Cloud Index Tracking:

Enabling Predictable Costs in Cloud Spot Markets

Supreeth Shastri and **David Irwin**

University of Massachusetts Amherst

Spot Servers are gaining significance in the cloud

Servers that may terminate anytime after an advance warning period

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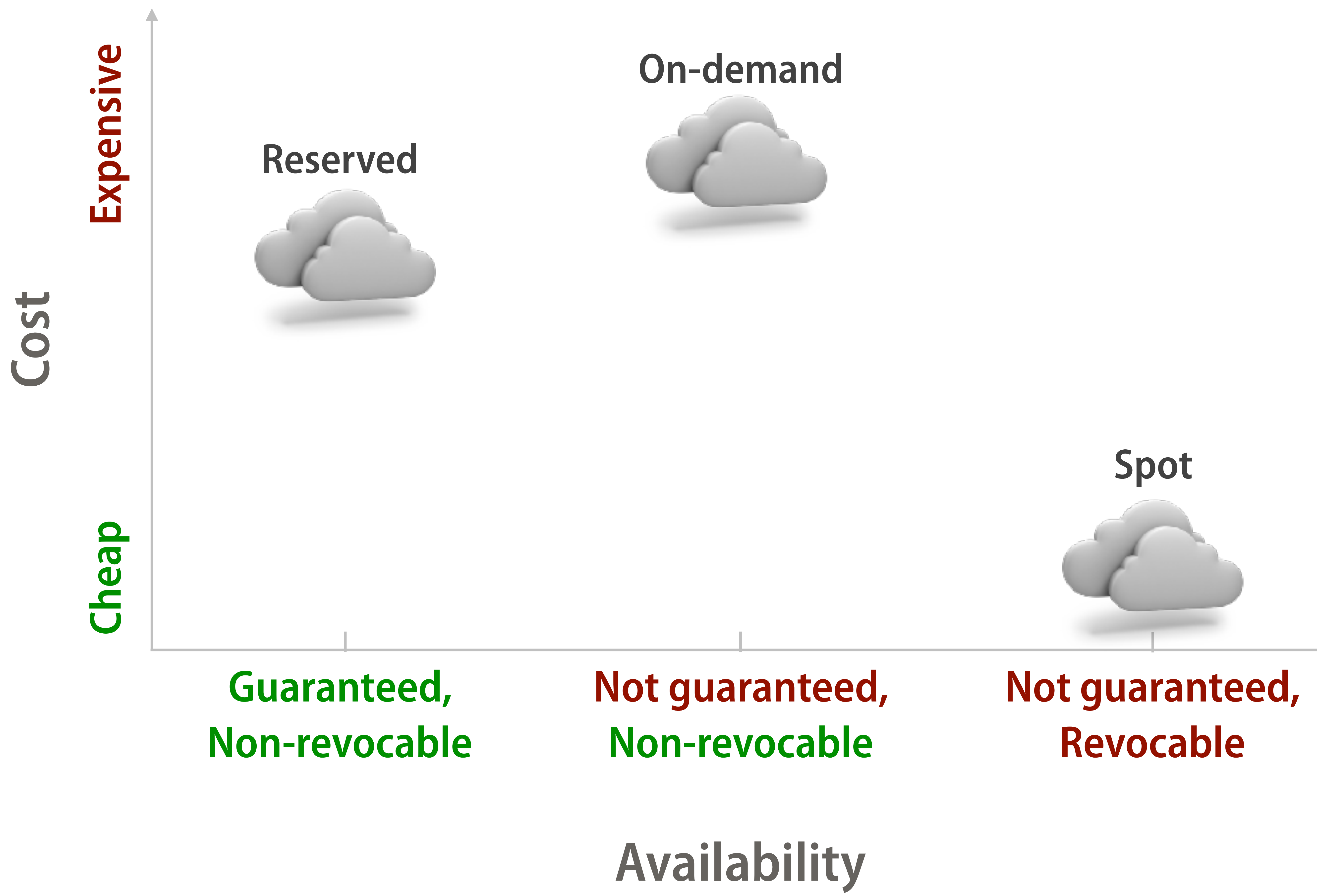

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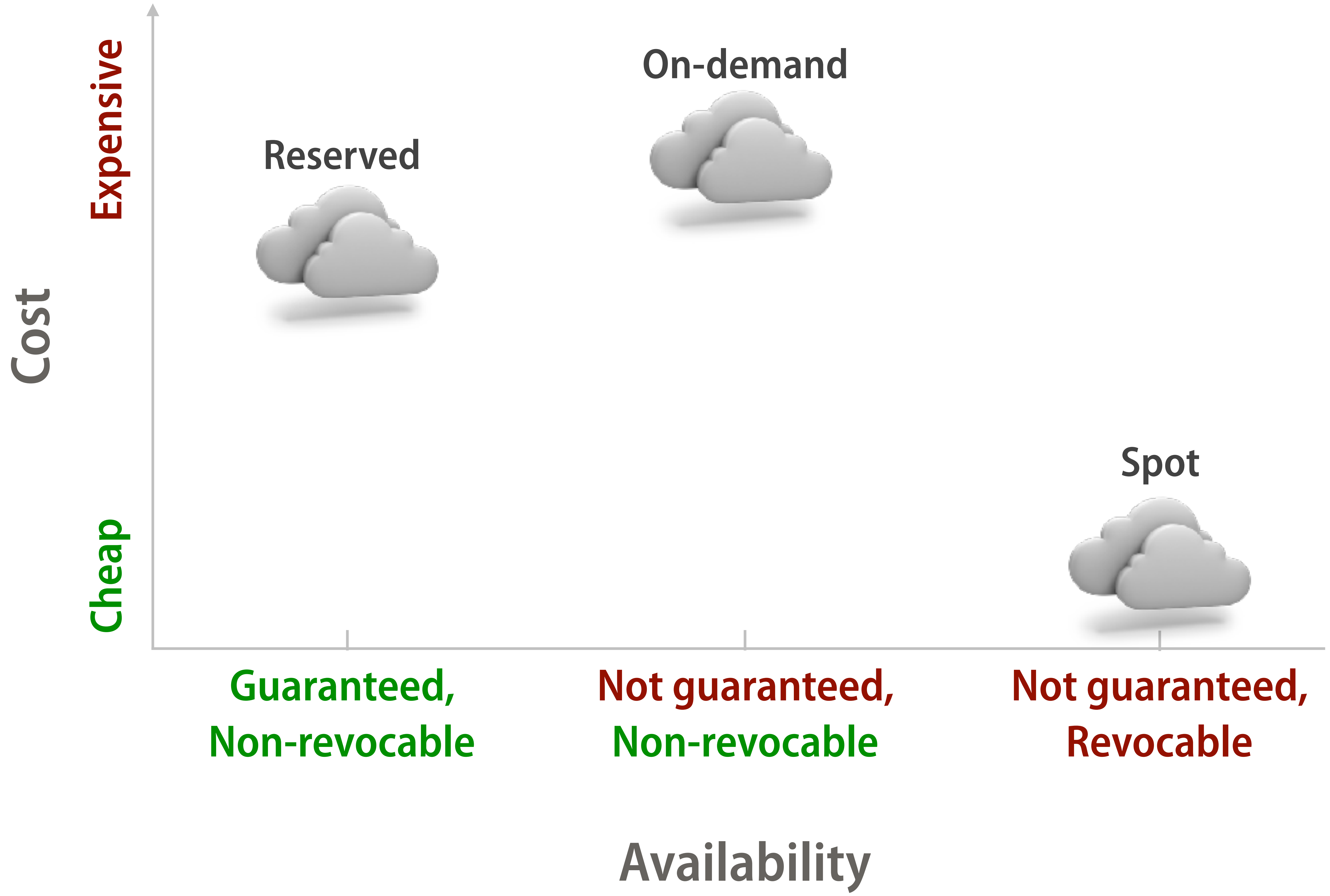


Spot instances helped scale our clusters up by **4X** during the discovery of the **Higgs Boson**

Fermilab

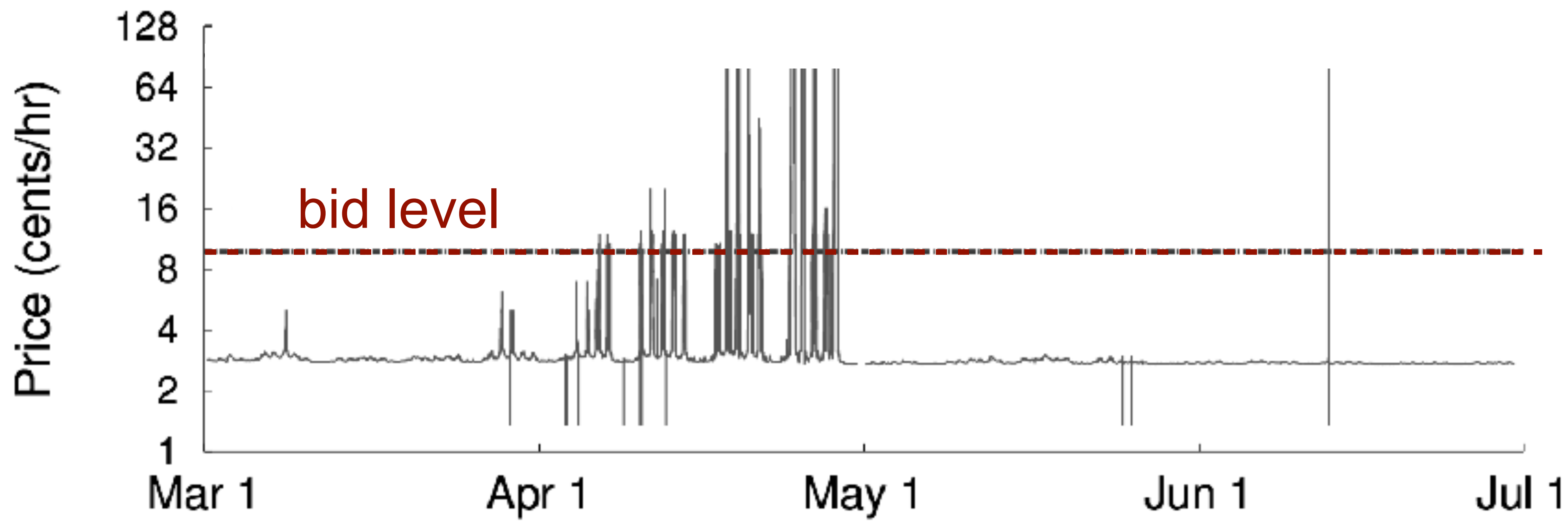
Researchers built the **largest** HPC cluster in the cloud with **1.1million** vCPUs on EC2 spot

