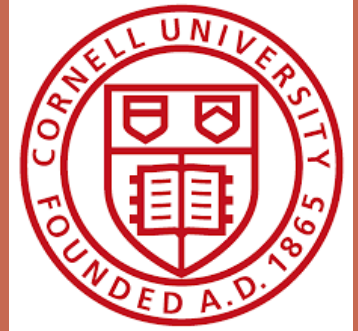
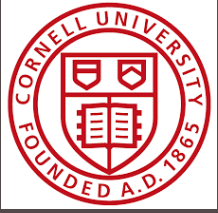


SUPERCLOUD: GOING BEYOND FEDERATED CLOUDS



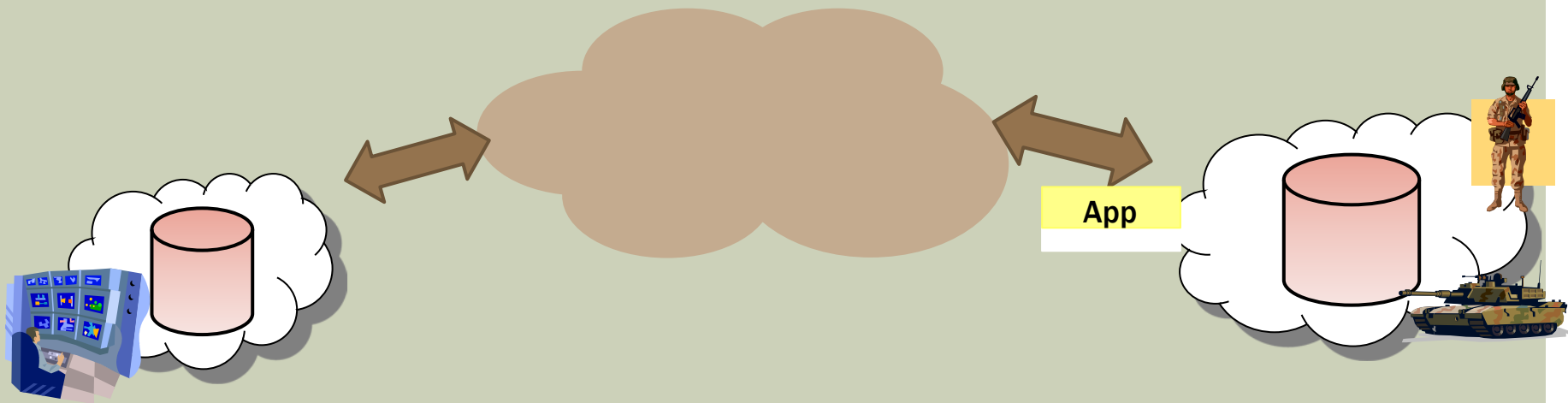
Hakim
Weatherspoon

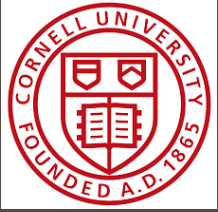
Robbert
van Renesse



CONTROLLING HIGH ASSURANCE CLOUD COMPUTATION

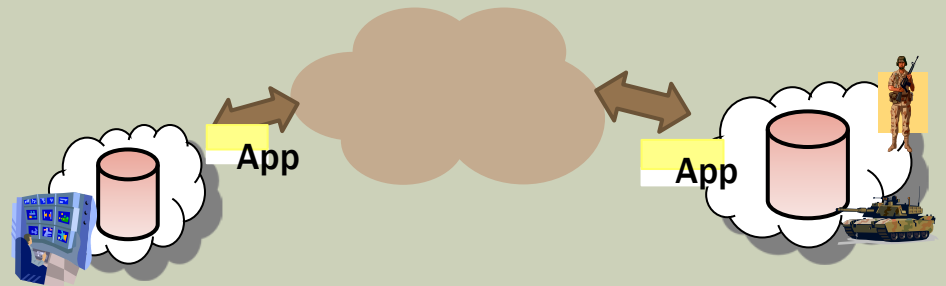
- Should we migrate critical data to computation
- . . . or vice versa?
 - E.g. app needs to import or export data



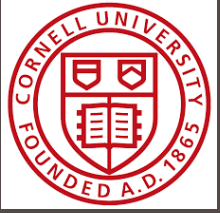


CONTROLLING HIGH ASSURANCE CLOUD COMPUTATION

- Should we migrate critical data to computation
- . . . or vice versa?
 - E.g. app needs to import or export data
- Challenges
 - Limited bandwidth tactical networks
 - Interoperability
 - Secure sharing



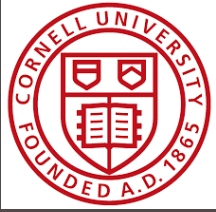
**How can we securely and efficiently
migration computation across the cloud?**



INFRASTRUCTURE AS A SERVICE

- Offer on-demand virtual machines
- Charge according to used hours
- Multiple data center locations





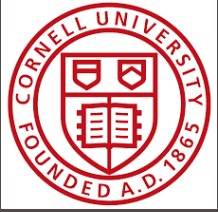
PROBLEM – SINGLE CLOUD

- Vendor lock-in
 - Latency limitation
 - No control of price
 - Availability limitation



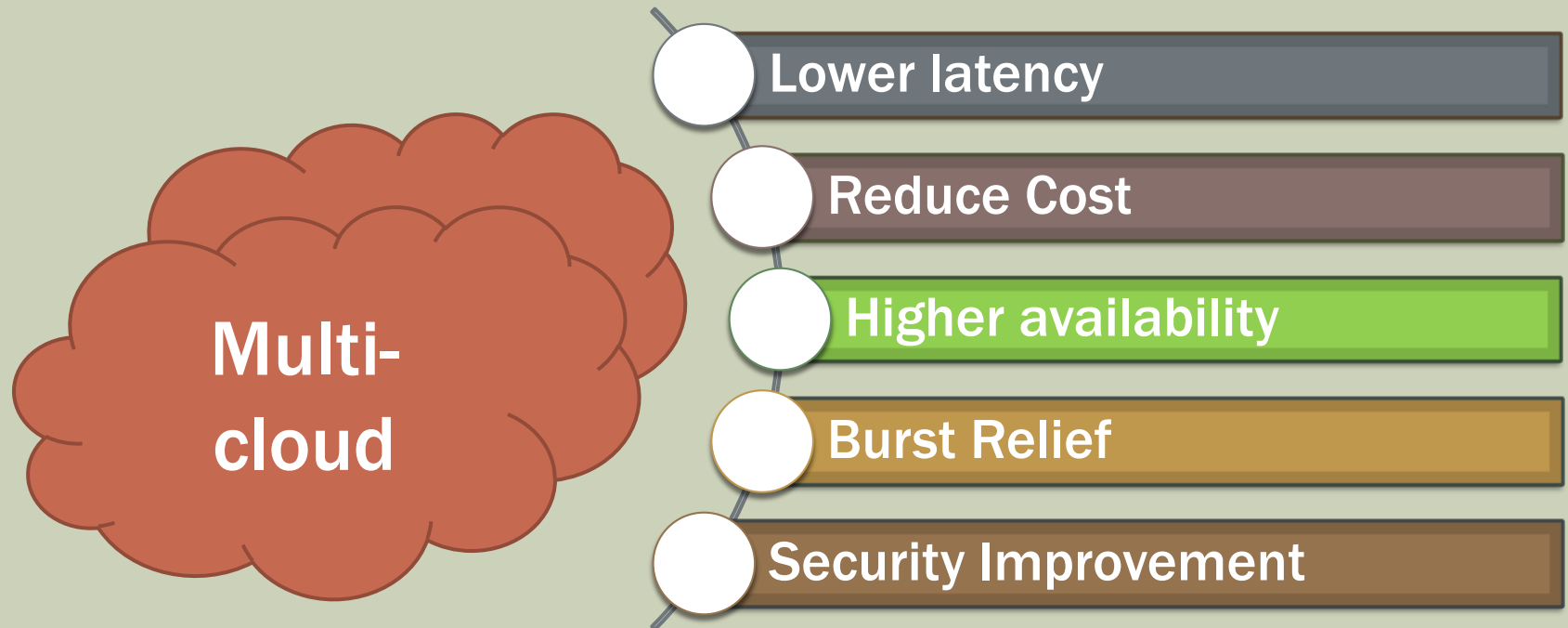
Which one?
Price?
Migration?
Availability?

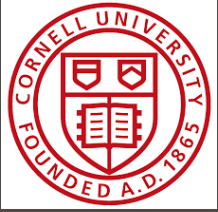




BENEFITS OF MULTIPLE CLOUDS

Provide power, control and flexibility to user

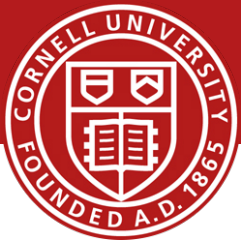




SUPERCLOUD

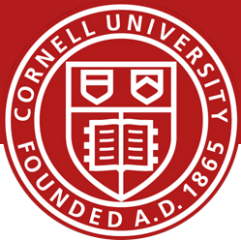
- The Supercloud goes beyond a Federated Cloud in that it
 - supports *user-level* migration between autonomous clouds;
 - Permits environment to include “stubs” for resources that actually are tied to specific places, making them seem to be available from anywhere;
 - supports a variety of underlying virtual machine monitors;
 - supports a shared but decentralized storage system and a novel virtualized network that can migrate with the app;
 - supports system-wide pub/sub for event notification.

