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What You Make Possible

TOMORROW starts here.

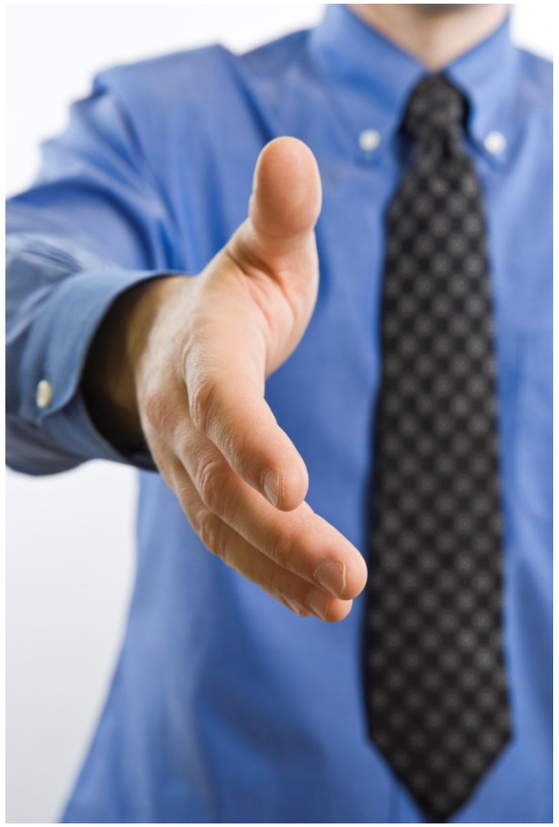
CISCO

Deployment Best Practices for VMware on UCS

BRKVIR-2662

Introductions

Let us get to know each other



- VMware server virtualisation
- VMware desktop virtualisation
- Cisco UCS
- Area of expertise
  - Networking
  - Storage
  - Compute
- Job function
  - Architecture
  - Operations
  - Management

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What We Will Cover

Deployment Best Practices for VMware on UCS

vCenter Plug-in

Networking

Compute

Rapid Deployment

Storage

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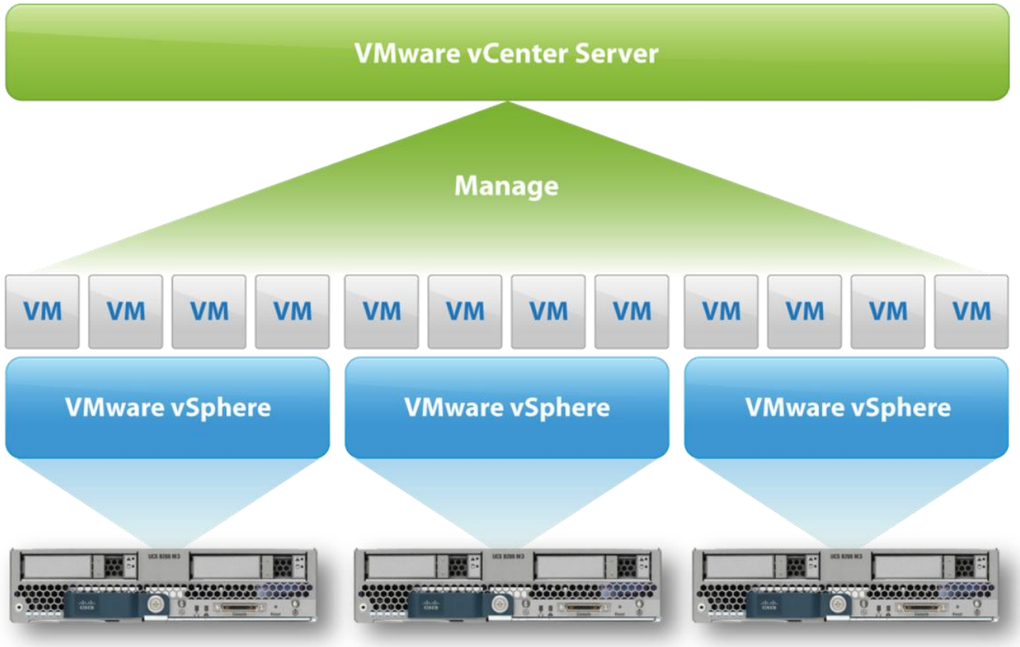
Cisco UCS vCenter Plug-in

Cisco UCS vCenter Plugin

Version 0.9(1) beta

- Extension for vSphere Web Client 5.1
- Requires vCenter 5.0 or higher
- Enables admins to view, manage and monitor UCS physical infrastructure
- Free at http://developer.cisco.com/web/unifiedcomputing/vmware



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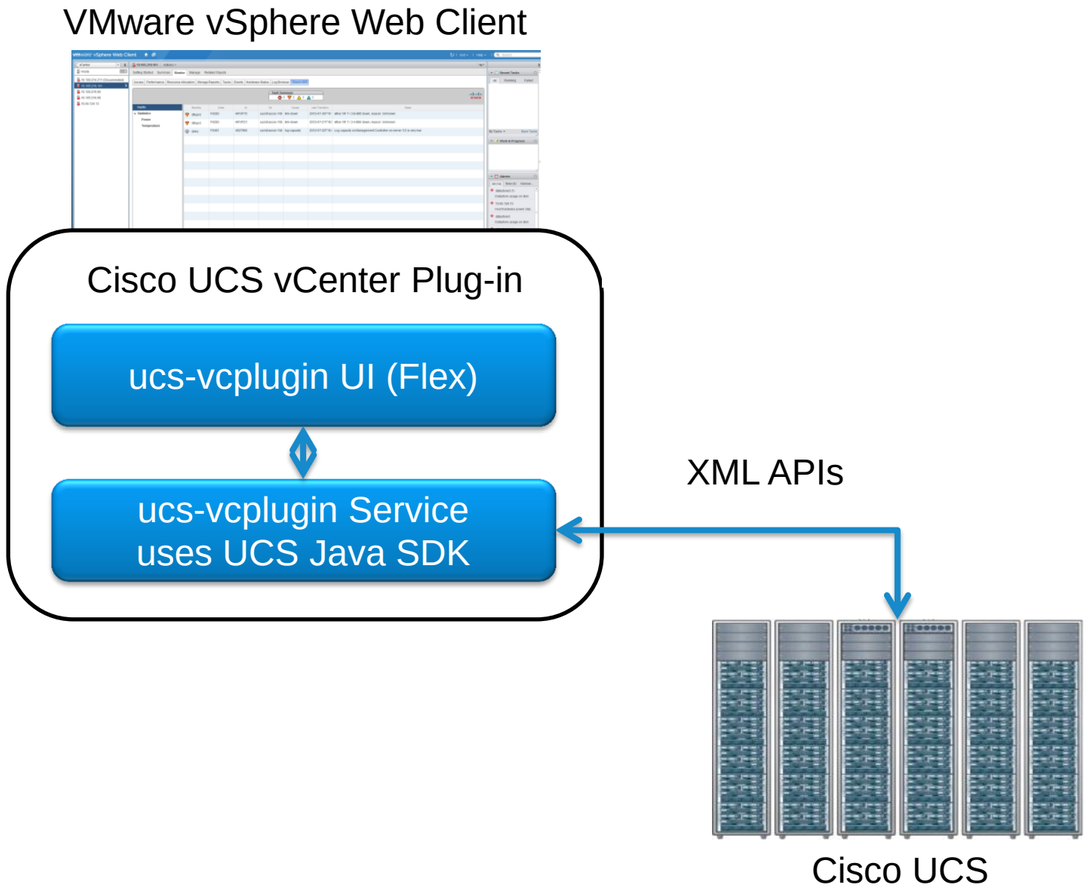
Cisco UCS vCenter Plug-in Architecture

- Two major components
  - UCS-vcplugin UI is Flex-based extension to VMware web client
  - UCS-plugin services uses XML API to get data from UCS
- v0.9(1) supports only one registration per UCS domain



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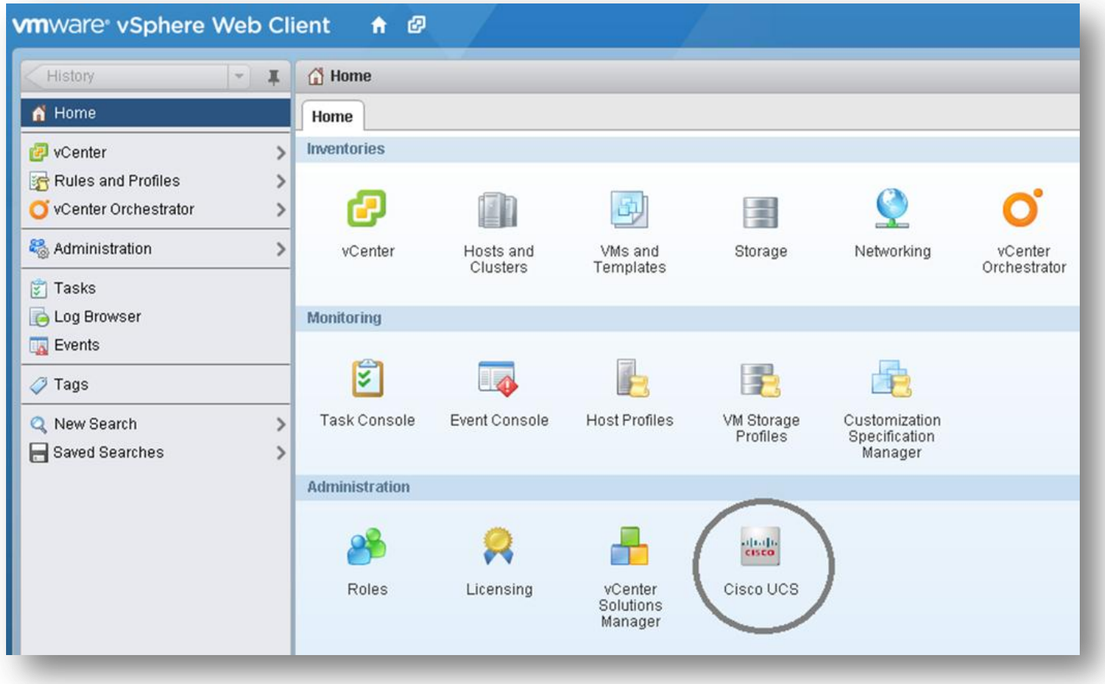
Cisco UCS vCenter Plug-in Capabilities

- Physical hierarchy view
- Health of servers and infrastructure
- Maps physical servers to ESX hosts
- For each ESX host:
  - Inventory
  - Firmware
  - Faults
  - Power/temp statistics
- KVM launch
- Toggle blue locater LED



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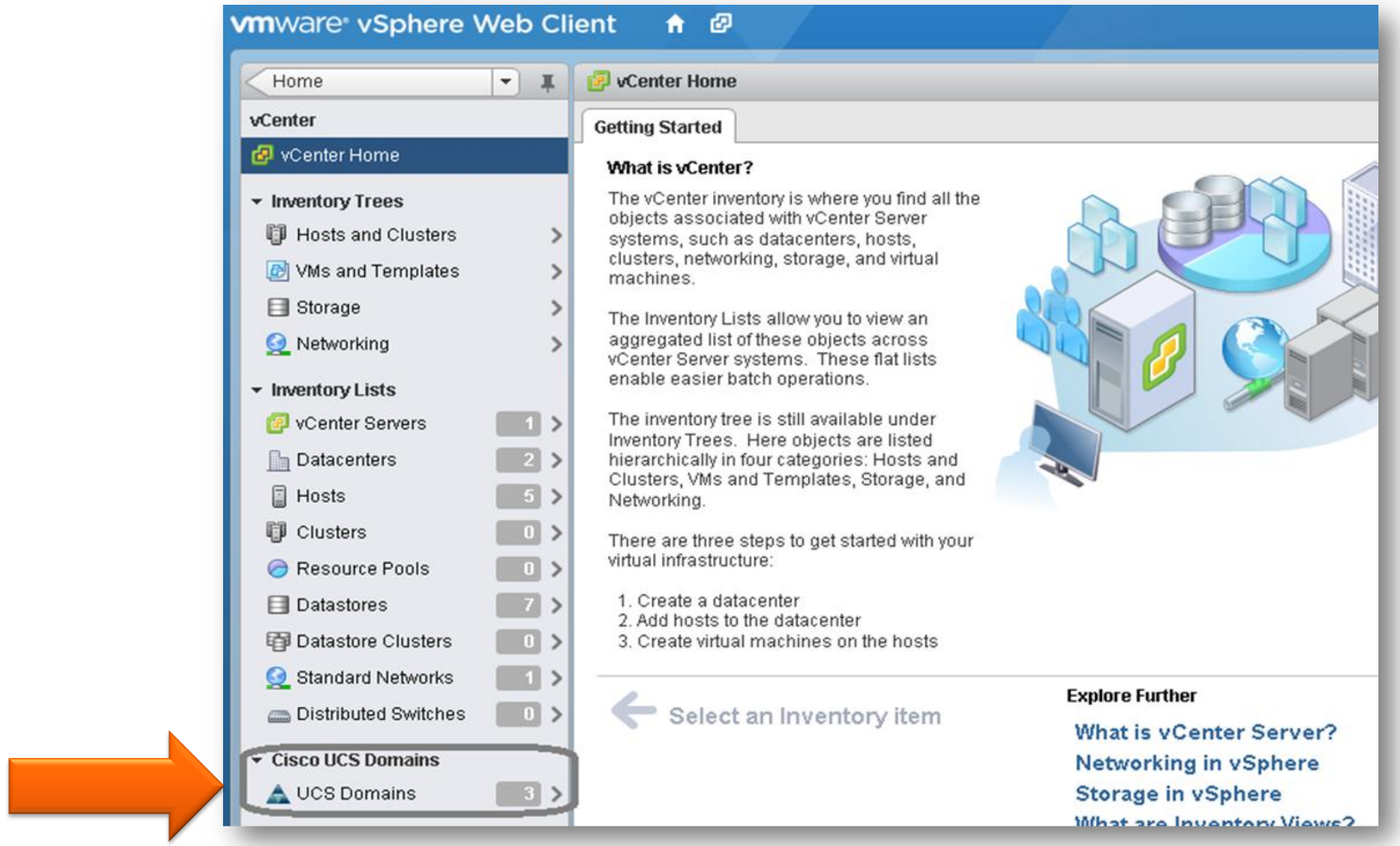
UCS Domains Shown in Inventory



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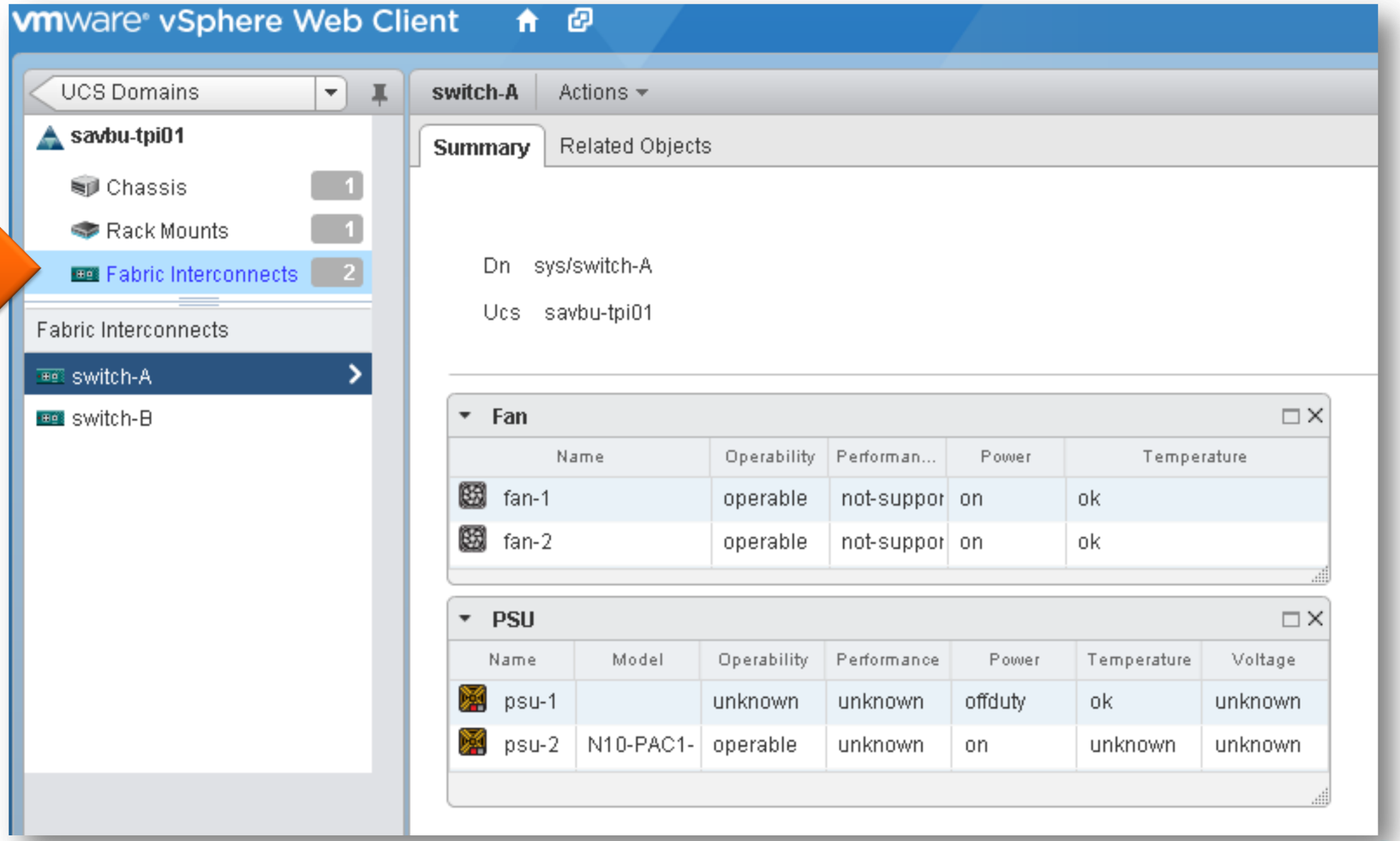
UCS Domain Inventory

Overview of domain components available



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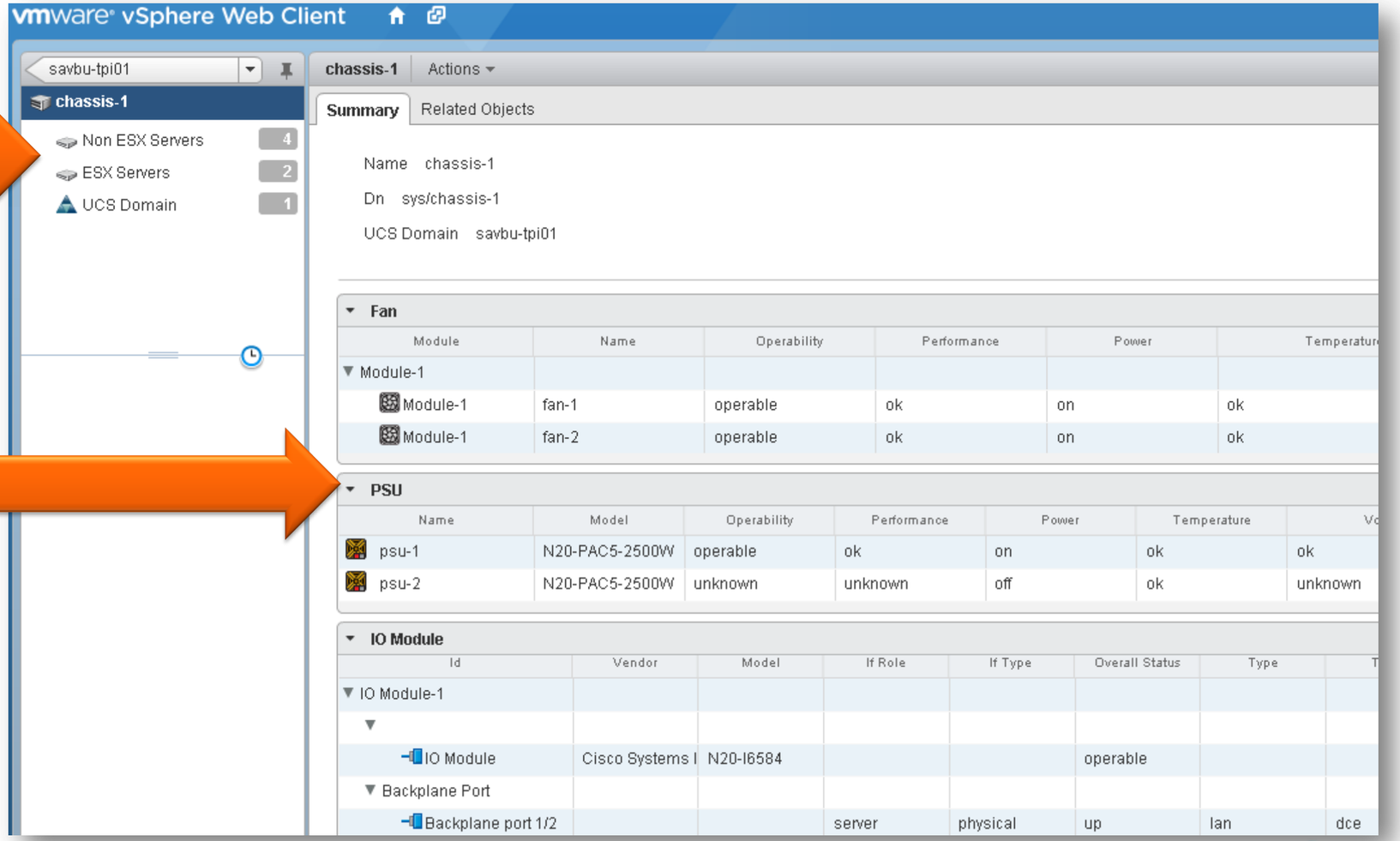
UCS Chassis View

ESX and non-ESX blades shown

Chassis details



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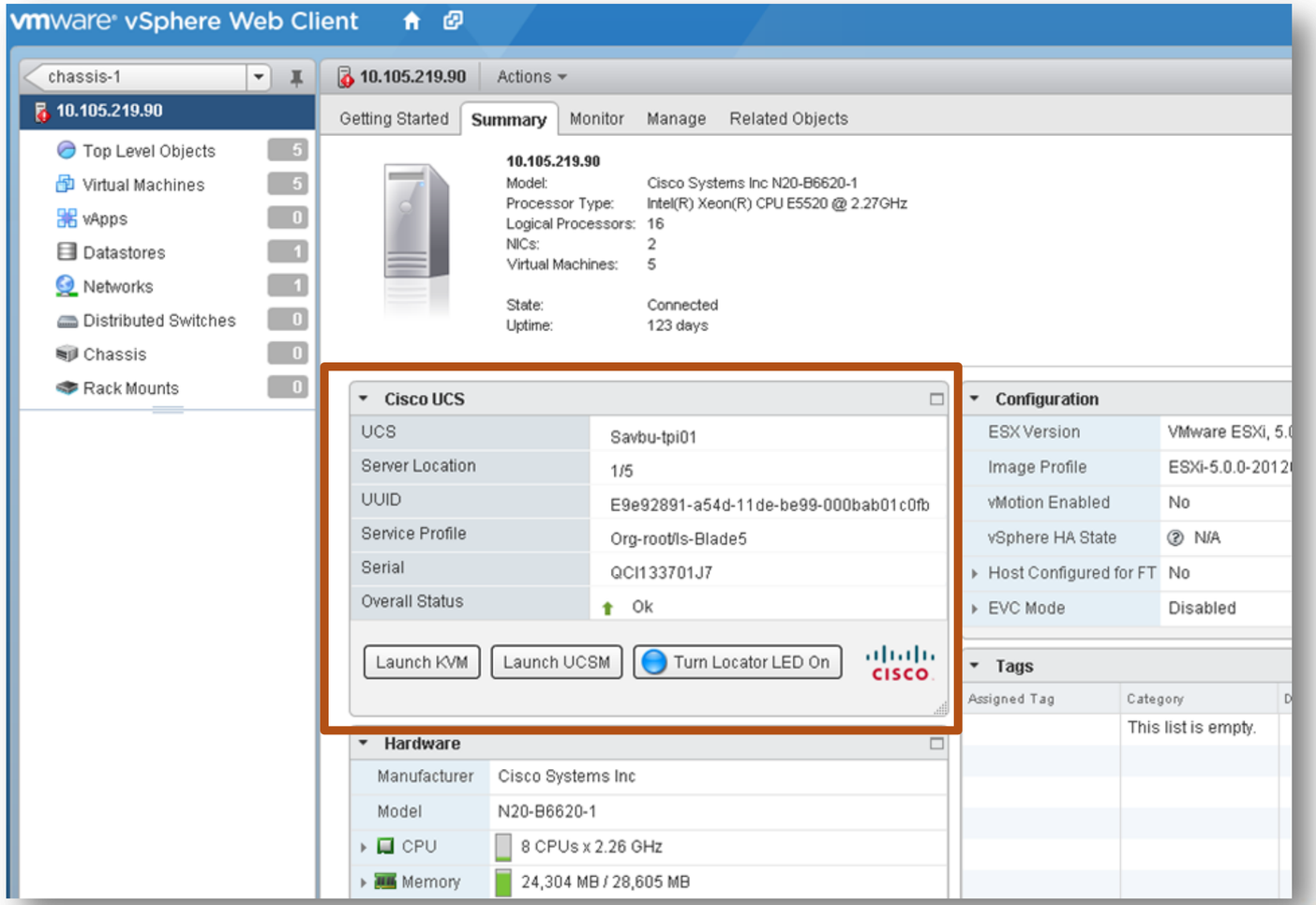
ESX Server Extension

