Optimizing Client-side Resource Utilization in Public Clouds

Swapnil Haria, Mihir Patil, Haseeb Tariq, Anup Rathi

Outline

- Motivation
- Solution
- Implementation
- Evaluation
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Cloud Services
(Not a distraction anymore[1])

[1] Jeff Bezos' Risky Bet, November 2006, http://www.bloomberg.com/bw/stories/2006-11-12/jeff-bezos-risky-bet

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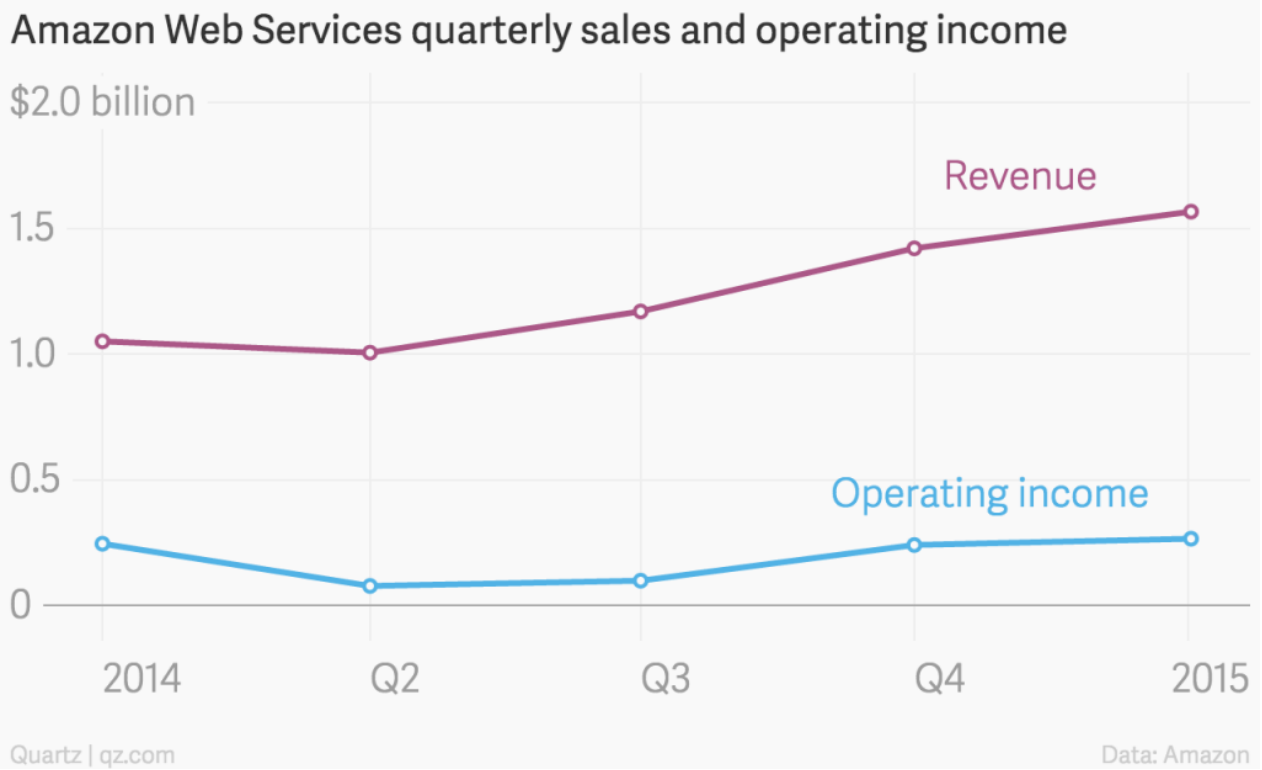
- 30 % of total cloud revenue
- Annual revenues crossed $5 Billion



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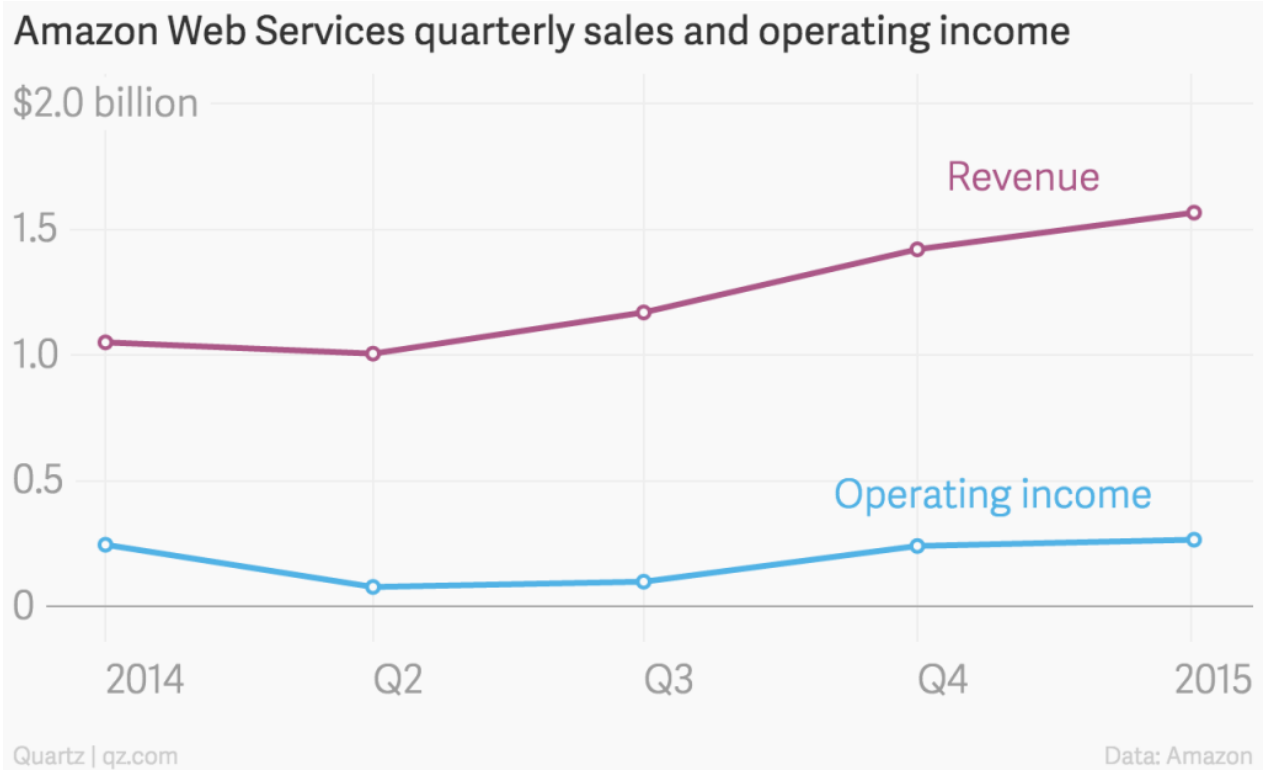

Other Players :

Google Compute Engine

[1] Jeff Bezos' Risky Bet, November 2006, http://www.bloomberg.com/bw/stories/2006-11-12/jeff-bezos-risky-bet

Popularity

- ZERO up-front capital expenses
- On-demand hardware availability
- Flexible pricing options

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Elastic Cloud Compute

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- ~~Flexible pricing options~~

"Amazon EC2 changes the economics of computing by allowing you to pay only for capacity that you actually use."

Elastic Cloud Compute

Limitations

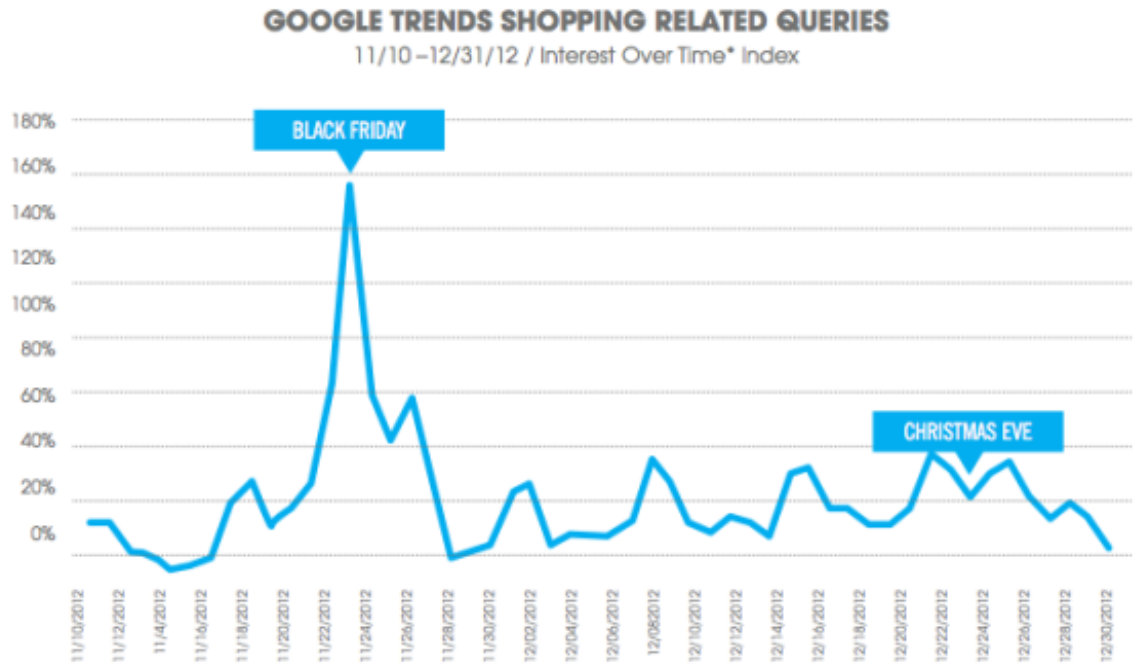
- Allocate resources in fixed sized chunks (EC2 Instances)
  - 1 core , 1GB RAM -> 36 core, 244 GB RAM

- Accurately predict application requirements
  - Undersized VM - Performance degradation
  - Oversized VM - Extra costs

Multiple applications, multiple VMs, no peace

Challenges

- Application requirements vary widely
  - Black Friday for e-commerce websites



http://www.xad.com/media-mentions/mobile-activity-on-xmas-eve-24-pct-higher-than-black-friday/