Unshackle the Cloud: xClouds

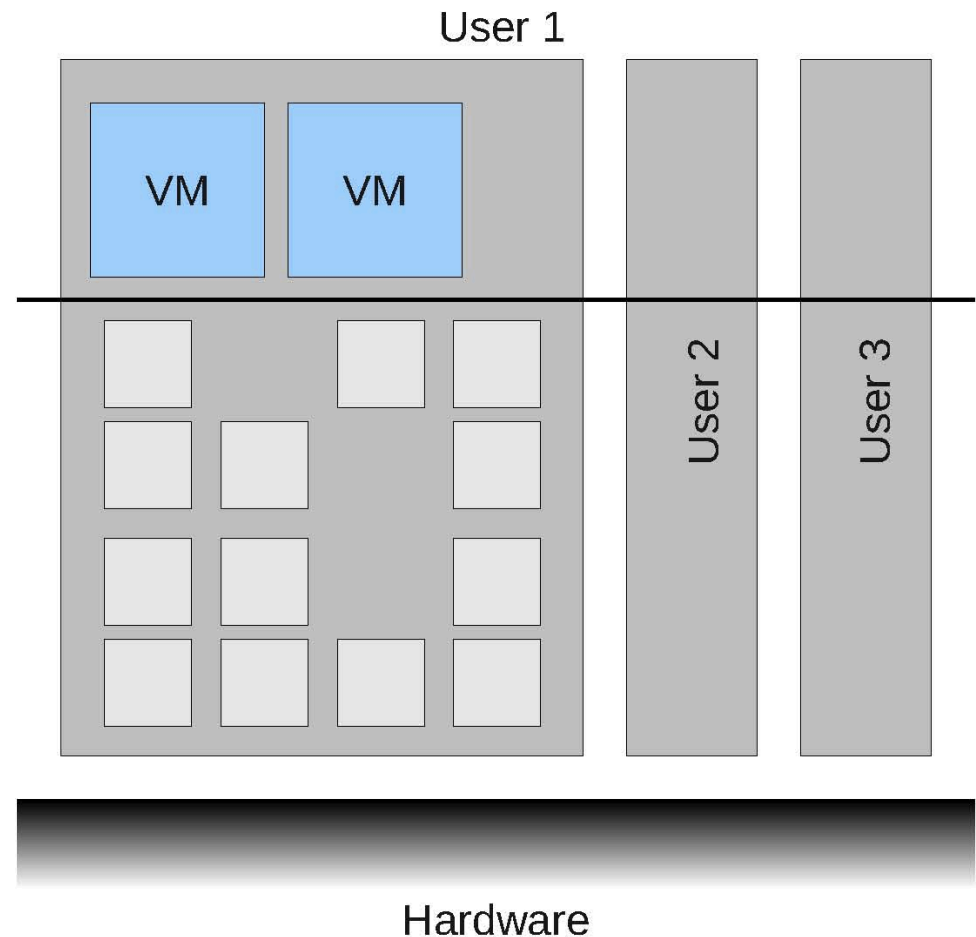


- Bring **extensibility** into IaaS clouds
- Allow users to run or implement **their own hypervisor-level services**
- Avoid lock-in with **user-centric homogenization**

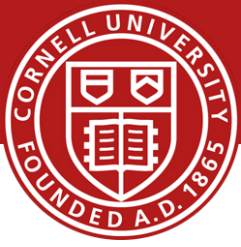
How to Build xClouds



- Users are isolated
- VMM composed of **modules**

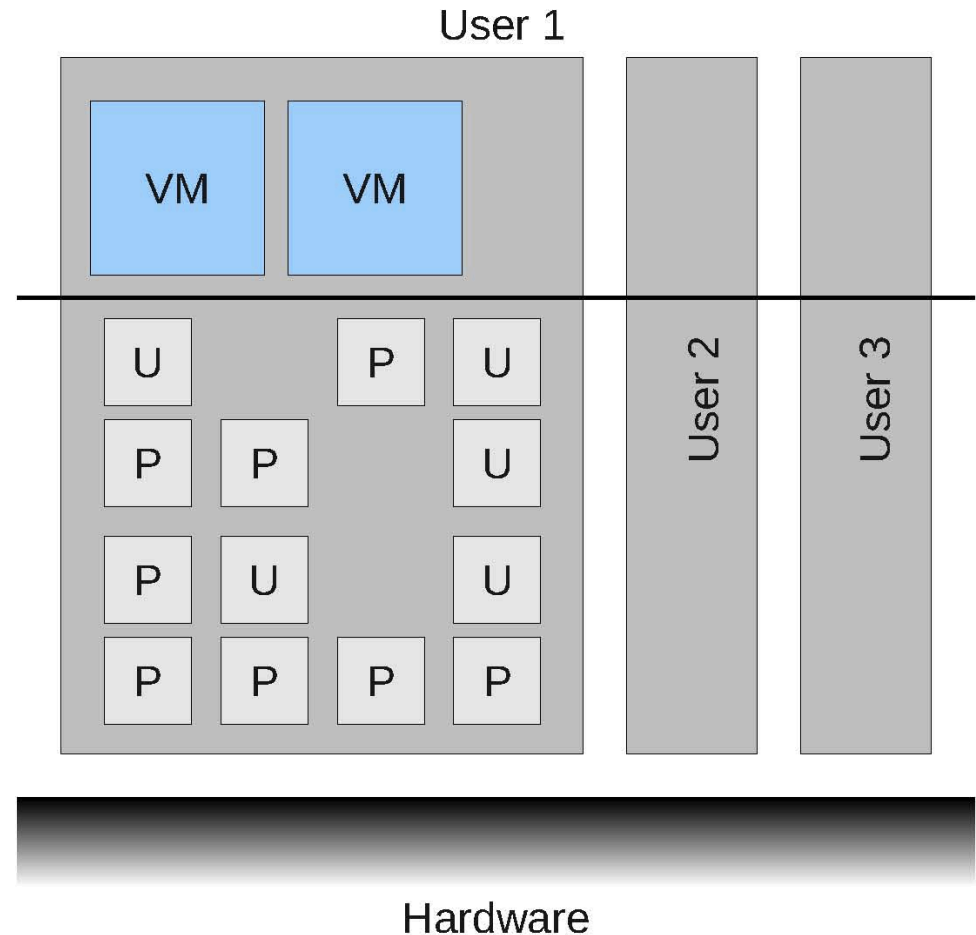


How to Build xClouds

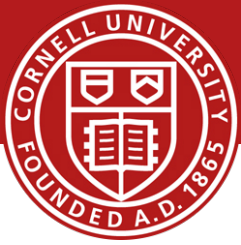


- Users are isolated
- VMM composed of **modules**
 - User / Provider

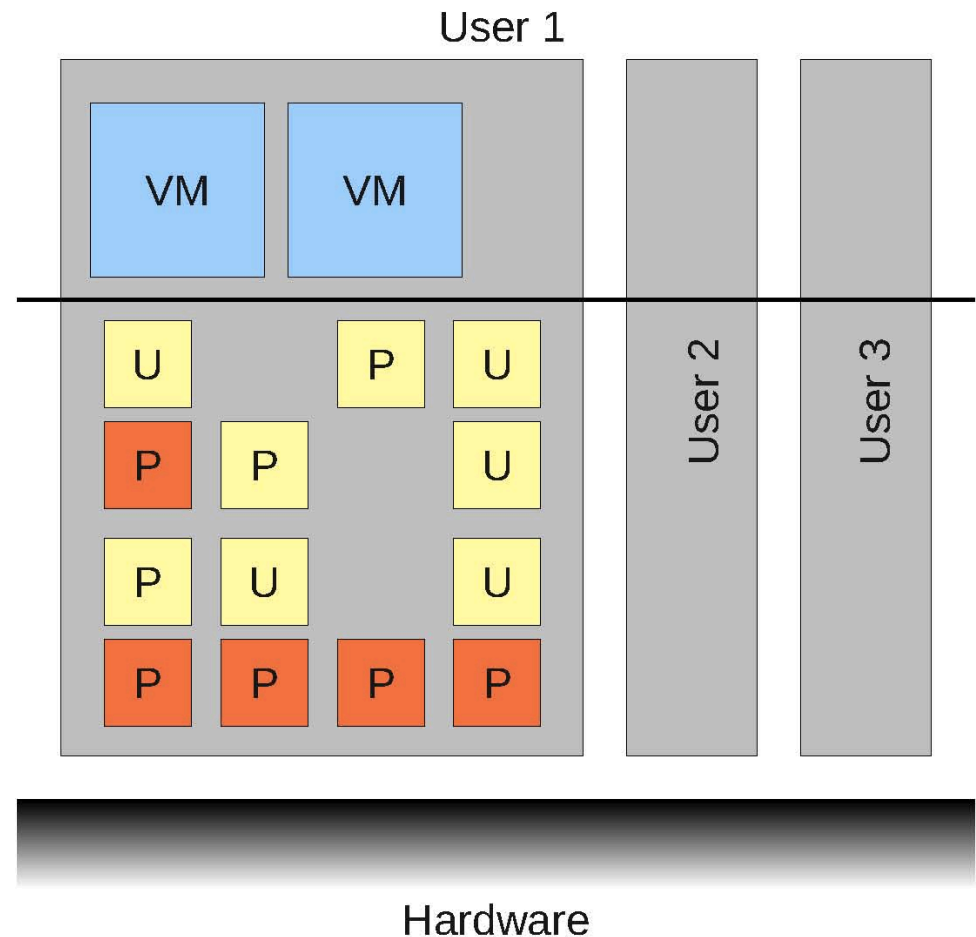
(U / P)



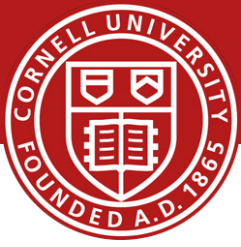
How to Build xClouds



- Users are isolated
- VMM composed of **modules**
 - User / Provider
(U / P)
 - Mutable / Immutable
(/)