Summary view

- Service profile name
- Server location
- Hardware inventory



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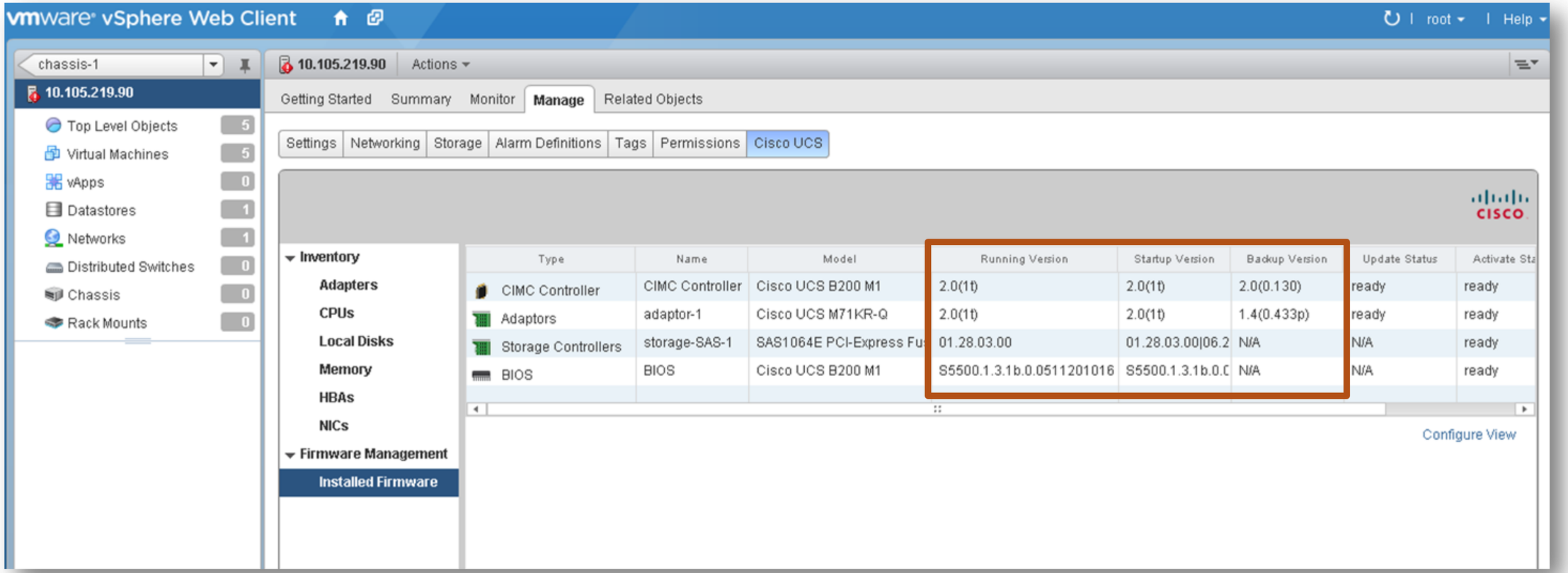
ESX Server Extension

Manage view



Inventory and firmware summary information

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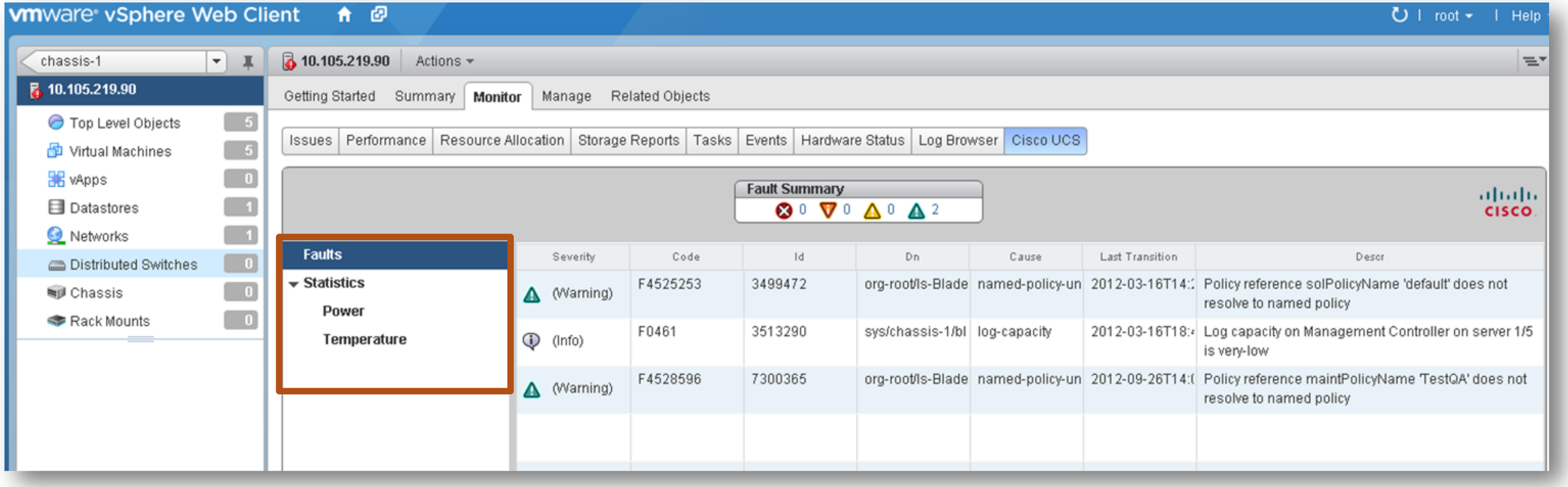
ESX Server Extension

Monitor view



Faults, power statistics and temperature statistics

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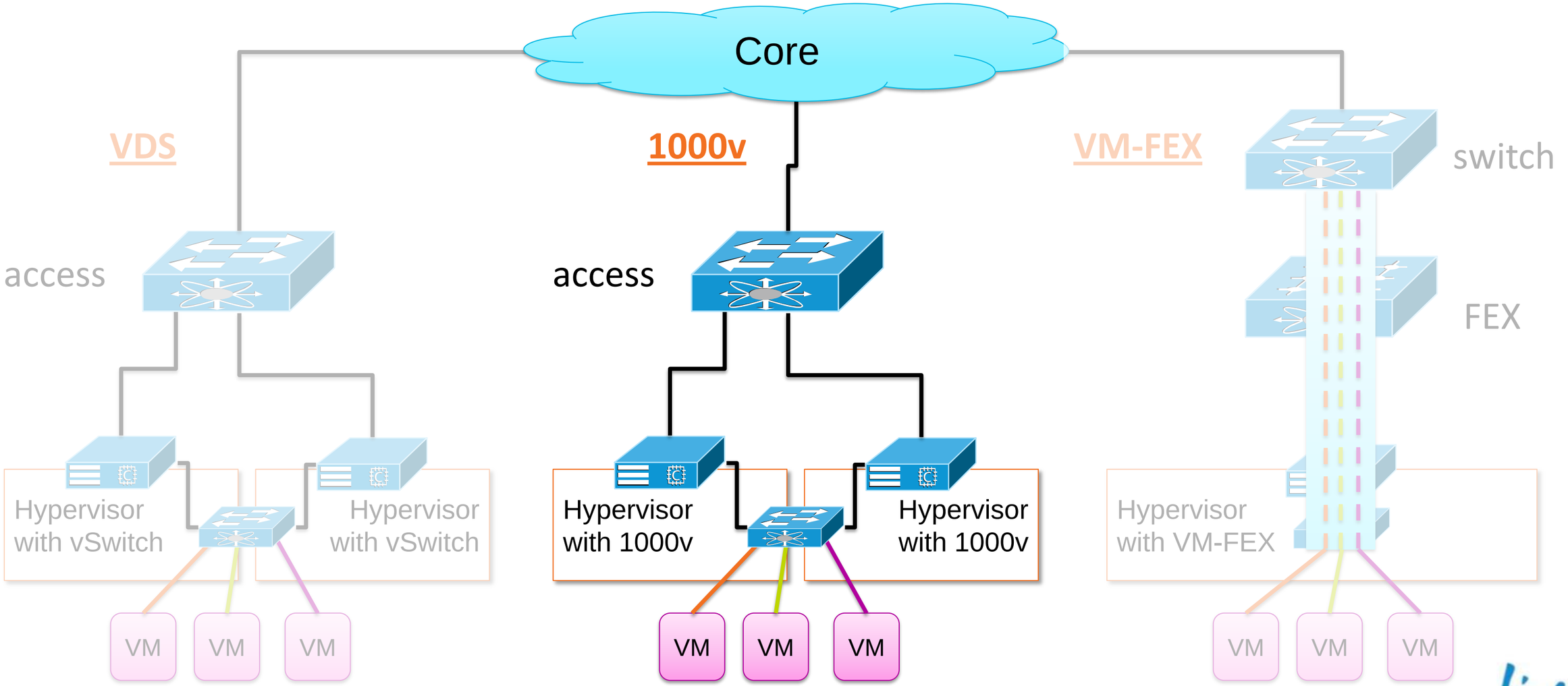
Networking

Three Ways to Provide IO to a VM

VMware VDS, Cisco 1000v, and Cisco VM-FEX



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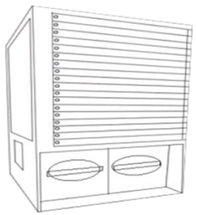
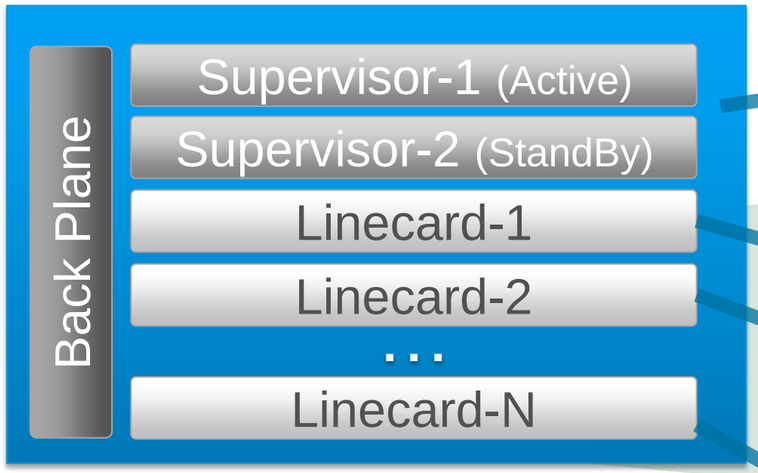
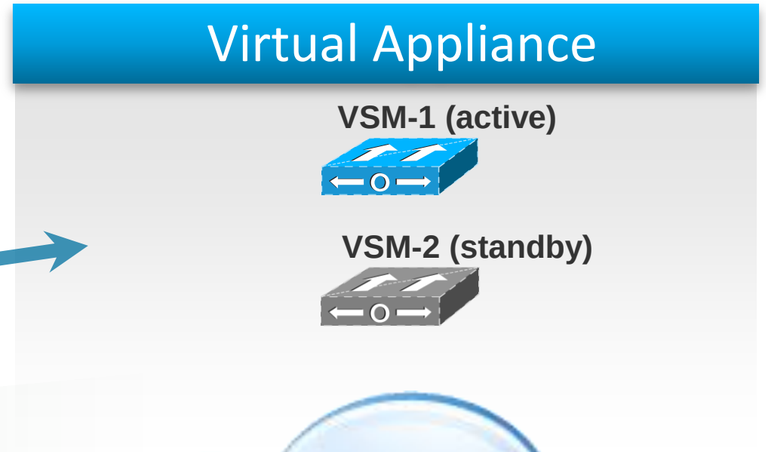
Nexus 1000V Architecture

A virtual modular switch with familiar NX-OS

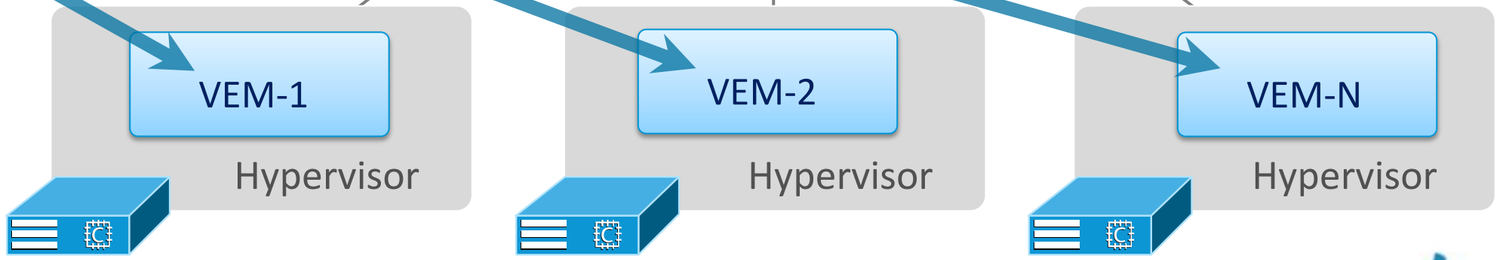






NX-OS
Control Plane

NX-OS
Data Plane



Modular Switch

VSM: Virtual Supervisor Module
VEM: Virtual Ethernet Module

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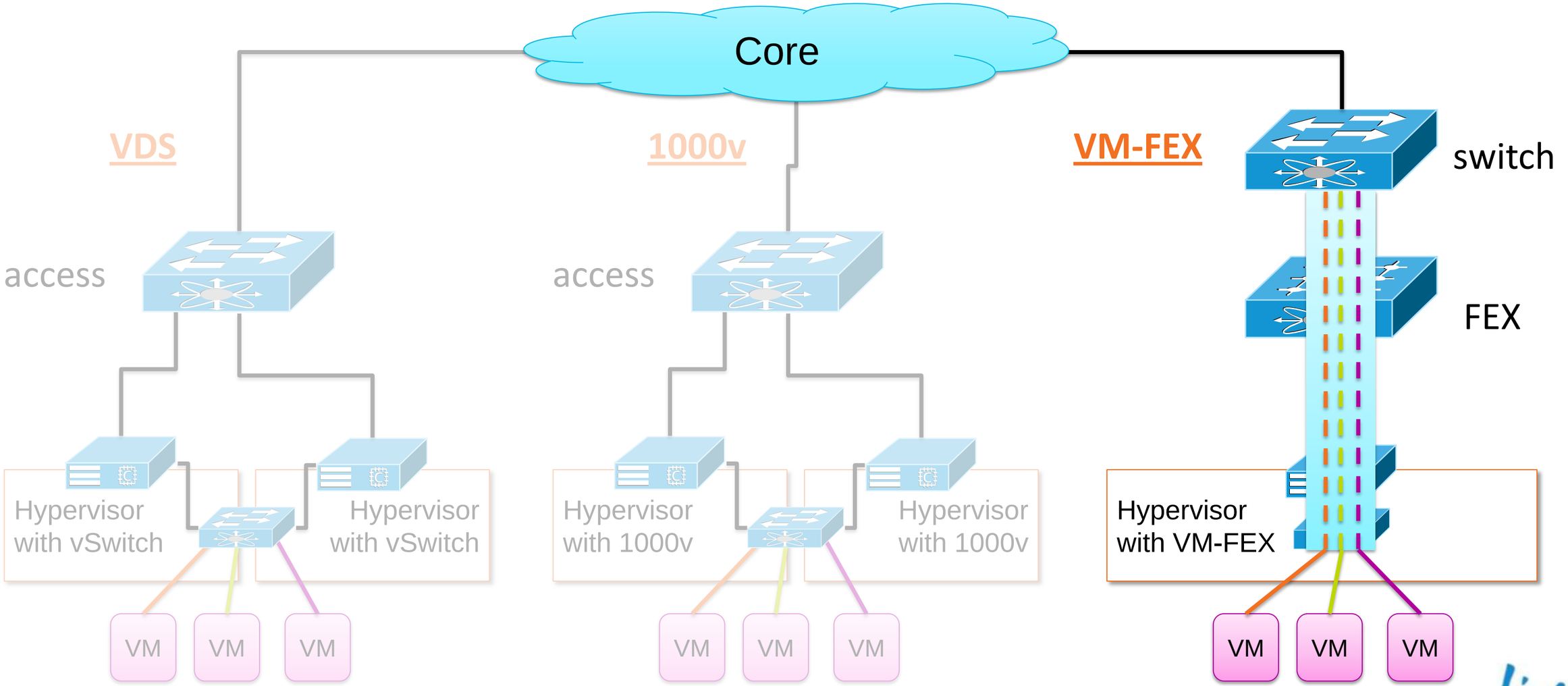
Three Ways to Provide IO to a VM

VMware VDS, Cisco 1000v, and Cisco VM-FEX



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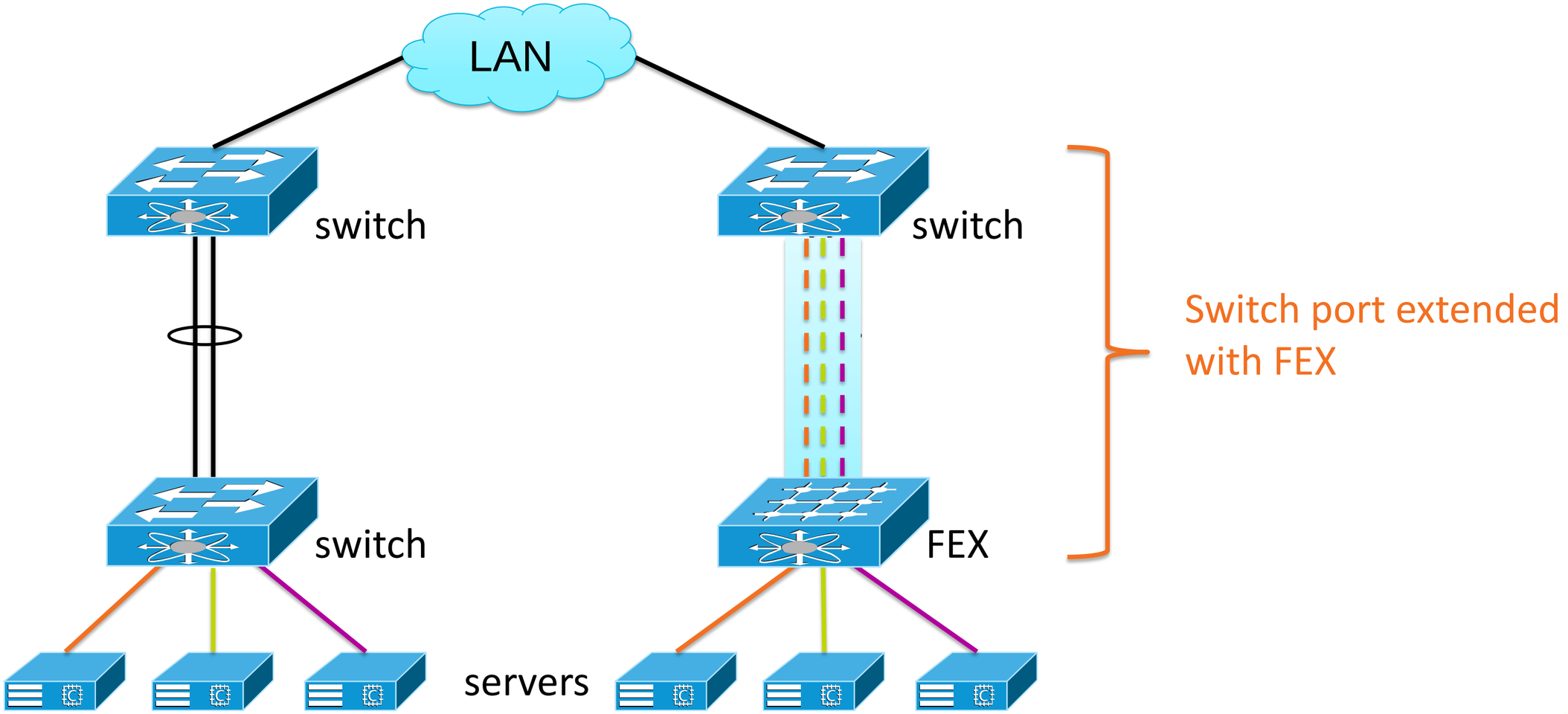
Fabric Extension (FEX)

Virtualising the network port



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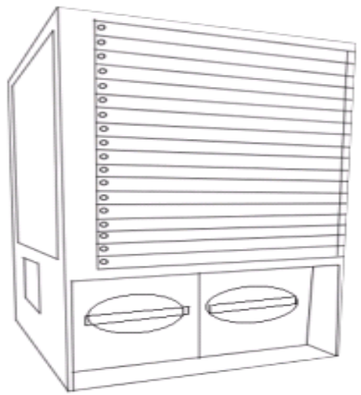
Nexus 5K Family with FEX

FEX puts switch ports closer to the load

Modular System



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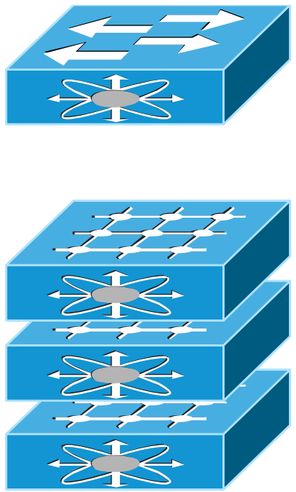
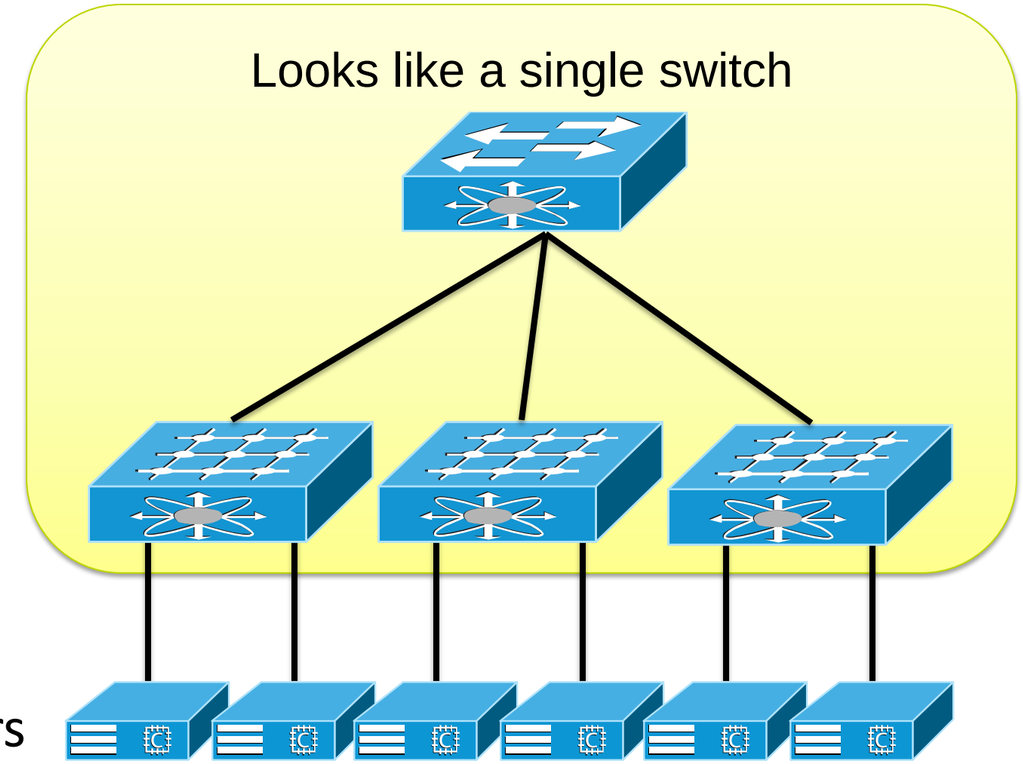
Distributed Modular System



Nexus 5K
(supervisor)

Nexus 2K
FEX
(line card)

Distributed Modular System



Distributed Modular System

- Nexus 2000 FEX is a Virtual Line Card to the Nexus 5000
- Nexus 5000 maintains all management & configuration
- No Spanning Tree between FEX & Nexus 5000

