Prediction-Based Power Oversubscription in Cloud Platforms

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Microsoft Research

Azure

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- Efficient resource utilization is key
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  - Better sustainability
- Power is typically a bottleneck resource
  - Massive underutilization due to provisioning peak power for each server

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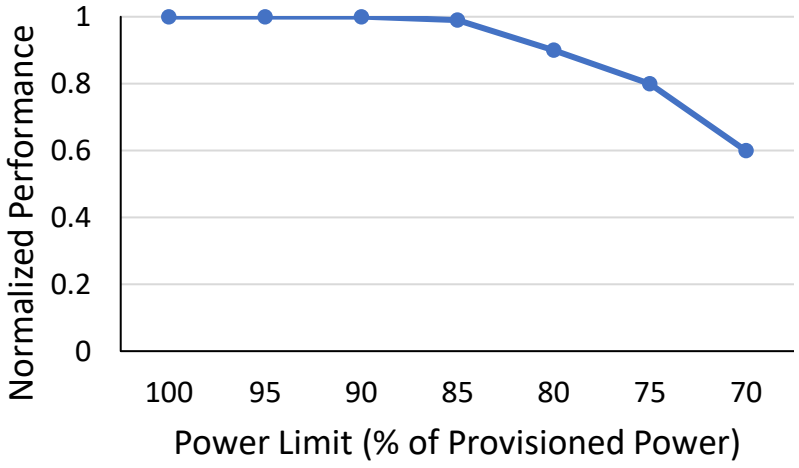
- Profile impact of capping on workloads
  - Oversubscribe power while protecting performance



Power capping impact on workload performance
(baseline: un-capped performance)

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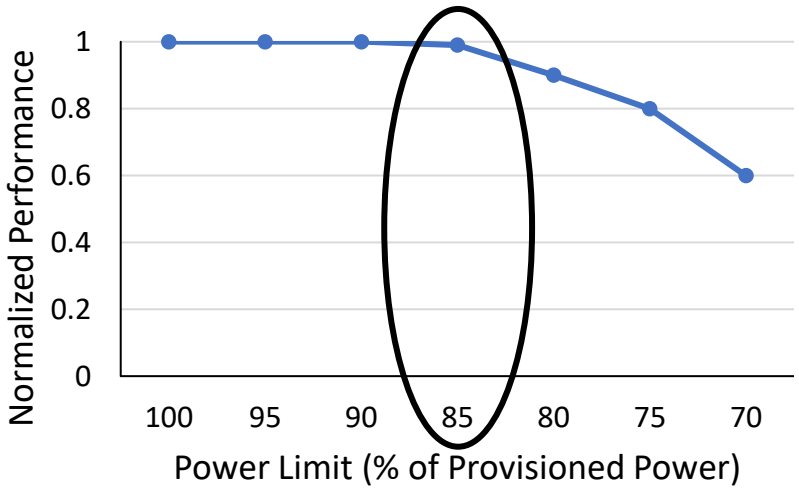

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Oversubscription is currently limited by performance impact of capping

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Fine-grained Power Capping for Oversubscription

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Solution: Criticality-aware per-VM power capping and oversubscription

- Provide power safety while protecting performance of critical VMs
- Strategy for criticality-aware oversubscription

Per-VM Power Capping Overview

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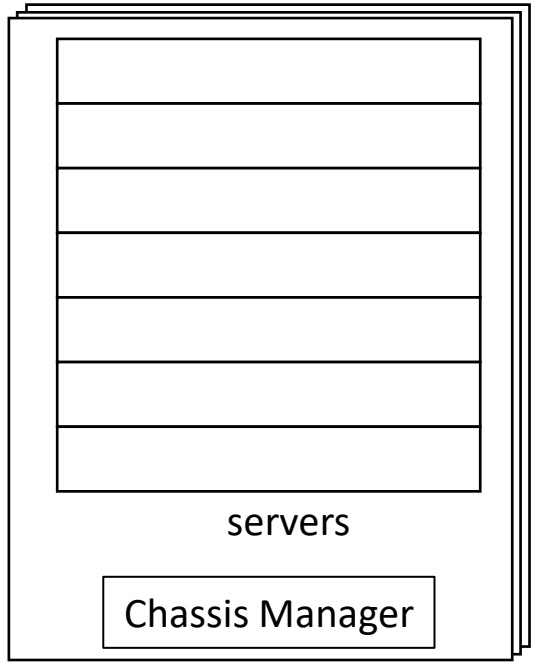