CLEMSON UNIVERSITY

Spot server pricing

while low on average, it is characterized by

variability and *deliberate revocations*



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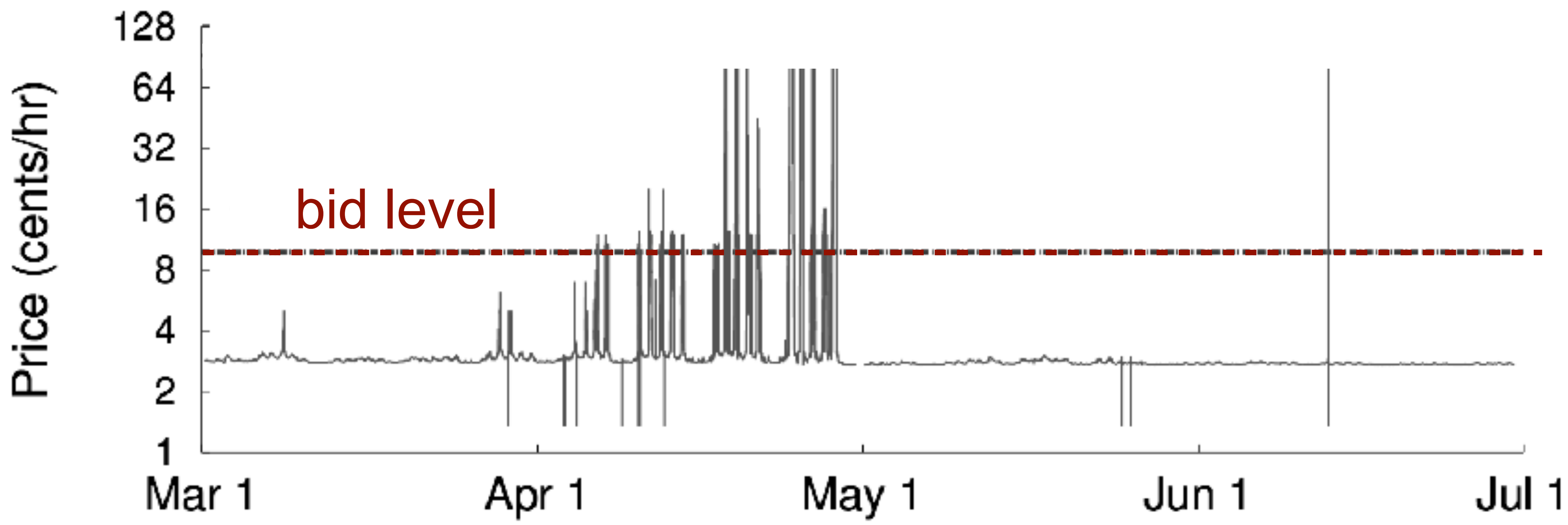

Predicting Spot Prices is an Active Area of Research

Ability to compare servers, plan IT budgets, and avoid disruptive revocations

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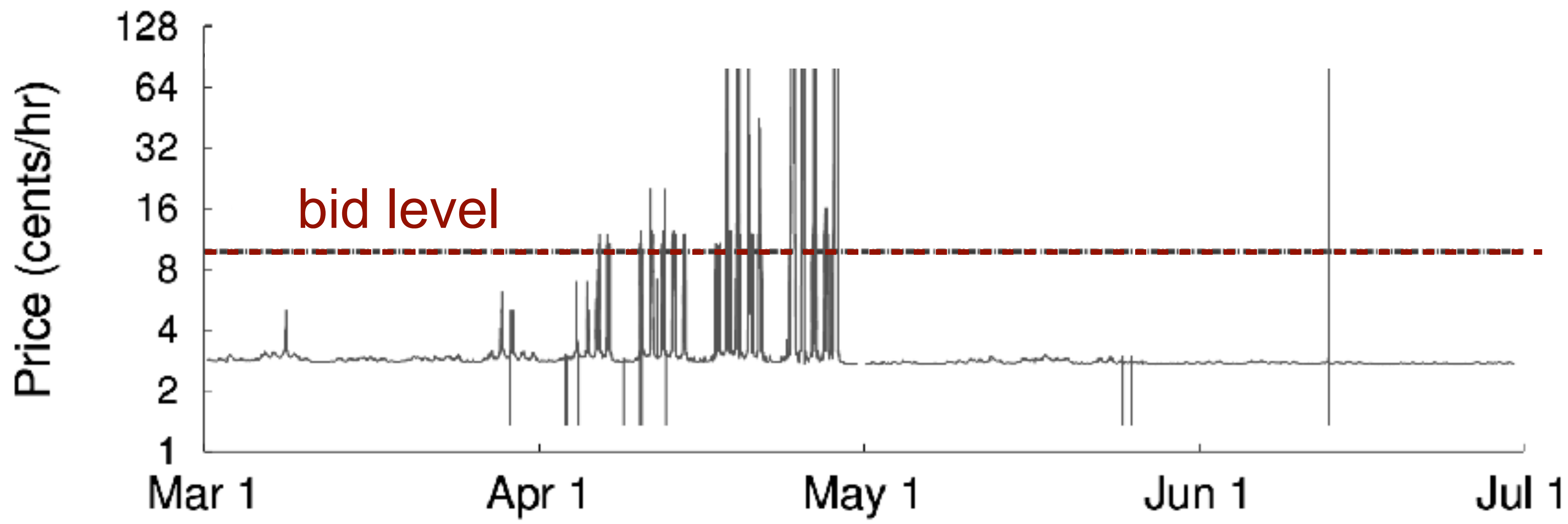

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2015	2016	2017	2018
Bid [**SIGCOMM**]	No-bid [**HotCloud**]	Prob-Guarantee [**SC**]	LSTM [**HPDC**]
SpotOn [**SoCC**]	Flint [**Eurosys**]	Proteus [**EuroSys**]	Tributary [**ATC**]
Cumulon [**VLDB**]	BOSS [**Infocom**]	Exosphere [**SIGMETRICS**]	

Predicting Spot Prices is Important

Prior work models individual spot server prices based on their **historical spot price data**

Accurately Predicting Spot Prices is ~~Important~~ *Difficult*

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68 • 2 • 2-5 • 14 • 2

Hardware config

OS types

Zones (datacenters)

Regions (country, state)

Time commitments

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68 · 2 · 2-5 · 14 · 2 = 7600+

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Hardware config		OS types		Zones (datacenters)		Regions (country, state)		Time commitments		worldwide markets

One size fits all model is unlikely

No visibility into market internals

Limited correlation with external variables

Image credit: www.cnbc.com/mad-money/

vs.

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Key Insight: A Market-based Index *for CLOUD*

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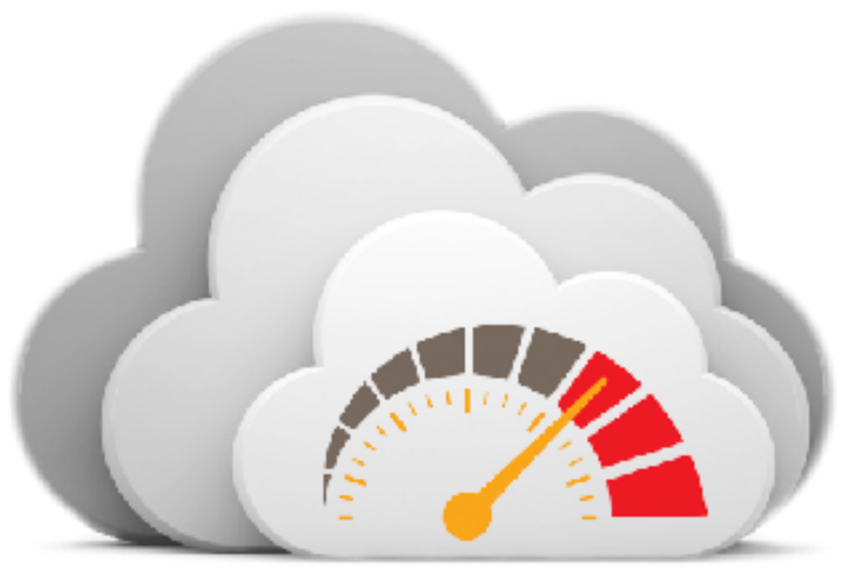
Key Insight: A Market-based Index *for CLOUD*

vs.

Rather than focusing exclusively on predicting **individual servers,**
cloud users should make decisions based on **broader market indices**

Image credit: www.cnbc.com/mad-money/



Cloud Index

intuition for our hypothesis

index **construction** methodology

validation on Amazon EC2

Index-tracking

techniques for **predictability**

design of index-tracking by server hopping

performance **evaluation**

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Aggregate idle VM capacity in public cloud datacenters tends to be stable

[SoCC 2014, SOSP 2017]

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We hypothesize that observing spot markets at **aggregate levels** (say, server family or datacenter levels) should lead to **stable prices**

Constructing a Market Index *for CLOUD*

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Characterizing an individual server i

Price = P_i , Memory = M_i GB

Compute = C_i ECUs

$$P_i^{norm} = \frac{P_i}{\sqrt{(C_i \cdot M_i)}}$$

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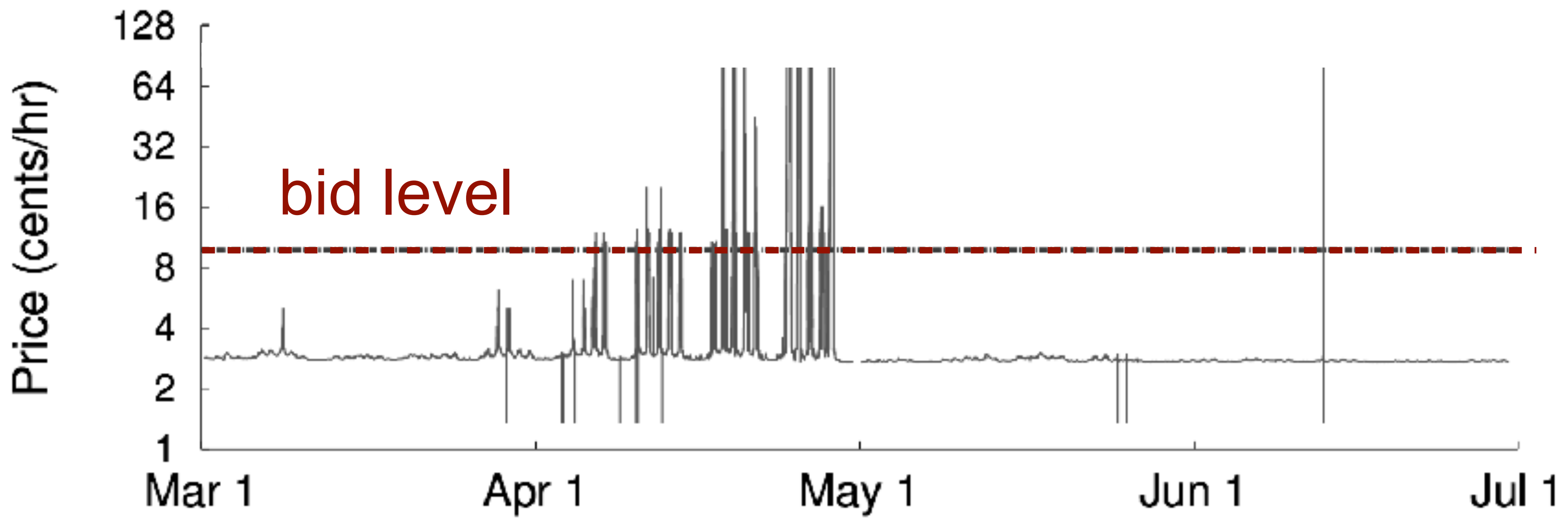
Cloud index value represents the **average price per unit of compute time**

