Transient Guarantees:

Maximizing the Value of Idle Cloud Capacity

Supreeth Shastri, Amr Rizk, David Irwin

UMassAmherst

Idle Cloud Capacity

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*❝ Shared warehouse scale machines tend to have **10-50%** utilization ❞*

[**2013**] *The Datacenter as a Computer: An Introduction to the Design of Warehouse-Scale Machines.*

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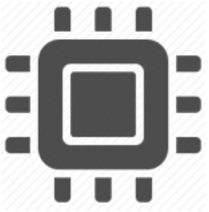
has its limitations

Selling Idle Cloud Capacity

amazon web services™ | EC2

Users bid in a
2nd price auction

EC2 continually evaluates supply-demand to price spot servers



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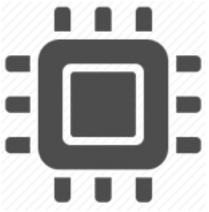

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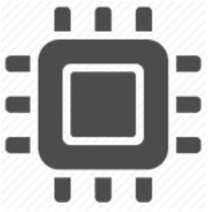

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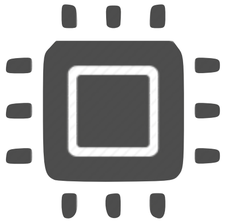
*❝ Experiment that discovered the **Higgs Boson** used AWS spot instances ❞*

Fermilab Scientific Computing Division

Compute Time vs. Commodity Markets



vs.

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Commodity markets are inherently *Volatile* and *Unpredictable*

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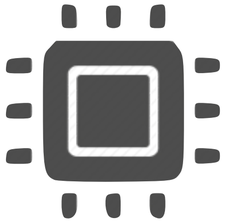

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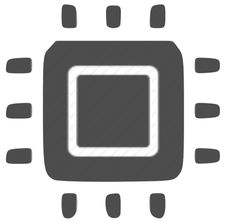

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Commodity markets are inherently *Volatile* and *Unpredictable*

Compute time is *Stateful*

1. *Losing a server unpredictably incurs an* **overhead**
2. *This overhead* **decreases** *the useful compute time of the server*

∴ *Market volatility* ***reduces*** *the value of* ***compute time*** *purchased*

How to Maximize the Value of Idle Cloud Capacity?

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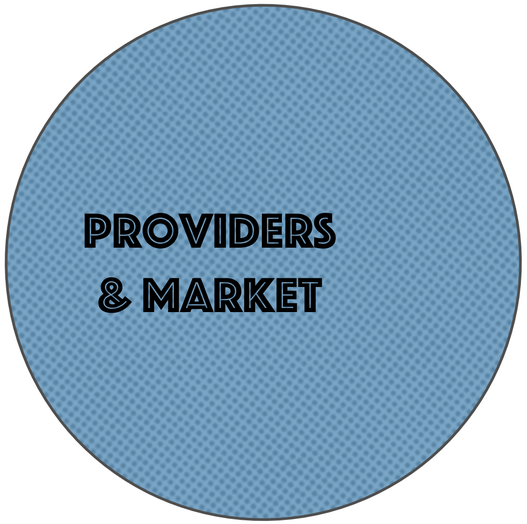
Amazon Spot-blocks [**Amazon '15**]

spot market dynamics [**HotCloud '16, ICDCS '16, ToEC '13**]



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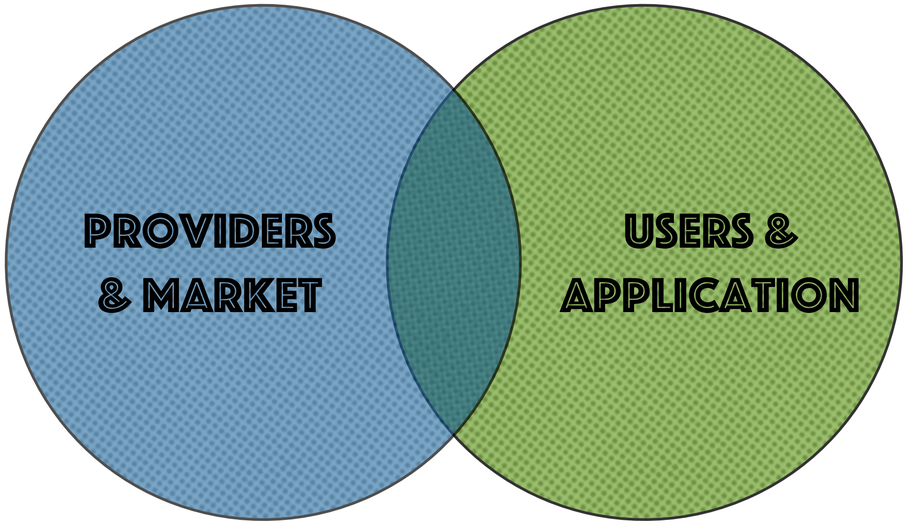

Modify applications for transiency [**HPDC '15, HPDC '14**]

Handle transiency at system-level [**SoCC '15, EuroSys '15**]

Design optimal bidding policies [**SIGCOMM '15, CLOUD '12**]

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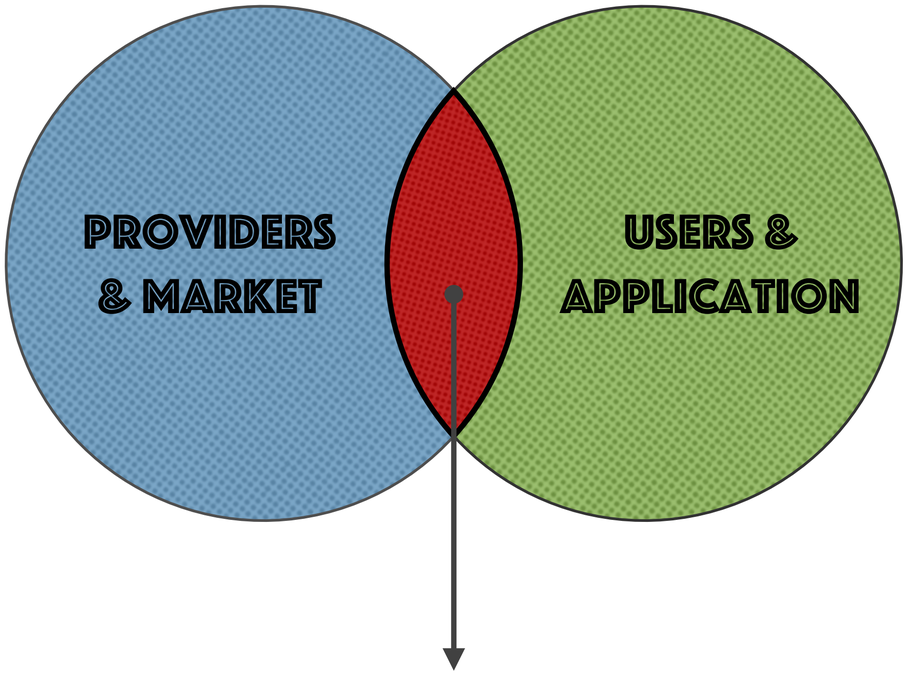

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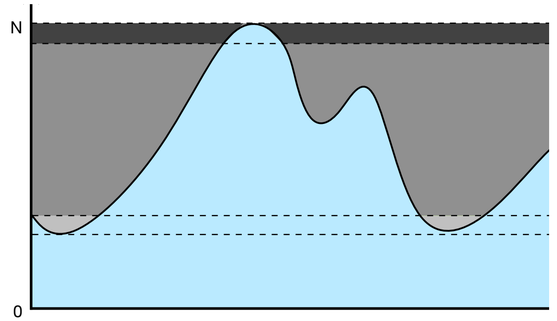
Rest of the Talk . . .

Transient Server Characteristics

Transient Guarantees

Evaluations



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Transient Servers are Intrinsically Less Valuable!

Batch job on a spot VM using checkpointing

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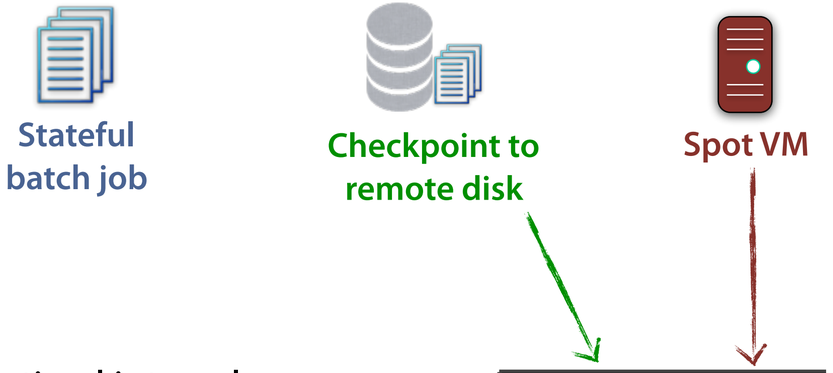

Optimal interval
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$$T_{opt} \approx \sqrt{(2 * \delta * MTTR)}$$

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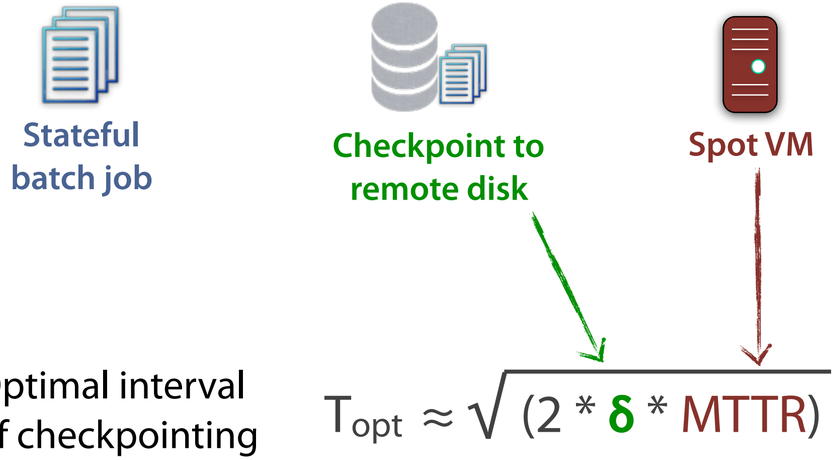

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Expected runtime

$$E[T_{spot}] = T + \left(\frac{T}{T_{opt}} * \delta\right) + \left(\frac{T}{MTTR} * \frac{T_{opt}}{2}\right)$$

Actual Runtime

Checkpointing Overhead

Recomputation

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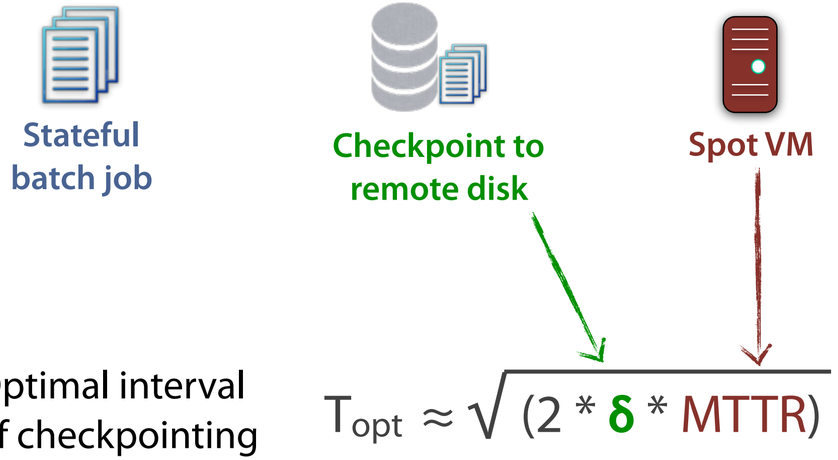

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Recomputation

❝ On average, transient servers get less work done per unit of time compared to an equivalent on-demand server ❞

Transient Servers are Intrinsically Less Valuable!

