

# Unshackle the Cloud!

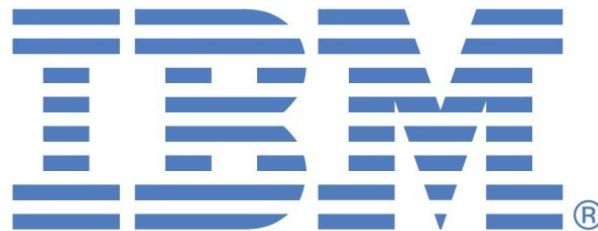
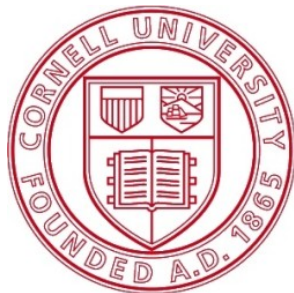


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# IaaS Clouds Offer Diverse Features

- Popular IaaS clouds are becoming **feature-rich**
  - Integrated monitoring
  - VM migration
  - CPU bursting
- **Hypervisor-level** innovations are emerging
  - Availability (e.g. Remus [Cully et al., NSDI 2008])
  - Security (e.g. Revirt [Dunlap et al., OSDI 2002])
  - Efficiency (e.g. Overdriver [Williams et al., VEE 2011])

# Users Don't Control Features

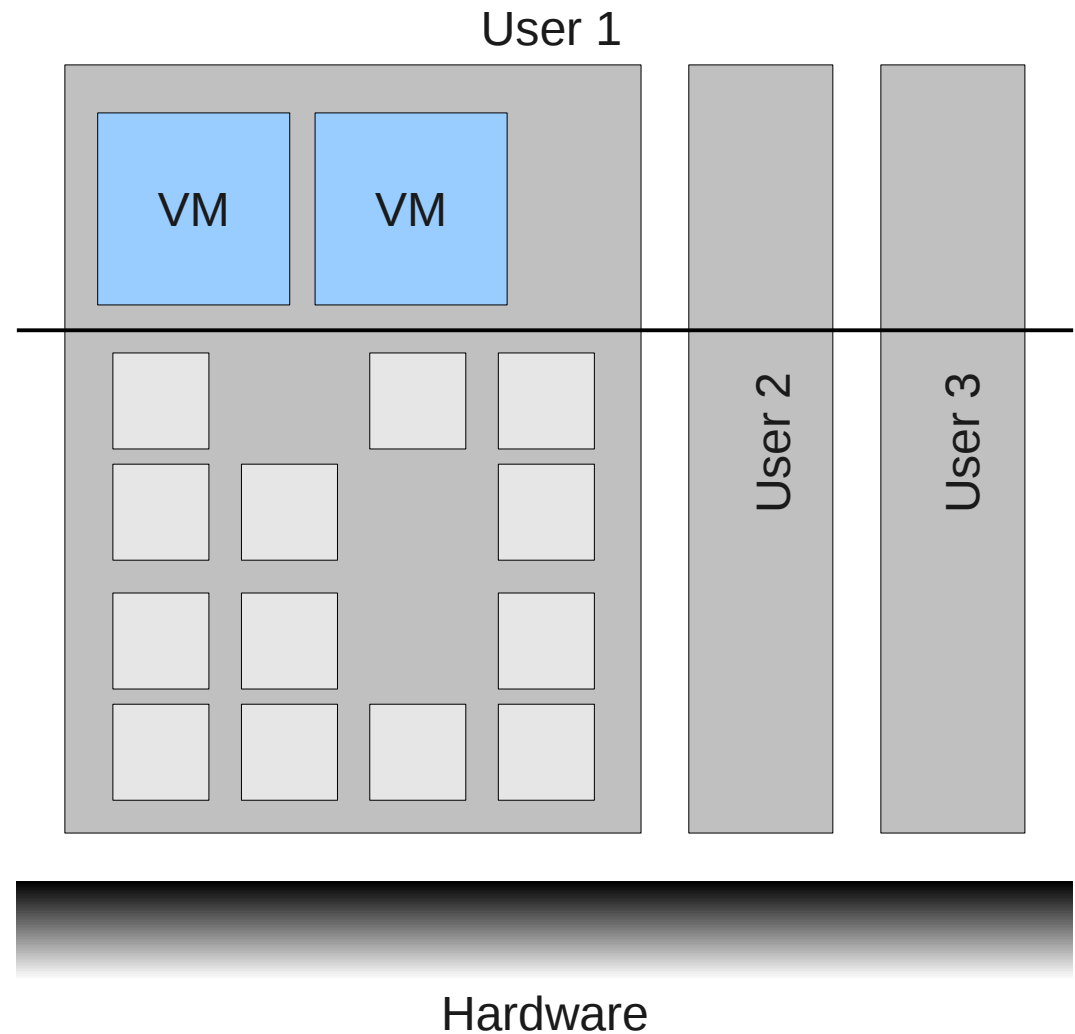
- Large cloud users with 100's or 1000's of VMs need control
- Must rely on provider to expose hypervisor-level features
- Tools and features lead to lock-in
- **Users can't implement hypervisor-level features themselves**

