Adaptive and flexible platforms for e-Science
- the future is cloudy

Johan Tordsson
Umeå University
tordsson@cs.umu.se

(joint work with Luis Tomás, Cristian Klein, Petter Svärd, Benoit Hudzia, Erik Elmroth, & Francisco Hernández)

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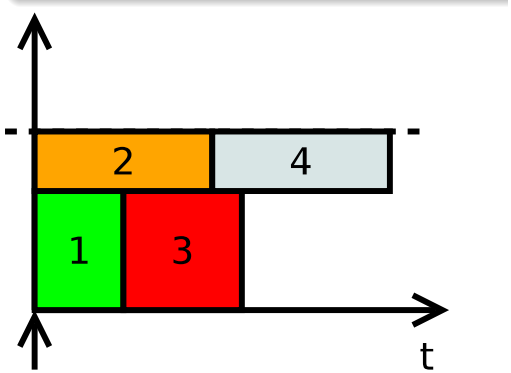
(eScience) challenge: Heterogeneity in computing

- Available platforms include
  - HPC Clusters
  - Grids
  - Accelerators (GPUs)
  - Clouds
- Programming models differ
  - Tools, languages, how to handle parallelisms/scalability, etc.
- Platforms also differ
  - Resource management systems

Resource management

- Batch system access
  - Waiting
- Dedicated resources
- Static
- Predictable?



- Instant access
- Shared resources
  - Noisy neighbors
- Dynamic?
- Unpredictable

Resource management

- Job completion time comparison

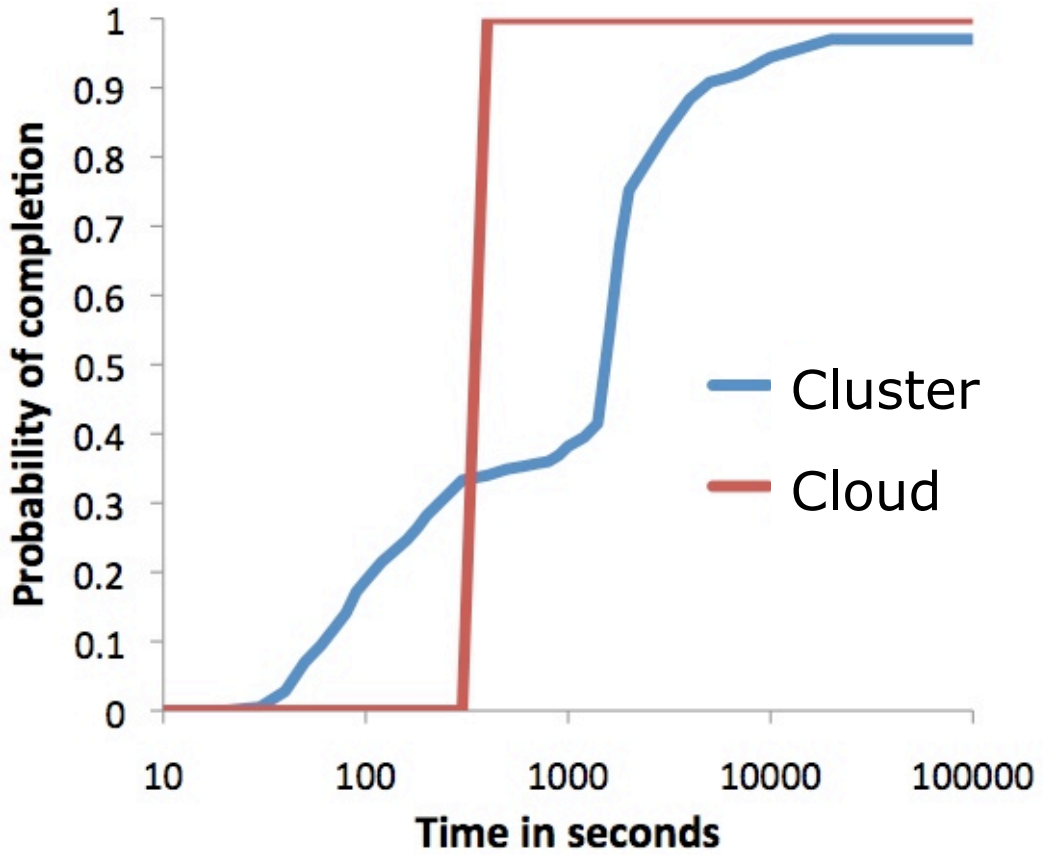


Image by Ian Foster

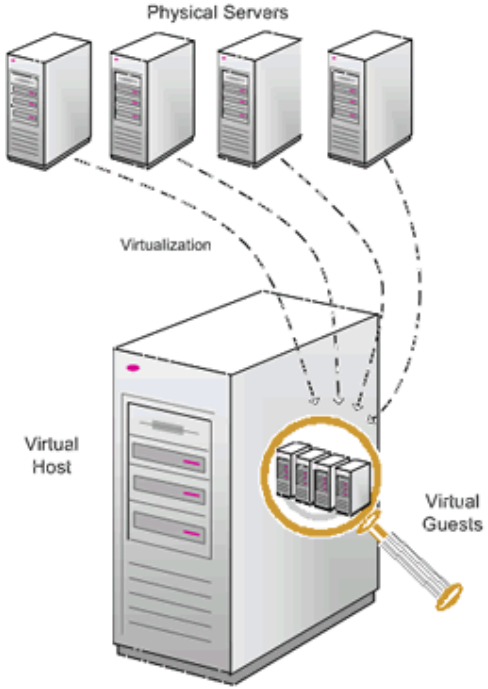
Addressing the challenge

Static -----> Dynamic

Unpredictable -----> Predictable

- More dynamic platforms?
- More adaptive applications?
- Collaboration?
  - Applications and platforms to interact