Challenges

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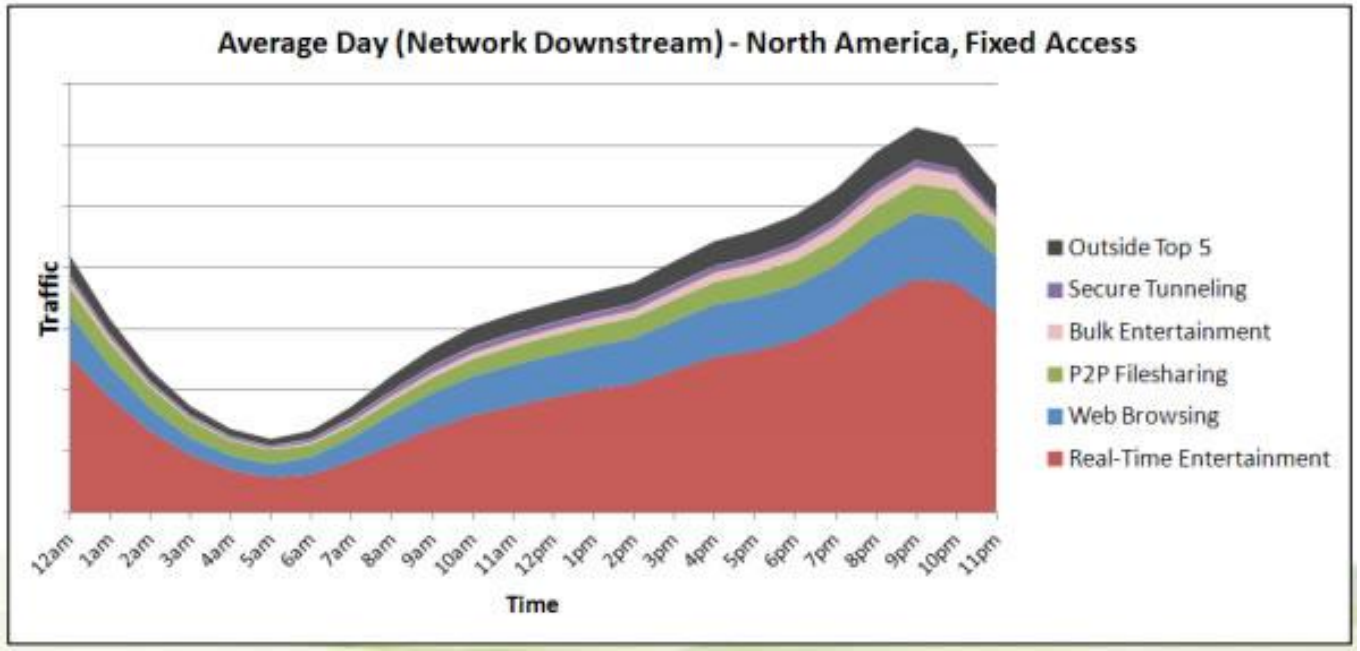
  - Evenings and late nights for Netflix



http://www.techspot.com/news/46048-netflix-represents-327-of-north-americas-peak-web-traffic.html

Challenges

- Application requirements vary widely
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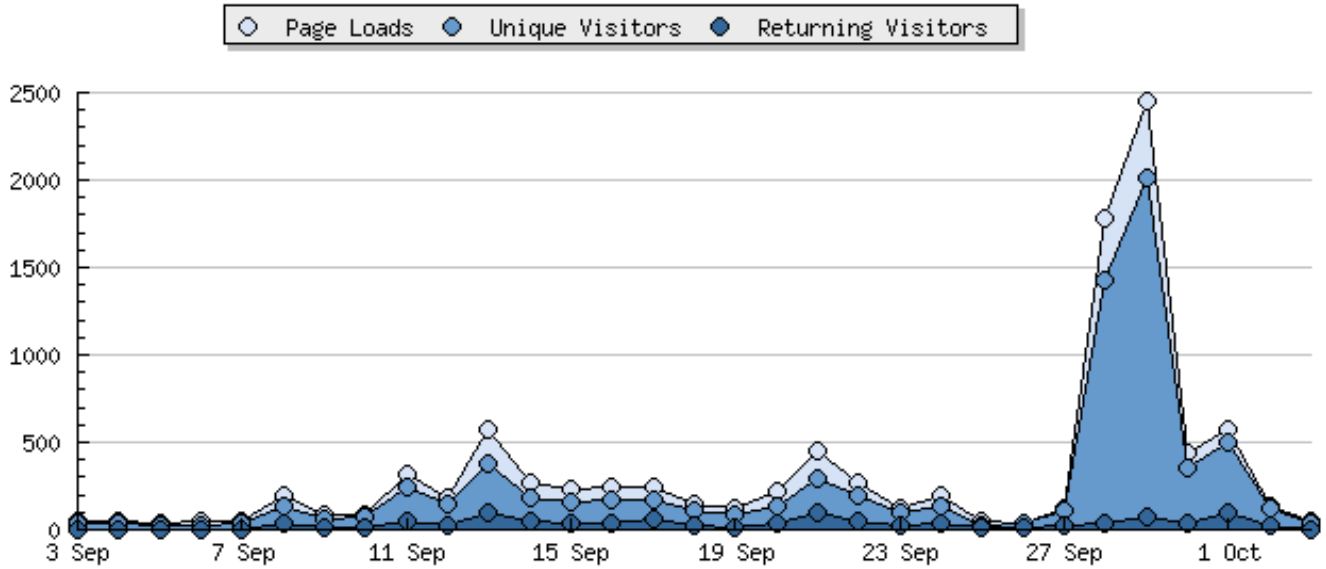
  - Evenings and late nights for Netflix
  - Slashdot effect!



Challenges

- Humans are ~~bad~~ terrible at estimating workload requirements[2]
- Study of developers at Twitter submitting jobs to datacenter
  - 70% overestimated by 10x
  - 20% underestimated by 5x

[2]**Quasar: Resource-Efficient and QoS-Aware Cluster Management**. Christina Delimitrou and Christos Kozyrakis. ASPLOS 2014.

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Resource as a Service[3]

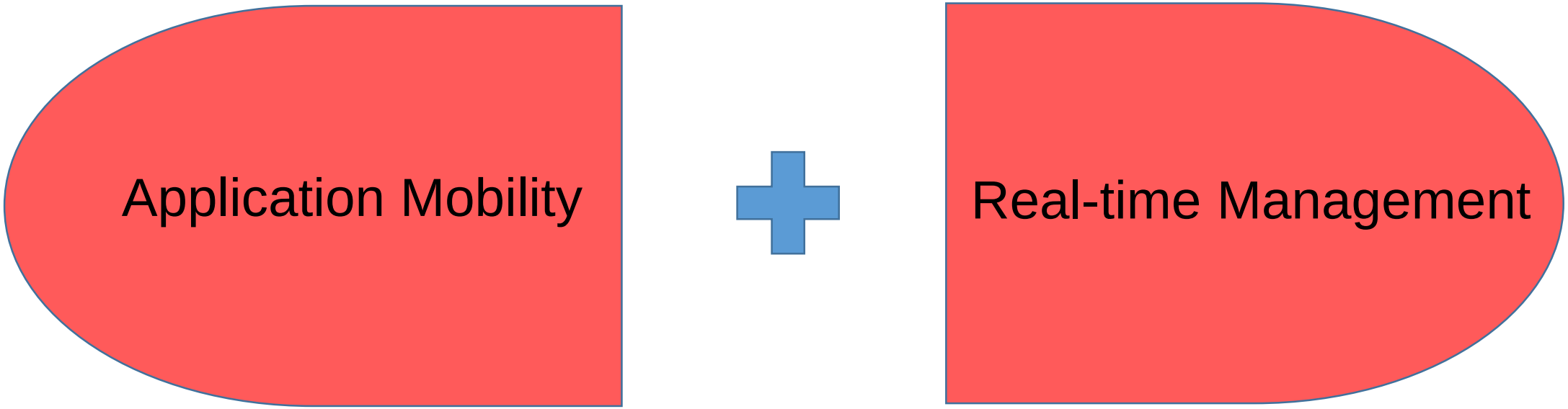
1. Fine grained cloud reservations
2. CPU (cycles), memory (pages), I/O (bandwidth), Time (seconds)

- Where does it stop?
- Reduces wasted costs, but difficult to reason about
- Hardware feasibility issues for service providers

[3] The rise of RaaS: the resource-as-a-service cloud. Orna Agmon Ben-Yehuda et al. Commun. ACM 2014

Proposal

Tell me more!



Application Mobility

- On-demand application migration across machines
- Conventional issues -
  - Application state stored in kernel (file descriptors, sockets)
  - Residual dependencies left on source machine
  - Execution Continuity

We need

- Process Isolation (even from kernel)
- Minimal state in kernel

Now where did I see that before?

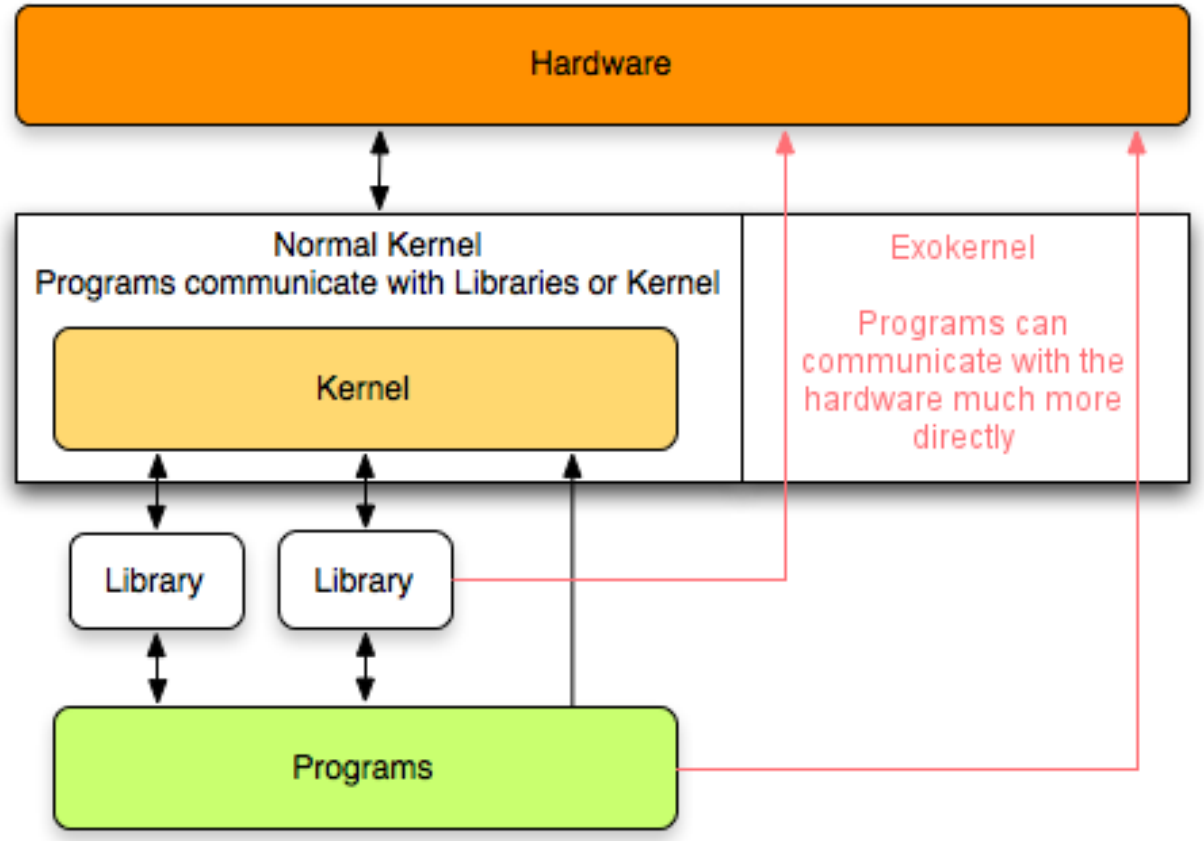


Image Source - Wikipedia

Where do I find one of these?