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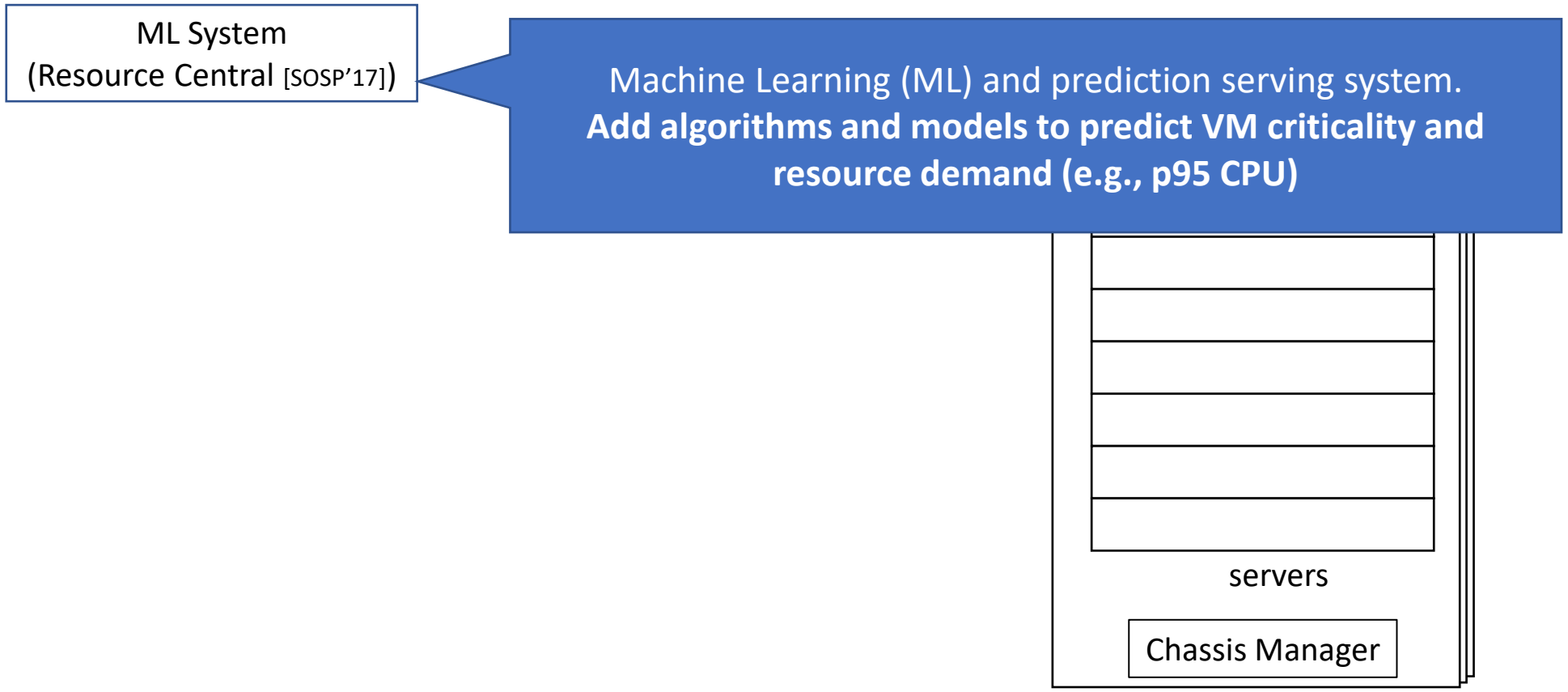
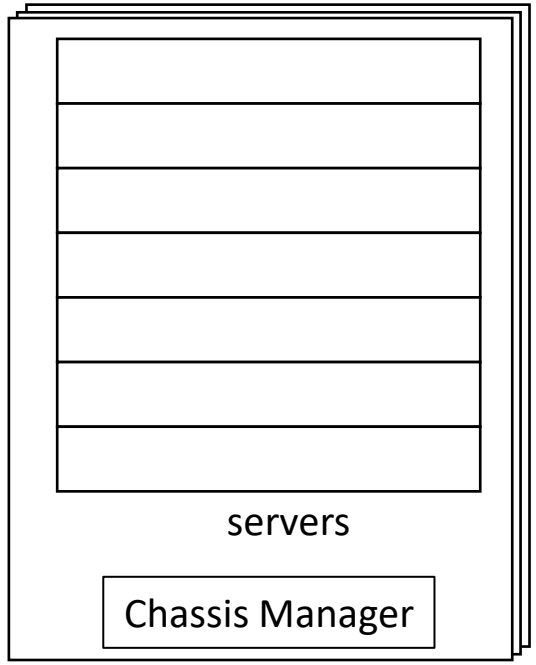