Over 6000 production customers
Over 5 million Nexus 2000 ports deployed

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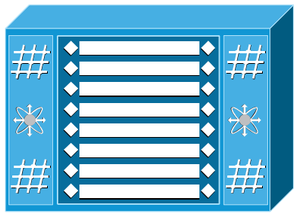
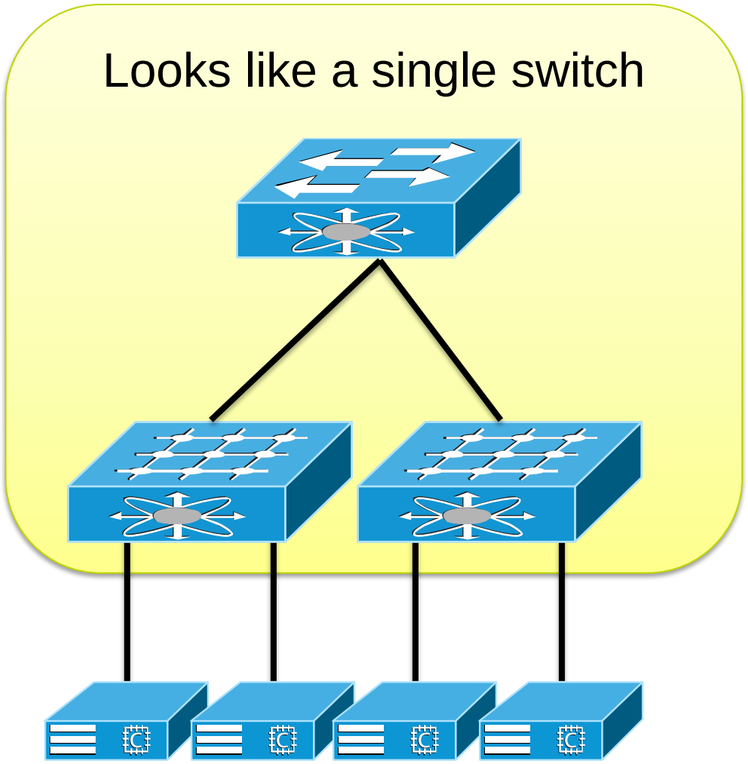
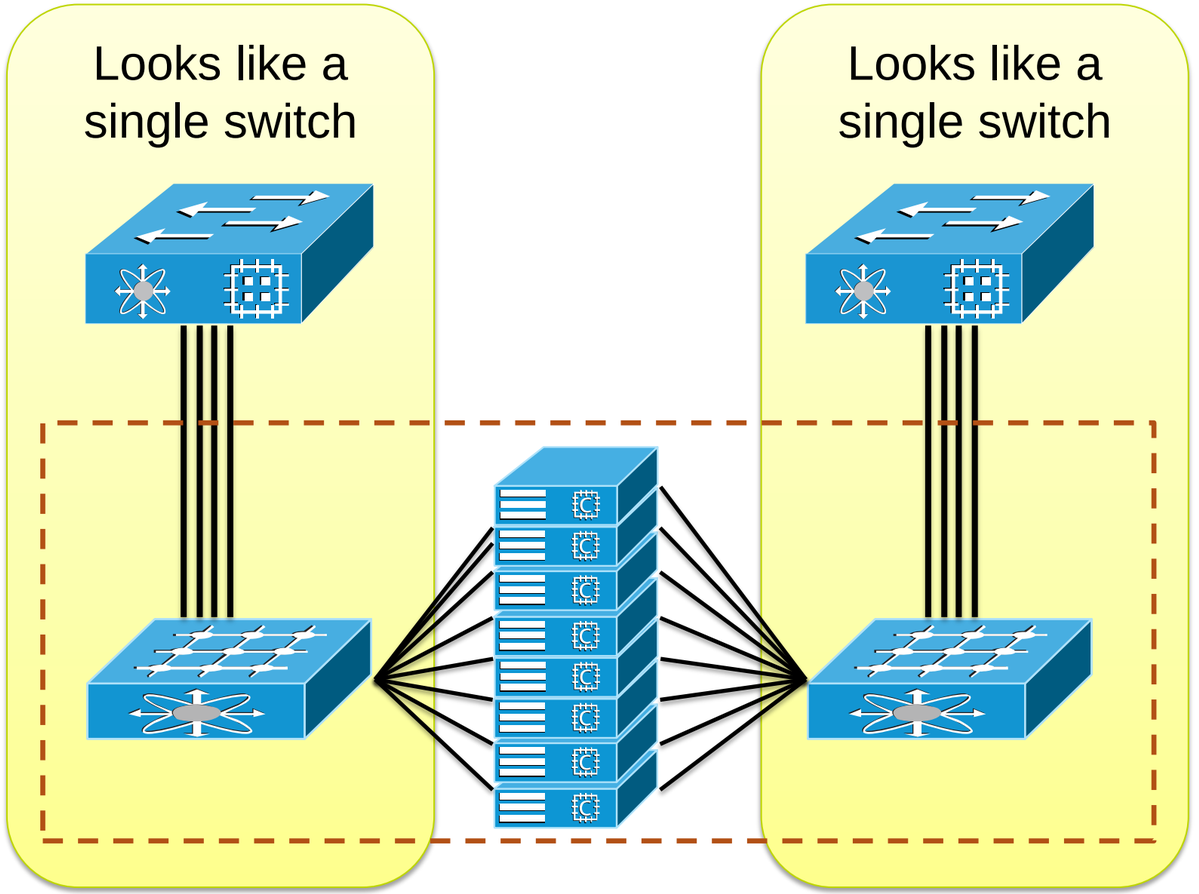
Cisco UCS Blade Chassis

FEX technology simplifies management



Distributed Modular System





UCS 5108 blade chassis = 8 blades + 2 FEX

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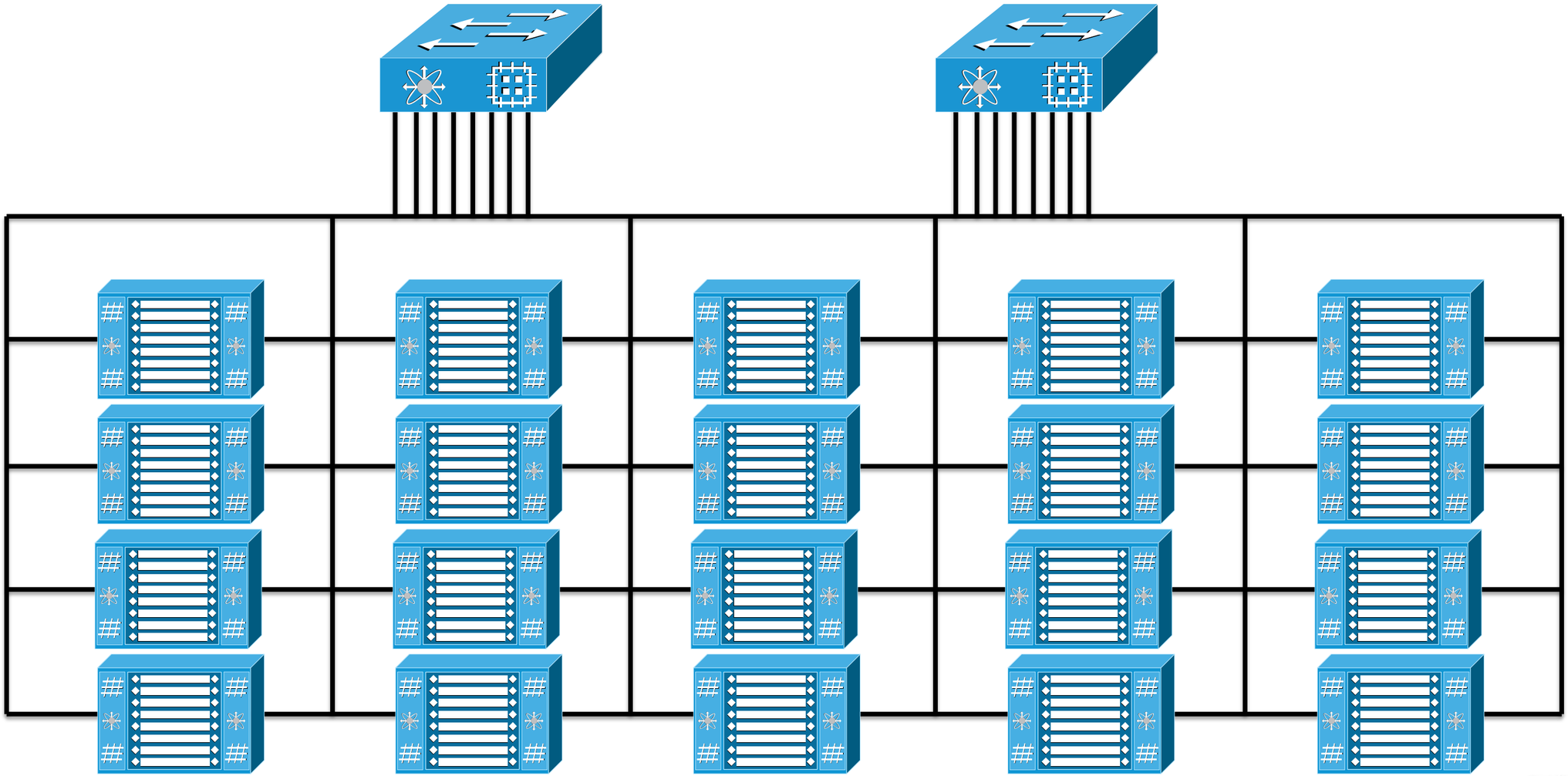
Cisco UCS Blade Chassis

Up to 160 blades can be part of one system



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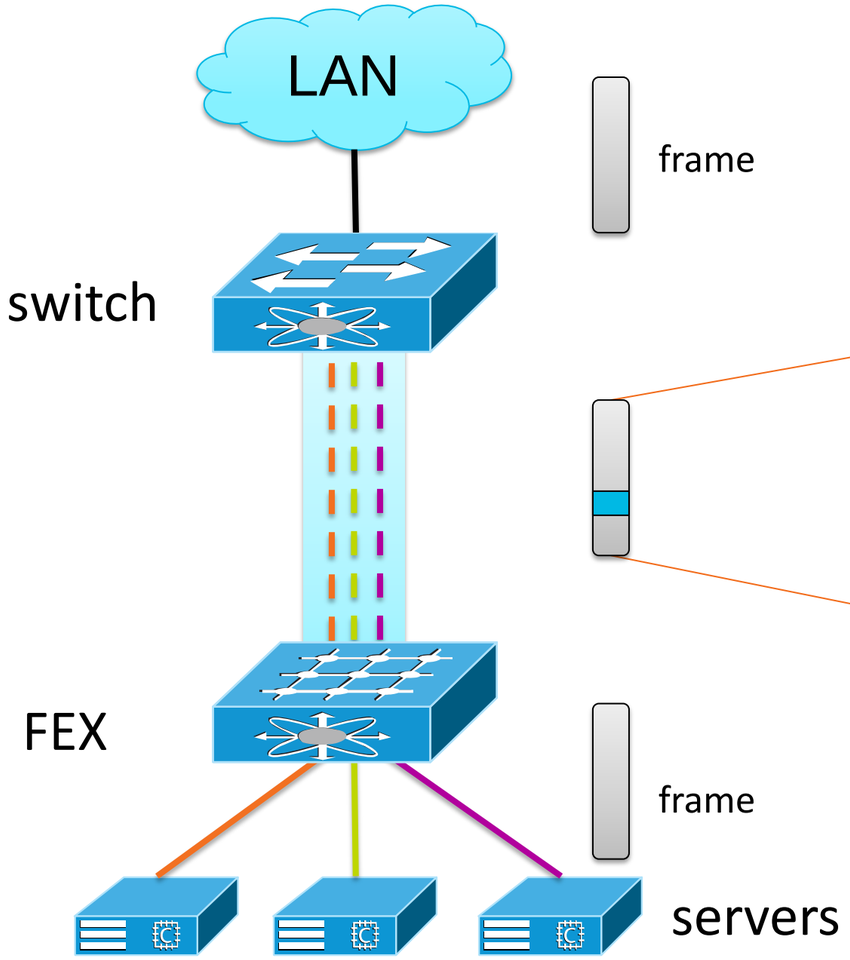
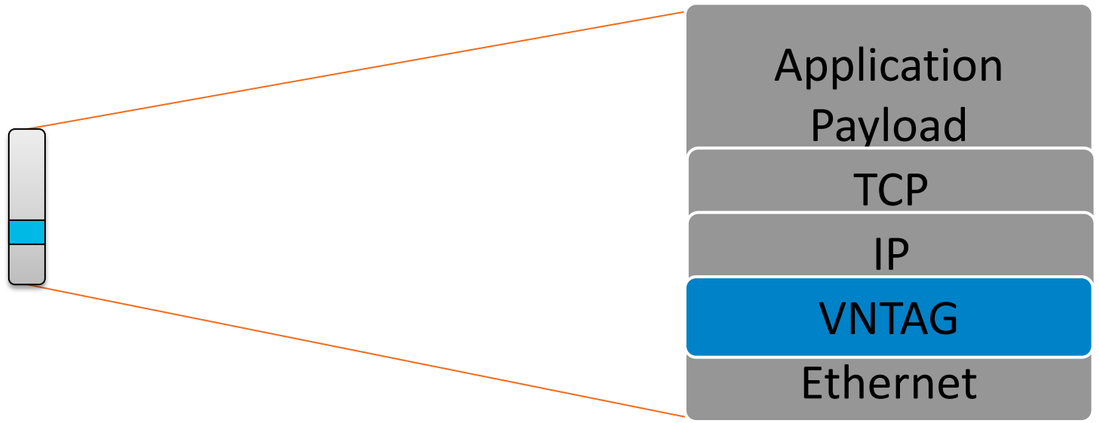
Key Architectural Component 1: VNTAG

Intra-chassis bus header





VNTAG = IEEE 802.1Qbh

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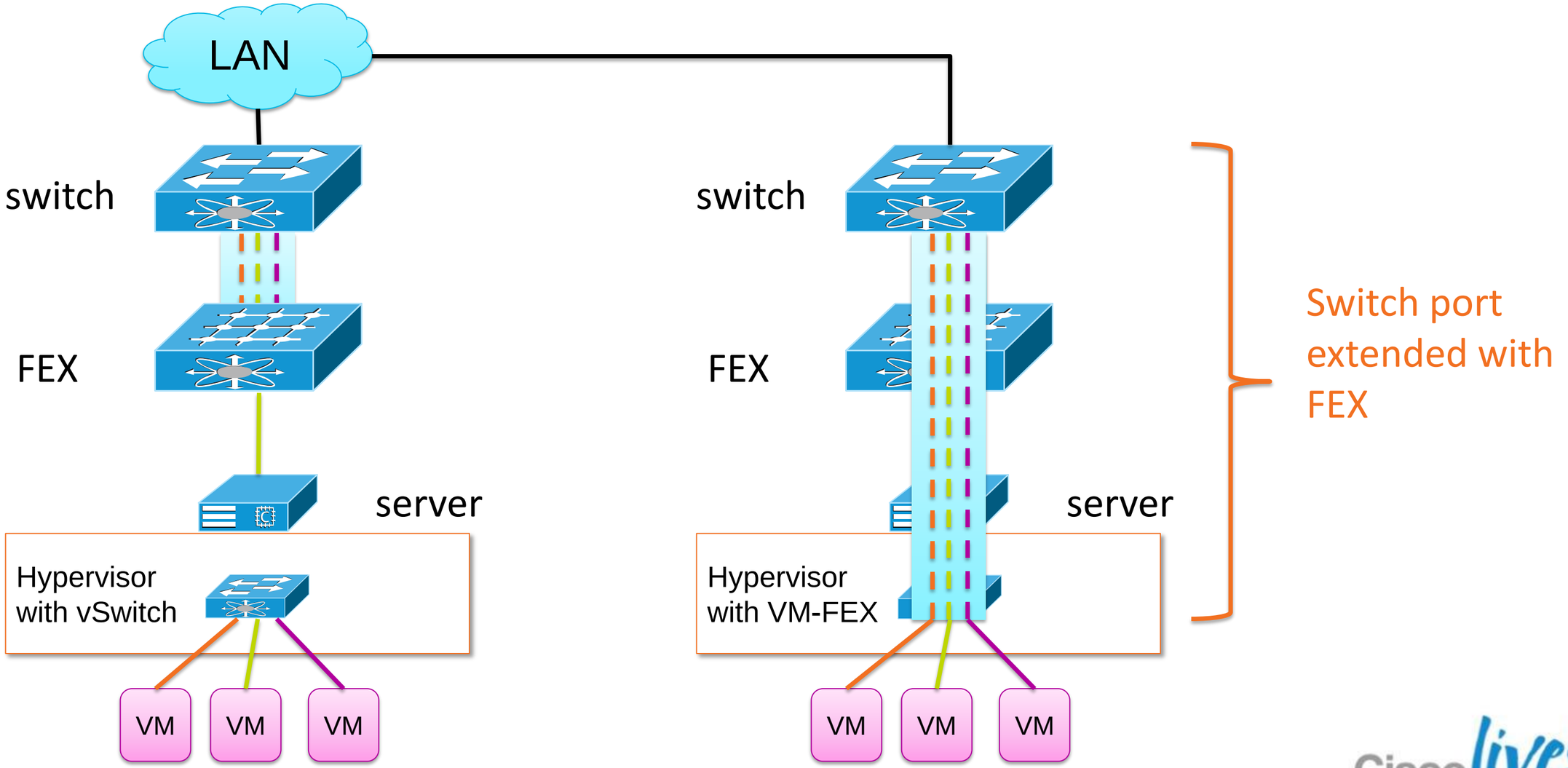
Extending FEX Architecture to VMs

FEX inside the server



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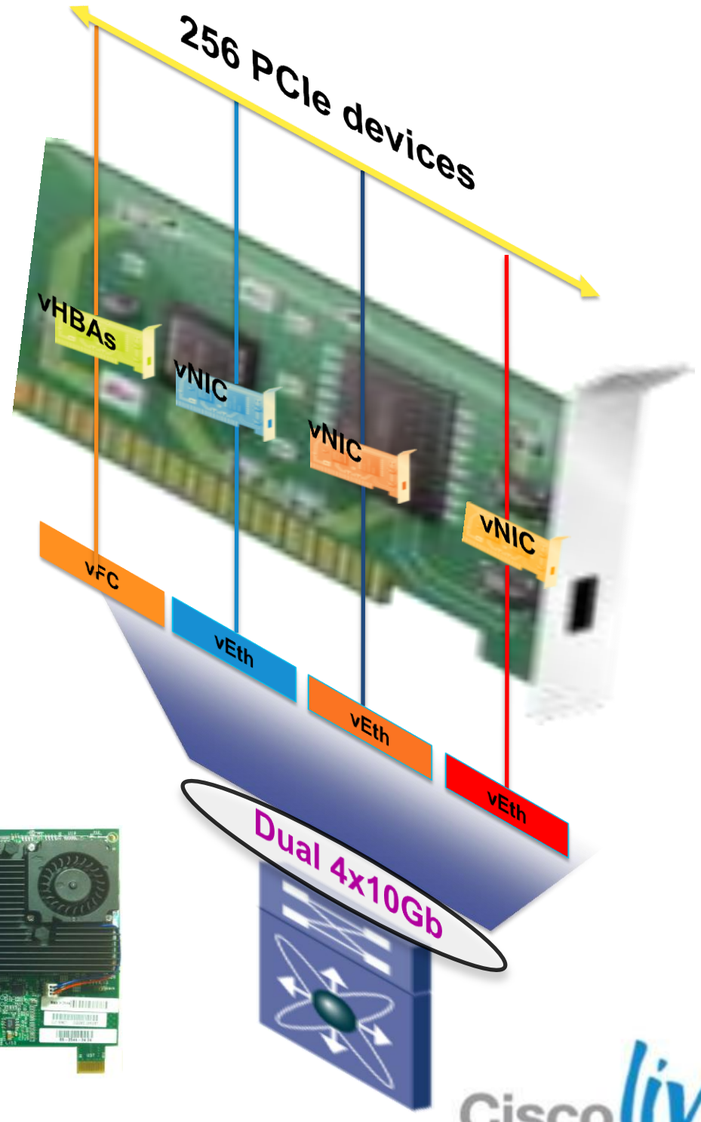
Key Architectural Component 2: UCS VIC

UCS Virtual Interface Card family

- 256 PCIe devices
  - Devices can be vNICs or vHBAs
  - Each device has a corresponding switch interface
- Bandwidth 2x4x10 Gb
  - Uses 4x10 Ether Channel, HW 40Gb Capable
  - vNICs/vHBAs NOT limited to 10Gb
- PCIe Gen-2 x 16
- Mezzanine and PCI



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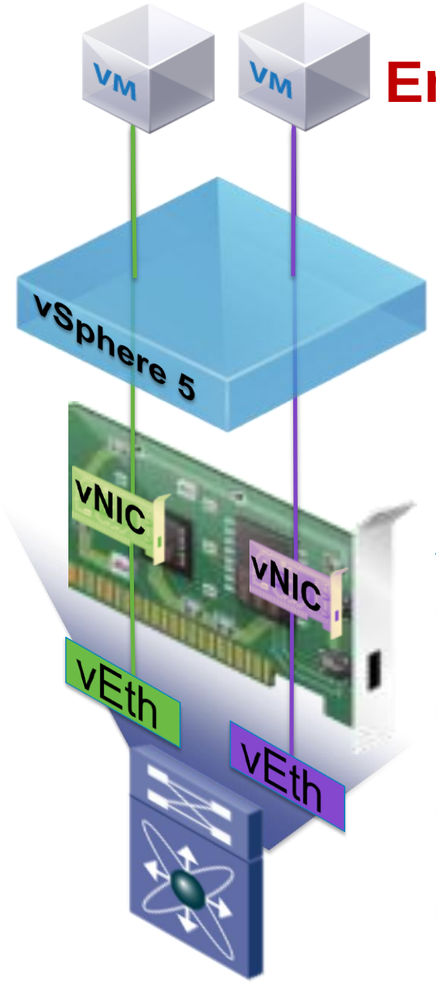
VM-FEX Modes of Operation

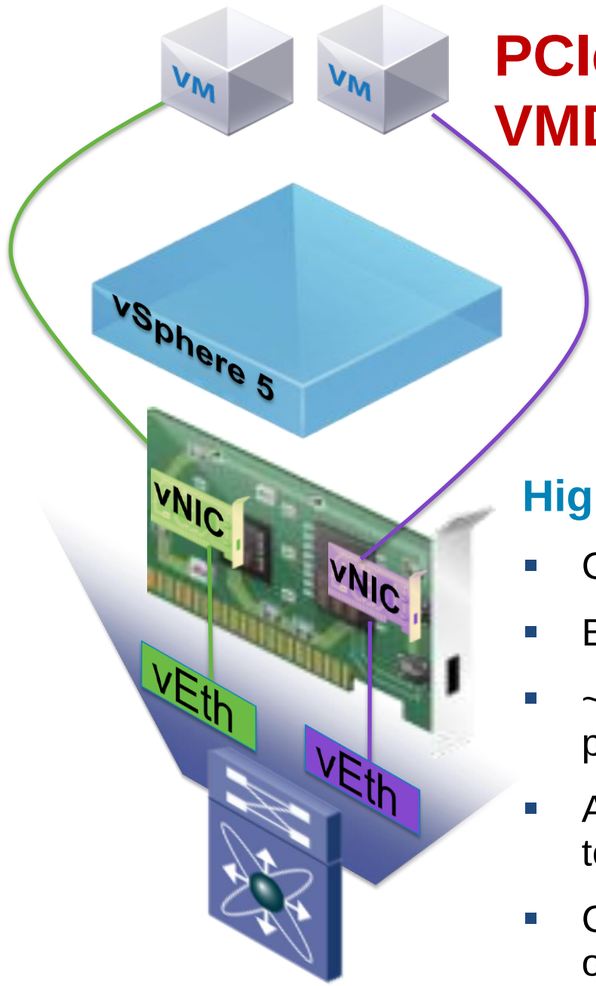
Enumeration vs. Hypervisor Bypass



Emulated Mode

Standard (Emulated) Mode

- Each VM gets a dedicated PCIe device
- ~12%-15% CPU performance improvement
- Appears as distributed virtual switch to hypervisor
- LiveMigration supported



PCIe Pass-Thru or VMDirectPath

High Performance Mode

- Co-exists with Standard mode
- Bypasses Hypervisor layer
- ~30% improvement in I/O performance
- Appears as distributed virtual switch to hypervisor
- Currently supported with ESX 5.0 only
- vMotion supported