Old idea, but making a comeback in Cloud OS

- Drawbridge from Microsoft Research
- MirageOS from University of Cambridge

Both (claim to) support application-migration!

Real-time Management

- Monitor application requirements in real-time

- Use application migration to organize processes on VMs

Real-time Management

- Monitor application requirements in real-time
  - Relatively easy
  - Working set sizes, idle cycles

- Use application migration to organize processes on VMs
  - Complex
  - Varying configurations and prices of VMs
  - Identifying processes to migrate
  - Downtime / Budgets!

Policies

Steps

- Determine migration events
- Identify process(es) for migration
- Choose target from existing VMs, if possible
- Figure out instance types for creating new VMs

Policies

Metrics (in order of priority)

- Maximize VM utilization
- Satisfy performance guarantees
- Minimize costs

User-Defined Parameters

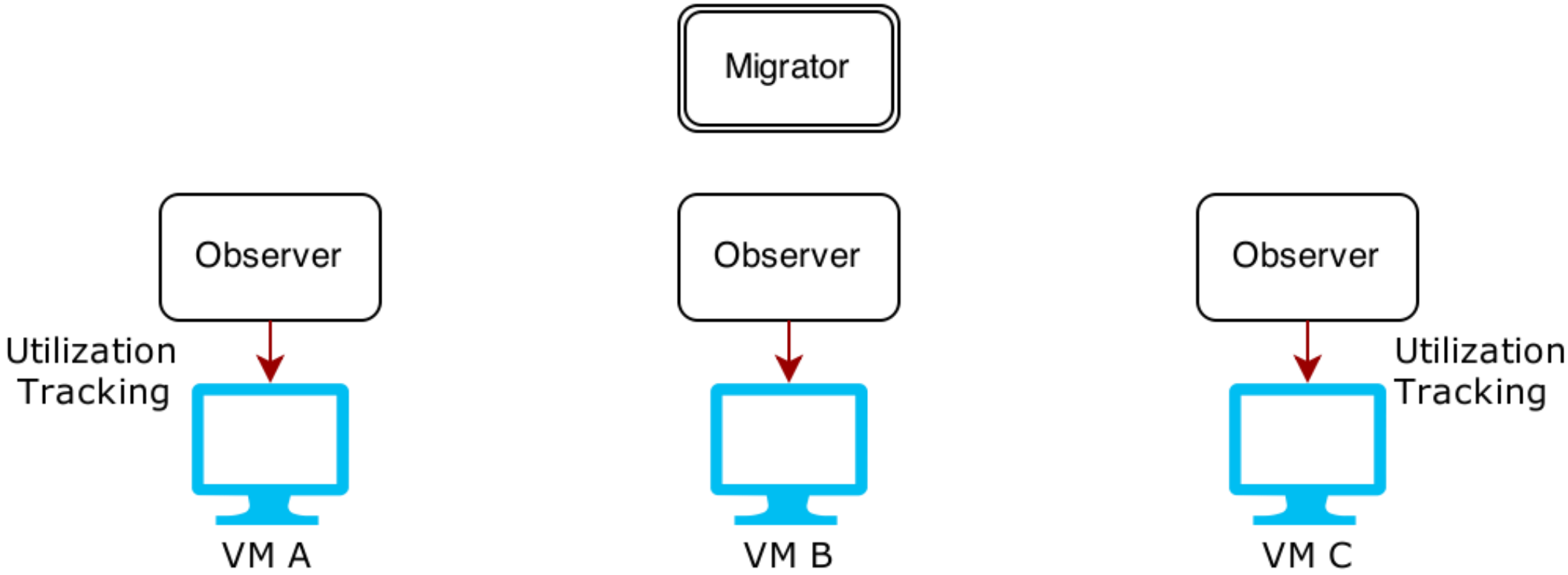
- Upper limit on cost
- Max downtime per process

Policies

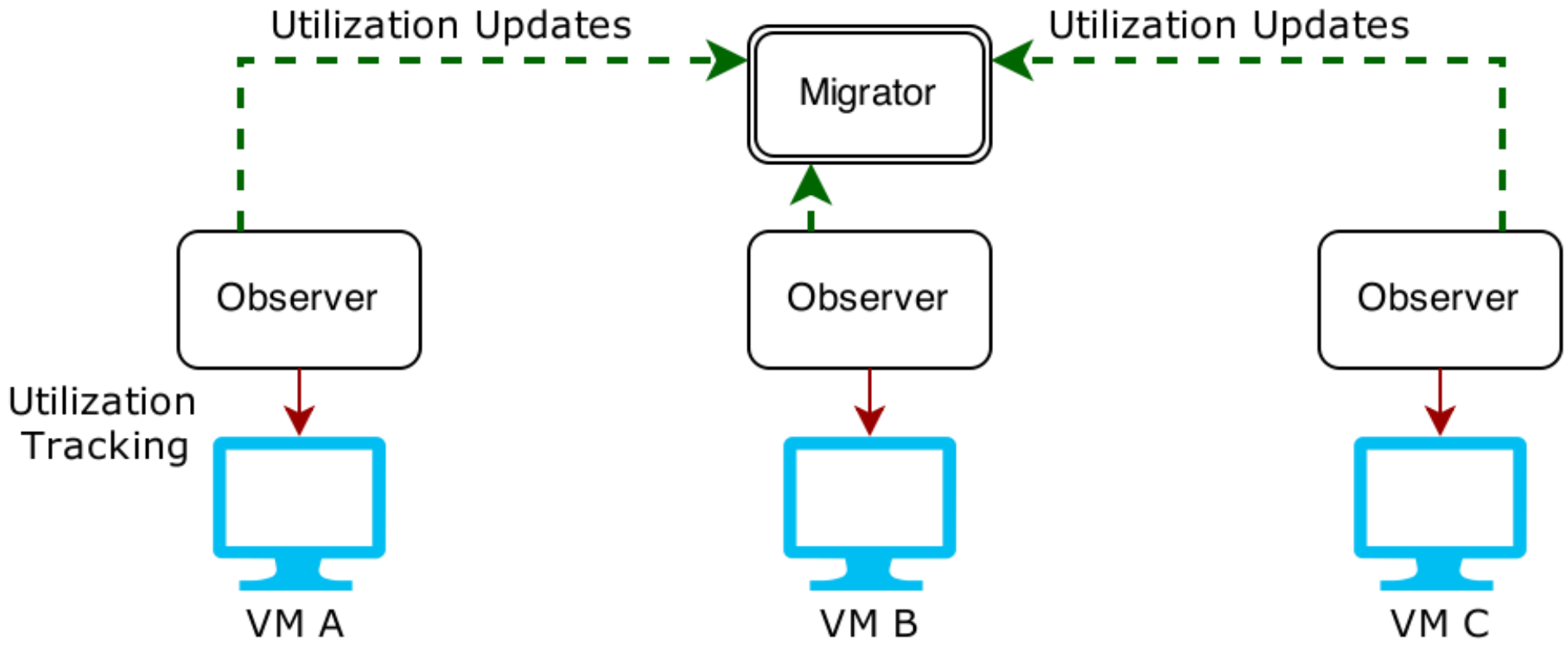
- **Single Application per VM**
  - Easy to reason about
  - Use naive best fit model to find target VMs

- **Multiple Applications per VM**
  - Highly complex optimization problem (NP-Hard)
  - Use Heuristics!
  - Use best fit and explore nearby options to find target VMs

