FlexPod Data Center with VMware vSphere 5.1 and Cisco Nexus 7000 Design Guide

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Cisco Validated Design

Building Architectures to Solve Business Problems

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VMware vSphere 5.1 on FlexPod with Nexus 7000 Using FCoE

Goal of This Document

Cisco® Validated Designs include systems and solutions that are designed, tested, and documented to facilitate and improve customer deployments. These designs incorporate a wide range of technologies and products into a portfolio of solutions that have been developed to address the business needs of our customers.

This document describes the Cisco and NetApp® FlexPod® solution, which is a validated approach for deploying Cisco and NetApp technologies as a shared cloud infrastructure.

Audience

The intended audience of this document includes, but is not limited to, sales engineers, field consultants, professional services, IT managers, partner engineering, and customers who want to take advantage of an infrastructure built to deliver IT efficiency and enable IT innovation.

Changes in FlexPod

The following design elements distinguish this version of FlexPod from previous models:

- Introduction of the Cisco Nexus® 7000 product family, providing the highest level of availability.
- End-to-end Fibre Channel over Ethernet (FCoE) delivering a unified Ethernet fabric.
- Single wire Cisco Unified Computing System™ Manager (Cisco UCS™ Manager) management for C-Series M3 servers with the VIC 1225 effectively doubling the server density per I/O module while reducing cabling cost.
- NetApp clustered Data ONTAP® delivering unified scale-out storage.

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FlexPod Solution Overview

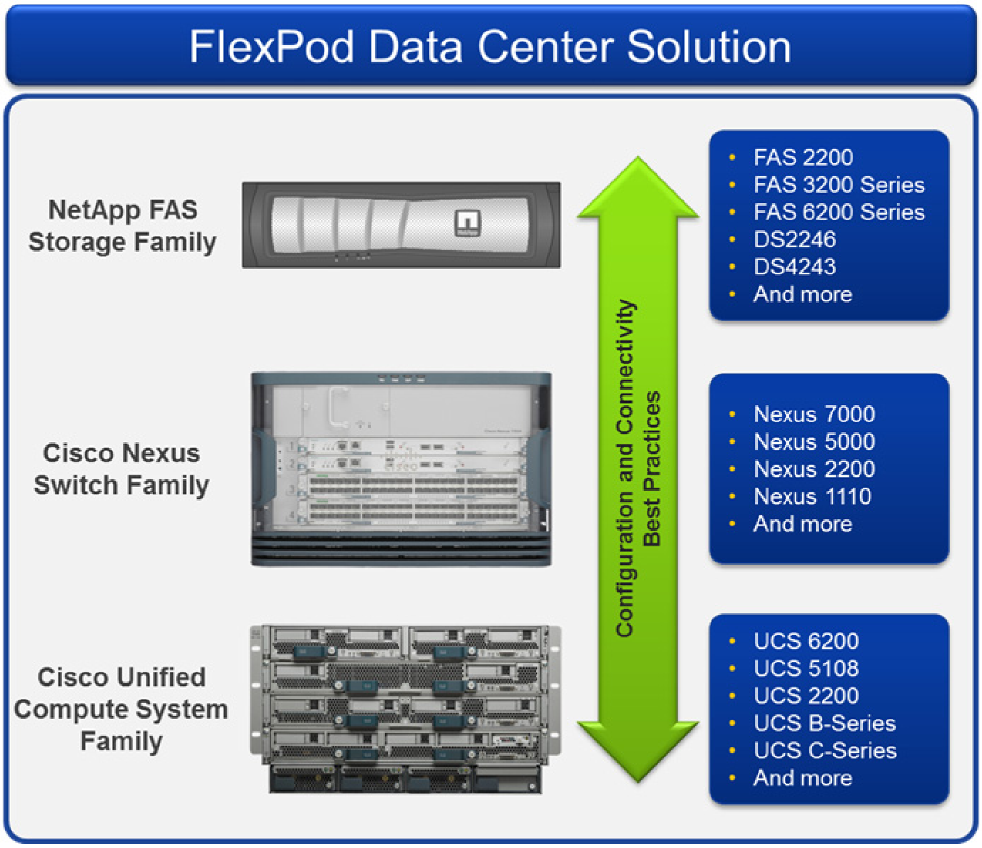
Industry trends indicate a vast data center transformation toward shared infrastructure and cloud computing. Enterprise customers are moving away from isolated centers of IT operation toward more cost-effective virtualized environments.

The objective of the move toward virtualization, and eventually to cloud computing, is to increase agility and reduce costs.

Especially because companies must address resistance to change in both their organizational and technical IT models, achieving this transformation can seem daunting and complex. To accelerate the process and simplify the evolution to a shared cloud infrastructure, Cisco and NetApp have developed a solution called VMware vSphere® on FlexPod.

FlexPod® is a predesigned, best practice data center architecture that is built on the Cisco UCS, the Cisco Nexus® family of switches, and NetApp Fabric Attached storage (FAS) or V-Series systems. FlexPod is a suitable platform for running a variety of virtualization hypervisors as well as bare metal operating systems and enterprise workloads. FlexPod delivers a baseline configuration and also has the flexibility to be sized and optimized to accommodate many different use cases and requirements. Figure 1 shows the components used in this solution, while also highlighting the inherent flexibility of FlexPod.

Figure 1 FlexPod Component Families



This document describes VMware vSphere 5.1 built on the FlexPod model from Cisco and NetApp and discusses design choices and deployment of best practices using this shared infrastructure platform.

Customer Challenges

As customers transition toward shared infrastructure or cloud computing, they face a number of questions, such as:

- How do I start the transition?
- What will my return on investment be?
- How do I build a future-proof infrastructure?
- How do I cost-effectively transition from my current infrastructure?
- Will my applications run properly in a shared infrastructure?
- How do I manage the infrastructure?

The FlexPod architecture is designed to help you answer these questions by providing proven guidance and measurable value. By introducing standardization, FlexPod helps customers mitigate the risk and uncertainty involved in planning, designing, and implementing a new data center infrastructure. The result is a more predictive and adaptable architecture capable of meeting and exceeding customers' IT demands.

FlexPod Program Benefits

Cisco and NetApp have thoroughly validated and verified the FlexPod solution architecture and its many use cases while creating a portfolio of detailed documentation, information, and references to assist customers in transforming their data centers to this shared infrastructure model. This portfolio includes, but is not limited to the following items:

- Best practice architectural design
- Workload sizing and scaling guidance
- Implementation and deployment instructions
- Technical specifications (rules for what is, and what is not, a FlexPod configuration)
- Frequently asked questions (FAQs)
- Cisco Validated Designs (CVDs) and NetApp Validated Architectures (NVAs) focused on a variety of use cases

Cisco and NetApp have also built an experienced support team focused on FlexPod solutions, from customer account and technical sales representatives to professional services and technical support engineers. The support alliance provided by NetApp and Cisco provides customers and channel services partners with direct access to technical experts who collaborate with multiple Vendors and have access to shared lab resources to resolve potential issues.

FlexPod supports tight integration with virtualized and cloud infrastructures, making it the logical choice for long-term investment. The following IT initiatives are addressed by the FlexPod solution.

Integrated System

FlexPod is a prevalidated infrastructure that brings together computing, storage, and network to simplify, accelerate, and minimize the risk associated with data center builds and application rollouts. These integrated systems provide a standardized approach in the data center supports staff expertise, application onboarding, and automation, as well as operational efficiencies that are important for compliance and certification.

Fabric Infrastructure Resilience

FlexPod is a highly available and scalable infrastructure that IT can evolve over time to support multiple physical and virtual application workloads. FlexPod has no single point of failure at any level, from the server through the network, to the storage. The fabric is fully redundant and scalable and provides seamless traffic failover should any individual component fail at the physical or virtual layer.

Fabric Convergence

FlexPod components are interconnected through the Cisco Unified Fabric network architecture, which supports both traditional LAN traffic and all types of storage traffic, including the lossless requirements for block-level storage transport over FC or FCoE. The Cisco Unified Fabric creates high-performance, low-latency, and highly available networks, serving a diverse set of data center needs.

FlexPod uses the Cisco Unified Fabric to offer a wire-once environment that accelerates application deployment. Cisco Unified Fabric also offers the efficiencies associated with infrastructure consolidation, including:

- Cost savings from the reduction in switches (LAN/SAN switch ports), associated cabling, rack space, all of which reduce capital expenditures (capex)
- Cost savings on power and cooling, which reduce operating expenses (opex)
- Migration to the faster 10 Gigabit Ethernet network, and in the future, to 40 Gigabit Ethernet and 100 Gigabit Ethernet
- Evolution to a converged network with little disruption to operations
- FlexPod with Cisco Unified Fabric helps you preserve investments in existing infrastructure, management tools, and staff training and expertise
- Simplified cabling, provisioning, and network maintenance to improve productivity and operational models

Network Virtualization

FlexPod delivers the capability to securely connect virtual machines into the network. This solution allows network policies and services to be uniformly applied within the integrated compute stack using technologies such as virtual LANs (VLANs), Quality of Service (QoS), and the Cisco Nexus 1000v virtual distributed switch. This capability enables the full utilization of FlexPod while maintaining consistent application and security policy enforcement across the stack even with workload mobility.

FlexPod provides a uniform approach to IT architecture, offering a well-characterized and documented shared pool of resources for application workloads. FlexPod delivers operational efficiency and consistency with the versatility to meet a variety of SLAs and IT initiatives, including:

- Application rollouts or application migrations
- Business continuity/disaster recovery
- Desktop virtualization
- Cloud delivery models (public, private, hybrid) and service models (IaaS, PaaS, SaaS)
- Asset consolidation and virtualization

FlexPod Design Details

This section provides an overview on the FlexPod design and also the topology differences between the FlexPod model with clustered Data ONTAP and Data ONTAP in 7-mode.

System Overview

FlexPod is a best practice data center architecture that includes three components:

- Cisco Unified Computing System (Cisco UCS)
- Cisco Nexus switches
- NetApp Fabric-Attached Storage (FAS) systems

These components are connected and configured according to best practices of both Cisco and NetApp and provide the ideal platform for running a variety of enterprise workloads with confidence. FlexPod can scale up for greater performance and capacity (adding compute, network, or storage resources individually as needed), or it can scale out for environments that need multiple consistent deployments (rolling out additional FlexPod stacks). FlexPod delivers a baseline configuration and also has the flexibility to be sized and optimized to accommodate many different use cases.

Typically, the more scalable and flexible a solution is, the more difficult it becomes to maintain a single unified architecture capable of offering the same features and functionalities across each implementation. This is one of the key benefits of FlexPod. Each of the component families shown in Figure 1 (Cisco UCS, Cisco Nexus, and NetApp FAS) offers platform and resource options to scale the infrastructure up or down, while supporting the same features and functionalities that are required under the configuration and connectivity best practices of FlexPod.

Design Principles

FlexPod addresses the following design principles and architecture goals:

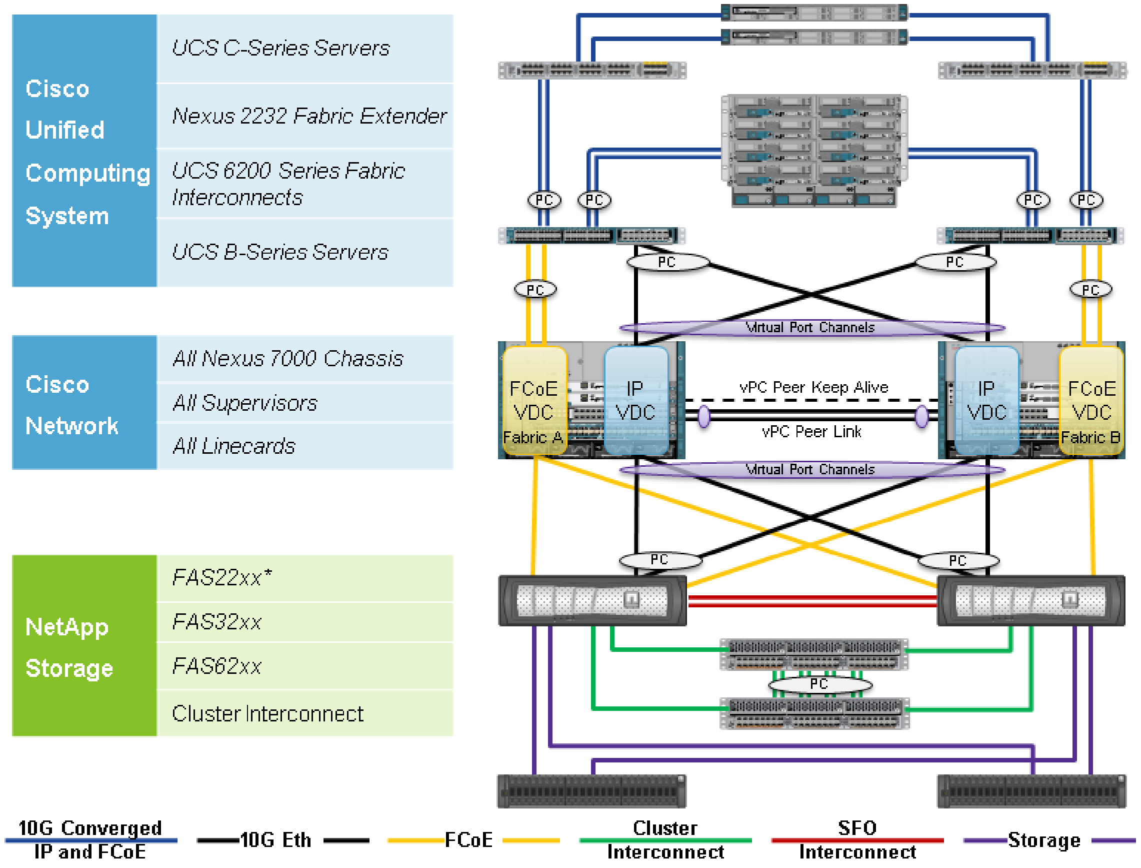
- **Application Availability**—Ensures that the services are accessible and ready to use.
- **Scalability**—Addresses increasing demands with appropriate resources.
- **Flexibility**—Provides new services or recovers resources without infrastructure modification requirements.
- **Manageability**—Facilitates efficient infrastructure operations through open standards and APIs.

Note Performance and comprehensive security are key design criteria that were not directly addressed in this project but have been addressed in other collateral, benchmarking and solution testing efforts. The functionality and basic security elements were validated.

FlexPod - Distinct Uplink Design

Figure 2 details FlexPod distinct uplink design with clustered Data ONTAP. As the illustration shows, the design is fully redundant in the compute, network, and storage layers. There is no single point of failure from a device or traffic path perspective.

Figure 2 FlexPod Distinct Uplink Design with Clustered Data ONTAP



*The FAS22xx fully supports IP-based storage, but does not support FCoE.

FlexPod distinct uplink design is an end-to-end Ethernet transport solution supporting multiple LAN and SAN protocols, most notably FCoE. The solution provides a unified 10GbE-enabled fabric, defined by dedicated FCoE uplinks and dedicated Ethernet uplinks between the Cisco UCS Fabric Interconnects and the Cisco Nexus switches, as well as converged connectivity between the NetApp storage devices and the same multipurpose Cisco Nexus platforms.

The distinct uplink design does not employ a dedicated SAN switching environment and requires no direct Fibre Channel connectivity. The Cisco Nexus 7000 Series Switches are configured in N-Port ID Virtualization (NPIV) mode, providing storage services for the FCoE-based traffic traversing its fabric.

As illustrated, link aggregation technologies play an important role, providing improved aggregate bandwidth and link resiliency across the solution stack. The NetApp storage controllers, Cisco Unified Computing System, and Cisco Nexus 7000 platforms support active port channeling using 802.3ad standard Link Aggregation Control Protocol (LACP). Port channeling is a link aggregation technique offering link fault tolerance, and traffic distribution (load balancing) for improved aggregate bandwidth across the member ports. In addition, the Cisco Nexus 7000 Series Switches feature virtual PortChannel (vPC) capabilities. The vPC allows links that are physically connected to two different Cisco Nexus 7000 series devices to appear as a single "logical" port channel to a third device, essentially offering device fault tolerance. The vPC addresses aggregate bandwidth, link, and device resiliency. The Cisco UCS Fabric Interconnects and NetApp FAS controllers benefit from the Cisco Nexus vPC abstraction, gaining link and device resiliency as well as full utilization of an non-blocking Ethernet fabric.

Note The Spanning Tree protocol does not actively block redundant physical links in a properly configured vPC-enabled environment, so all ports should forward on the vPC member ports.

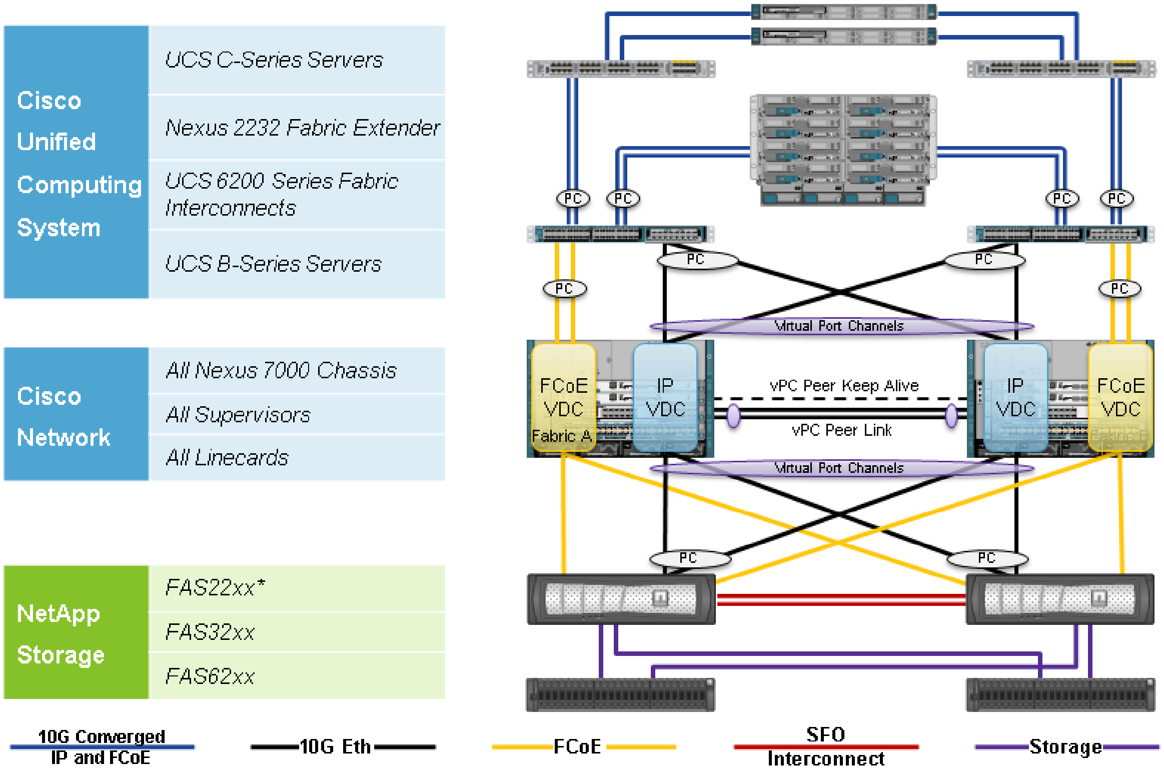
This dedicated uplink design leverages FCoE-capable NetApp FAS controllers. From a storage traffic perspective, both standard LACP and Cisco vPC link aggregation technologies play an important role in FlexPod distinct uplink design. Figure 2 shows the use of dedicated FCoE uplinks between the Cisco UCS Fabric Interconnects and Cisco Nexus 7000 Unified Switches. The Cisco UCS Fabric Interconnects operate in the N-Port Virtualization (NPV) mode, meaning the servers' FC traffic is either manually or automatically pinned to a specific FCoE uplink, in this case either of the two FCoE port channels are pinned. The use of discrete FCoE port channels with distinct VSANs allows an organization to maintain traditional SAN A/B fabric separation best practices, including separate zone databases. The vPC links between the Cisco Nexus 7000 switches' and NetApp storage controllers' Unified Target Adapters (UTAs) are utilized for the Ethernet traffic, and dedicated FCoE links between the systems maintain SAN A/B fabric segregation.

Figure 2 shows the initial storage configuration of this solution, as a two-node HA pair with the NetApp clustered Data ONTAP. An HA pair consists of like storage nodes such as FAS22xx, 32xx, or 62xx Series. Scalability is achieved by adding storage capacity (disk/shelves) to an existing HA pair, or by adding HA pairs into the cluster or storage domain. For SAN environments, the NetApp clustered Data ONTAP offering allows up to three HA pairs that include six clustered nodes to form a single logical entity and large resource pool of storage that can be easily managed, logically carved, and efficiently consumed. For NAS environments, up to 24 nodes can be configured. In both the scenarios, the HA interconnect allows each HA node pair to assume control of its partner's storage (disk/shelves) directly. The local physical high-availability storage failover capability does not extend beyond the HA pair. Furthermore, a cluster of nodes does not have to include similar hardware. Rather, individual nodes in an HA pair are configured alike, allowing customers to scale as needed, as they bring additional HA pairs into the larger cluster.

Network failover is independent of the HA interconnect. Network failover of each node in the cluster is supported by both the interconnect and switching fabric, permitting cluster, data and management network interfaces to fail over to different nodes in the cluster, which extends beyond the HA pair.

Figure 3 shows FlexPod distinct uplink design with Data ONTAP operating in 7-Mode. Data ONTAP operating in 7-Mode is NetApp's traditional functional model. As depicted, the FAS devices are configured in an HA pair delivering five nines availability. Scalability is achieved through the addition of storage capacity (disk/shelves), as well as through additional controllers such as FAS2200, 3200, or 6200 Series. The controllers are only deployed in HA pairs, meaning more HA pairs can be added for scalability, but each pair is managed separately.