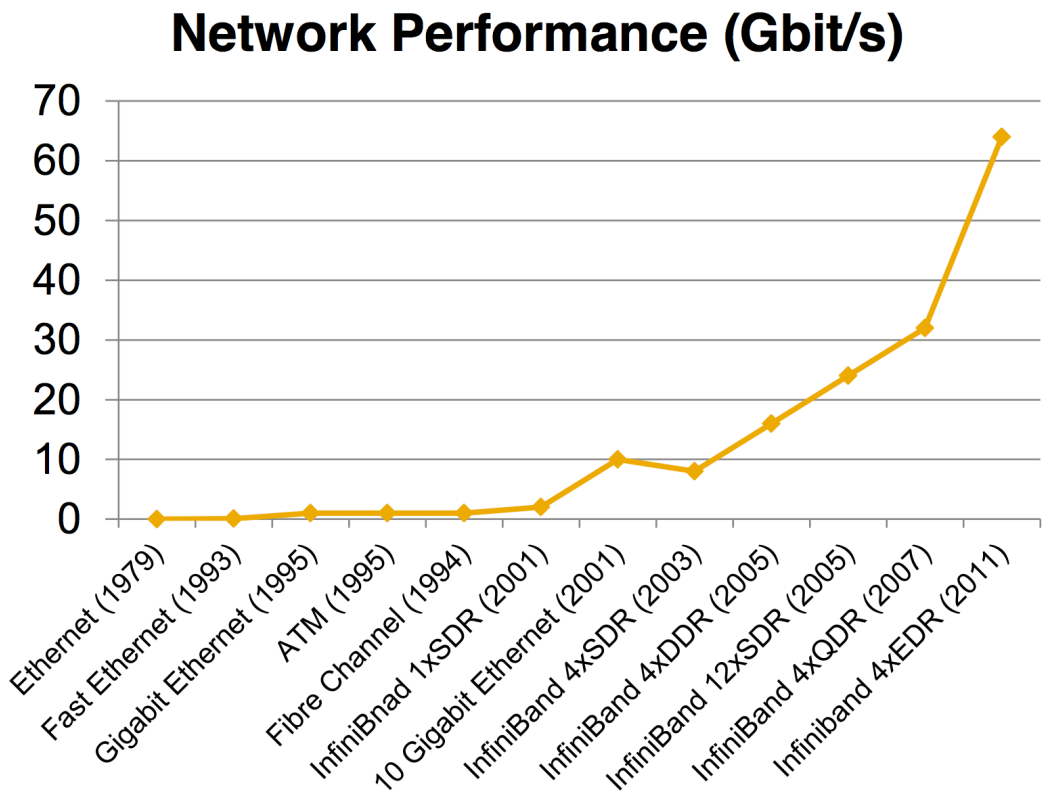
More dynamic platforms?



- Hardware *virtualization*
- *Virtual machines (VMs)* & *containers*
  - KVM, Xen, etc & Docker etc.
- Application benefits
  - Run multiple OS
    - Cross-platform execution
  - Supports different OS and library versions
  - Isolation
- Platform benefits
  - Consolidation, fewer servers
  - Simplified management, Isolation
  - Increased utilization, etc.

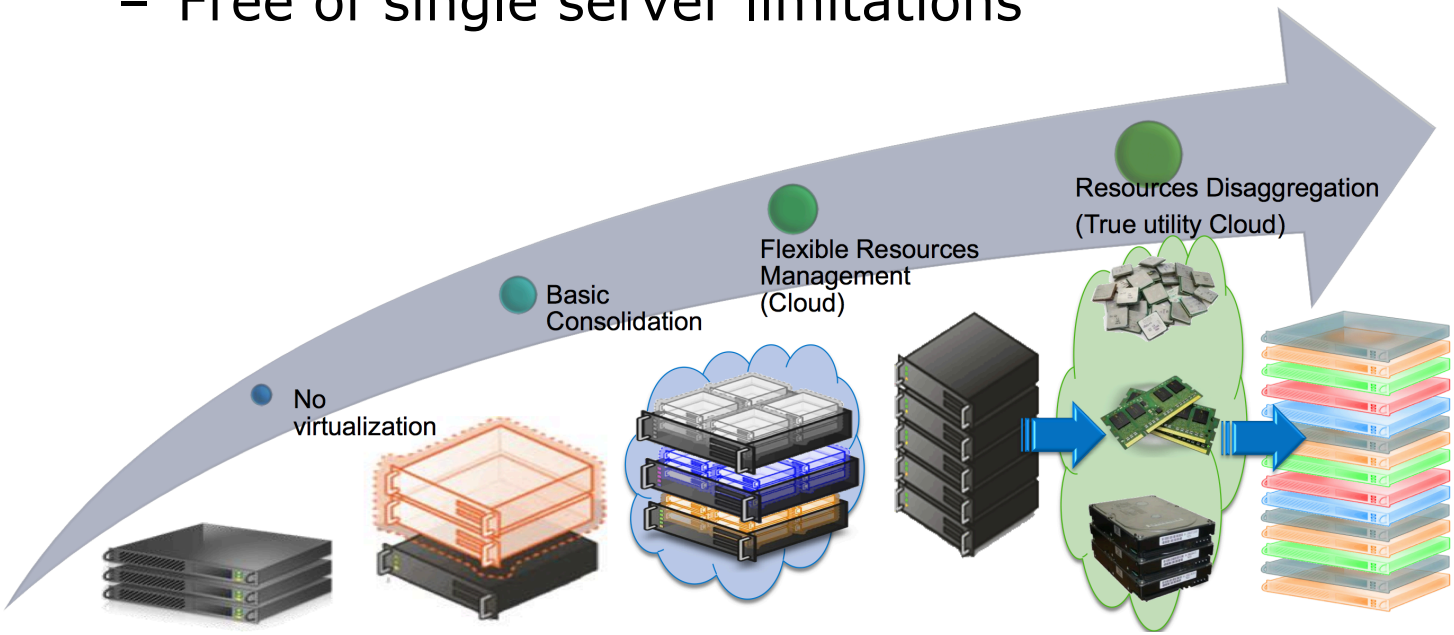
(Even) more dynamic platforms? - current hardware trends