Software Architecture



Software Architecture



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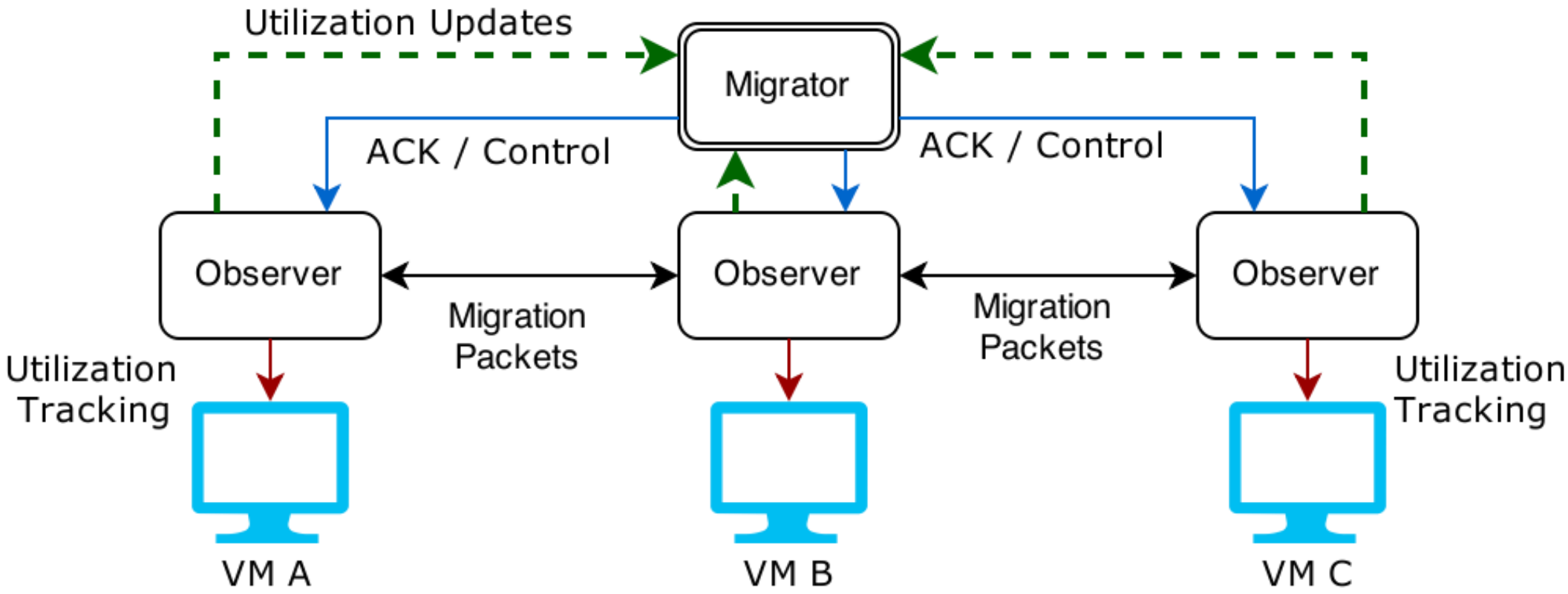

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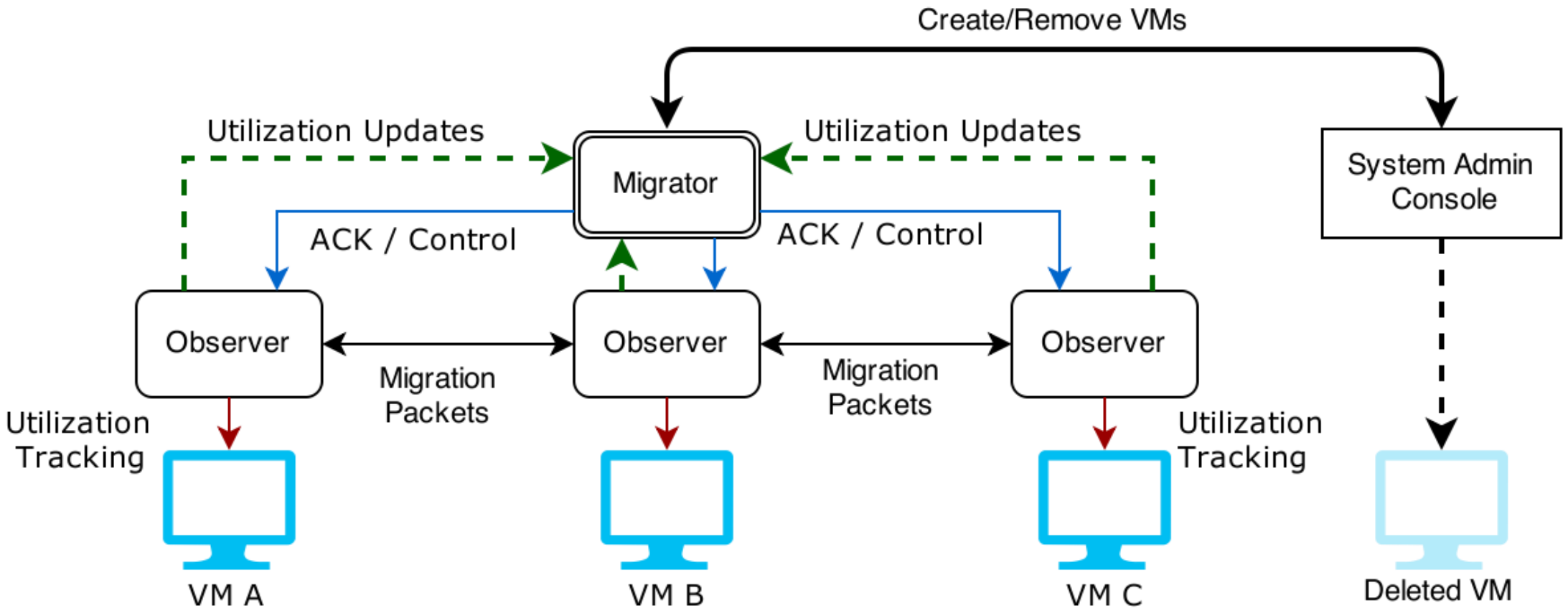

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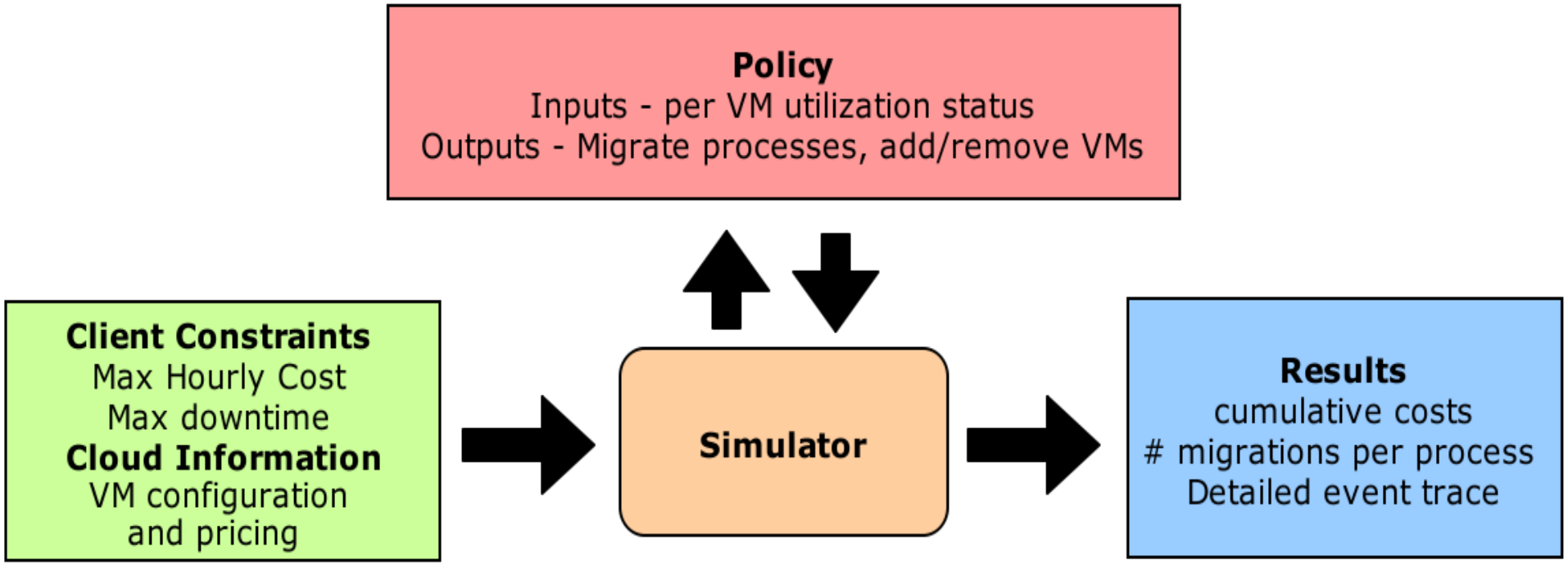
Proof of Concept Model

- Linux Containers (lxc)
  - Emulate isolated processes on Drawbridge/MirageOS

- Checkpoint/Restore in Userspace (CRIU)
  - Checkpoint containers on VM A
  - Migrate files to VM B
  - Restore on VM B

Simulator

- Rapidly validate migration policies
- Evaluate the influence of policy parameters on results
- Written in about 2000 lines of Java code