Equilibrium Price of Transient Server
(or *price when spot stops being cheap*)

$$P_{eq} = P_{on\text{-}demand} * \frac{T_{on\text{-}demand}}{E[T_{spot}]}$$

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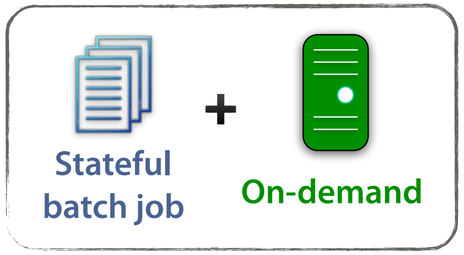
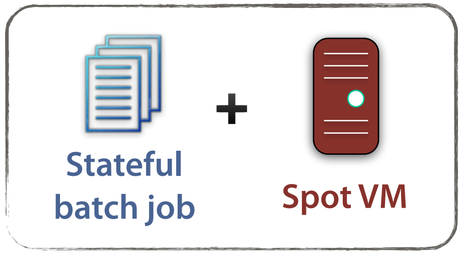


Completion time
12 hours



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20 hours

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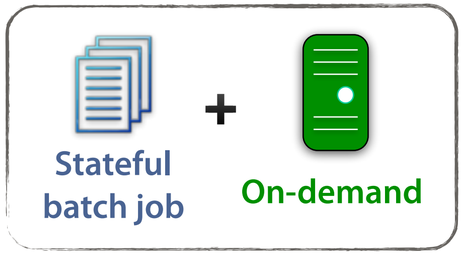

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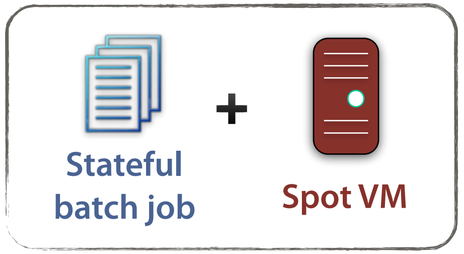

Completion time
20 hours

❝ For this application, a spot server with **40%** *discount, provides* **no savings at all** *❞*

Distilling the Transient Server Characteristics

We identify **three** key metrics: **Availability**, **VOLATILITY**, *Predictability*

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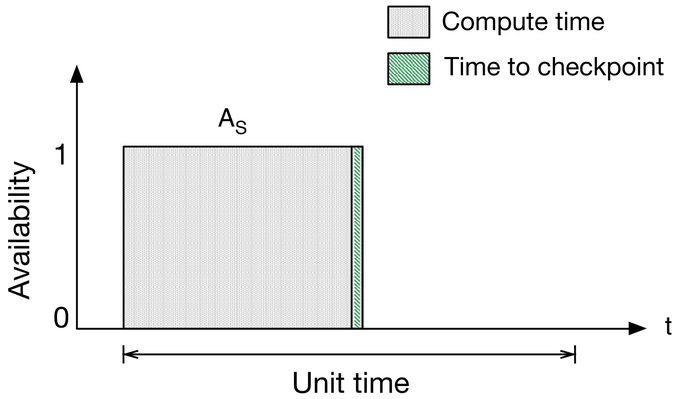

Limited Availability

Checkpoints = 1

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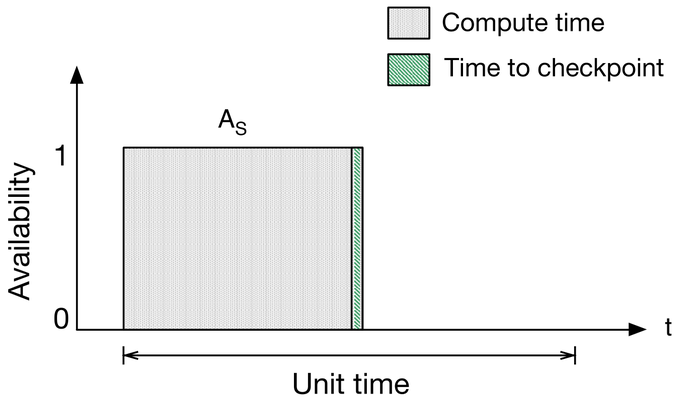

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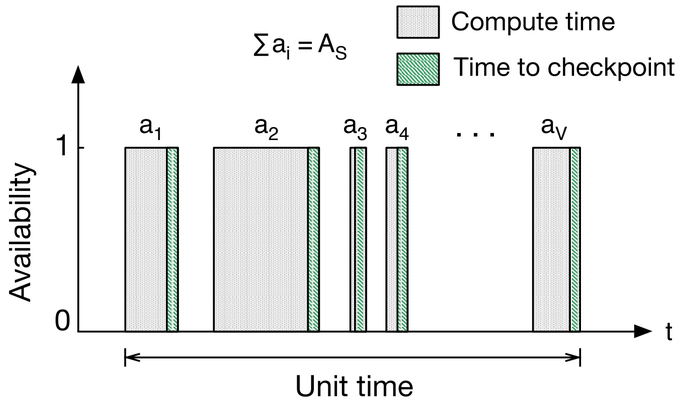

Limited Availability
+ **Volatility**

Checkpoints = no. of revocations

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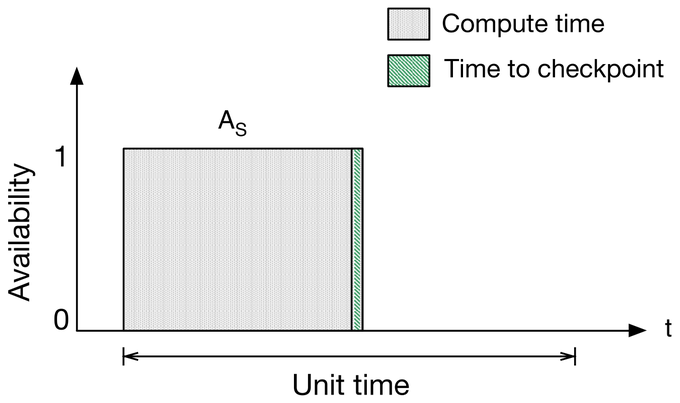

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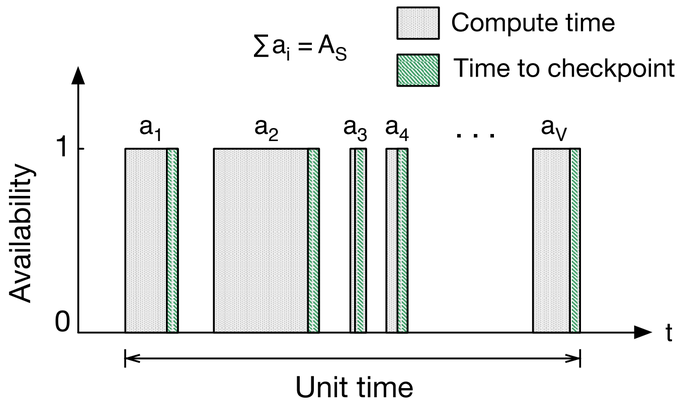

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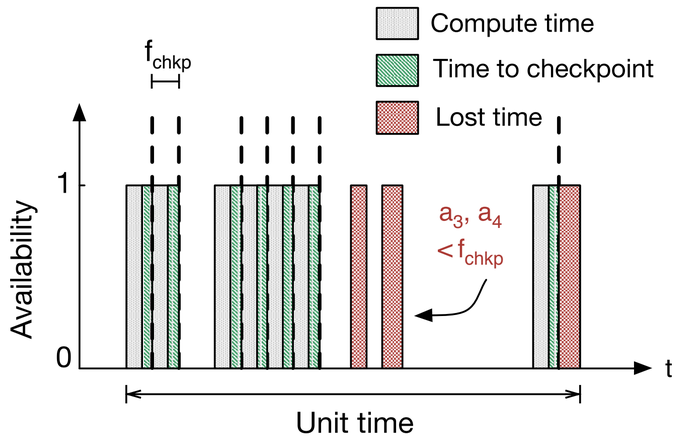
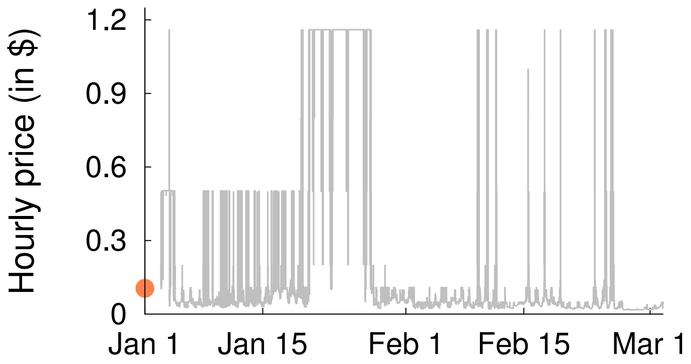