# Unshackle the Cloud with Extensible Clouds: 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

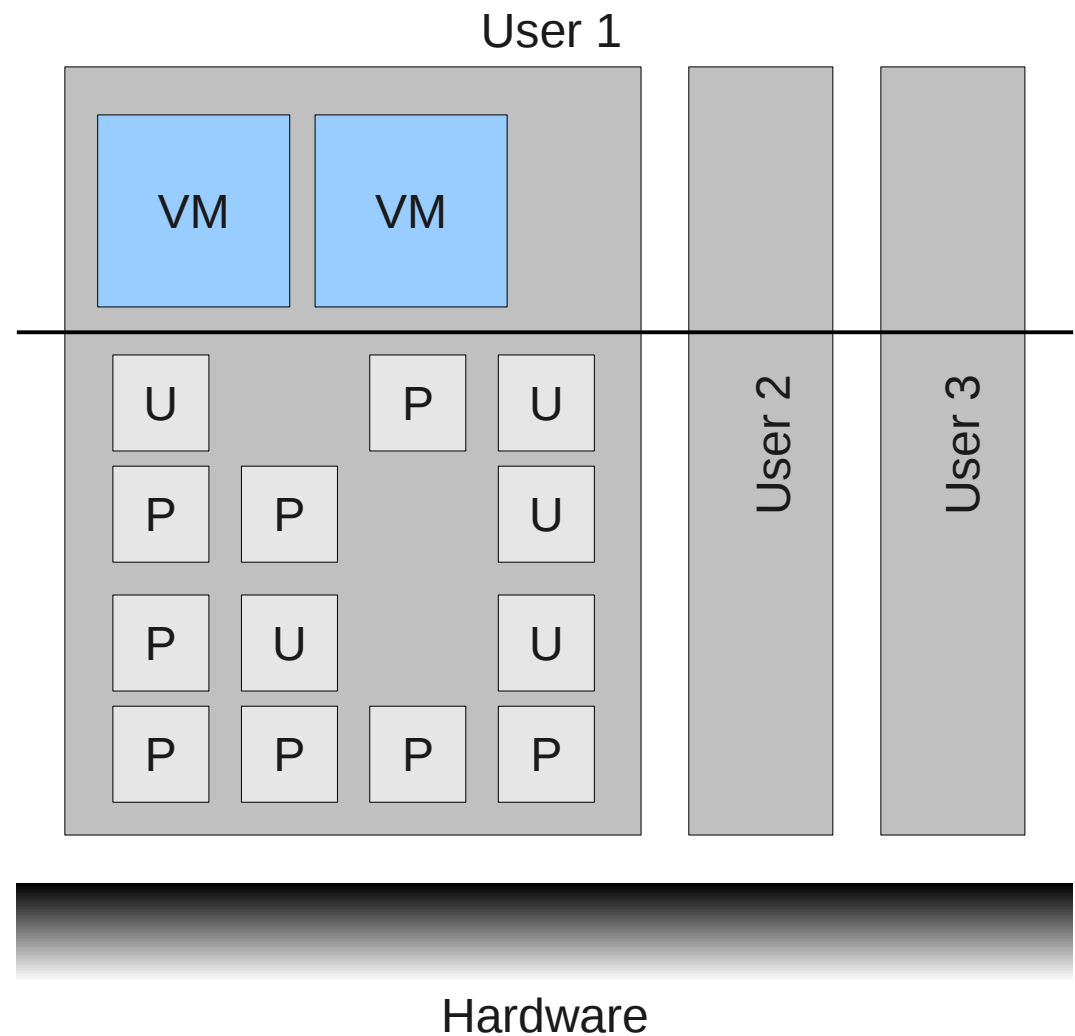
- Users are isolated
- VMM composed of **modules**