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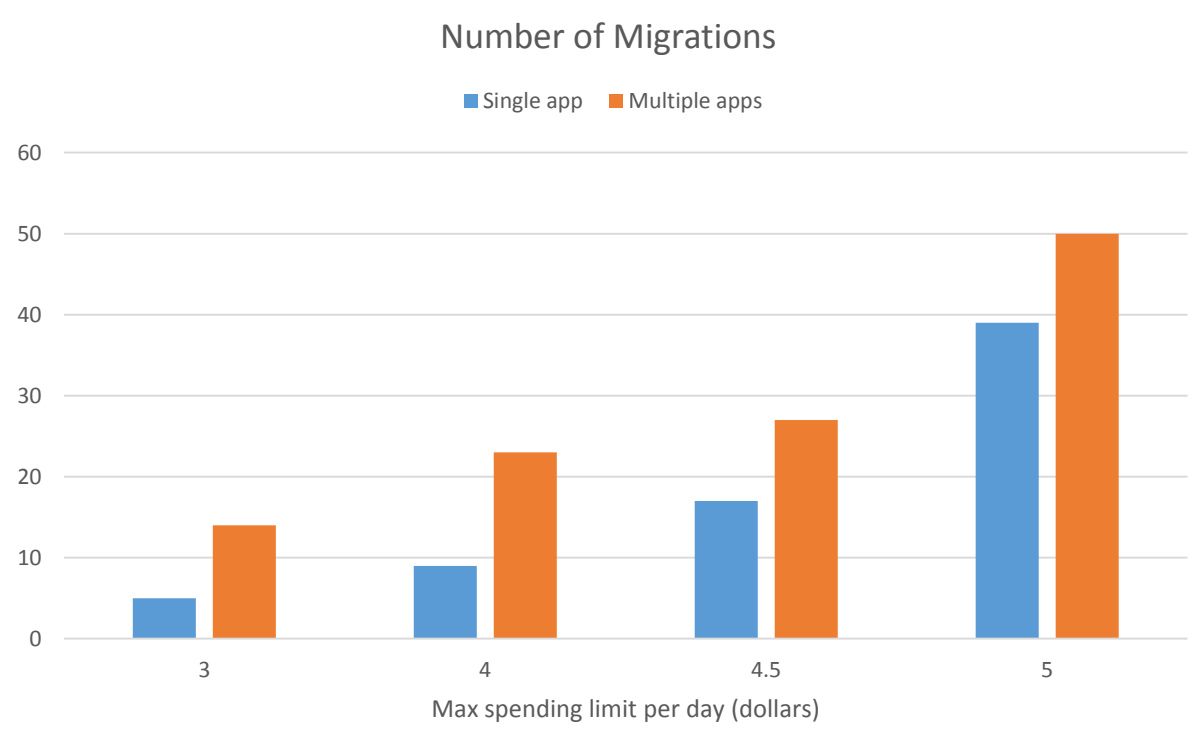
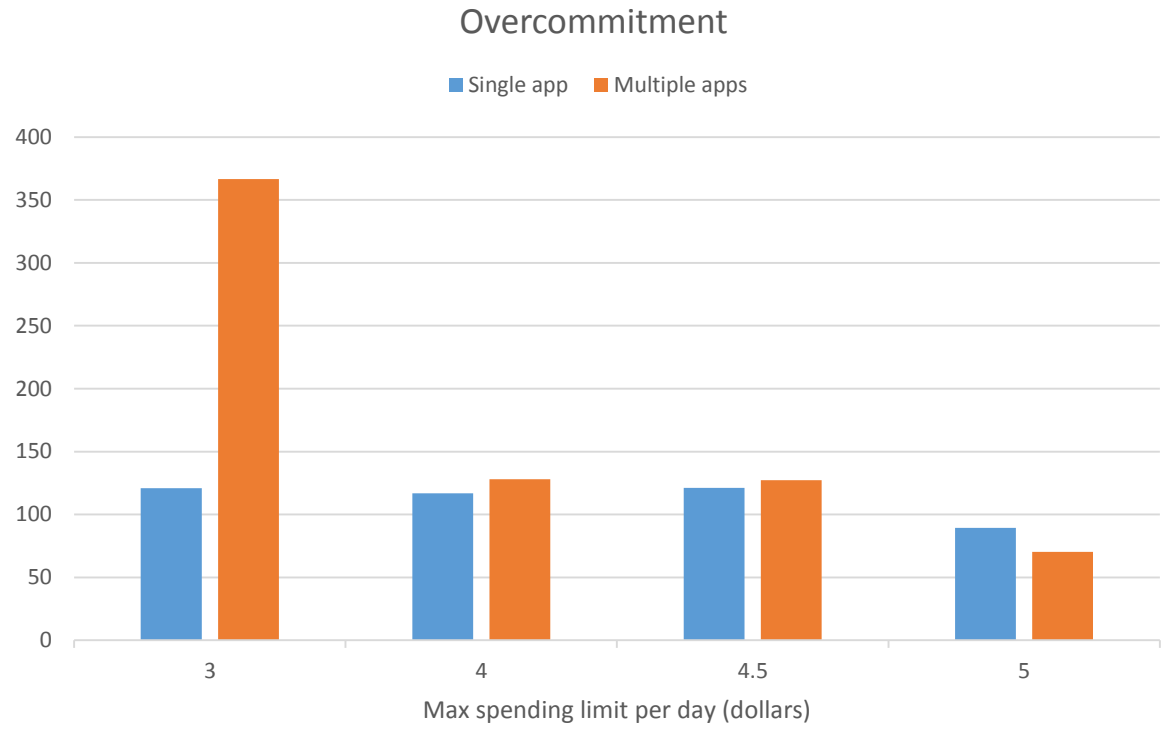
Experimental Setup

- **Proof of concept model(WIP)**
  - Live migrating SPEC benchmarks running in LXC
  - Observed downtime – 30 seconds (depending of process size)

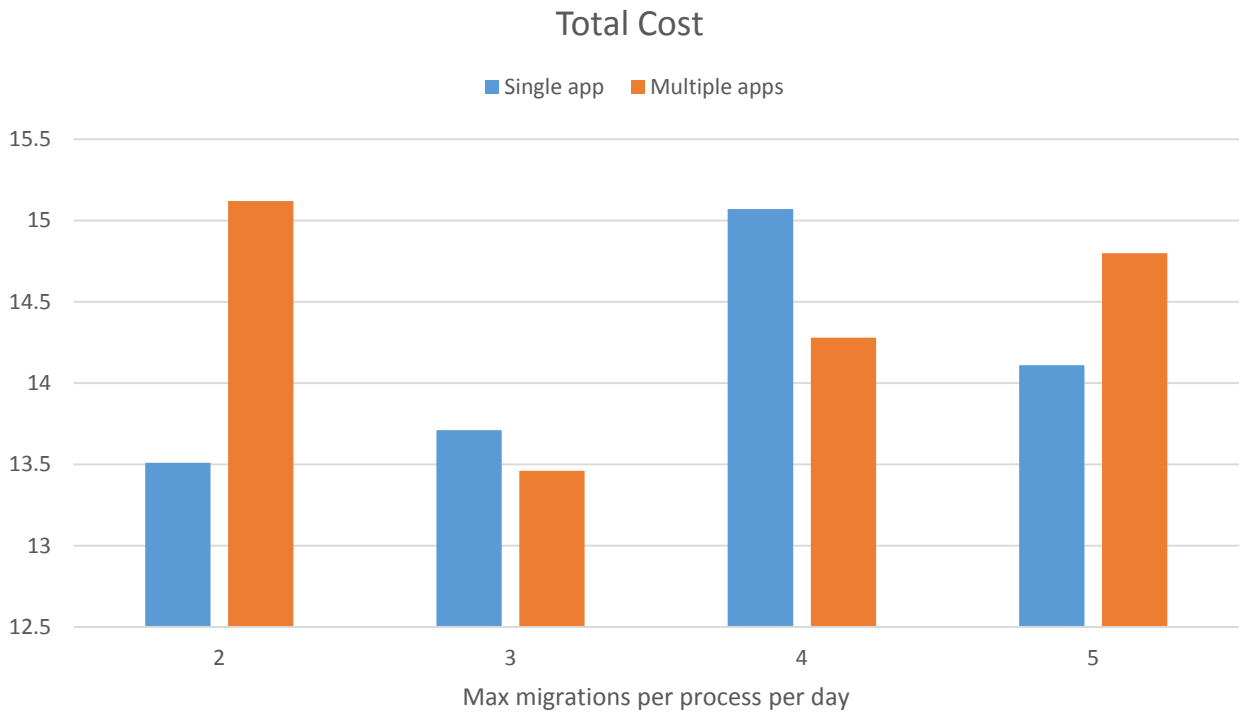
- **Migration Policy Simulations**
  - Used our own random workload generator
  - 2 workloads of each type – static, high variability and low variability