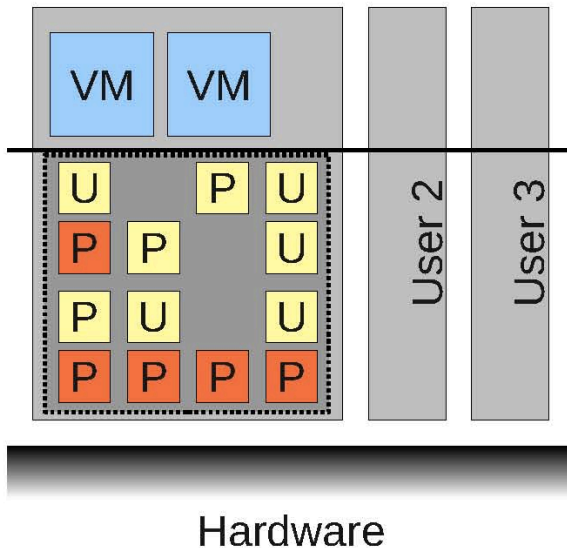
How to Build xClouds: Alternatives



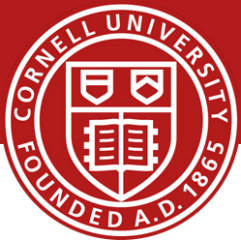
Download VMM Extensions

e.g SPIN, VINO

Providers must adopt new VMM



How to Build xClouds: Alternatives



Download VMM Extensions

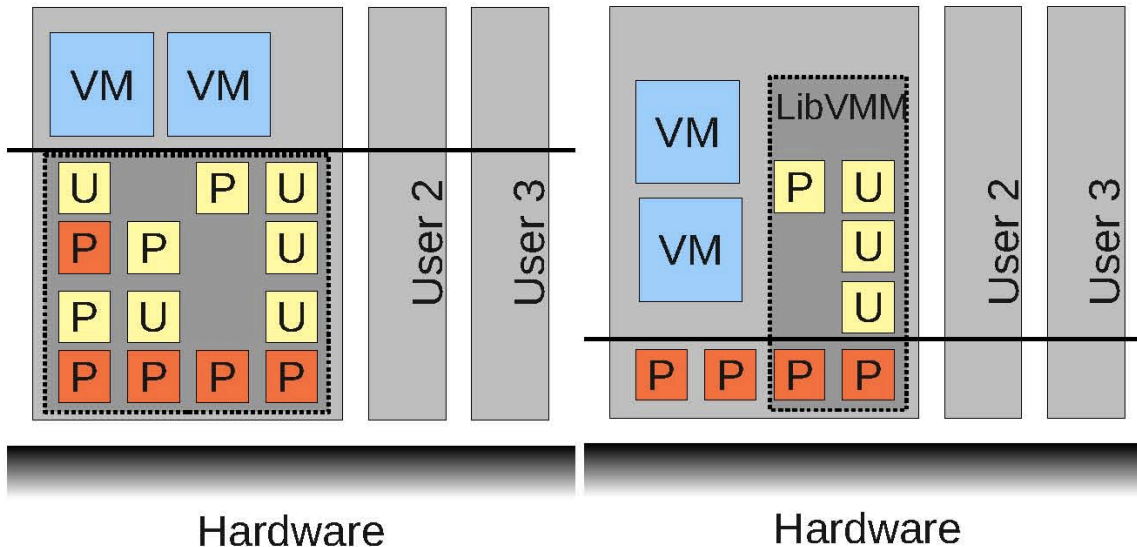
e.g SPIN, VINO

Providers must adopt new VMM

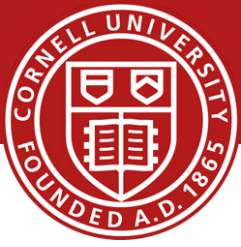
Expose Hardware Through VMM

e.g. Exokernel

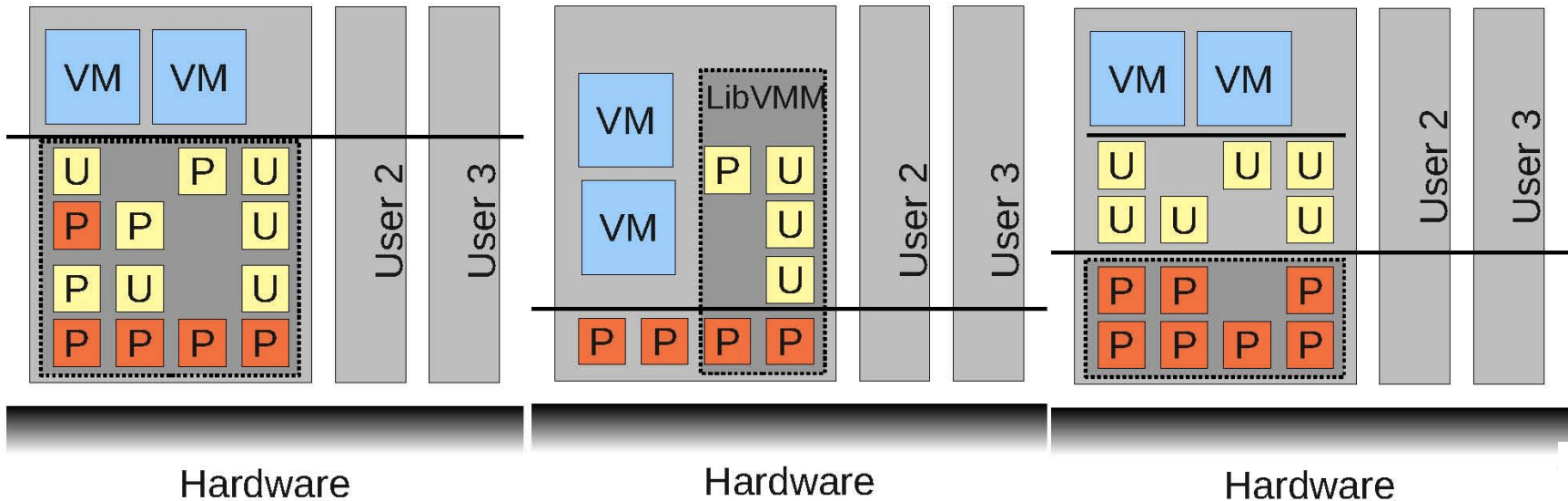
Providers must adopt new VMM

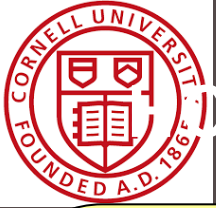


How to Build xClouds: Alternatives

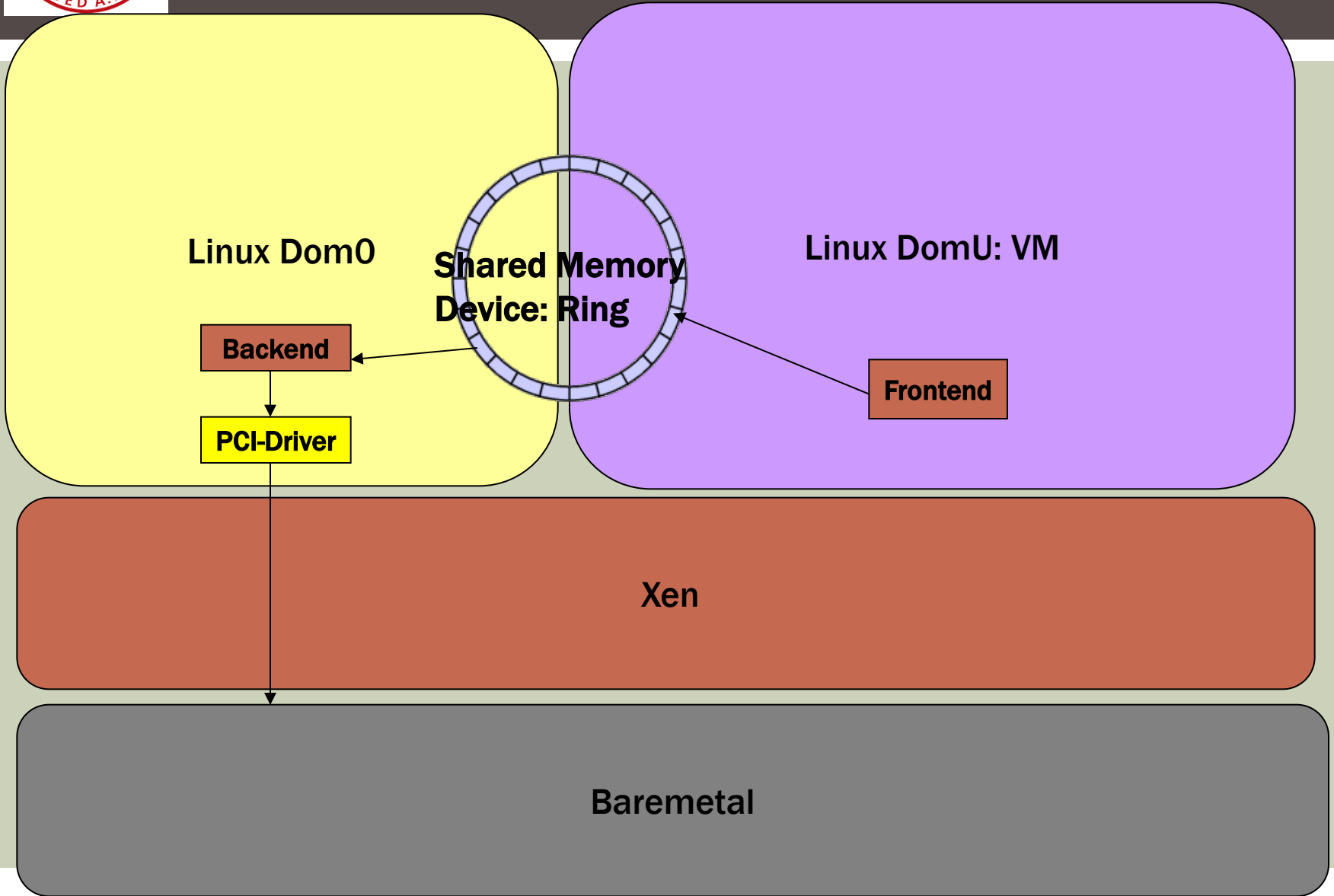


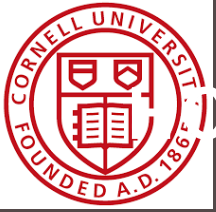
Download VMM Extensions	Expose Hardware Through VMM	Add Another VMM
e.g. SPIN, VINO	e.g. Exokernel	e.g. Turtles Project
Providers must adopt new VMM	Providers must adopt new VMM	Turtles needs VMM support, but...