Limited Availability + Volatility
+ **Unpredictability**

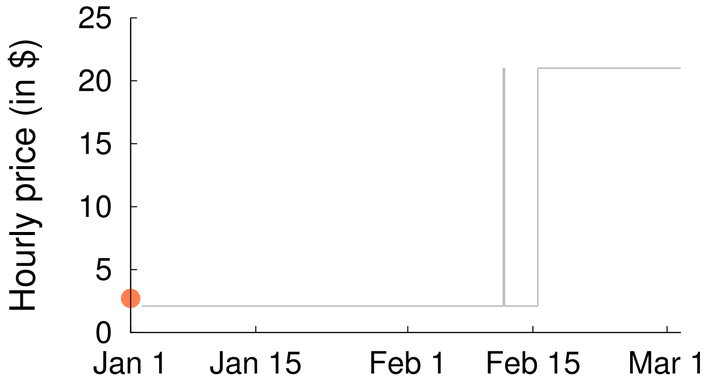
Periodic checkpointing

Back To Amazon Spot Markets . . .



c4.large (Linux) us-east-1

Mature markets are
more volatile and less predictable



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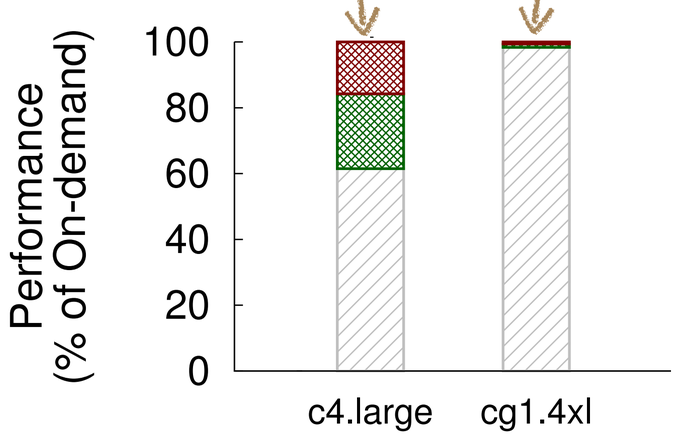
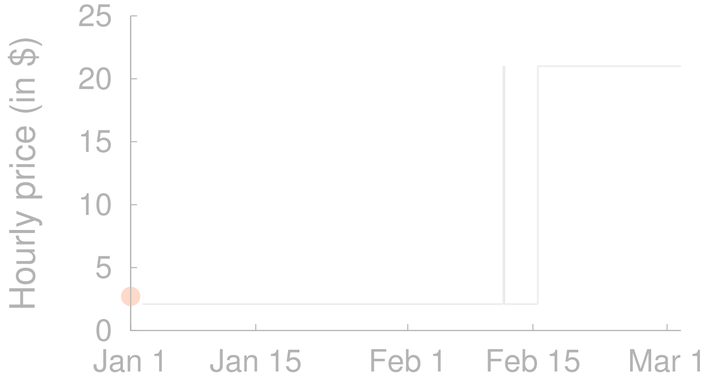


Performance of markets



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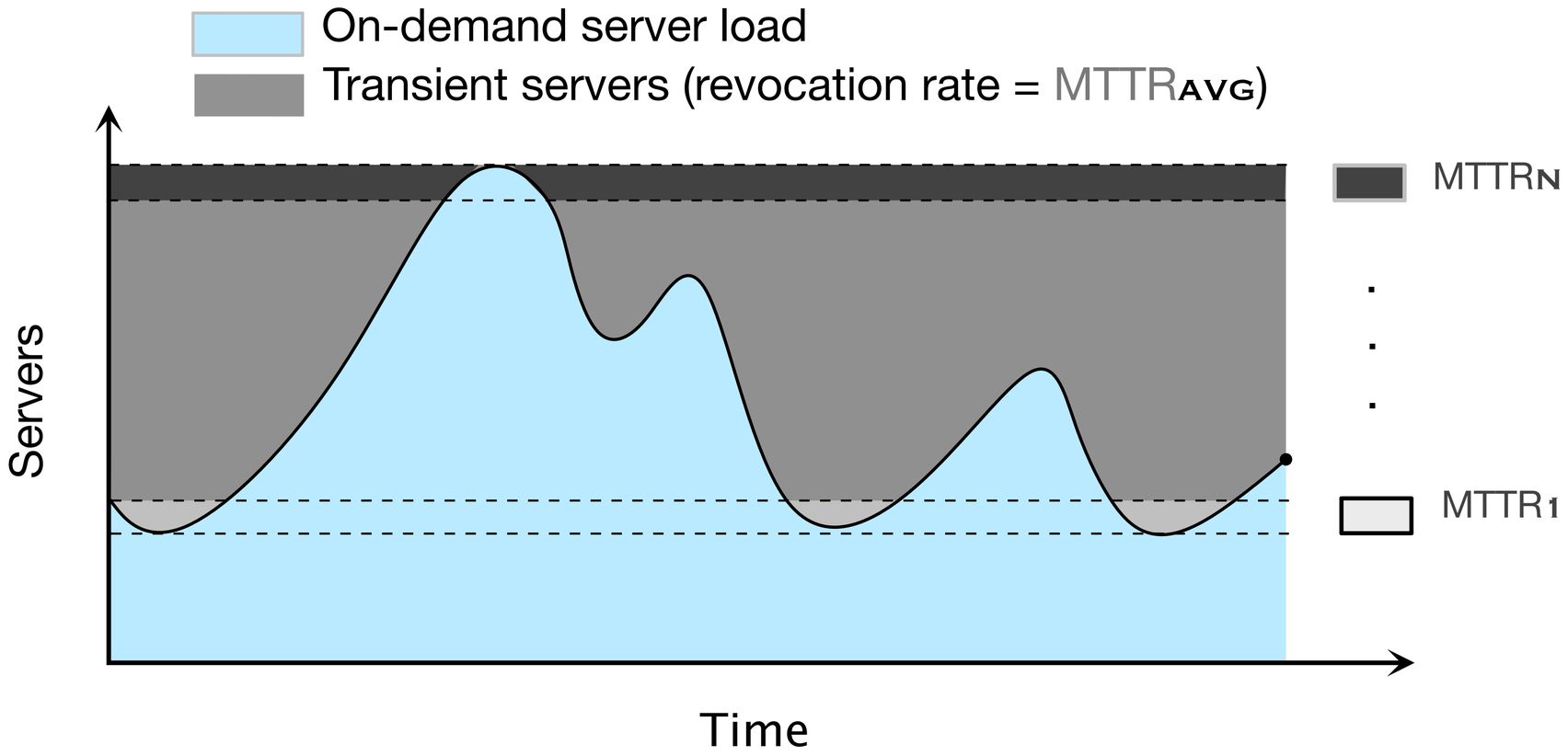
Transient Guarantees

❝ Uncertainty is more stressful than knowing for sure something bad will happen ❞

nature COMMUNICATIONS

de Berker, Archy O., et al. *"Computations of uncertainty mediate acute stress responses in humans."* Nature communications 7 (2016)

Characterizing Idle Capacity



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Idle Cloud Capacity

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Idle Cloud Capacity

EC2 Spot and
GCE Preemptible

No explicit information on availability and volatility

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Idle Cloud Capacity

Highly Volatile nodes ← → **Highly Available nodes**

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No explicit information on availability and volatility

Max Performance
Offering

Every server sold with its unique revocability characteristics

Transient Guarantees

Providing probabilistic assurances on *availability, volatility and predictability* of transient servers

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E.g., ***Transient Classes with advertised MTTR for each class***

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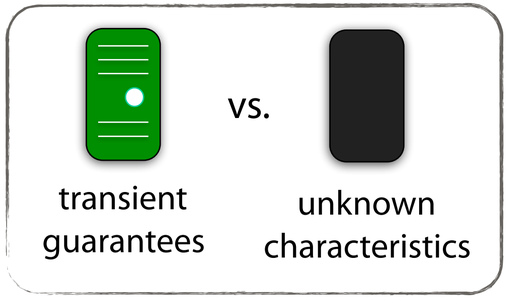

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Value the servers correctly (users and providers)

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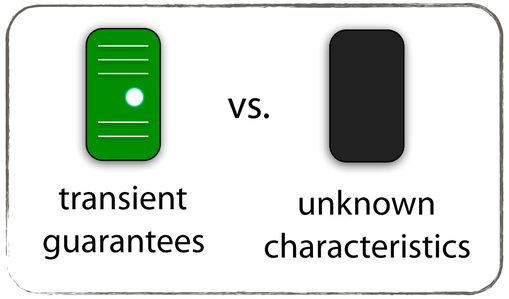

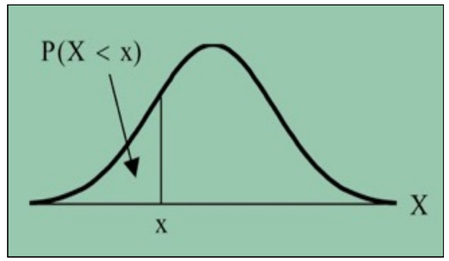

Advertised characteristics

Value the servers correctly (users and providers)

Probabilistic assurance

Revoke any server anytime (providers)

Fine-tune fault-tolerance (users)

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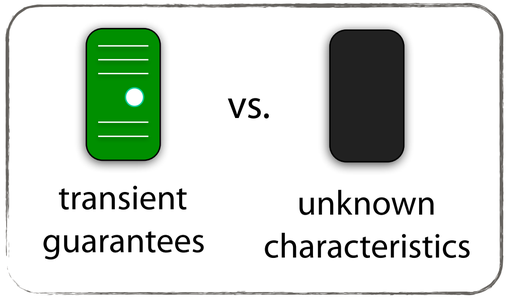

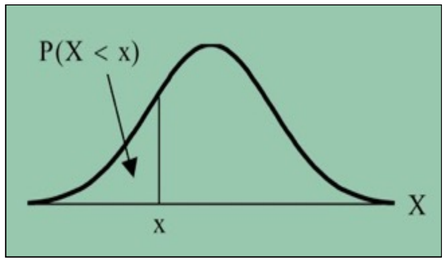

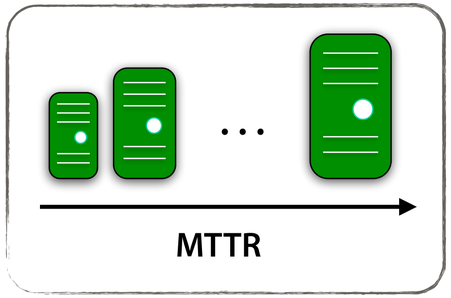

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Value the servers correctly (users and providers)