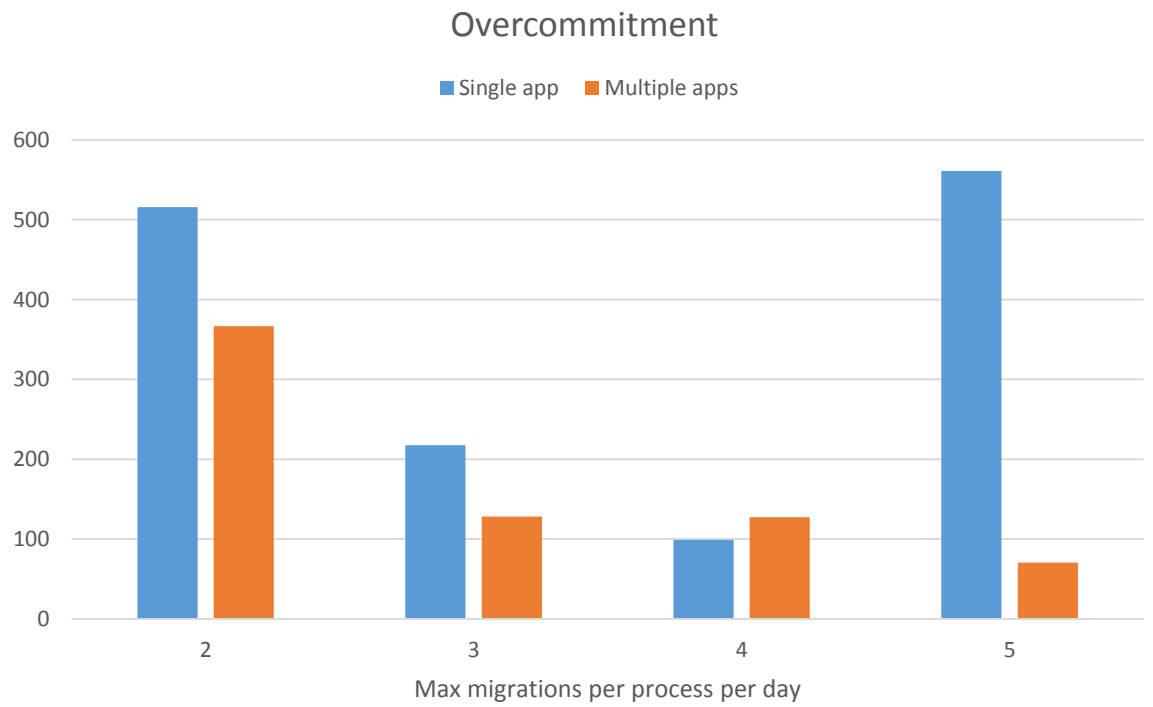
Capping Costs



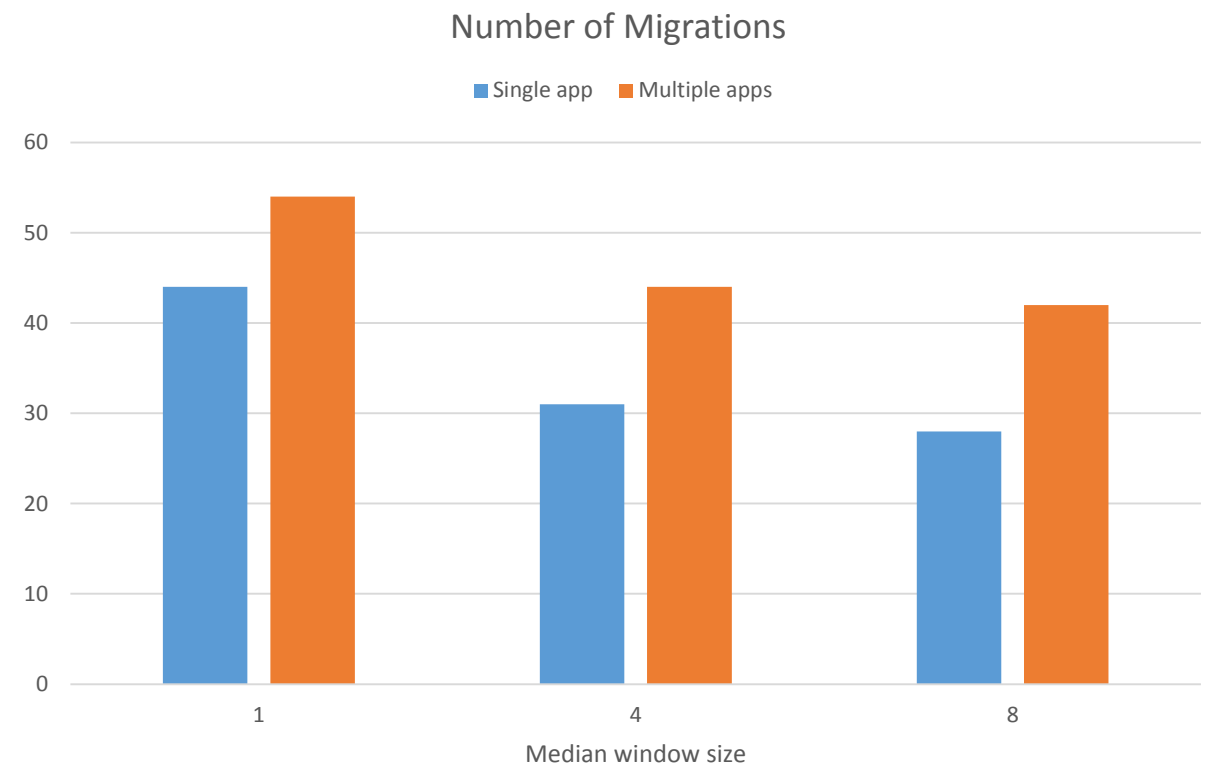


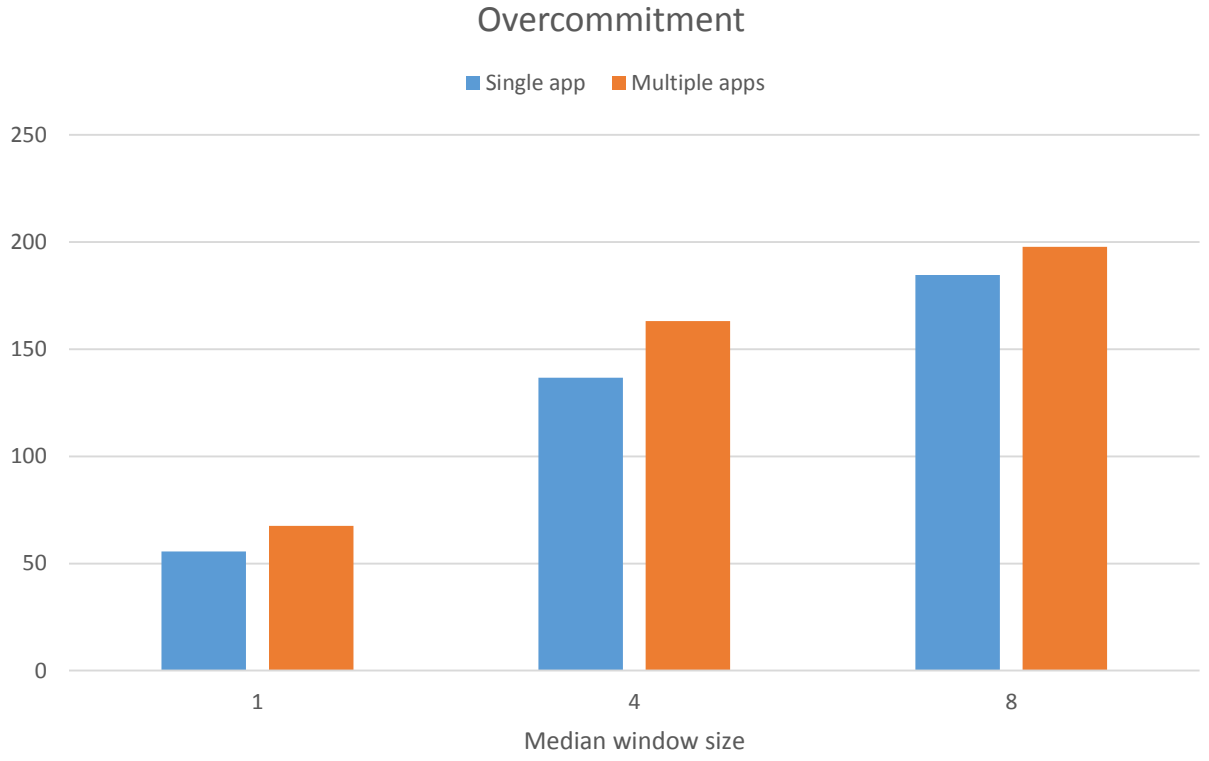
Constraining Downtime





Suppressing Spikes





Show me the money

- **Baseline**
  - Used same workloads as the simulation
  - Picked from available VMs that would best fit the workloads
  - No migrations!
  - Cost for 3 days - $45.36

- **Our solution**
  - No migration policy requires more than $15 for 3 days
  - 66% money saved!

Conclusions

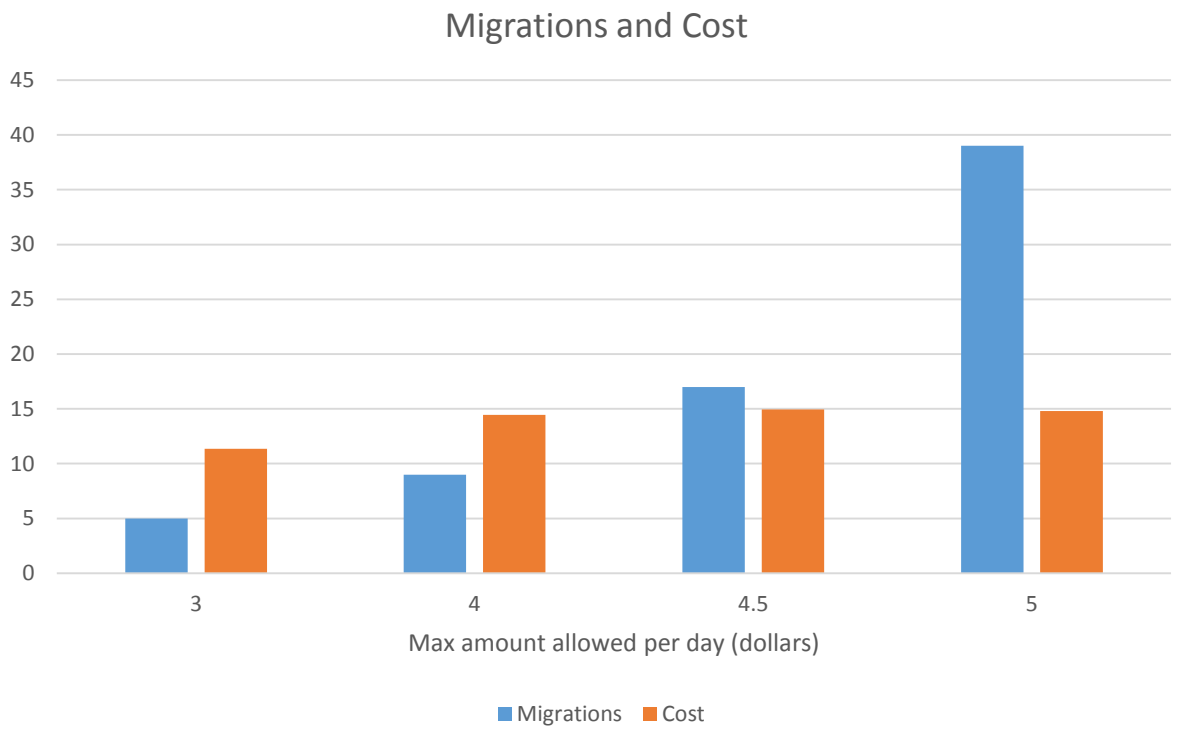
- Streamlining cloud operations important with increasing scale
- Current IaaS reservation models insufficient
- Better support needed from cloud providers
  - Amazon EC2 Container Service
- Migration policies have to optimize in a multi-dimensional space
  - Simple ones offer savings too!

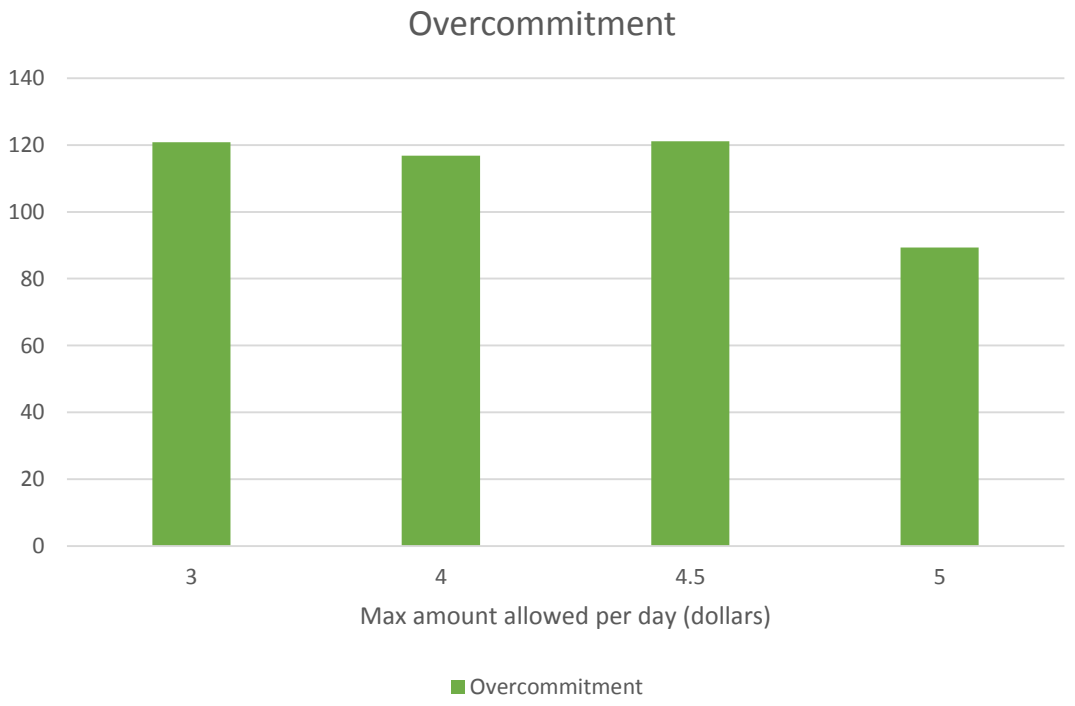
Questions?