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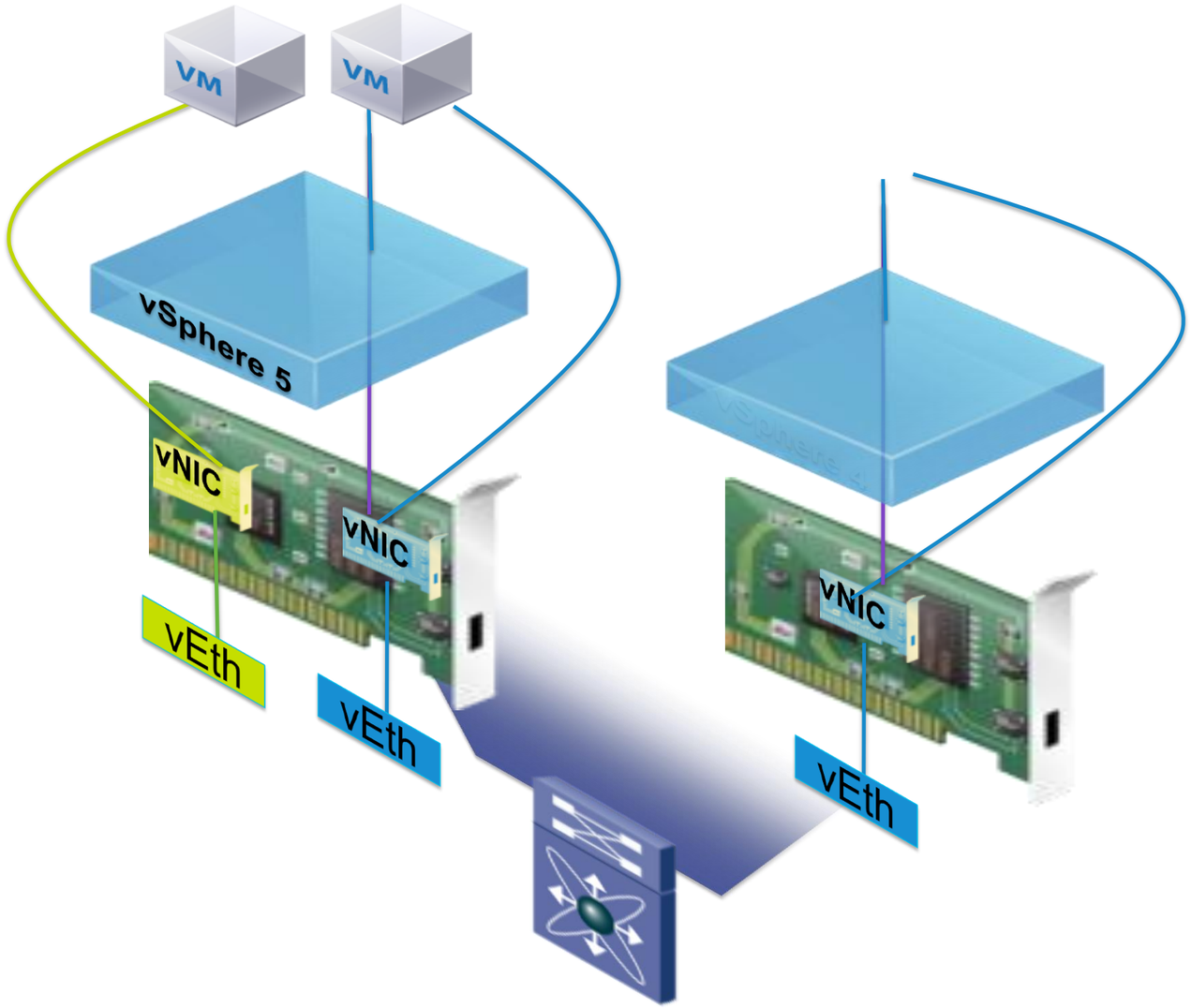
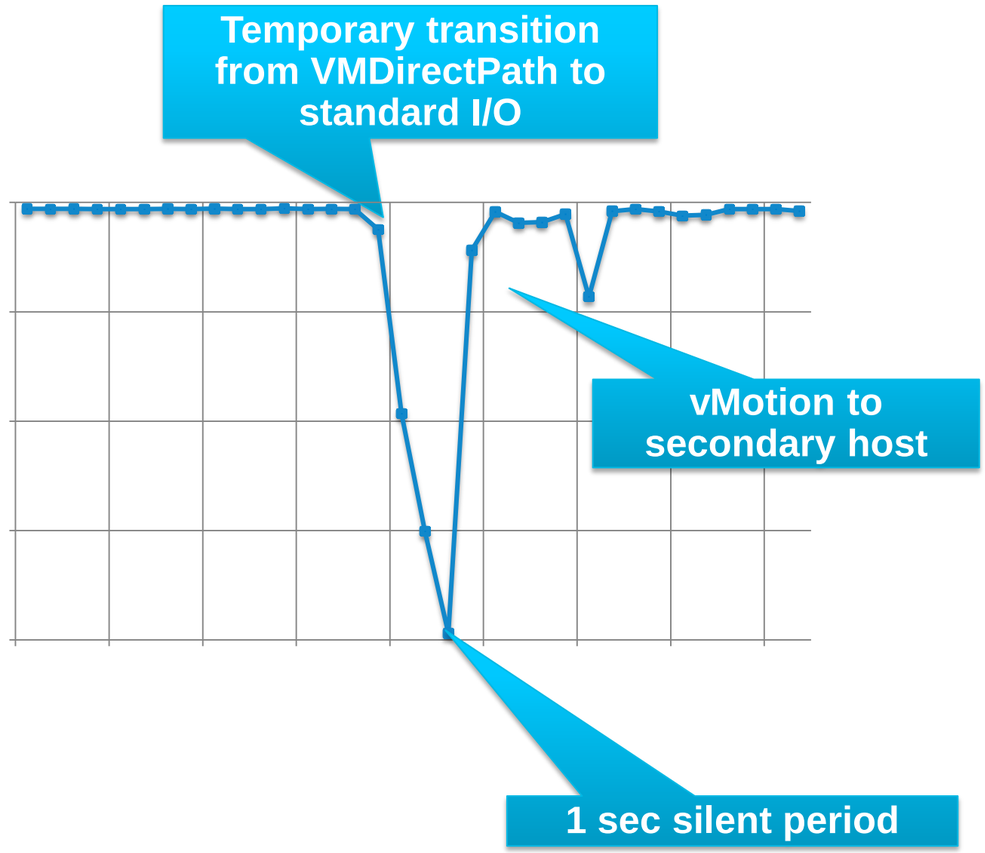
VM-FEX Operational Model

vMotion with Hypervisor Bypass (VMDirectPath with VM-FEX)





- VM Sending TCP stream (1500MTU)
- UCS B200 M2 blades with UCS VIC card

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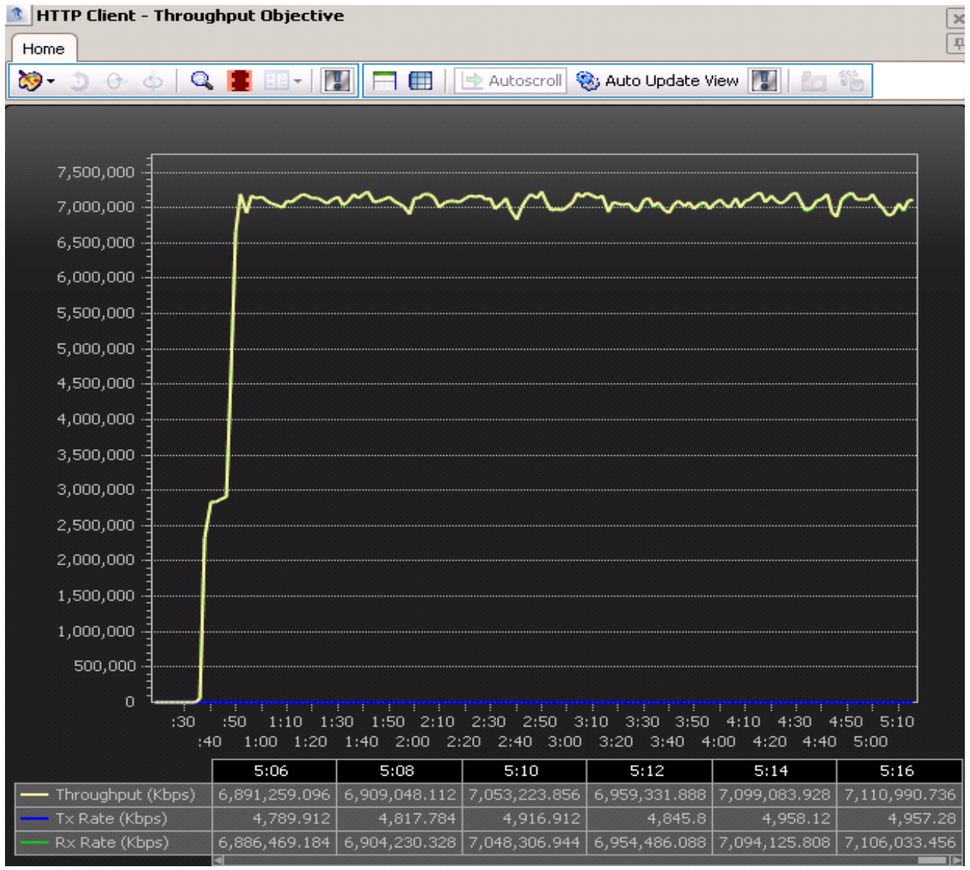
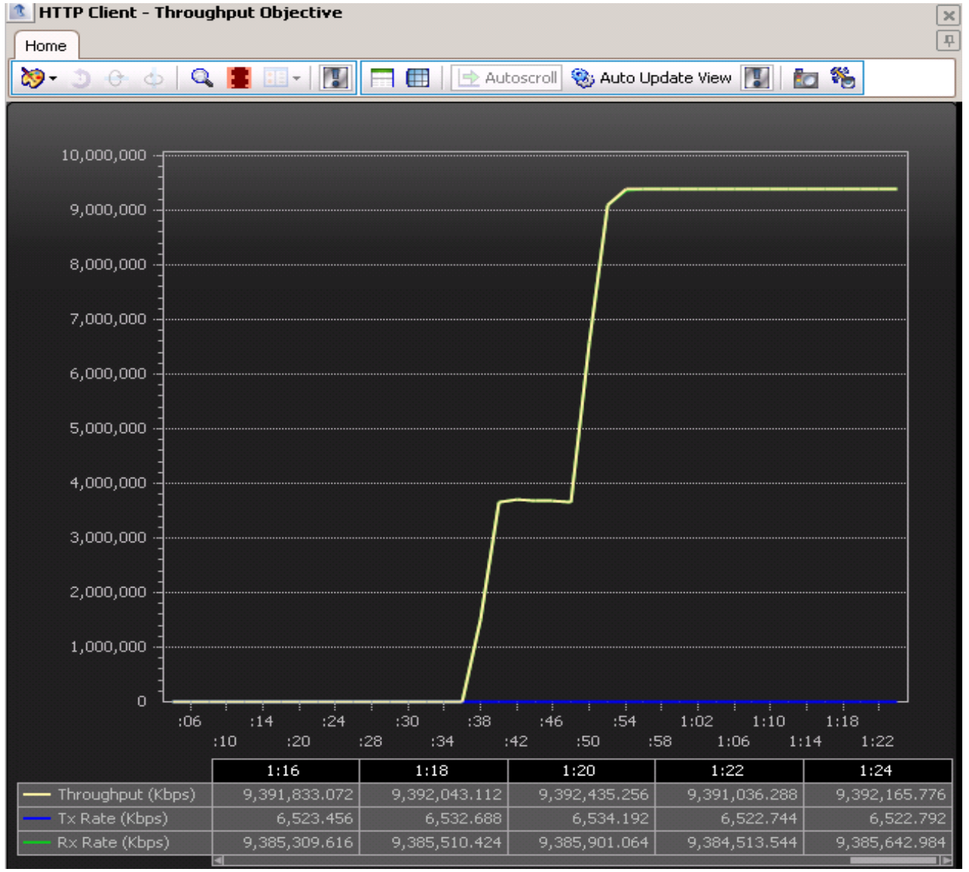
VM-FEX Performance Review

Test of 10 VM's running HTTP and FTP Gets with IxLoad



Virtual Switch, CPU at ~65%



VM-FEX, CPU at ~ 37%

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Compute

Intel E5-2600 Processor Improvements

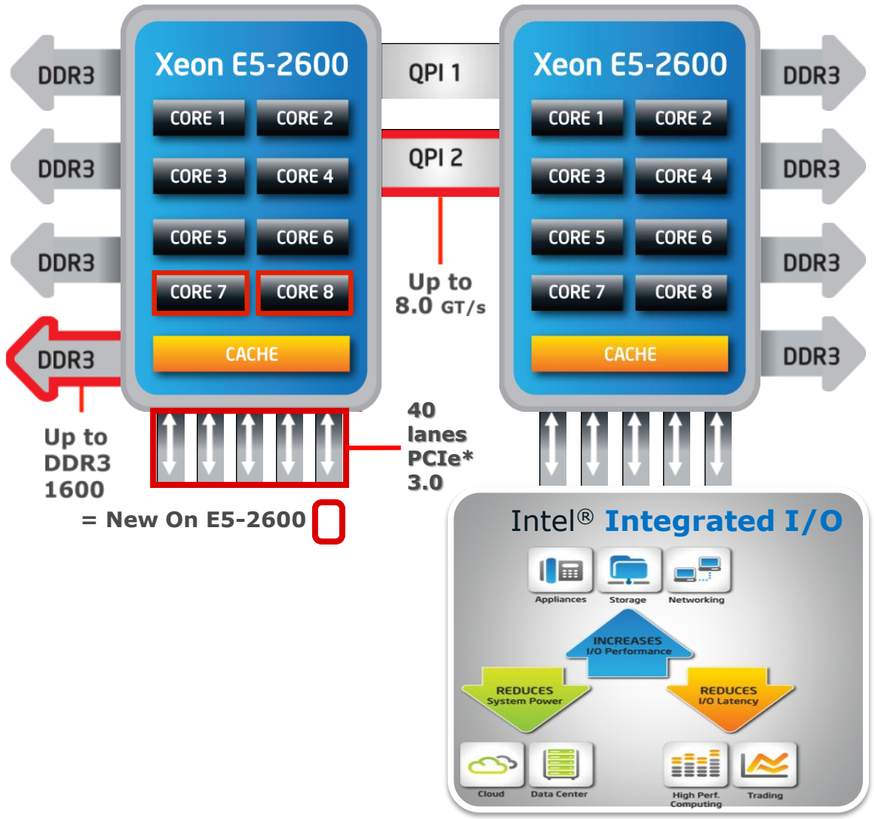
More Cores

More Memory

More Integration

Reduces I/O latency by as much as 30%
PCIe 3.0 improves I/O by as much as 2X

More Bandwidth



For more information: http://www.intel.com/go/performance

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Top Bin E7 Versus Top Bin E5

	E7-2870	E5-2690
Power (W)	130 ✓	135
Cores	10 ✓	8
Cache	30M ✓	20M
Speed (GHz)	2.40	2.90 ✓
QPI	6.4GT/s	8.0GT/s ✓
SPECint	267.5	348.5 ✓
SPECfp	184.5	254.5 ✓
Recommended Cost	$4,227	$2,057 ✓

Higher performance at half the price. Which one do you prefer?

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E7 Versus E5 Proc Comparison

To be fair…

- Most comparisons are not as extreme
- Most sizing exercises show E7 systems to be superior
- E5-2600 systems substantially less expensive

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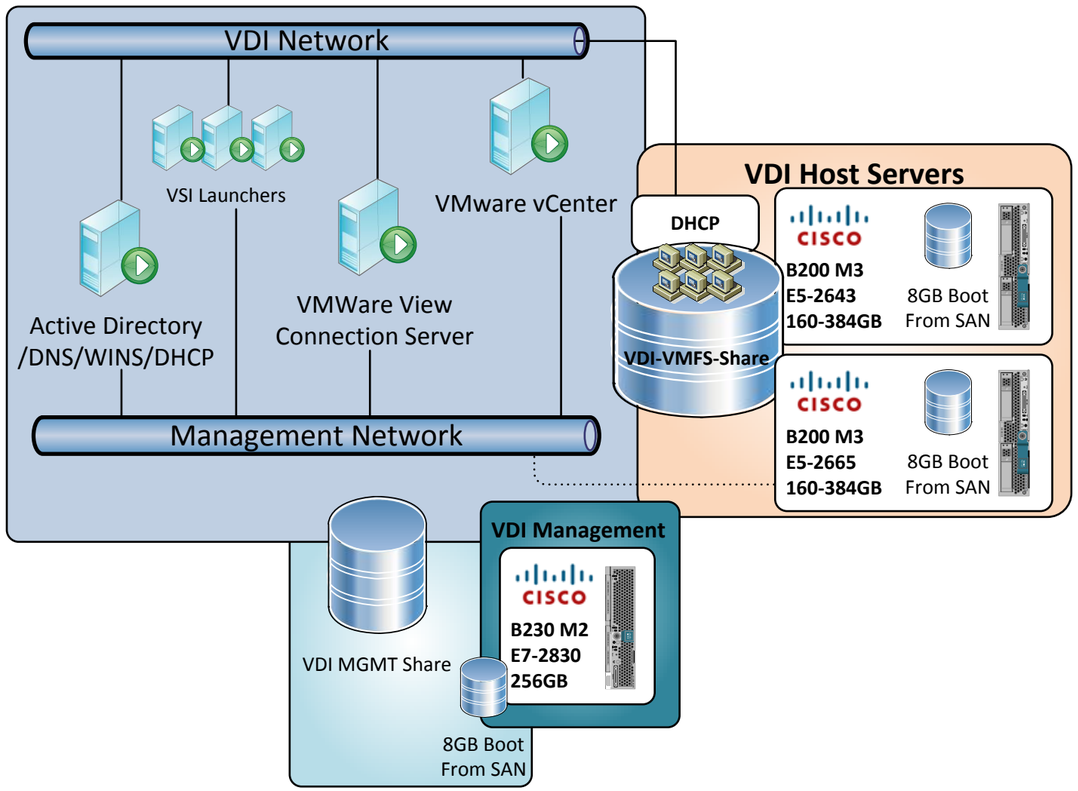
Lessons Learned From VDI Testing

Compute trends relevant to general server virtualisation



Logical test environment

- Various UCS B200 M3 configurations
- Login Consultants' Virtual Session Indexer (Login VSI) 3.6.1 benchmark
- Login VSI's Medium with Flash workload
- VMware View 5.1.1
- Microsoft Windows 7 SP1 32-bit virtual desktops
- Pure Storage FlashArray with Purity version 2.0.2.

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Configuration Settings for Tests

Configuration	Setting(s)
Login VSI Configuration Settings	• Medium with Flash workload generator • 4,000ms response cut off
Windows 7 Configuration	• 1.5GB memory for all tests • 32-bit Windows 7 SP1 and Windows updates through September 1, 2012
ESX Host Configuration	• Power management set to High Performance in vSphere • BIOS settings have C1E disabled in UCSM policy • ESXi-5.0.0-623860-custom (Cisco specific build of ESXi with drivers)
VM Configuration	• 1vCPU and 2vCPU configurations
View Configuration	• Linked clones • View Optimisation* registry changes on all Virtual desktops • Did not use profile management • Did not use host Cache for View

* http://www.vmware.com/files/pdf/vmware-view-optimizationguidewindows7-en.pdf

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Processor Comparison

	Intel E5-2643	Intel E5-2665
Number of Cores	4	8
Clock Speed	3.3 GHz	2.4 GHz
Max Turbo Frequency	3.5 GHz	3.1 GHz
Max TDP	130W	115W
Cache	20M	20M
Recommended Customer Price (Tray)	$885	$1440
SPEC CINT2006 Rate	187.5	305
SPEC CFP2006 Rate	167.5	233.5
SPEC Blend/Core	44.38	33.6

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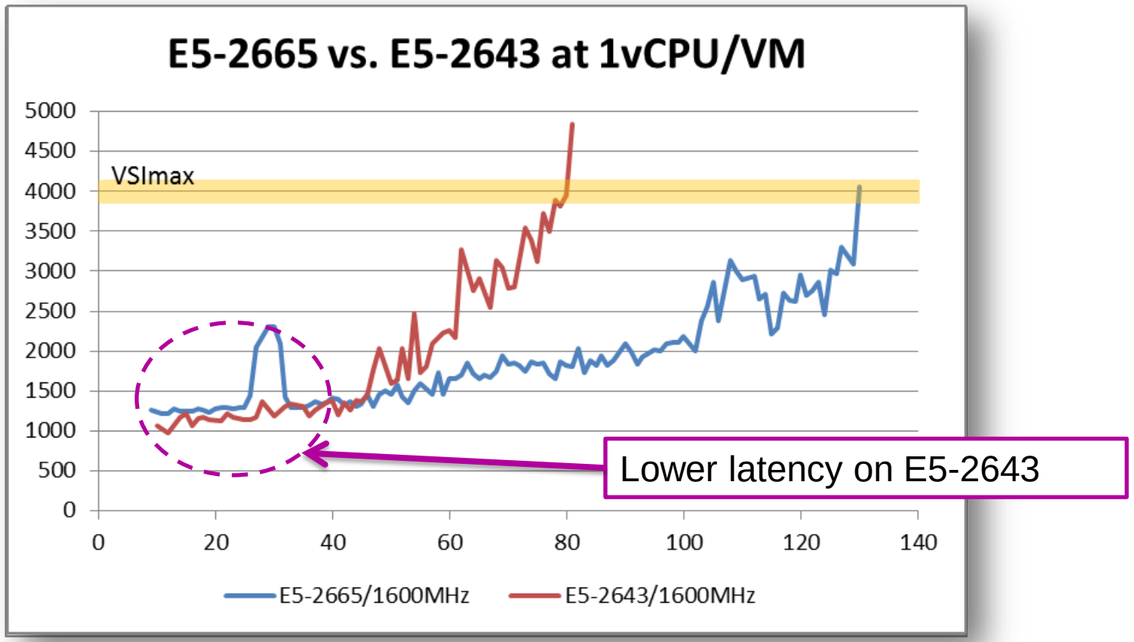
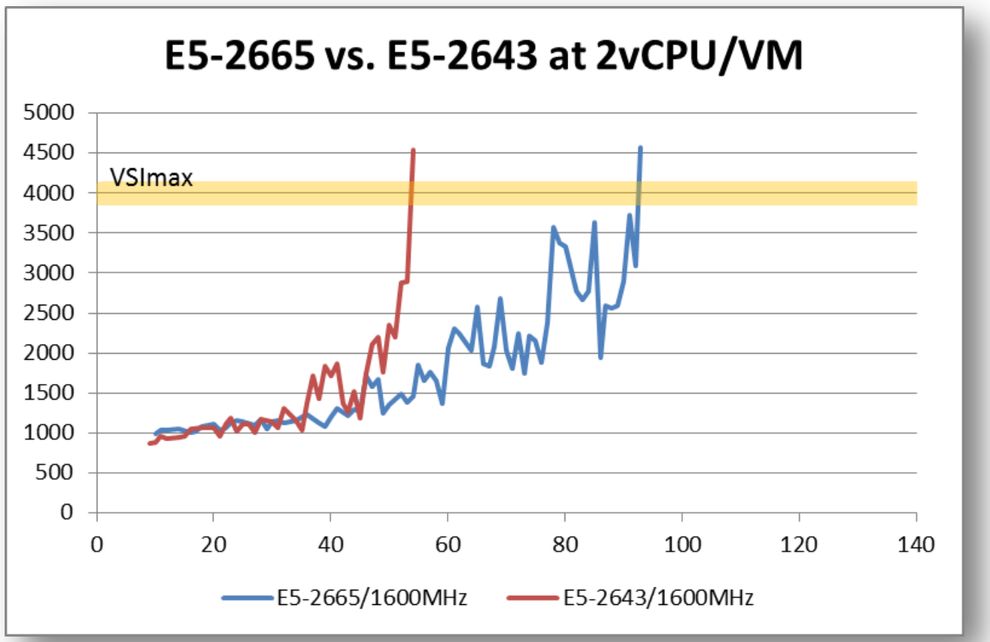
Question 1

Which is more important, core count or core speed?

- E5-2665 achieves 60-72% better density
- E5-2643 has lower latency at small desktop counts
- When density is the goal, core count is more important





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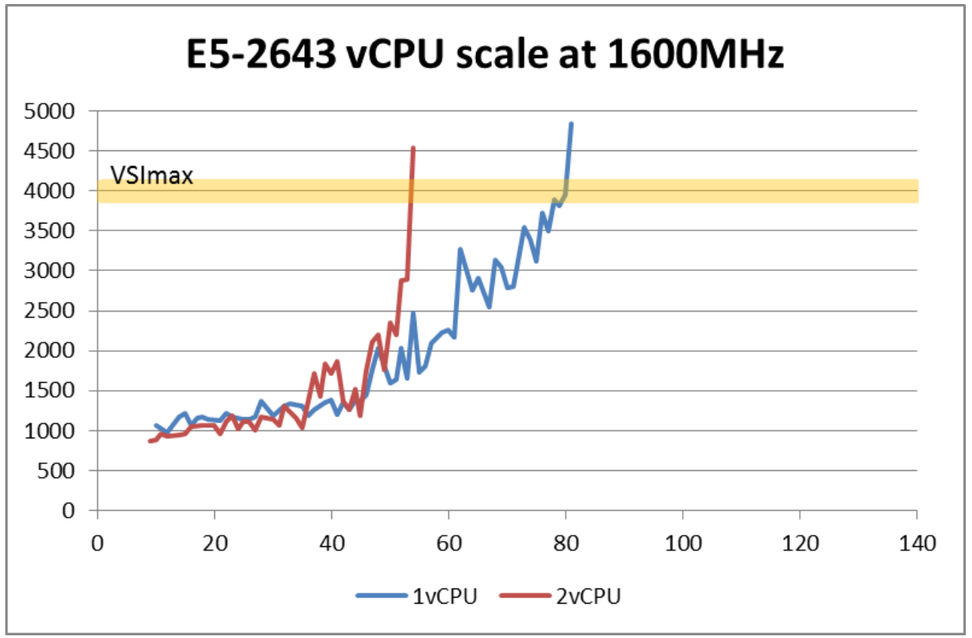
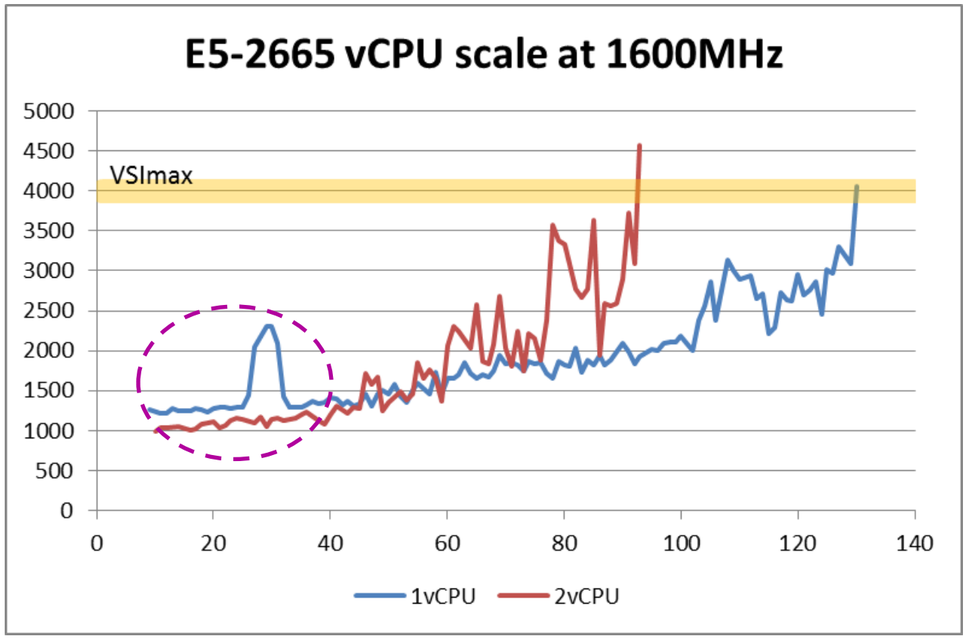
Question 2

How well does a system scale with multi-vCPU VMs?