Figure 3 FlexPod Distinct Uplink Design with Data ONTAP in 7-Mode

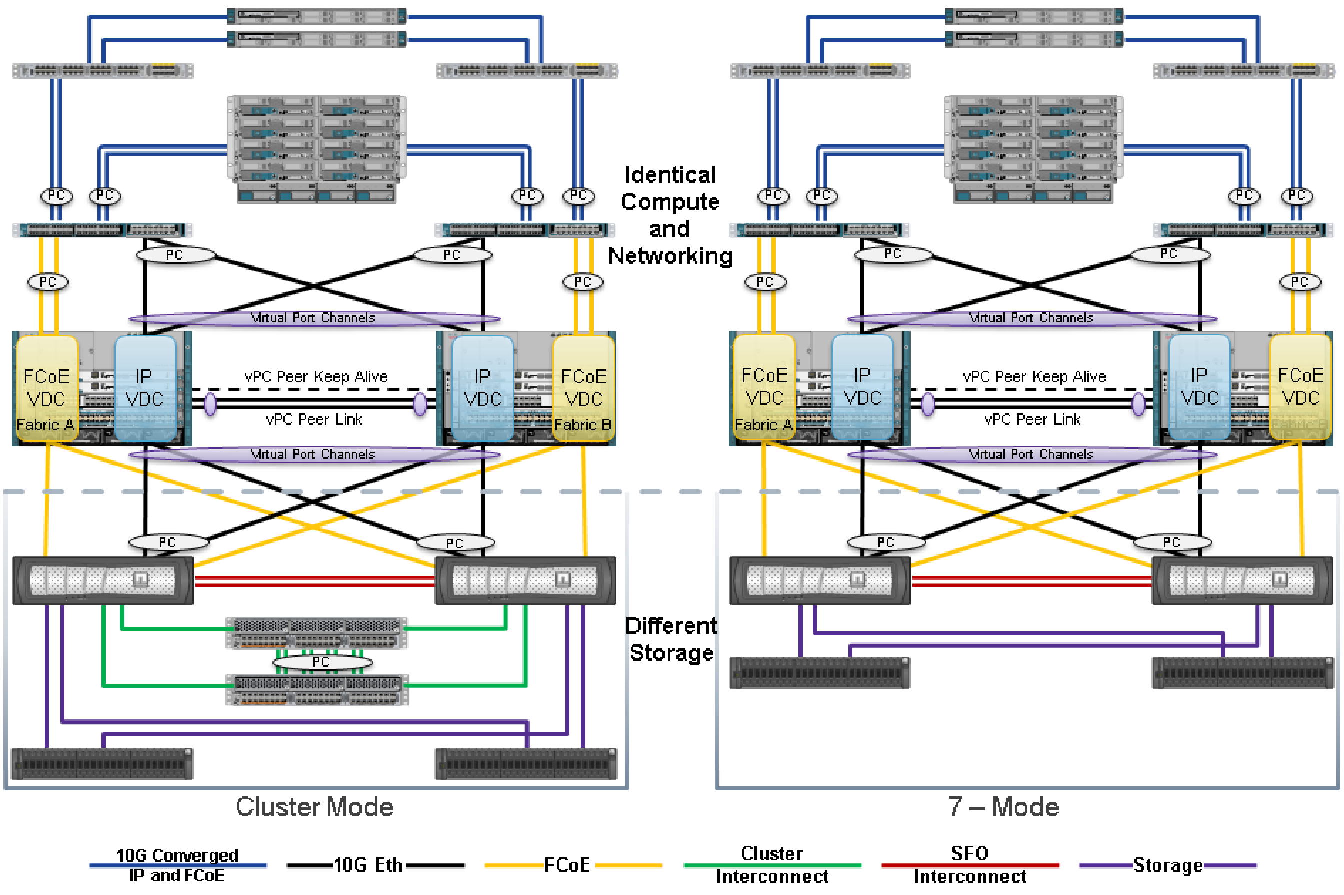


*The FAS22xx fully supports IP-based storage, but does not support FCoE.

Figure 4 shows the topology differences between FlexPod model with the clustered Data ONTAP or Data ONTAP operating in 7-Mode. As shown in Figure 4, the Cisco UCS and Cisco Nexus components do not require any modifications. These layers of the stack are essentially unaware of the storage controllers' mode of operation. The differences occur within the NetApp domain of FlexPod configuration. Clustered Data ONTAP requires cluster interconnect switches to connect the storage controllers (nodes) composing the cluster.

Note Data ONTAP 8.1.2 supports up to six nodes (three HA pairs) in a SAN cluster.

Figure 4 FlexPod Model Comparison



It is a fundamental design decision to leverage clustered Data ONTAP or 7-Mode, because these cannot be run simultaneously on the same controller, and the choice will influence hardware requirements, the logical construction of FlexPod stack, and ultimately the operational practices of the enterprise. Organizations having the following requirements should consider adopting clustered Data ONTAP:

- Large to midsize enterprises that are seeking scalable, shared IT solutions for nondisruptive operations
- New installations
- Existing clustered Data ONTAP 8.x and Data ONTAP GX organizations that are looking to upgrade
- Organizations deploying an enterprise content repository

Organizations with the following characteristics or needs might want to use the 7-Mode design:

- Existing Data ONTAP 7G and Data ONTAP 8.x 7-Mode customers who are looking to upgrade
- Midsize enterprises; customers who are primarily interested in the FAS2000 Series
- Customers who absolutely require SnapVault®, synchronous SnapMirror®, MetroCluster™, SnapLock® software, IPv6, or Data ONTAP Edge

Note It is always advisable to seek counsel from experts. Consult your NetApp account team or partner for further guidance.

"Logical Build" section on page 29 provides more details regarding the virtual design of the environment consisting of VMware vSphere, Cisco Nexus 1000v virtual distributed switching, and NetApp storage controllers.

Integrated System Components

The following components are required to deploy the Distinct Uplink design:

- Cisco Unified Compute System
- Cisco Nexus 7000 Series Switch
- NetApp Unified Storage capable of supporting FCoE storage target adapters
- VMware vSphere

Cisco Unified Computing System

The Cisco Unified Computing System is a next-generation solution for blade and rack server computing. Cisco UCS is an innovative data center platform that unites compute, network, storage access, and virtualization into a cohesive system designed to reduce total cost of ownership (TCO) and increase business agility. The system integrates a low-latency, lossless 10 Gigabit Ethernet unified network fabric with enterprise-class, x86-architecture servers. The system is an integrated, scalable, multi-chassis platform in which all resources participate in a unified management domain. Managed as a single system whether it has one server or 160 servers with thousands of virtual machines, the Cisco UCS decouples scale from complexity. The Cisco UCS accelerates the delivery of new services simply, reliably, and securely through end-to-end provisioning and migration support for both virtualized and non-virtualized systems.

The Cisco Unified Computing System consists of the following components:

- Cisco UCS Manager— Provides unified, embedded management of all software and hardware components in the Cisco UCS. For more information on Cisco UCS Manager, see:

  http://www.cisco.com/en/US/products/ps10281/index.html

- Cisco UCS 6200 Series Fabric Interconnects—Are a family of line-rate, low-latency, lossless, 10-Gbps Ethernet and Fibre Channel over Ethernet interconnect switches providing the management and communication backbone for the Unified Computing System. Cisco UCS supports VM-FEX technology, see "Cisco VM-FEX" section on page 19 for details. For more information on Cisco UCS 6200 Series Fabric Interconnects, see:

  http://www.cisco.com/en/US/products/ps11544/index.html

- Cisco UCS 5100 Series Blade Server Chassis—Supports up to eight blade servers and up to two fabric extenders in a six-rack unit (RU) enclosure. For more information on Cisco UCS 5100 Blade Chassis, see:

  http://www.cisco.com/en/US/products/ps10279/index.html

- Cisco UCS B-Series Blade Servers— Increase performance, efficiency, versatility and productivity with these Intel based blade servers. For more information on Cisco UCS Blade Servers, see:

  http://www.cisco.com/en/US/partner/products/ps10280/index.html

- Cisco UCS C-Series Rack Mount Server—Deliver unified computing in an industry-standard form factor to reduce total cost of ownership and increase agility. For more information on Cisco UCS Rack Mount Servers, see:

  http://www.cisco.com/en/US/products/ps10493/index.html

- Cisco UCS Adapters—Wire-once architecture offers a range of options to converge the fabric, optimize virtualization and simplify management. Cisco adapters support VM-FEX technology, see "Cisco VM-FEX" section on page 19 for details. For more information Cisco UCS Adapters, see:

  http://www.cisco.com/en/US/products/ps10277/prod_module_series_home.html

Cisco Nexus 7000 Series Switch

The modular Cisco Nexus 7000 Series switch offers a comprehensive one-platform solution for data center networks. It offers aggregation, high density, and end-of-row and top-of-rack server connectivity. For campus core deployments, it provides a scalable, highly resilient, high-performance solution. The Cisco Nexus 7000 Series platform runs on Cisco NX-OS Software. It was specifically designed for the most mission-critical deployments in the data center and on campus.

The Cisco Nexus 7000 Series was designed around four principles:

- **Infrastructure scalability**
  - Design that provides scalability to more than 15Tbps for ongoing investment protection
  - Support for consolidated networks with virtual port channel innovations to scale beyond 1500 ports
  - Multicore, multithreaded OS to optimize CPU resources and offload tasks to processors distributed across the modules
  - Cisco Trusted Security (Cisco TrustSec®) for scalable security with link-layer encryption, security group access control lists, and role-based access control
  - Flexible NetFlow to optimize the network infrastructure, reducing operating costs and improving capacity planning capabilities
- **Operational continuity**
  - Lossless nondisruptive upgrades for zero-service downtime through no single point of failure in the system hardware and a modular operating system
  - Innovative stateful process restart for nondisruptive operations in event of process termination
  - Comprehensive Extensible Markup Language (XML) API for total platform control
- **Transport flexibility**
  - Foundation for unified fabrics with Cisco DCE unified I/O and FCoE
  - Virtualized control plane and data plane forwarding for optimized performance
  - Virtual device contexts (VDCs) to maximize software and hardware resource utilization while providing strong security and software fault isolation
  - Built to currently support high-density GbE and 10GbE and the emerging 40Gbps and 100Gbps Ethernet standards
- **Data center switching features**
  - In-Service Software Upgrade (ISSU) enables hitless upgrades with zero packet loss
  - NetFlow provides visibility and flexible monitoring and control over the network
  - Multihop FCoE provides director-class FCoE on a modular platform to offer rich LAN and SAN services
  - OTV and LISP enable seamless workload mobility across geographically separated data centers
  - MPLS service supports multi-tenant segmentation within and between data centers

   - FabricPath/TRILL allows scalable data center networks to be built without the tree protocol

For more information on Cisco Nexus 7000 Series Switches, see:

http://www.cisco.com/en/US/products/ps9402/index.html

Cisco Nexus 2232PP 10 Gigabit Etherenet Fabric Extender

The Cisco Nexus 2232PP 10Gigabit Fabric Extender provides 32 10 Gigabit Ethernet and Fibre Channel Over Ethernet (FCoE) Small Form-Factor Pluggable Plus (SFP+) server ports and eight 10 Gigabit Ethernet and FCoE SFP+ uplink ports in a compact 1 rack unit (1RU) form factor.

The built-in standalone software, Cisco Integrated Management Controller (CIMC), manages Cisco UCS C-Series Rack Mount Servers. When a C-Series Rack Mount Server is integrated with Cisco UCS Manager, via the Cisco Nexus 2232 Fabric Extender platform, the CIMC does not manage the server anymore. Instead it is managed with the Cisco UCS Manager software. The server is managed using the Cisco UCS Manager GUI or Cisco UCS Manager CLI. The Cisco Nexus 2232 Fabric Extender provides data and control traffic support for the integrated C-Series servers.

Cisco Nexus 1000v

Cisco Nexus 1000V Series Switches provide a comprehensive and extensible architectural platform for virtual machine (VM) and cloud networking. These switches are designed to accelerate server virtualization and multitenant cloud deployments in a secure and operationally transparent manner. Integrated into the VMware vSphere hypervisor, and fully compatible with VMware vCloud® Director, the Cisco Nexus 1000V Series provides:

- Advanced virtual machine networking, based on Cisco NX-OS operating system and IEEE 802.1Q switching technology
- Cisco vPath technology for efficient and optimized integration of virtual network services
- Virtual Extensible Local Area Network (VXLAN), supporting cloud networking

These capabilities help ensure that the virtual machine is a basic building block of the data center, with full switching capabilities and a variety of Layer 4 through 7 services in both dedicated and multitenant cloud environments. With the introduction of VXLAN on the Nexus 1000V Series, network isolation among virtual machines can scale beyond traditional VLANs for cloud-scale networking.

The Cisco Nexus 1000V Series Switches are virtual machine access switches for the VMware vSphere environments running the Cisco NX-OS operating system. Operating inside the VMware® ESX® or ESXi™ hypervisors, the Cisco Nexus 1000V Series provides:

- Policy-based virtual machine connectivity
- Mobile virtual machine security and network policy
- Nondisruptive operational model for your server virtualization and networking teams
- Virtualized network services with Cisco vPath providing a single architecture for L4 –L7 network services such as load balancing, firewalling and WAN acceleration

The Cisco Nexus 1000V distributed virtual switch is an optional component within the solution. The Cisco Nexus 1000V was used in the validation of this solution; however, customers can also use a standard VMware vSwitch or a VMware VDS. The VSM in this solution is running from the Cisco Nexus 1110-X appliance, which is also an optional component.

For more information on Cisco Nexus 1000V Series Switches and Cisco Nexus 1010 Virtual Services Appliance, see:

http://www.cisco.com/en/US/products/ps9902/index.html

http://www.cisco.com/en/US/products/ps10785/index.html

Cisco VM-FEX

Cisco VM-FEX technology collapses virtual switching infrastructure and physical switching infrastructure into a single, easy-to-manage environment. Benefits include:

- Simplified operations—Eliminates the need for a separate, virtual networking infrastructure
- Improved network security—Contains VLAN proliferation
- Optimized network utilization—Reduces broadcast domains
- Enhanced application performance—Off loads virtual machine switching from host CPU to parent switch Application Specific Integrated Circuits (ASICs)

Cisco VM-FEX is supported on VMware ESX hypervisors and fully supports workload mobility through VMware vMotion.

The Cisco VM-FEX eliminates the virtual switch within the hypervisor by providing individual Virtual Machines (VMs) virtual ports on the physical network switch. VM I/O is directly sent to the upstream physical network switch that takes full responsibility for VM switching and policy enforcement. This leads to consistent treatment for all network traffic, virtual or physical. The Cisco VM-FEX reduces the number of network management points by an order of magnitude as the physical and the virtual switching layers are consolidated into a single switching infrastructure.

The UCS VIC leverages VMware's Direct Path I/O technology to significantly improve throughput and latency of VM I/O. Direct Path allows direct assignment of Personal Computer interconnect express (PCIe) devices to VMs. VM I/O bypasses the hypervisor layer and is placed directly on the PCIe device associated with the VM. The Cisco VM-FEX unifies the virtual and physical networking infrastructure by allowing a switch ASIC to perform switching in hardware, not on a software based virtual switch. The Cisco VM-FEX is off loads the ESXi hypervisor, which may improve the performance of any hosted VM applications.

NetApp FAS and Data ONTAP

NetApp solutions are user friendly, easy to manage, and quick to deploy and offer increased availability while consuming fewer IT resources. This means that they dramatically lower the lifetime total cost of ownership. Whereas others manage complexity, NetApp eliminates it. A NetApp solution includes hardware in the form of controllers and disk storage and the NetApp Data ONTAP operating system.

NetApp offers the NetApp Unified Storage Architecture. The term "unified" refers to a family of storage systems that simultaneously support Storage Area Network (SAN), Network Attached Storage (NAS), and iSCSI across many operating environments such as VMware, Windows®, and UNIX®. This single architecture provides access to data by using industry-standard protocols, including NFS, CIFS, iSCSI, FCP, SCSI, FTP, and HTTP. Connectivity options include standard Ethernet (10/100/1000, or 10GbE) and Fibre Channel (1, 2, 4, or 8Gb/sec). In addition, all systems can be configured with high-performance Solid State Drives (SSDs) or Serial ATA (SAS) disks for primary storage applications, low-cost SATA disks for secondary applications (backup, archive, and so on), or a mix of the different disk types.

A storage system running Data ONTAP has a main unit, also known as the controller or storage engine, which is the hardware device that receives and sends data. This unit detects and gathers information about the hardware configuration, the storage system components, the operational status, hardware failures, and other error conditions.

A storage system uses storage on disk shelves. The disk shelves are the containers or device carriers that hold disks and associated hardware such as power supplies, connectivity interfaces, and cabling.

If storage requirements change over time, the NetApp storage offers the flexibility to change quickly, as needed and without expensive and disruptive "forklift" upgrades. For example, a LUN can be changed from FC access to iSCSI access without moving or copying the data. Only a simple dismount of the FC LUN and a mount of the same LUN using iSCSI would be required. In addition, a single copy of data can be shared between Windows and UNIX systems while allowing each environment to access the data through native protocols and applications. If a system was originally purchased with all SATA disks for backup applications, high-performance SAS disks could be added to support primary storage applications such as Oracle®, Microsoft® Exchange Server, or ClearCase.

NetApp storage solutions provide redundancy and fault tolerance through clustered storage controllers, hot-swappable redundant components (such as cooling fans, power supplies, disk drives, and shelves), and multiple network interfaces. This highly available and flexible architecture enables customers to manage all data under one common infrastructure while achieving mission requirements. The NetApp Unified Storage Architecture allows data storage with higher availability and performance, easier dynamic expansion, and more unrivalled ease of management than any other solution.

The storage efficiency built into Data ONTAP provides substantial space savings, allowing more data to be stored at a lower cost. Data protection provides replication services, making sure that valuable data is backed up and recoverable. The following features provide storage efficiency and data protection:

- **Thin provisioning**—Volumes are created using "virtual" sizing. They appear to be provisioned to their full capacity, but are actually created much smaller and use additional space only when it is actually needed. Extra unused storage is shared across all volumes, and the volumes can grow and shrink on demand.
- **Snapshot™ copies**—Automatically scheduled point-in-time copies that write only changed blocks, with no performance penalty. The Snapshot copies consume minimal storage space, since only changes to the active file system are written. Individual files and directories can easily be recovered from any Snapshot copy, and the entire volume can be restored back to any Snapshot state in seconds.
- **FlexClone® volumes**—Near-zero space, instant "virtual" copies of datasets. The clones are writable, but only changes to the original are stored, so they provide rapid, space-efficient creation of additional data copies ideally suited for dev/test environments.
- **Deduplication**—Removes redundant data blocks in primary and secondary storage, with flexible policies to determine when the deduplication process is run.
- **Compression**—Compresses data blocks. Compression can be run whether or not deduplication is enabled and can provide additional space savings, whether run alone or together with deduplication.
- **SnapMirror**—Volumes can be asynchronously replicated either within the cluster or to another cluster.

For more information on NetApp Data ONTAP, see:

http://www.netapp.com/us/products/platform-os/data-ontap-8/index.aspx

Data ONTAP Operating in 7-Mode

As previously mentioned customers have a choice of deploying their NetApp storage environment operating in 7-Mode or clustered Data ONTAP. Data ONTAP operating in 7-Mode provides customers a broad suite of application integrations, storage efficiencies, and a legacy of customer satisfaction.

As well known and trusted as Data ONTAP operating in 7-Mode is, technology companies must always look toward new innovations. For this reason NetApp has continually invested in clustered Data ONTAP, which truly changes the conversation of storage from a cost-center discussion to one in which storage can add value to the company.

Data ONTAP operating in 7-Mode is deployed on an HA pair of controllers that is discrete from any other storage systems in the environment and is managed as such. For this reason, the scalability with clustered Data ONTAP is superior to that of 7-Mode, which is further discussed in "Clustered Data ONTAP" section on page 21.

Clustered Data ONTAP

With the release of clustered Data ONTAP 8.1, NetApp introduces enterprise-ready, unified scale-out storage. Clustered Data ONTAP is the basis for large virtualized shared storage infrastructures that are architected for nondisruptive operations over the system lifetime. Controller nodes are deployed in HA pairs, with these HA pairs participating in a single storage domain or cluster.

Data ONTAP scale-out is a way to respond to growth in a storage environment. All storage controllers have physical limits to their expandability: number of CPUs, memory slots, and space for disk shelves that dictate the maximum capacity and controller performance. If more storage or performance capacity is needed, it might be possible to add CPUs and memory or install additional disk shelves, but ultimately the controller becomes completely populated, with no further expansion possible. At this stage the only option is to acquire another controller. One way to do this is to "scale up": that is, to add additional controllers in such a way that each is a completely independent management entity that does not provide any shared storage resources. If the original controller is to be completely replaced by the newer and larger controller, data migration is required to transfer the data from the old controller to the new one. This is time-consuming and potentially disruptive and most likely requires configuration changes on all of the attached host systems.

If the newer controller can coexist with the original controller, there are now two storage controllers to be individually managed, and there are no native tools to balance or reassign workloads across them. The situation becomes worse as the number of controllers increases. If the scale-up approach is used, the operational burden increases consistently as the environment grows, and the end result is a very unbalanced and difficult-to-manage environment. Technology refresh cycles require substantial planning in advance, lengthy outages, and configuration changes, which introduce risk into the system.

By contrast, using scale-out means that as the storage environment grows, additional controllers are added seamlessly to the resource pool residing on a shared storage infrastructure. Host and client connections as well as datastores can move seamlessly and nondisruptively anywhere in the resource pool, so that existing workloads can be easily balanced over the available resources, and new workloads can be easily deployed. Technology refreshes (replacing disk shelves, adding or completely replacing storage controllers) are accomplished while the environment remains online and continues serving data.

Although scale-out products have been available for some time, these were typically subject to one or more of the following shortcomings:

- Limited protocol support (NAS only)
- Limited hardware support (supports only a particular type of storage controller or a very limited set)
- Little or no storage efficiency (thin provisioning, deduplication, compression)
- Little or no data replication capability

Therefore, while these products are well positioned for certain specialized workloads, they are less flexible, less capable, and not robust enough for broad deployment throughout the enterprise.

Data ONTAP is the first product to offer a complete scale-out solution, and it offers an adaptable, always-available storage infrastructure for today's highly virtualized environment.