- CPU, RAM, Disk access has "stopped" getting faster[2]
- Network bandwidth is still increasing
- Remote resources get closer



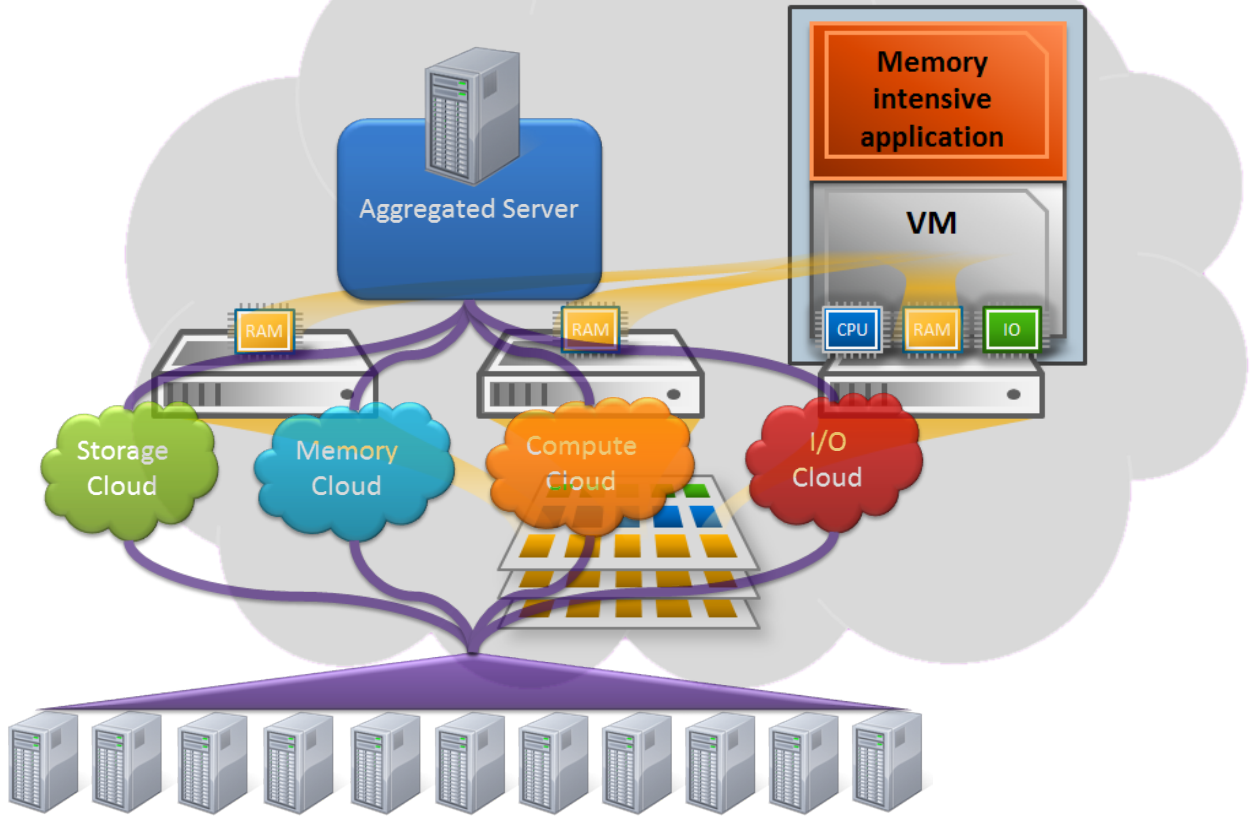
Server disaggregation

- Aggregate server resources into pools
  - Memory, Compute and I/O
- Easier provisioning and scaling
  - Scale by adding more resources from the pools
  - Free of single server limitations