- Going from 1vCPU to 2vCPU yielded 66-72% as many desktops
- Increasing vCPU count impacts scale, even with **the same workload**
- Advice: don't give a VM more vCPUs unless it needs it

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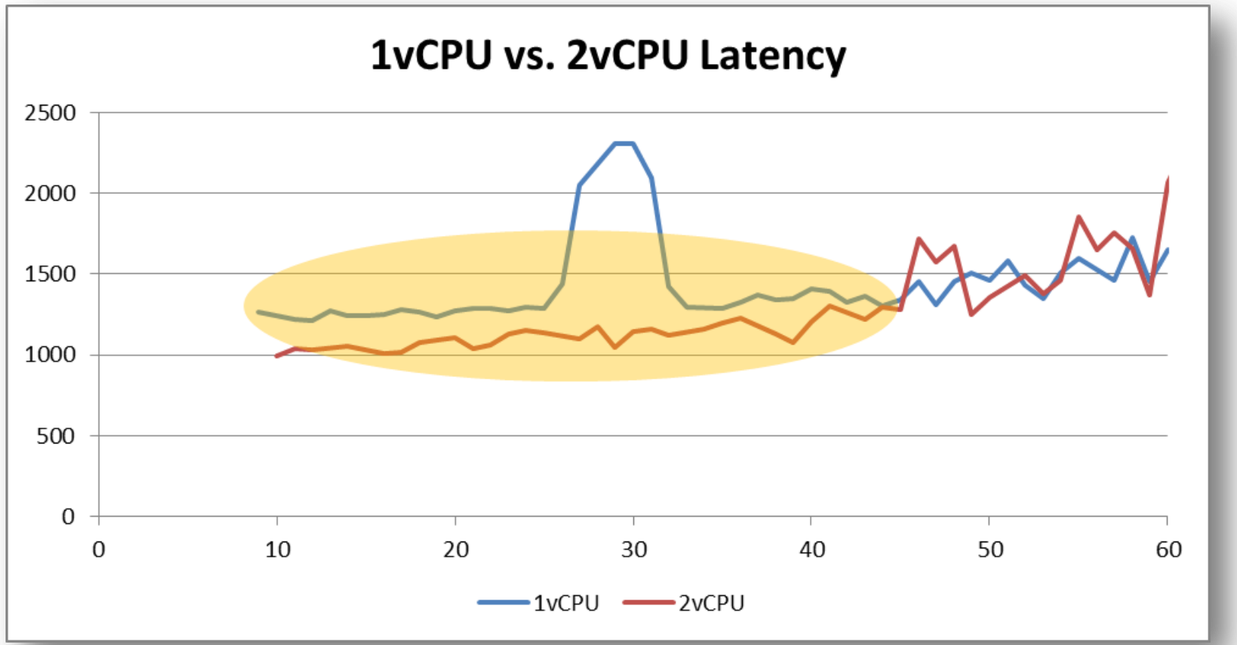
Question 2 Continued

How well does a system scale with multi-vCPU VMs?

- Purpose of multi vCPU machine is better performance
- Graph shows better performance (lower latency)
- Performance benefits taper off after 45 desktops



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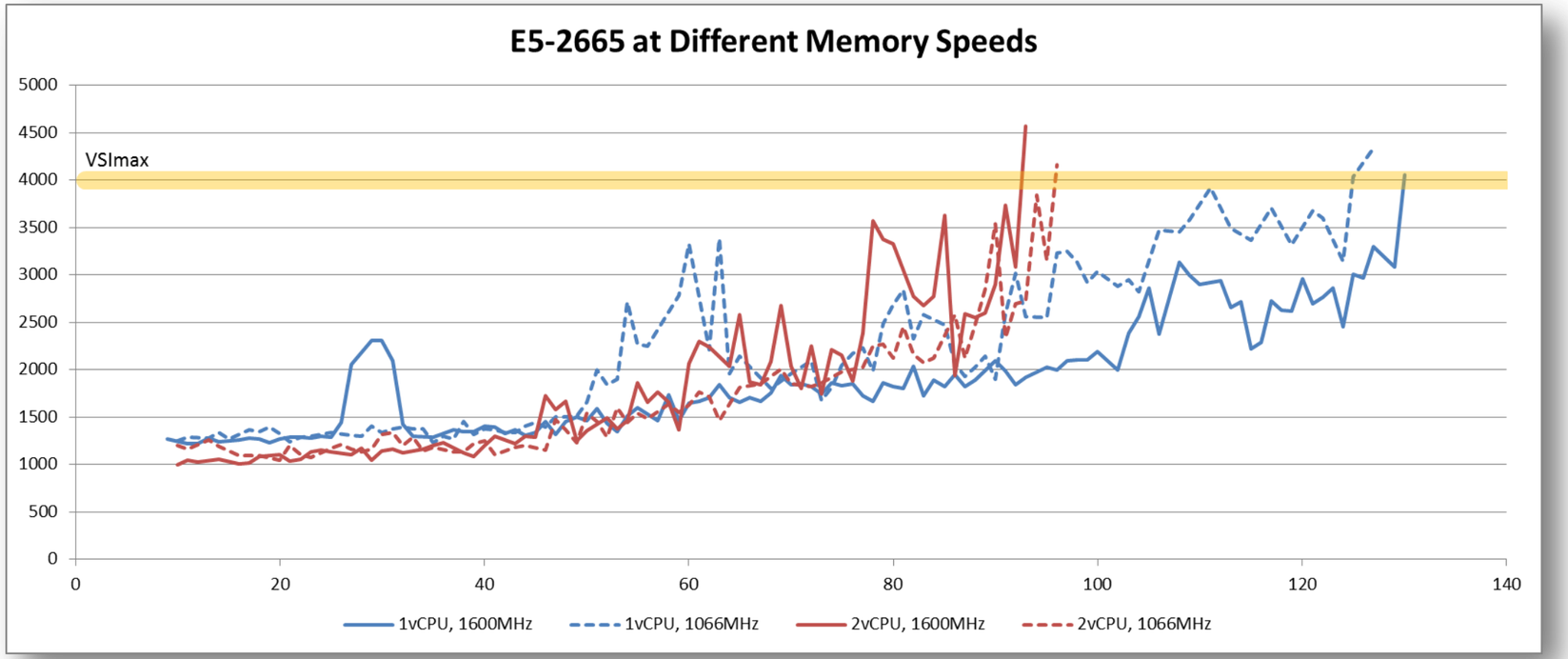
Question 3

How does memory speed affect scalability?

- At 1vCPU (blue lines), only 4% difference between 1600MHz and 1066MHz
- At 2vCPU (red lines), only 3% difference between 1600MHz and 1066MHz
- In both cases, the difference is negligible



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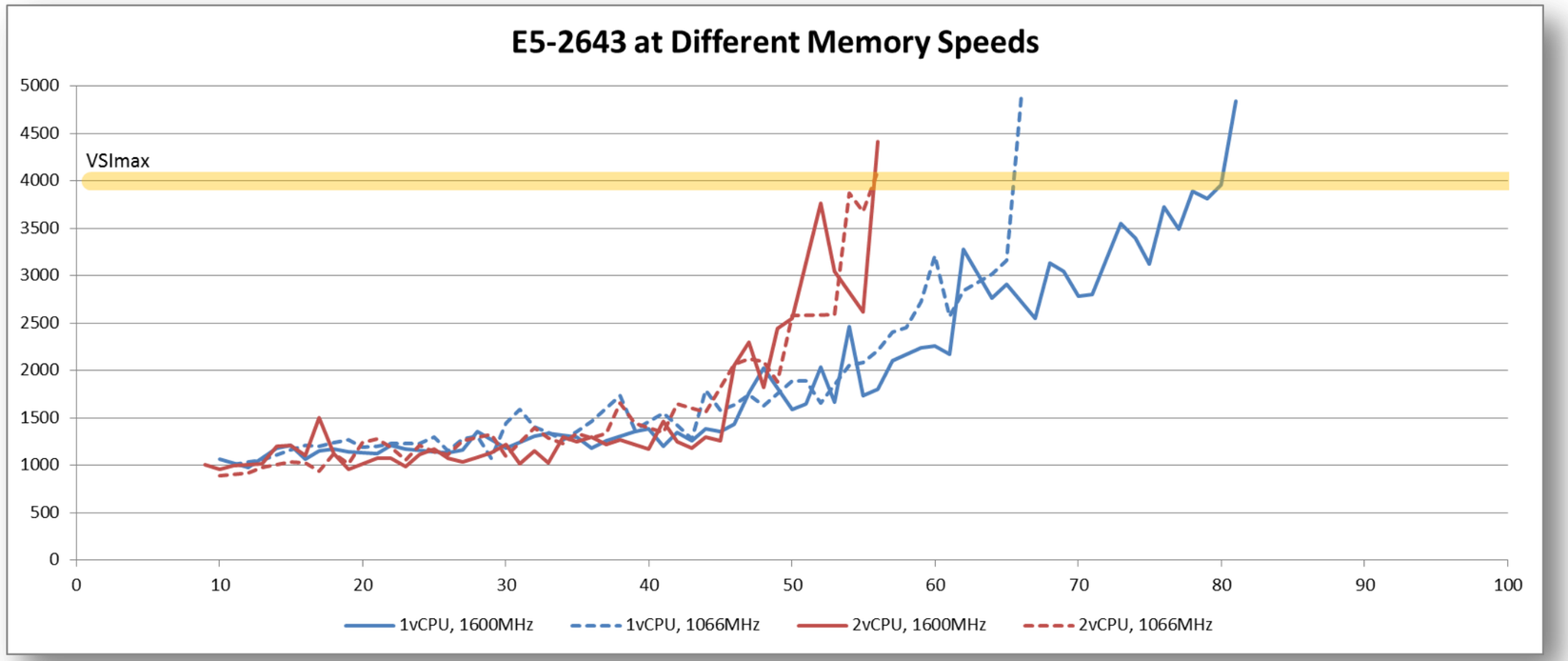
Question 3 Continued

How does memory speed affect scalability?

- At 2vCPU, performance difference is negligible
- At 1vCPU, E5-2643 saw huge 23% performance difference
- What is the cause? A higher VM/core ratio?



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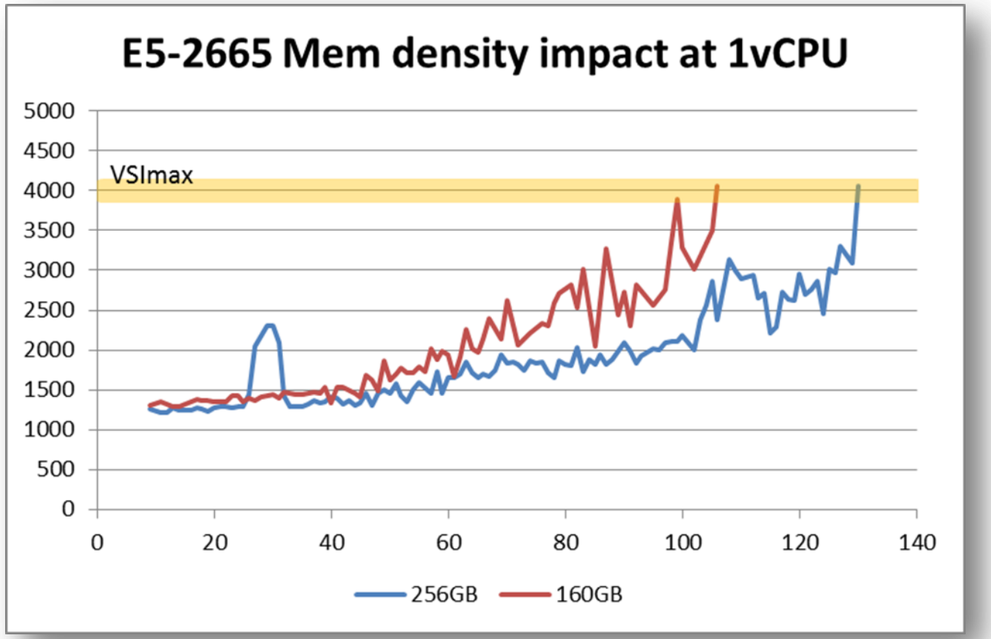
Question 4

How does memory capacity affect VDI scalability

- At 160GB system memory
  - Theoretical limit 98 desktops
  - Actual test reached 106 desktops
  - VMware memory overcommit gave ~12%
- At 256GB system memory
  - Theoretical limit 157 desktops
  - Actual test reached 130 desktops
  - System ran out of CPU
- Lesson: understand system constraints



Theoretical

98 desktops X (1.5GB + 130MB overhead) = **160GB**

157 desktops X (1.5GB + 130MB overhead) = **256GB**

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Rapid Deployment and Automation

Stateless Computing

What does it mean to you?

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Stateless: UCS Service Profiles

- RAID settings
- Disk scrub actions

- Number of vHBAs
- HBA WWN assignments
- FC Boot Parameters
- HBA firmware

- FC Fabric assignments for HBAs

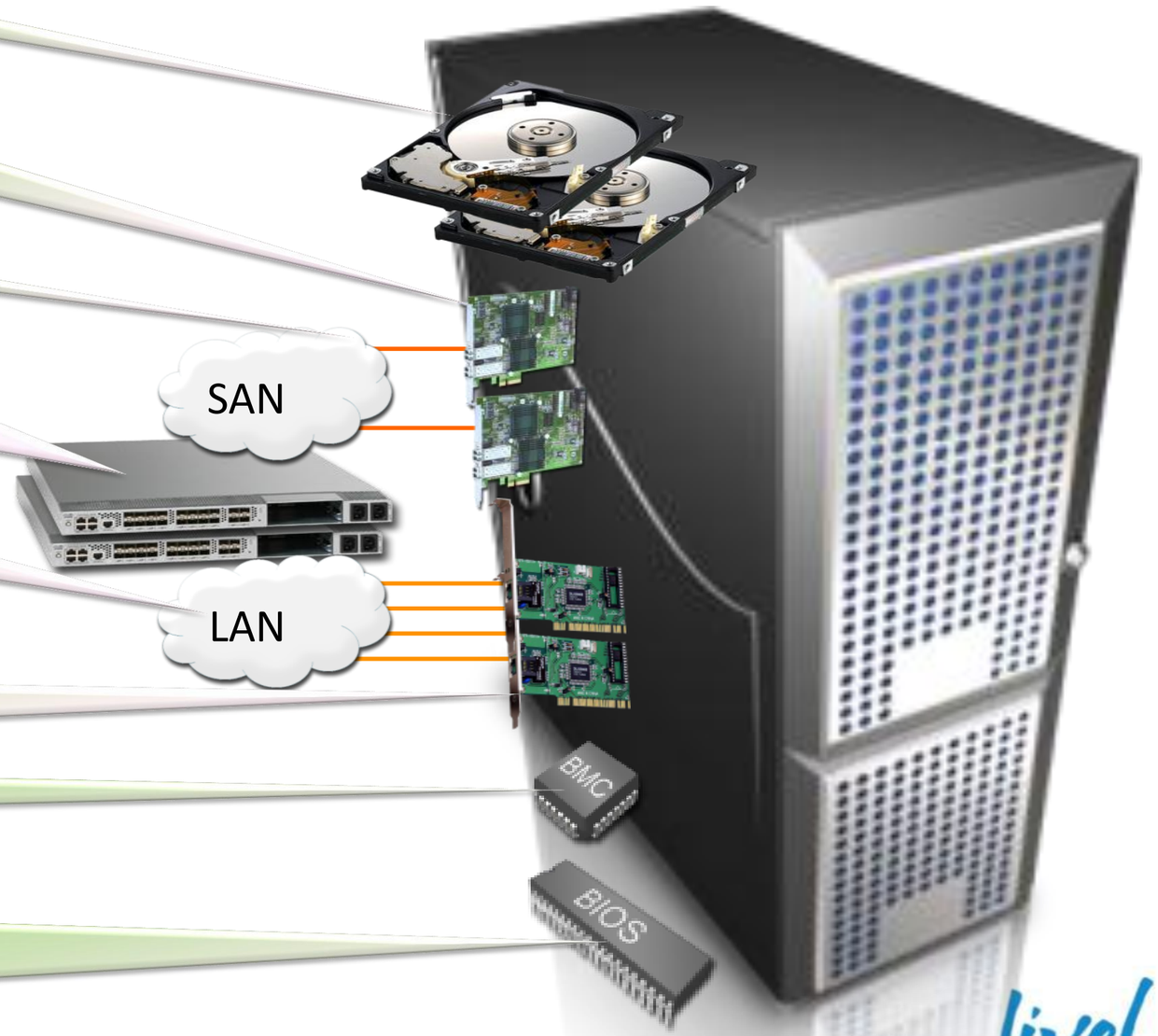
- QoS settings
- Border port assignment per vNIC
- NIC Transmit/Receive Rate Limiting

- VLAN assignments for NICs
- VLAN tagging config for NICs

- Number of vNICs
- PXE settings\
- NIC firmware
- Advanced feature settings

- Remote KVM IP settings
- Call Home behaviour
- Remote KVM firmware

- Server UUID
- Serial over LAN settings
- Boot order
- IPMI settings
- BIOS scrub actions
- BIOS firmware
- BIOS Settings



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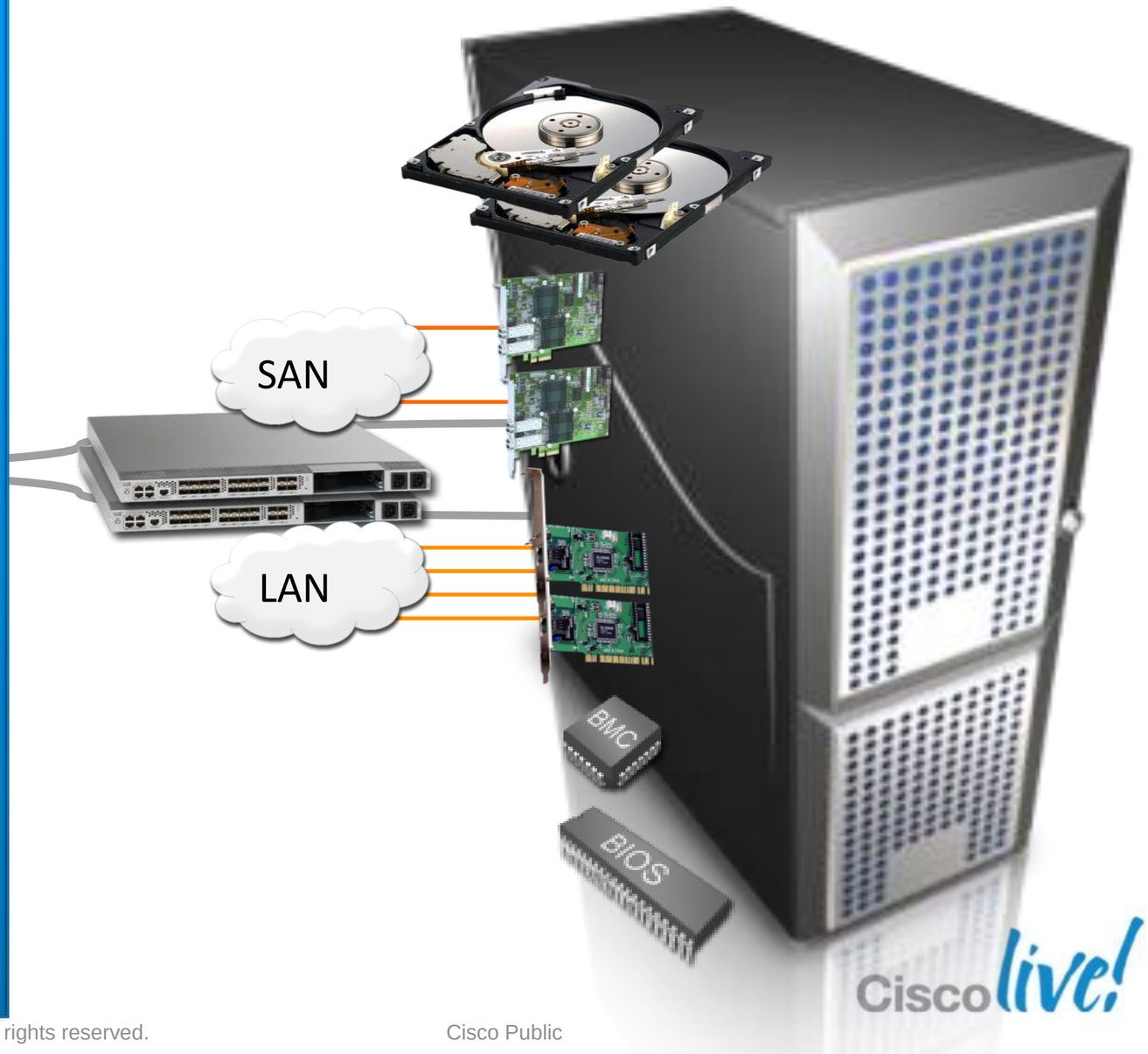
Stateless: UCS Service Profiles

- NIC MACs
- HBA WWNs
- Server UUID
- VLAN Assignments
- VLAN Tagging
- FC Fabrics Assignments
- FC Boot Parameters
- Number of vNICs
- Boot order
- PXE settings
- IPMI Settings
- Number of vHBAs
- QoS
- Call Home
- Template Association
- Org & Sub Org Assoc.
- Server Pool Association
- Statistic Thresholds
- BIOS scrub actions
- Disk scrub actions
- BIOS firmware
- Adapter firmware
- BMC firmware
- RAID settings
- Advanced NIC settings
- Serial over LAN settings
- BIOS Settings



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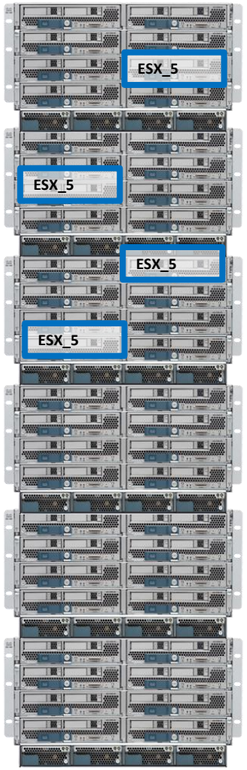
Creating and Moving Service Profiles

- **State** is decoupled from **hardware**
- Easy to redeploy HW for other applications
- Dynamic provisioning
  - Speed/agility
  - Consistency
- Simplified management

Service Profile: ESX_5
Network1: www_prod
Network1 QoS: Gold
MAC : 08:00:69:10:78:ED
Boot Order: LOCAL
FW: WebServerBundle



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Quickly Recover From ESX Host Failure