# How to Build xClouds

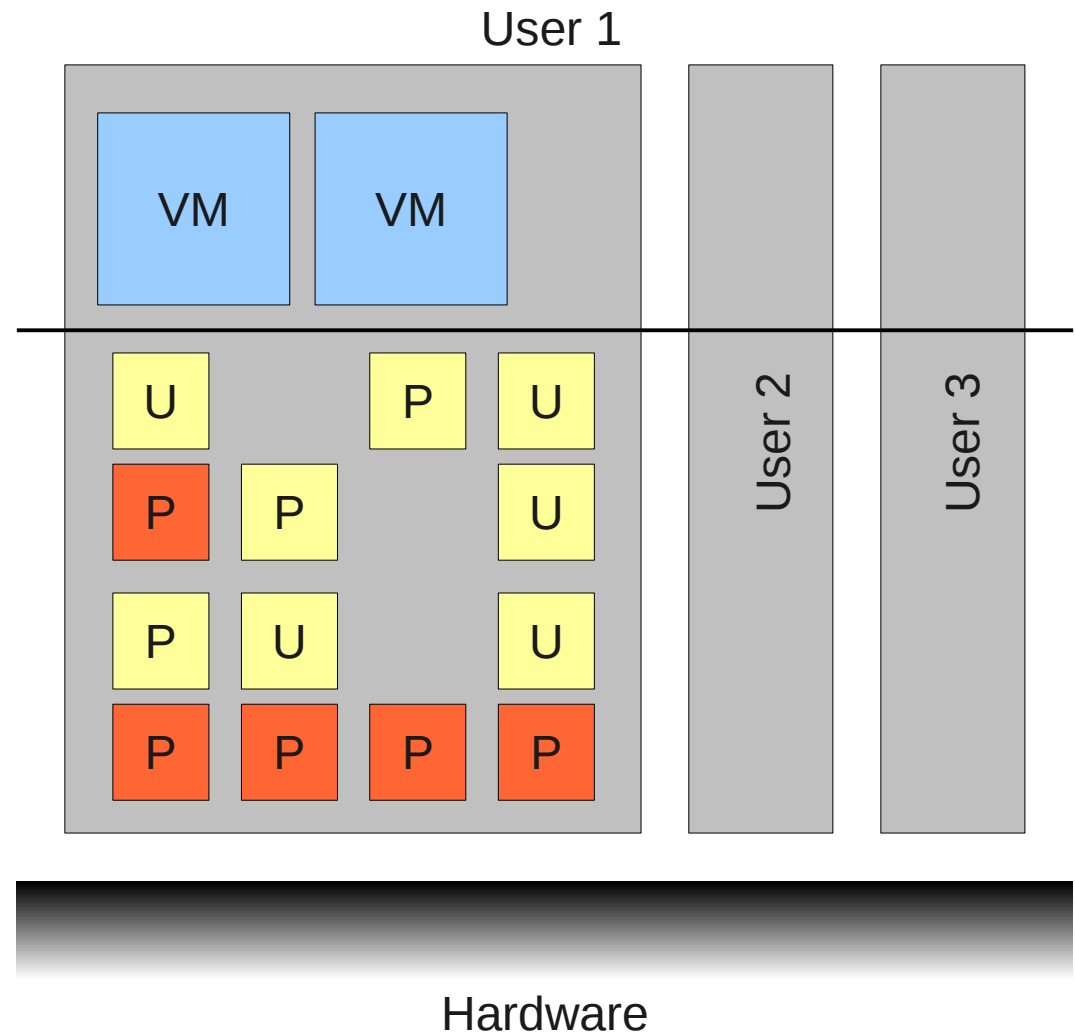
- Users are isolated
- VMM composed of **modules**
  - User / Provider