VMware vSphere

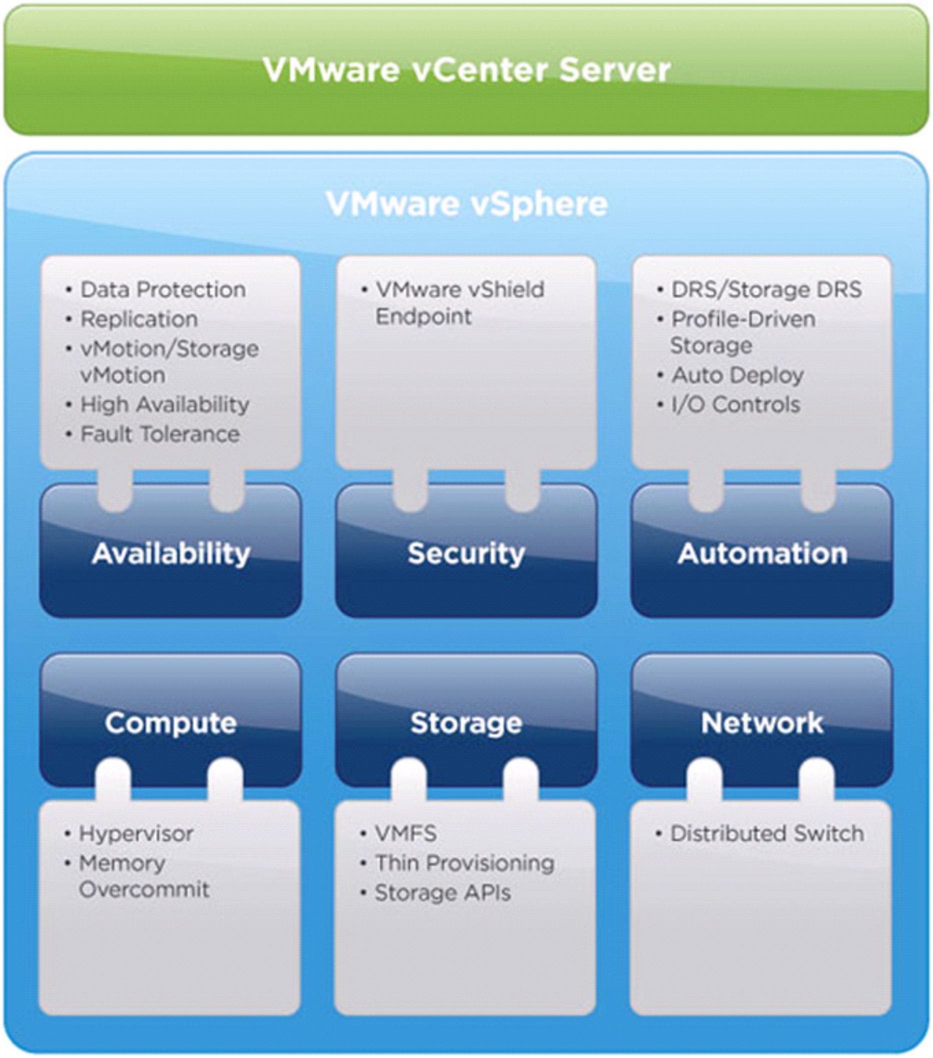
VMware vSphere is a virtualization platform for holistically managing large collections of infrastructure resources such as CPUs, storage, networking; as a seamless, versatile, and dynamic operating environment. Unlike traditional operating systems that manage an individual machine, the VMware vSphere aggregates the infrastructure of an entire data center to create a single powerhouse with resources that can be allocated quickly and dynamically to any application in need.

The VMware vSphere provides revolutionary benefits, but with a practical, nondisruptive evolutionary process for legacy applications. Existing applications can be deployed on VMware vSphere with no changes to the application or the OS on which they are running.

VMware vSphere provides a set of application services that enable applications to achieve unparalleled levels of availability, and scalability. As shown in Figure 5, VMware vSphere delivers core capabilities to meet numerous application and enterprise demands. The VMware vSphere 5.1 built on FlexPod integrated system highlights the following vSphere features to deliver:

- Availability
  - Workload mobility via vMotion
  - High Availability through vSphere clustering technology offering virtual machine resiliency in the event of physical server or guest OS failures
- Automation
  - VMware Distributed Resource Scheduler (DRS) offering dynamic workload distribution to align resource utilization with business priorities and compute capacity. DRS provides efficient use of compute resources and subsequently power consumption.
- Compute
  - VMware vSphere ESXi hypervisor providing efficient memory, storage and compute abstraction for virtual machines
- Network
  - VMware vSphere supports third party virtual distributed switches such as the Cisco Nexus 1000v providing a resilient and fully integrated virtualized network access layer.
- Storage
  - Thin provisioning allows over provisioning of storage resources to improve storage utilization and improve capacity planning
  - Virtual Machine File System (VMFS) is a clustered file system allowing multiple hosts simultaneous read and writes access to a single volume located on a SCSI-based device over FC, FCoE or iSCSI. VMFS-5 supports a maximum of 32 hosts connected to a single volume that may be up to 64 TB in size.

Figure 5 VMware vSphere Feature Overview



The VMware vSphere environment delivers a robust application environment. For example, with VMware vSphere, all applications can be protected from downtime with VMware High Availability (HA) and VMware Fault Tolerance (FT), without the complexity of conventional clustering. In addition, applications can be scaled dynamically to meet changing loads with capabilities such as Hot Add and VMware Distributed Resource Scheduler (DRS).

For more information on VMware vSphere, see:

http://www.vmware.com/products/datacenter-virtualization/vsphere/overview.html

Domain and Element Management

This section of the document provides general descriptions of the domain and element managers used during the validation effort. The following managers were used:

- Cisco UCS Manager
- NetApp OnCommand®

- VMware vCenter™ Server

Cisco Unified Computing System Manager

Cisco UCS Manager provides unified, centralized, embedded management of all Cisco Unified Computing System software and hardware components across multiple chassis and thousands of virtual machines. Administrators use this software to manage the entire Cisco UCS as a single logical entity through an intuitive GUI, a command-line interface (CLI), or an XML API.

The Cisco UCS Manager resides on a pair of Cisco UCS 6200 Series Fabric Interconnects using a clustered, active-standby configuration for high availability. The software gives administrators a single interface for performing server provisioning, device discovery, inventory, configuration, diagnostics, monitoring, fault detection, auditing, and statistics collection. Cisco UCS Manager service profiles and templates support versatile role- and policy-based management, and system configuration information can be exported to configuration management databases (CMDBs) to facilitate processes based on IT Infrastructure Library (ITIL) concepts.

Compute nodes are deployed in a UCS environment by leveraging UCS service profiles. Service profiles let server, network, and storage administrators treat Cisco UCS servers as raw computing capacity to be allocated and reallocated as needed. The profiles define server I/O properties, personalities, properties and firmware revisions and are stored in the Cisco UCS 6200 Series Fabric Interconnects. Using service profiles, administrators can provision infrastructure resources in minutes instead of days, creating a more dynamic environment and more efficient use of server capacity.

Each service profile consists of a server software definition and the server's LAN and SAN connectivity requirements. When a service profile is deployed to a server, Cisco UCS Manager automatically configures the server, adapters, fabric extenders, and fabric interconnects to match the configuration specified in the profile. The automatic configuration of servers, network interface cards (NICs), host bus adapters (HBAs), and LAN and SAN switches lowers the risk of human error, improves consistency, and decreases server deployment times.

Service profiles benefit both virtualized and non-virtualized environments. The profiles increase the mobility of non-virtualized servers, such as when moving workloads from server to server or taking a server offline for service or an upgrade. Profiles can also be used in conjunction with virtualization clusters to bring new resources online easily, complementing existing virtual machine mobility.

For more information on Cisco UCS Manager, see:

http://www.cisco.com/en/US/products/ps10281/index.html

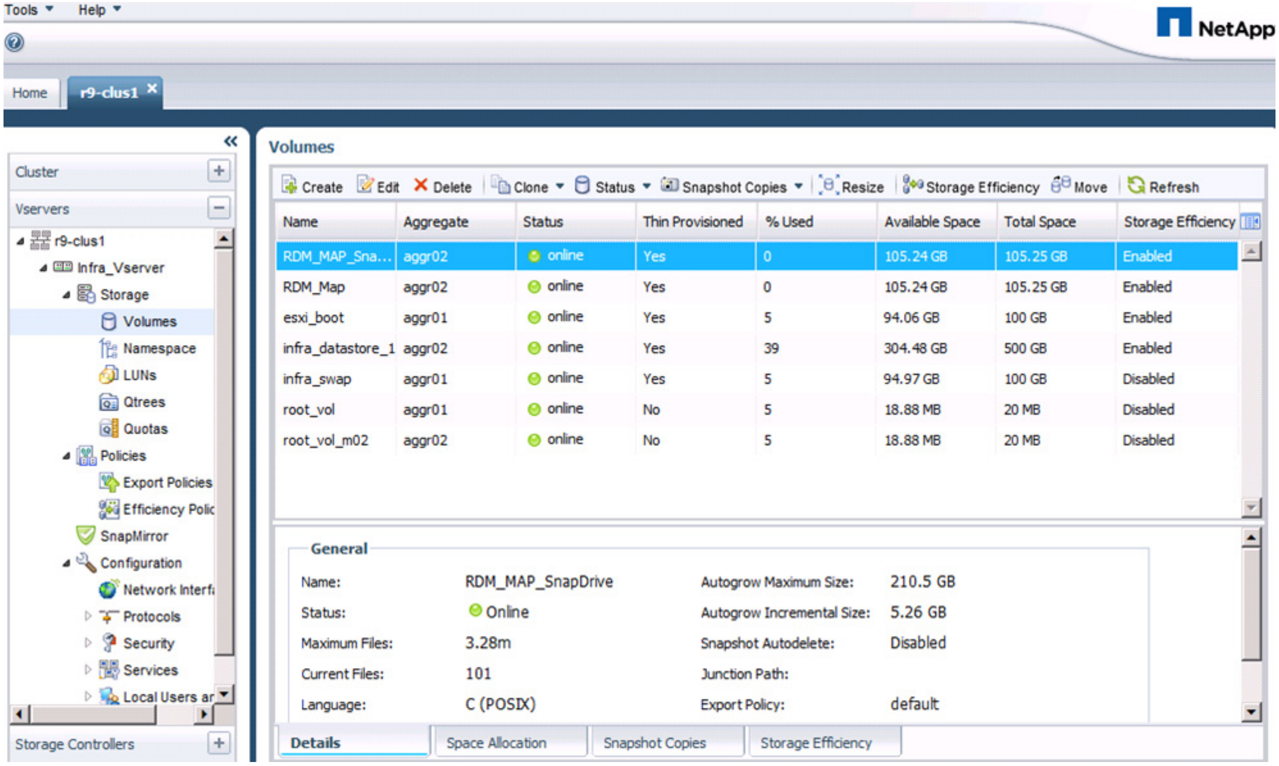
NetApp OnCommand System Manager

NetApp OnCommand System Manager makes it possible for administrators to manage individual or clusters of NetApp storage systems through an easy-to-use browser-based interface. System Manager comes with wizards and workflows, simplifying common storage tasks such as creating volumes, LUNs, qtrees, shares, and exports, which saves time and prevents errors. System Manager works across all the NetApp storage such as FAS2000, FAS3000, and FAS6000 Series and V-Series systems.

NetApp OnCommand Unified Manager complements the features of System Manager by enabling the monitoring and management of storage within the NetApp storage infrastructure.

The solution uses both OnCommand System Manager and OnCommand Unified Manager to provide storage provisioning and monitoring capabilities within the infrastructure. Figure 6 shows a screen sample in NetApp OnCommand System Manager.

Figure 6 NetApp OnCommand System Manager Example



Name	Aggregate	Status	Thin Provisioned	% Used	Available Space	Total Space	Storage Efficiency
RDM_MAP_Sna...	aggr02	online	Yes	0	105.24 GB	105.25 GB	Enabled
RDM_Map	aggr02	online	Yes	0	105.24 GB	105.25 GB	Enabled
esxi_boot	aggr01	online	Yes	5	94.06 GB	100 GB	Enabled
infra_datastore_1	aggr02	online	Yes	39	304.48 GB	500 GB	Enabled
infra_swap	aggr01	online	Yes	5	94.97 GB	100 GB	Disabled
root_vol	aggr01	online	No	5	18.88 MB	20 MB	Disabled
root_vol_m02	aggr02	online	No	5	18.88 MB	20 MB	Disabled

General

Name: RDM_MAP_SnapDrive

Status: Online

Maximum Files: 3.28m

Current Files: 101

Language: C (POSIX)

Autogrow Maximum Size: 210.5 GB

Autogrow Incremental Size: 5.26 GB

Snapshot Autodelete: Disabled

Junction Path:

Export Policy: default

VMware vCenter Server

VMware vCenter Server is the simplest and most efficient way to manage VMware vSphere, irrespective of the number of VMs you have. It provides unified management of all hosts and VMs from a single console and aggregates performance monitoring of clusters, hosts, and VMs. VMware vCenter Server gives administrators a deep insight into the status and configuration of compute clusters, hosts, VMs, storage, the guest OS, and other critical components of a virtual infrastructure. A single administrator can manage 100 or more virtualization environment workloads using VMware vCenter Server, more than doubling typical productivity in managing physical infrastructure. As shown in Figure 5, VMware vCenter manages the rich set of features available in a VMware vSphere environment.

For more information on VMware vCenter Server, see:
http://www.vmware.com/products/vcenter-server/overview.html

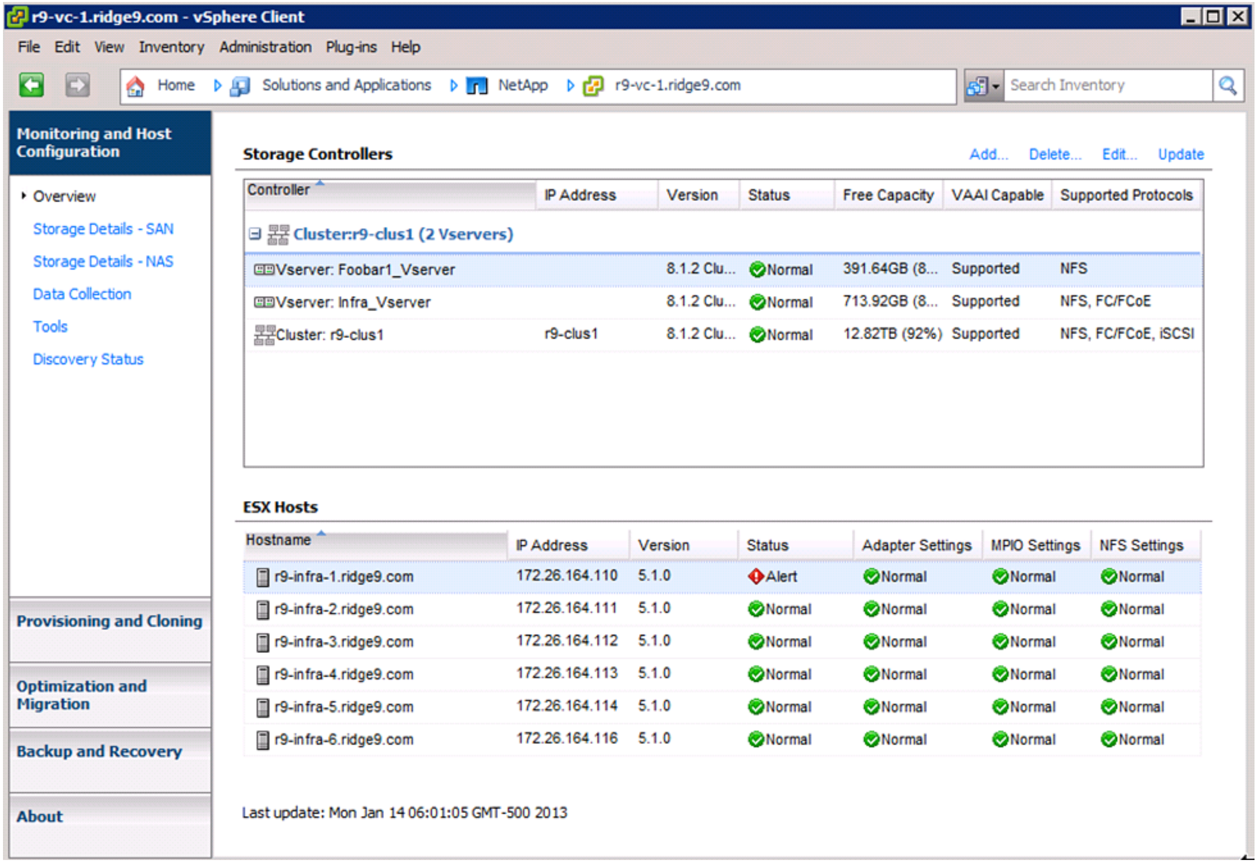
VMware vCenter Server Plug-Ins

vCenter Server plug-ins extend the capabilities of vCenter Server by providing more features and functionality. Some plug-ins are installed as part of the base vCenter Server product, for example, vCenter Hardware Status and vCenter Service Status, while other plug-ins are packaged separately from the base product and require separate installation. These are some of the plug-ins used during the FlexPod validation process.

NetApp Virtual Storage Console

The NetApp VSC software delivers storage configuration and monitoring, datastore provisioning, VM cloning, and backup and recovery of VMs and datastores. VSC also includes an Application Programming Interface (API) for automated control. VSC delivers a single VMware plug-in that provides end-to-end VM lifecycle management for VMware environments using NetApp storage. VSC is delivered as a VMware vCenter Server plug-in. It is available to all VMware vSphere Clients that connect to the VMware vCenter Server. This is different from a client-side plug-in that must be installed on every VMware vSphere Client. The VSC software can be installed either on the VMware vCenter Server or on a separate Microsoft Windows Server® instance or VM. Figure 7 shows a screen sample in NetApp Virtual Storage Console.

Figure 7 NetApp Virtual Storage Console Example



Storage Controllers

Controller	IP Address	Version	Status	Free Capacity	VAAI Capable	Supported Protocols
Cluster:r9-clus1 (2 Vservers)						
Vserver: Foobar1_Vserver		8.1.2 Clu...	Normal	391.64GB (8...	Supported	NFS
Vserver: Infra_Vserver		8.1.2 Clu...	Normal	713.92GB (8...	Supported	NFS, FC/FCoE
Cluster: r9-clus1	r9-clus1	8.1.2 Clu...	Normal	12.82TB (92%)	Supported	NFS, FC/FCoE, iSCSI

ESX Hosts

Hostname	IP Address	Version	Status	Adapter Settings	MPIO Settings	NFS Settings
r9-infra-1.ridge9.com	172.26.164.110	5.1.0	Alert	Normal	Normal	Normal
r9-infra-2.ridge9.com	172.26.164.111	5.1.0	Normal	Normal	Normal	Normal
r9-infra-3.ridge9.com	172.26.164.112	5.1.0	Normal	Normal	Normal	Normal
r9-infra-4.ridge9.com	172.26.164.113	5.1.0	Normal	Normal	Normal	Normal
r9-infra-5.ridge9.com	172.26.164.114	5.1.0	Normal	Normal	Normal	Normal
r9-infra-6.ridge9.com	172.26.164.116	5.1.0	Normal	Normal	Normal	Normal

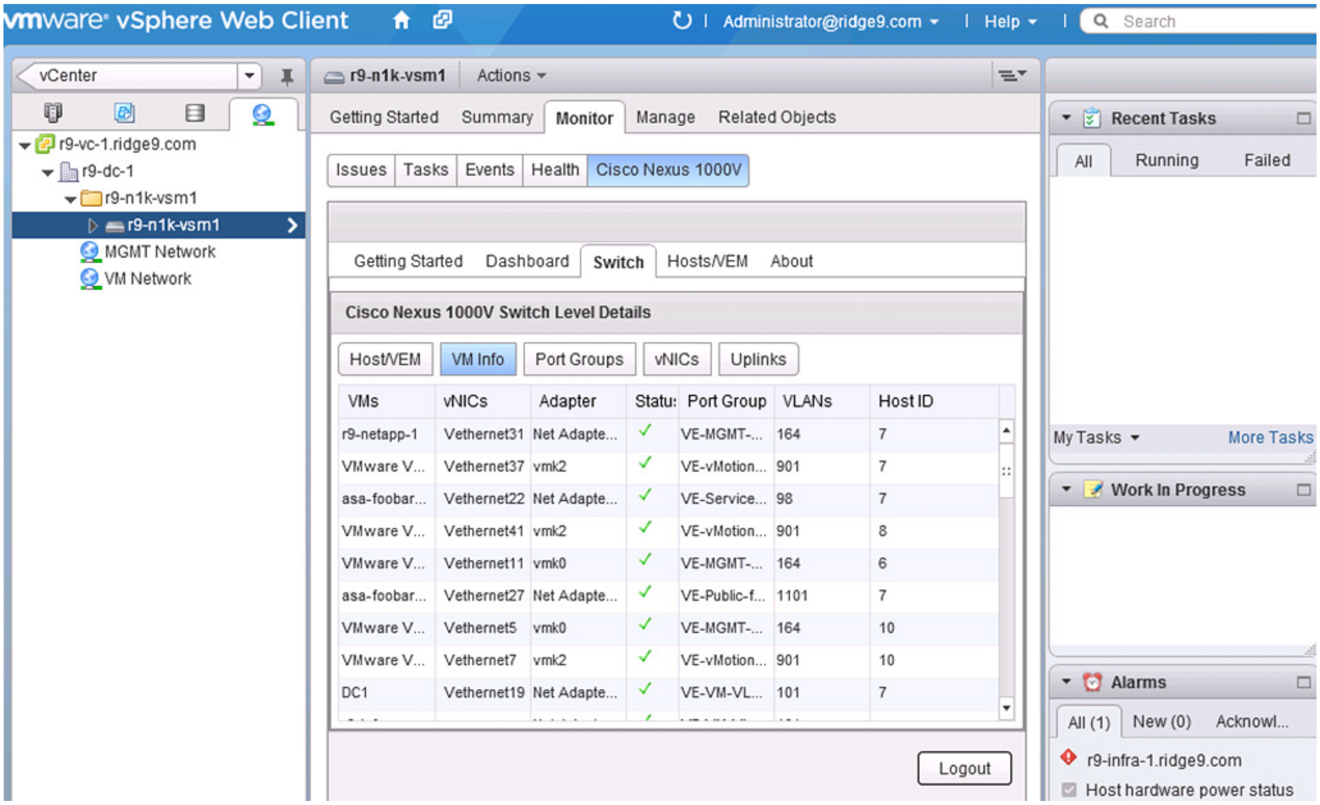
Last update: Mon Jan 14 06:01:05 GMT-500 2013

Cisco Nexus 1000v vCenter Plug-in

Cisco Nexus 1000V Release 4.2.1.SV2.1.1a supports a vCenter plug-in. It provides the server administrators a view of the virtual network and a visibility into the networking aspects of the Cisco Nexus 1000V virtual switch. The vCenter plug-in is supported on VMware vSphere Web Clients only. VMware vSphere Web Client enables you to connect to a VMware vCenter Server system to manage a Cisco Nexus 1000V through a browser. The vCenter plug-in is installed as a new tab in the Cisco Nexus 1000V as part of the user interface in vSphere Web Client.