Per-VM Power Capping Overview

ML System
(Resource Central [SOSP'17])

VM Scheduler
(Protean [OSDI'20])

VM placement with rules to tightly pack VMs on servers.
Add rules for distributing power via criticality and utilization-aware VM placement.



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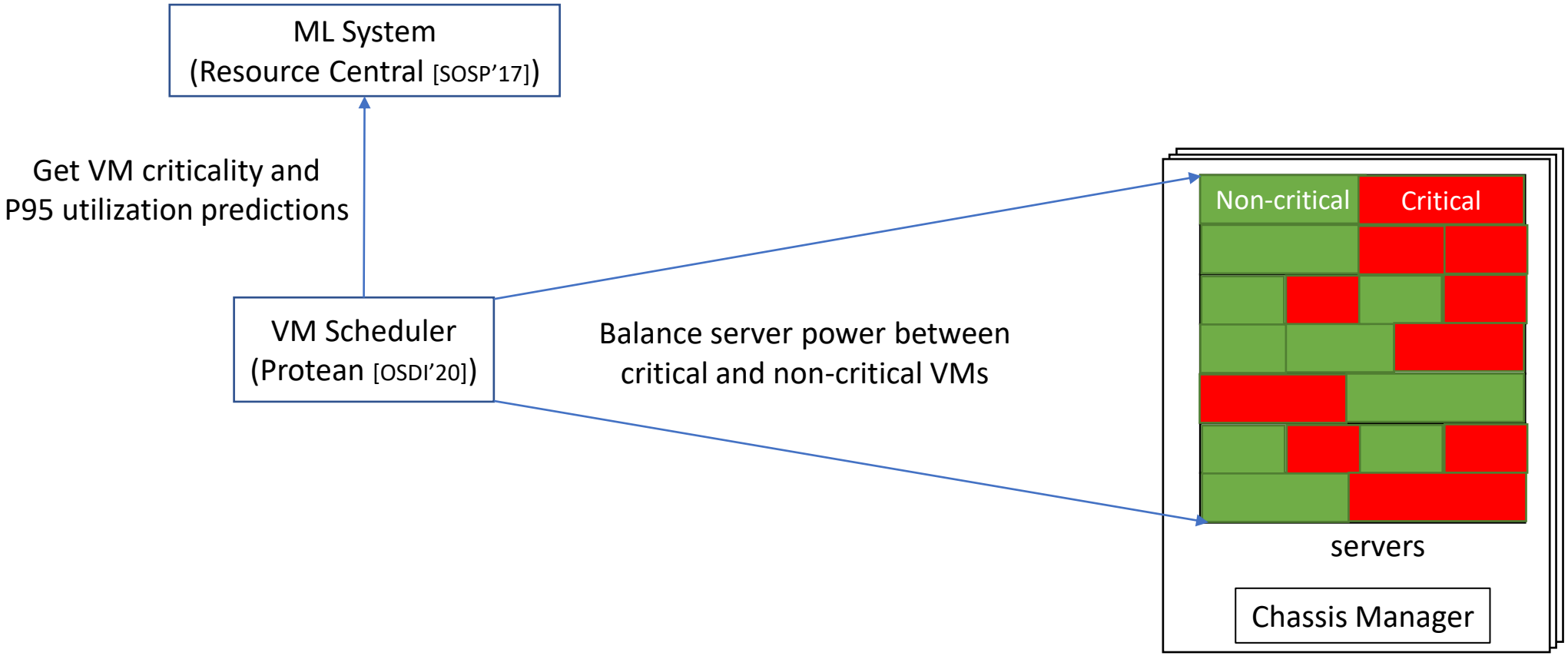