( U / P )



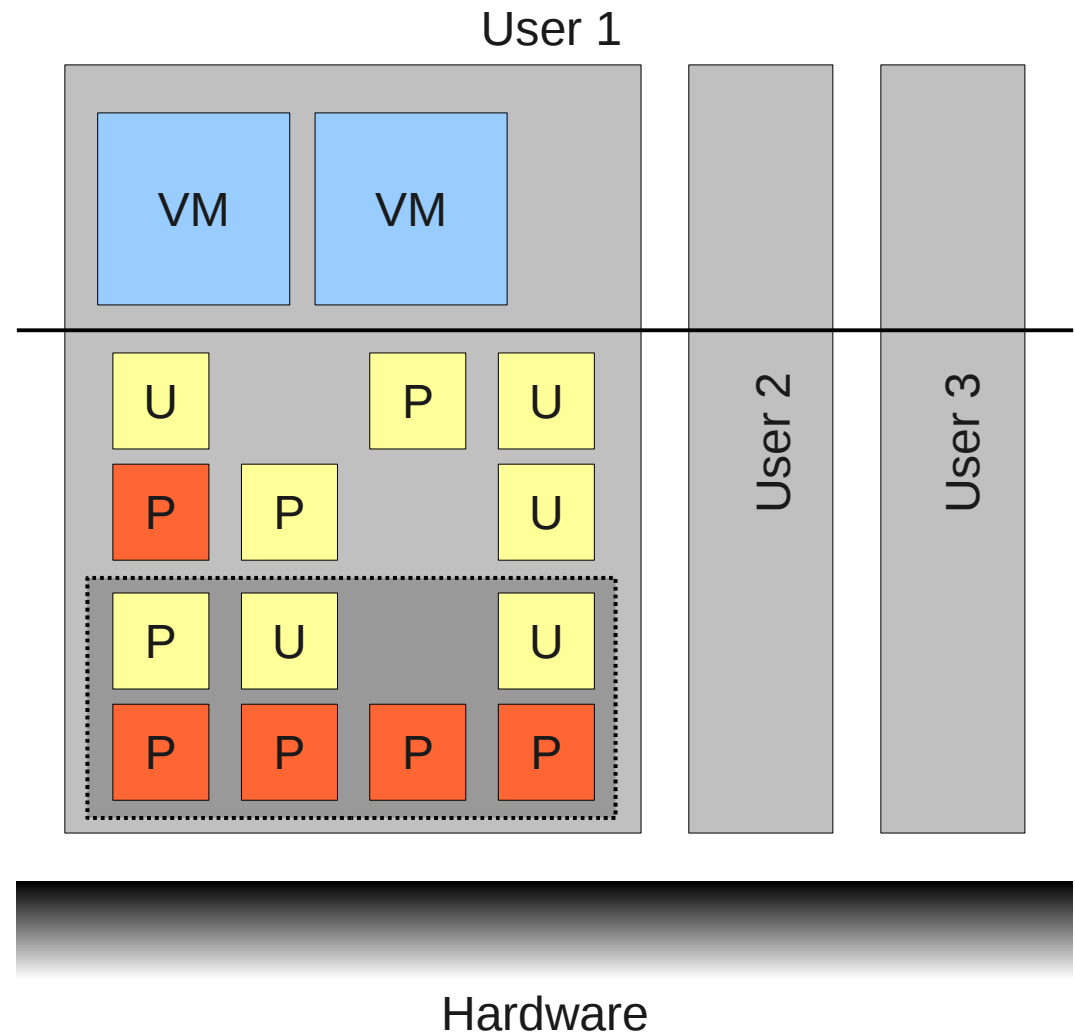
# How to Build xClouds

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



# How to Build xClouds

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



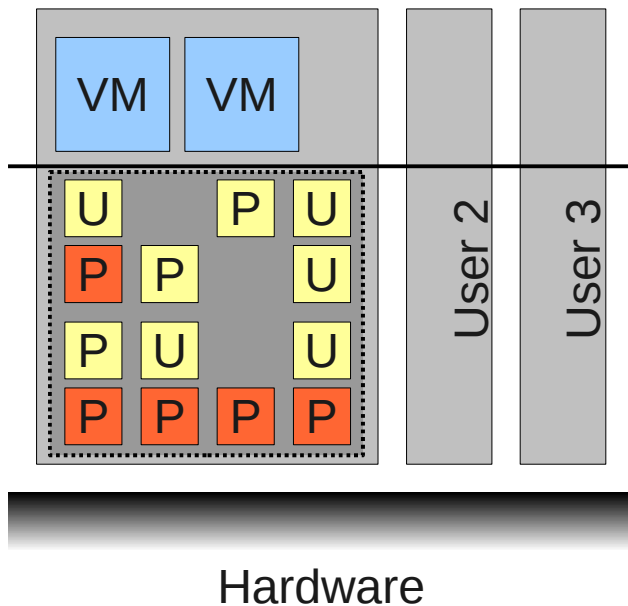