Probabilistic assurance

Revoke any server anytime (providers)
Fine-tune fault-tolerance (users)

Differentiated offering

Higher revenue (providers)
Better choice (users)

Constructing Transient Classes

Partition N servers into K classes, with class c containing n_c servers

$$N = \sum_{c=1}^{K} n_c$$

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Worst

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.
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K = N
Best

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$$O(N^K)$$

intractable for large N and K

Policies for partitioning:
equal-split, greedy-split

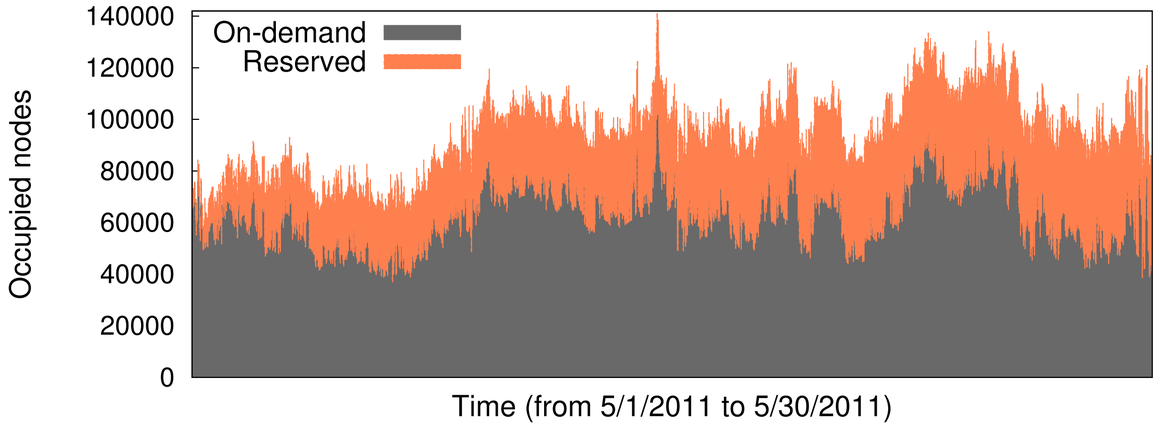
EValuations

How do transient characteristics look in a **real-world cluster**?

Do **transient classes** improve server performance?

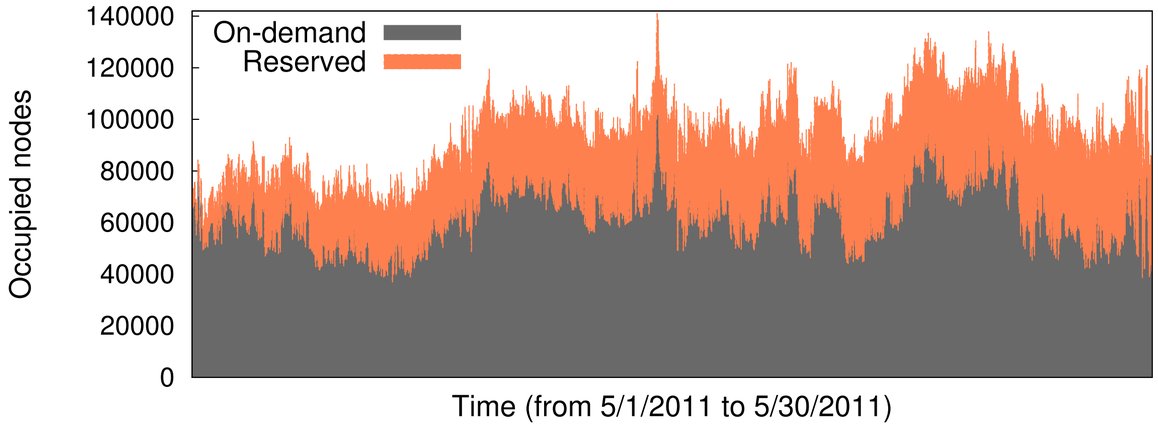
How close can we get to the **maximum** value?

Idle Capacity ⇢ Transient Servers



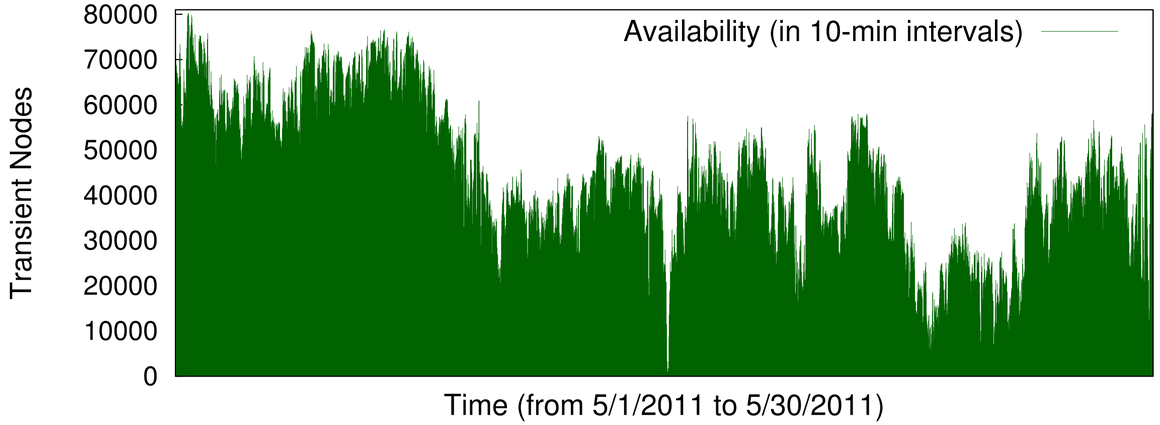
Server allocation from a production cluster at ***Google*** and the resulting idle capacity

Idle Capacity ⇢ Transient Servers

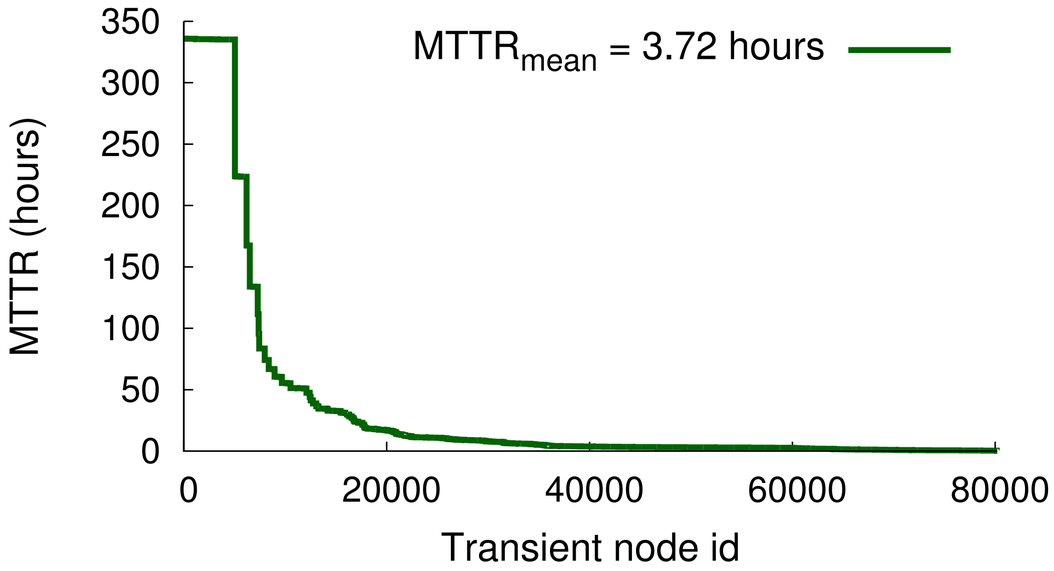


Server allocation from a production cluster at ***Google*** and the resulting idle capacity