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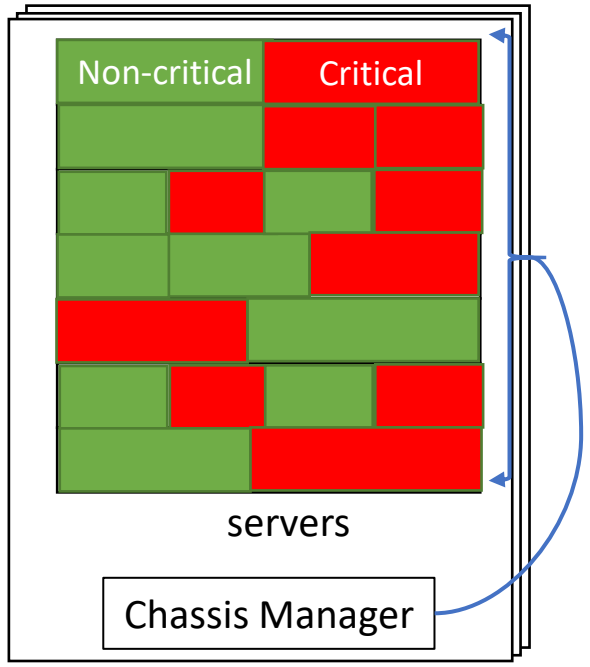

Chassis power draw > limit

- Start power capping on servers

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Criticality-aware capping for safety while protecting perf of critical VMs

Non-critical
VM

Critical
VM

Per-VM capping controller

Hypervisor

C C C C C C

server

Non-critical
Critical

servers

Chassis Manager

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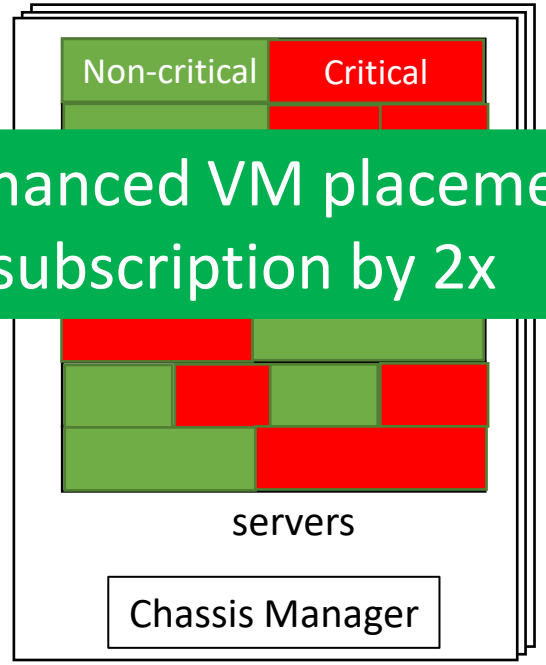
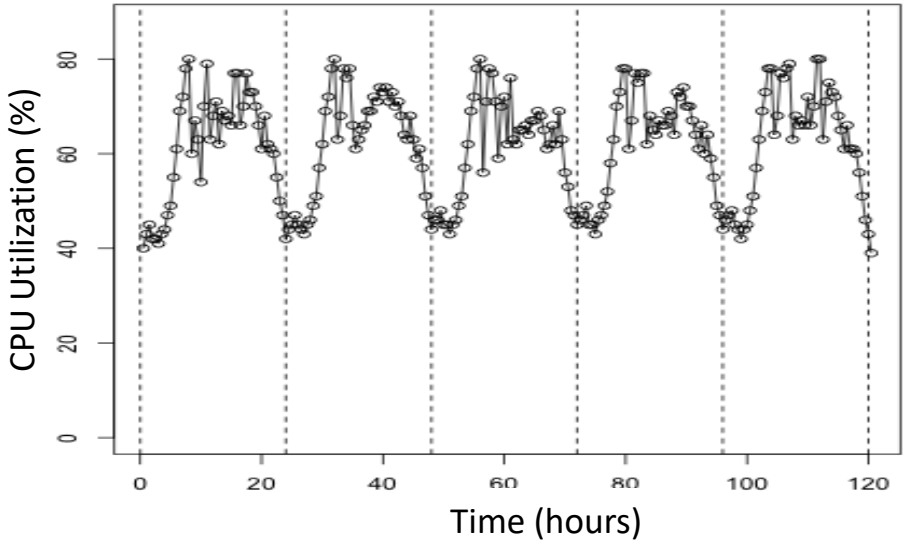