BACKUPS

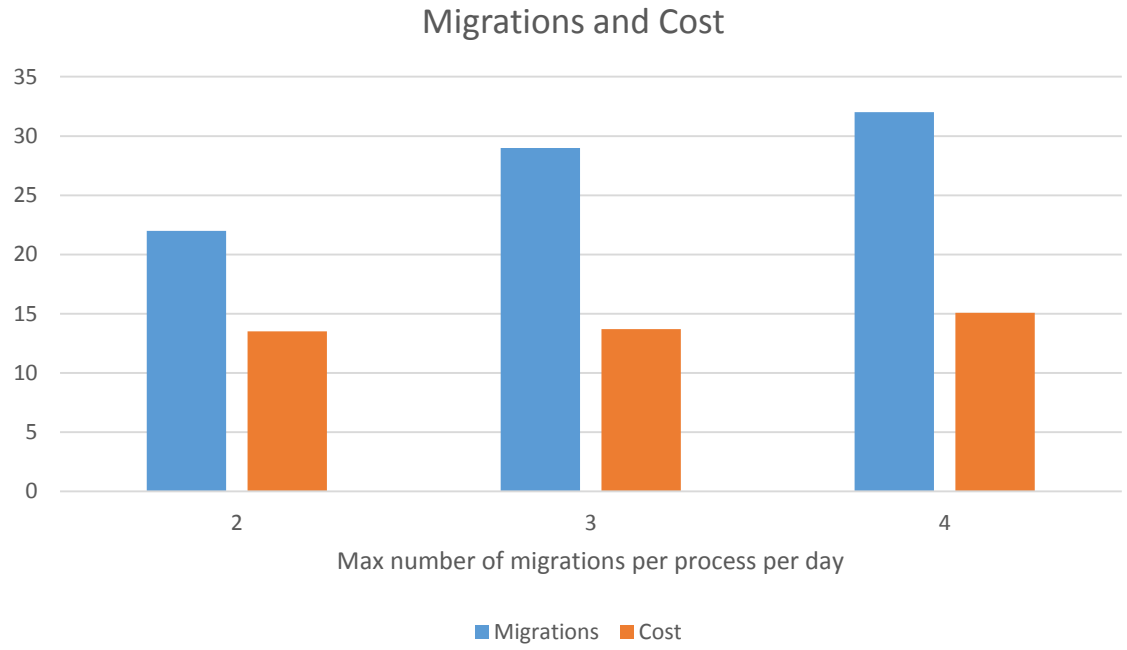
Single application per VM

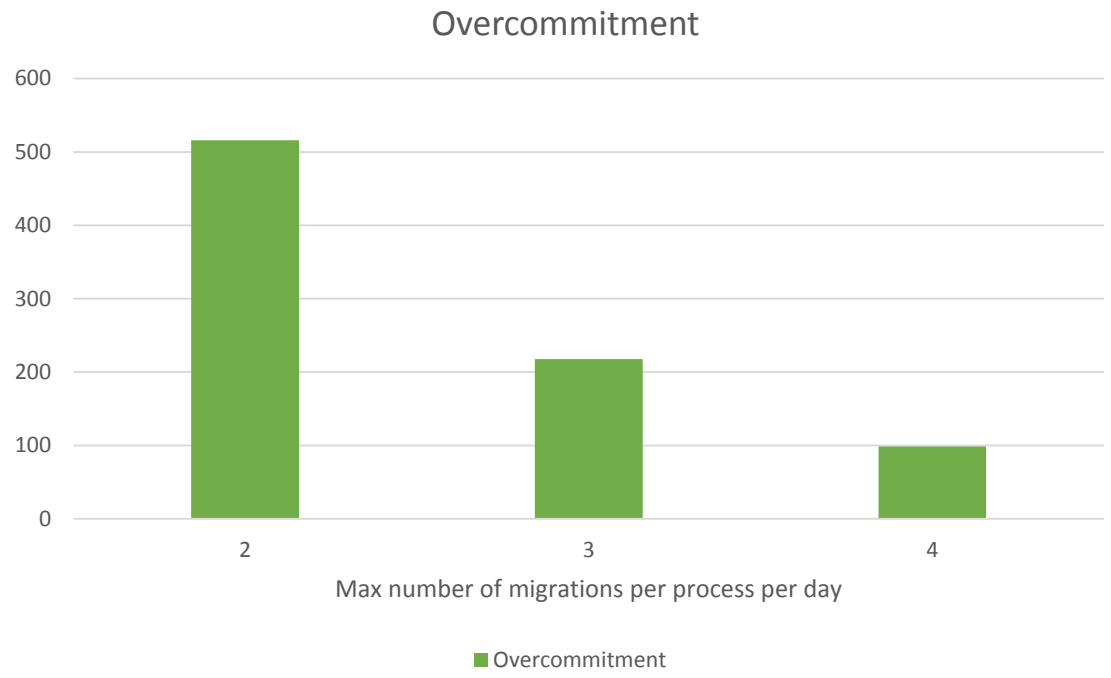
Effect of cost per day



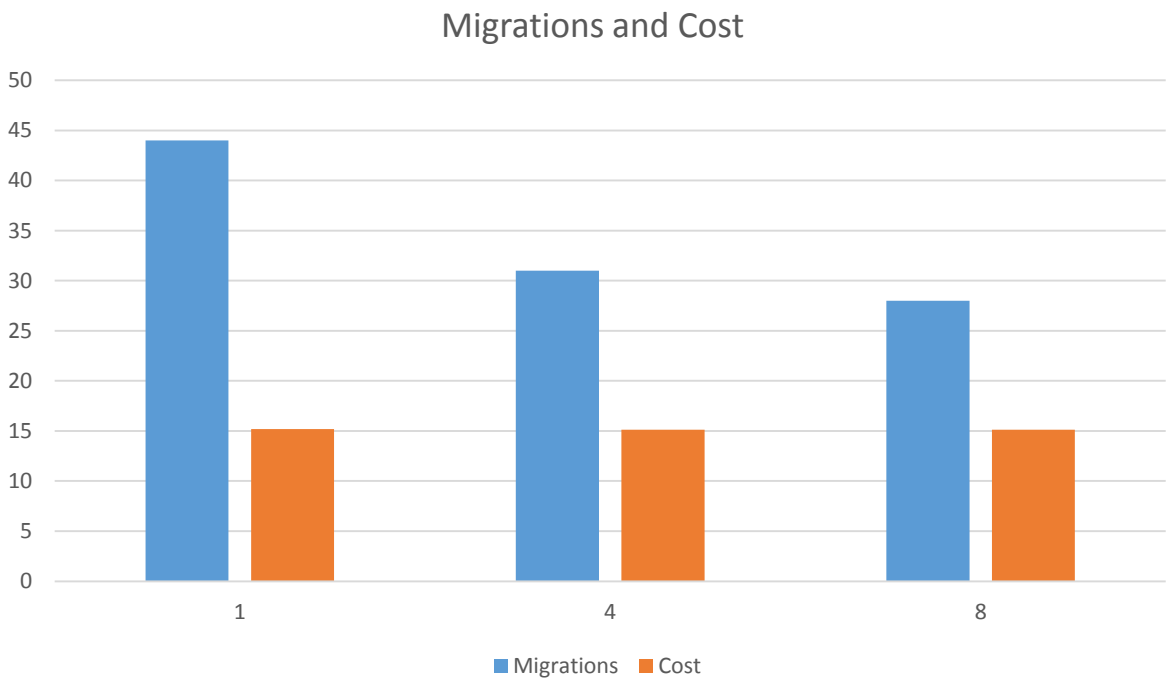


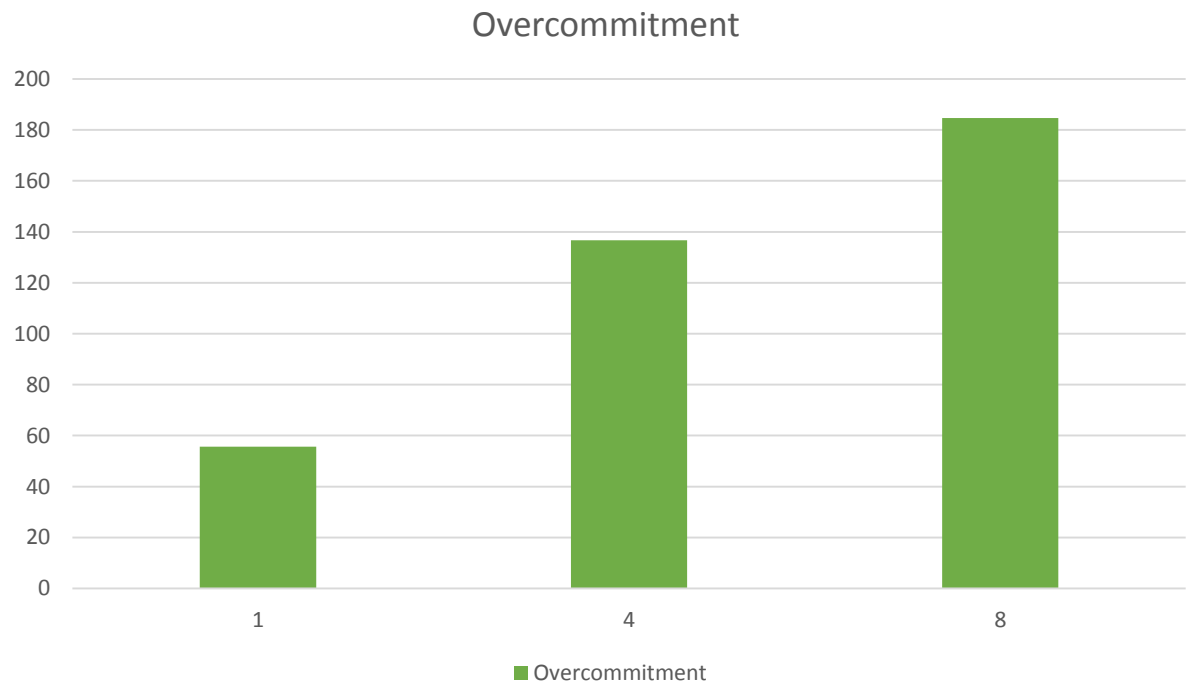
Migrations cap





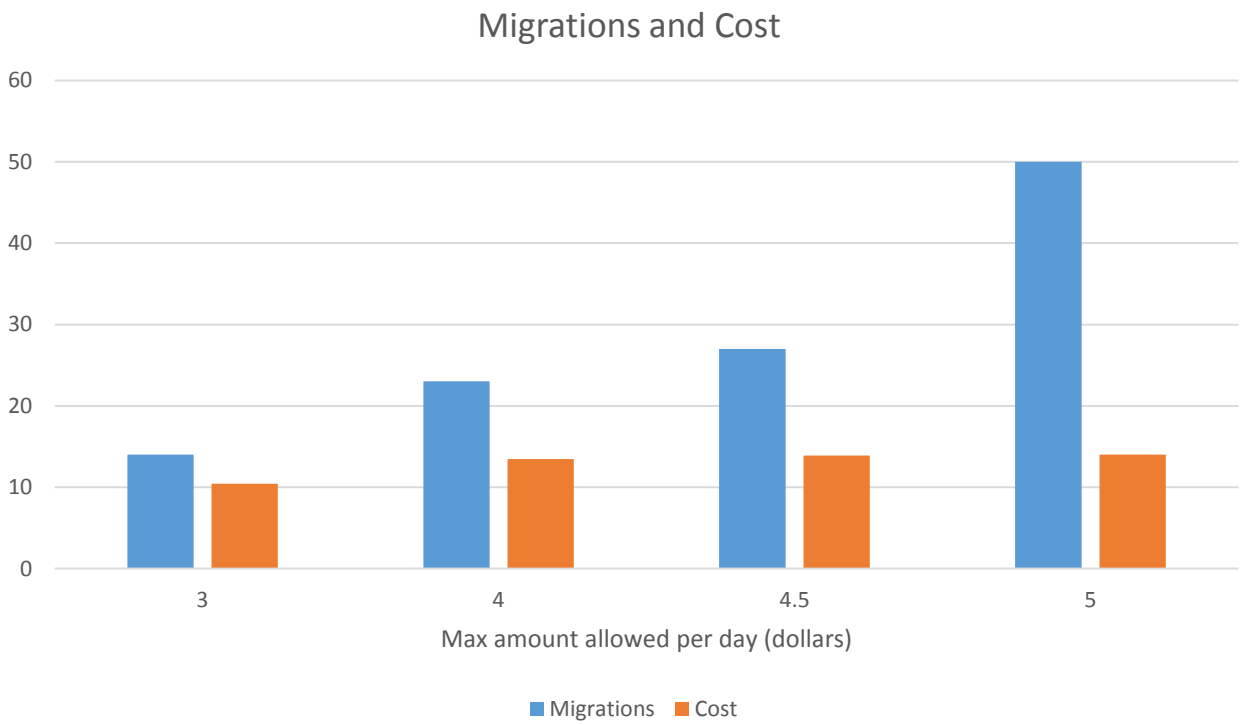
Median window variations