Availability of transient servers varies considerably over time

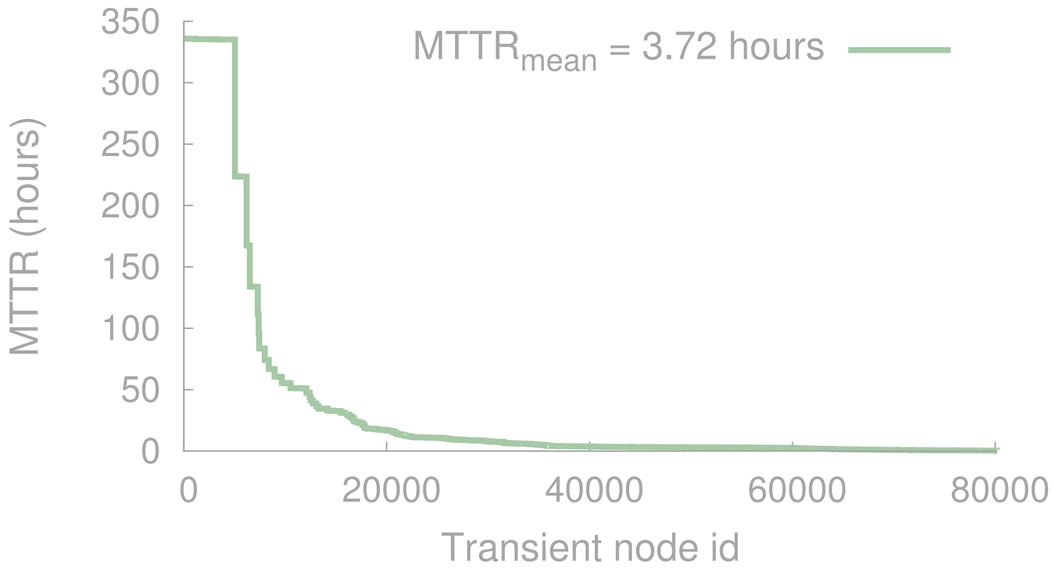


Transient Server Characteristics



Transient Servers exhibit
a ***wide range*** of characteristics

Transient Server Characteristics



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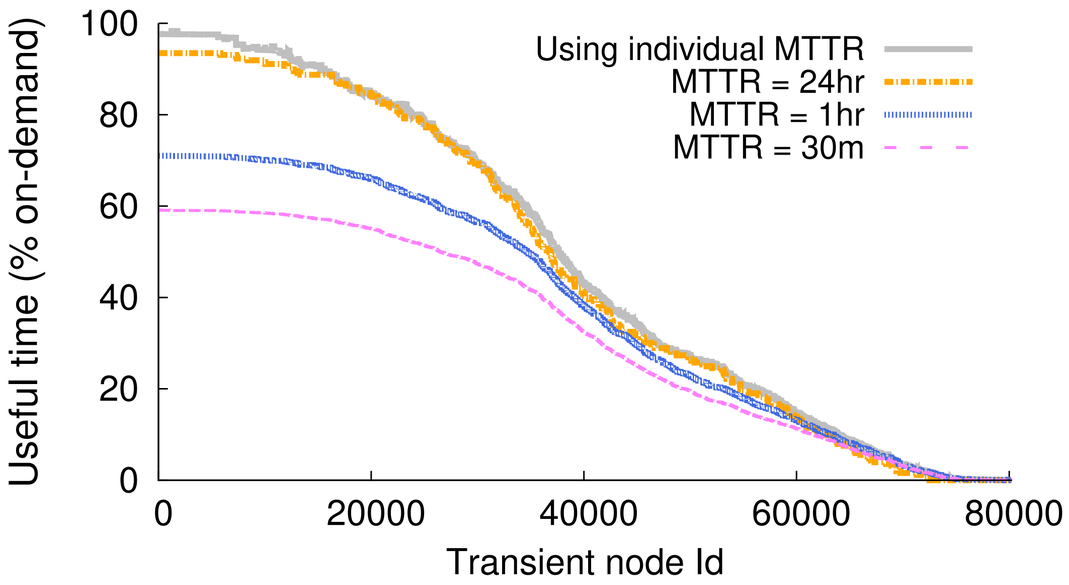

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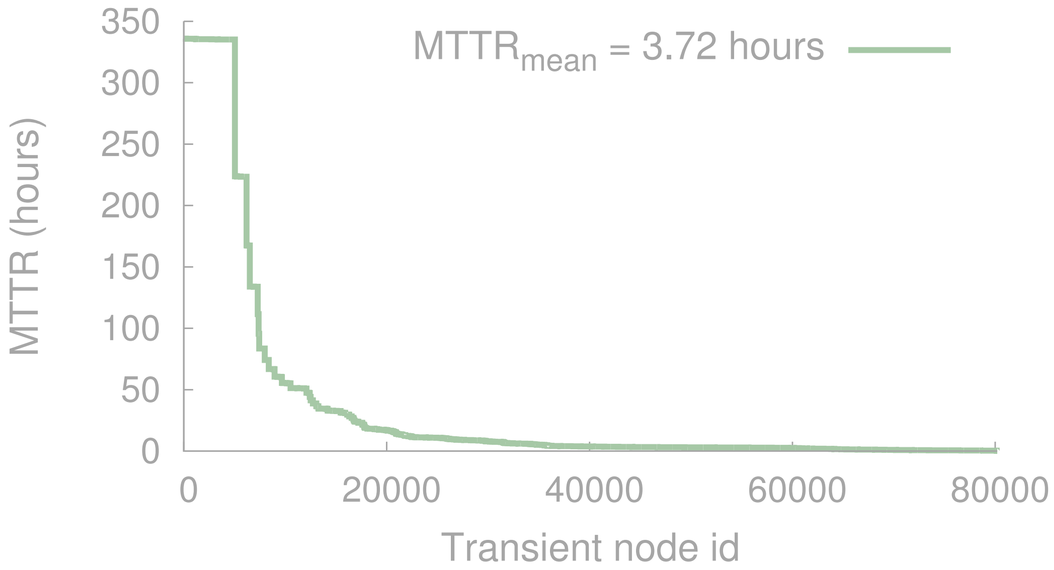

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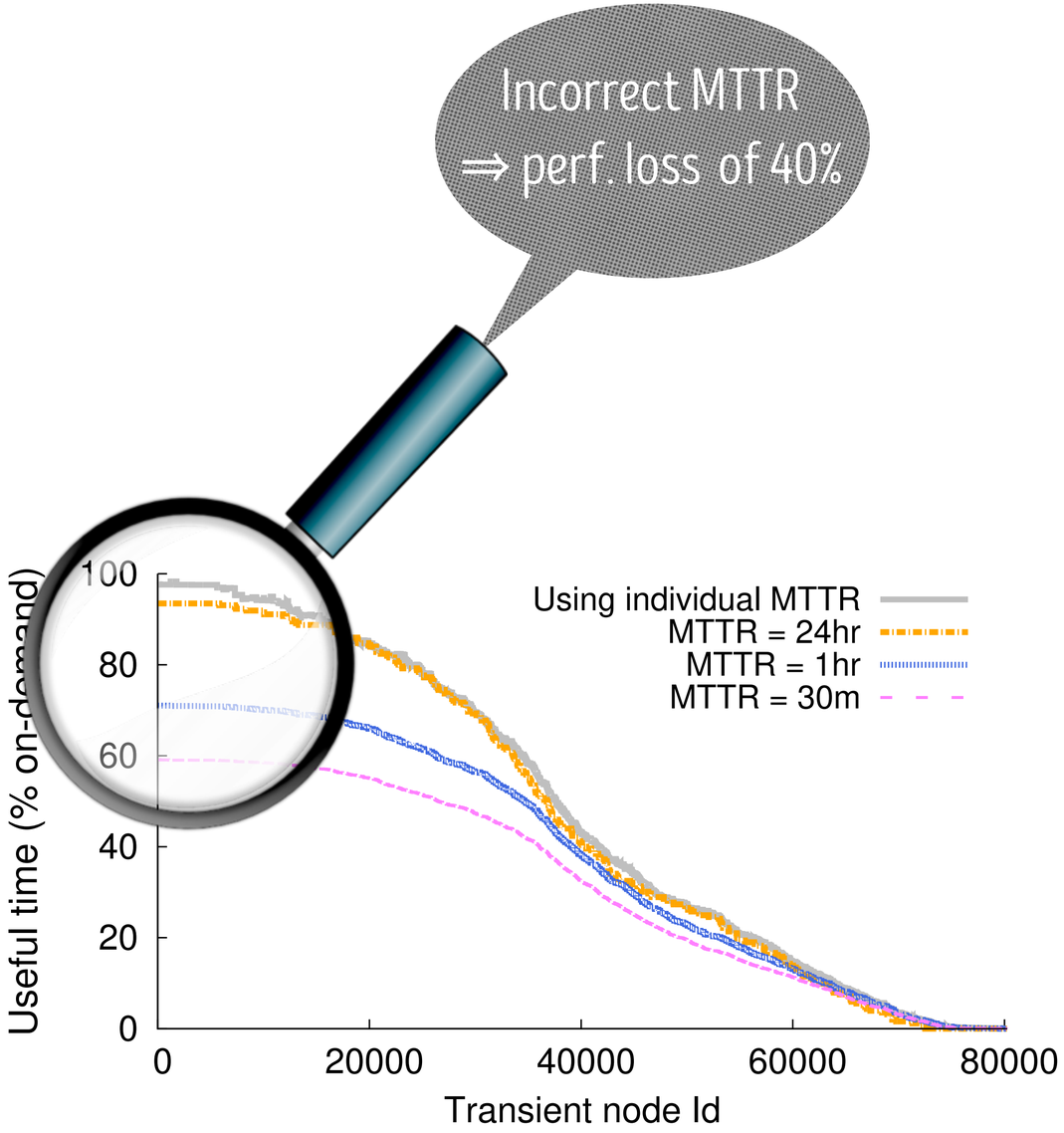
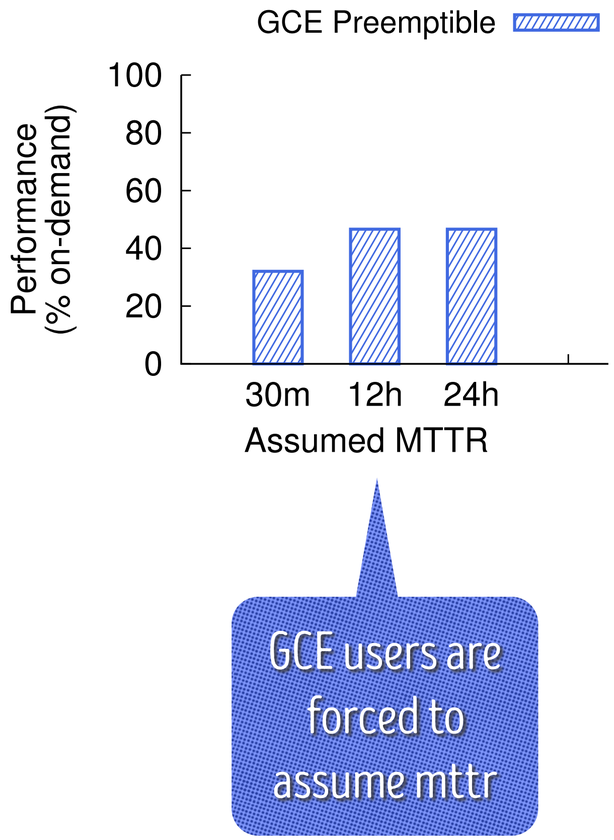