Relaxed box model virtualization

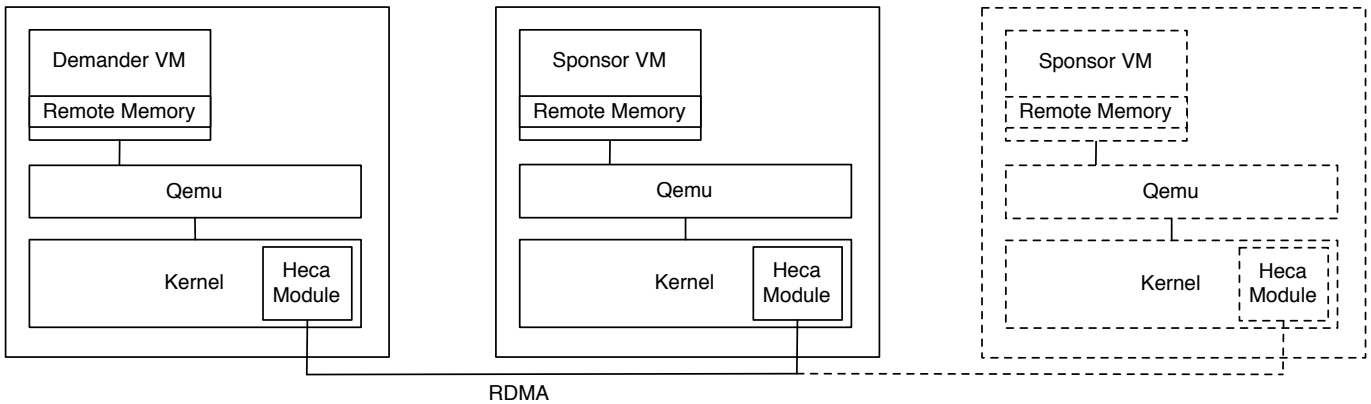
For enhanced workload mixing (space)

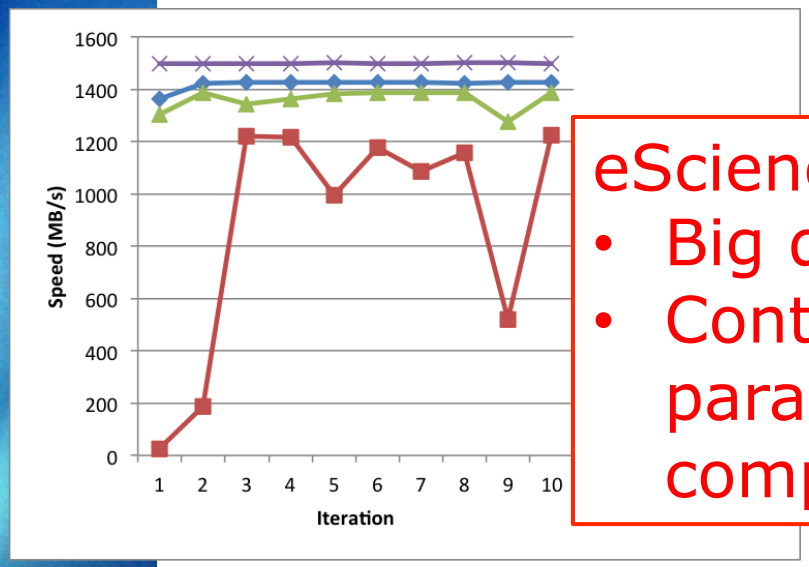


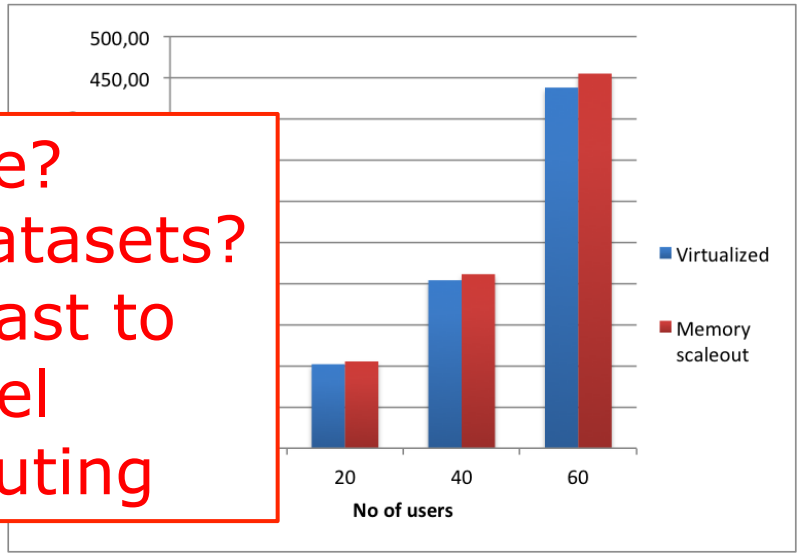
P. Svärd, J. Tordsson, B. Hudzia, E. Elmroth. Hecatonchire: Enabling Multi-Host VMs by Resource Aggregation and Pooling. *EuroPar 2014*

Partial results

Modified KVM hypervisor
RDMA data transport
Infiniband network
Unmodified applications







eScience?

- Big datasets?
- Contrast to parallel computing

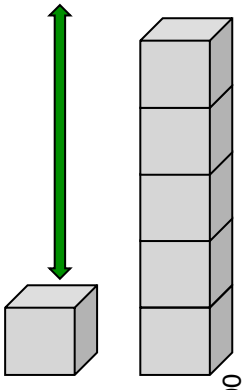
Linux memory benchmark
8 GB VM, 33% remote