The vCenter plug-in allows the administrators to view the configuration aspects of the VSM. With the vCenter plug-in, the server administrators can export the necessary networking details from the vCenter server, investigate the root cause of and prevent the networking issues, and deploy the virtual machines with suitable policies. The server administrators can monitor and manage the resources effectively with the network details provided in the vCenter plug-in. Figure 8 shows a screen sample in Cisco Nexus 1000v vCenter Plug-in.

Figure 8 Cisco Nexus 1000v vCenter Plug-in Example



VMs	vNICs	Adapter	Statu:	Port Group	VLANs	Host ID
r9-netapp-1	Vethernet31	Net Adapte...	✓	VE-MGMT-...	164	7
VMware V...	Vethernet37	vmk2	✓	VE-vMotion...	901	7
asa-foobar...	Vethernet22	Net Adapte...	✓	VE-Service...	98	7
VMware V...	Vethernet41	vmk2	✓	VE-vMotion...	901	8
VMware V...	Vethernet11	vmk0	✓	VE-MGMT-...	164	6
asa-foobar...	Vethernet27	Net Adapte...	✓	VE-Public-f...	1101	7
VMware V...	Vethernet5	vmk0	✓	VE-MGMT-...	164	10
VMware V...	Vethernet7	vmk2	✓	VE-vMotion...	901	10
DC1	Vethernet19	Net Adapte...	✓	VE-VM-VL...	101	7

FlexPod Implementation and Design

This section describes the implementation details of FlexPod design with NetApp clustered Data ONTAP and Data ONTAP operating in 7-mode.

Physical Build

Hardware and Software Revisions

Table 1 describes the hardware and software versions used during solution validation. It is important to note that Cisco, NetApp, and VMware have interoperability matrixes that should be referenced to determine support for any specific implementation of FlexPod. For more information on Interoperability Matrix, see the following links:

- NetApp Interoperability Matrix Tool

  http://support.netapp.com/matrix/

- Cisco UCS Hardware and Software Interoperability Tool http://www.cisco.com/web/techdoc/ucs/interoperability/matrix/matrix.html

- VMware Compatibility Guide

  http://www.vmware.com/resources/compatibility/search.php

Table 1 Validated Software and Firmware Versions

Layer	Device	Image	Comments
Compute	Cisco UCS Fabric Interconnects 6200 Series	2.1(1e)	Embedded management
	Cisco UCS B-200 M2	2.1(1e)	Software bundle release
	Cisco UCS B-200 M3	2.1(1e)	Software bundle release
	Cisco UCS C-220 M2	2.1(1e)	Software bundle release
	Cisco UCS C-220 M3	2.1(1e)	Software bundle release
	Cisco E-NIC	2.1.2.38	Ethernet driver for Cisco VIC
	Cisco F-NIC	1.5.0.20	FCoE driver for Cisco VIC
Network	Cisco Nexus 7000 (F-series module required for FCoE support)	6.1(2)	Operating System version
Storage	NetApp FAS Model 3250-AE	Clustered Data ONTAP 8.1.2	Operating System version
	Cisco Nexus 5596UP Cluster Interconnect	5.2(1)N1(1)	Operating System version

Table 1 Validated Software and Firmware Versions

Layer	Device	Image	Comments
Software	Cisco UCS hosts	VMware vSphere ESXi™ 5.1	Operating System version
	Microsoft .NET Framework	3.5.1	Feature enabled within Windows operating system
	Microsoft SQL Server®	Microsoft SQL Server 2008 R2 SP1	VM (1 each): SQL Server DB
	VMware vCenter™	5.1	VM (1 each): VMware vCenter
	NetApp OnCommand System Manager	5.1	VM (1 each): OnCommand
	NetApp Virtual Storage Console (VSC)	4.1	Plug-in within VMware vCenter
	Cisco Nexus 1000v	4.2(1)SV2(1.1a)	Virtual services blade within the 1110-x
	Cisco Nexus 1110-X	4.2(1)SV1(5.1a)	Virtual services appliance
	NetApp NFS Plug-in for VMware vStorage APIs for Array Integration (VAAI)	1.0-018	Plug-in within VMware vCenter

Logical Build

Figure 2 and Figure 3 show the distinct uplink design structure. The design is physically redundant across the stack, addressing Layer 1 high-availability requirements, but there are additional Cisco and NetApp technologies and features that make for an even more effective solution. This section of the document discusses the logical configuration validated for FlexPod. The topics covered include:

- FlexPod - distinct uplink design with clustered Data ONTAP
- FlexPod - distinct uplink design with Data ONTAP operating in 7-Mode

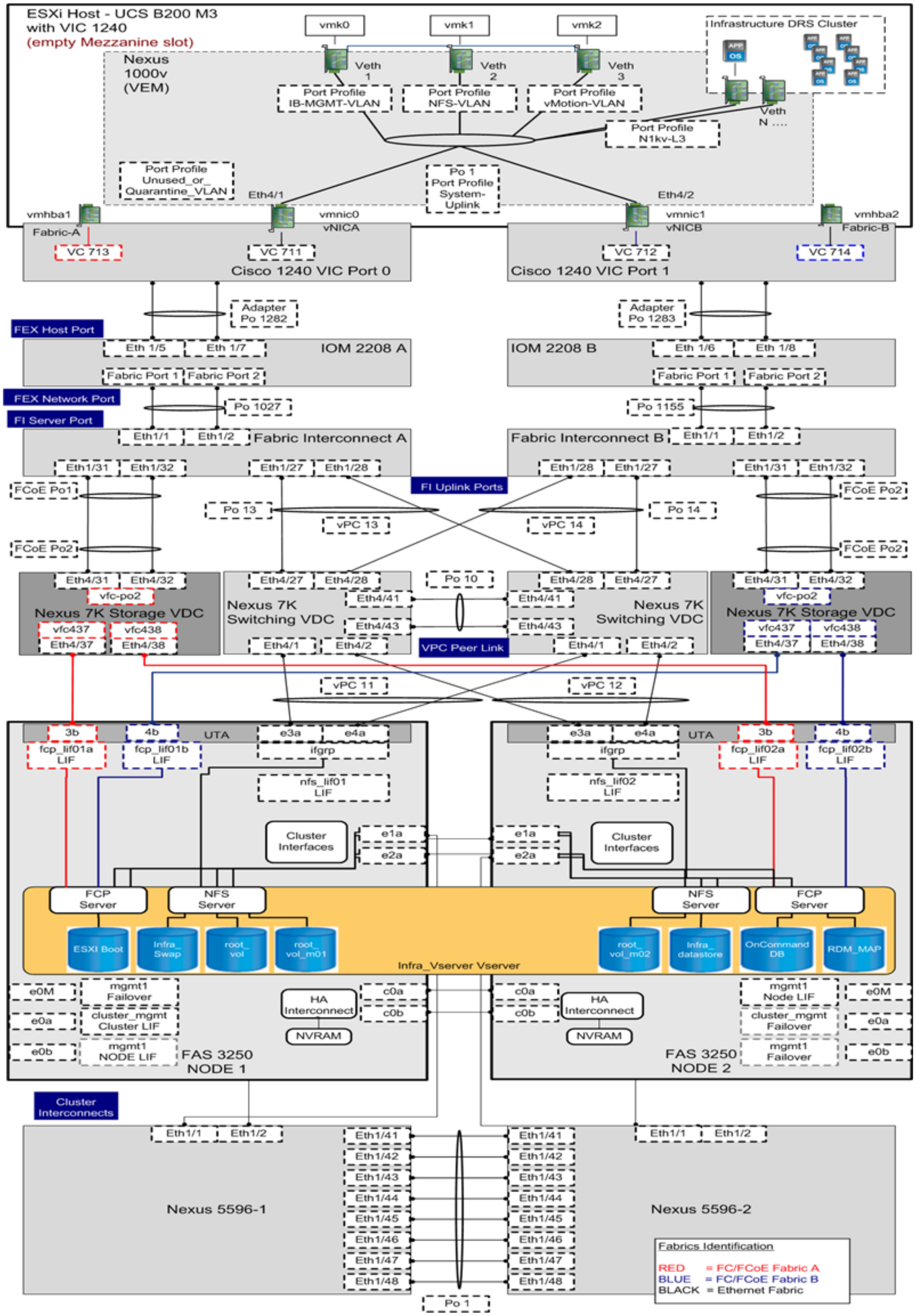
FlexPod - Distinct Uplink Design with Clustered Data ONTAP

Figure 9 details the distinct uplink design with a clustered Data ONTAP logical model. The following sections will describe the role of each component within this model of the FlexPod system.

Note

- The example in Figure 9 showcases the use of the Cisco Nexus 1000v virtual distributed switch in the architecture.
- FlexPod design includes the integration of Cisco VM-FEX technology.

Figure 9 FlexPod Distinct Uplink Design with Clustered Data ONTAP



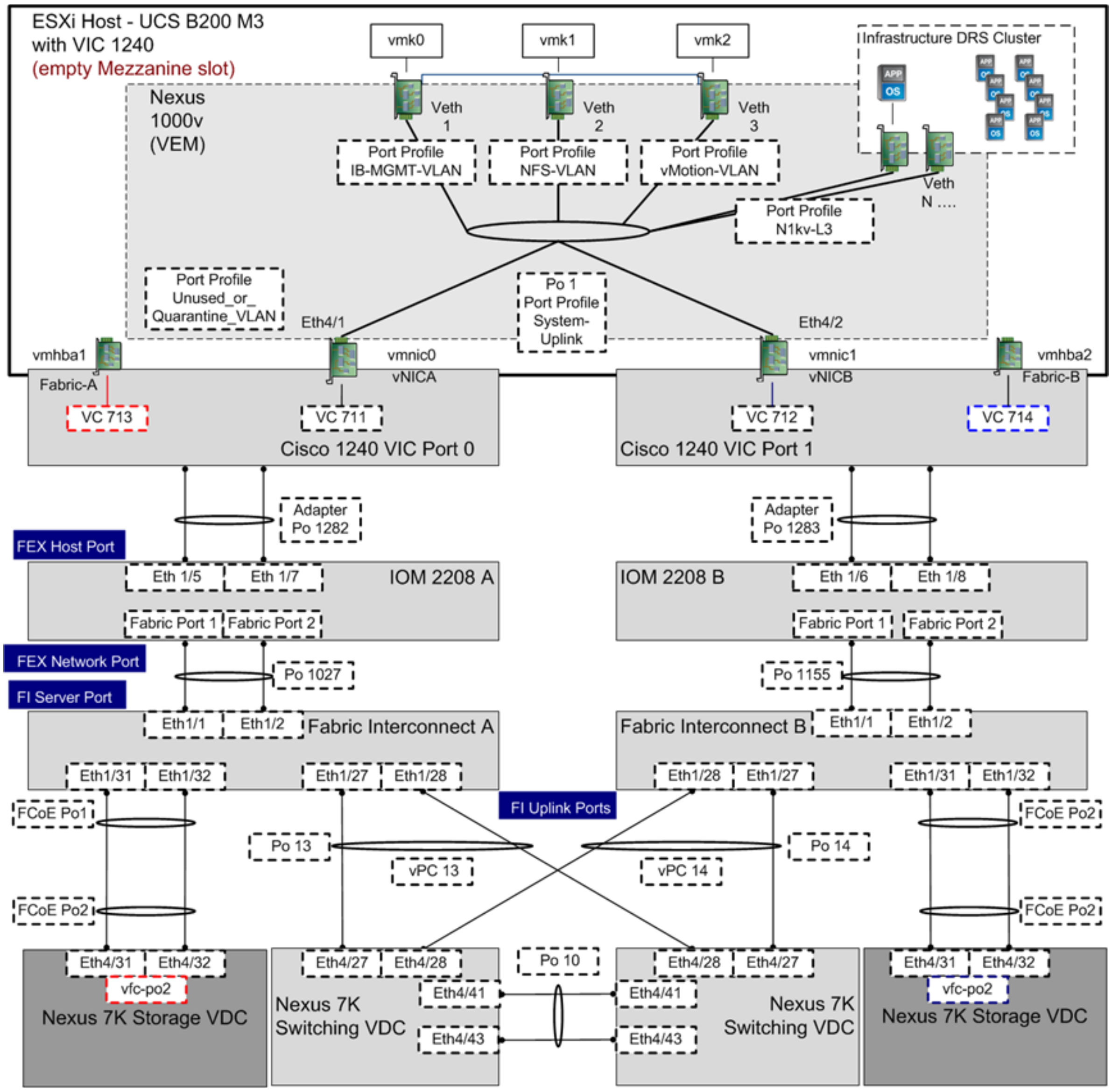
Cisco Unified Computing System

The FlexPod design simultaneously supports both B-Series and C-Series deployments. This section of the document discusses the integration of each deployment into FlexPod.

Cisco Unified Computing System – B-Series Server Design

The Cisco Unified Computing System supports the virtual server environment by providing a robust, highly available, and extremely manageable compute resource. As shown in Figure 10 the components of the Cisco UCS system offer physical redundancy and a set of logical structures to deliver a very resilient FlexPod compute domain. In this validation effort, multiple UCS B-Series servers' service profiles are SAN booted over FCoE as VMware ESXi nodes. The ESXi nodes consisted of Cisco UCS B200-M3 Series Blades with Cisco UCS 1240 VIC adapters. These nodes were allocated to a VMware DRS and HA enabled cluster, supporting infrastructure services such as vSphere Virtual Center, Microsoft Active Directory and database services.

Figure 10 FlexPod Distinct Uplink Design - Cisco UCS B-Series and Nexus 7000 Focus



As shown in Figure 10, the Cisco UCS 1240 VIC presents four virtual PCIe devices to the VMware ESXi node, two virtual 10 Gigabit Ethernet NICs (vNIC) and two virtual Host Bus Adapters (vHBA). The vSphere environment identifies these as vmnics and vmhbas respectively. The ESXi operating system is unaware that these are virtual adapters. The result is a dual-homed ESXi node to the remaining network from a LAN and SAN perspective.

In FlexPod the vHBA adapters use FCoE as a transport protocol across the Fabric. The ESXi node has connections to two independent fabrics, Fabrics A and B. The Cisco UCS domain constructs distinct virtual circuits (in this example VC 713 and VC 714) to maintain fabric separation and integrity.

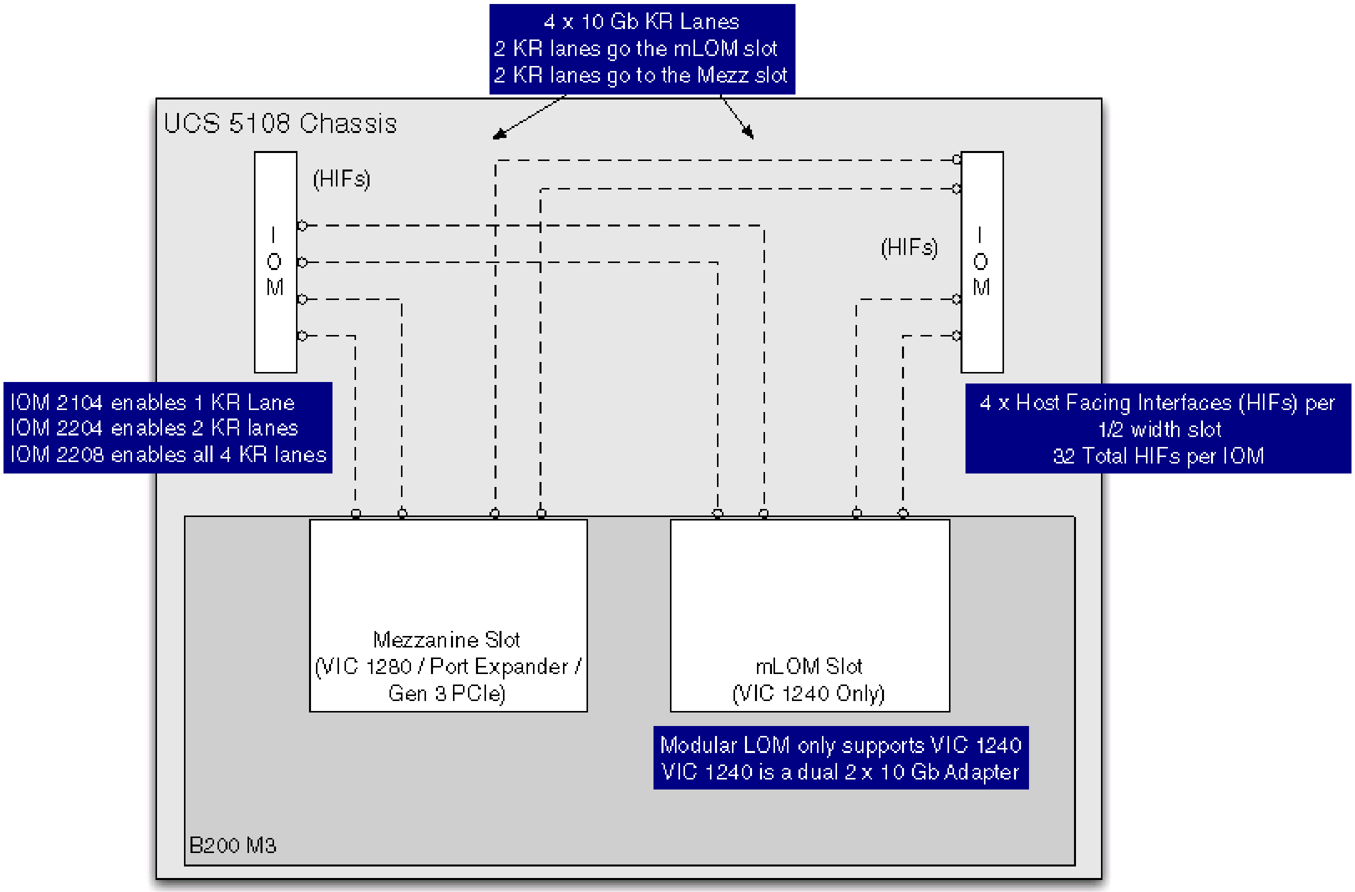
FlexPod allows organizations to adjust the individual components of the system to meet their particular scale or performance requirements. FlexPod continues this practice. One key design decision in the Cisco UCS domain is the selection of I/O components. There are numerous combinations of I/O adapter, fabric extenders and fabric interconnects available; so, it is important to understand the impact of these selections on the overall flexibility, scalability and resiliency of the fabric.

Figure 11 shows the available backplane connections in the UCS 5100 Series Chassis. As the illustration shows, each of the two fabric extenders (I/O module) has four 10GBASE KR (802.3ap) standardized Ethernet backplane paths available for connection to the half-width blade slot. This means that each half-width slot has the potential to support up to 80Gb of aggregate traffic. What is realized depends on several factors namely:

- Fabric Extender model (2204XP or 2208XP)
- Modular LAN on Motherboard (mLOM) card
- Mezzanine Slot card

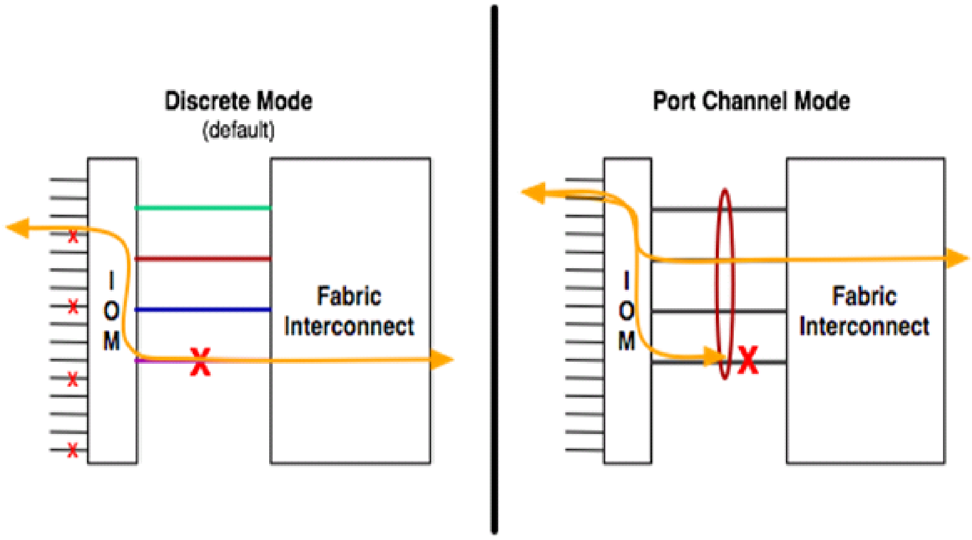
The Cisco UCS 2208XP Series Fabric Extenders, installed in each blade chassis, have eight 10 Gigabit Ethernet, FCoE-capable, Enhanced Small Form-Factor Pluggable (SFP+) ports that connect the blade chassis to the fabric interconnect. The Cisco UCS 2204 has four external ports with identical characteristics to connect to the fabric interconnect. Each Cisco UCS 2208XP has thirty-two 10 Gigabit Ethernet ports connected through the midplane KR lanes to each half-width slot in the chassis, while the 2204XP has sixteen 10 Gigabit Ethernet ports. This means the 2204XP enables two KR lanes per half-width blade slot while the 2208XP enables all four. The number of KR lanes indicates the potential I/O available to the chassis and therefore blades.