Performance of Transient Servers



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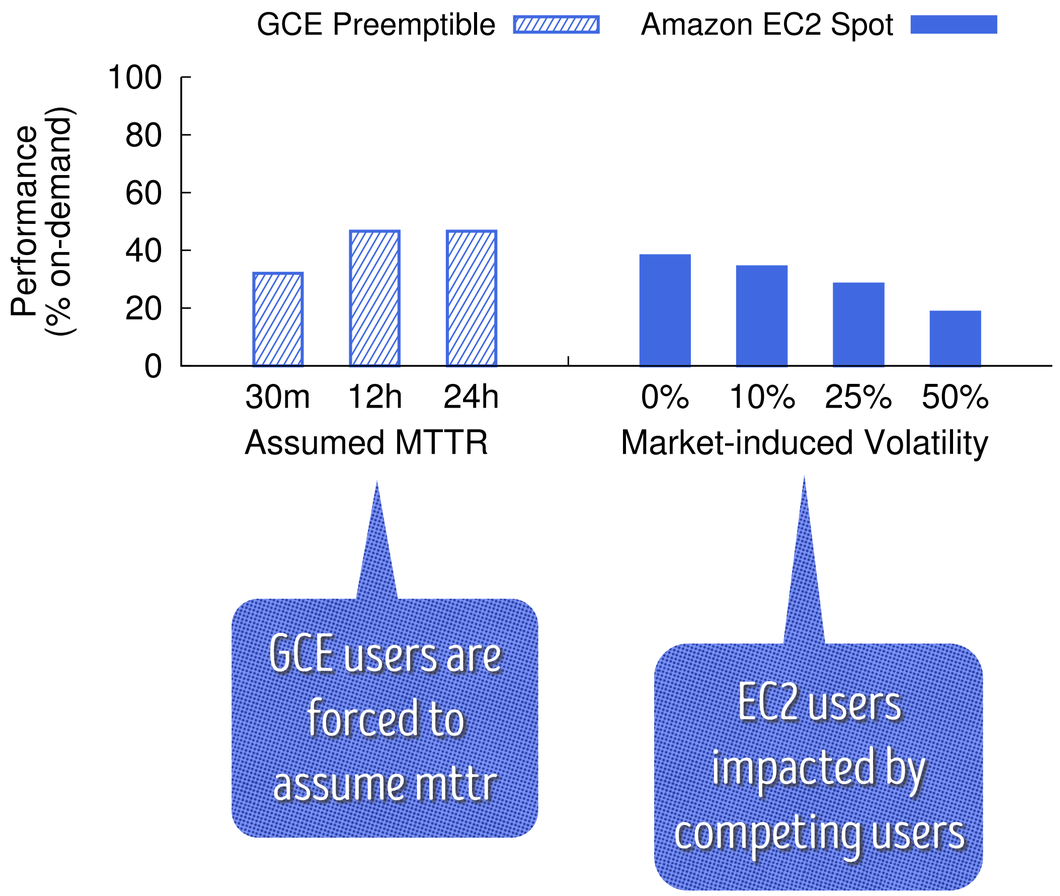

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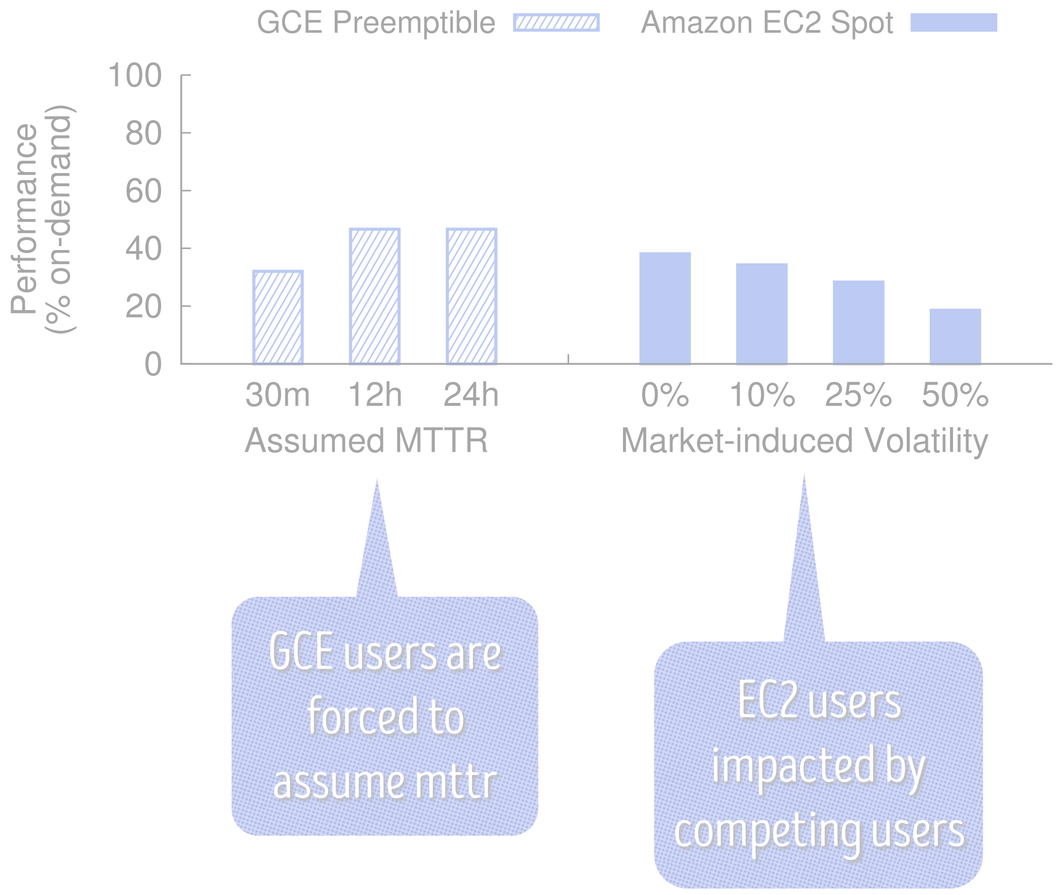
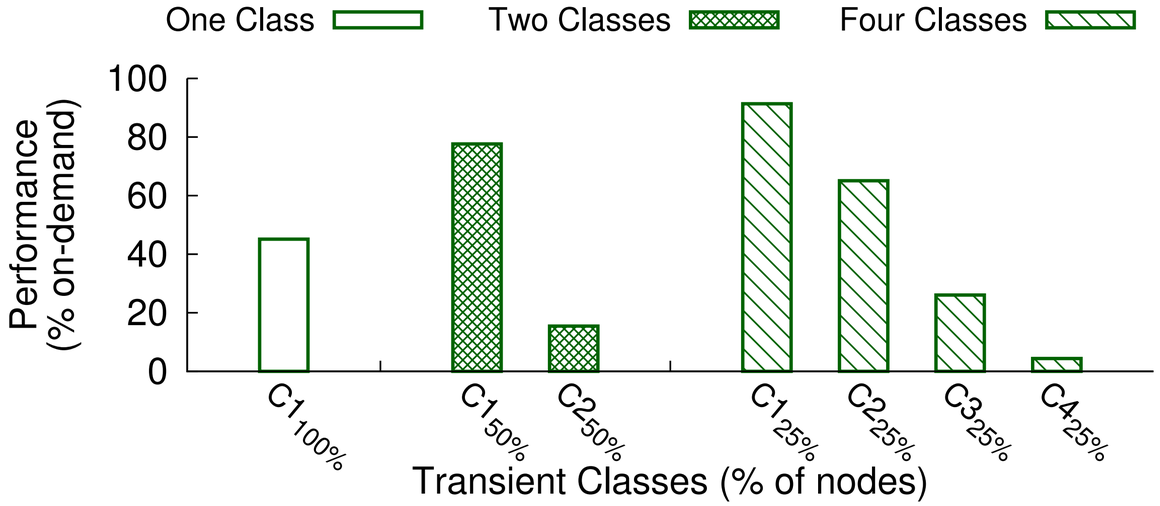
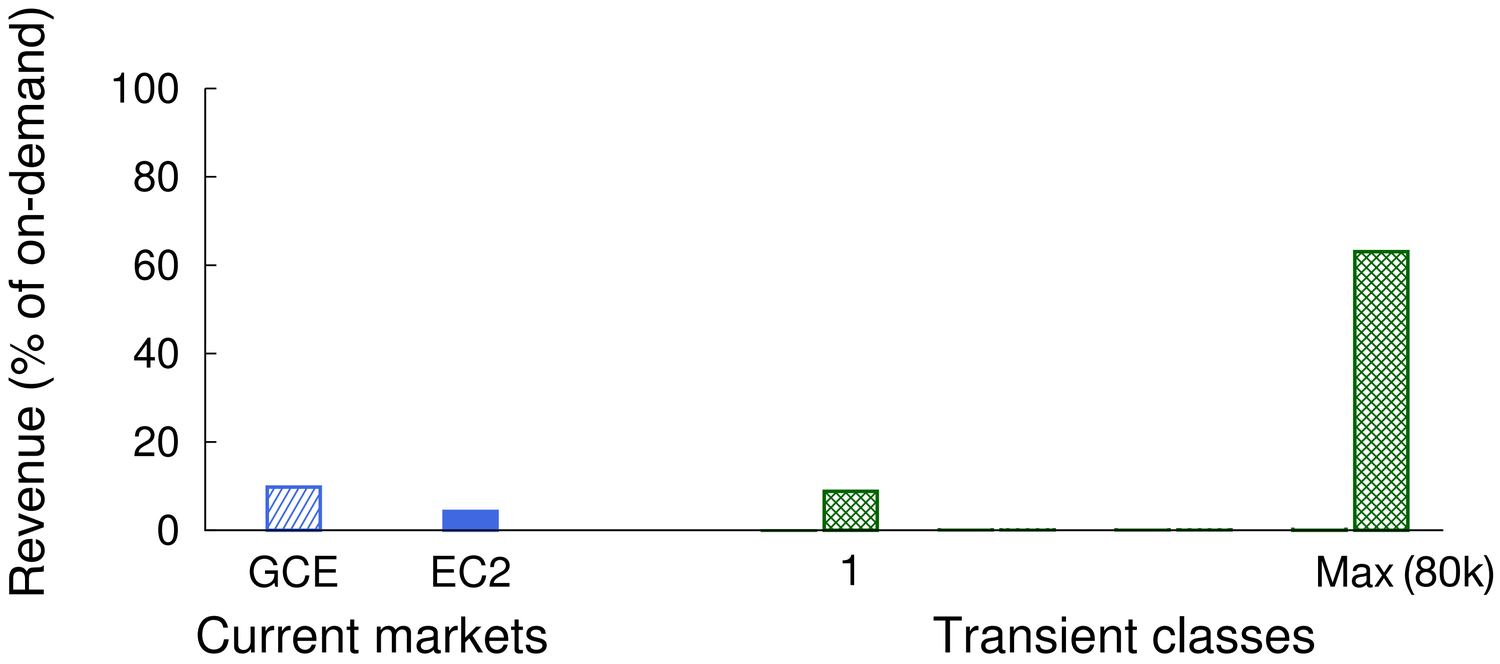