Per-VM power management using ML models, enhanced VM placement and per-VM power capping can increase oversubscription by 2x

Inferring criticality of opaque VMs (challenge #1)

- Insight: User-facing workloads exhibit diurnal load pattern



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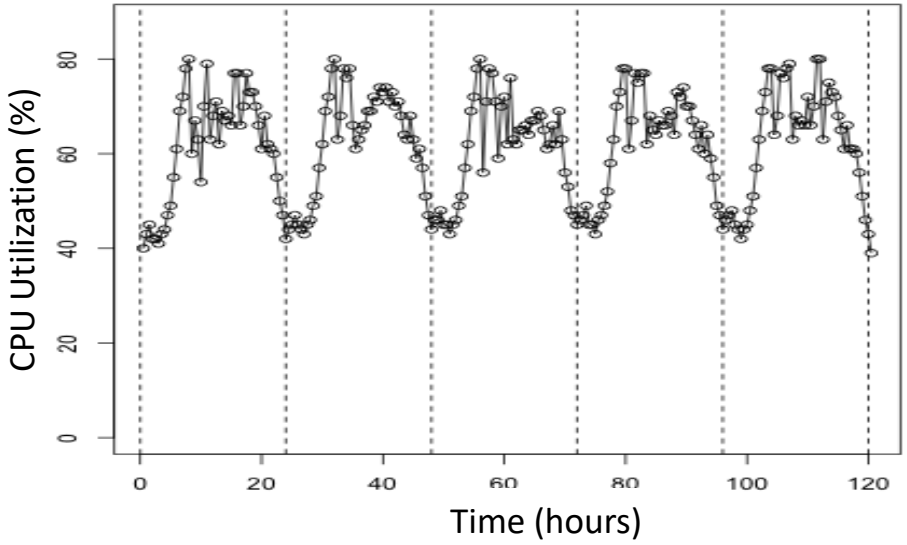

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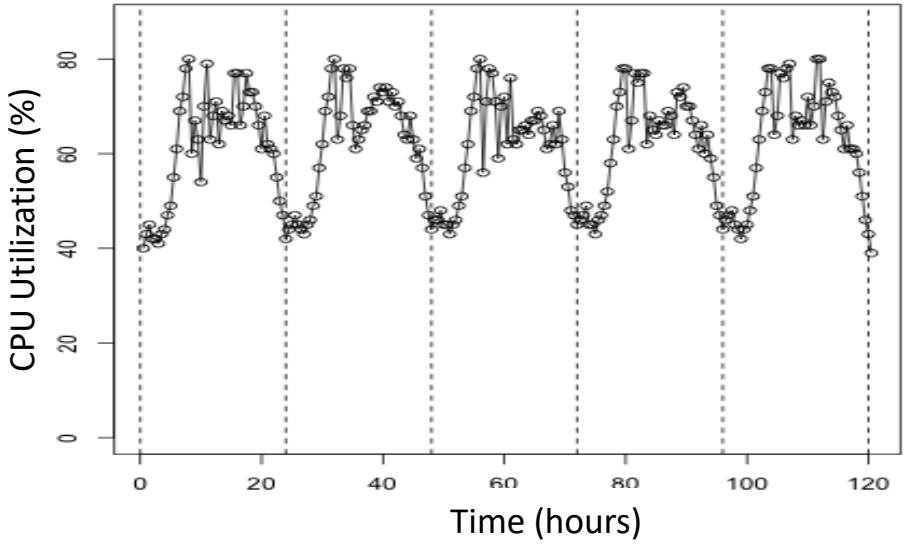