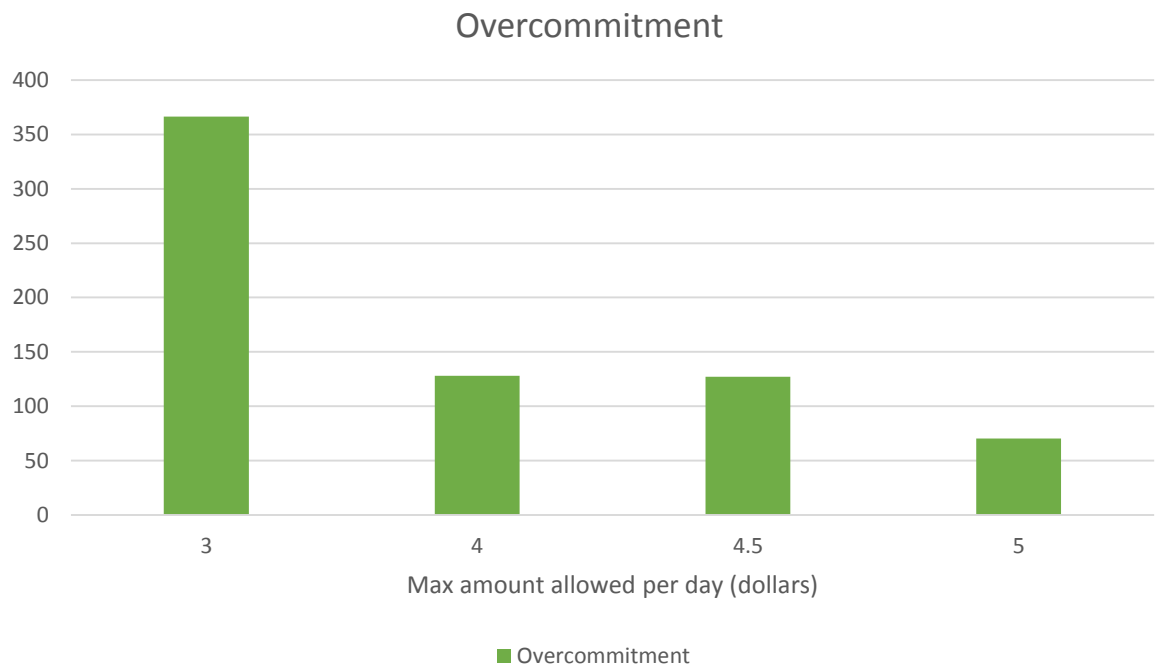




Multiple applications per VM

Effect of cost per day





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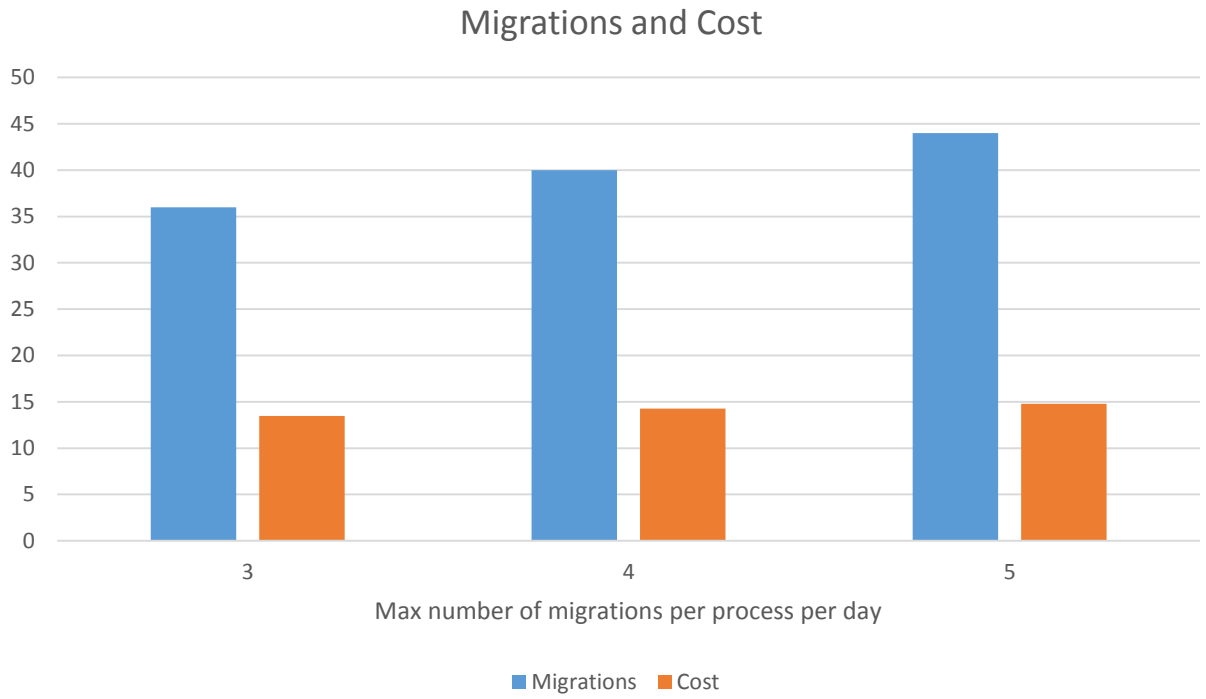

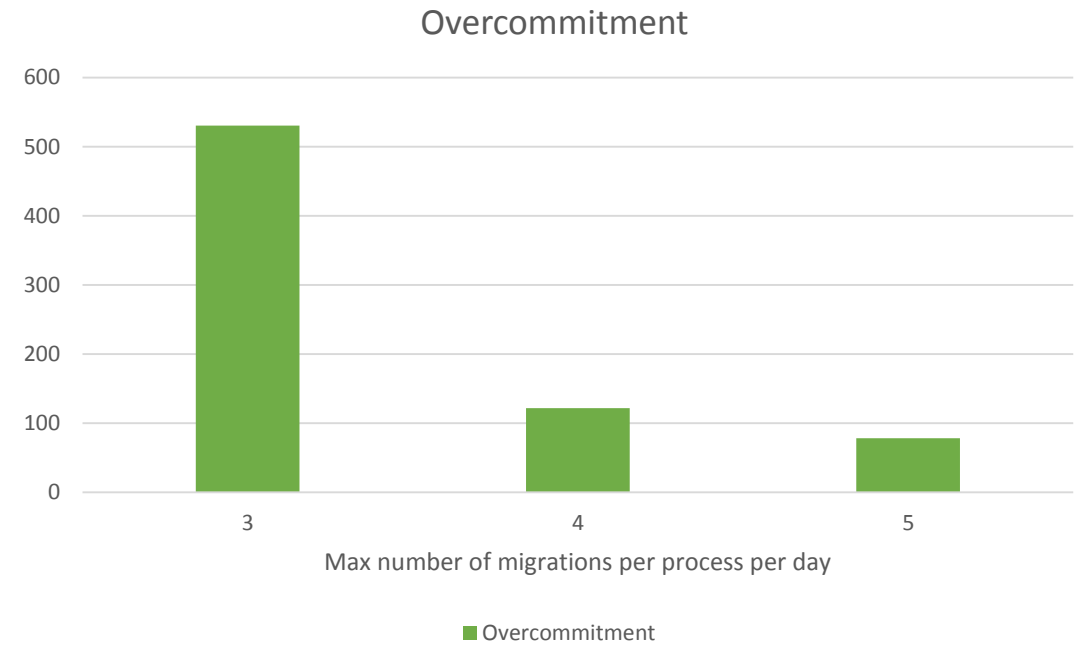

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