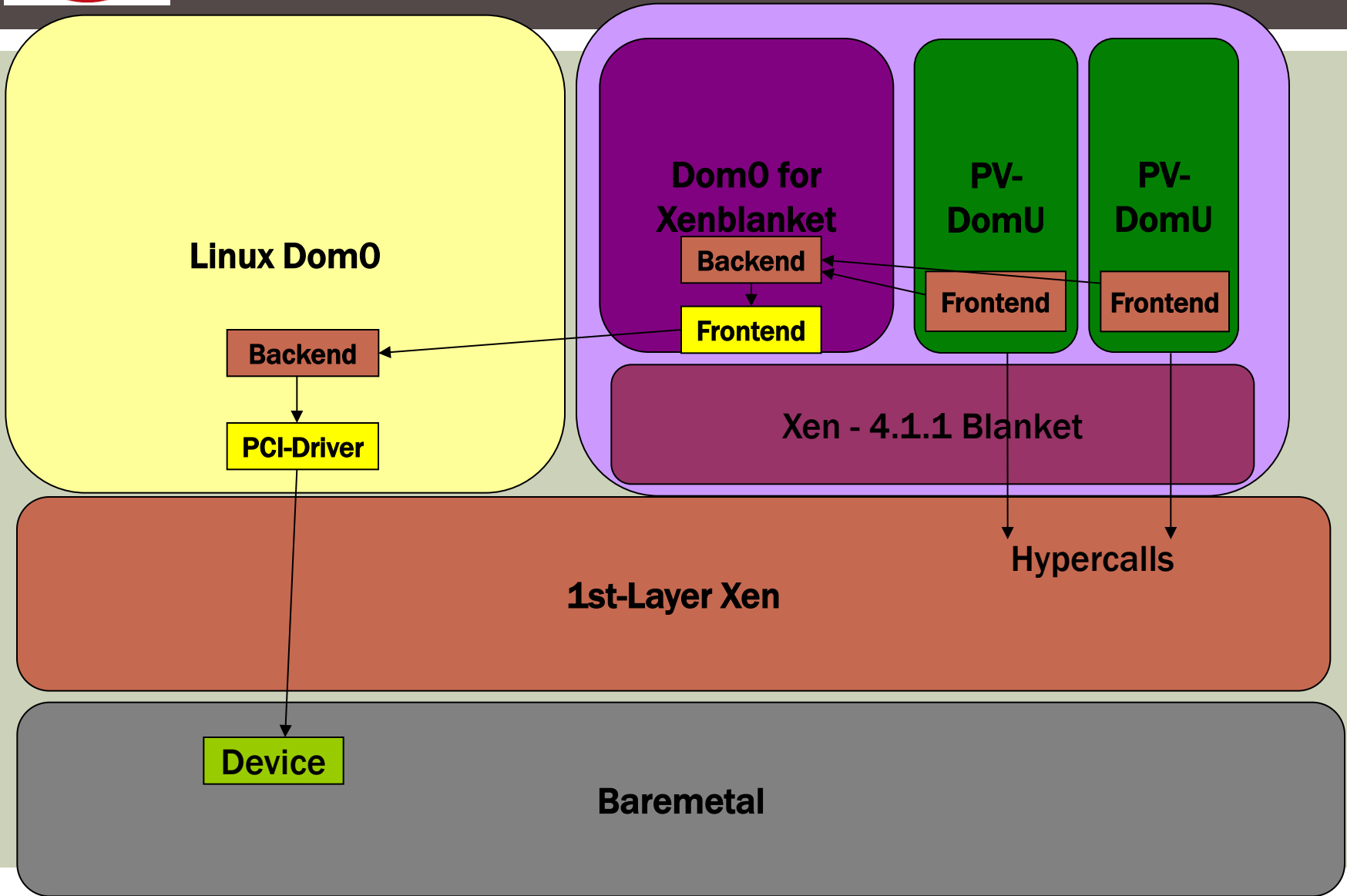


HOW TO BUILD XCLOUDS: ANOTHER LAYER

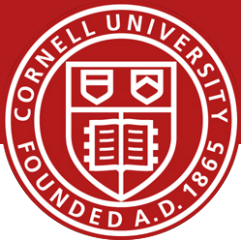




HOW TO BUILD XCLOUDS: ANOTHER LAYER



xClouds works Today!

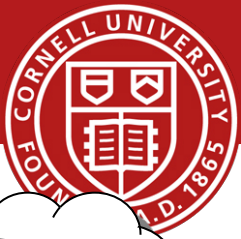


- Nested paravirtual device drivers
- Xen on EC2

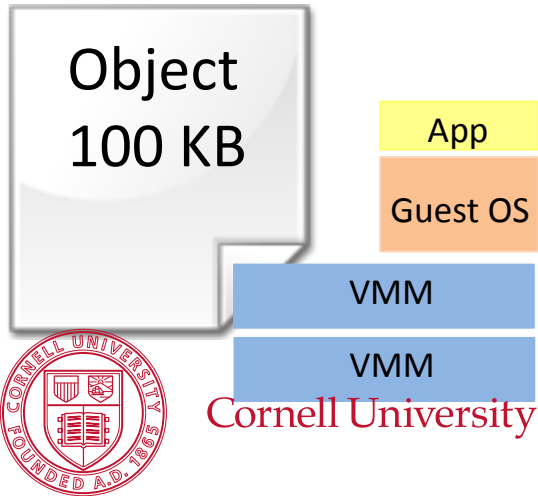
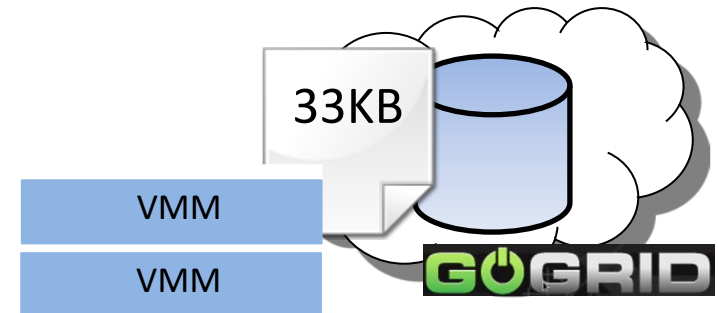
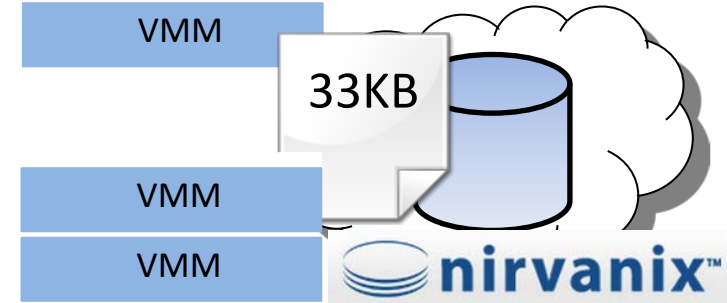
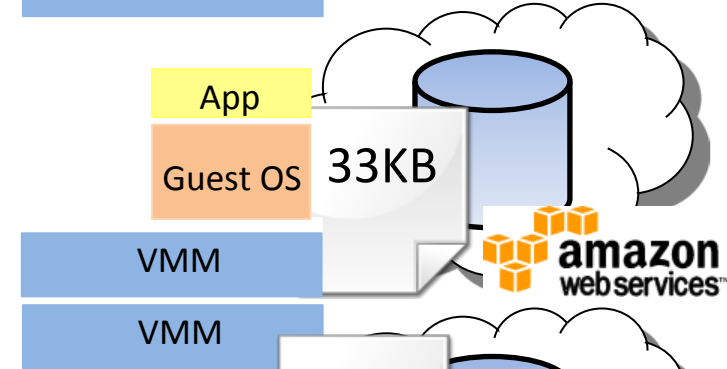
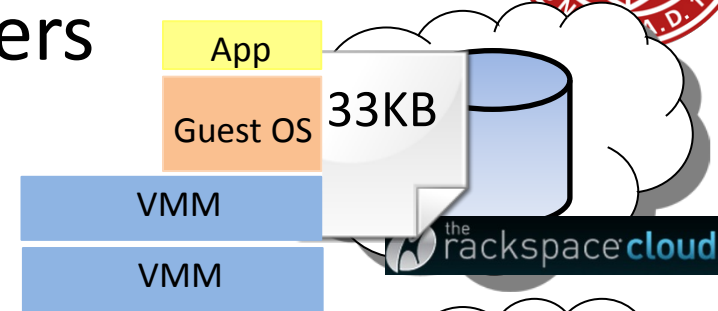
The screenshot shows the AWS Management Console interface. The top navigation bar includes the AWS logo and the text "AWS Management Console". Below this, the URL "aws.amazon.com" is visible. The main content area is titled "System Log: i-dbad5fb7". On the left side, there is a navigation menu with "Amazon S3" and "Amazon EC2" tabs, and a "Navigation" section with "Region:" and "EC2 Dashb". The main log area displays the following text:

```
XEN  
512=194521  
http://www.cl.cam.ac.uk/netos/xen  
University of Cambridge Computer Laboratory  
Xen version 3.1.2-194.32.1.el5 (mockbuild@centos.org)  
Latest ChangeSet: unavailable  
(XEN) Command line: com1-115200 8m1 console=com1
```

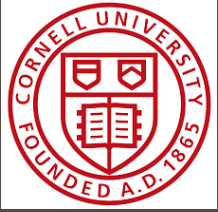
xClouds works Today!