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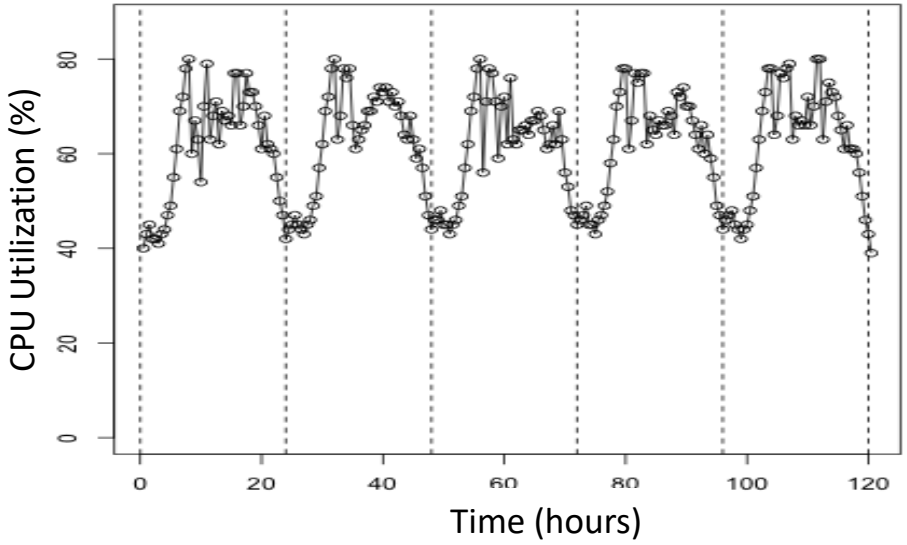
- Static overrides
  - “Always-throttle” list of VMs (e.g., internal non-production)
  - “Do-not-throttle” list of VMs (e.g., all third-party, gaming)



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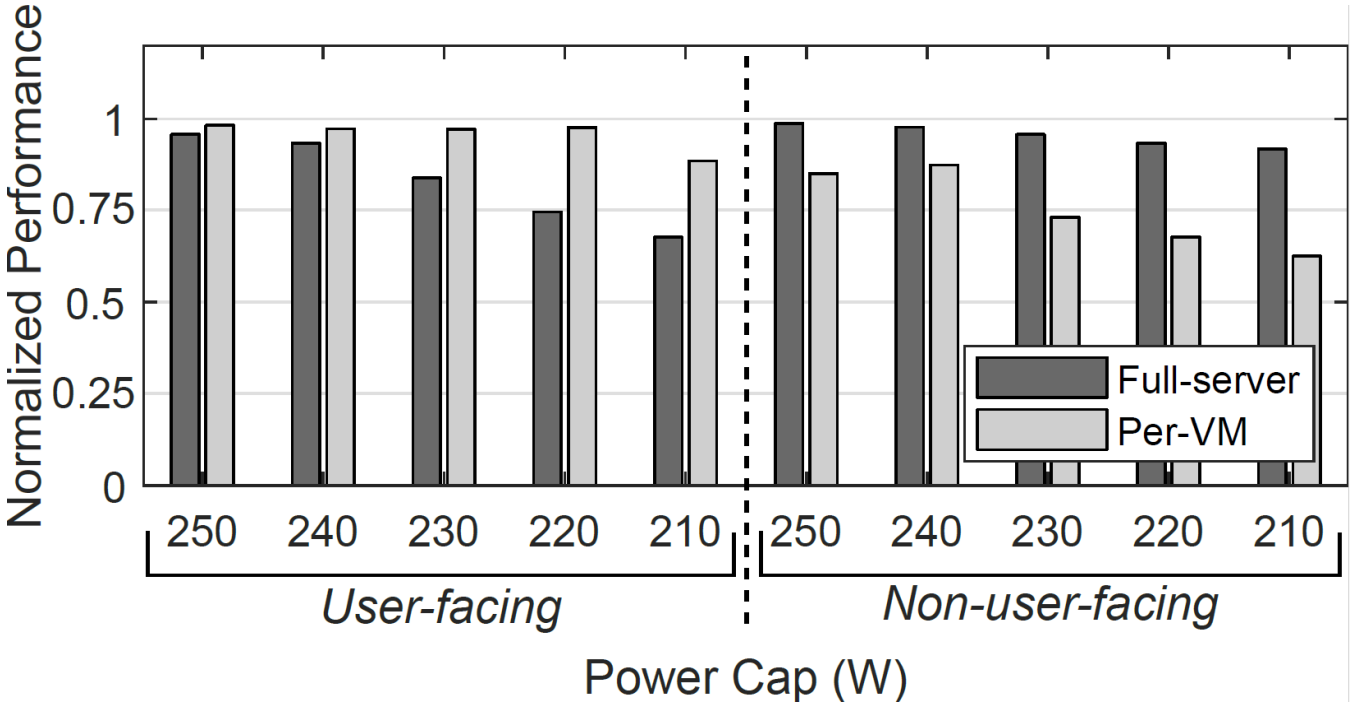