for the selected group of servers

Individual Server Level



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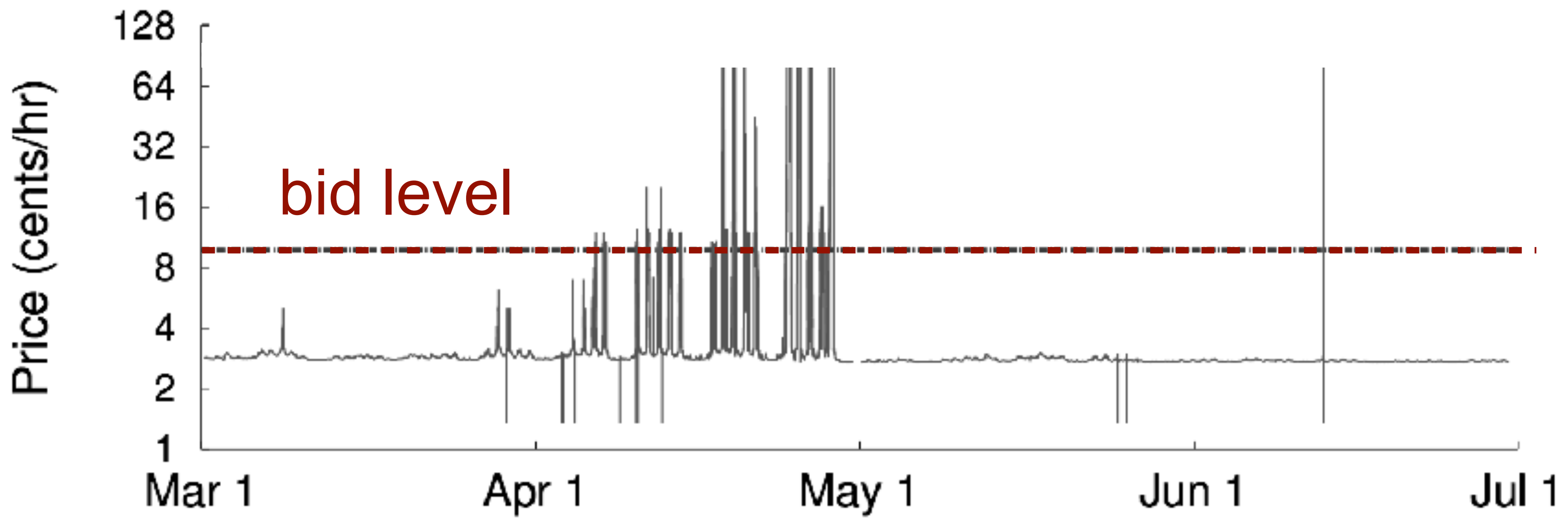
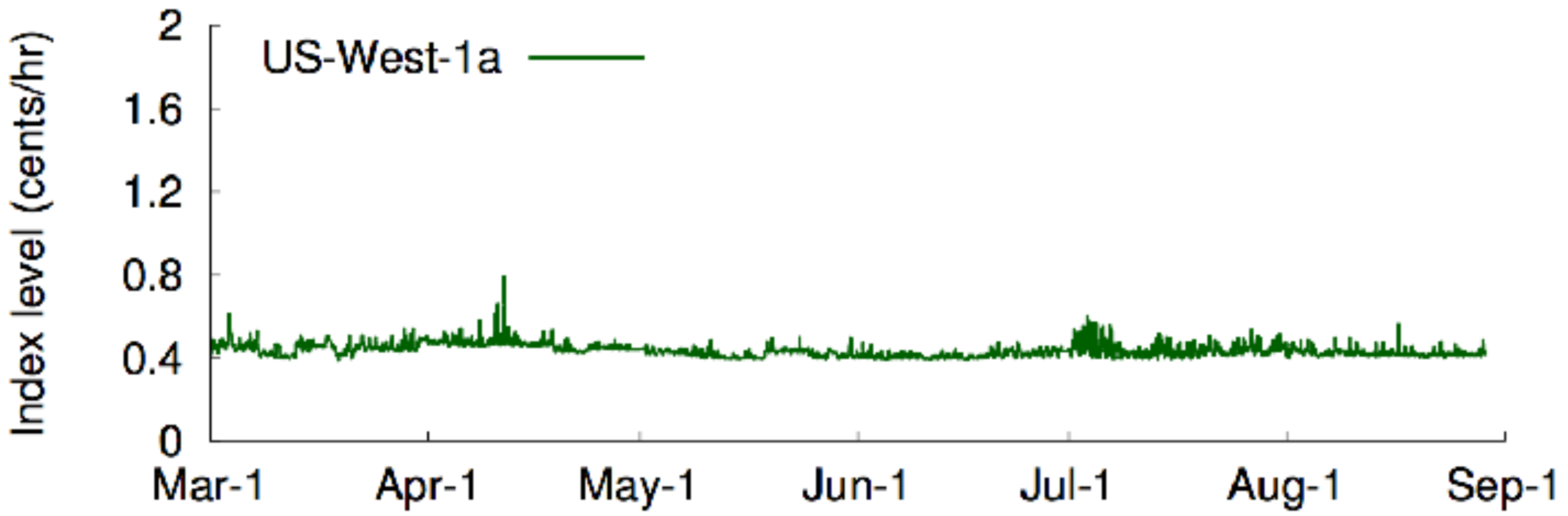


Datacenter Level (US-West-1a)



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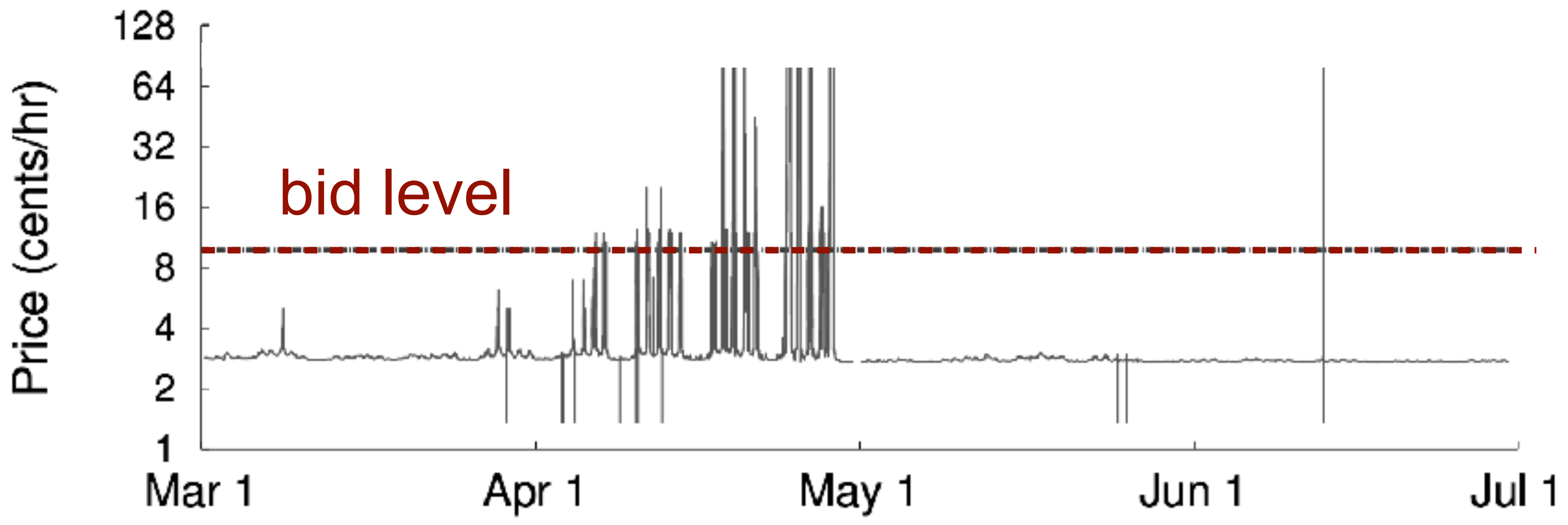
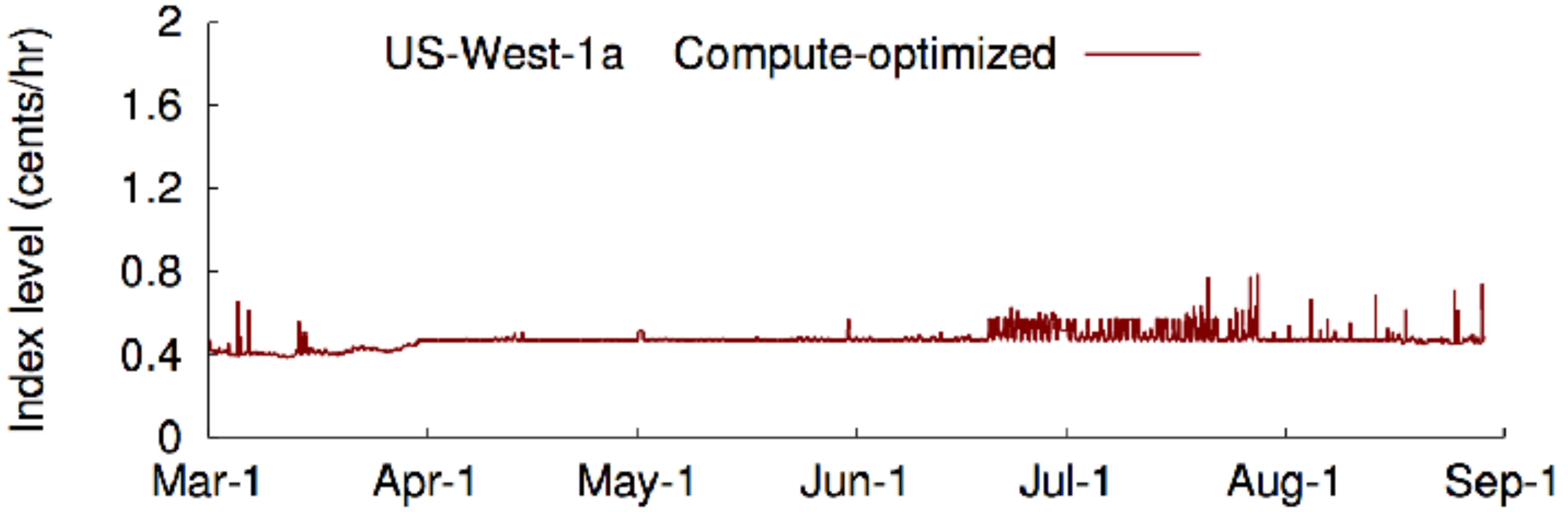
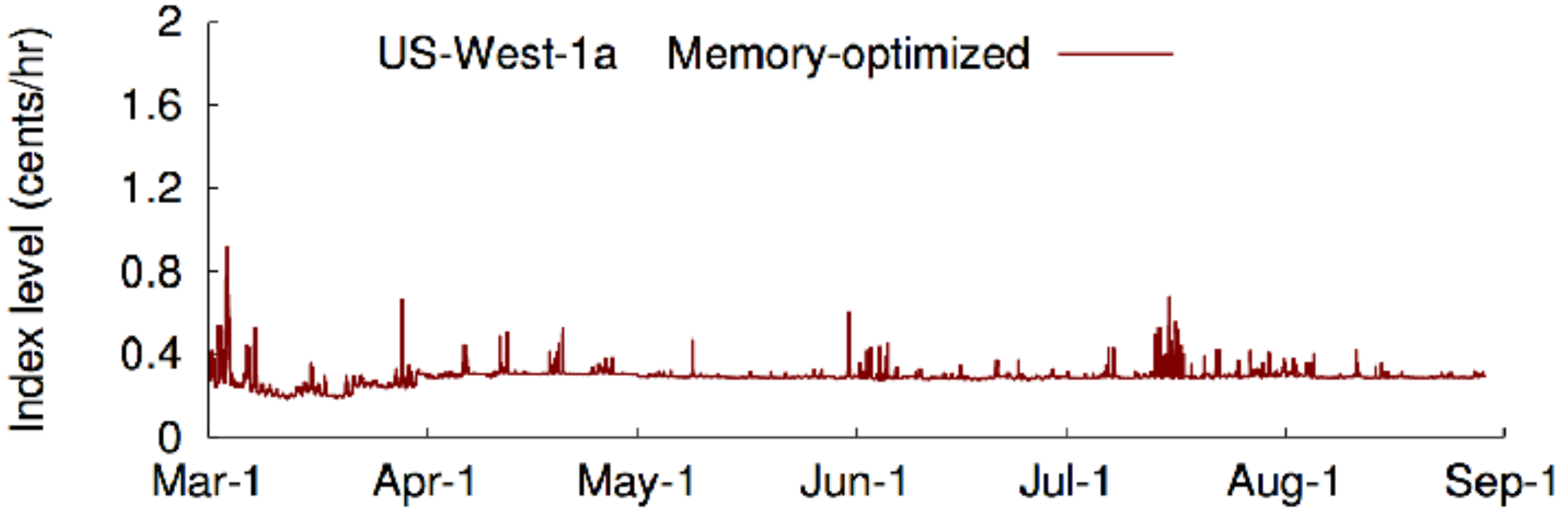