Figure 11 Cisco UCS 5100 Chassis Backplane Connections


4 x 10 Gb KR Lanes
2 KR lanes go the mLOM slot
2 KR lanes go to the Mezz slot
UCS 5108 Chassis
(HIFs)
I O M
(HIFs)
I O M
IOM 2104 enables 1 KR Lane
IOM 2204 enables 2 KR lanes
IOM 2208 enables all 4 KR lanes
4 x Host Facing Interfaces (HIFs) per 1/2 width slot
32 Total HIFs per IOM
Mezzanine Slot
(VIC 1280 / Port Expander / Gen 3 PCIe)
mLOM Slot
(VIC 1240 Only)
Modular LOM only supports VIC 1240
VIC 1240 is a dual 2 x 10 Gb Adapter
B200 M3

Port-aggregation is supported by the second-generation Cisco UCS 6200 Series Fabric Interconnects, 2200 Series Fabric Extenders and 1200 Series Virtual Interface Cards (VIC) support port aggregation. This capability allows for workload rebalancing between these devices providing link fault tolerance in addition to increased aggregate bandwidth within the fabric. It should be noted that in the presence of second generation VICs and FEX fabric port channels will automatically be created in the fabric. Fabric port channels between the FEXs and fabric interconnects are controlled through the Chassis/FEX discovery policy. Figure 12 shows the two modes of operation for this policy. In Discrete Mode, each FEX KR connection and server connection is tied or pinned to a network fabric connection homed to a port on the fabric interconnect. In the presence of a failure on the external “link” all KR connections are disabled within the FEX I/O module. In the case of a fabric port channel discovery policy, the failure of a network fabric link allows for redistribution of flows across the remaining port channel members. This is less disruptive to the fabric.

Figure 12 Example of Discrete Mode versus Port Channel Mode Example



Note First generation Cisco UCS hardware is compatible with the second-generation gear but it will only operate in discrete mode.

Figure 13 shows one of the Cisco UCS B200-M3 backplane connections validated for the FlexPod. The Cisco UCS B200M3 server uses a VIC 1240 in the mLOM slot with an empty mezzanine slot. The Cisco UCS Fabric Extender 2204XP enables 2 KR lanes to the half-width blade while the global discovery policy dictates the formation of a fabric port channel. Figure 10 details on particular instance of this configuration. Notice that the instantiation of fabric port channels Po1027 and Po1155 between the fabric interconnect and FEX pairs due to the discovery policy, and the automatic port channels formed between Po1282 and Po1283 at the adapter and FEX level.

Figure 13 Validated UCS Backplane Configurations Using VIC 1240 Only

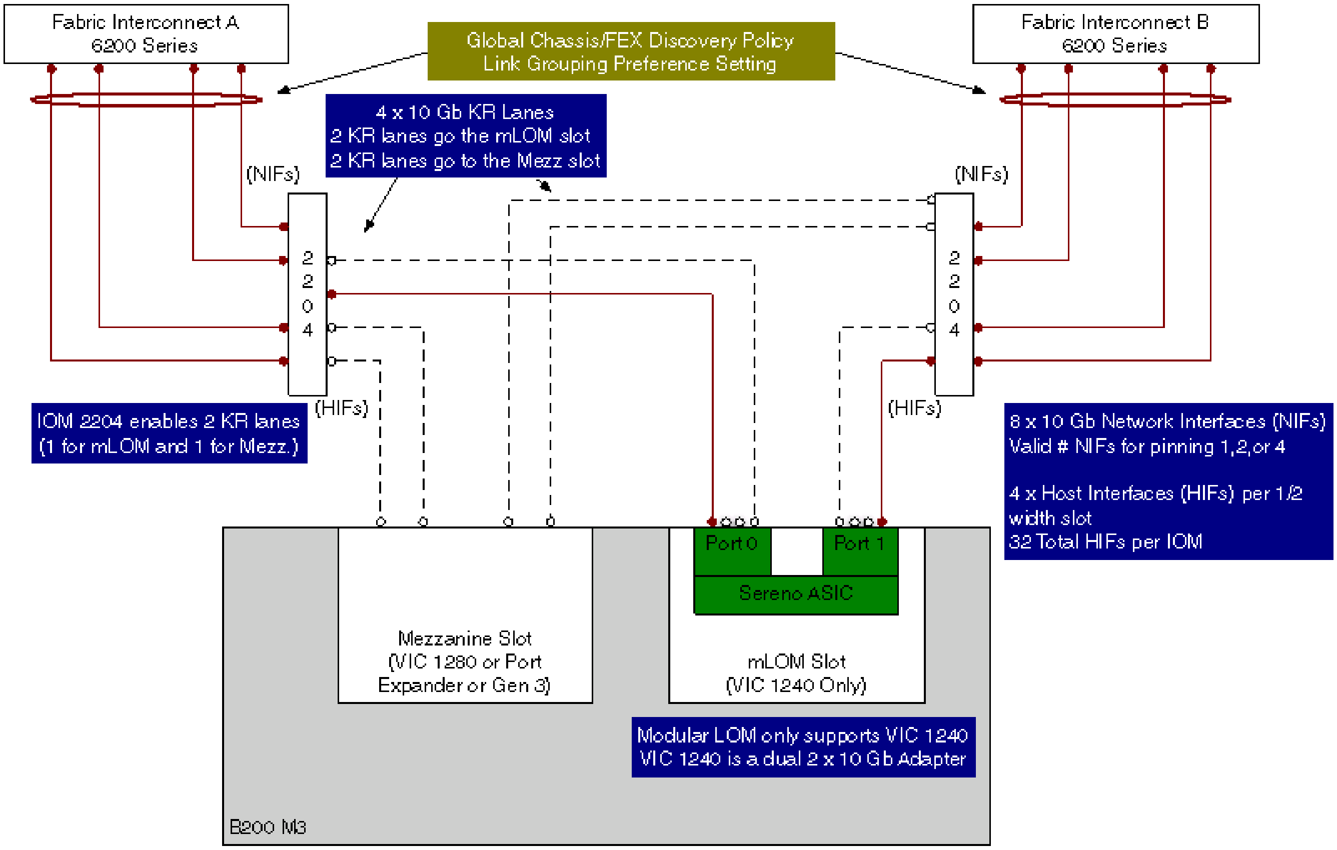
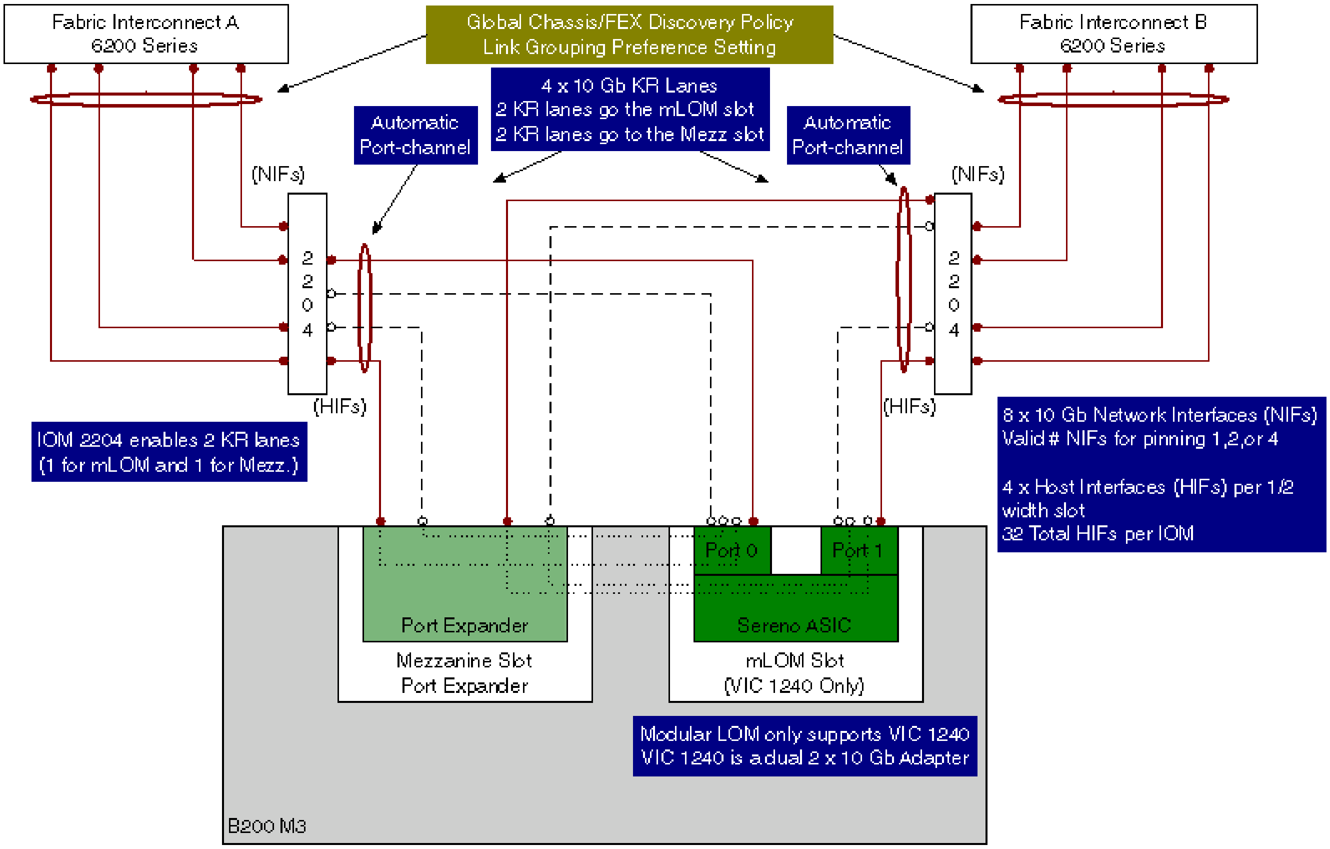

Fabric Interconnect A
6200 Series
Global Chassis/FEX Discovery Policy
Link Grouping Preference Setting
Fabric Interconnect B
6200 Series
4 x 10 Gb KR Lanes
2 KR lanes go the mLOM slot
2 KR lanes go to the Mezz slot
(NIFs)
(NIFs)
2204
2204
IOM 2204 enables 2 KR lanes
(1 for mLOM and 1 for Mezz.)
(HIFs)
(HIFs)
8 x 10 Gb Network Interfaces (NIFs)
Valid # NIFs for pinning 1,2,or 4
4 x Host Interfaces (HIFs) per 1/2 width slot
32 Total HIFs per IOM
Port 0
Port 1
Sereno ASIC
Mezzanine Slot
(VIC 1280 or Port Expander or Gen 3)
mLOM Slot
(VIC 1240 Only)
Modular LOM only supports VIC 1240
VIC 1240 is a dual 2 x 10 Gb Adapter
B200 M3

Figure 14 shows another Cisco UCS B200-M3 instance in the test bed. In this instance the mezzanine slot is populated with the port expander option. This passive device provides connectivity for the unused ports on the Cisco UCS VIC 1240, essentially enabling the 40-Gb potential of the mLOM card. Beyond the raw capacity improvements is the creation of two more automatic port channels between the FEX and the server. This provides link resiliency at the adapter level and double the bandwidth available to the system. (dual 2x10Gb).

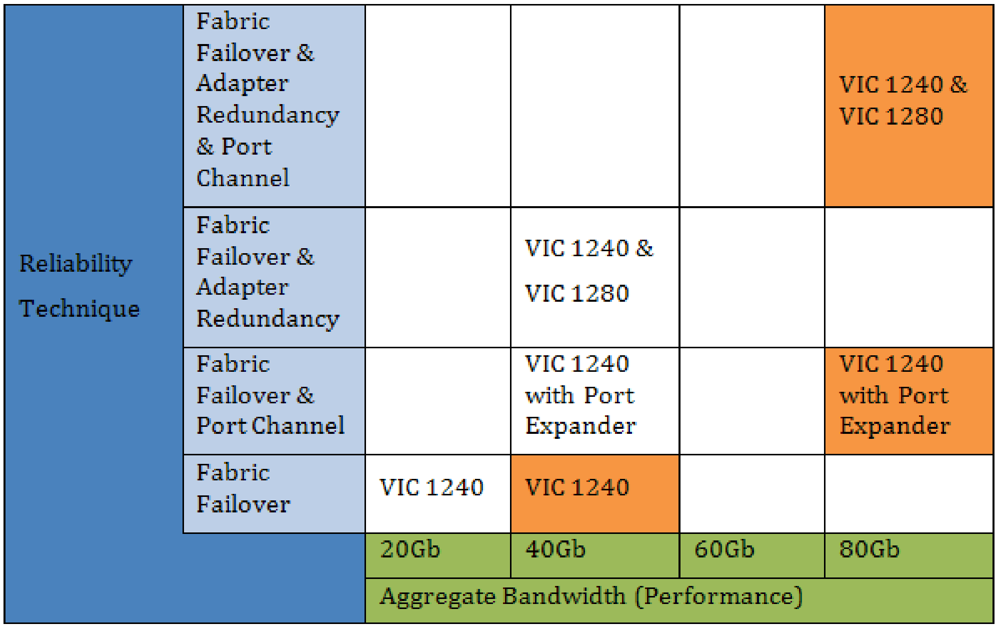
Figure 14 Validated UCS Backplane Configuration Using VIC 1240 with Port Extender


Fabric Interconnect A
6200 Series
Global Chassis/FEX Discovery Policy
Link Grouping Preference Setting
Fabric Interconnect B
6200 Series
4 x 10 Gb KR Lanes
2 KR lanes go the mLOM slot
2 KR lanes go to the Mezz slot
Automatic
Port-channel
Automatic
Port-channel
(NIFs)
(NIFs)
2204
2204
(HIFs)
(HIFs)
IOM 2204 enables 2 KR lanes
(1 for mLOM and 1 for Mezz.)
8 x 10 Gb Network Interfaces (NIFs)
Valid # NIFs for pinning 1,2,or 4
4 x Host Interfaces (HIFs) per 1/2
width slot
32 Total HIFs per IOM
Port Expander
Mezzanine Slot
Port Expander
Port 0
Port 1
Sereno ASIC
mLOM Slot
(VIC 1240 Only)
Modular LOM only supports VIC 1240
VIC 1240 is a dual 2 x 10 Gb Adapter
B200 M3

Note See "Appendix: Cisco UCS Fabric Interconnect and IOM Connectivity Diagrams" section on page 54 for additional combinations of UCS second-generation hardware and the connectivity options they provide.

Figure 15 describes the availability and performance aspects of the second-generation Cisco UCS I/O gear.

Figure 15 Cisco UCS VIC Availability for FEX 2204XP and 2208XP Options



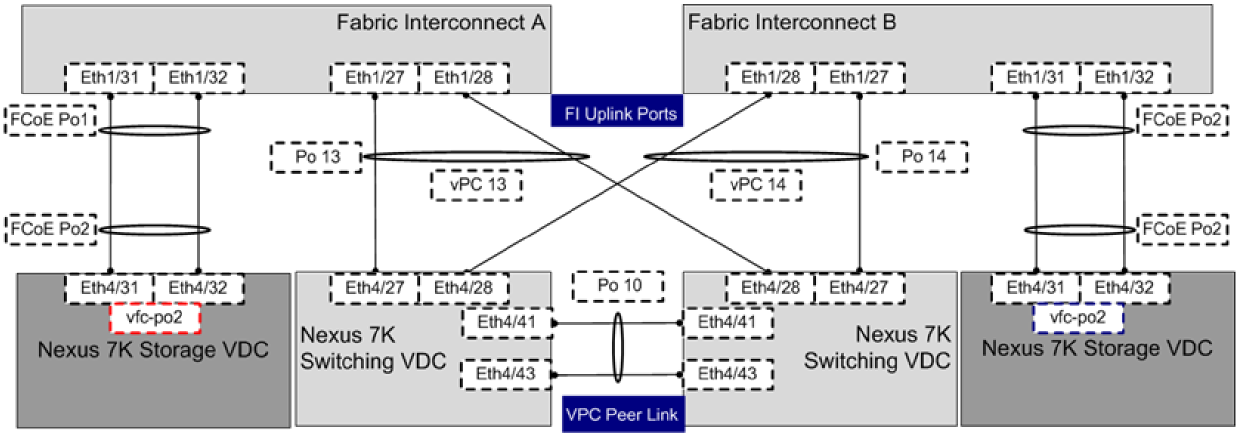
Reliability Technique	Fabric Failover & Adapter Redundancy & Port Channel				VIC 1240 & VIC 1280
	Fabric Failover & Adapter Redundancy		VIC 1240 & VIC 1280		
	Fabric Failover & Port Channel		VIC 1240 with Port Expander		VIC 1240 with Port Expander
	Fabric Failover	VIC 1240	VIC 1240		
		20Gb	40Gb	60Gb	80Gb
		Aggregate Bandwidth (Performance)			

*Orange shading indicates the FEX 2208XP is in use. All other values are based on the FEX 2204XP model.

Note

- Cisco UCS VIC Availability for FEX 2204XP and 2208XP assumes the presence of Cisco UCS 6200 Series Fabric Interconnects.
- Fabric failover is not required for deployments using the Cisco Nexus 1000v. For more information on Fabric Failover in the presence of the Cisco Nexus 1000v, see: http://www.cisco.com/en/US/prod/collateral/switches/ps9441/ps9902/white_paper_c11-558242.html
- Third Party Gen-3 PCIe adapters are not validated as part of FlexPod

Figure 16 FlexPod Distinct Uplink Design - Cisco UCS FI and Nexus 7000 Focus



As shown in Figure 16, the FlexPod defines two FCoE port channels (Po1 & Po2) and two LAN port channels (Po13 & Po14). The FCoE port channels only carry only Fibre Channel traffic that is associated to a VSAN/VLAN set, with the set in turn supported only on one side of the fabric A or B. As in this example, the vHBA “FABRIC-A” is defined in the service profile. The vHBA uses a virtual circuit, VC 713, to traverse the UCS unified fabric to port channel Po1 where FCoE traffic egresses the Cisco UCS domain and enters the Cisco Nexus 7000 platform. Fabric A supports a distinct VSAN, which is not present on Fabric B, thus maintaining fabric isolation.

A balanced and predictable fabric is critical within any data center environment. As designed, the FlexPod accommodates a myriad of traffic types (vMotion, NFS, FCoE, control traffic, and so on) and is capable of absorbing traffic spikes and protect against traffic loss. To address these requirements the Cisco UCS QoS system classes and Cisco Nexus policies should be configured. In this validation effort the FlexPod was configured to support jumbo frames with an MTU size of 9000. Enabling jumbo frames allows the FlexPod environment to optimize throughput between devices while simultaneously reducing the consumption of CPU resources. This class was assigned to the Best-Effort class. Jumbo frames are important to make sure MTU settings are applied uniformly across the stack to prevent fragmentation and the negative performance implications due to inconsistent MTUs.

Cisco Unified Computing System – C-Series Server Design

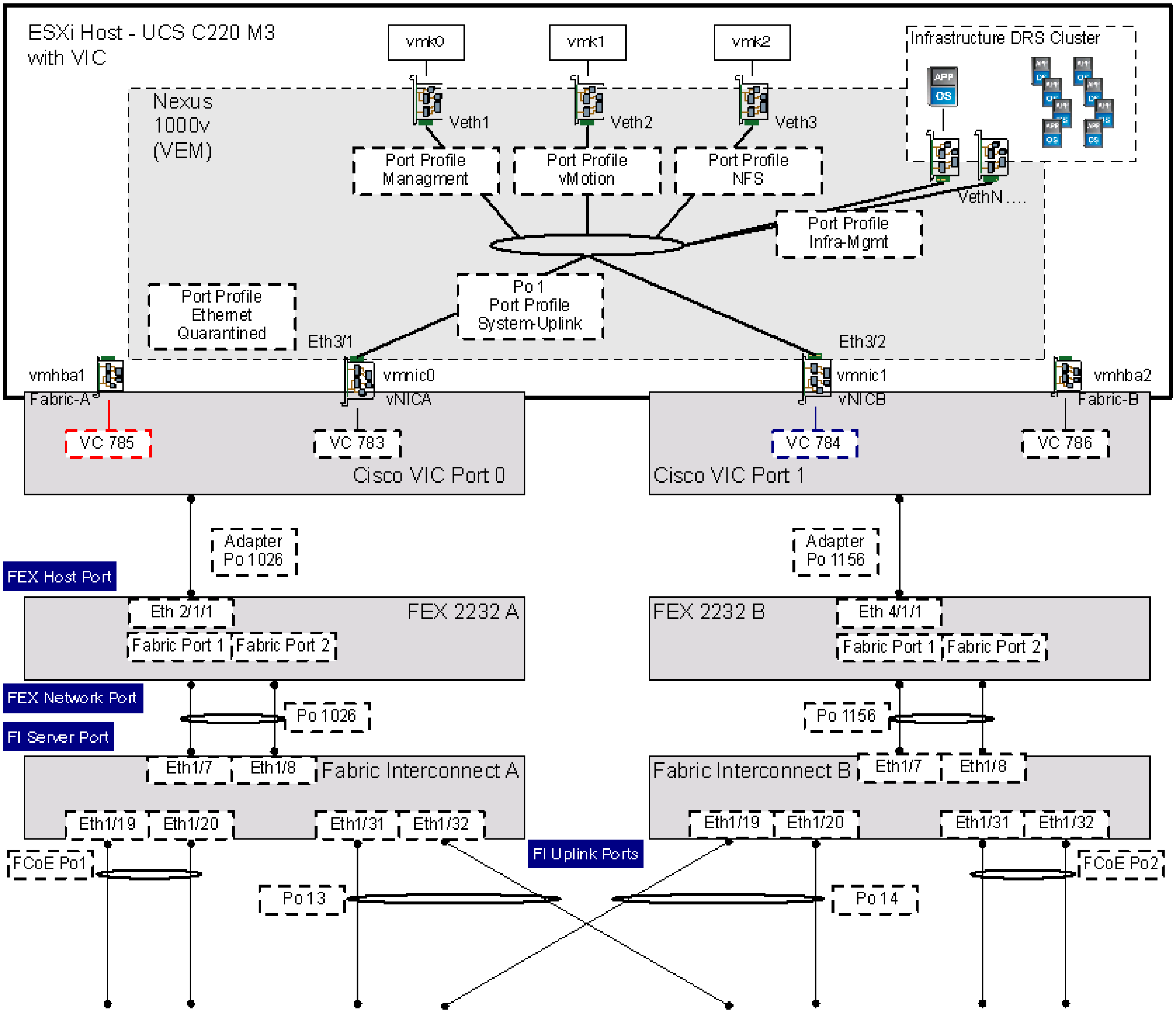
Cisco UCS Manager 2.1 provides two connectivity modes for Cisco UCS C-Series Rack Mount Server management. The two connectivity modes are as follows:

- Dual-wire management (Shared LOM)—This management mode is supported in the Cisco UCS Manager releases earlier than 2.1. Shared LAN on Motherboard (LOM) ports on the rack server are used exclusively for carrying management traffic. A separate cable connected to one of the ports on the PCIe card carries the data traffic. Using two separate cables for managing data traffic and management traffic is referred to as dual-wire management.
- Single-wire management (Sideband)—Cisco UCS Manager release version 2.1 introduces an additional rack server management mode using Network Controller Sideband Interface (NC-SI). Cisco UCS VIC 1225 uses the NC-SI, which can carry both data traffic and management traffic on the same cable. This new feature is referred to as single-wire management and will allow for denser server to FEX deployments.