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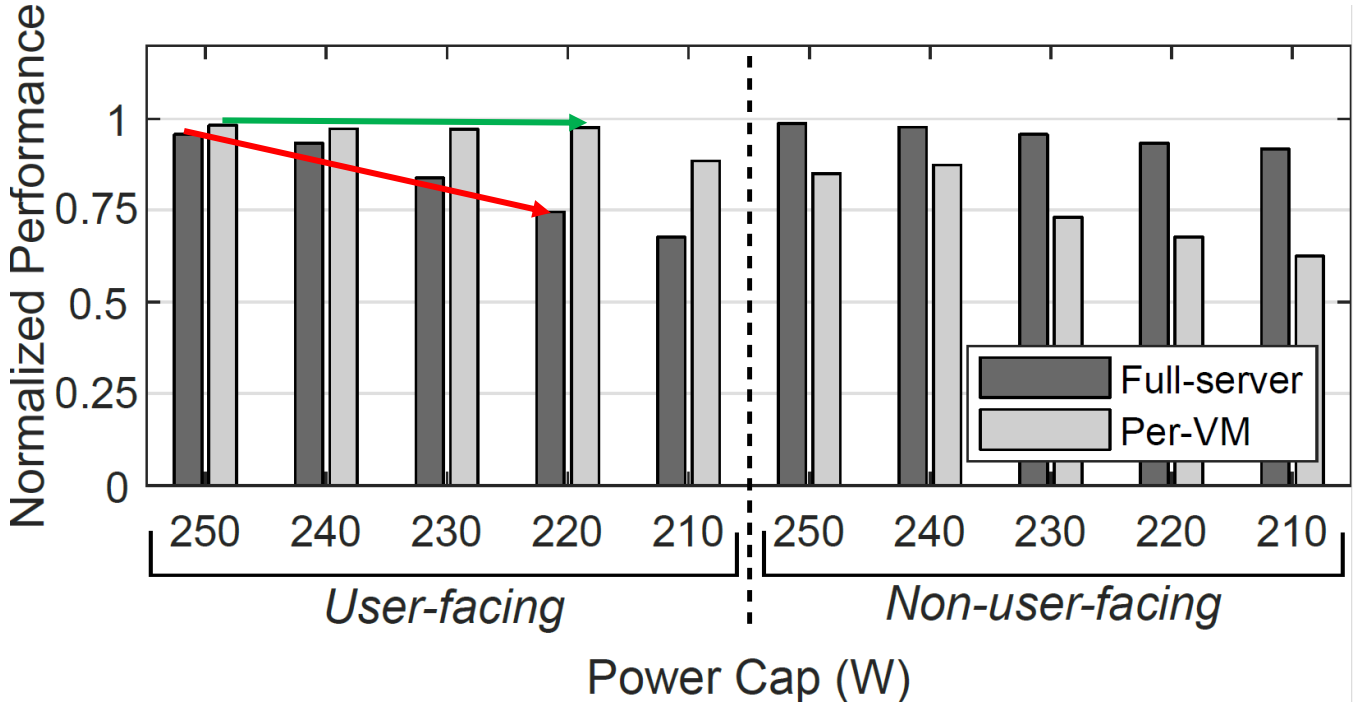