Server Family Level (US-West-1a)





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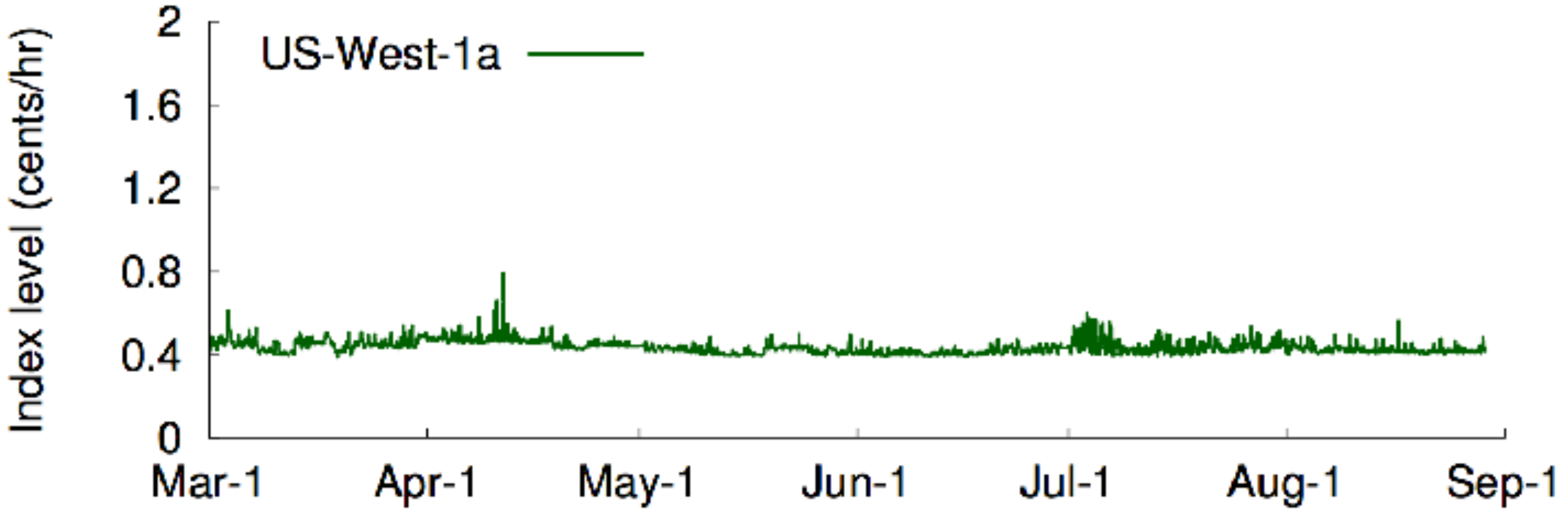

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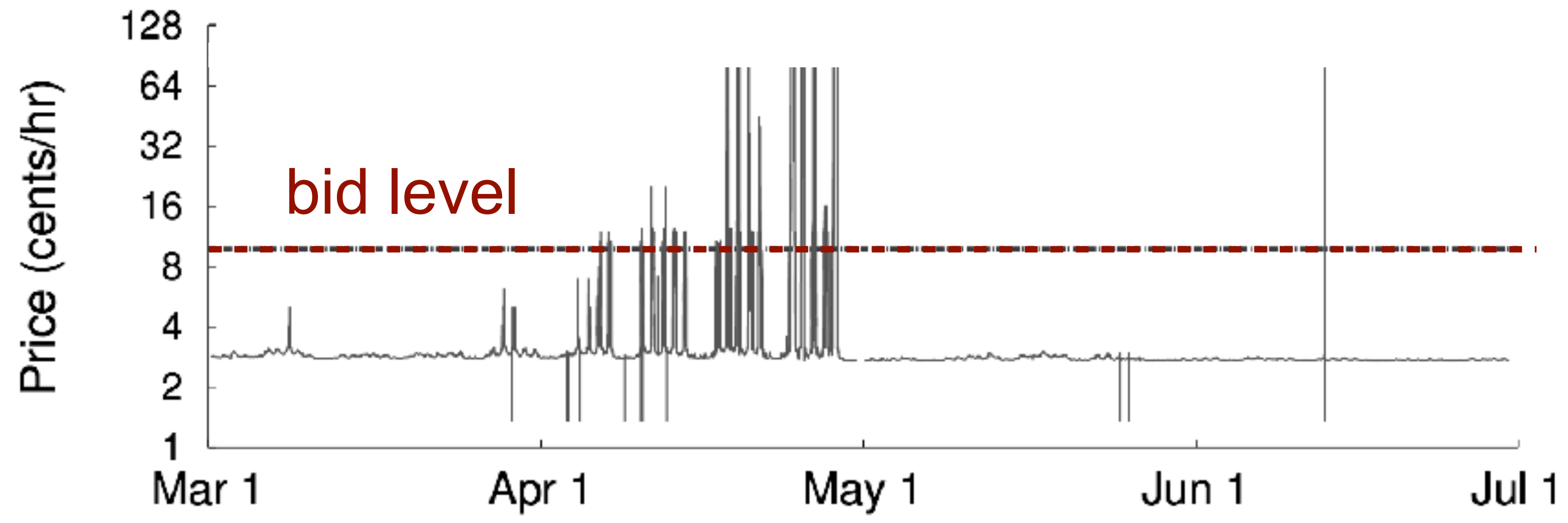

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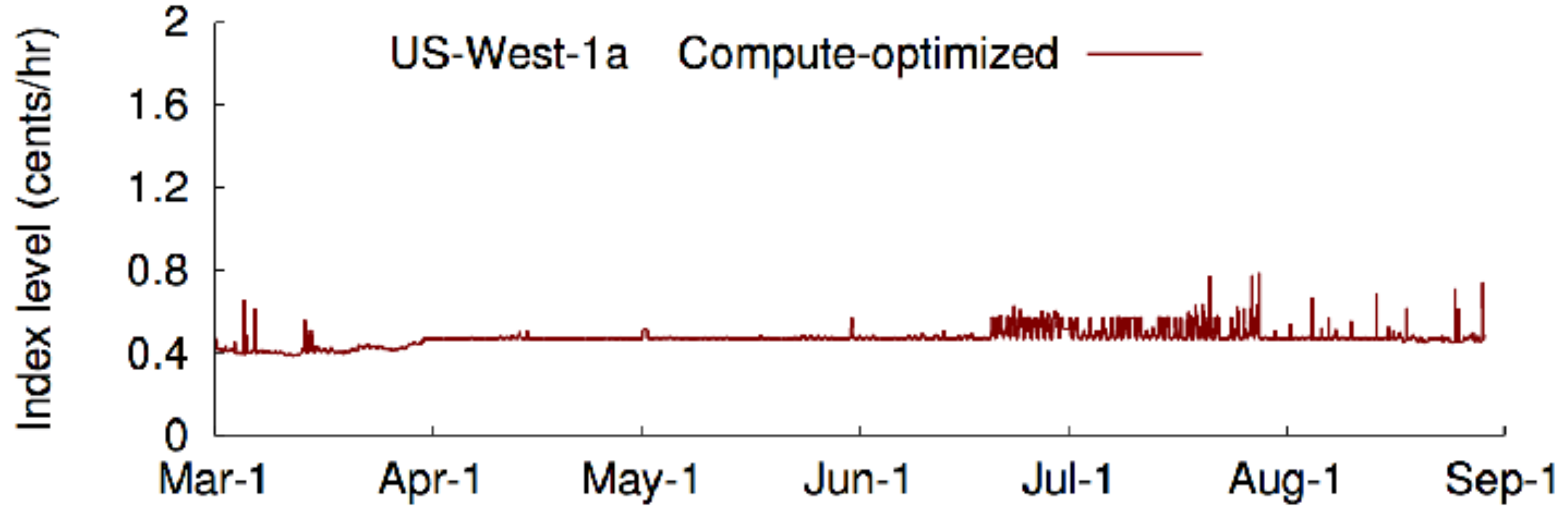