Transient Classes create
differentiated server pools



Provider's Revenue from Transient Offering



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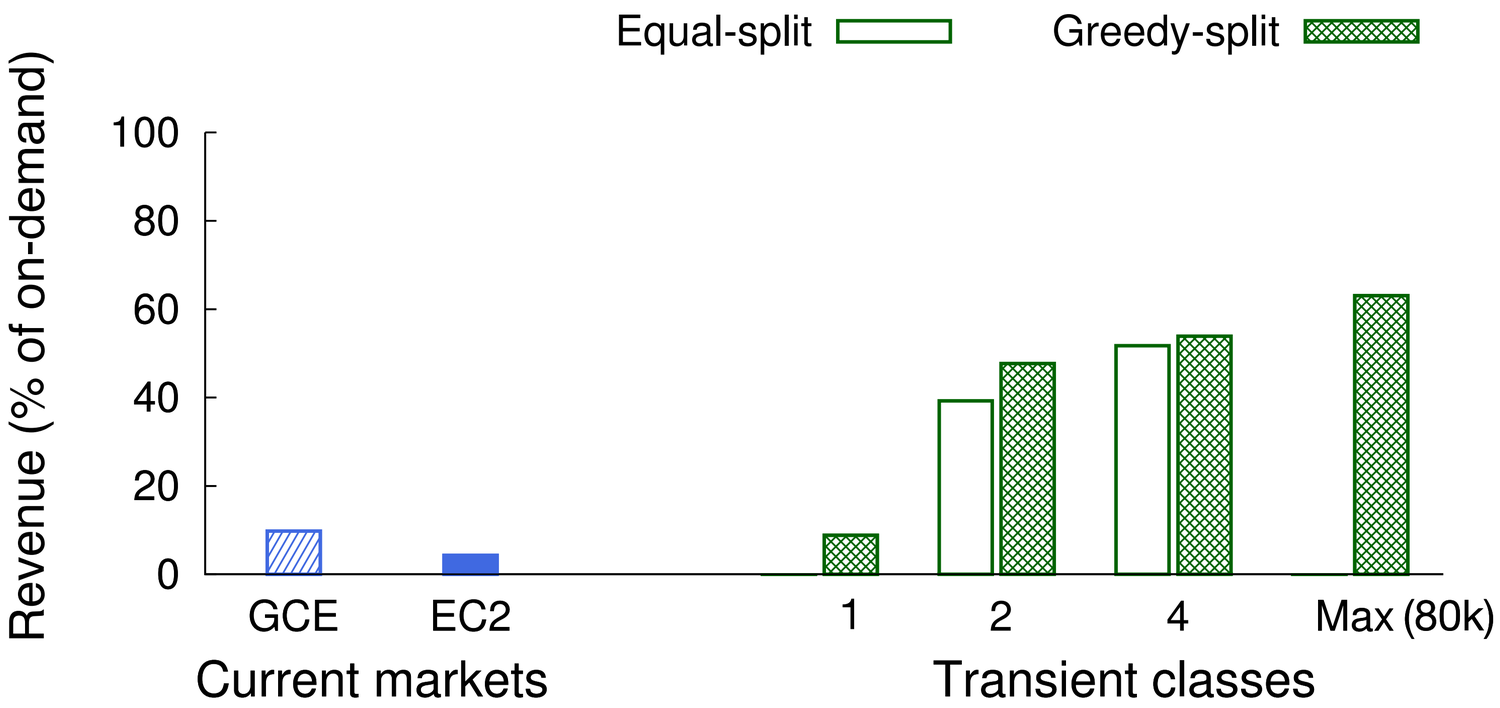

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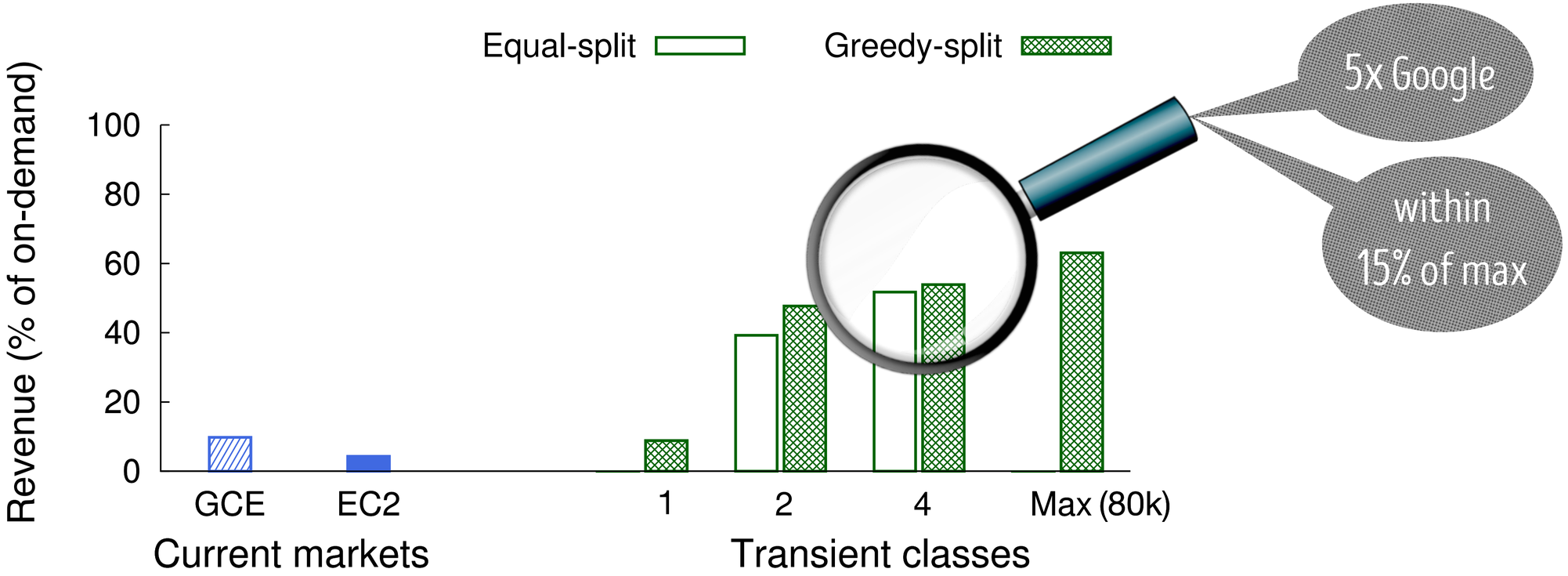

Conclusion

Transient servers are a new concept, and current markets do not maximize their value

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Transient Server Characteristics

Availability
Volatility
Predictability

Transient Guarantees

Transient Classes
Policies for Server Partitioning
Server Pricing

Evaluations

Prevent performance loss up to 40%

Revenue ⬆ 5x

Thank you!

Supreeth Shastri

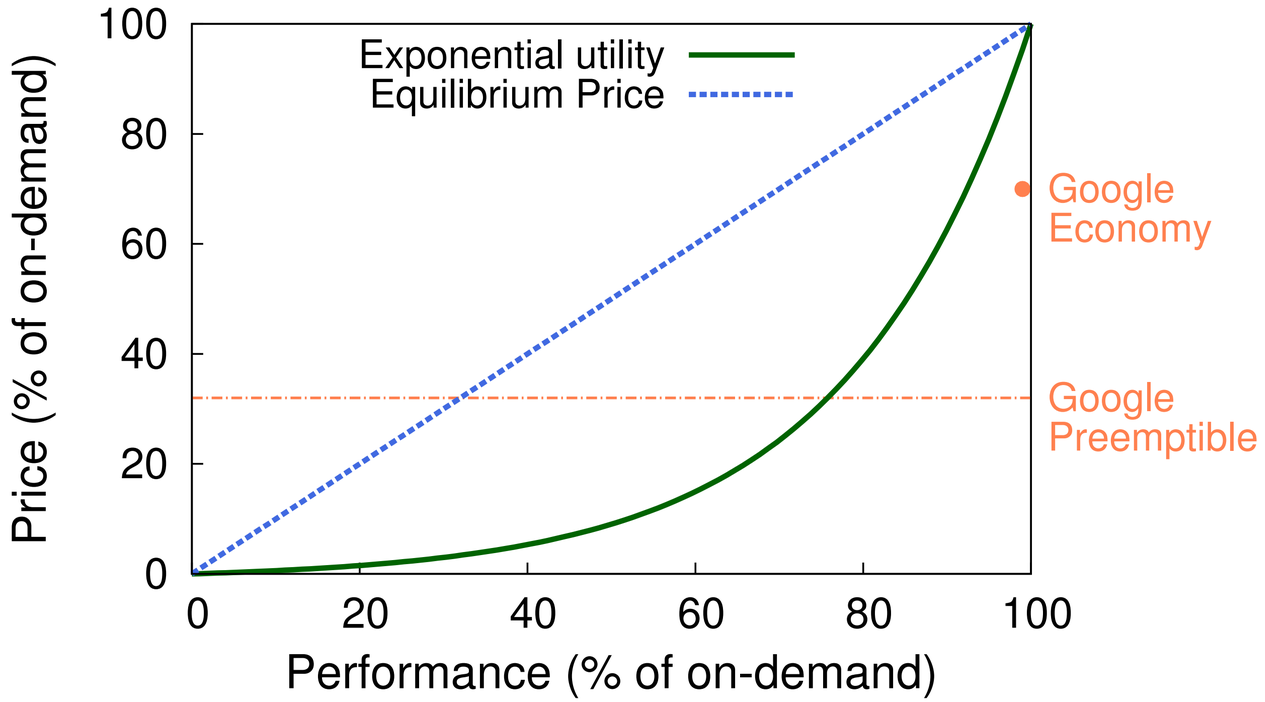
http://people.umass.edu/shastri/

UMassAmherst

Comparing Current Transient Markets

Pricing	Real-time, supply-demand based	Fixed, discounted
Allocation	Users compete in 2nd price auction	Unknown
Revocation	When market prices goes above the user bid	Unknown (max 24 hours)
Warning time	120 seconds	30 seconds
Spot markets	~2000	~250

Pricing Transient Servers



Distilling the Transient Server Characteristics

Availability, **VOLATILITY**, *Predictability* affect the performance differently

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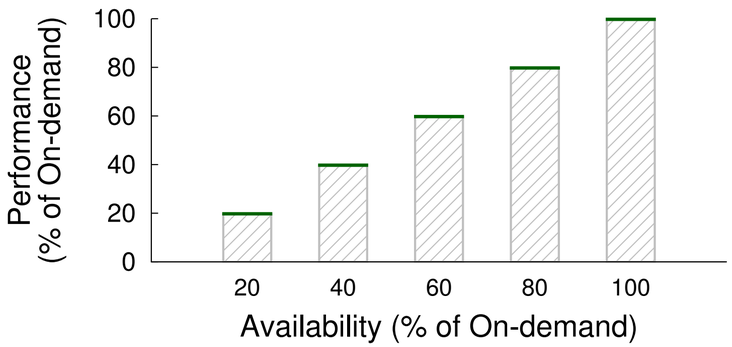