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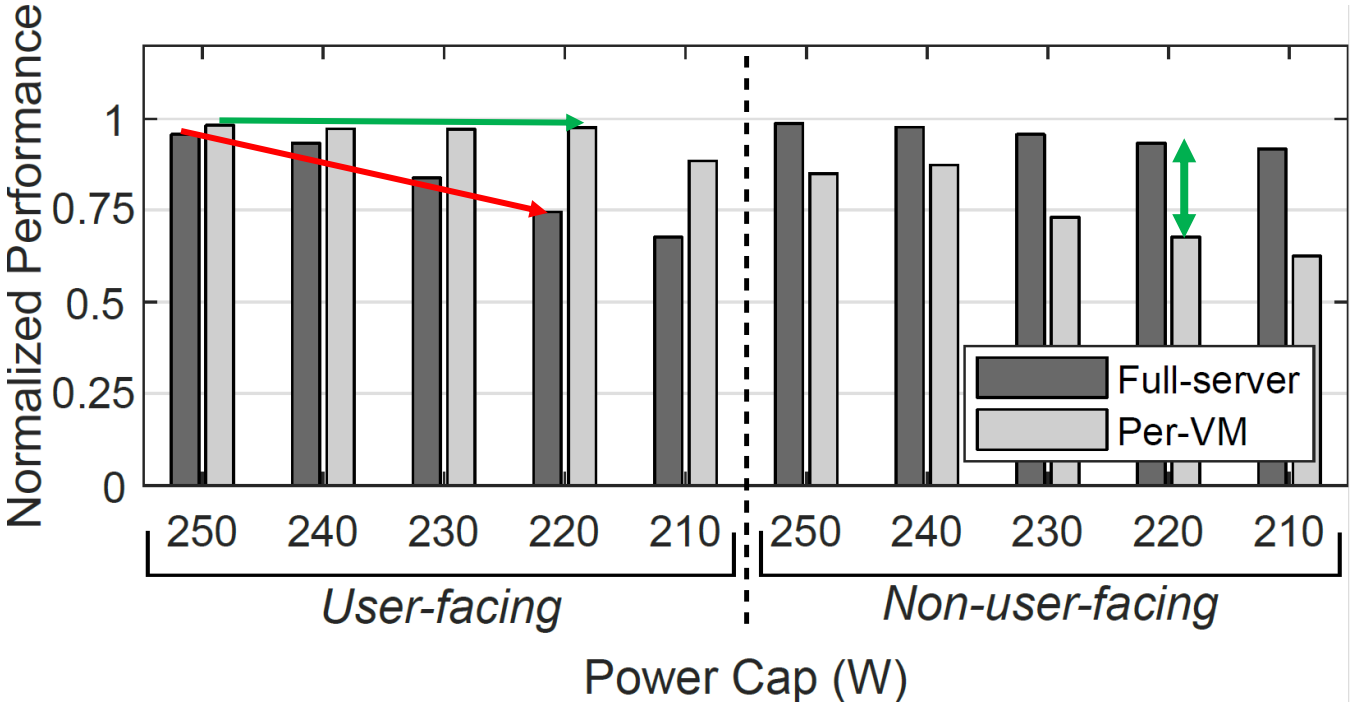

- Per-VM enables additional harvesting while protecting perf of critical VMs
  - Trade-off: Increased perf degradation for non-critical VMs
  - Relaxed perf requirement of workloads on non-critical VMs (e.g., internal non-production)

Oversubscription Strategy with Per-VM Capping

- Insight: Differentiated (per-VM) capping for harvesting power from chassis
  - **Constraints**: # capping events and perf (frequency) reduction for critical and non-critical VMs

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Approach	Harvested power (%)	Savings ($10/W)
Traditional (no oversubscription)	0	0
State-of-the-art (w/ full-server capping)	6.2%	$79.4M
Predictions for internal and non-premium external VMs	12.1%	$154.9M

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Per-VM capping allow us to be selective
and increase the amount of **oversubscription by 2x!**

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  3. Server support for per-VM capping

Conclusions

- Limited power oversubscription on cloud platforms to restrict performance impact
- Solution: Prediction-based per-VM power capping
  - Algorithm and ML models for predicting performance criticality and VM utilization
  - Criticality- and utilization-aware VM placement
  - On-server criticality-aware power management system
  - Strategy for criticality-aware oversubscription
- Main result: Increase oversubscription by 2x while protecting critical workloads

Thank you!