Local boot media breaks stateless computing

- No local disk
- No USB flash drive
- No SD card

Local boot media is something an admin has to touch or move

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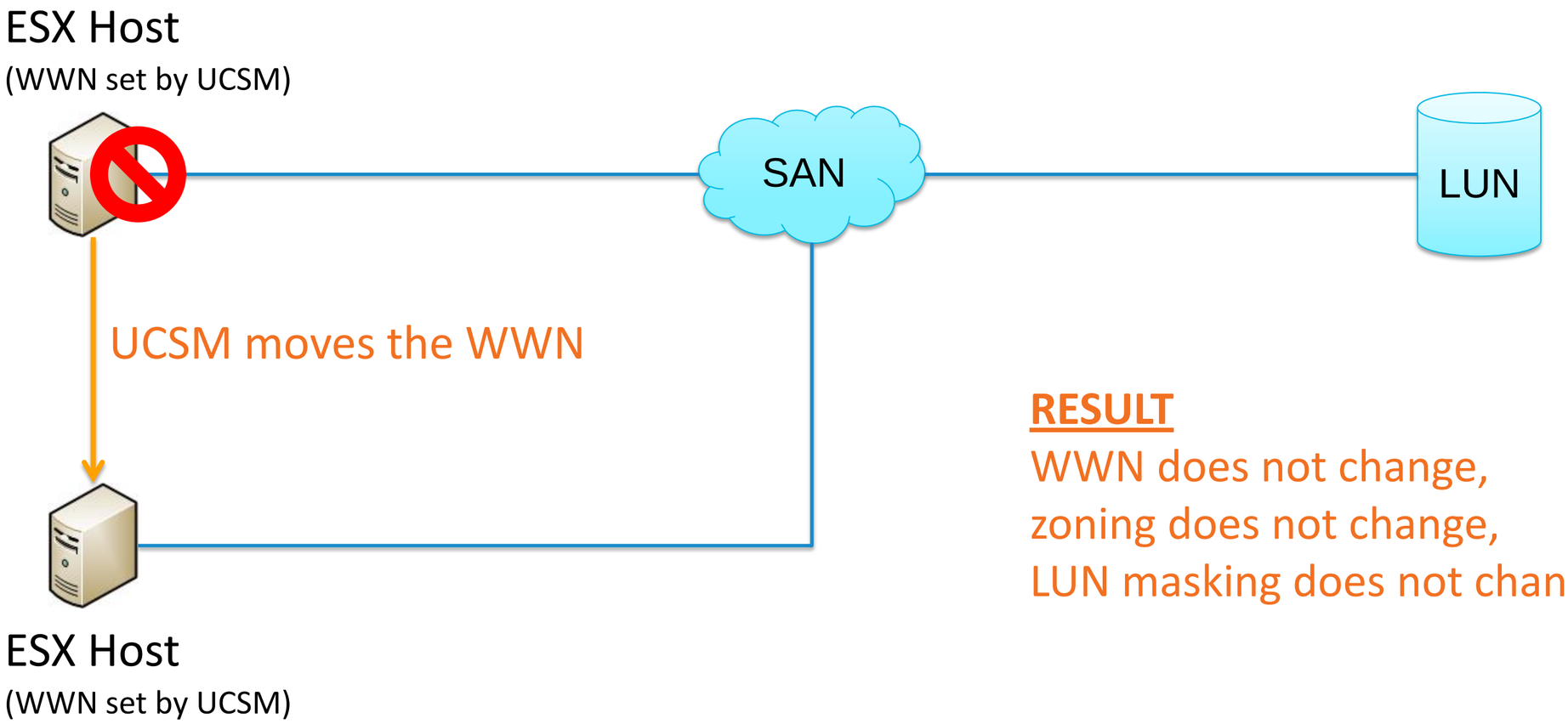
Quickly Recover From ESX Host Failure

Boot from SAN



RESULT

WWN does not change,
zoning does not change,
LUN masking does not change

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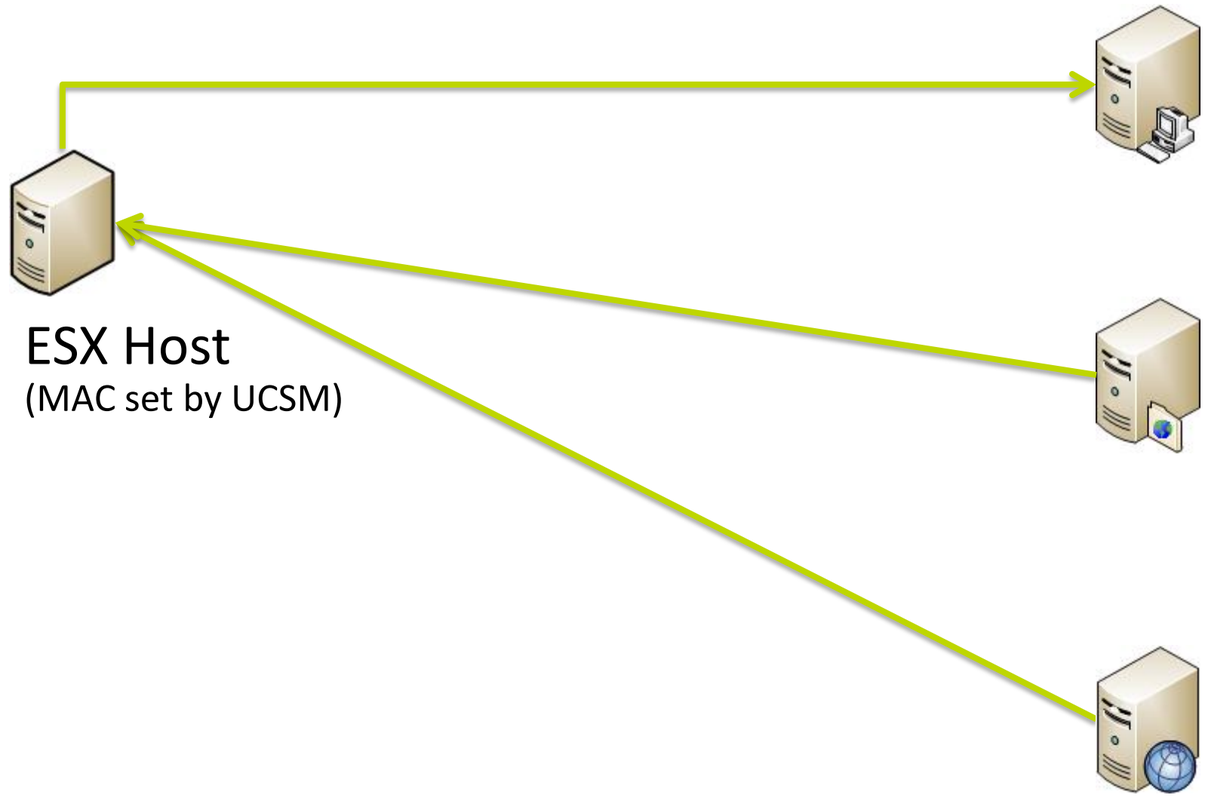
Quickly Recover From ESX Host Failure

VMware Auto Deploy (boot from Ethernet)



DHCP Server

set option 66 NextServer = IP of TFTP server
set option 67 FileName = name of PXE boot file
provides host with IP & FileName for boot

TFTP Server

gPXE boot image downloaded from vCenter
provides host gPXE boot image to perform HTTP boot from Auto Deploy server

Auto Deploy Server

rules engine and profiles configured with PowerCLI
uses host MAC, IP, etc. in rules engine to assign a host profile

What happens when this host fails?

Use UCS Manager to move the MAC to spare server.

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Auto Deploy Methods in vSphere 5.1

All three modes work well with UCS stateless computing

- Stateless
  - Host boot order: PXE only
  - Loads image and configuration from AD server on every reboot
- Stateless caching
  - Host boot order: PXE then local disk
  - Caches ESXi image to local disk; used only if PXE fails
- Stateful Install
  - Host boot order: local disk then PXE
  - Uses AD to install to disk

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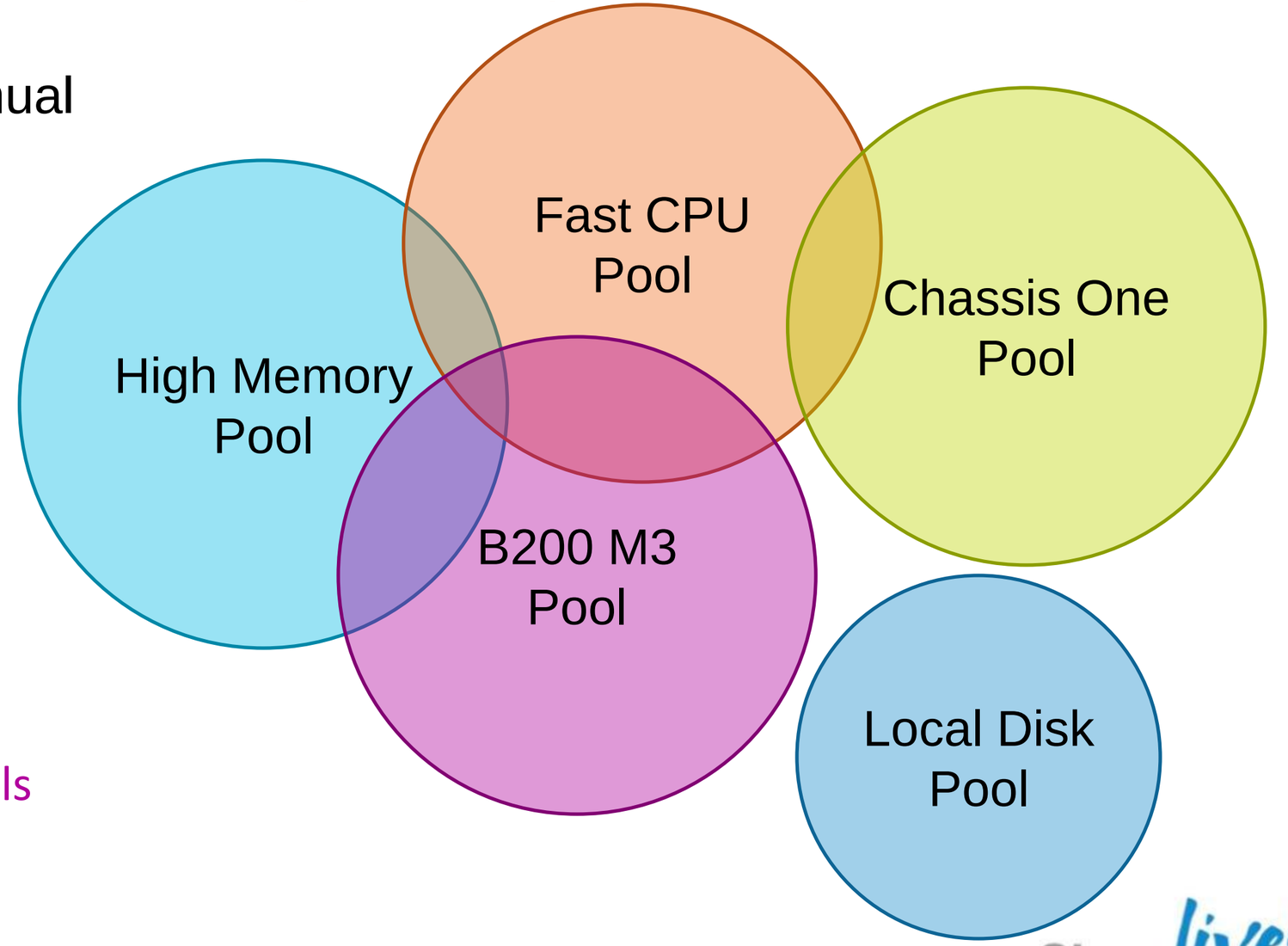
Using Server Pools

Don’t assign profiles to servers – assign them to pools

- Pools can be static/manual
- Pools can be dynamic
- Pools can overlap

The true power of pools



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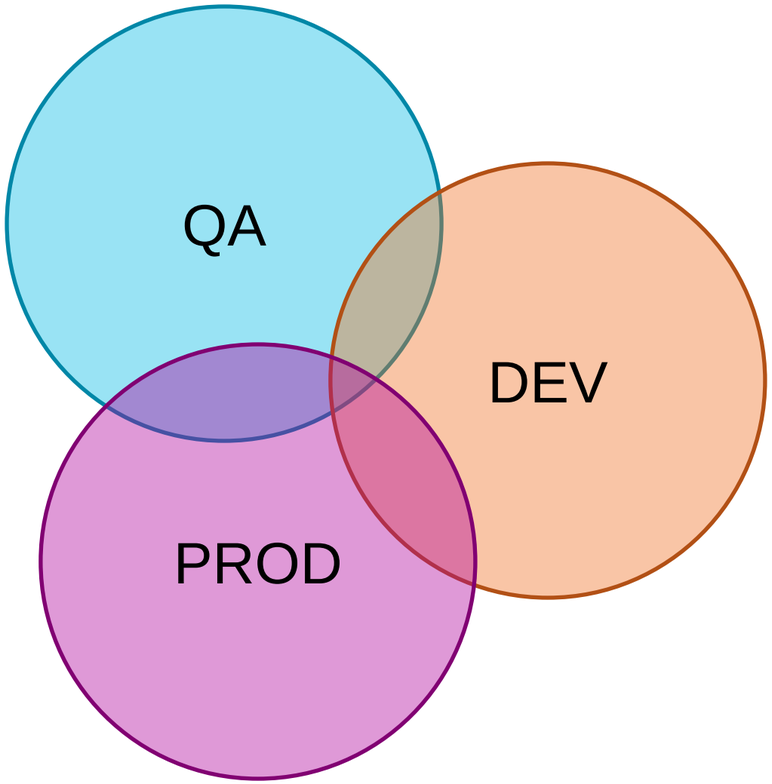
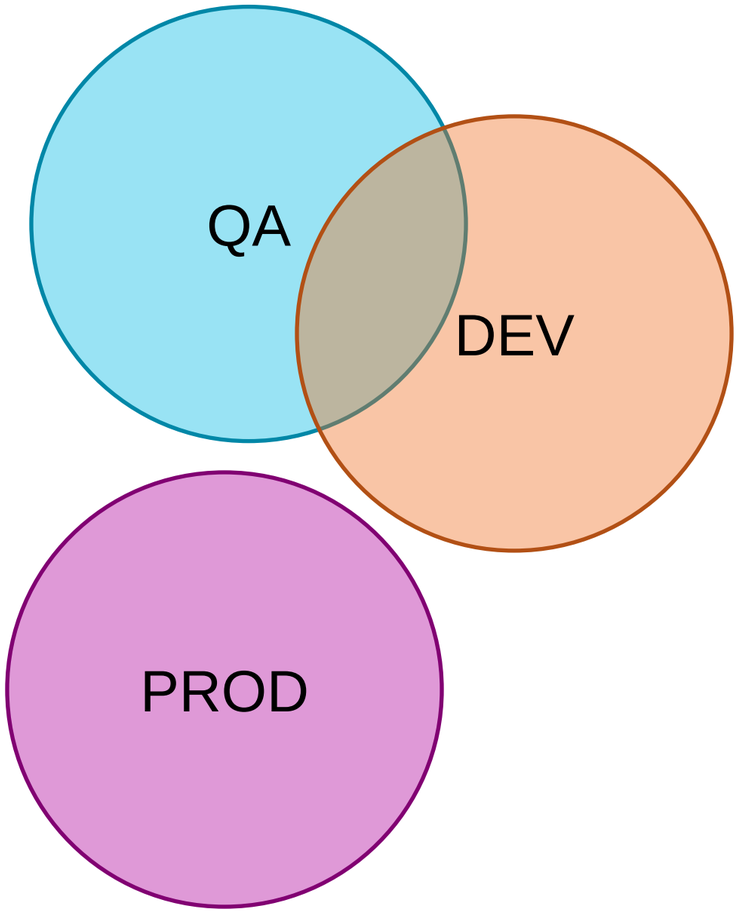
Beware That Pools Can Overlap

Don’t accidentally take resources away from one pool



-OR-



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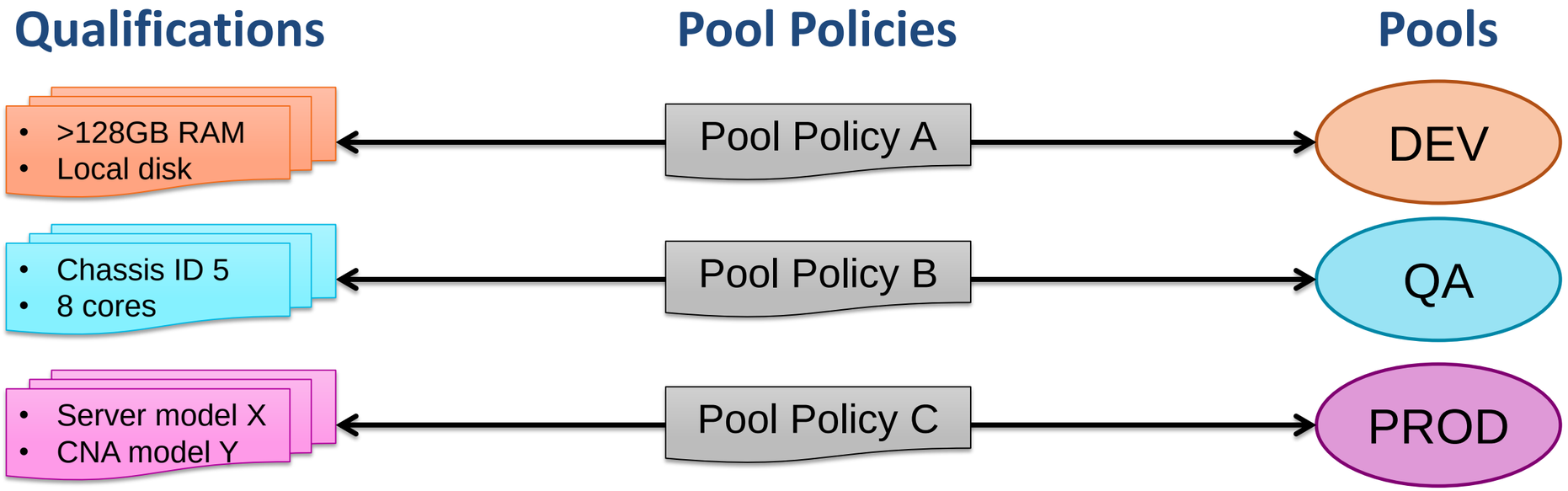
Creating Dynamic Pools

Relationship between pools and policies

1. Create **Server Pool Policy Qualifications**
2. Create empty **Server Pools**
3. Link each **Server Pool** to **Qualification(s)** with a **Pool Policy**



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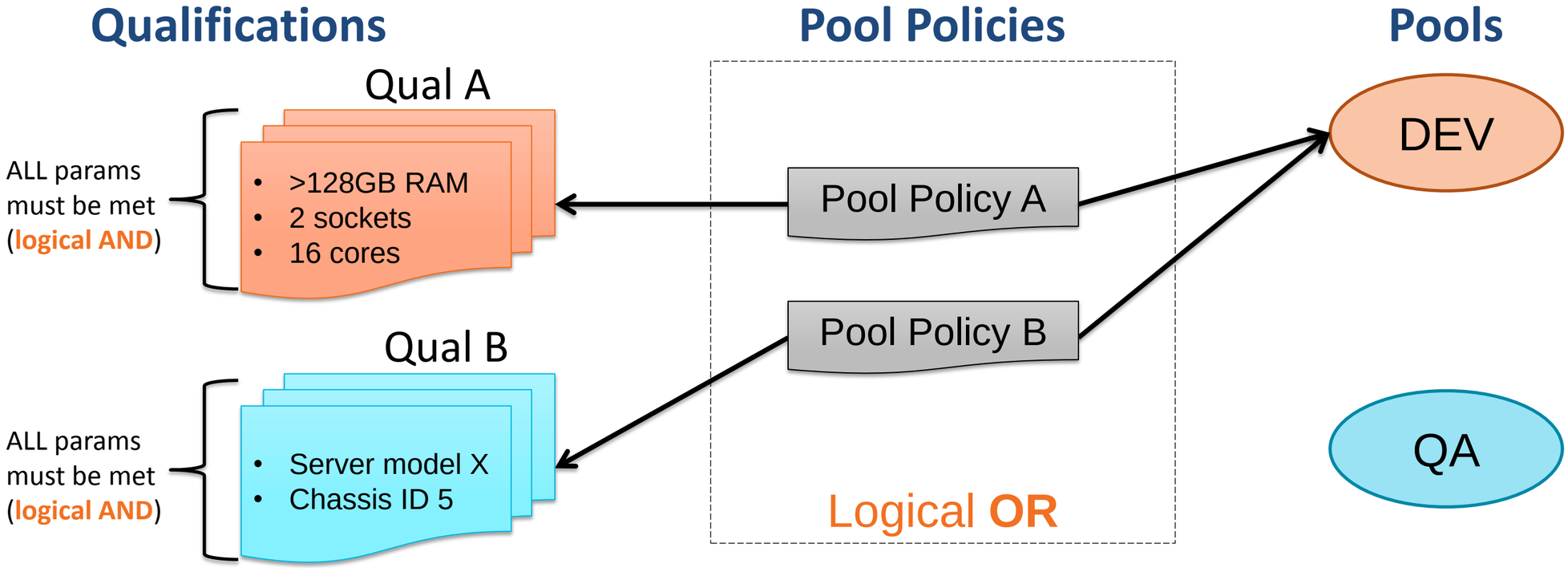
Dynamic Pool Advanced Scenario 1

Pools can be fed by more than one qualification policy



IF (Qual A is TRUE) OR (Qual B is TRUE) THEN add server to DEV pool

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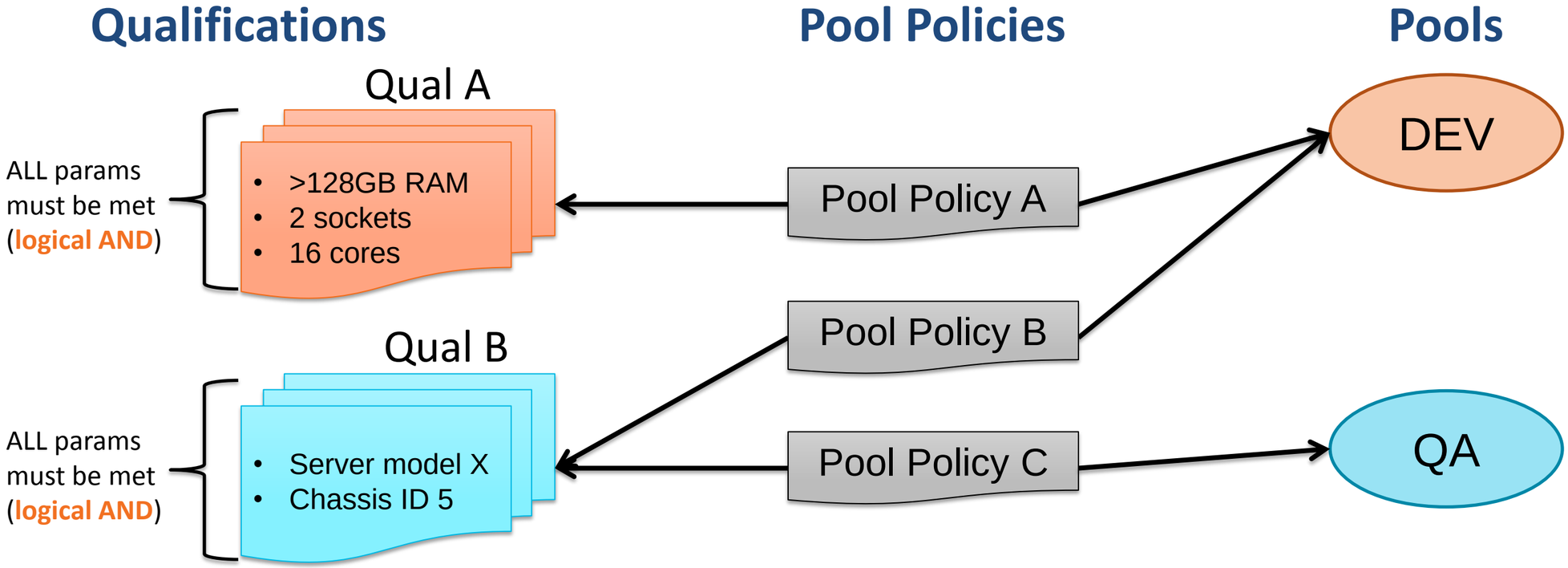
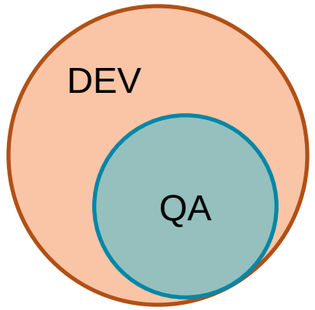
Dynamic Pool Advanced Scenario 2

One pool can be a subset of another



QA pool is a SUBSET of the DEV pool



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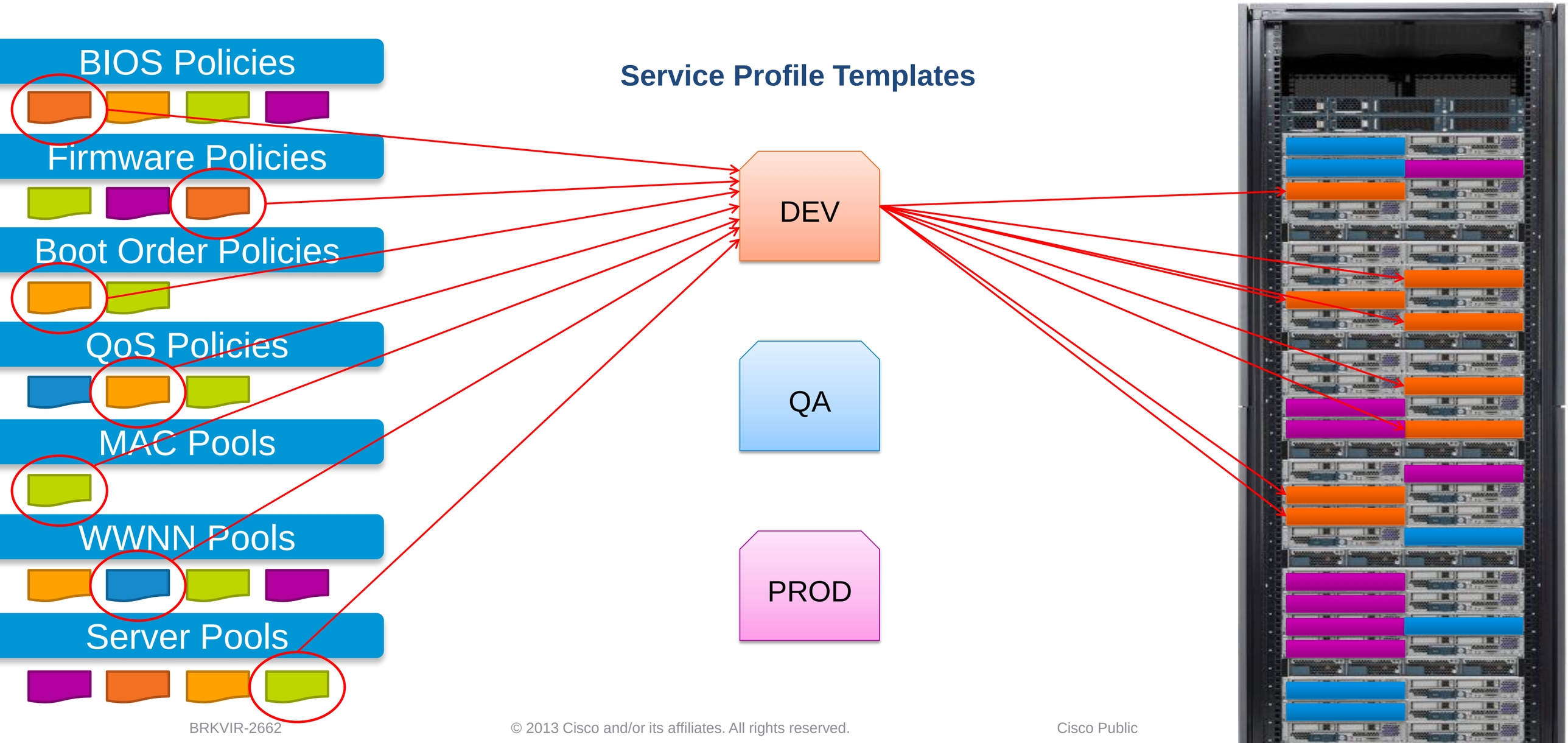
Templates Promote Agility, Consistency