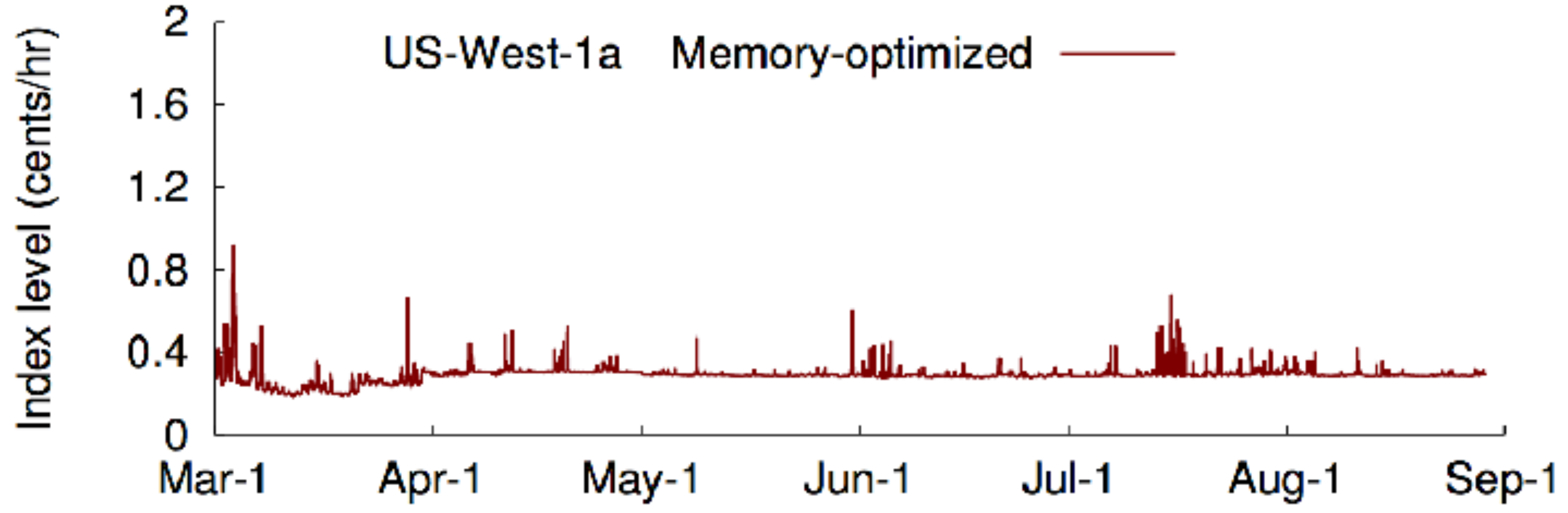

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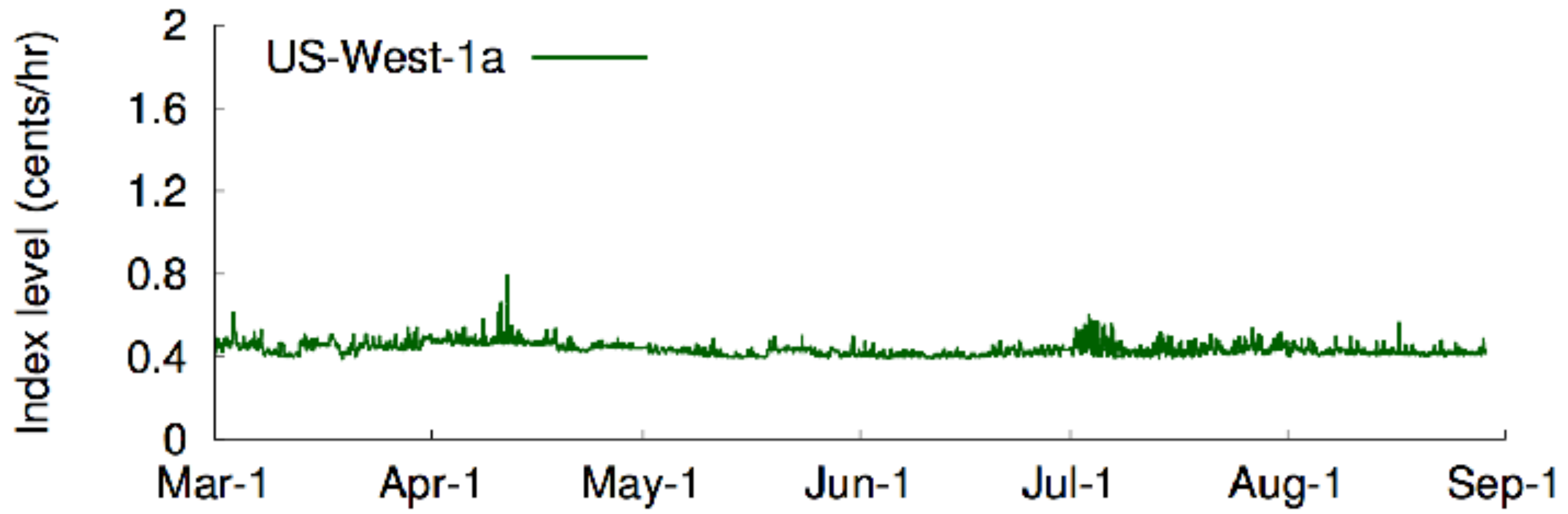
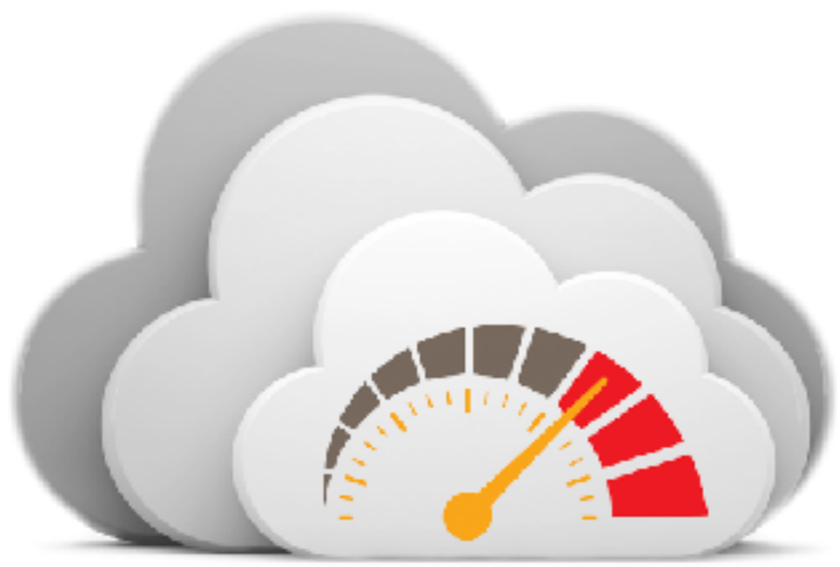


Price prediction is more accurate and stable at **datacenter-** and **server family level** than **individual** level



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Index-tracking

- techniques for **predictability**
- **design** of index-tracking by server hopping
- performance **evaluation**

Design elements

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Index-tracking in financial markets

Investments that match the returns of an index.

Construct a portfolio such that its constituent items are same as those present in the index.

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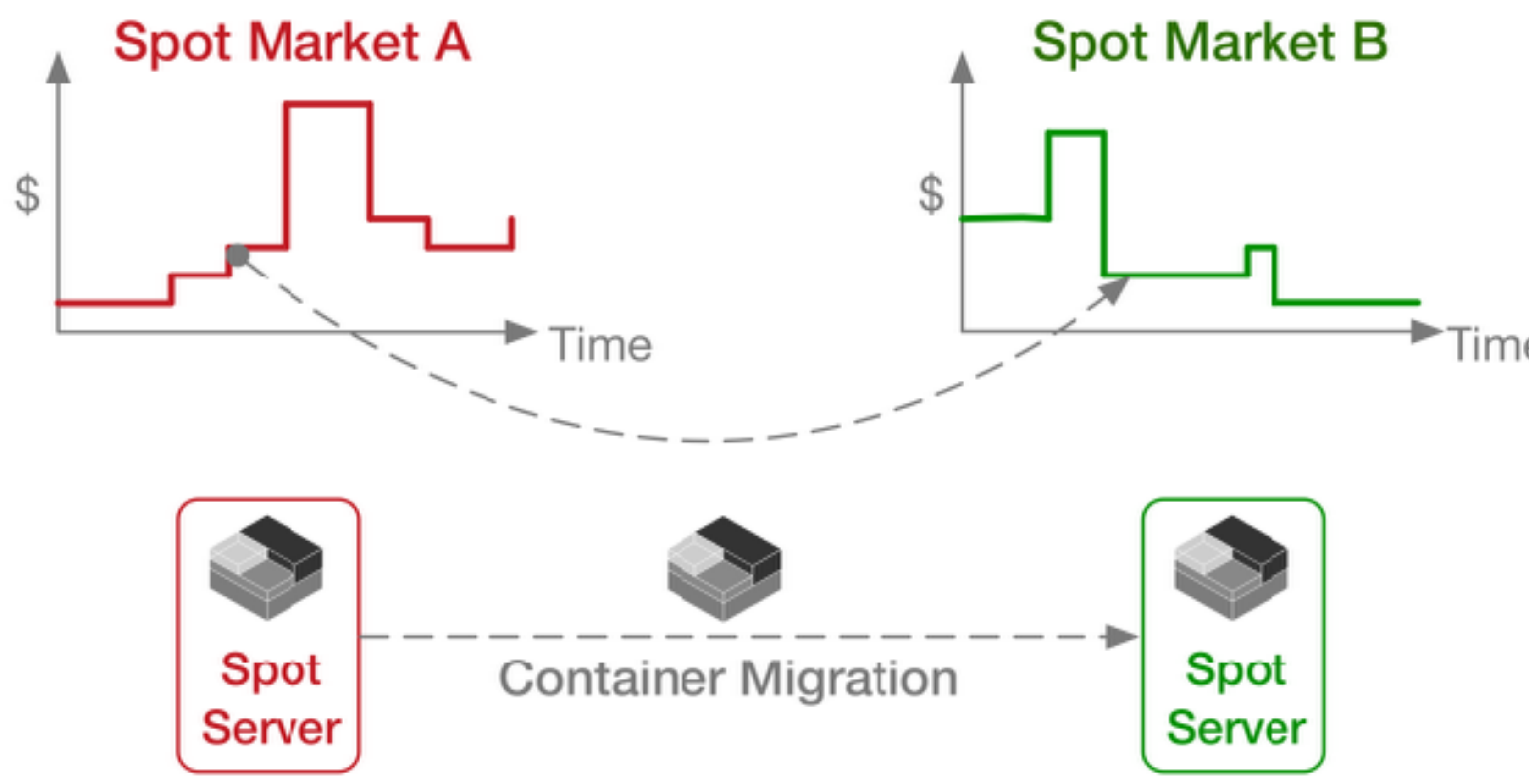
Server hopping in cloud markets



A container that automatically hops spot VMs as market conditions change [**SoCC 2017**].

Increasing cost-efficiency, lowers revocations

Index Tracking by Server Hopping

Achieving index-level cost-efficiency despite market volatility

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Determine a broad set of **candidate markets**, and then compute its market index

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If market conditions violate the index invariant, then **transparently hop** to a better server

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Achieving index-level cost-efficiency despite market volatility

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Server Choice

Select a server that shows best balance between **risk** (price volatility) vs. **reward** (cost-efficiency)

$$\text{Sharpe ratio} = \frac{(\mathbb{I} - \acute{P}_i)}{\text{std-dev}(\mathbb{I} - \acute{P}_i)}$$

$\mathbb{I}$ = Index-level, and $\acute{P}_i$ = Spot server's normalized efficiency

LXC based prototype for EC2 spot markets

https://umass-sustainablecomputinglab.github.io/cloudIndex/

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Evaluation

- Does index-tracking achieve **predictable expenses**?
- How does cost-availability of index-tracking **compare to others?**

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We compare **three systems** for running **two classes** of applications on EC2 spot markets

Spot server with **static prediction** (SpotFleet)	vs.	Spot server with **cost-based hopping** (HotSpot)	vs.	Spot server with **index-tracking**