# Design Alternatives

## Download VMM Extensions

e.g SPIN, VINO

Providers must adopt new VMM



# Design Alternatives

**Download VMM Extensions**

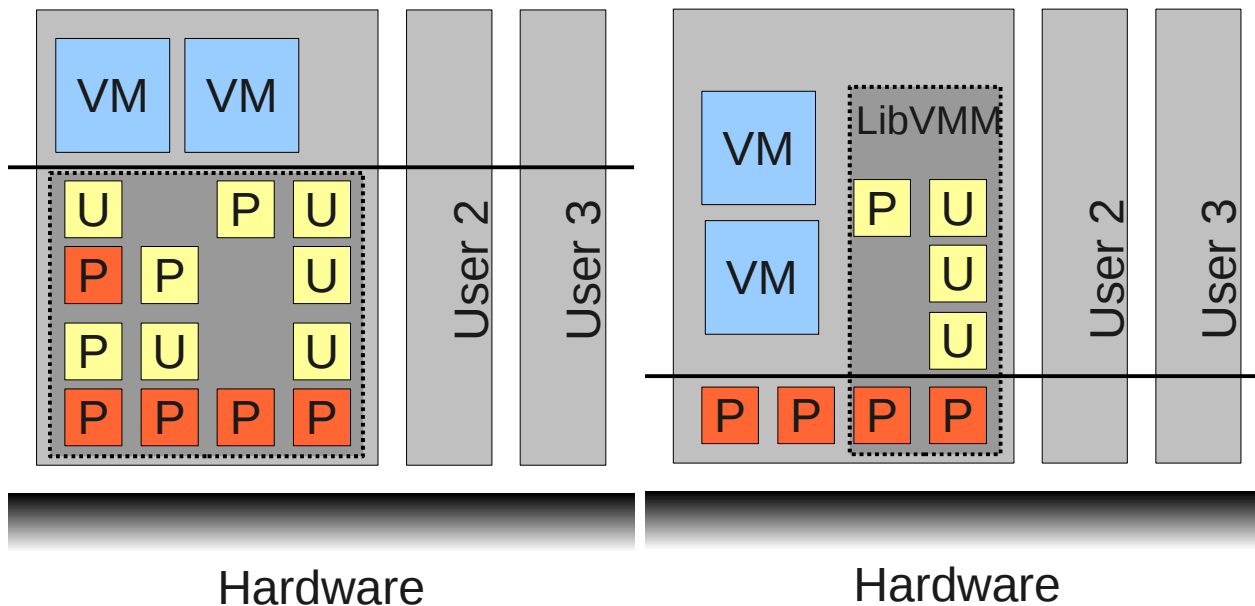
e.g SPIN, VINO

Providers must adopt new VMM

**Expose Hardware Through VMM**

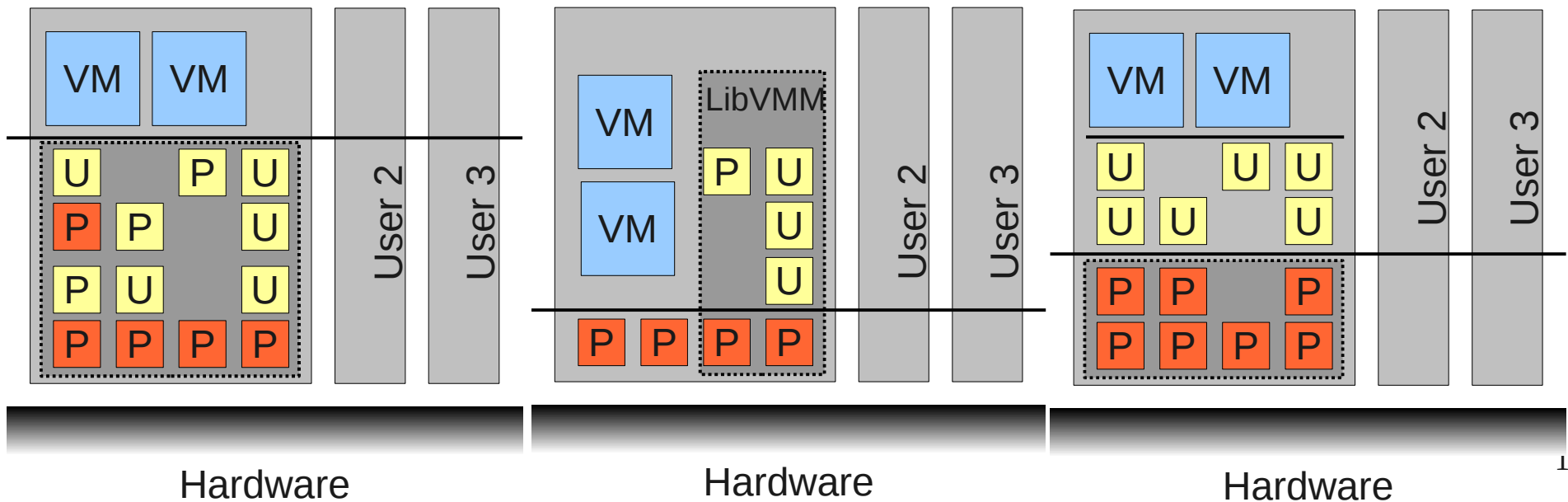