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Cisco Unified Computing System

Optimised and Designed as an Integrated System

Cisco UCS™ Manager

(Read / Write Configuration Interfaces)

UCS Manager GUI and CLI

Cisco UCS Fabric Interconnects

(Read Only / Cut Through Interfaces)

SNMP, Syslog, SMTP, SMASH CLP, CIM XML, Smart Call Home

Cisco UCS I/O modules

Cisco UCS Blade Server Chassis

Cisco UCS Blade and Rack Servers

(Cut through Interfaces to CIMC)

Serial over LAN, KVM, IPMI

Cisco UCS I/O Adapters

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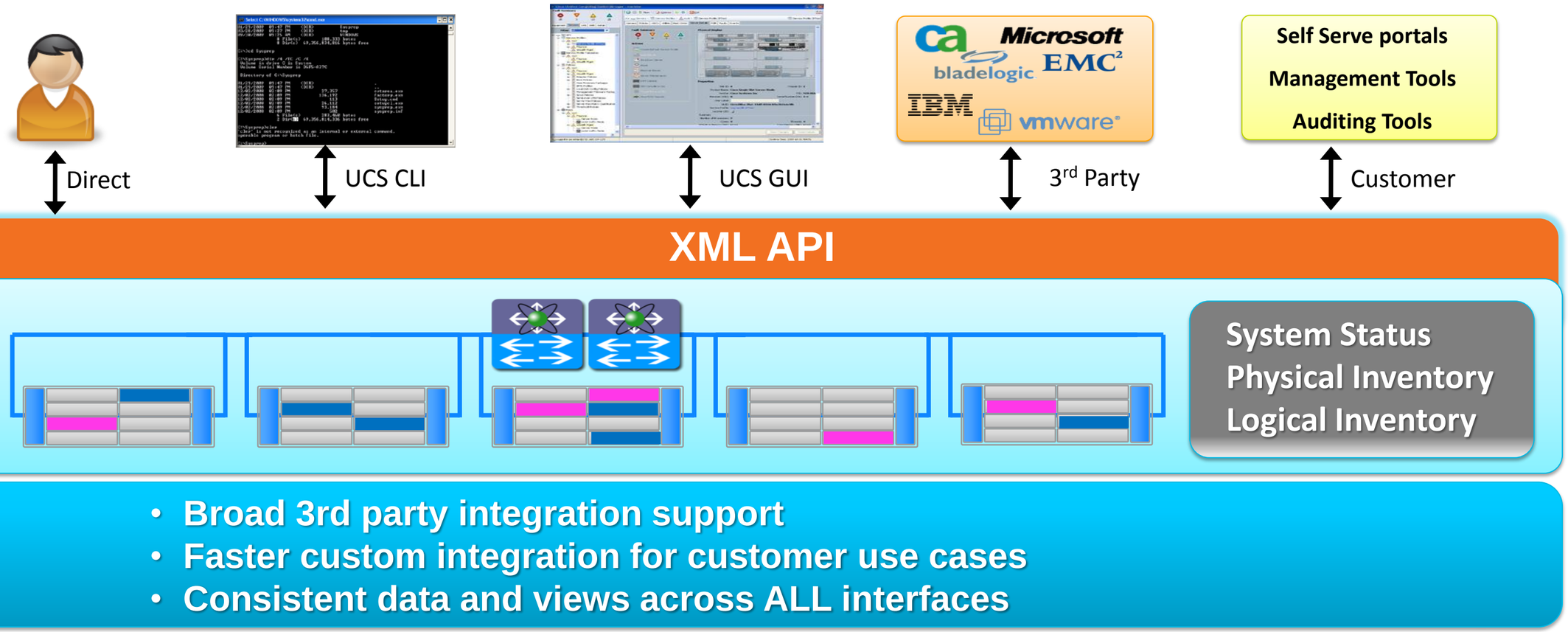
Programmatic Infrastructure

- Comprehensive XML API, standards-based interfaces
- Bi-Directional access to physical & logical internals



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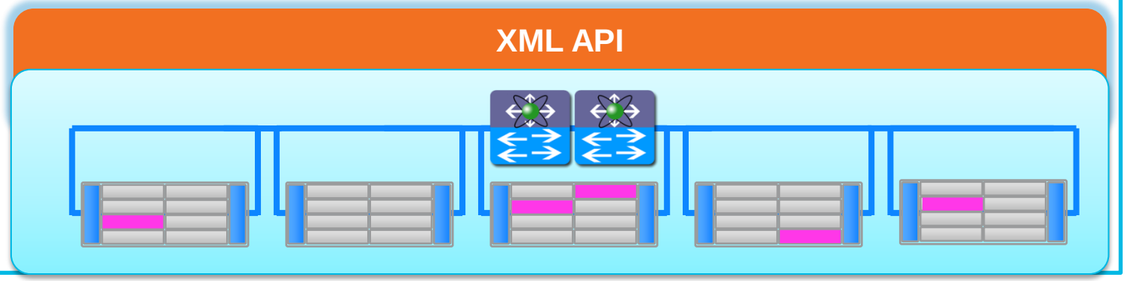
UCS XML API Overview

UCS XML API Features

- Communicates over HTTP / HTTPS
- XML Based, Transactional
- XML Transactions are Order Agnostic
- Standard Request / Response cycle
- Role Based Authentication
- Object Model Hierarchy
- Built-in Object Browser
- Published XML Schema
- Java Doc Style documentation
- High Availability
- Event Stream



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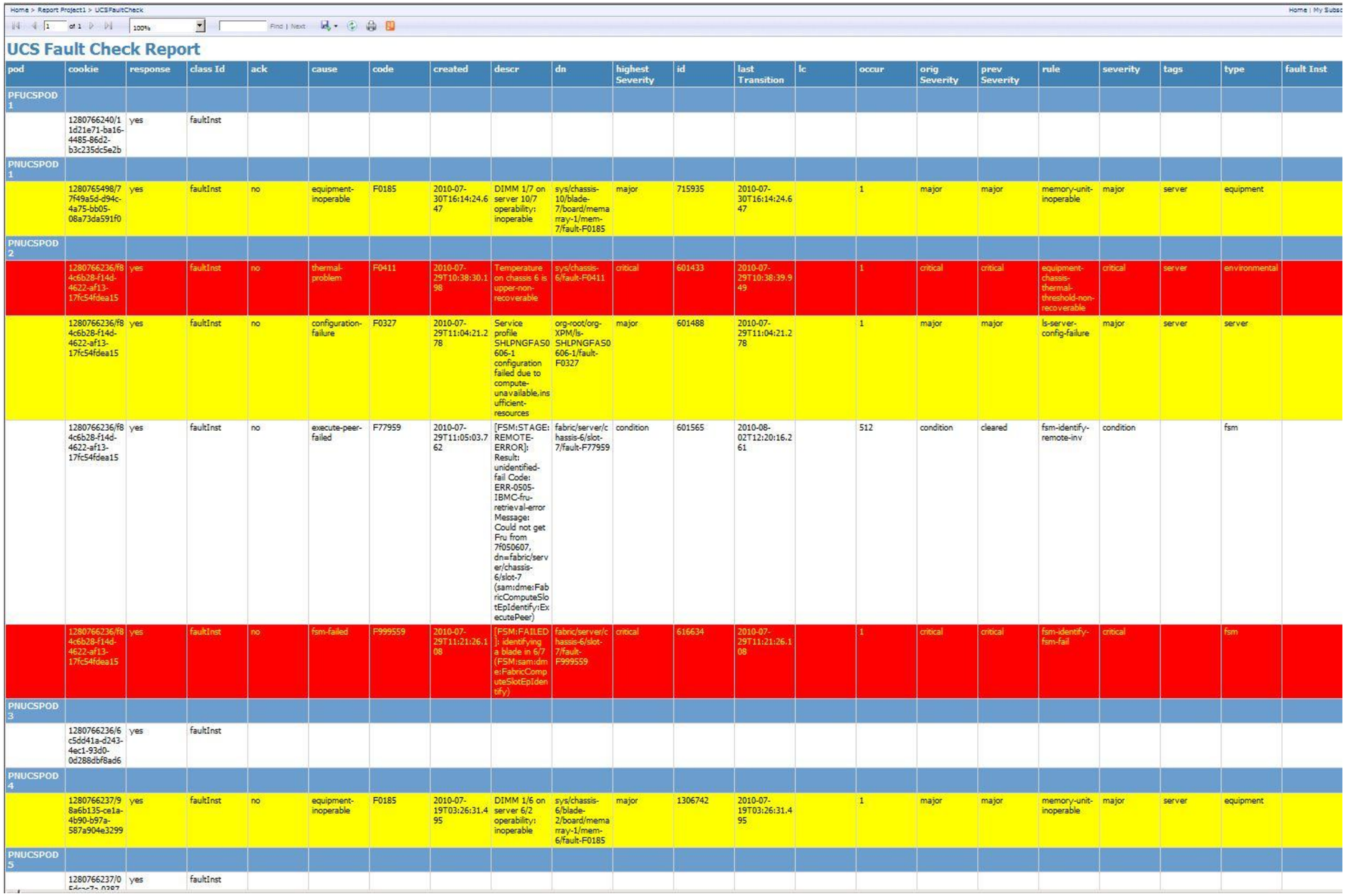
A Very Simple XML Query



Home > Report Project1 > UCSFaultCheck

Home | My Subsc

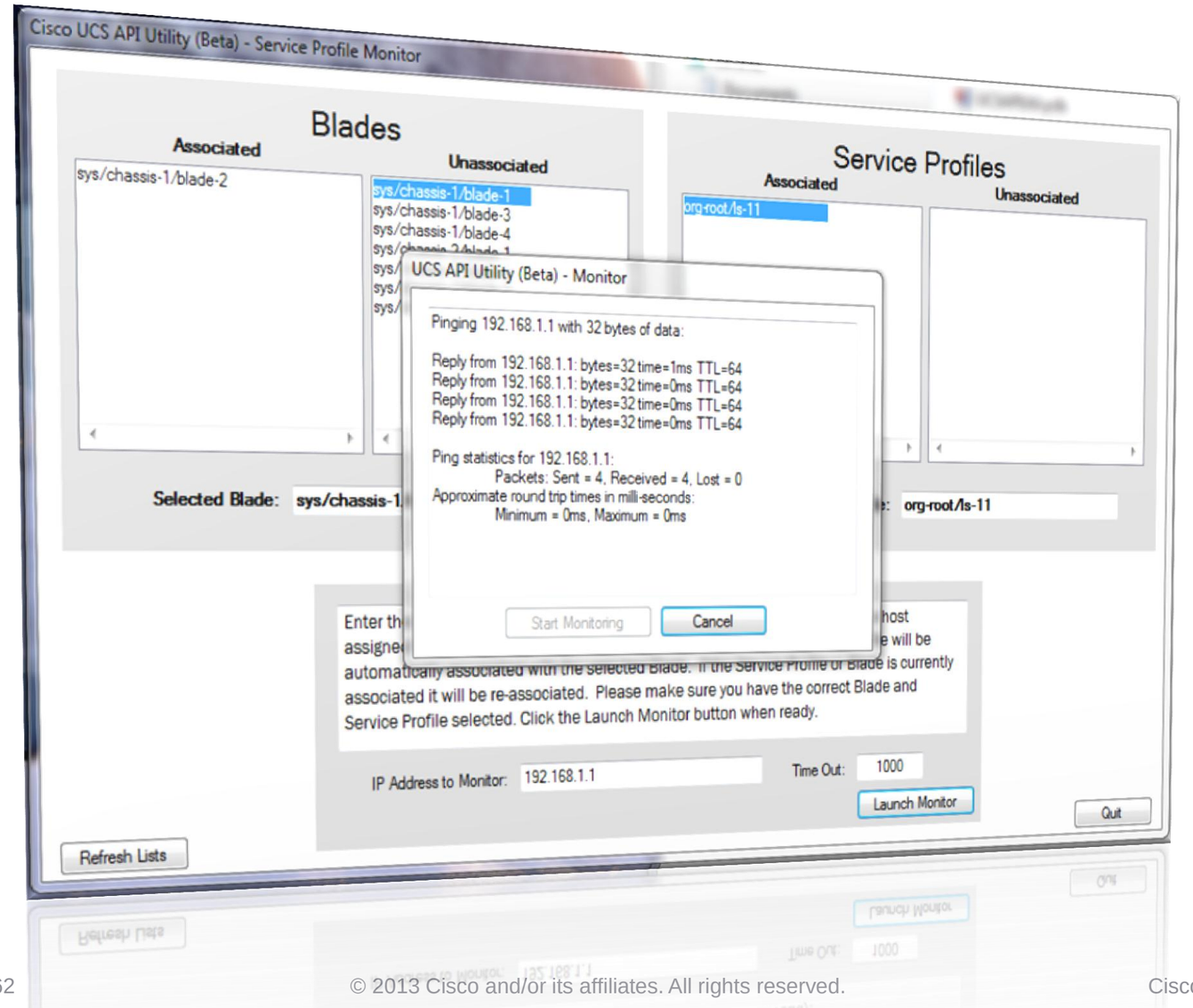
1 of 1 100% Find | Next

UCS Fault Check Report

pod	cookie	response	class Id	ack	cause	code	created	descr	dn	highest Severity	id	last Transition	lc	occur	orig Severity	prev Severity	rule	severity	tags	type	fault Inst
PFUCSPOD 1																					
	1280766240/11d21e71-ba16-4485-86d2-b3c235dc5e2b	yes	faultInst																		
PNUCSPOD 1																					
	1280765498/77f49a5d-d94c-4a75-bb05-08a73da591f0	yes	faultInst	no	equipment-inoperable	F0185	2010-07-30T16:14:24.647	DIMM 1/7 on server 10/7 operability: inoperable	sys/chassis-10/blade-7/board/memarray-1/mem-7/fault-F0185	major	715935	2010-07-30T16:14:24.647		1	major	major	memory-unit-inoperable	major	server	equipment	
PNUCSPOD 2																					
	1280766236/f84c6b28-f14d-4622-af13-17fc54fdea15	yes	faultInst	no	thermal-problem	F0411	2010-07-29T10:38:30.198	Temperature on chassis 6 is upper-non-recoverable	sys/chassis-6/fault-F0411	critical	601433	2010-07-29T10:38:39.949		1	critical	critical	equipment-chassis-thermal-threshold-non-recoverable	critical	server	environmental	
	1280766236/f84c6b28-f14d-4622-af13-17fc54fdea15	yes	faultInst	no	configuration-failure	F0327	2010-07-29T11:04:21.278	Service profile SHLPNGFAS0606-1 configuration failed due to compute-unavailable,insufficient-resources	org-root/org-XPM/ls-SHLPNGFAS0606-1/fault-F0327	major	601488	2010-07-29T11:04:21.278		1	major	major	ls-server-config-failure	major	server	server	
	1280766236/f84c6b28-f14d-4622-af13-17fc54fdea15	yes	faultInst	no	execute-peer-failed	F77959	2010-07-29T11:05:03.762	[FSM:STAGE:REMOTE-ERROR]: Result: unidentified-fail Code: ERR-0505-IBMC-fru-retrieval-error Message: Could not get Fru from 7f050607, dn=fabric/server/chassis-6/slot-7 (sam:dme:FabricComputeSlotEpIdentify:ExecutePeer)	fabric/server/chassis-6/slot-7/fault-F77959	condition	601565	2010-08-02T12:20:16.261		512	condition	cleared	fsm-identify-remote-inv	condition		fsm	
	1280766236/f84c6b28-f14d-4622-af13-17fc54fdea15	yes	faultInst	no	fsm-failed	F999559	2010-07-29T11:21:26.108	[FSM:FAILED]: identifying a blade in 6/7 (FSM:sam:dme:FabricComputeSlotEpIdentify)	fabric/server/chassis-6/slot-7/fault-F999559	critical	616634	2010-07-29T11:21:26.108		1	critical	critical	fsm-identify-fsm-fail	critical		fsm	
PNUCSPOD 3																					
	1280766236/6c5dd41a-d243-4ec1-93d0-0d288dbf8ad6	yes	faultInst																		
PNUCSPOD 4																					
	1280766237/98a6b135-ce1a-4b90-b97a-587a904e3299	yes	faultInst	no	equipment-inoperable	F0185	2010-07-19T03:26:31.495	DIMM 1/6 on server 6/2 operability: inoperable	sys/chassis-6/blade-2/board/memarray-1/mem-6/fault-F0185	major	1306742	2010-07-19T03:26:31.495		1	major	major	memory-unit-inoperable	major	server	equipment	
PNUCSPOD 5																					
	1280766237/0	yes	faultInst																		

Write Your Own App

Expose only features you want exposed OR create new functionality



Purpose-built console for Service Profile monitoring

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Cisco Developer Network

Web based developer community

http://developer.cisco.com/web/unifiedcomputing/home

- **Downloads:**
  - UCS Platform Emulator (UCSPE)
  - goUCS Automation Tool
  - XML API, Perl, PowerShell code samples (44 and counting)
  - Microsoft – PowerShell library, SCOM MP
  - HP Software – HPOM, HPOO integration modules
- **Documentation:**
  - Programming & developer guides
  - White papers
  - Reference guides (XML model, Faults)
- **Collaboration:**
  - Blogs
  - Peer to peer forums
  - Videos
  - Access to Cisco subject matter experts

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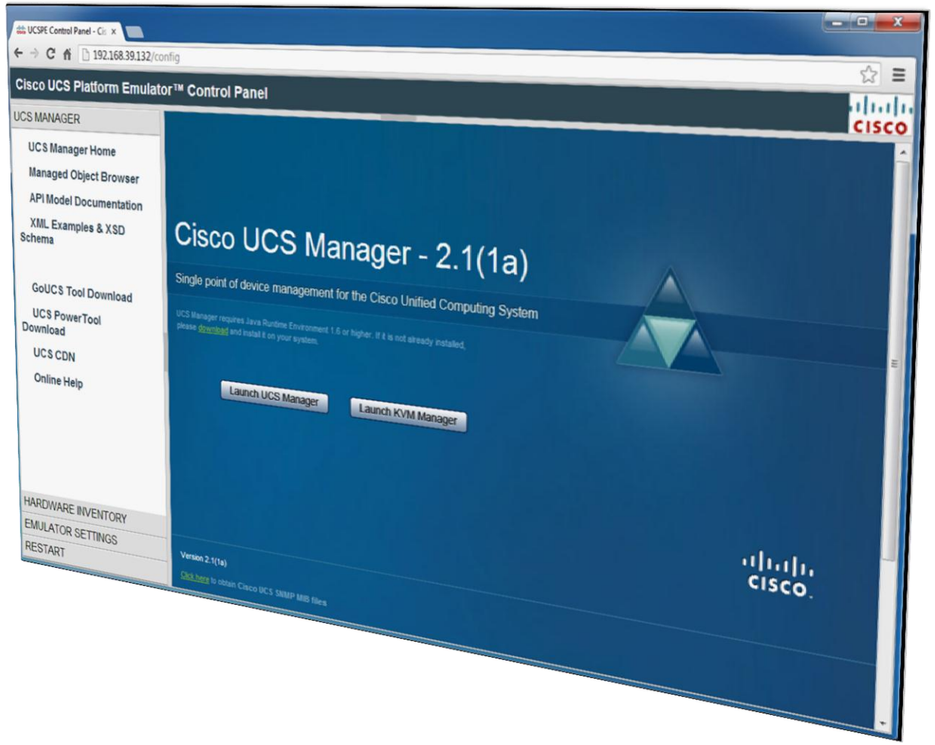
UCS Platform Emulator (UCSPE)

No UCS hardware needed for code development



- Full featured emulator
- Installs as a Virtual Machine
- Support for all XML API calls
- Object Browser to view the UCSM model
- Import & replicate existing live UCS Manager physical inventory
- Share saved inventories among UCS Platform Emulators
- Drag-n-drop hardware builder to create custom physical inventory

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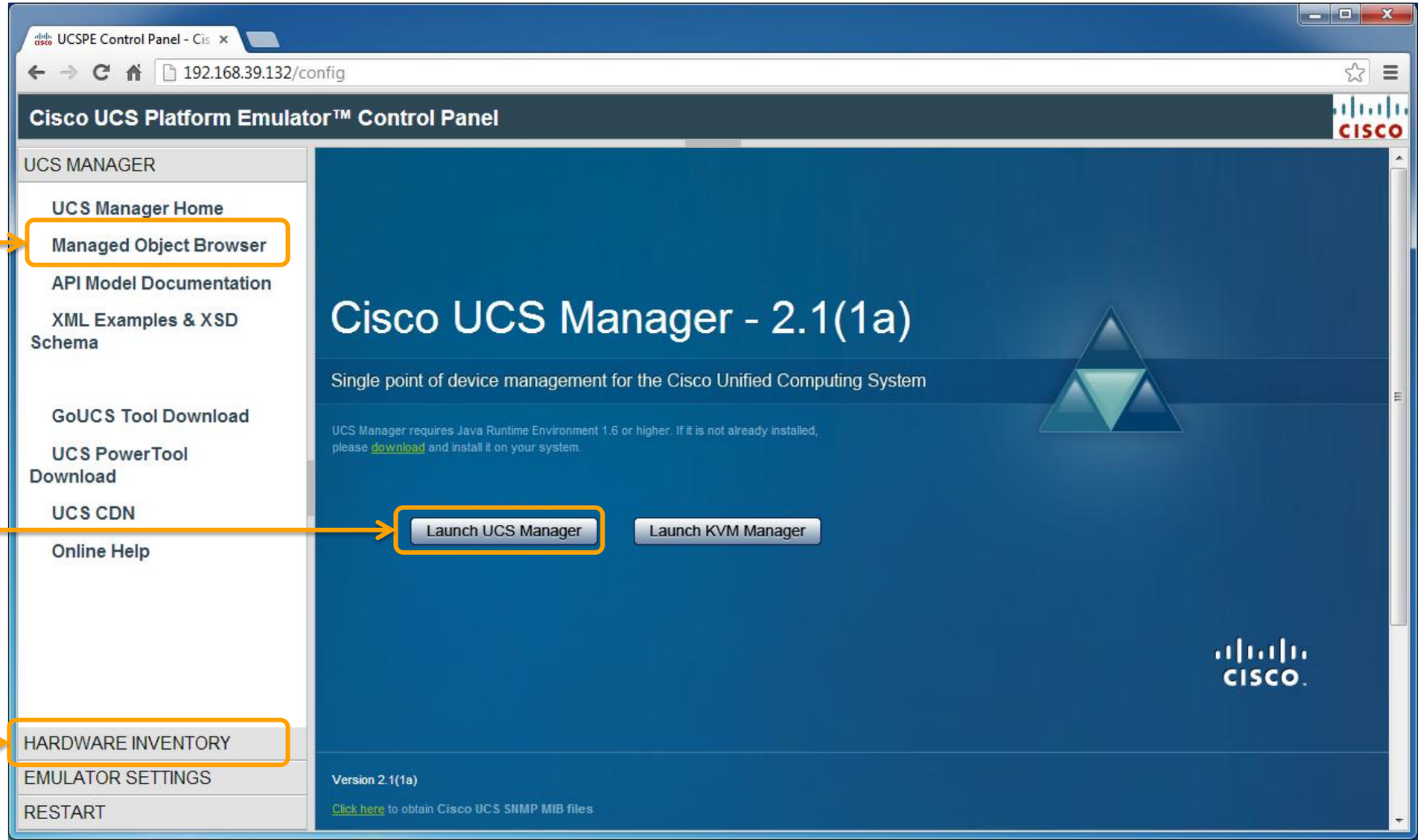
UCS Platform Emulator: Great DEV Tool