Note The FlexPod Distinct Uplink design is capable of supporting both single and dual wire management. In the lab both implementations were used but at the time for this CVD the NetApp IMT only supports the dual-wire option. Make sure to verify single-wire support with your trusted advisors or through the NetApp IMT tool.

Figure 17 shows the connectivity of the UCS C-Series server into the Cisco UCS domain. From a functional perspective the 1 RU Cisco Nexus 2232PP FEX replaces the Cisco UCS 2204 or 2208 FEX that are located with the Cisco UCS 5108 blade chassis. Each 10 Gigabit Ethernet VIC port connects to fabric A or B through FEX. The Cisco UCS FEX and FIs form port channels automatically based on the chassis discovery policy providing a link resiliency to the Cisco UCS C-Series Server. This is identical to the behavior of the FEX to fabric interconnect connectivity. From a logical perspective the virtual circuits formed within the Cisco UCS domain are consistent between B and C Series deployment models and the virtual constructs formed at the VMware vSphere or Cisco Nexus 1000v layer are unaware in either case.

Figure 17 FlexPod Distinct Uplink Design Cisco UCS C-Series VIC 1225 Example



Cisco Nexus 7000 Series Switch

As Figure 9 shows, the Cisco Nexus 7000 Series Switch provides a unified Ethernet and FCoE data center switching fabric, for communications between the Cisco UCS domain, the NetApp storage system and the enterprise network. From an Ethernet perspective, the Cisco Nexus 7000 uses virtual PortChannel (vPC) allowing links that are physically connected to two different Cisco Nexus 7000 Series devices to appear as a single PortChannel to a third device. In the FlexPod topology both Cisco UCS Fabric Interconnects and NetApp storage systems are connected to the Cisco Nexus 7000 switches through vPC. vPC provides the following benefits:

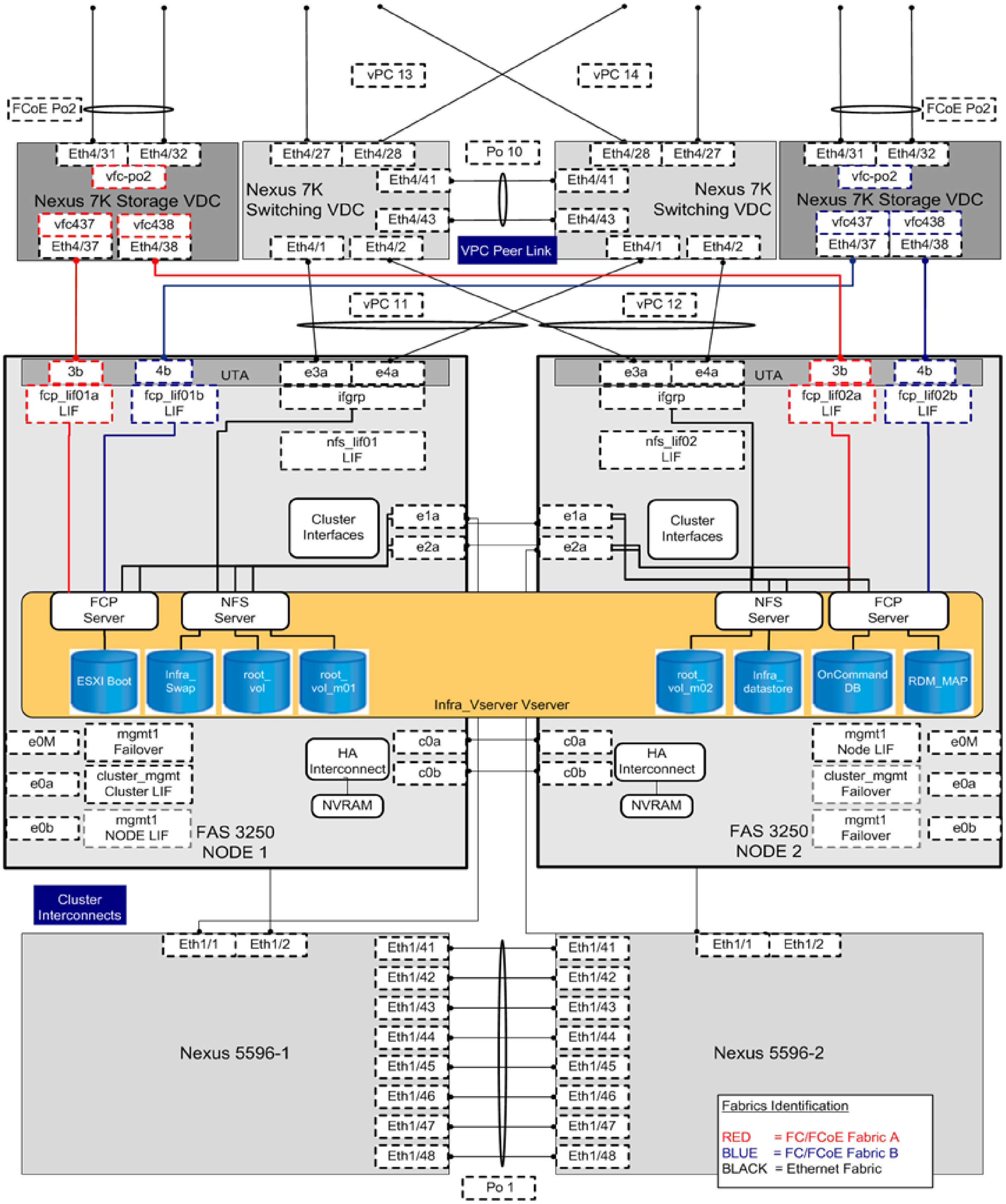
- Allows a single device to use a port channel across two upstream devices
- Eliminates Spanning Tree Protocol blocked ports

- Provides a loop-free topology
- Uses all available uplink bandwidth
- Provides fast convergence if either one of the physical links or a device fails
- Provides link-level resiliency
- Helps ensure high availability of the overall FlexPod system

vPC requires a “peer link”, which is shown as port channel 10 in Figure 18. It is crucial that the fabrics do not mix, maintaining SAN A/B isolation best practices. The vPC links facing the Cisco UCS Fabric Interconnects, Po 13 and Po14, do not carry any FCoE traffic. Make sure not to define any FCoE VLANs on these links.

The vPC peer keepalive link is an important component of a vPC configuration. The peer keepalive link allows each vPC enabled switch to monitor the health of its peer. This link accelerates convergence and reduces the occurrence of split-brain scenarios. In this validated solution, the vPC peer keepalive link uses the out-of-band management network. This link is not shown in Figure 18.

Figure 18 FlexPod Discrete Uplink Design - Nexus 7000 and NetApp Storage Focus



The storage solution utilizes the F-series module and a dedicated Storage VDC on each Cisco Nexus 7000 Series switch. This allows complete SAN A/SAN B isolation within the FlexPod environment. In each of the Storage VDCs a port channel, Po2, is dedicated to FCoE and connected to the Cisco UCS Fabric Interconnects. Each discrete port channel supports a single VLAN associated with Fabric A or Fabric B. A virtual Fiber Channel interface (vfc) is then bound to the logical port channel interface.

The NetApp storage controllers are interconnected to the Cisco Nexus 7000 Storage VDCs using two dedicated links, one for each SAN. In this CVD, NetApp Controller 1 & 2's LIF A interconnects to SAN A vfc437 and vfc438 respectively. Similarly, the NetApp Controller's LIF B interconnects to SAN B using vfc437 and vfc438 respectively. This assures universal accessibility of the fabric to each of the NetApp storage node in case of link or device failures. To maintain SAN A/B isolation Storage VDCs in the Nexus 7000 A and B are associated to a different VLAN/VSAN pairing, meaning the interconnections facing the NetApp storage systems have unique FCoE VLANs defined on each Cisco Nexus switch.

Note It is considered a best practice to name your vfc for the port channel it is residing on, for example vfc437 is on port 4/37.

The Cisco Nexus 7000 Series switch in the FlexPod design provides Fibre Channel over Ethernet services to the UCS and NetApp FAS platforms. Internally the Cisco Nexus 7000 platforms need to be configured to support FCoE zoning to enforce access policy between Cisco UCS-based initiators and NetApp FAS-based targets. Without a zoning configuration there will be no communication between the initiators and targets.

FlexPod is a converged infrastructure platform. This convergence is possible due to the support of Ethernet enhancements across the integrated compute stack with regard to the bandwidth allocation and flow control based on the traffic classification. As such, it is important to implement these QoS techniques to ensure quality of service in the FlexPod configuration.

- Priority Flow Control (PFC) 802.1Qbb - Lossless Ethernet using a PAUSE on a per Class of Service (CoS)
- Enhanced Transmission Selection (ETS) 802.1Qaz - Traffic Protection through bandwidth management
- Data Center Bridging Capability Exchange (DCBX) – Negotiates Ethernet functionality between devices (PFC, ETS and CoS values)

The Cisco Nexus 7000 Series Switch supports these capabilities through QoS policies. QoS is manually enabled using Cisco MQC (Modular QoS CLI) providing class based traffic control. The Cisco Nexus system will instantiate the basic QoS classes for Ethernet traffic and a system FCoE class (class-fcoe) when the FCoE feature and QoS are enabled. It is important to align the QoS setting (CoS, MTU) within the Cisco Nexus 7000 switch, the UCS Fabric Interconnects, and the Cisco Nexus 1000v configurations. Realize that DCBX signaling can impact the NetApp controller be sure to allocate the proper bandwidth based on the site application needs to the appropriate CoS classes and to keep MTU settings consistent in the environment to avoid fragmentation issues and improve performance.

The following summarizes the best practices used in the validation of the FlexPod architecture:

- Nexus 7000 features enabled
  - Fibre Channel over Ethernet (FCoE) which uses the Priority Flow Control (802.1Qbb), Enhanced Transmission Selection (802.1Qaz) and Data Center Bridging eXchange (802.1Qaz) to provide a lossless fabric.
  - N-Port ID Virtualization (NPIV) allows the network fabric port (N-Port) to be virtualized and support multiple fibre channel initiators on a single physical port.
  - Link Aggregation Control Protocol (LACP part of 802.3ad).
  - Cisco Virtual Port Channeling (vPC) for link and device resiliency.
  - Link Layer Discovery Protocol (LLDP) allows the Nexus 7000 to share and discover DCBX features and capabilities between neighboring FCoE capable devices.

  - Enable Cisco Discovery Protocol (CDP) for infrastructure visibility and troubleshooting.
- vPC considerations
  - Define a unique domain ID.
  - Set the priority of the intended vPC primary switch lower than the secondary (default priority is 32768).
  - Establish peer keepalive connectivity.   It is recommended to use the out-of-band management network (mgmt0) or a dedicated switched virtual interface (SVI).
  - Enable vPC auto-recovery feature.
  - Enable IP ARP synchronization to optimize convergence across the vPC peer link.

Note Cisco Fabric Services over Ethernet (CFSoE) is responsible for synchronization of configuration, Spanning Tree, MAC and VLAN information which removes the requirement for explicit configuration. The service is enabled by default.

  - A minimum of two 10 Gigabit Ethernet connections are required for vPC peer-link
  - All port channels should be configured in LACP active mode

Note NetApp controllers support LACP normal rate mode (Hello message every 30secs).

- Spanning tree considerations
  - Ensure the path cost method is set to long. This setting   accounts for 10Gbe Ethernet links in the environment.
  - The spanning tree priority was not modified. The assumption being this is an access layer deployment.
  - Loopguard is disabled by default.
  - BPDU guard and filtering are enabled by default.
  - Bridge assurance is only enabled on the vPC Peer Link.
  - Ports facing the NetApp storage controller and UCS are defined as “edge” trunk ports.

For information on Cisco Nexus 7000 Series Switches configuration details, see: http://www.cisco.com/en/US/partner/products/ps9402/products_installation_and_configuration_guides_list.html

VMware vCenter and vSphere

VMware vSphere 5.1 provides a platform for virtualization and comprises multiple components and features. In this validation effort the following were used:

- VMware ESXi—A virtualization layer that is run on physical servers that abstracts processor, memory, storage, and resources into multiple virtual machines.
- VMware vCenter Server—The central point for configuring, provisioning, and managing virtualized IT environments. It provides essential data center services such as access control, performance monitoring, and alarm management.
- VMware vSphere SDKs—Feature that provides standard interfaces for VMware and third-party solutions to access VMware vSphere.

- vSphere Virtual Machine File System (VMFS)—A high- performance cluster file system for ESXi virtual machines.
- vSphere High Availability (HA)—A feature that provides high availability for virtual machines. If a server fails, the affected virtual machines are restarted on other available servers that have spare capacity.
- vSphere Distributed Resource Scheduler (DRS)—Allocates and balances computing capacity dynamically across collections of hardware resources for virtual machines. This feature includes distributed power management (DPM) capabilities that enable a data center to significantly reduce its power consumption.

Cisco Nexus 1000v Switch

The Cisco Nexus 1000v is a virtual Distributed Switch (vDS) that fully integrates into a VMware vSphere enabled environment. The Cisco Nexus 1000v operationally emulates a physical modular switch, with a Virtual Supervisor Module (VSM) providing control and management functionality to multiple line cards. In the case of the Nexus 1000v, the ESXi nodes become modules in the virtual switch when the Cisco Virtual Ethernet Module (VEM) is installed. Figure 19 describes the Cisco Nexus 1000v architecture.

Figure 19 Cisco Nexus 1000v Architecture

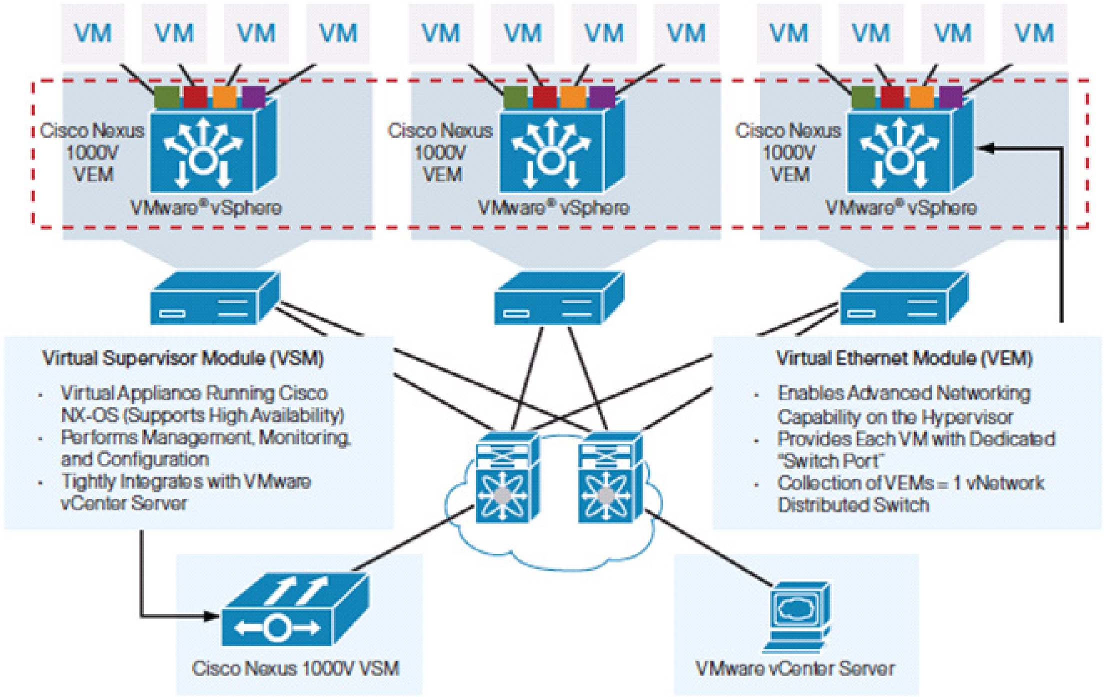

VM
VM
VM
VM
Cisco Nexus 1000V VEM
VMware® vSphere
Virtual Supervisor Module (VSM)
- Virtual Appliance Running Cisco NX-OS (Supports High Availability)
- Performs Management, Monitoring, and Configuration
- Tightly Integrates with VMware vCenter Server
Virtual Ethernet Module (VEM)
- Enables Advanced Networking Capability on the Hypervisor
- Provides Each VM with Dedicated "Switch Port"
- Collection of VEMs = 1 vNetwork Distributed Switch
Cisco Nexus 1000V VSM
VMware vCenter Server

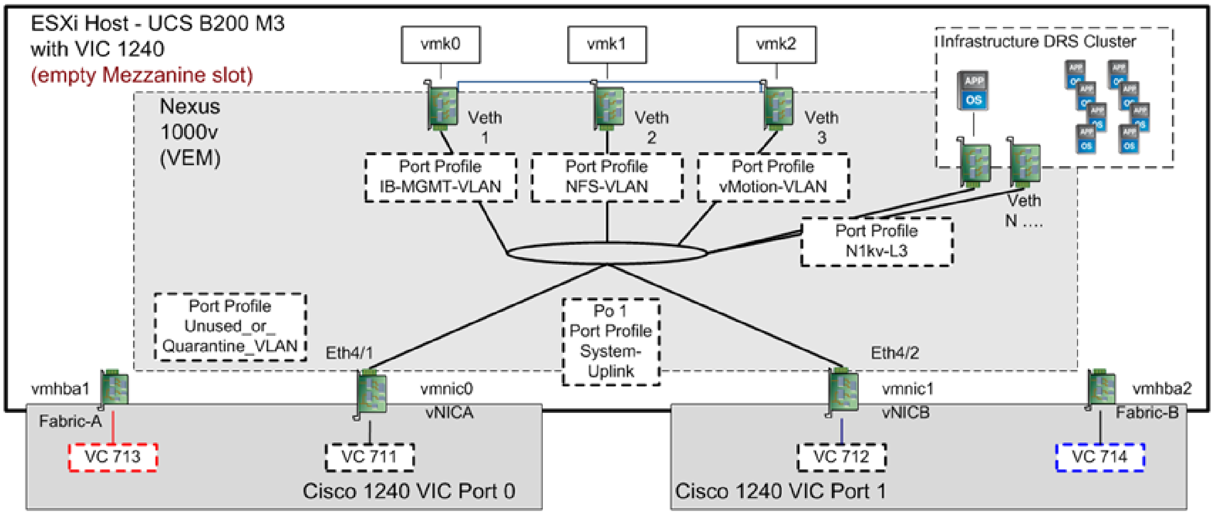
Figure 20 shows a single ESXi node with a VEM registered to the Cisco Nexus 1000v VSM. The ESXi vmnics are presented as Ethernet interfaces in the Cisco Nexus 1000v. In this example, the ESXi node is the third module in the virtual distributed switch as the Ethernet interfaces are labeled as module/interface #. The VEM takes configuration information from the VSM and performs Layer 2 switching and advanced networking functions, such as:

- PortChannels
- Quality of service (QoS)

- Security (Private VLAN, access control lists (ACLs), and port security)
- Monitoring (NetFlow, Switch Port Analyzer (SPAN), and Encapsulated Remote SPAN (ERSPAN))
- vPath providing efficient traffic redirection to one or more chained services such as the Cisco Virtual Security Gateway and Cisco ASA 1000v

Note FlexPod architecture will fully support other intelligent network services offered via the Cisco Nexus 1110-X such as Cisco VSG, ASA1000v, and vNAM.

Figure 20 FlexPod Discrete Uplink Design - Cisco Nexus 1000v Focus



The Cisco Nexus 1000v supports port profiles. Port profiles are logical templates that can be applied to the Ethernet and virtual Ethernet interfaces available on the Nexus 1000v. In FlexPod architecture, the Cisco Nexus 1000v aggregates the Ethernet uplinks into a single port channel named the “System-Uplink” port profile for fault tolerance and improved throughput.

Note The Cisco Nexus 1000v provides link failover detection. It is therefore recommended to disable UCS Fabric Failover within the vNIC template.

The VM facing virtual Ethernet ports employ port profiles customized for each virtual machines network, security and service level requirements. The FlexPod architecture employs three core VMkernel NICs (vmknics) each with their own port profile:

- vmk0 – ESXi management
- vmk1 – NFS interface
- vmk2 – vMotion interface

The NFS and vMotion interfaces are private subnets supporting data access and VM migration across the FlexPod infrastructure. The management interface support remote VMware vCenter access and if necessary ESXi shell access.

The Cisco Nexus 1000v also supports Cisco’s MQC to assist in uniform operation and ultimately, enforcement of QoS policies across the infrastructure. The Cisco Nexus 1000v supports marking at the edge and policing traffic from VM-to-VM.