Long-running Single-node App

E.g., IoT sinks, crypto miners, p2p file trackers

Bulk-synchronous Parallel Jobs

MapReduce type workload from Google traces

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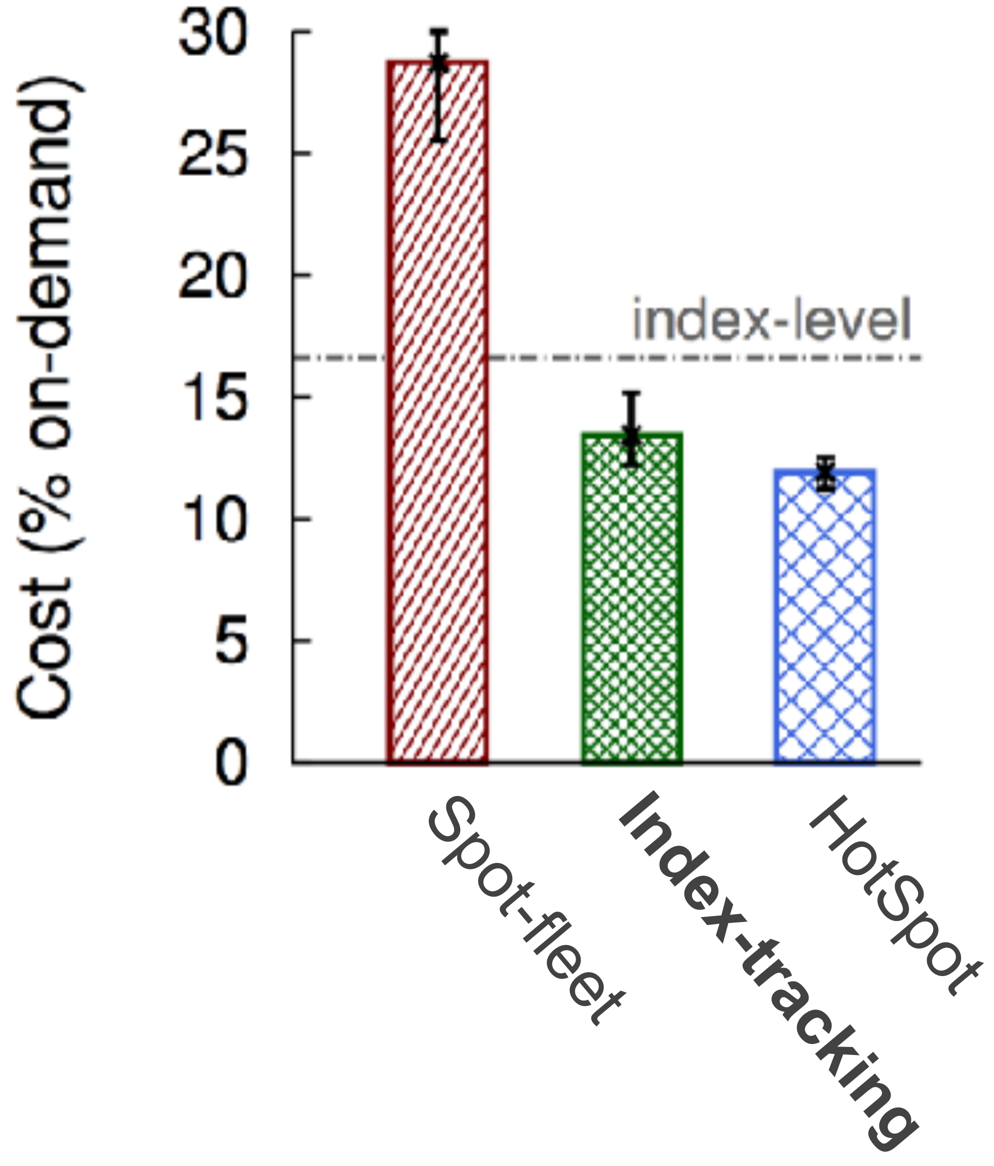

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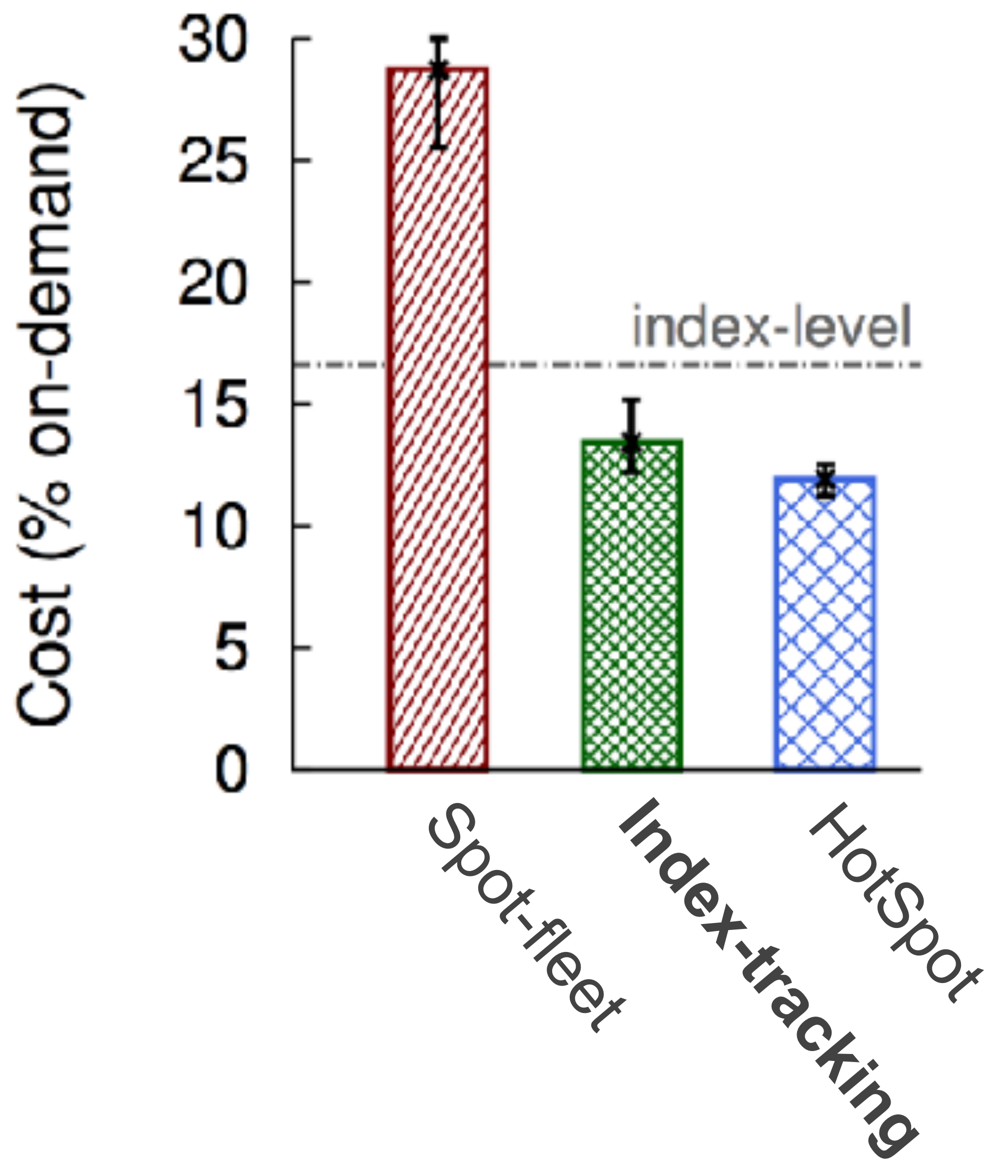

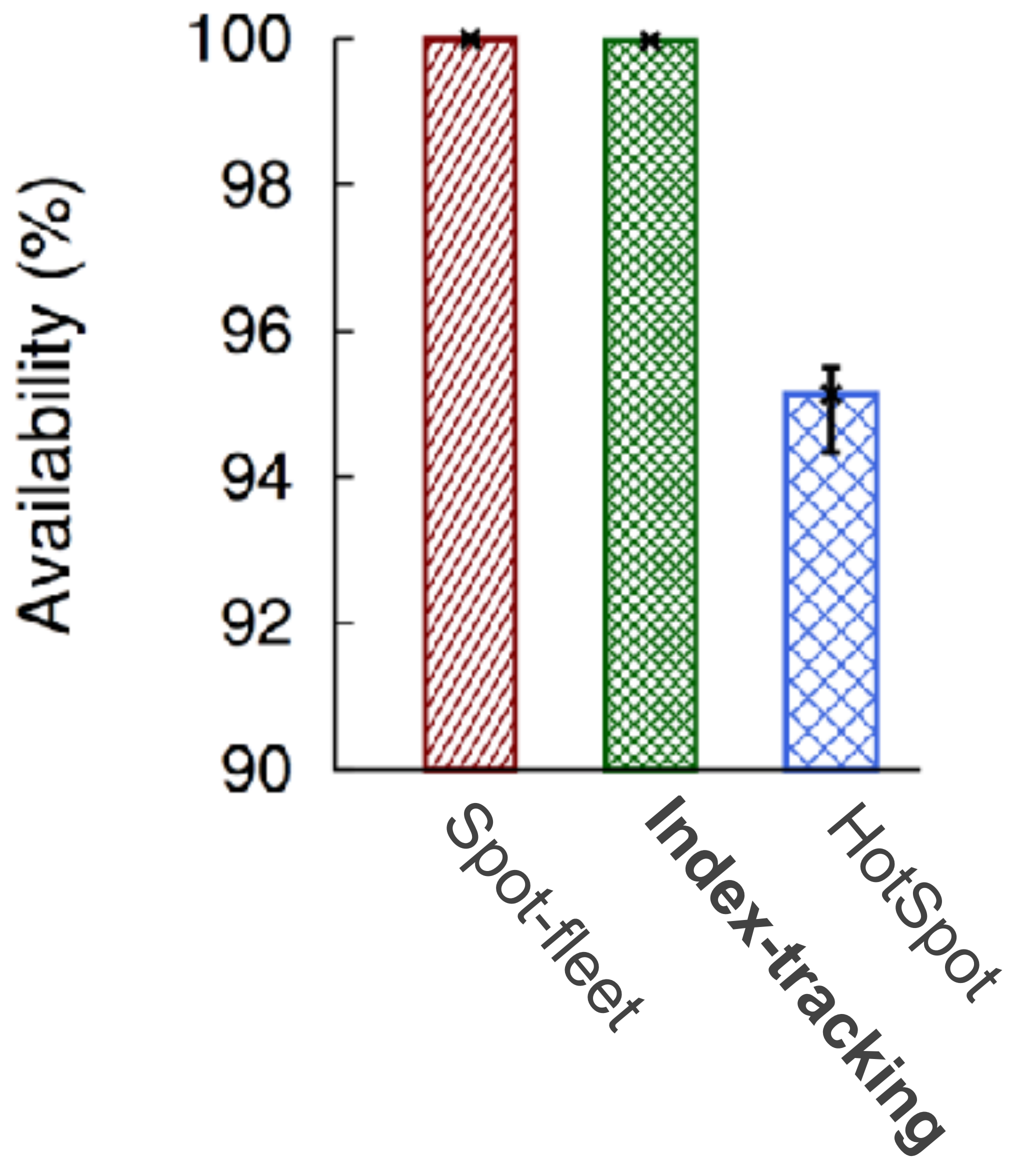

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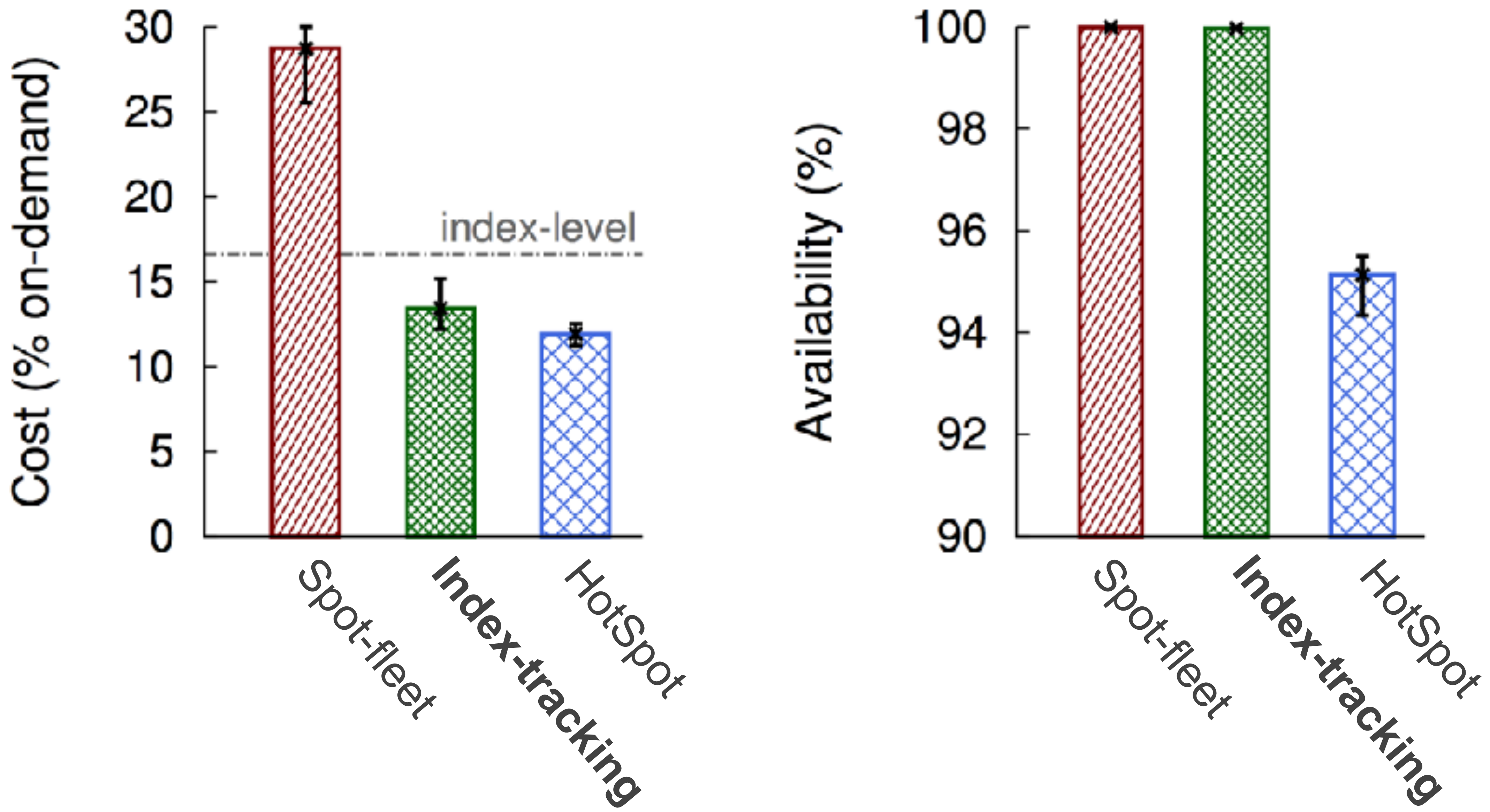