e.g. Exokernel

Providers must adopt new VMM



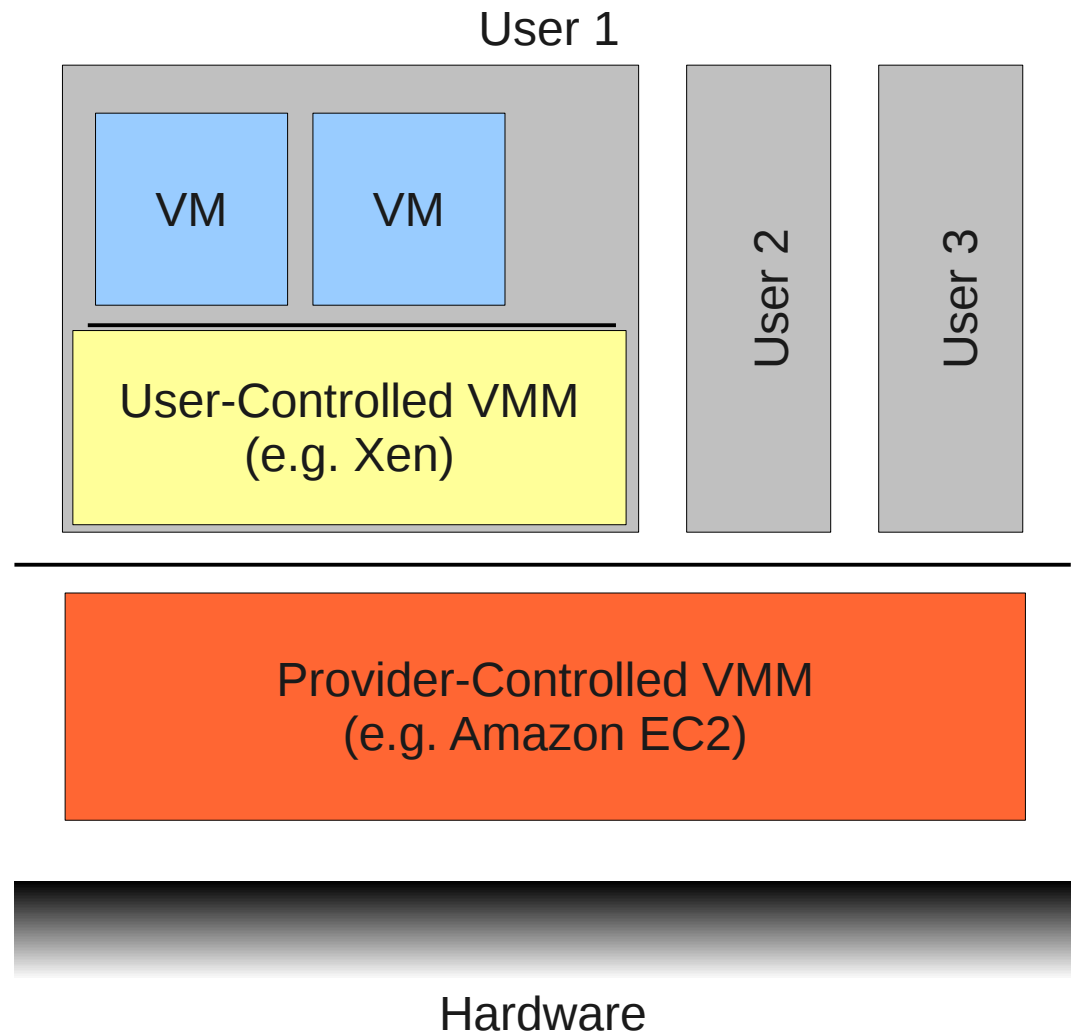
# Design Alternatives

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...



# Nested Virtualization can be Deployed Today!

- Use PV or BT for user-controlled VMM