SAP HANA, 2.5 TB (!)
In-memory DB
1 TB RAM vs 50% remote

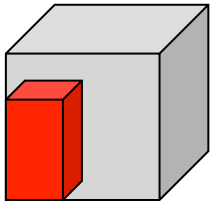
More dynamic platforms? - Overbooking

(Cloud) utilization issues

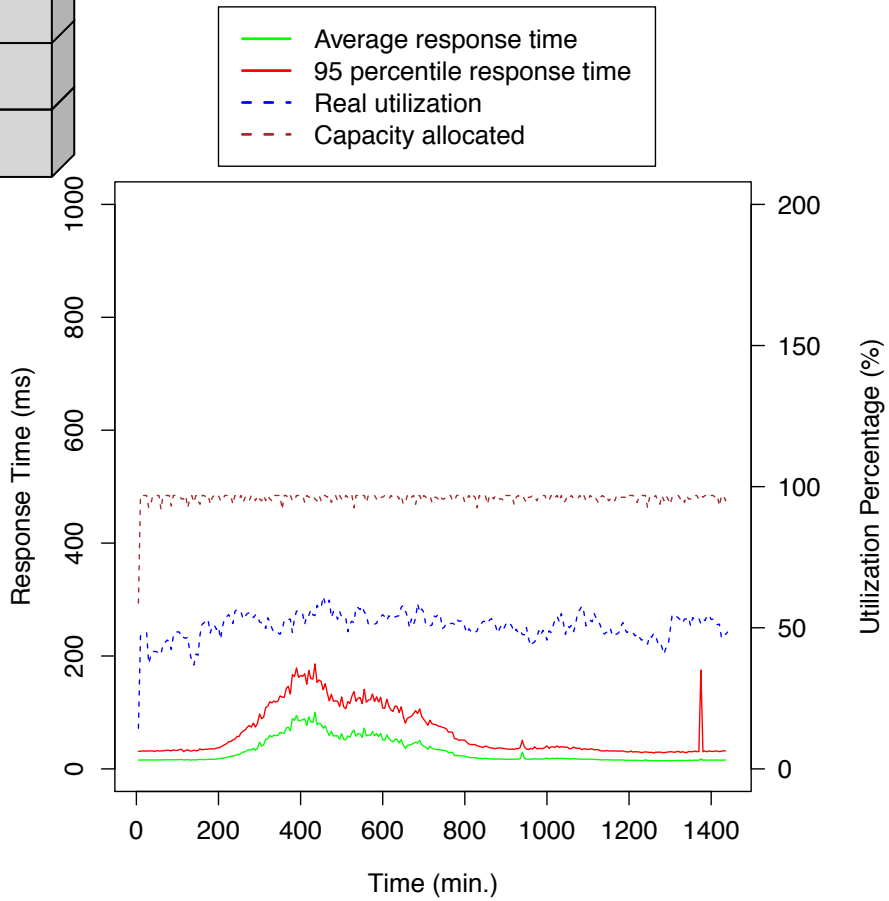
- Elasticity



- User overestimates

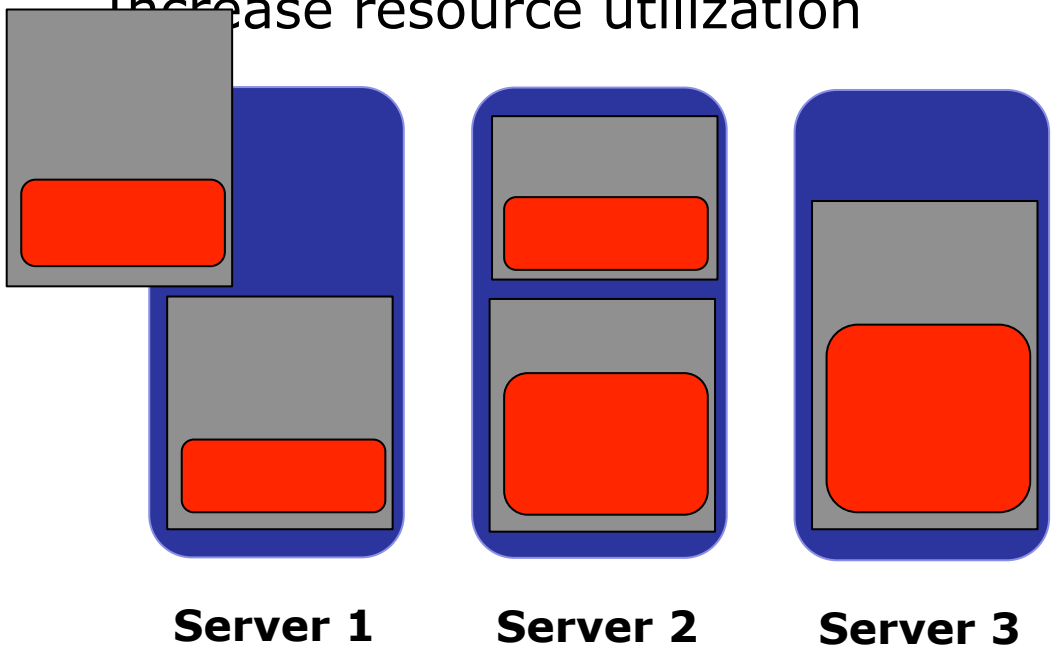


- T-shirt problem



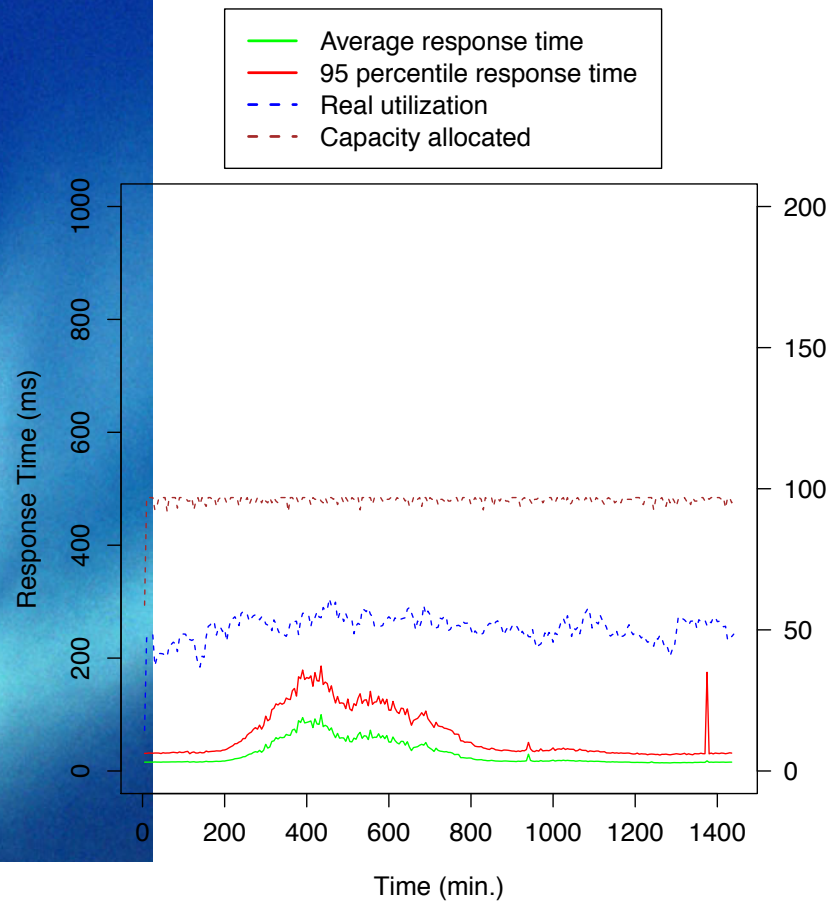
Overbooking

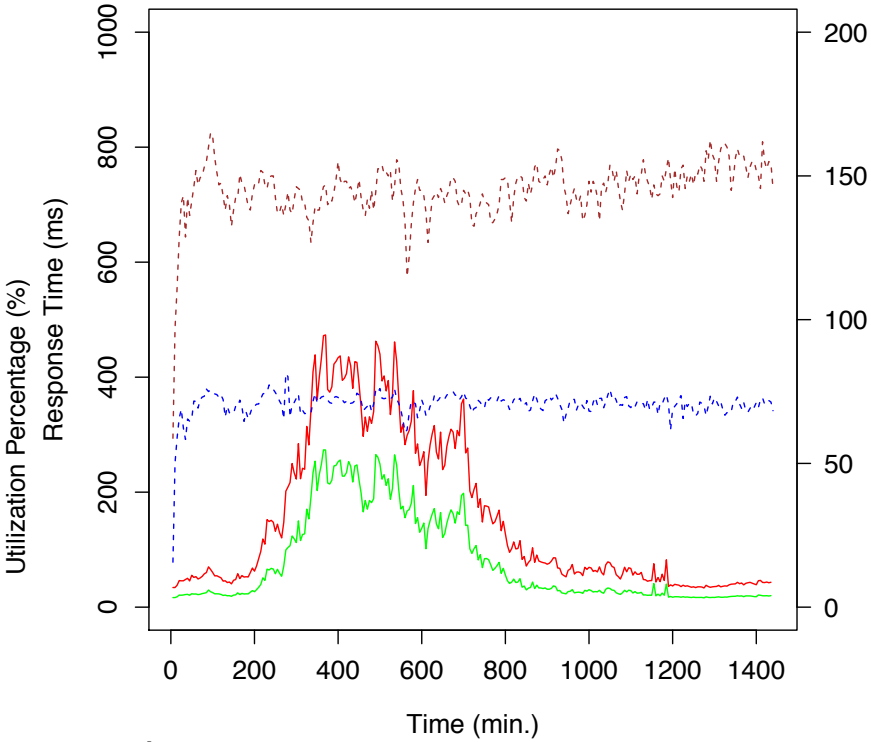
- ***Allocate more VMs than physical resources***
  - CPU, Memory, I/O
  - Higher VM consolidation
  - Increase resource utilization



Overbooking

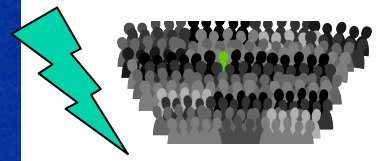
- Admission control
  - How many VMs to accept?
- Scheduling
  - Where to allocate the VMs?
- Load predictions
- Fuzzy risk assessment
- Feedback to adjust (PID controllers)





L. Tomás and J. Tordsson, An autonomic approach to risk-aware data center overbooking, *IEEE Transactions on Cloud Computing*, 2014