For more information on Best Practices in Deploying Cisco Nexus 1000V Series Switches on Cisco UCS B and C Series Cisco UCS Manager Servers, see: http://www.cisco.com/en/US/prod/collateral/switches/ps9441/ps9902/white_paper_c11-558242.html

Cisco Virtual Machine Fabric Extender (VM-FEX)

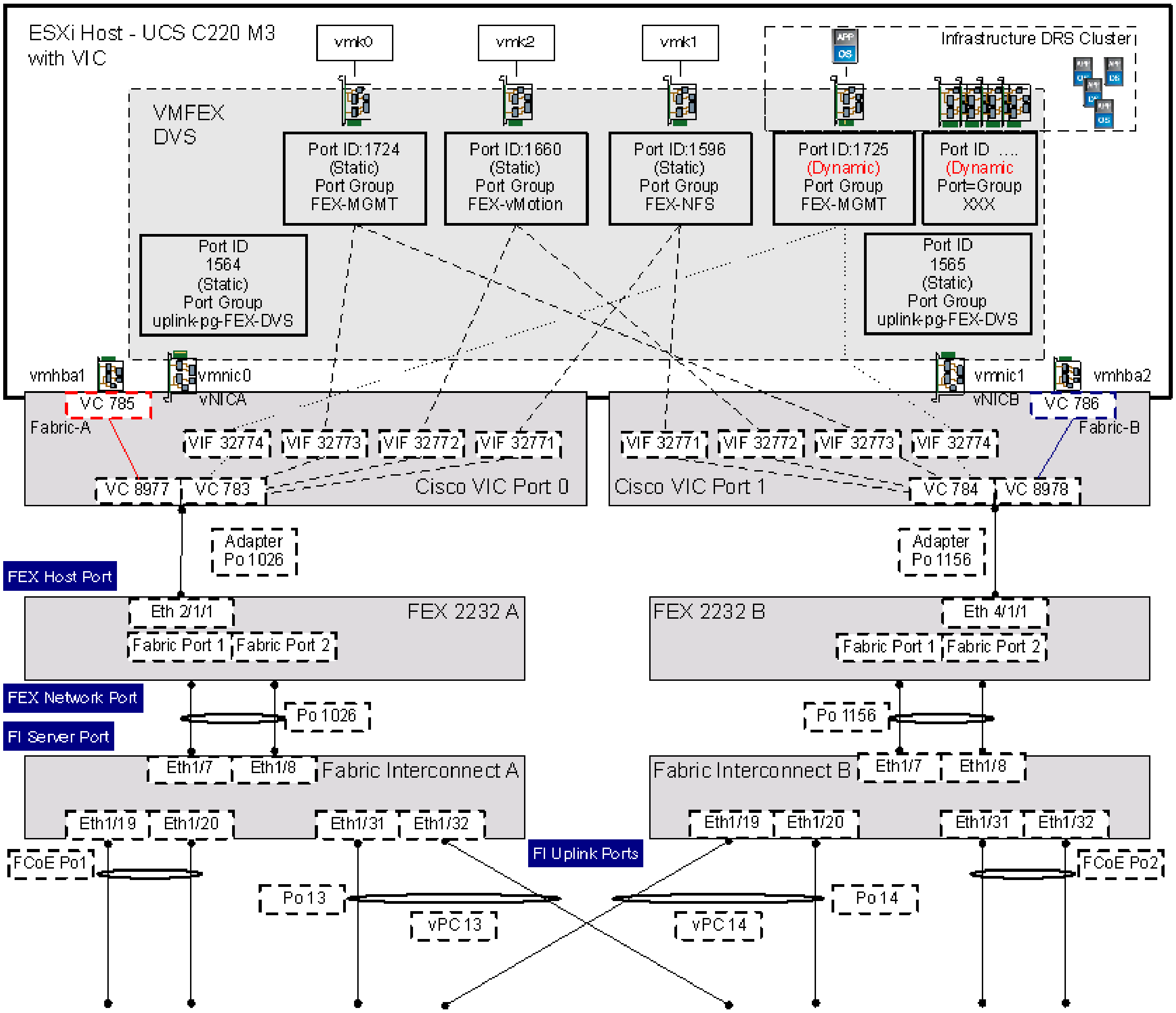
Cisco Virtual Machine Fabric Extender (VM-FEX) is a technology that addresses both management and performance concerns in the data center by unifying physical and virtual switch management. The use of Cisco's VM-FEX collapses both virtual and physical networking into a single infrastructure, reducing the number of network management points and enabling consistent provisioning, configuration and management policy within the enterprise. This is achieved by joining the Cisco UCS Manager to the VMware vCenter management platform via the Cisco UCS vDS VMware plug-in. This integration point between the physical and virtual domains of the data center allows administrators to efficiently manage both their virtual and physical network resources. The decision to use VM-FEX is typically driven by application requirements such as performance and the operational preferences of the IT organization.

The Cisco UCS Virtual Interface Card (VIC) offers each VM a virtual Ethernet interface or vNIC. This vNIC provides direct access to the Cisco UCS Fabric Interconnects and Cisco Nexus 5500 Series Switches where forwarding decision can be made for each VM using Cisco VM-FEX interface. Cisco VM-FEX technology supports two modes of operation:

- Emulated mode
  - The hypervisor emulates a NIC (also referred to as a back-end emulated device) to replicate the hardware it virtualizes for the guest virtual machine. The emulated device presents descriptors, for read and write, and interrupts to the guest virtual machine just as a real hardware NIC device would. One such NIC device that VMware ESXi emulates is the vmxnet3 device. The guest OS in turn instantiates a device driver for the emulated NIC. All the resources of the emulated devices' host interface are mapped to the address space of the guest OS.
- PCIe Pass-Through or VMDirectPath mode
  - Virtual Interface Card uses PCIe standards-compliant IOMMU technology from Intel and VMware's VMDirectPath technology to implement PCIe Pass-Through across the hypervisor layer and eliminate the associated I/O overhead. The Pass-Through mode can be requested in the port profile associated with the interface using the "high-performance" attribute.

As shown in Figure 21, the path for a single VM is fully redundant across the Cisco fabric. The VM has an active virtual interface (VIF) and standby (VIF) defined on the adapter, an adapter that is dual-homed to Fabric A and B. Combined with the UCS Fabric Failover feature the VM-FEX solution provides fault tolerance and removes the need for software based HA teaming mechanisms. If the active uplink fails the vNIC will automatically fail over to the standby uplink and simultaneously update the network via gratuitous ARP. In this example, the active links are solid and the standby links are dashed. The VM-FEX dynamic connection policy defines the fabric path preference and convergence behavior allowing system administrators to fine-tune their approach to resiliency.

Figure 21 FlexPod Discrete Uplink Design - Cisco VM-FEX Focus



The Cisco Fabric Extender technology provides both static and dynamic vNICs. As illustrated in this example, vmk0, vmk1 and vmk2 are static adapters presented to the VMware vSphere environment. Static vNICA and vNICB are assigned to the VM-FEX distributed virtual switch while Fabric A and B static vHBAs provide SAN A and B connectivity for block based storage access. From a VMware ESXi host perspective the vNICs and vHBAs are PCIe devices and do not require any special consideration or configuration. As shown the Cisco UCS vNIC construct equates to a VMware virtual network interface card (vmnic) and is identified as such.

Dynamic vNICs are allocated to virtual machines and removed as the VM reaches the end of its lifecycle. Figure 21 details a dynamic vNIC associated with a particular VM. From a vSphere perspective the VM is assigned to the VM-FEX DVS on port 1725. This port maps to two VIFs, 32774, which are essentially an active/standby pair defined on Fabric A and B. The red line indicates the current active fabric path in this example B. The Cisco UCS Manager allows administrators to assign a preferred active path (A or

B) or assign no preference allowing the Cisco UCS Manager to provision active dynamic vNICs equally between fabric interconnects. The maximum number of Virtual Interfaces (VIF) that can be defined on a Cisco VIC Adapter depends on the following criteria and must be considered in any VM-FEX design:

- The presence of jumbo frames
- The combination of Fabric Interconnects (6100 / 6200) and Fabric Extenders (2104 / 2204/ 2208)
- The maximum number of port links available to the Cisco UCS IOM Fabric Extender
- The number of supported static and dynamic vNICs and vHBAs on the Cisco VIC Adapters
- The version of vSphere version

Note Cisco VM-FEX requires that the ESXi host must have the Cisco Virtual Ethernet Module (VEM) software bundled installed.

For more information on the configuration limits associated with VM-FEX, see: http://www.cisco.com/en/US/partner/docs/unified_computing/ucs/sw/configuration_limits/2.1/b_UCS_Configuration_Limits_2_1.html

Cisco VM-FEX is configurable in standard or high performance mode from the Cisco UCS Manager port profile tab. In standard mode, some of the ESXi nodes virtualization stack is used for VM network I/O. In high performance mode, the VM completely bypasses the hypervisor and DVS accessing the Cisco VIC adapter directly. The high performance model takes advantage of VMware DirectPath I/O. DirectPath off loads the host CPU and memory resources that are normally consumed managing VM networks. This is a design choice primarily driven by performance requirements and VMware feature availability.

Note The following VMware vSphere features are only available for virtual machines configured with DirectPath I/O on the Cisco UCS through Cisco Virtual Machine Fabric Extender (VM-FEX) distributed switches.

- vMotion
- Hot adding and removing of virtual devices
- Suspend and resume
- High availability
- DRS
- Snapshots

The following features are unavailable for virtual machines configured with DirectPath on any server platform:

- Record and replay
- Fault tolerance

For more information on Cisco VM-FEX Best Practices for VMware ESX Environment Deployment Guide, see:
http://www.cisco.com/en/US/solutions/collateral/ns340/ns517/ns224/ns944/vm_fex_best_practices_deployment_guide.html#wp9001031

NetApp Storage Controllers

NetApp Clustered Data ONTAP allows one or more storage HA pairs that are interconnected to be managed as a single system or pool of storage resources. Figure 22 details the logical configuration of the clustered Data ONTAP environment used during validation. The physical cluster consists of two NetApp storage controllers (nodes) configured in an HA pair and two cluster interconnect switches; disks and shelves are not shown in this example. The fundamental connections or network types defined for a clustered Data ONTAP solution include:

- HA interconnect—A dedicated interconnect between two nodes permitting the formation of HA pairs. These are also known as storage failover pairs.
- Cluster interconnect—A dedicated high-speed, low-latency, private network used for communication between nodes.
- Management network—A network used for administration of the nodes, cluster, and virtual storage servers (Vservers).
- Data network—A network used by clients to access data.

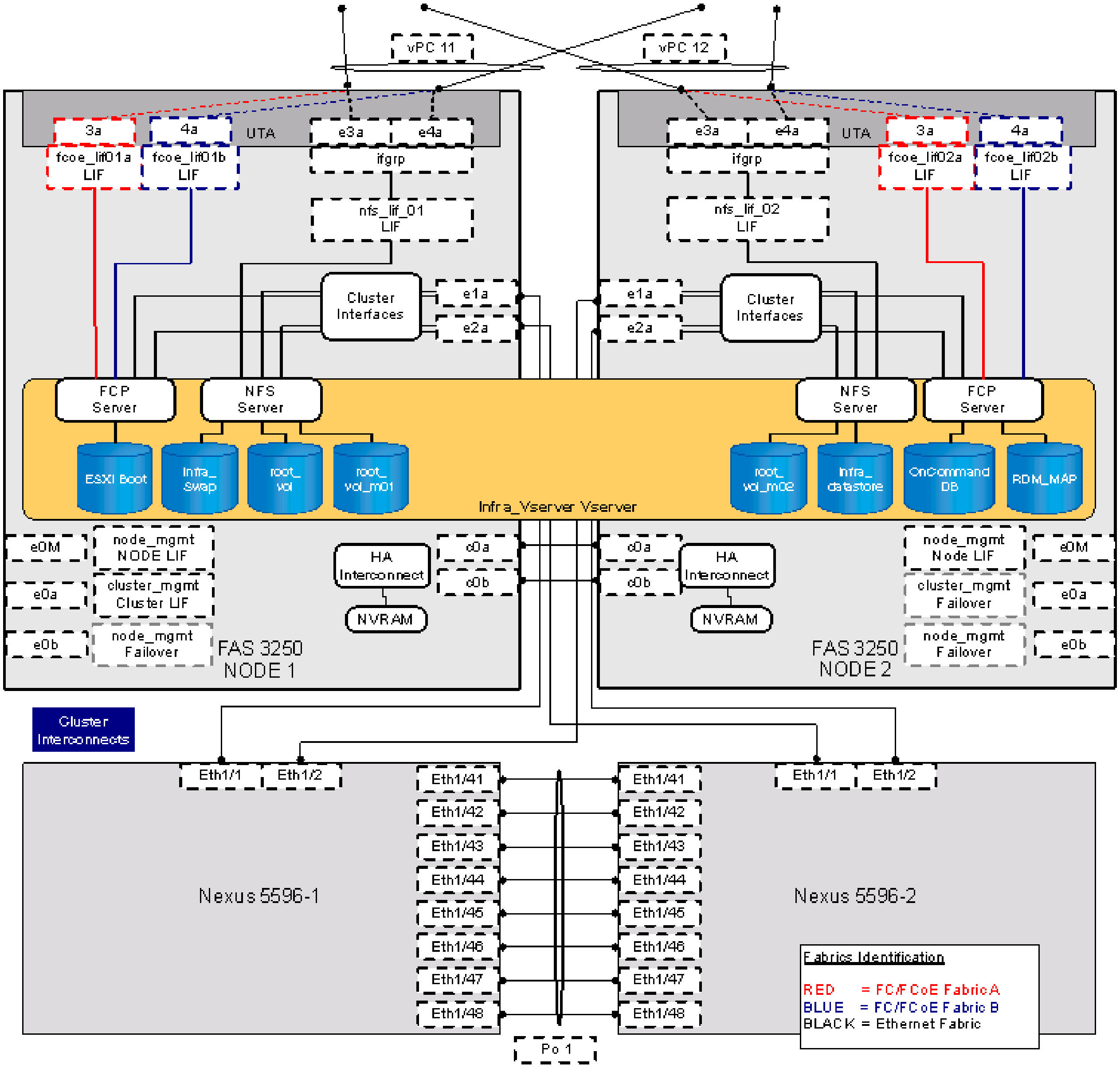
Note The maximum number of nodes for a single cluster serving SAN data is six.

As illustrated, the storage controllers use multiple constructs to abstract the physical resources. These elements include:

- Ports—A physical port such as e0a or e1a or a logical port such as a virtual LAN (VLAN) or an interface group (ifgrp).
- Ifgrps—A collection of physical ports to create one logical port constitutes an interface group. NetApp's interface group is a link aggregation technology and may be deployed in single (active/passive), multiple (always "on"), or dynamic (active LACP) mode, but it is recommended to use only dynamic interface groups to take advantage of LACP-based load distribution and link failure detection.
- LIF—A logical interface that is associated to a physical port, interface group, or VLAN interface. More than one LIF may be associated to a physical port at the same time. There are three types of LIFs:
  - NFS LIF
  - iSCSI LIF
  - FC LIF

  LIFs are logical network entities that have the same characteristics as physical network devices but are not tied to physical objects. LIFs used for Ethernet traffic are assigned specific Ethernet-based details such as IP addresses and iSCSI qualified names and then are associated with a specific physical port capable of supporting Ethernet. LIFs used for FC-based traffic are assigned specific FC-based details such as worldwide port names (WWPNs) and then are associated with a specific physical port capable of supporting FC or FCoE. NAS LIFs can be non disruptively migrated to any other physical network port throughout the entire cluster at any time, either manually or automatically (by using policies), whereas SAN LIFs rely on MPIO and ALUA to notify clients of any change in the network topology.
- Vserver—A Vserver is a secure virtual storage server that contains data volumes and one or more LIFs, through which it serves data to the clients. A Vserver securely isolates the shared virtualized data storage and network and appears as a single dedicated server to its clients. Each Vserver has a separate administrator authentication domain and can be managed independently by a Vserver administrator.

Figure 22 FlexPod Discrete Uplink Design - NetApp Storage Controller Focus



Nodes 1 and 2 form a two-node storage failover pair through the HA interconnect direct connection. The FlexPod design uses the following port and interface assignments:

- Port 3a and 4a on each node support FCoE data traffic that is accessible through an FC LIF assigned to SAN A or B (red or blue fabric).
- Ethernet ports e3a and e4a on each node are members of a multimode LACP interface group for Ethernet data. This interface group has a LIF associated with it to support NFS traffic.
- Ports e0M are on each node and support a LIF dedicated to node management. Port e0b is defined as a failover port supporting the “node_mgmt” role.
- Ports e0a supports cluster management data traffic through the cluster management LIF. This port and LIF allow for administration of the cluster from the failover port and LIF if necessary.

- Ports c0a and c0b on each node support the HA interconnect processes. These connections do not support any data traffic but only control processes.
- Ports e1a and e2a are cluster interconnect ports for data traffic. These ports connect to each of the Cisco Nexus 5596 cluster interconnect switches.
- The Cisco Nexus cluster interconnect switches support a single ISL port channel (Po1).

Note For information on the cluster interconnect switch configuration provided by NetApp, see: https://library.netapp.com/ecm/ecm_get_file/ECMP1115327

The solution defines a single infrastructure Vserver to own and export the necessary data to run the VMware vSphere infrastructure. This Vserver specifically owns the following flexible volumes:

- **Root volume**—A flexible volume that contains the root of the Vserver namespace.
- **Root volume load-sharing mirrors**—A mirrored volume of the root volume to accelerate reads throughput. In this instance it is labeled root_vol_m01 and root_vol_m02.
- **Boot volume**—A flexible volume that contains ESXi boot LUNs. These ESXi boot LUNs are exported through FC/FCoE to the Cisco UCS servers.
- **Infrastructure datastore volume**—A flexible volume that is exported through NFS to the ESXi host and is used as the infrastructure NFS datastore to store VM files.
- **Infrastructure swap volume**—A flexible volume that is exported through NFS to each ESXi host and used to store VM swap data.
- **OnCommand_DB**—A flexible volume supporting a Fibre Channel LUN for OnCommand services.
- **RDM_MAP**—A flexible volume supporting a Fibre Channel–accessible VMFS datastore for storing Raw Device Mapping (RDM) files.

The NFS datastores are mounted on each VMware ESXi host in the VMware cluster and are provided by NetApp clustered Data ONTAP through NFS over the 10GbE network.

The Vserver essentially has a minimum of one LIF per protocol per node to maintain volume availability across the cluster nodes. The LIFs use failover groups, which are network polices defining the ports or interface groups available to support a single LIF migration or a group of LIFs migrating within or across nodes in a cluster. Remember, multiple LIFs may be associated with a network port or interface group. In addition to failover groups, the clustered Data ONTAP system uses failover policies. Failover polices define the order in which the ports in the failover group are prioritized. Failover policies define migration policy in the event of port failures, port recoveries, or user-initiated requests.

The most basic possible storage failover scenarios in this cluster are as follows:

- Node1 fails, and Node2 takes over Node1's storage.
- Node2 fails, and Node1 takes over Node2's storage.

The remaining node network connectivity failures are addressed through the redundant port, interface groups, and logical interface abstractions afforded by the clustered Data ONTAP system.

FlexPod Discrete Uplink Design with Data ONTAP Operating in 7-Mode

Figure 23 shows the FlexPod with Data ONTAP operating in 7-Mode. 7-Mode consists of only two storage controllers with shared media. 7-Mode does not scale beyond a single pair of controllers as compared to the clustered Data ONTAP. From a design perspective, the Cisco Nexus and Cisco UCS component configurations are identical to the previously defined FlexPod configuration with clustered Data ONTAP. The differences reside only with the NetApp storage domain.

Note In FlexPod with Data ONTAP 7-mode, storage controllers do not require the cluster interconnect switches.

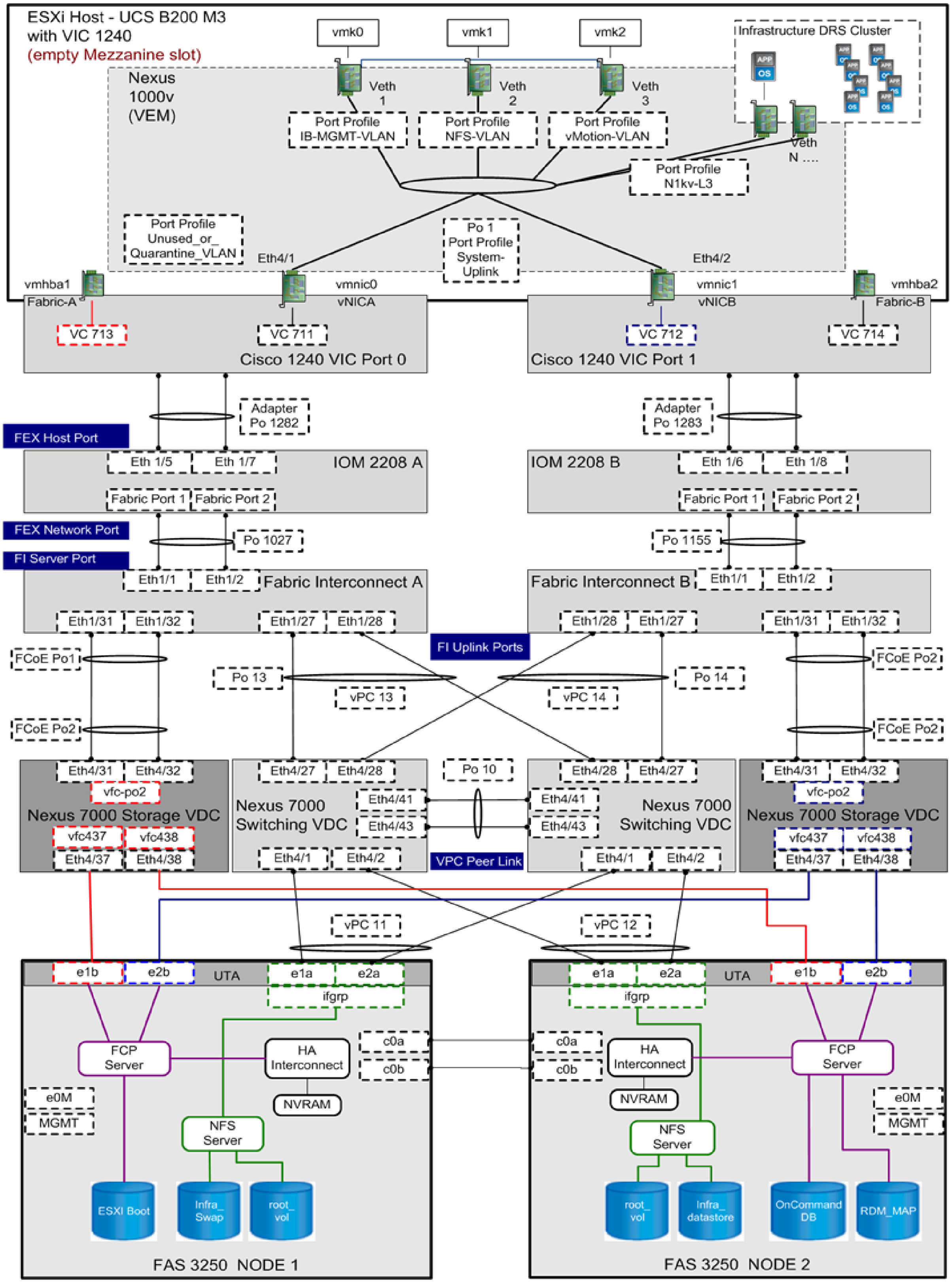
The NetApp FAS controllers use redundant 10GbE converged adapters configured in a two-port interface group (ifgrp). Each port of the ifgrp is connected to one of the upstream switches, allowing multiple active paths by utilizing the Cisco Nexus vPC feature. Interface group is a mechanism that allows the aggregation of a network interface into one logical unit. Combining links aids in network availability and bandwidth. NetApp provides three types of interface groups for network port aggregation and redundancy:

- Single mode
- Static multimode
- Dynamic multimode

It is recommended to use dynamic multimode interface groups because of its increased reliability and error reporting feature and also because it is compatible with Cisco Virtual Port Channels. A dynamic multimode interface group uses Link Aggregation Control Protocol (LACP) to group multiple interfaces together to act as a single logical link. This provides intelligent communication between the storage controller and Cisco Nexus switches, and enables load balancing across physical interfaces as well as failover capabilities.