- No provider cooperation necessary

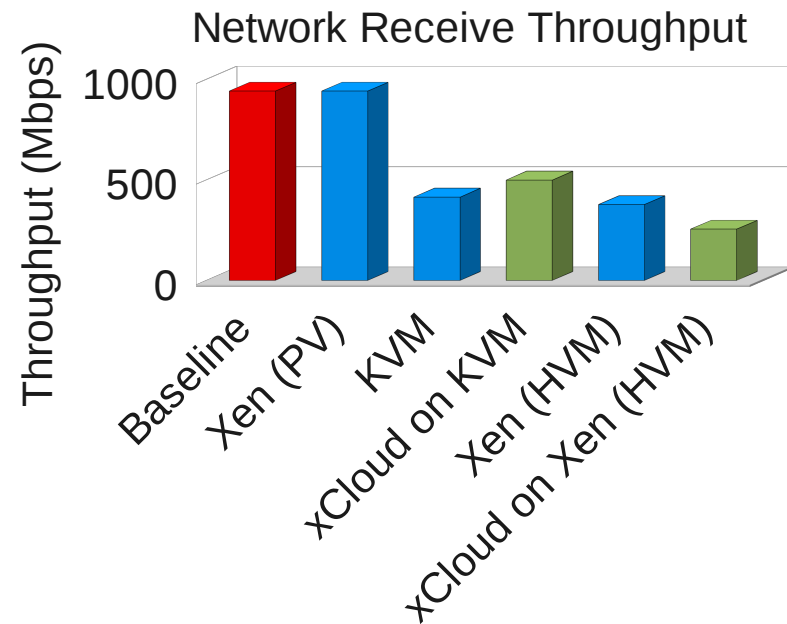


# Evaluation: Will xClouds Perform?

- Compared single and nested setups with Xen (PV) as the second-layer hypervisor
- Microbenchmarks
  - Nested perf. comparable to single-layer PV