- Nested paravirtual device drivers
- Xen on EC2

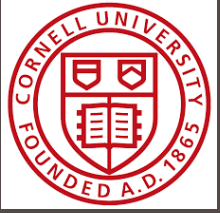


- Can create your own *Cloud-within-a-Cloud*



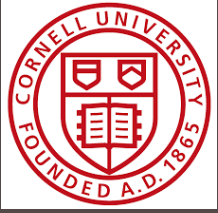
HOW TO BUILD XCLOUDS: ANOTHER LAYER

- **Event-Channel Drivers for virtual interrupts**
 - One for Receive Event from 1st-Layer Xen: virtual interrupts
 - One for multiplexing to nested DomU
- **Grant Page Table Drivers for shared memory**
 - One for Shared Ring buffer with 1st-Layer Dom0
 - One for sharing memory with/or between nested DomUs
- **Two Xenbus drivers**
 - One for connect to 1st-Layer shared memory devices
 - One for nested DomUs to connect to nested shared memory devices
- **Block and Net Frontend Drivers**
 - - For virtual disk and network devices of nested Dom0



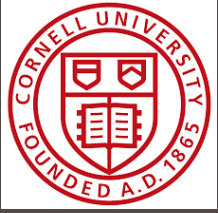
HYPERCALL PASSTHROUGH

- **Need Hypercall Passthrough**
 - Nested Dom0 must be able to get information about shared memory devices from 1st Layer-Xen
 - Nested Dom0 can only issue hypercall to Nested Xen
 - So, nested Xen should help passthrough related hypercalls



KILLER APPS FOR THE SUPERCLOUD

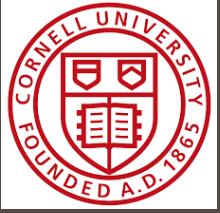
- Sensitive Resource
- Follow the sun
- Geographic proximity
- Spot Instances
- Dynamic Resource Scaling
- Bursting



KILLER APPS FOR THE SUPERCLOUD

- **Sensitive resource**
 - Some provider has a special device, or special data
 - Supercloud allows you to add a “stub” for it to your environment. Looks like a normal local device or local data file / database

- **If you access the resource, SuperCloud migrates your VM to where it resides**
 - Moving computation to data on demand avoids locking app to the place where that resource resides



SUPERCLOUD CHALLENGES

Uniform VM image?

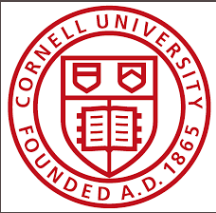
- using nested virtualization

Cross-cloud migration?

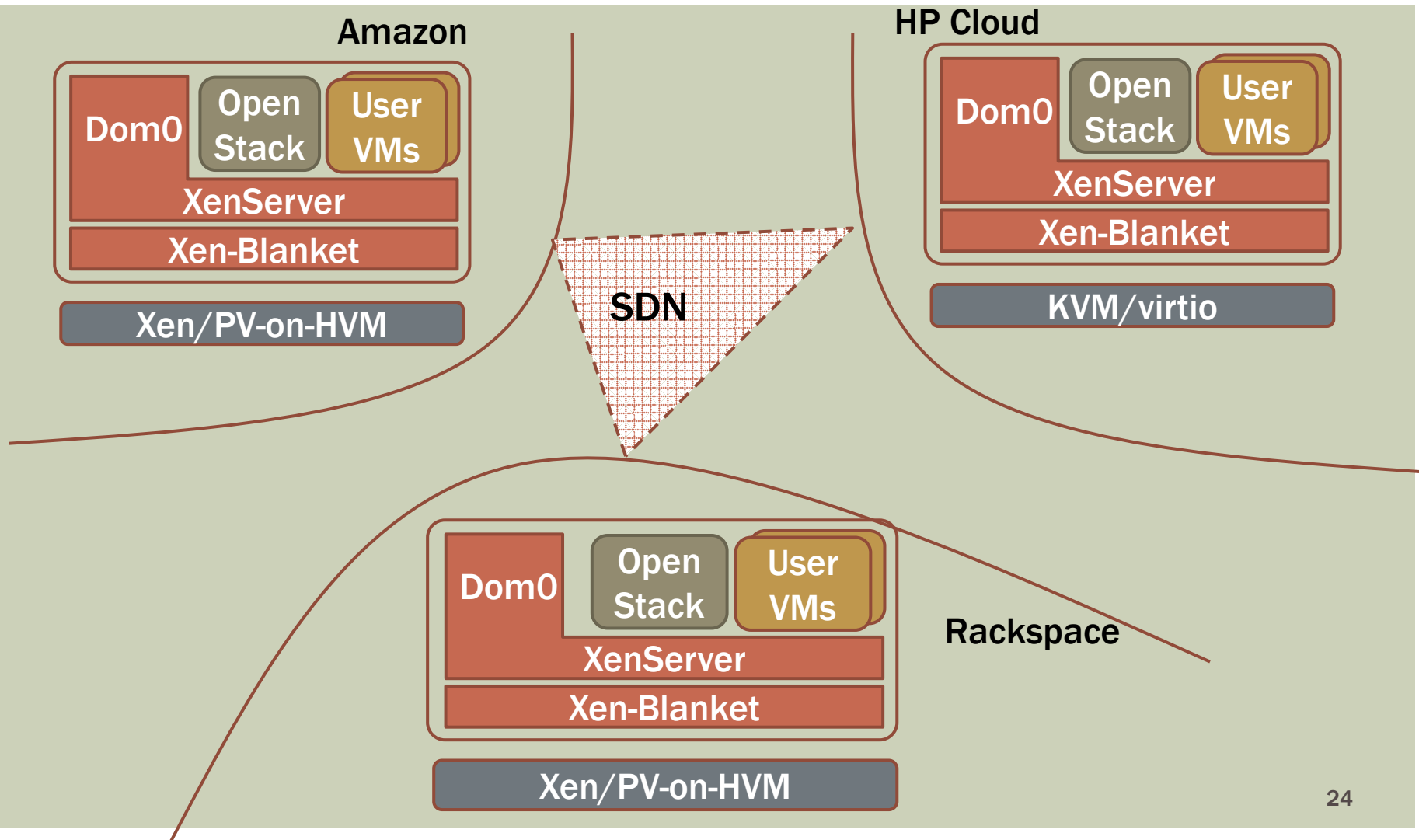
- developed a new image storage facility

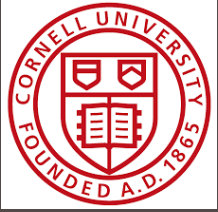
Transparent networking?