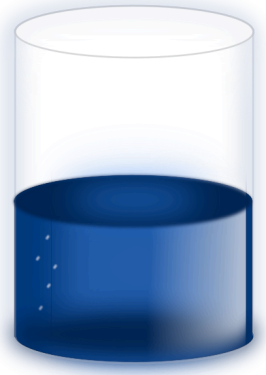
More adaptive applications? Brownout - handle unexpected load variations



flash-crowds

failures

Noisy neighbors



capacity shortage

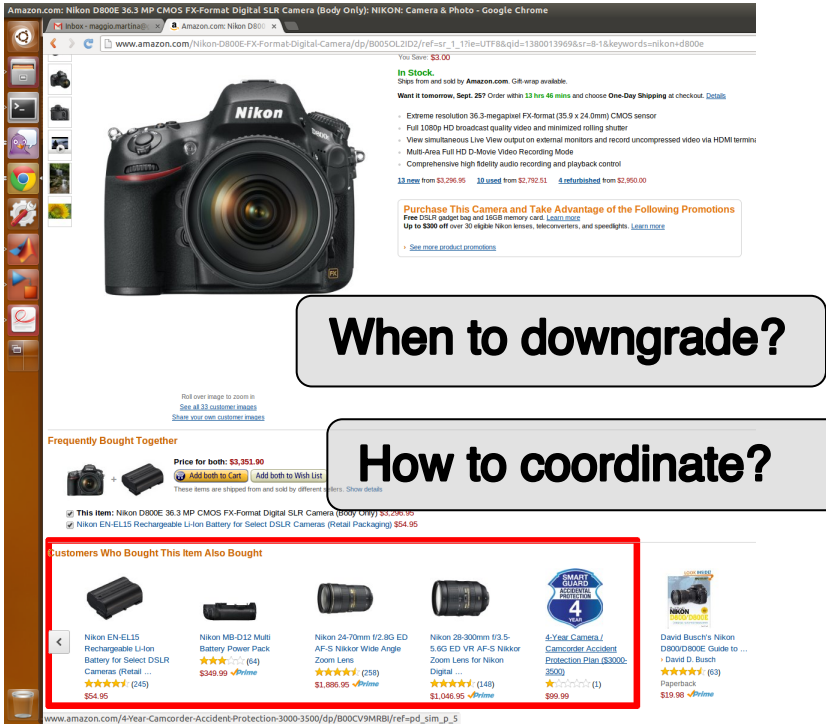
unresponsive application

- 82% of users give up on lost payment transactions*
- 25% of end-users leave if load time > 4s**
- 20% reduced income if 0.5s longer load time***
- **Impact on your eScience applications?**

* JupiterResearch ** Amazon ***Google

Brownout - graceful performance degradation

- Disable optional functionality on a per-request level
- Goals:
  - Maximize optional computing
  - Avoid high response times
- eScience usage?
  - Mesh refinement?
  - Rate-adaptive computing?
  - Real-time simulations?

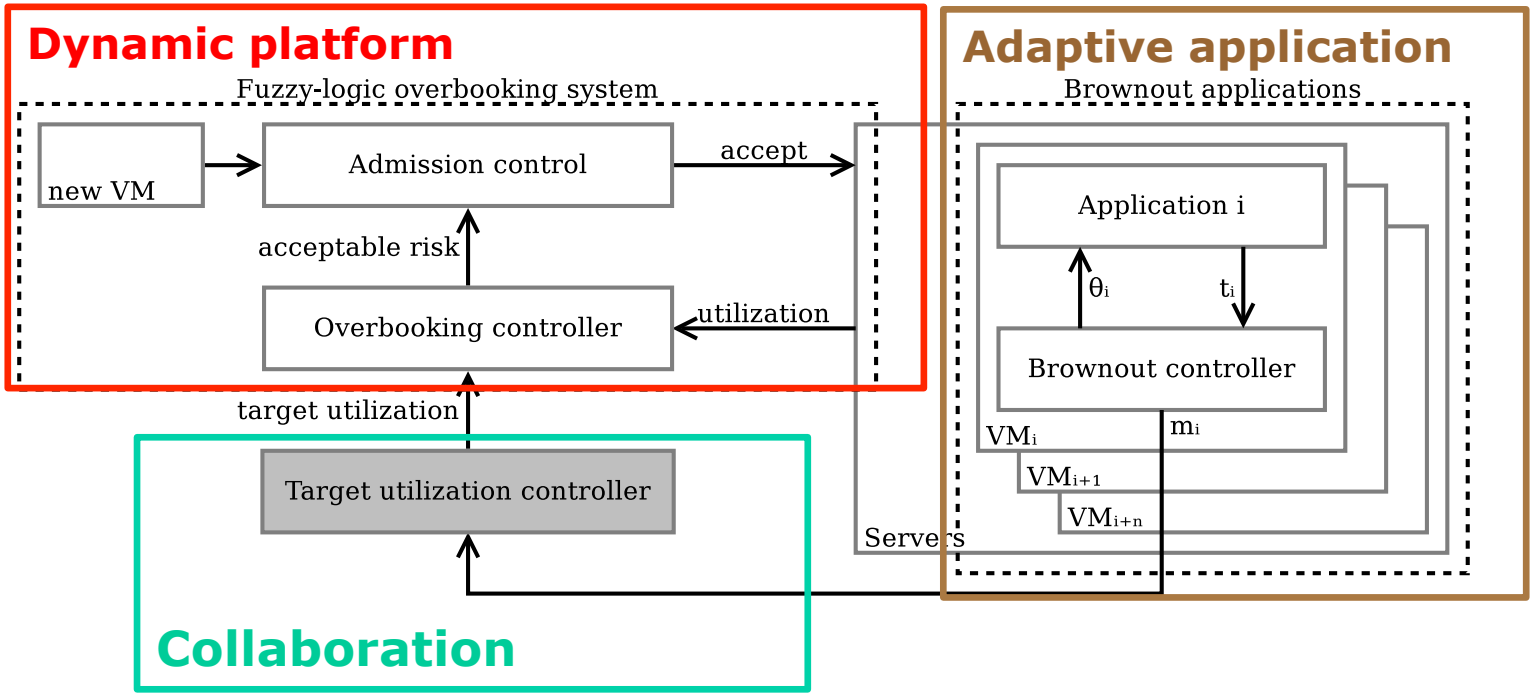


When to downgrade?