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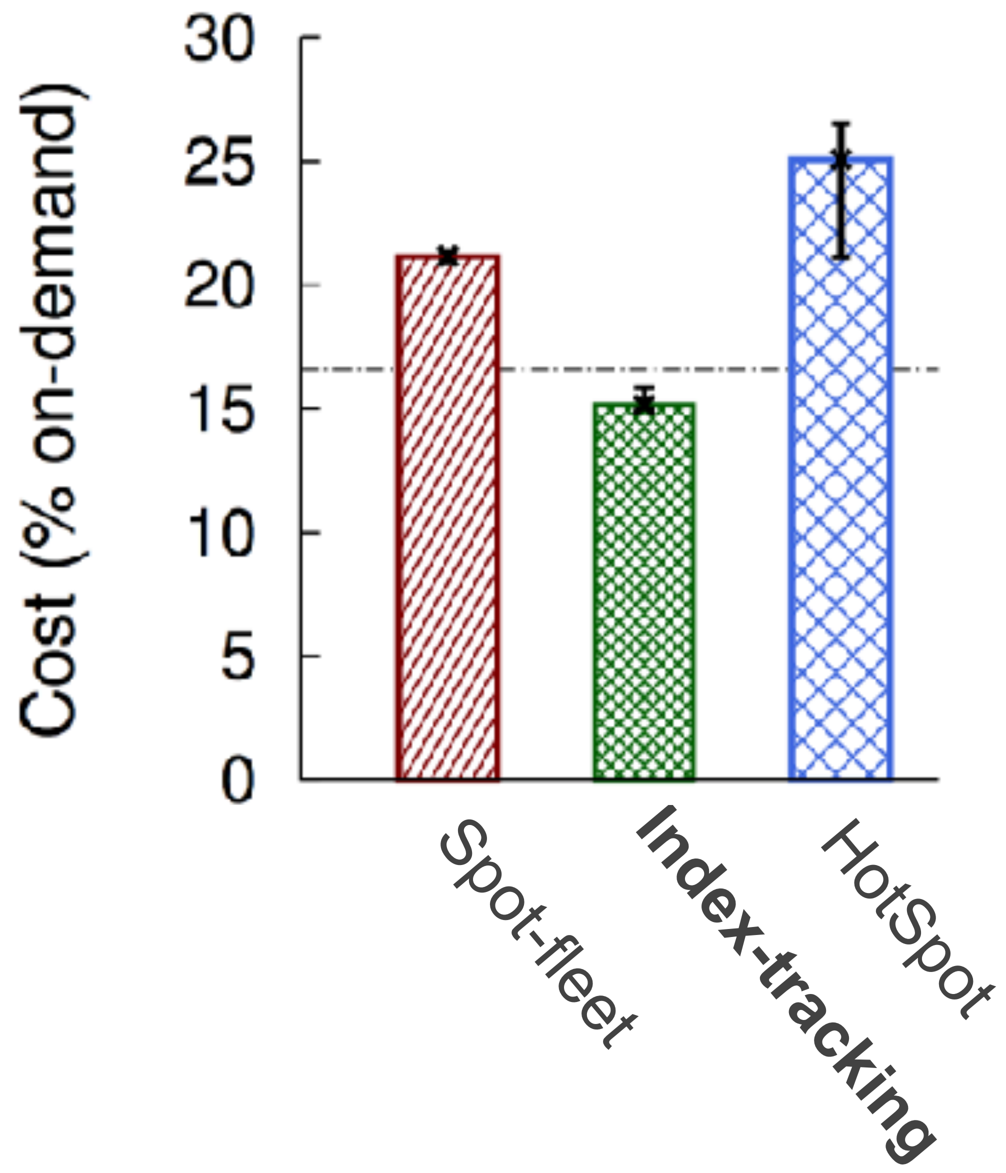

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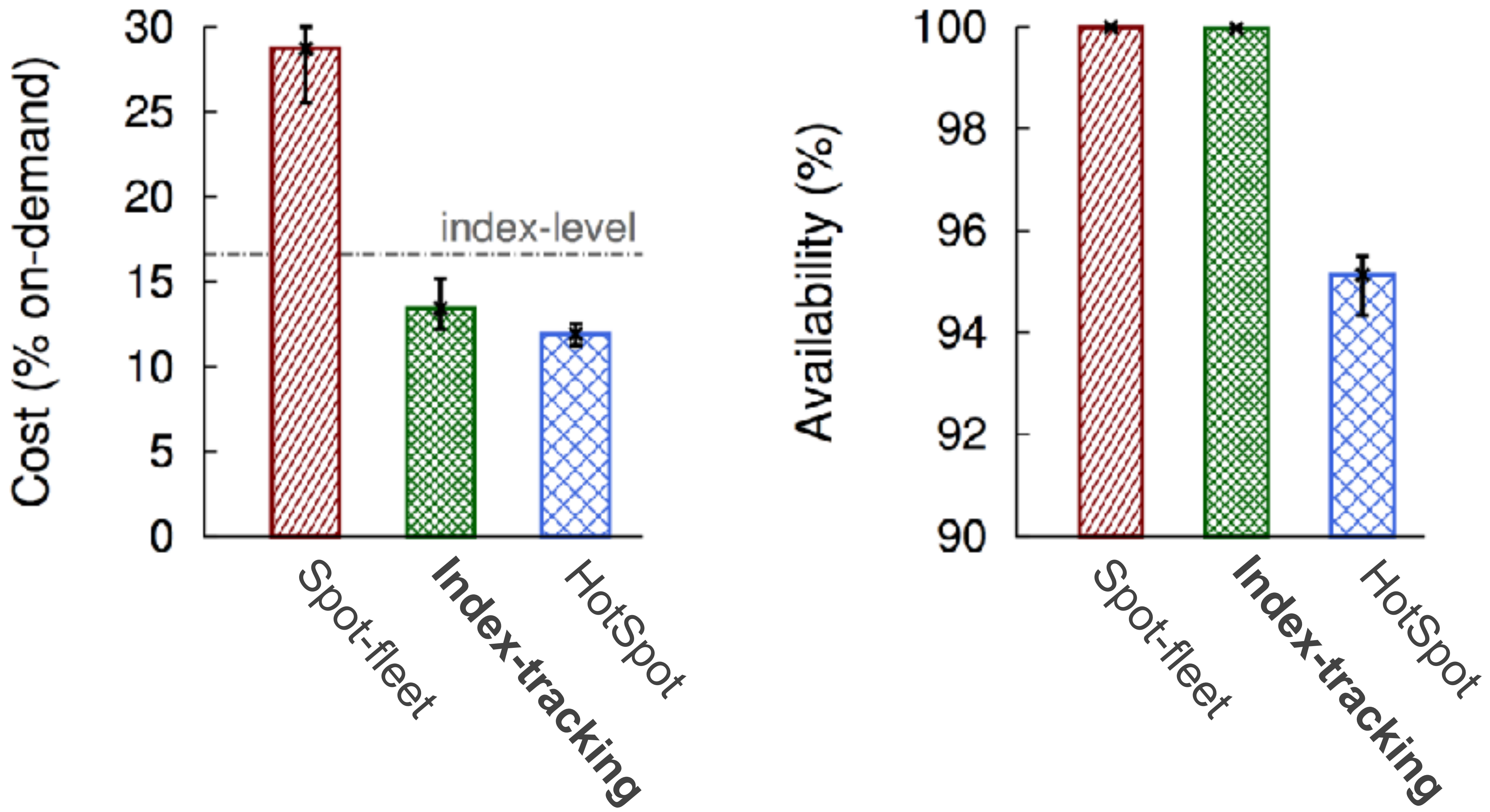

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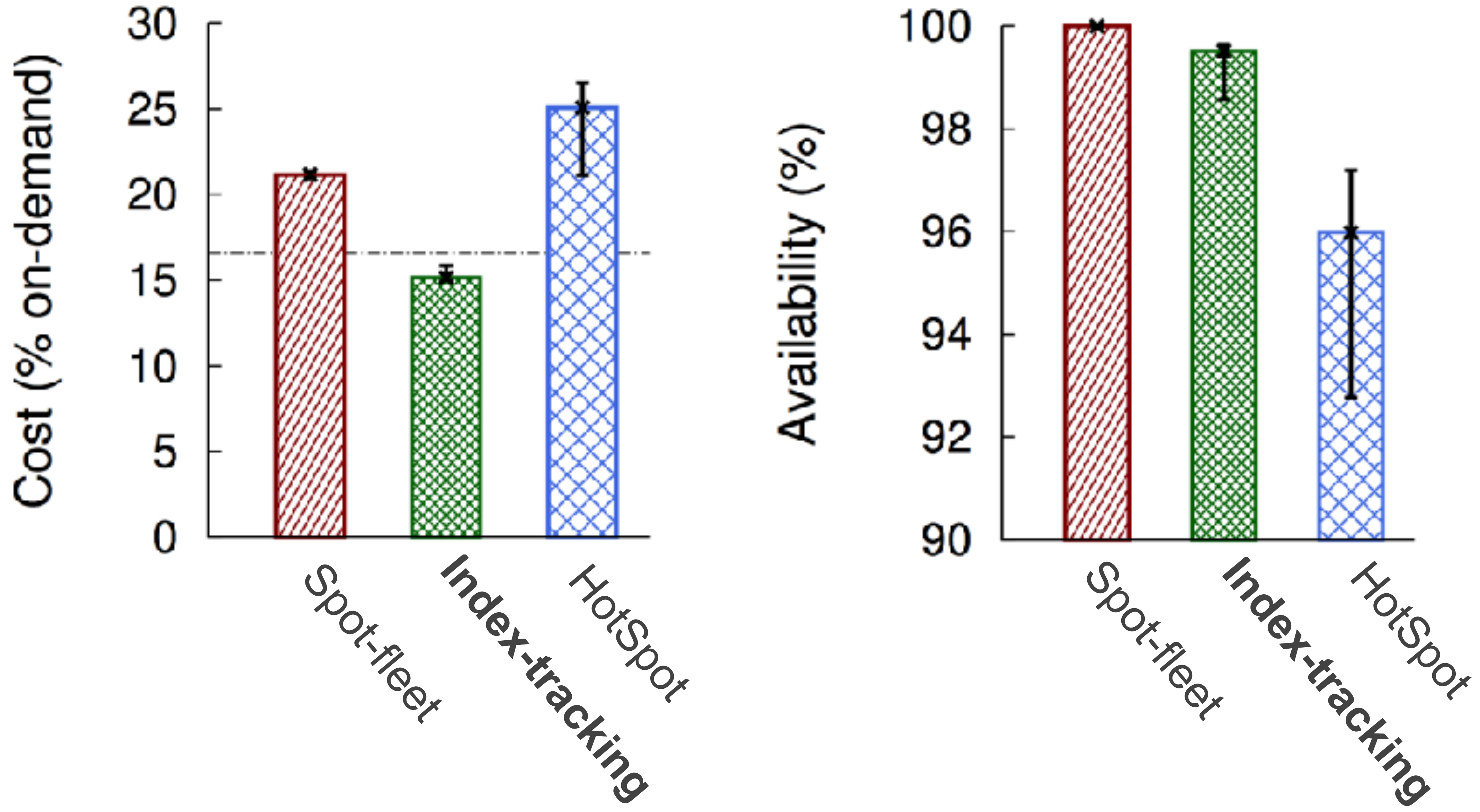