Browse XML objects

UCS Manager GUI

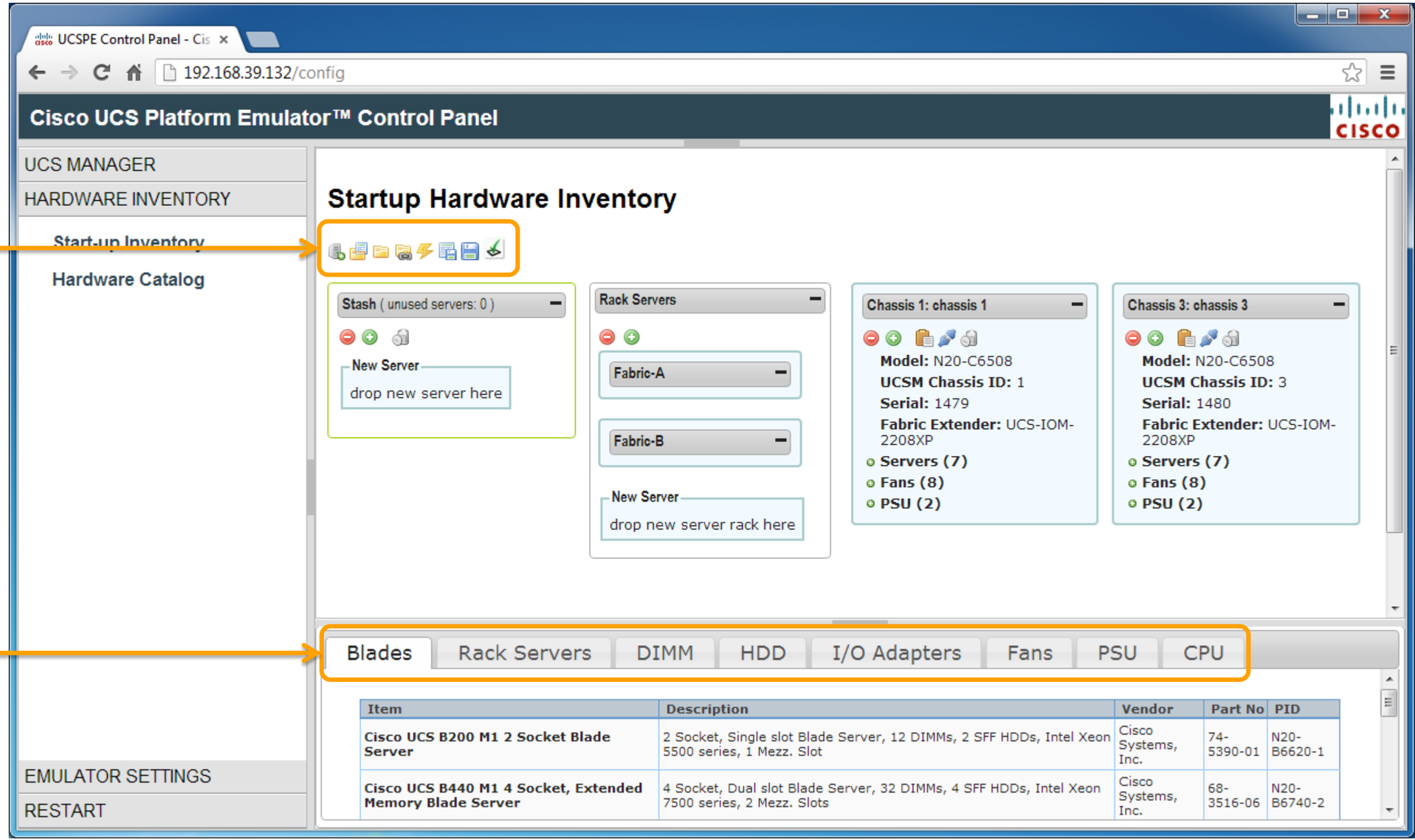
Change emulated HW



UCS Platform Emulator: Great DEV Tool

Import inventory from live UCS system

Build and replicate custom blades



PowerShell is Common Scripting Method

- Plain English cmdlets
- Pipeline commands
- Strong library/module/snapin support
- Strong support in Microsoft environments
- Free development tools

PowerTool

PowerCLI

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Scripting with PowerShell

```
PS C:\> Get-Command -Module CiscoUcsPS | Measure-Object
```

```
Count    : 1506
```

Over 1500 cmdlets for UCS

```
PowerCLI C:\> Get-Command -PSSnapin (Get-PSSnapin | ? {$_.Name -match
"VMware"}) | Measure-Object
```

```
Count    : 301
```

Over 300 cmdlets for VMware

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Real World Scripting Example

How many and what kind of DIMM is in every server I own?

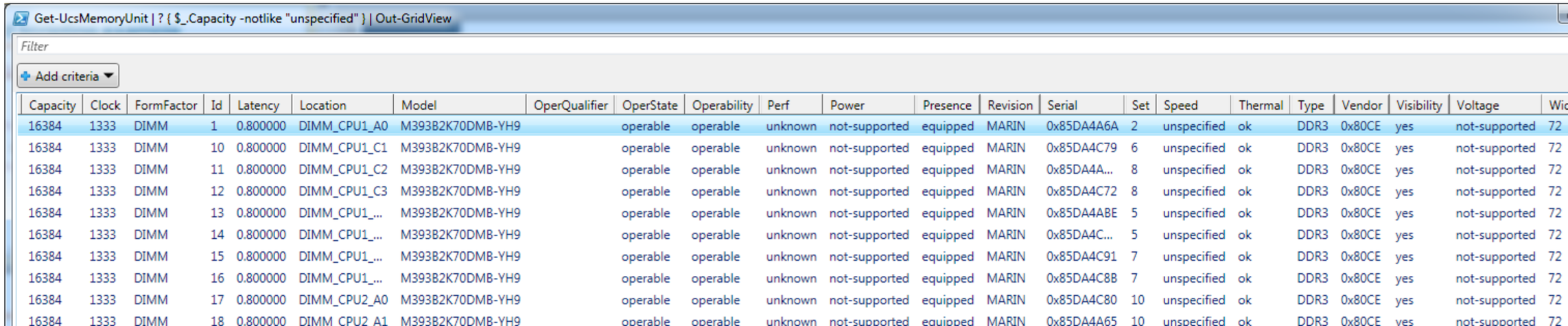
```
Get-UcsMemoryUnit | ? {$_.Capacity -notlike "unspecified"} | ft Bank, Capacity, Dn, Id, Location, Model, Serial, Type, Vendor -AutoSize
```

Or dump it to Excel…

```
Get-UcsMemoryUnit | ? {$_.Capacity -notlike "unspecified"} | Export-Csv -Path "mem.csv"
```

Or dump it to the screen…

```
Get-UcsMemoryUnit | ? {$_.Capacity -notlike "unspecified"} | Out-GridView
```



Capacity	Clock	FormFactor	Id	Latency	Location	Model	OperQualifier	OperState	Operability	Perf	Power	Presence	Revision	Serial	Set	Speed	Thermal	Type	Vendor	Visibility	Voltage	Wi
16384	1333	DIMM	1	0.800000	DIMM_CPU1_A0	M393B2K70DMB-YH9		operable	operable	unknown	not-supported	equipped	MARIN	0x85DA4A6A	2	unspecified	ok	DDR3	0x80CE	yes	not-supported	72
16384	1333	DIMM	10	0.800000	DIMM_CPU1_C1	M393B2K70DMB-YH9		operable	operable	unknown	not-supported	equipped	MARIN	0x85DA4C79	6	unspecified	ok	DDR3	0x80CE	yes	not-supported	72
16384	1333	DIMM	11	0.800000	DIMM_CPU1_C2	M393B2K70DMB-YH9		operable	operable	unknown	not-supported	equipped	MARIN	0x85DA4A...	8	unspecified	ok	DDR3	0x80CE	yes	not-supported	72
16384	1333	DIMM	12	0.800000	DIMM_CPU1_C3	M393B2K70DMB-YH9		operable	operable	unknown	not-supported	equipped	MARIN	0x85DA4C72	8	unspecified	ok	DDR3	0x80CE	yes	not-supported	72
16384	1333	DIMM	13	0.800000	DIMM_CPU1_...	M393B2K70DMB-YH9		operable	operable	unknown	not-supported	equipped	MARIN	0x85DA4ABE	5	unspecified	ok	DDR3	0x80CE	yes	not-supported	72
16384	1333	DIMM	14	0.800000	DIMM_CPU1_...	M393B2K70DMB-YH9		operable	operable	unknown	not-supported	equipped	MARIN	0x85DA4C...	5	unspecified	ok	DDR3	0x80CE	yes	not-supported	72
16384	1333	DIMM	15	0.800000	DIMM_CPU1_...	M393B2K70DMB-YH9		operable	operable	unknown	not-supported	equipped	MARIN	0x85DA4C91	7	unspecified	ok	DDR3	0x80CE	yes	not-supported	72
16384	1333	DIMM	16	0.800000	DIMM_CPU1_...	M393B2K70DMB-YH9		operable	operable	unknown	not-supported	equipped	MARIN	0x85DA4C8B	7	unspecified	ok	DDR3	0x80CE	yes	not-supported	72
16384	1333	DIMM	17	0.800000	DIMM_CPU2_A0	M393B2K70DMB-YH9		operable	operable	unknown	not-supported	equipped	MARIN	0x85DA4C80	10	unspecified	ok	DDR3	0x80CE	yes	not-supported	72
16384	1333	DIMM	18	0.800000	DIMM_CPU2_A1	M393B2K70DMB-YH9		operable	operable	unknown	not-supported	equipped	MARIN	0x85DA4A65	10	unspecified	ok	DDR3	0x80CE	yes	not-supported	72

Real World Scripting Example

Which profile is associated with a specific MAC address?

```
$mac = "4f"
Get-UcsVnic | ? {$_.Addr -match $mac} | Format-Table Ucs, Dn, Addr -AutoSize
```

```
Ucs              Dn                                                          Addr
---              --                                                          ----
OPK-SELAB-Area51 org-root/org-jamarche/ls-jmESXTest01/ether-jmESXvmnic1 00:25:B5:AA:E0:4F
OPK-SELAB-Area51 org-root/org-VDI_TEST/ls-M3_ESXi_2/ether-vnic0         00:25:B5:10:00:4F
OPK-SELAB-Area51 org-root/org-VDI_TEST/ls-VI_MGMT/ether-vNIC0           00:25:B5:20:10:4F
```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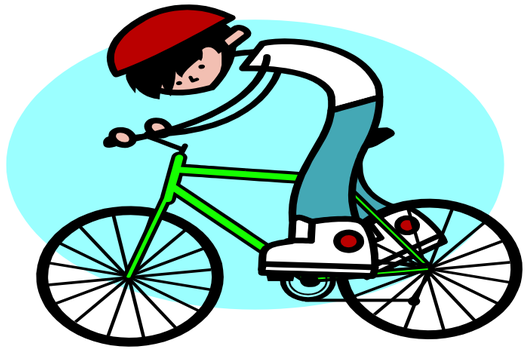
Objects

"An object is a collection of parts and how to use them"

Parts

- Front Wheel
- Back Wheel
- Pedals
- Saddle
- Frame



How to use

- Pedal
- Steer Left
- Steer Right
- Apply Front Brake
- Apply Rear Brake

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Objects

~~Parts~~
Properties

DisplayName

Status

RequiredServices

Windows Service

~~How to use~~
Methods

Stop()

Start()

Pause()

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Demo Time!

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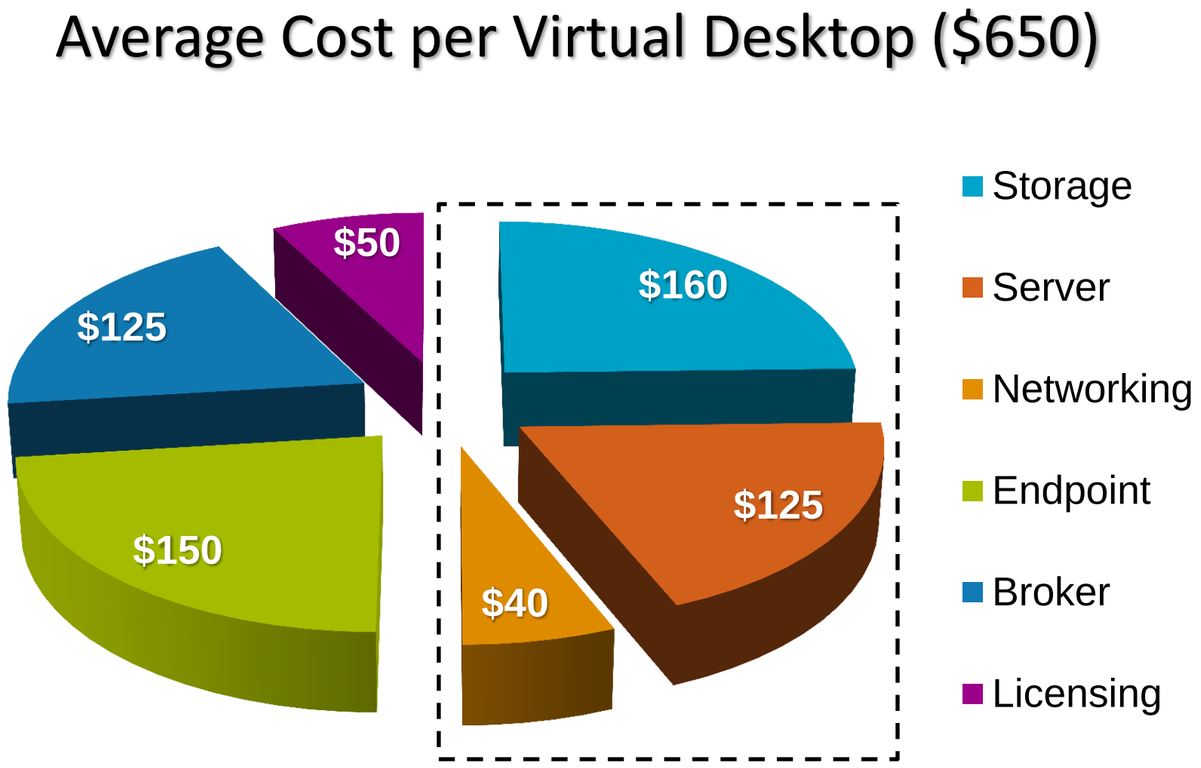
Storage Considerations

Cost

Where does your VDI money go?



Source: 2011 Morgan Stanley Desktop Survey

Server, Storage and Networking on average comprise 50% of solution TCO per desktop

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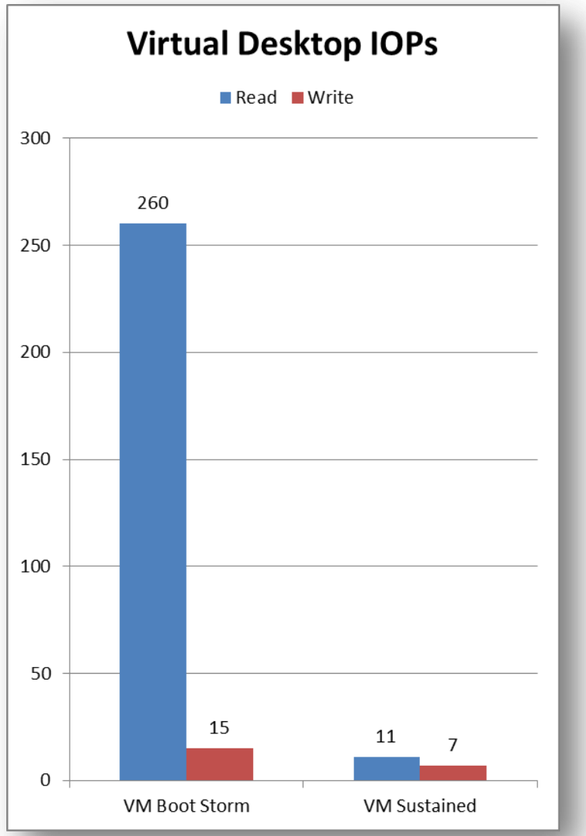
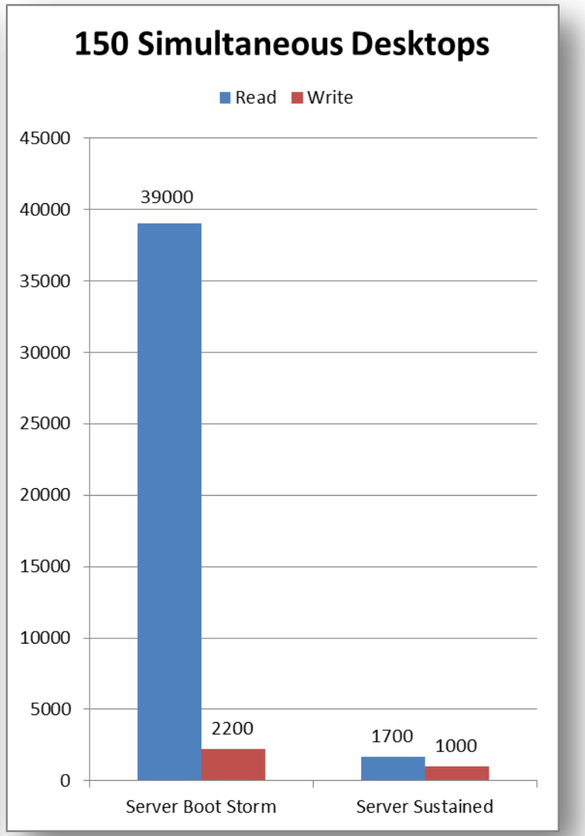
VDI Boot and Login Storms

More lessons learned from earlier VDI testing





- Single Win7 VM can demand 260 read IOPS during boot
- Single ESX host can demand 39K read IOPS during VM boot storm

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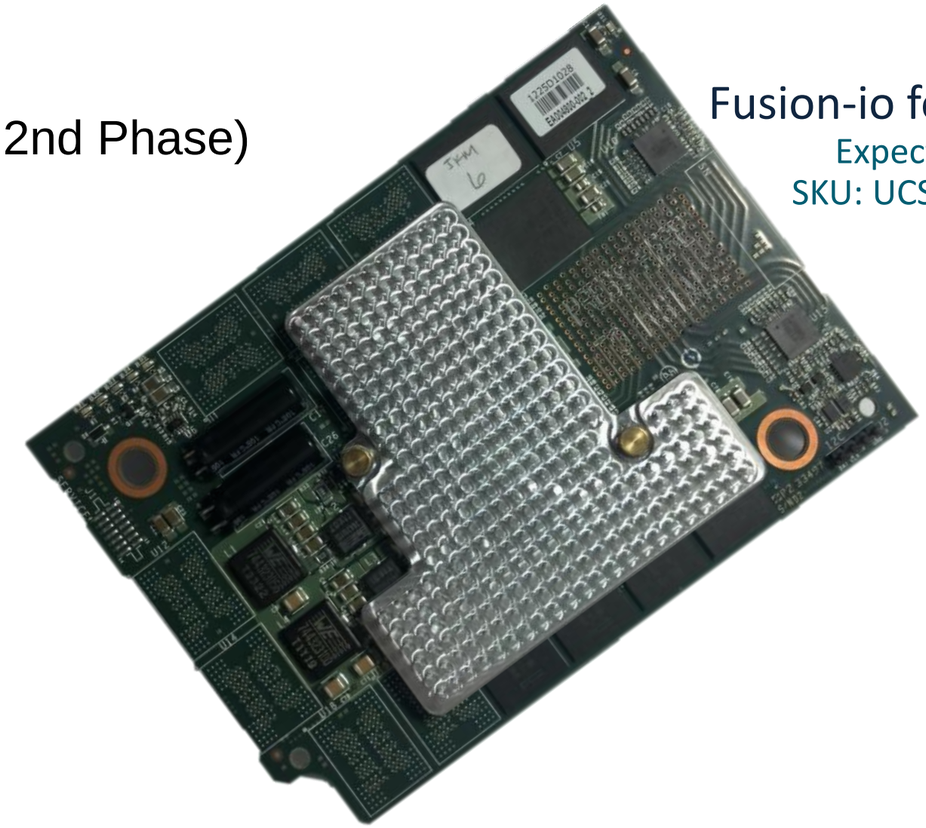
Fusion-io Mezzanine Card for UCS Blades

Expanding the Unified Computing blade option portfolio

- Create new ultra-low latency storage tiers
- Boost in-server application performance with database and virtualisation workloads
- Specs:
  - 785 GB MLC Flash capacities (365 GB MLC 2nd Phase)
  - 1.5GB/s Bandwidth (1MB Read)
  - 1.1GB/s Bandwidth (1MB Write)
  - 141,000 IOPS (512B Random Read)
  - 535,000 IOPS (512B Random Write)
  - 15µs Write Latency, 68µs Read Latency
- HW supported: all M3 blades
- SW supported: UCS Manager 2.1+



Fusion-io for UCS B-Series
Expected Q1CY13
SKU: UCSB-F-FIO-785M

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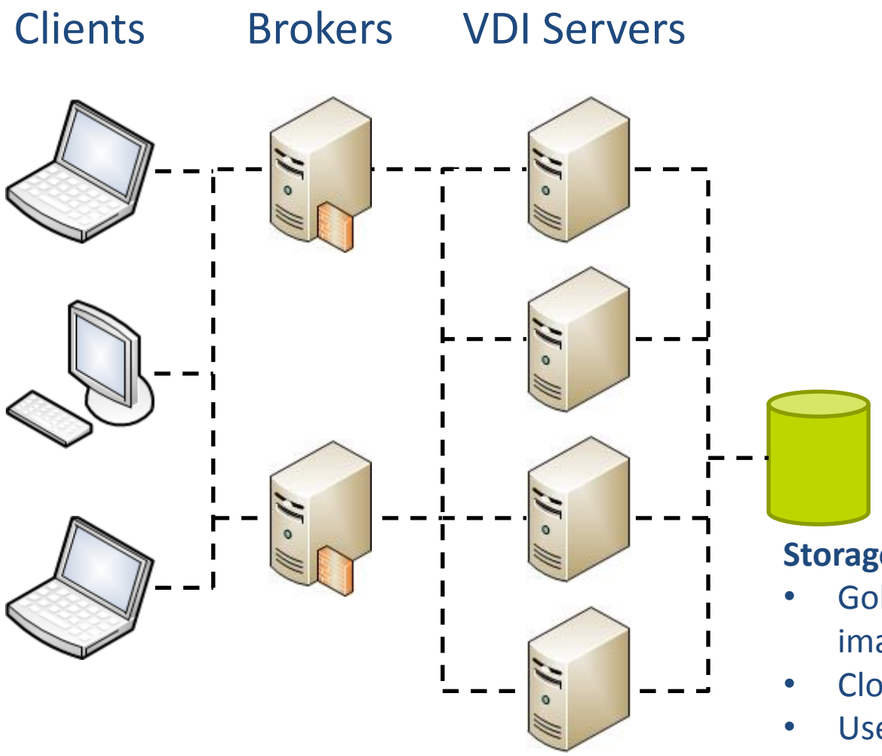
VDI With and Without Local Cache

Caching Golden Master Image (GMI) saves IOPS

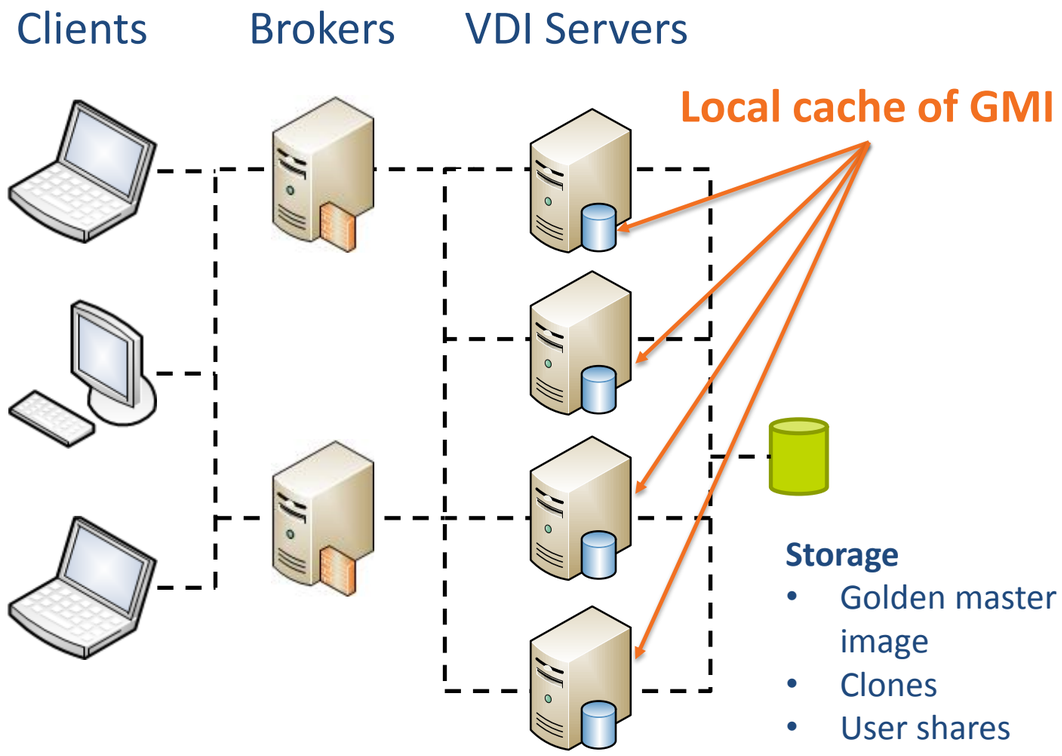
Traditional VDI



Storage

- Golden master image
- Clones
- User shares
- Profiles

VDI with caching



Storage

- Golden master image
- Clones
- User shares
- Profiles

Fusion-io doesn't change your storage needs. It changes your storage performance needs.

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