How to coordinate?

C. Klein, M. Maggio, K-E. Årzén, F. Hernández-Rodriguez, Brownout: Building More Robust Cloud Applications, *36th International Conference on Software Engineering*.

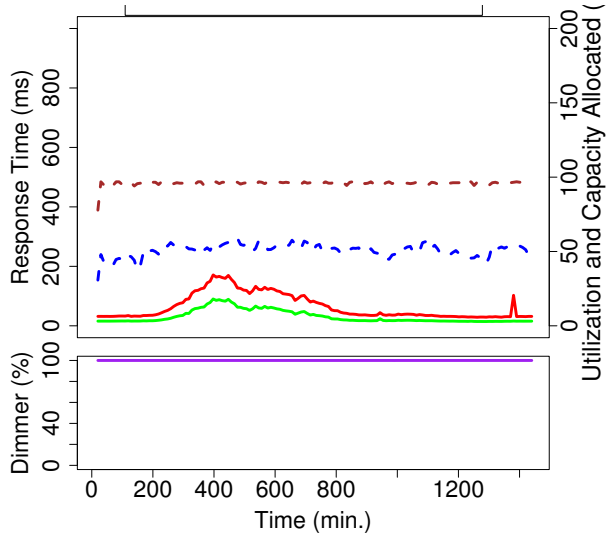
Application-Platform Collaboration?
BOB: Brownout + OverBooking



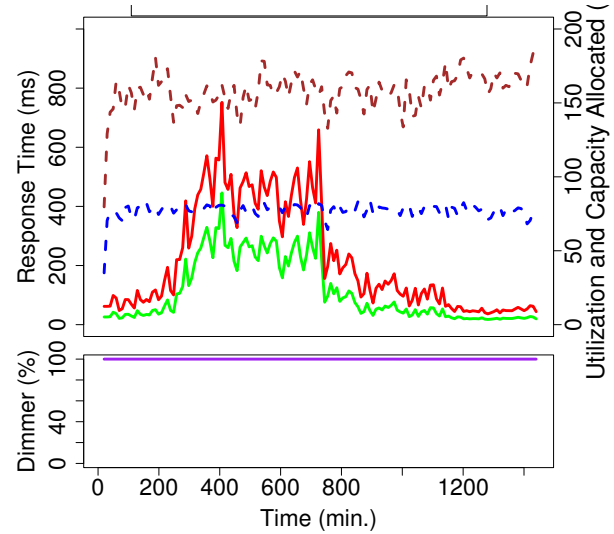
Collaboration - two approaches:

- naïve: brownout and overbooking used “as-is”
- smart: explicit communication is added

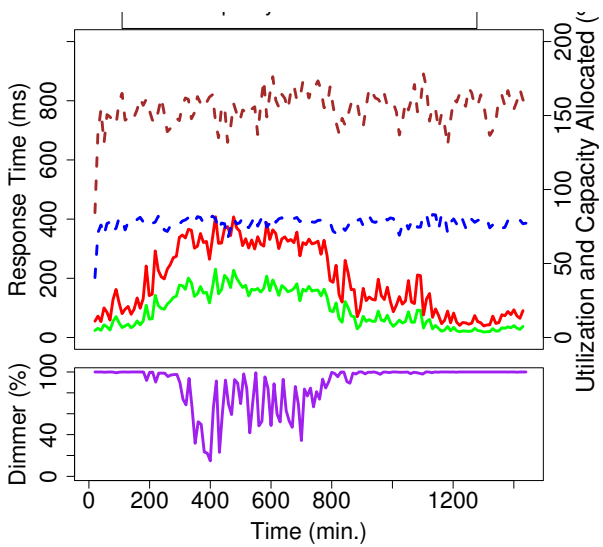
Sample results



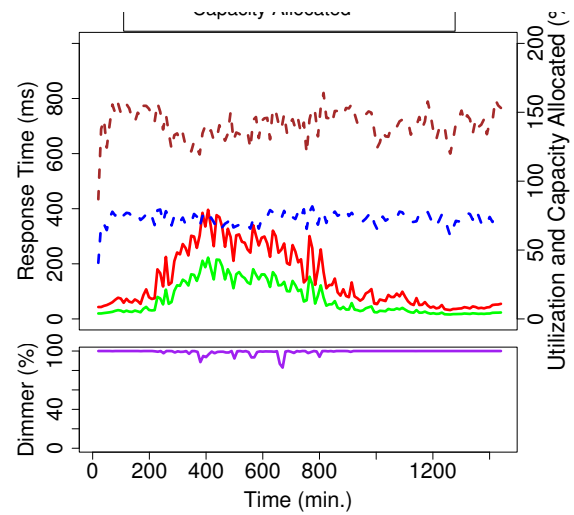
(a) Without overbooking



(b) With overbooking



(c) Naïve BOB



(d) Smart BOB

L Tomás, C Klein, J Tordsson, F Hernandez, The straw that broke the camel's back: safe cloud overbooking, *Cloud and Autonomic Computing (CAC) 2014*

Conclusions & perspectives

- Future computing platform will be diverse and more dynamic
- New (programming) paradigms will appear

- Adaptive applications key
- Applications must collaborate with platforms
  - Careful design of interacting adaptive systems required