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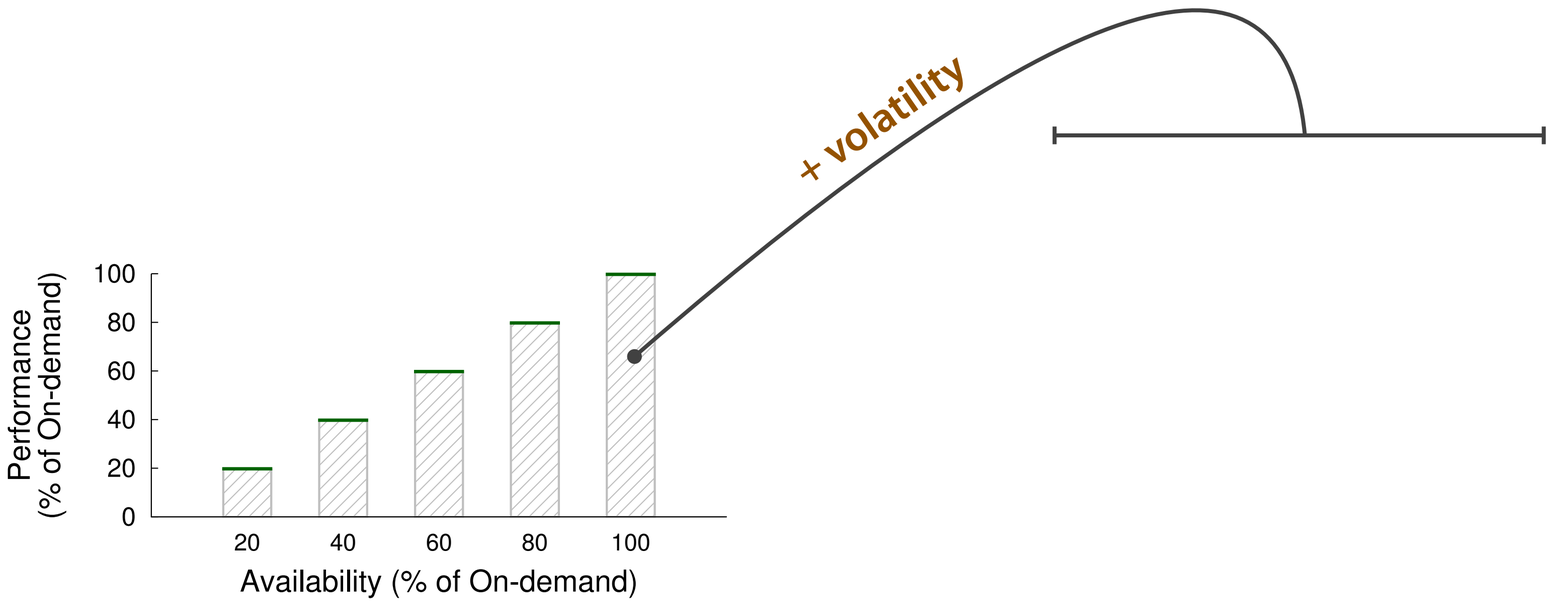

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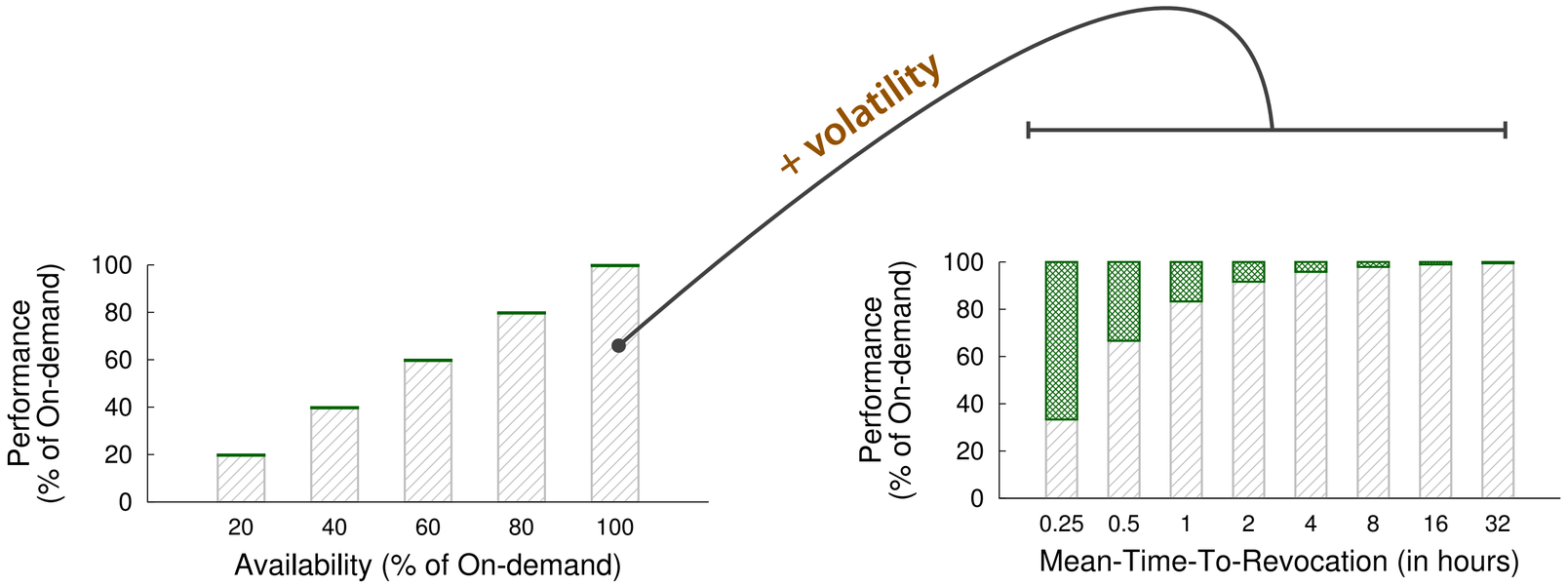

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High volatility (~2 rev/hr) can induce overheads of **~35%**

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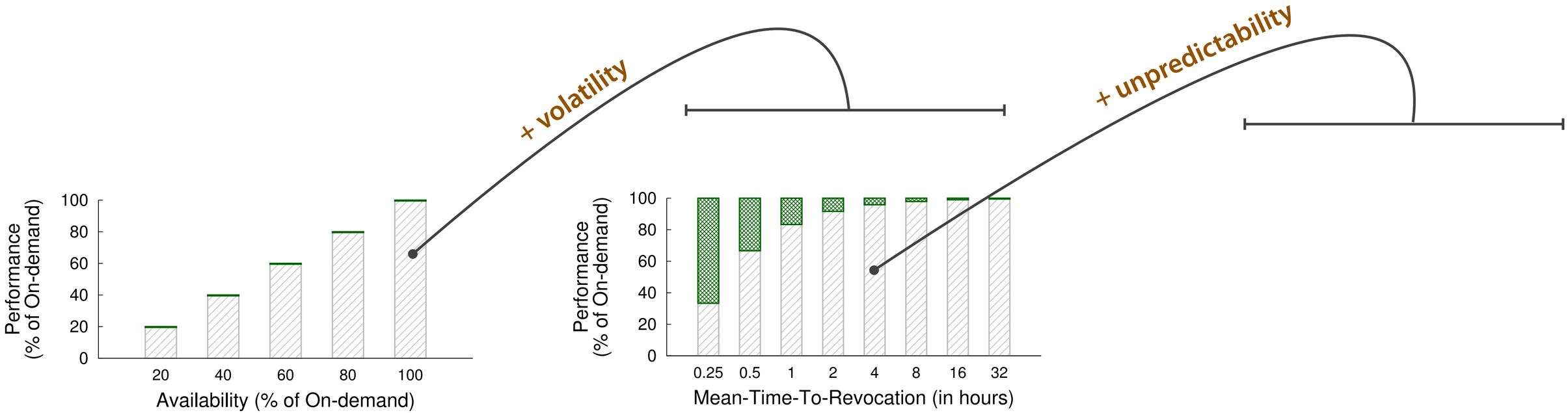

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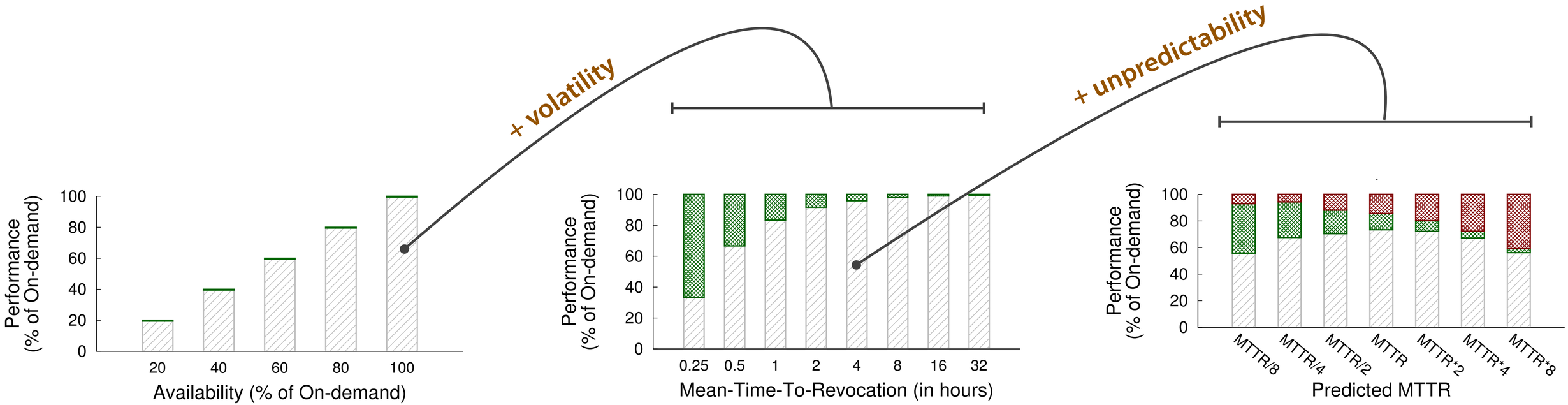

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Unpredictability incurs overheads of **25-40%**