- based on SDN: Open vSwitch and VXLAN



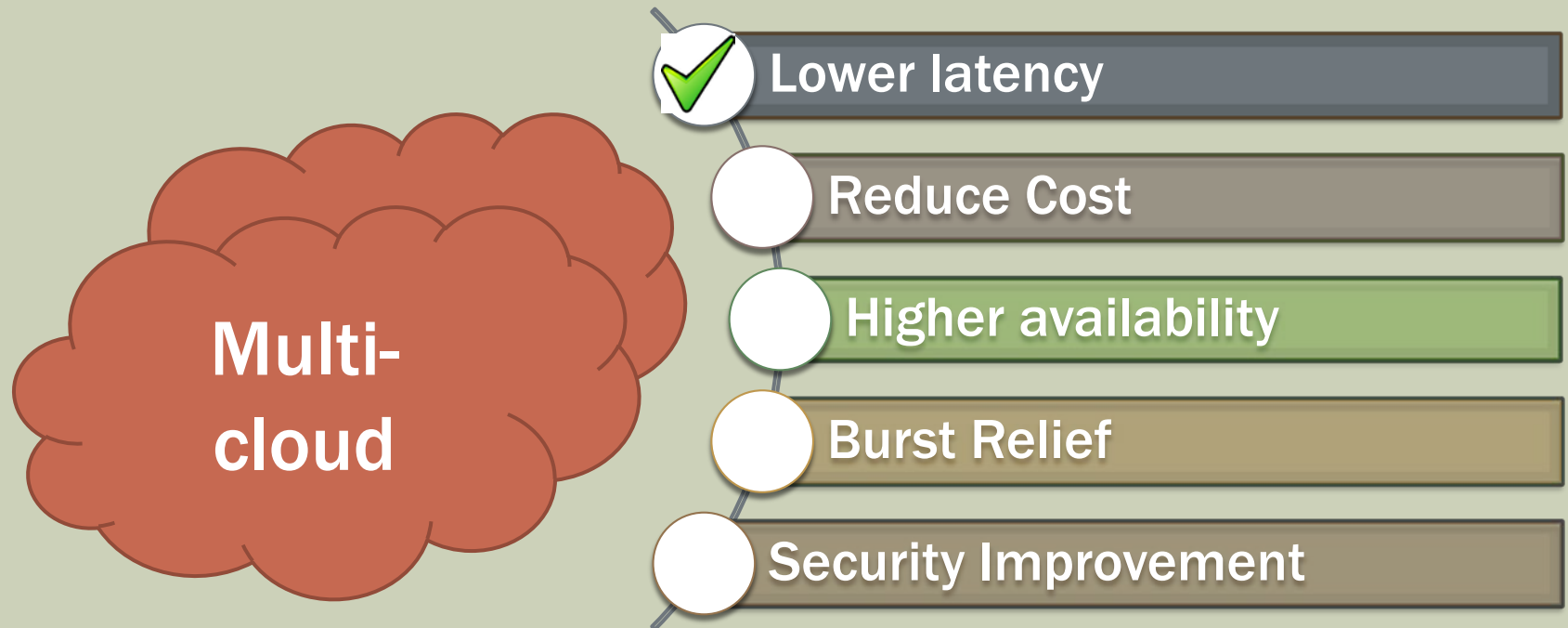
SUPERCLOUD ARCHITECTURE

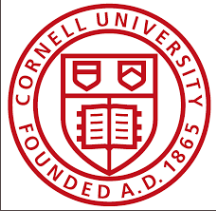




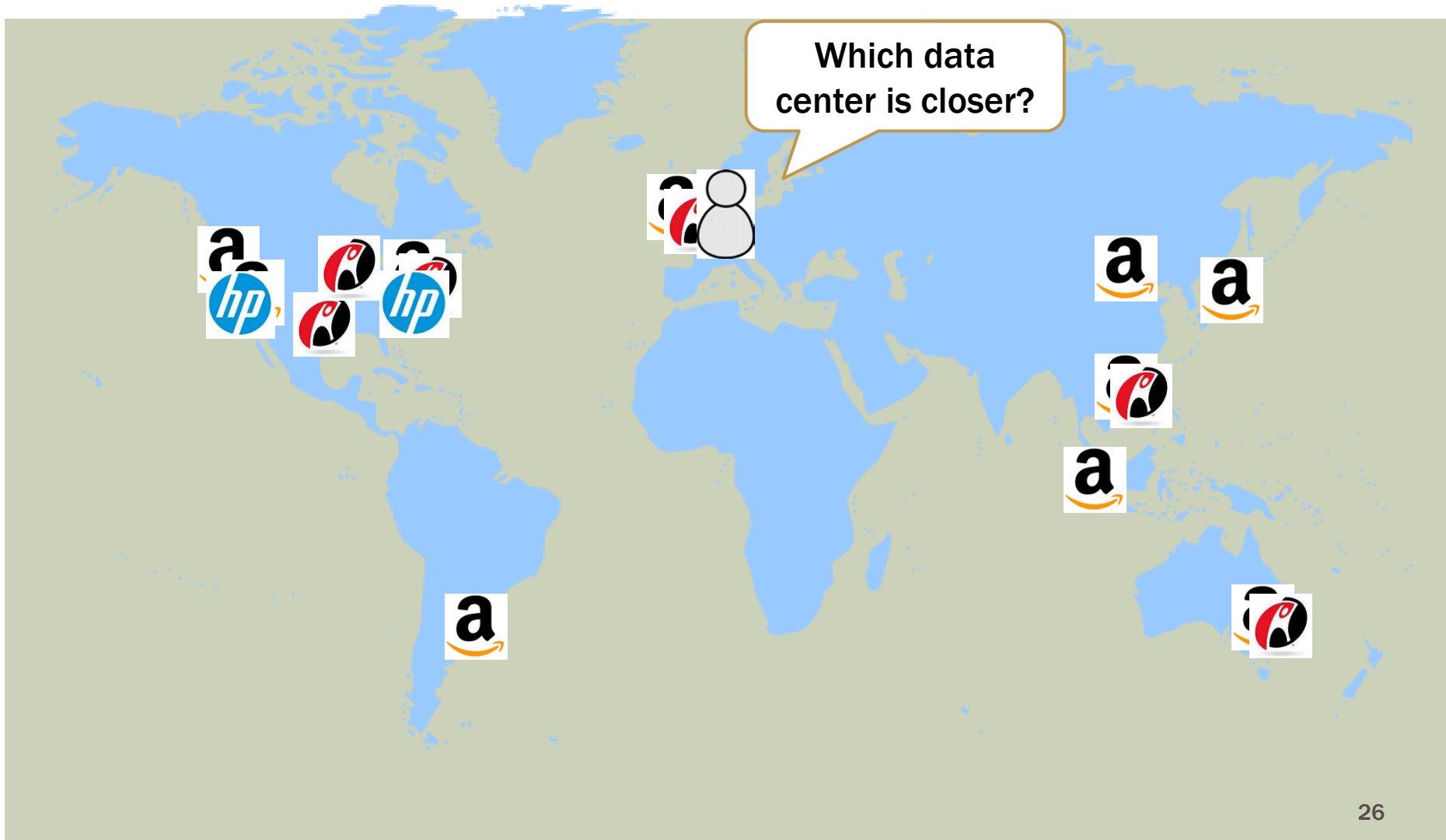
BENEFITS OF MULTIPLE CLOUDS

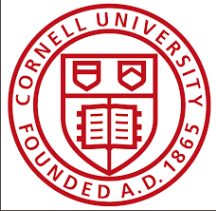
Provide power, control and flexibility to user