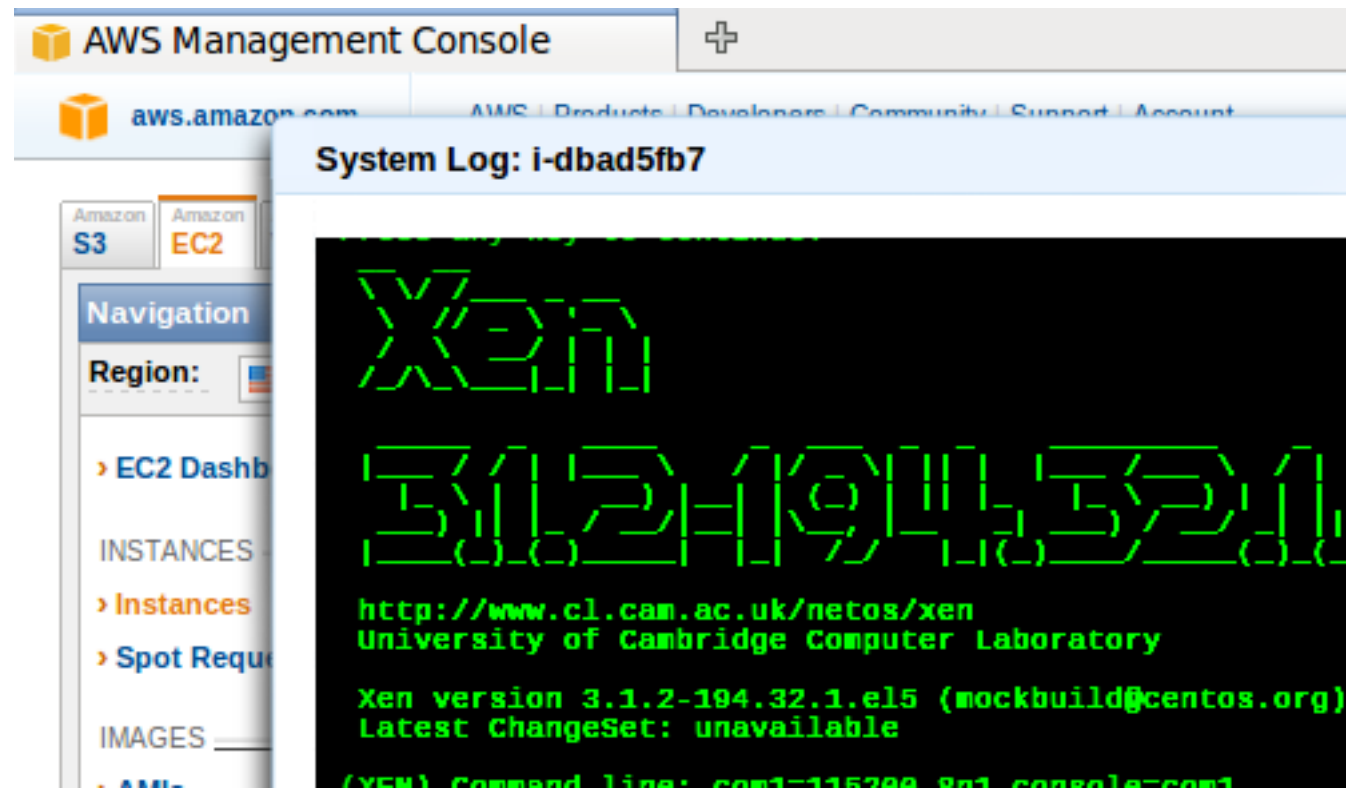
# Evaluation: Will xClouds Perform?

- Compared single and nested setups with Xen (PV) as the second-layer hypervisor
- Microbenchmarks
  - Nested perf. comparable to single-layer PV
- Device I/O benchmarks
  - Xen is not designed to run on PV hardware
  - Nested PV is essential for device I/O



# xClouds Work Today!

- Nested paravirtual device drivers
- Xen on EC2 HVM instance
- Ongoing work



*“Nature is a mutable cloud which is always and never the same”*

– Ralph Waldo Emerson

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