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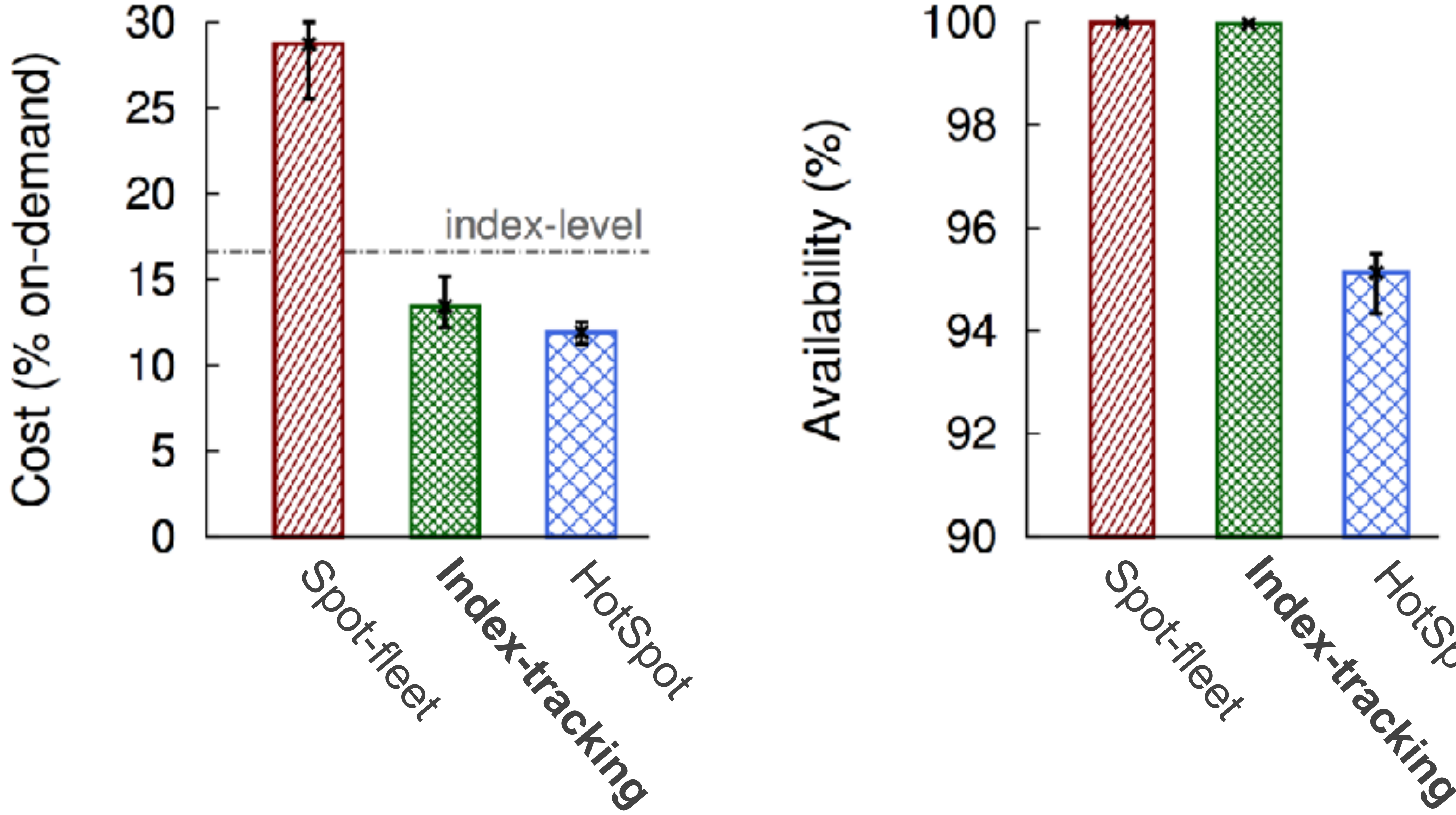

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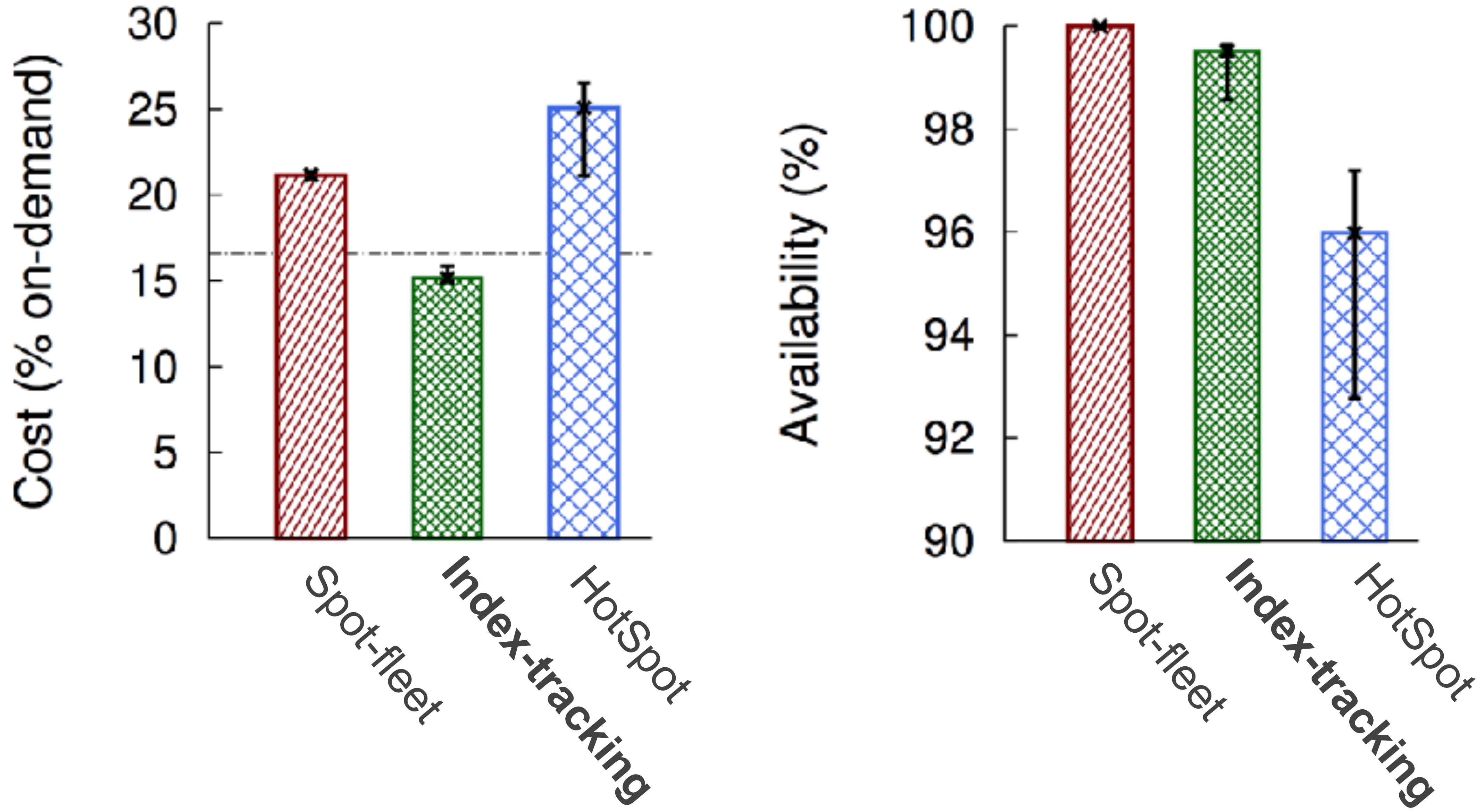

Index-Tracking not only meets the **predicted cost-efficiency** but also achieves the **best cost-availability tradeoff** compared to other approaches.

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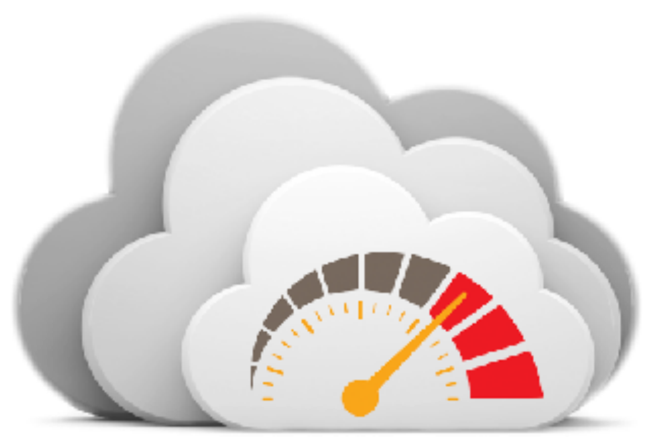

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Design technique for **index tracking by server hopping**

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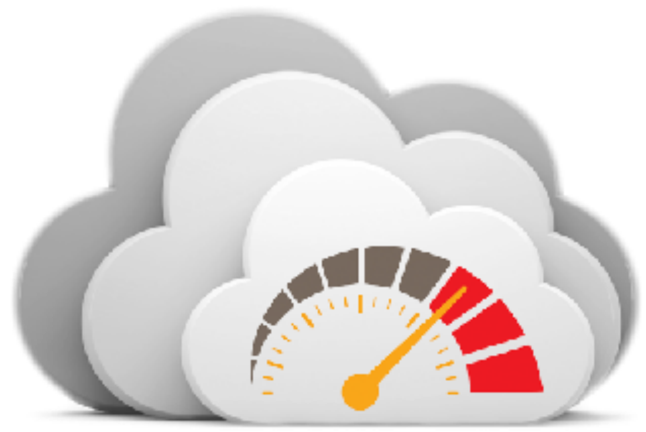

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Evaluations

Index-level cost-efficiency

vs. other approaches

Achieves predictable costs with higher availability across applications