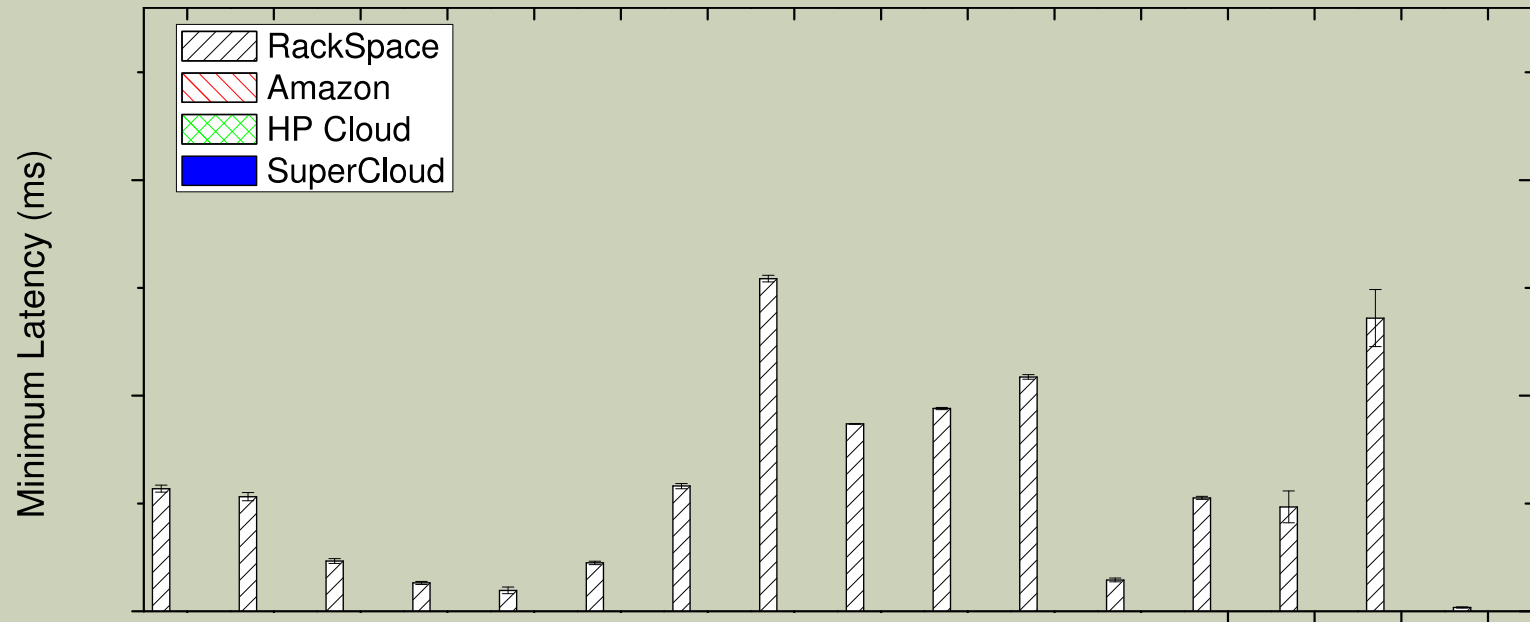


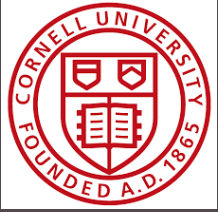
CONTENT DELIVERY NETWORK



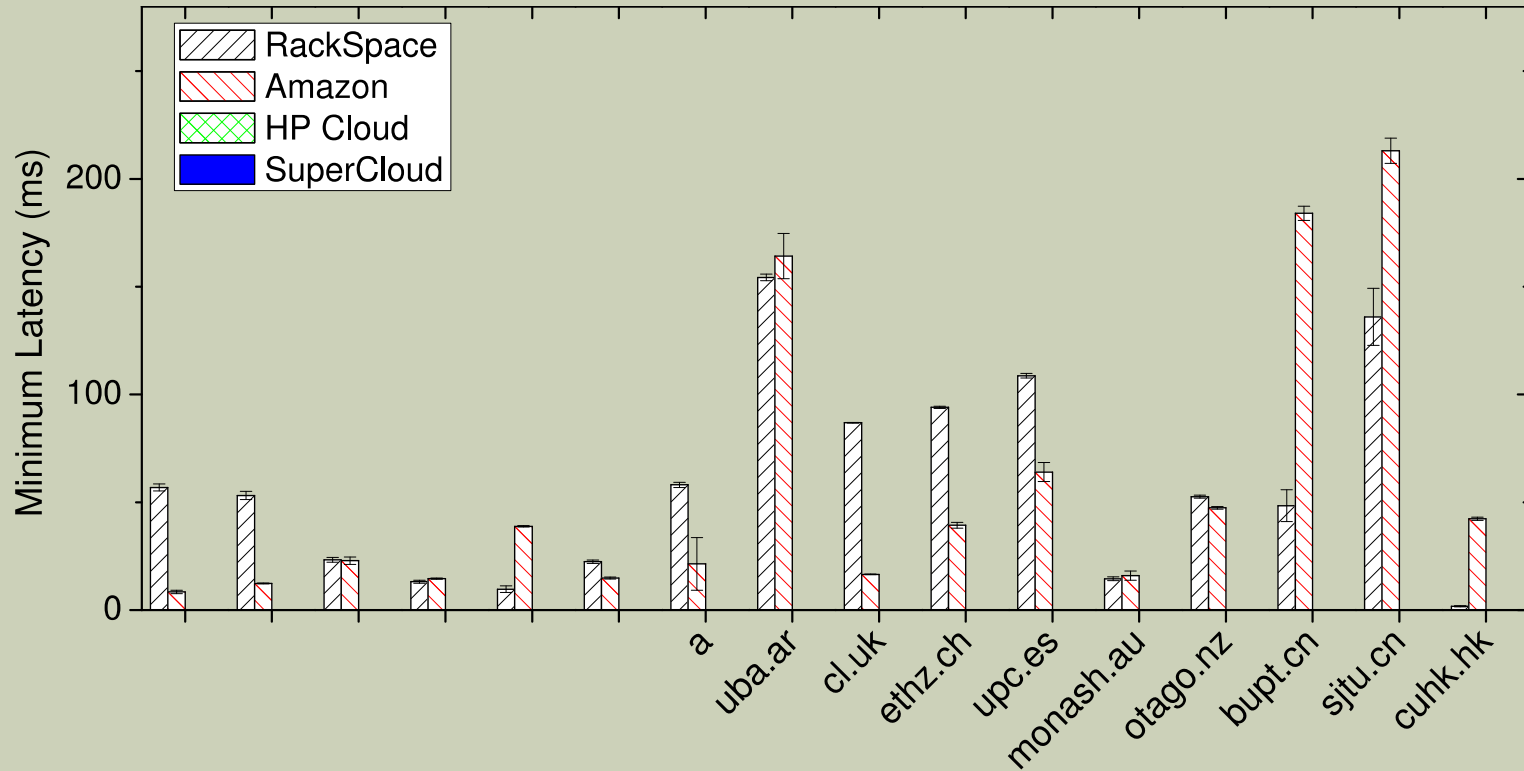


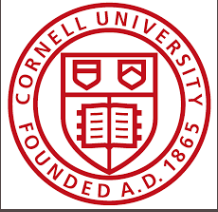
CONTENT DELIVERY NETWORK



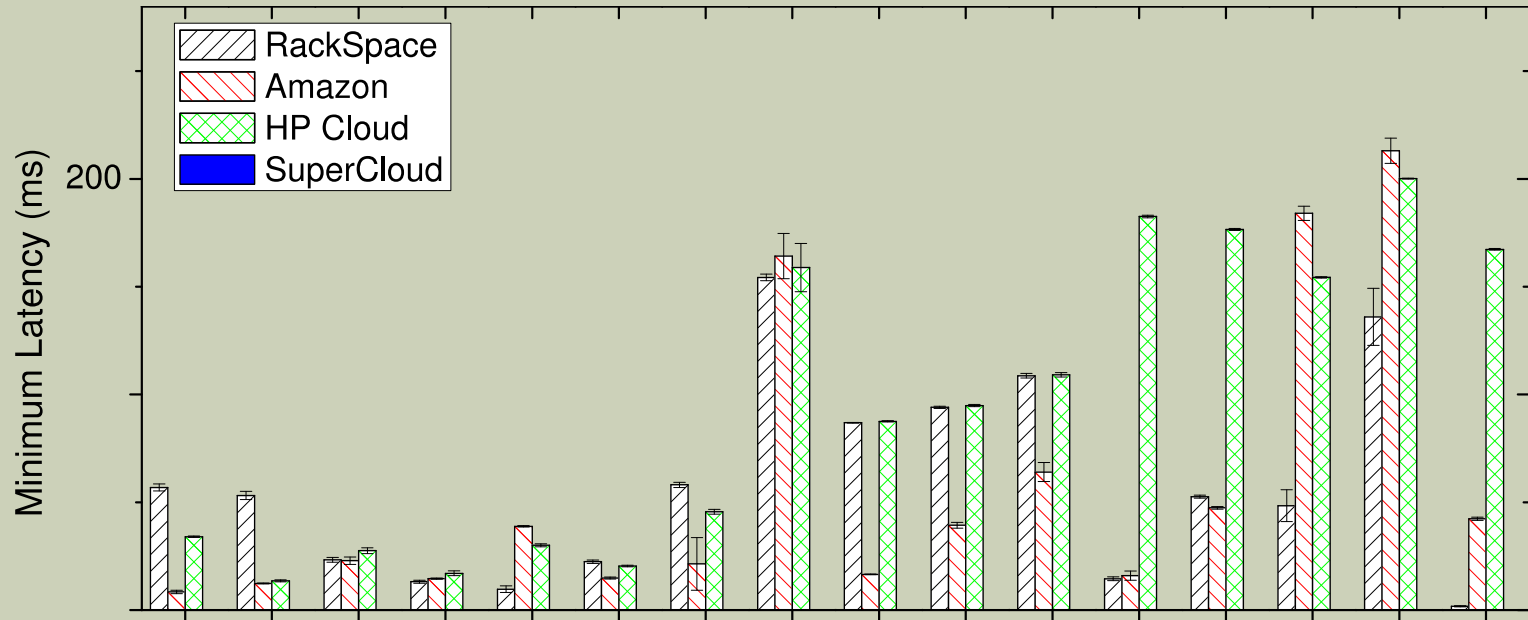


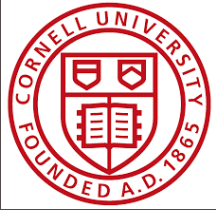
CONTENT DELIVERY NETWORK



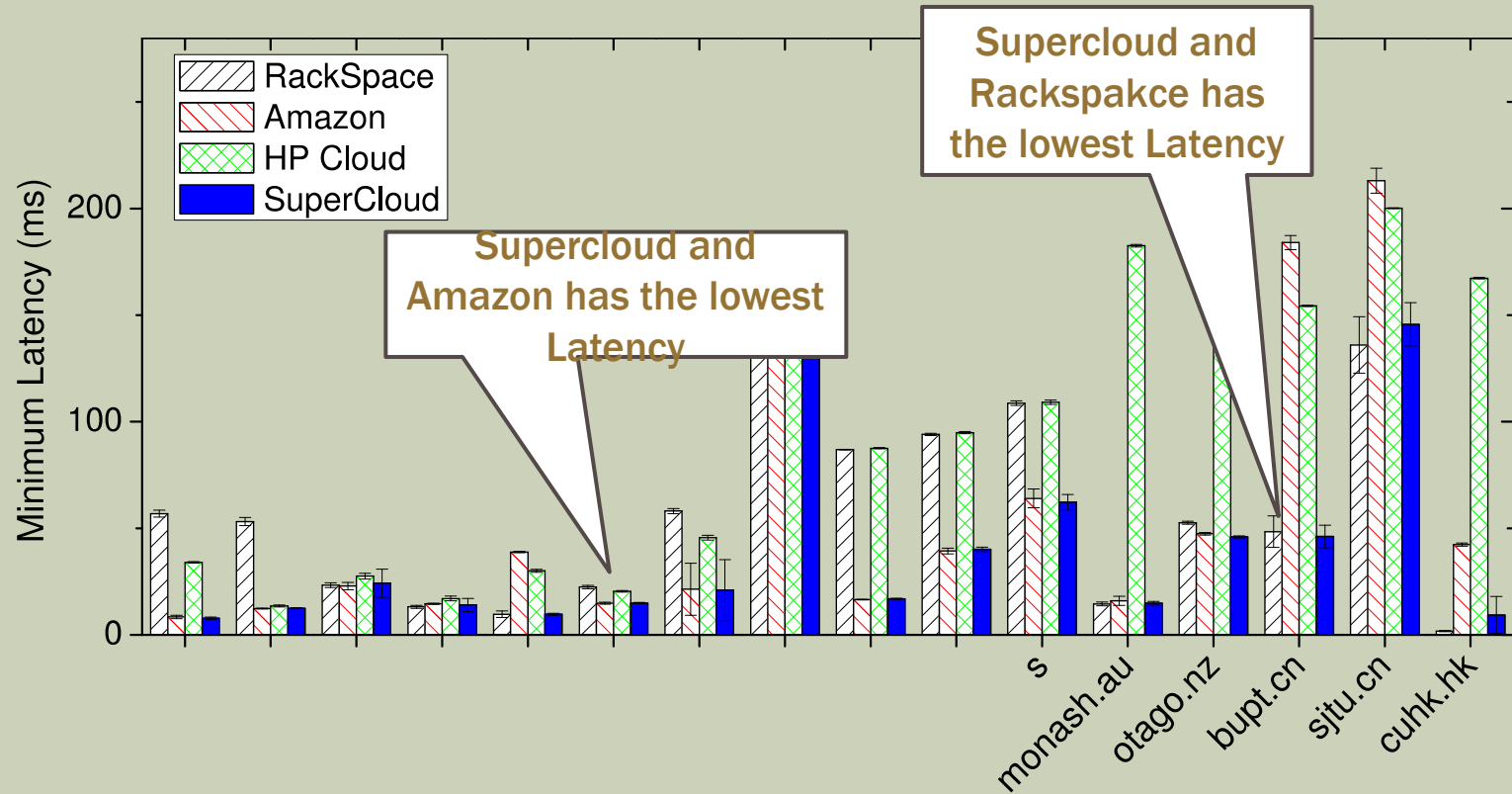


CONTENT DELIVERY NETWORK

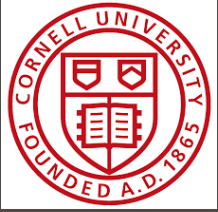




CONTENT DELIVERY NETWORK

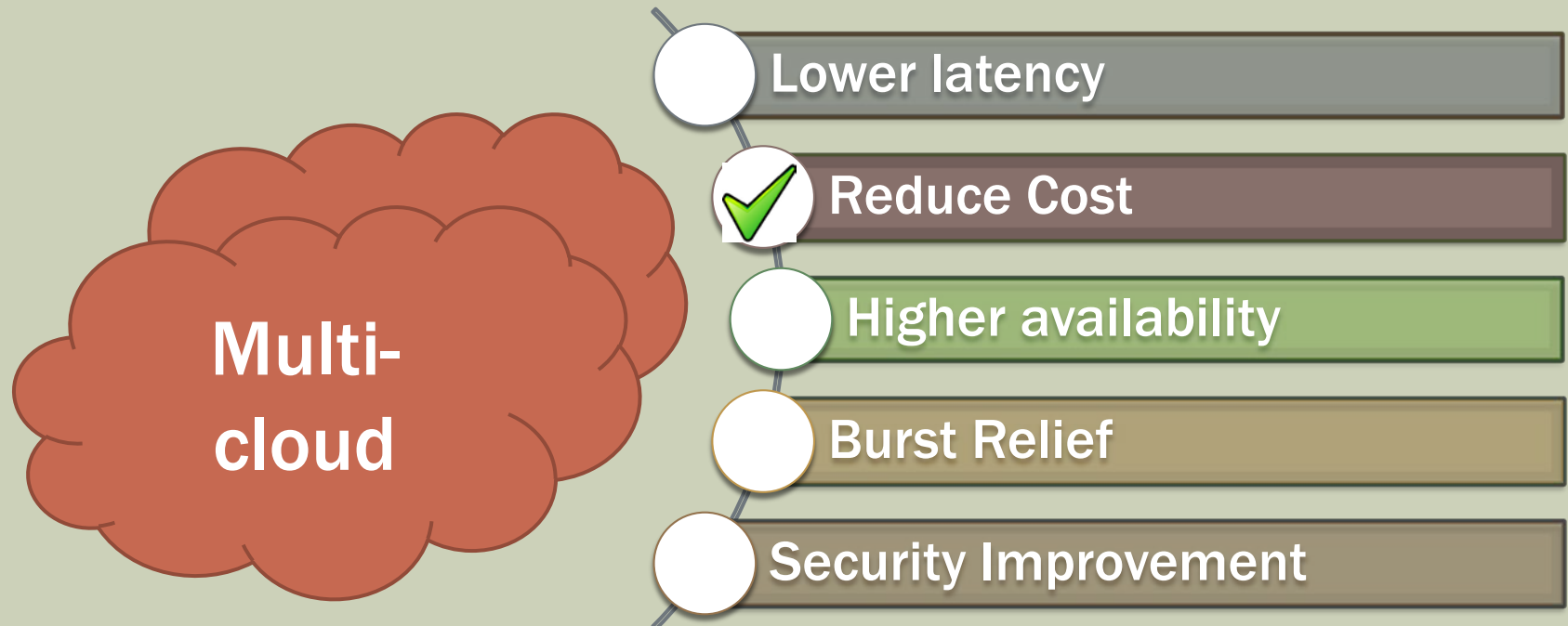


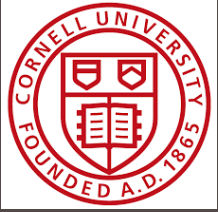
■ SuperCloud is closer to the clients



BENEFITS OF MULTIPLE CLOUDS

Provide power, control and flexibility to user



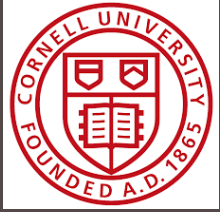


SPOT INSTANCE

- Amazon Spot Instance
 - Dramatic Price Change
 - Usually Cheap
 - Charges hourly
 - Ready to be terminated

Can't save money when prices goes high

Only stateless jobs!



