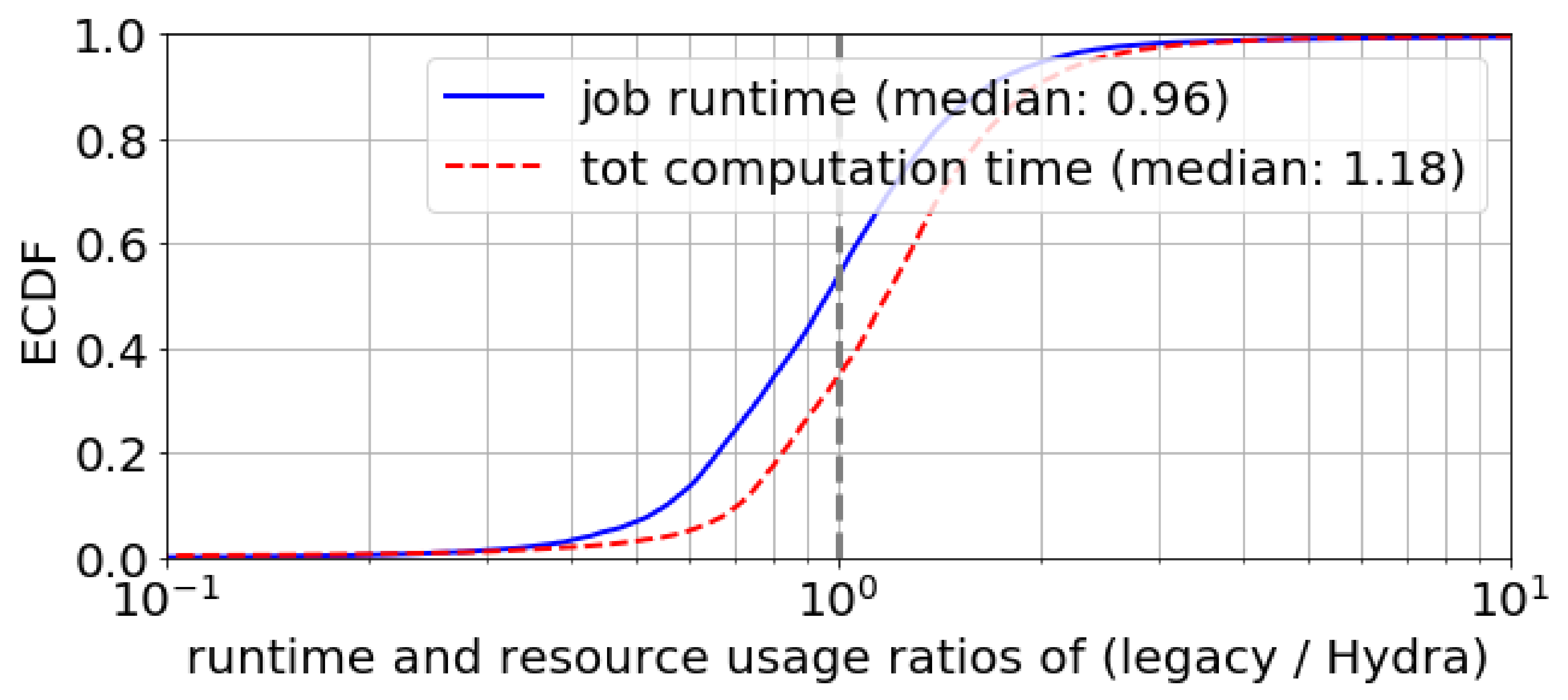
UTILIZATION

FEDERATED DESIGN IMPROVES LOAD BALANCING, WHILE RETAINING UTILIZATION!



PERFORMANCE

JOBS PERFORM JUST AS WELL (AND TASKS ARE AS EFFICIENT)!



QUALITATIVE EXPERIENCE

- In-place migration: we changed and engine mid-flight

- Happy customers can now play with OSS tech + MS stack!
- Federated design improved ***operability***:
  - Experiment at sub-cluster granularity
  - OSS innovation is easier to leverage
- Policy-driven design:
  - Allows us to dynamically adapt and experiment

CONCLUSION

- Hydra’s federated architecture got us:
  - Multi-framework / Scale / Utilization / Operability
- Exciting journey from 0 to:
  - >250k nodes
  - >200K LoC open-source code
  - 11 published papers

If you want to be part of our next project, we are hiring!