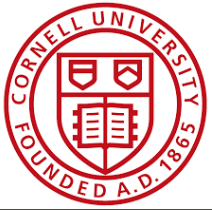
SMART SPOT INSTANCE

■ SuperCloud on Spot Instances

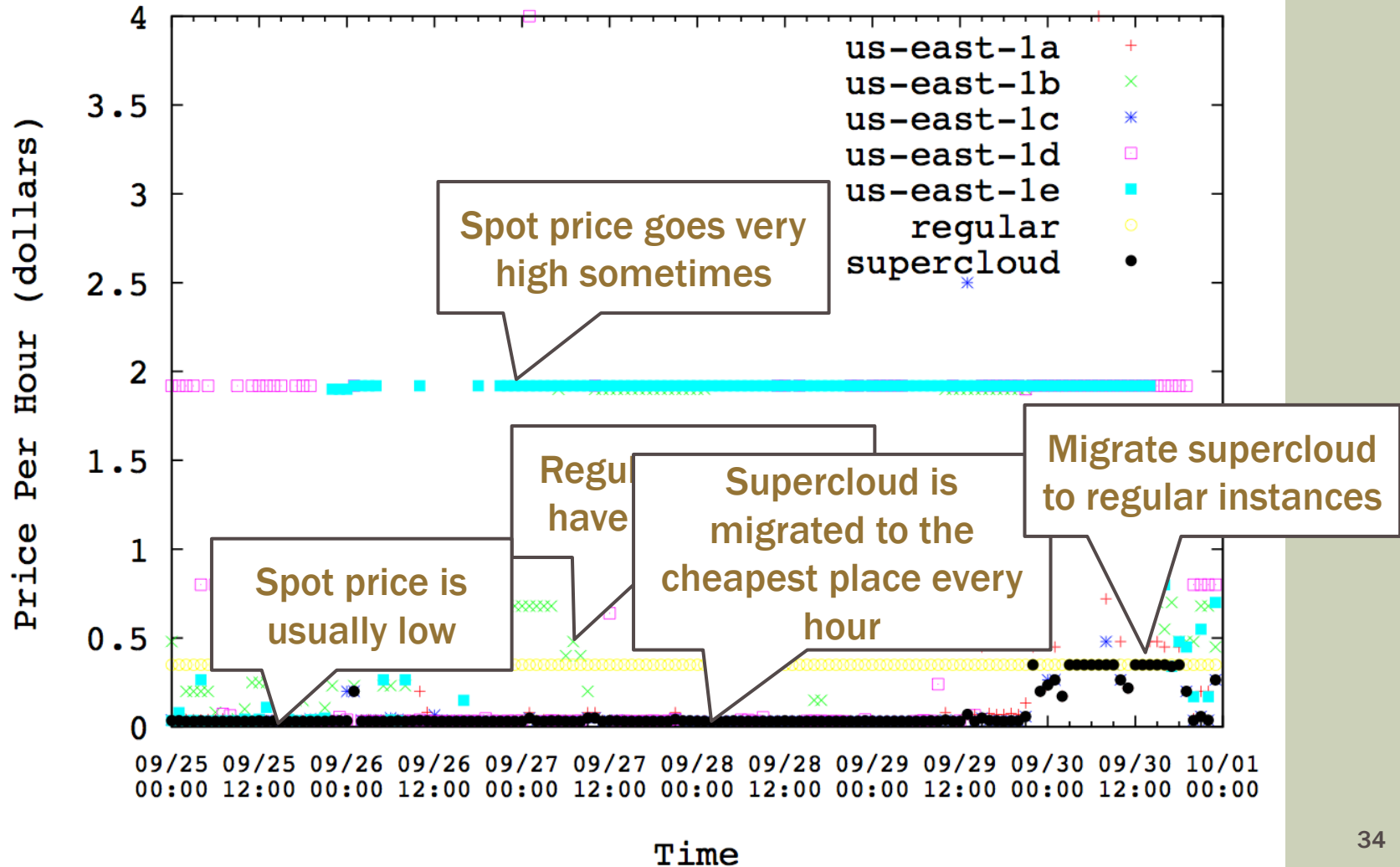
- Migrate out to other places when instances being terminated
- Migrate to the cheapest place when starting new billing hours

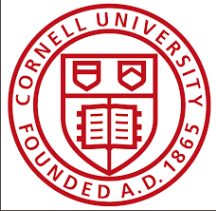
■ Benefits

- No termination
- Lower budget

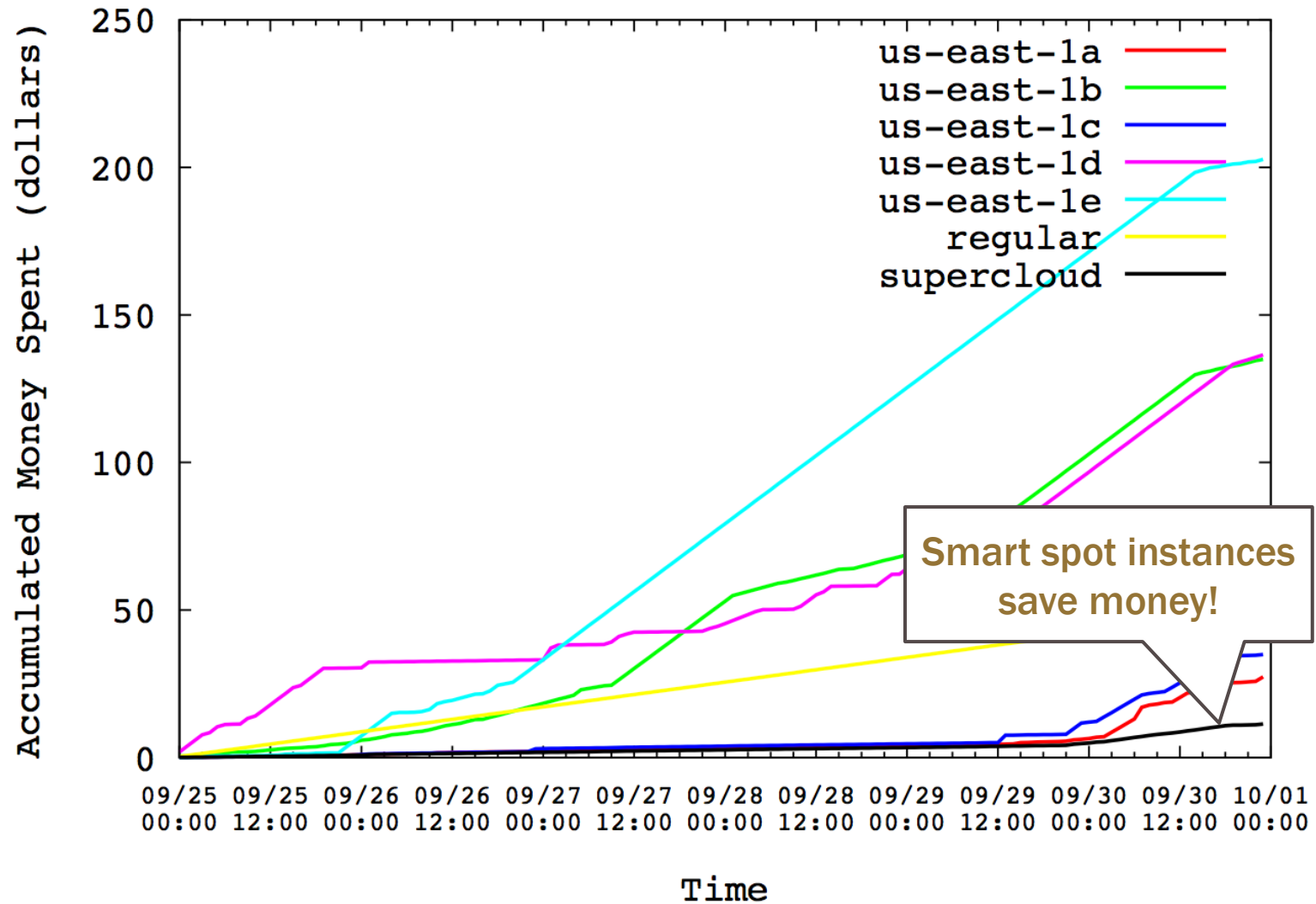


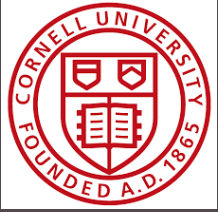
SPOT INSTANCE PRICE HISTORY





ACCUMULATED PRICE





SUMMARY

- **SuperCloud uses Xen on Xen virtualization**
 - Has some extra overheads, obviously
 - But enables migration of the entire VM and its runtime environment
- **SuperCloud is able to...**
 - Moves computation to data if data is big, sensitive, special device on a special host, etc
 - Can also migrate to chase lowest-priced resources
- **Transparent to the application: standard OS APIs**