From a Fibre Channel perspective, the SAN A (red in Figure 23) and SAN B (blue in Figure 23) fabric isolation is maintained across the architecture with dedicated FCoE channels and virtual interfaces. The 7-Mode design allocates Fibre Channel interfaces with SAN A and SAN B access for each controller in the HA pair.

Figure 23 FlexPod Discrete Uplink Design with Data ONTAP Operating in 7-Mode



Conclusion

FlexPod is the optimal shared infrastructure foundation on which to deploy a variety of IT workloads. Cisco and NetApp have created a platform that is both flexible and scalable for multiple use cases and applications. One common use case is to deploy VMware vSphere as the virtualization solution, as described in this document. From virtual desktop infrastructure to SAP®, FlexPod can efficiently and effectively support business-critical applications running simultaneously from the same shared infrastructure. The flexibility and scalability of FlexPod also enable customers to start out with a right-sized infrastructure that can ultimately grow with, and adapt to their evolving business requirements.

Appendix: Cisco UCS Fabric Interconnect and IOM Connectivity Diagrams

This appendix illustrates the backplane connectivity models available with the UCS B-Series platform. The models shown use a global FEX discovery policy preferring link aggregation or port channeling. The user should be aware that a pinned configuration may also be set in the same global policy.

Figure 24 provides a generic view of the connectivity available between the Cisco UCS Fabric Extenders (FEX IO modules) and the half width Cisco UCS B200 M3 blade server. The remaining figures explore various IO module and adapter configurations.

Figure 24 Generic UCS B-Series M3 Backplane Illustration

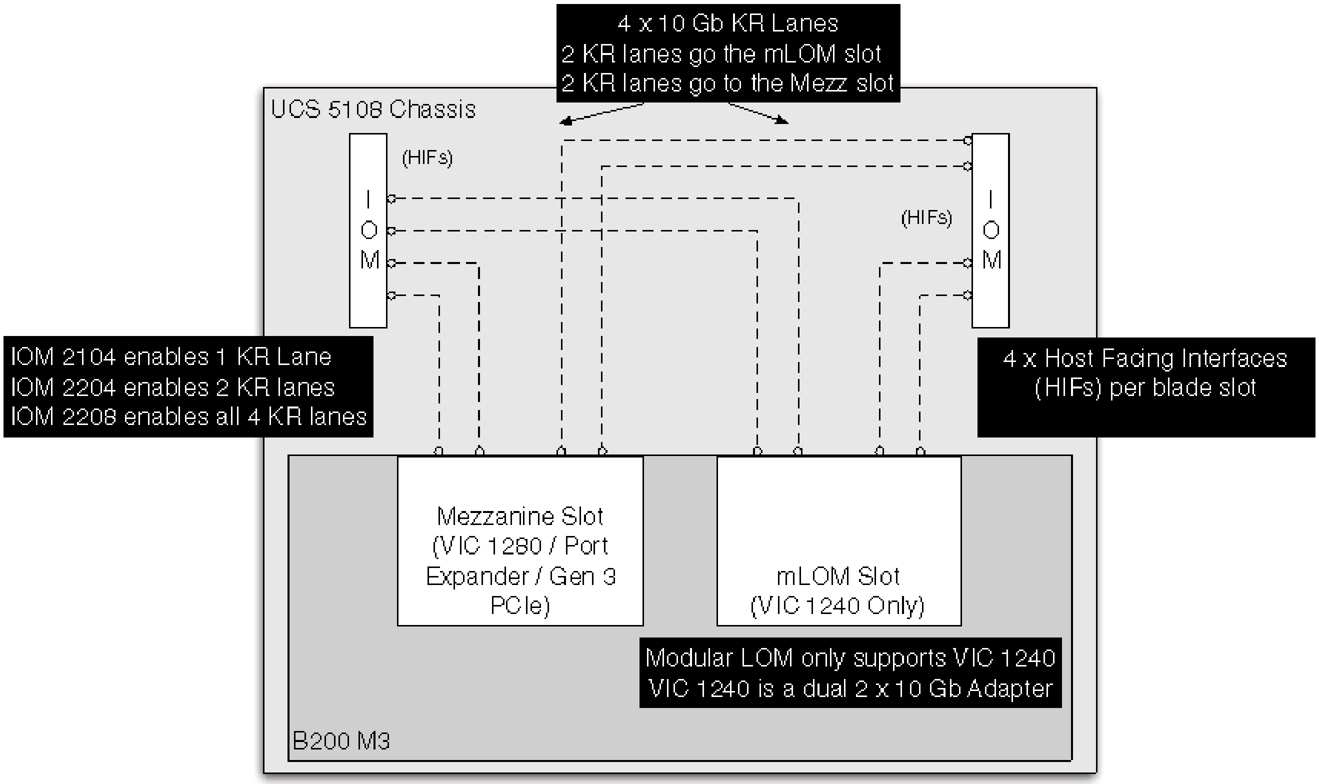

4 x 10 Gb KR Lanes
2 KR lanes go the mLOM slot
2 KR lanes go to the Mezz slot
UCS 5108 Chassis
(HIFs)
IOM
(HIFs)
IOM
IOM 2104 enables 1 KR Lane
IOM 2204 enables 2 KR lanes
IOM 2208 enables all 4 KR lanes
4 x Host Facing Interfaces
(HIFs) per blade slot
Mezzanine Slot
(VIC 1280 / Port
Expander / Gen 3
PCIe)
mLOM Slot
(VIC 1240 Only)
Modular LOM only supports VIC 1240
VIC 1240 is a dual 2 x 10 Gb Adapter
B200 M3

Figure 25 shows two 10 Gbps active connections between the Cisco UCS VIC 1240 and 2104 Fabric Extenders.

Figure 25 Connectivity Illustration with FEX model 2104 and VIC 1240

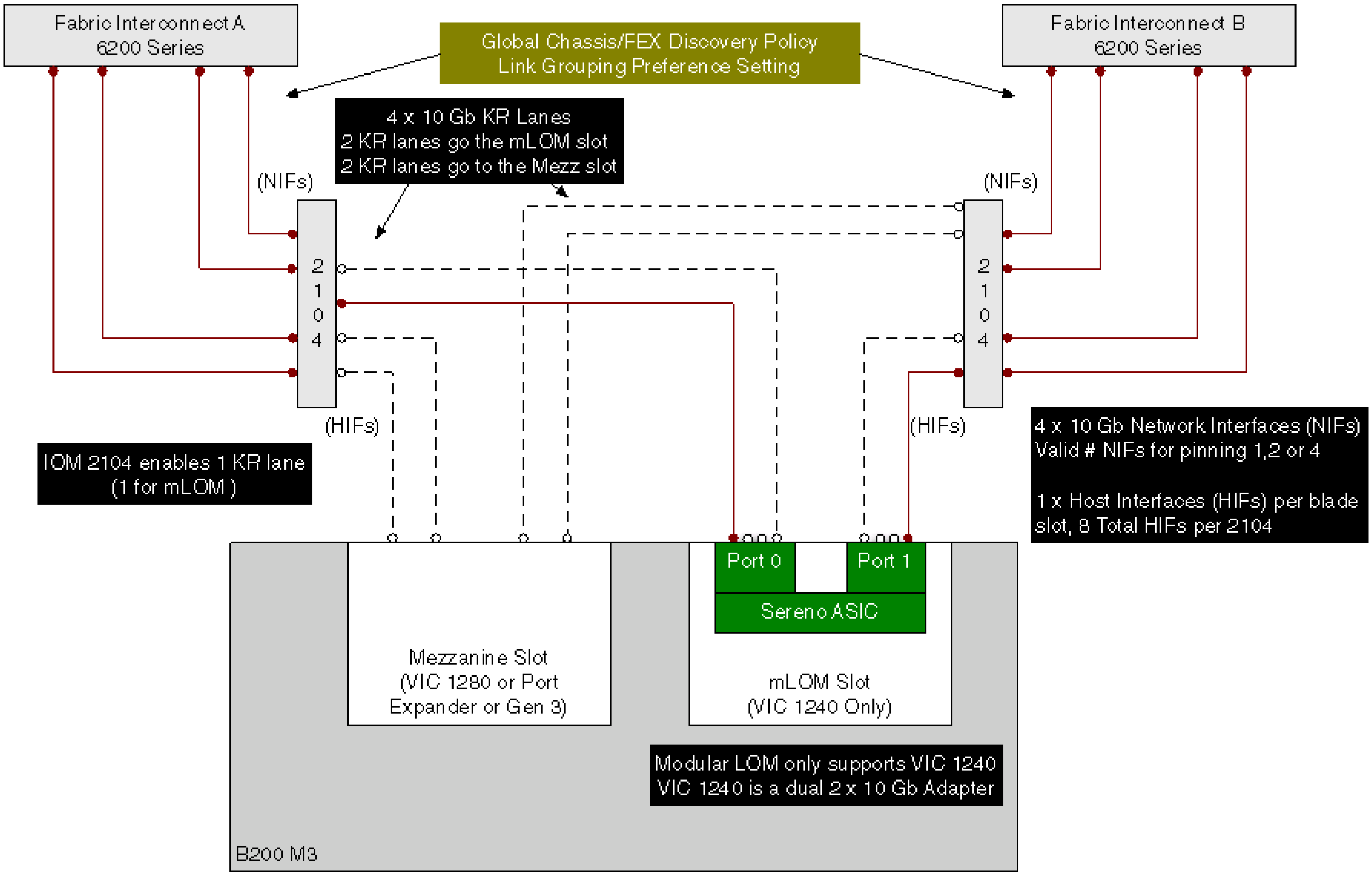

Fabric Interconnect A
6200 Series
Global Chassis/FEX Discovery Policy
Link Grouping Preference Setting
Fabric Interconnect B
6200 Series
4 x 10 Gb KR Lanes
2 KR lanes go the mLOM slot
2 KR lanes go to the Mezz slot
(NIFs)
(NIFs)
2104
2104
(HIFs)
(HIFs)
IOM 2104 enables 1 KR lane
(1 for mLOM)
4 x 10 Gb Network Interfaces (NIFs)
Valid # NIFs for pinning 1,2 or 4
1 x Host Interfaces (HIFs) per blade slot, 8 Total HIFs per 2104
Port 0
Port 1
Sereno ASIC
Mezzanine Slot
(VIC 1280 or Port Expander or Gen 3)
mLOM Slot
(VIC 1240 Only)
Modular LOM only supports VIC 1240
VIC 1240 is a dual 2 x 10 Gb Adapter
B200 M3

Figure 26 shows two 10 Gbps active connections between the Cisco UCS VIC 1240 and 2204 Fabric Extenders.

Figure 26 Connectivity Illustration with FEX model 2204 and VIC 1240

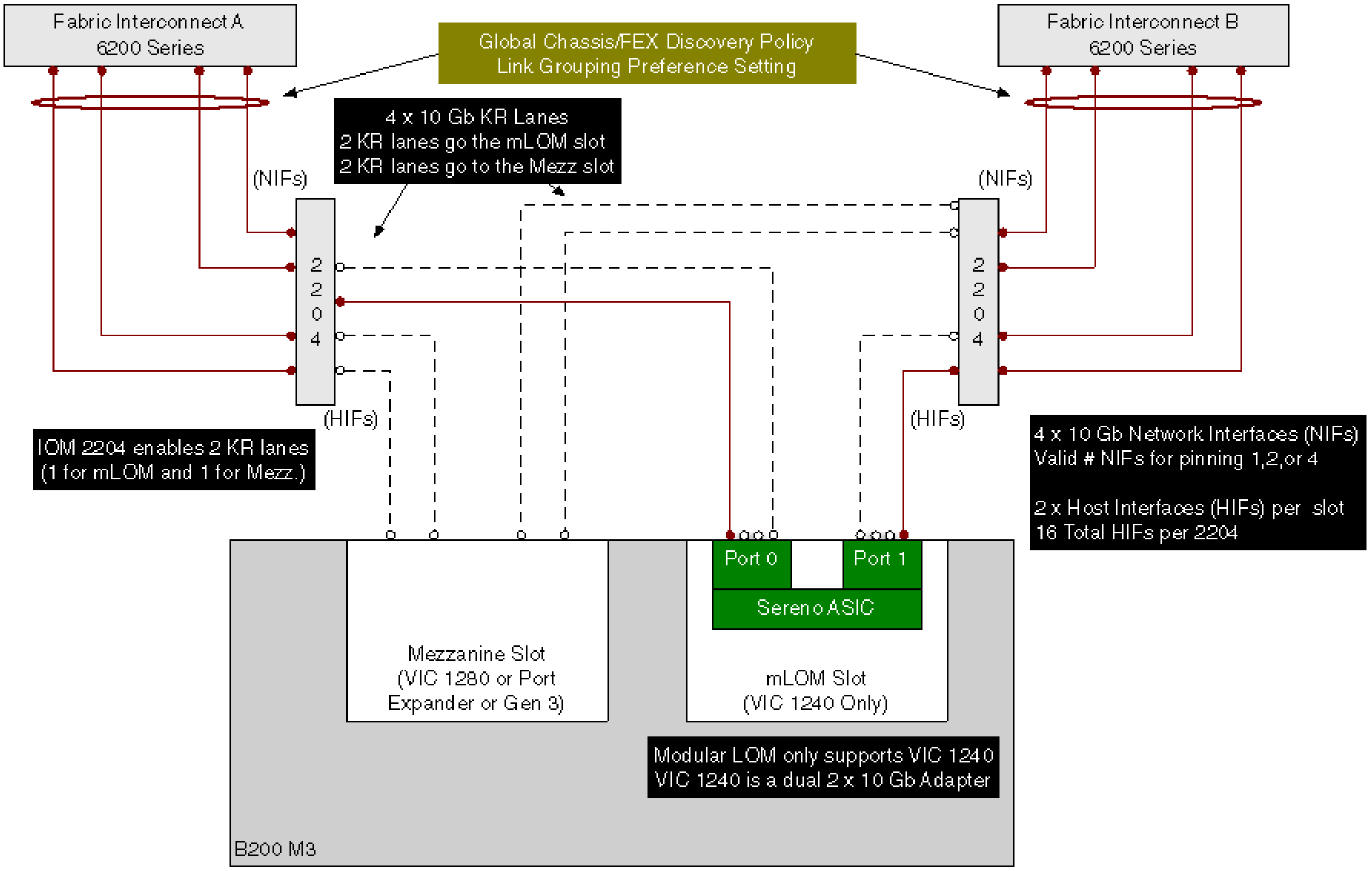
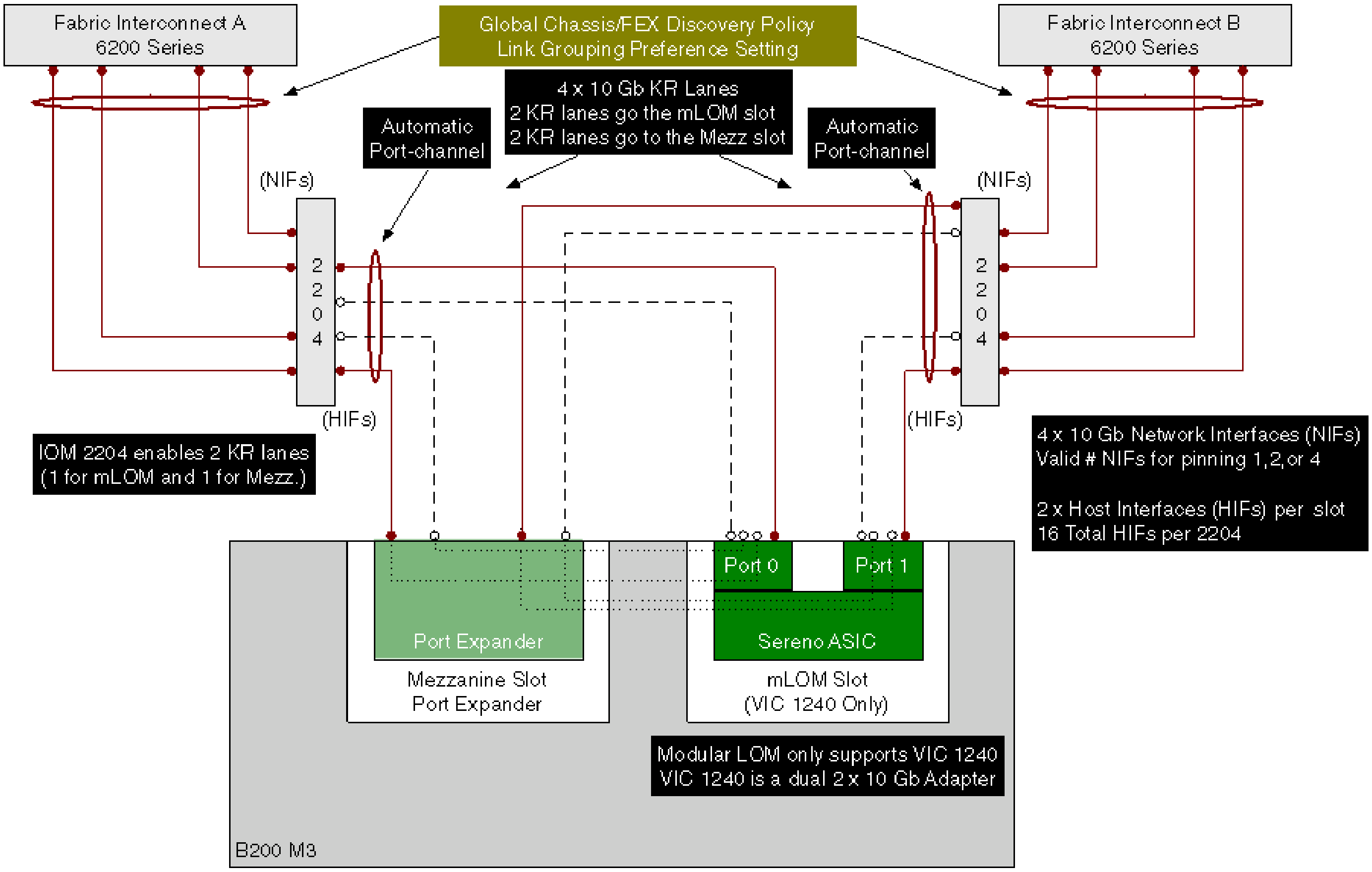

Fabric Interconnect A
6200 Series
Global Chassis/FEX Discovery Policy
Link Grouping Preference Setting
Fabric Interconnect B
6200 Series
4 x 10 Gb KR Lanes
2 KR lanes go the mLOM slot
2 KR lanes go to the Mezz slot
(NIFs)
(NIFs)
2204
2204
(HIFs)
(HIFs)
IOM 2204 enables 2 KR lanes
(1 for mLOM and 1 for Mezz.)
4 x 10 Gb Network Interfaces (NIFs)
Valid # NIFs for pinning 1,2,or 4
2 x Host Interfaces (HIFs) per slot
16 Total HIFs per 2204
Port 0
Port 1
Sereno ASIC
Mezzanine Slot
(VIC 1280 or Port
Expander or Gen 3)
mLOM Slot
(VIC 1240 Only)
Modular LOM only supports VIC 1240
VIC 1240 is a dual 2 x 10 Gb Adapter
B200 M3

Figure 27 shows two 20 Gbps port channels created by adding a port expander card to the mezzanine slot of the blade server using a Cisco UCS VIC 1240 card in the mLOM slot in combination with the Cisco UCS 2204 Fabric Extenders.

Figure 27 B200 M3 Connectivity Illustration with FEX model 2204, VIC 1240 and Port Expander



Fabric Interconnect A
6200 Series
Global Chassis/FEX Discovery Policy
Link Grouping Preference Setting
Fabric Interconnect B
6200 Series
4 x 10 Gb KR Lanes
2 KR lanes go the mLOM slot
2 KR lanes go to the Mezz slot
Automatic
Port-channel
Automatic
Port-channel
(NIFs)
(NIFs)
2
2
0
4
2
2
0
4
(HIFs)
(HIFs)
IOM 2204 enables 2 KR lanes
(1 for mLOM and 1 for Mezz.)
4 x 10 Gb Network Interfaces (NIFs)
Valid # NIFs for pinning 1,2,or 4
2 x Host Interfaces (HIFs) per slot
16 Total HIFs per 2204
Port 0
Port 1
Port Expander
Sereno ASIC
Mezzanine Slot
Port Expander
mLOM Slot
(VIC 1240 Only)
Modular LOM only supports VIC 1240
VIC 1240 is a dual 2 x 10 Gb Adapter
B200 M3

Figure 28 shows a Cisco UCS B200 M3 half-width blade server with both the Cisco UCS VIC 1240 and VIC 1280 adapters using the Cisco UCS 2204 Fabric Extenders. This results in 4 independent 10 Gbps connections.

Figure 28 B200 M3 Connectivity Illustration with FEX model 2204, VIC 1240 and VIC 1280

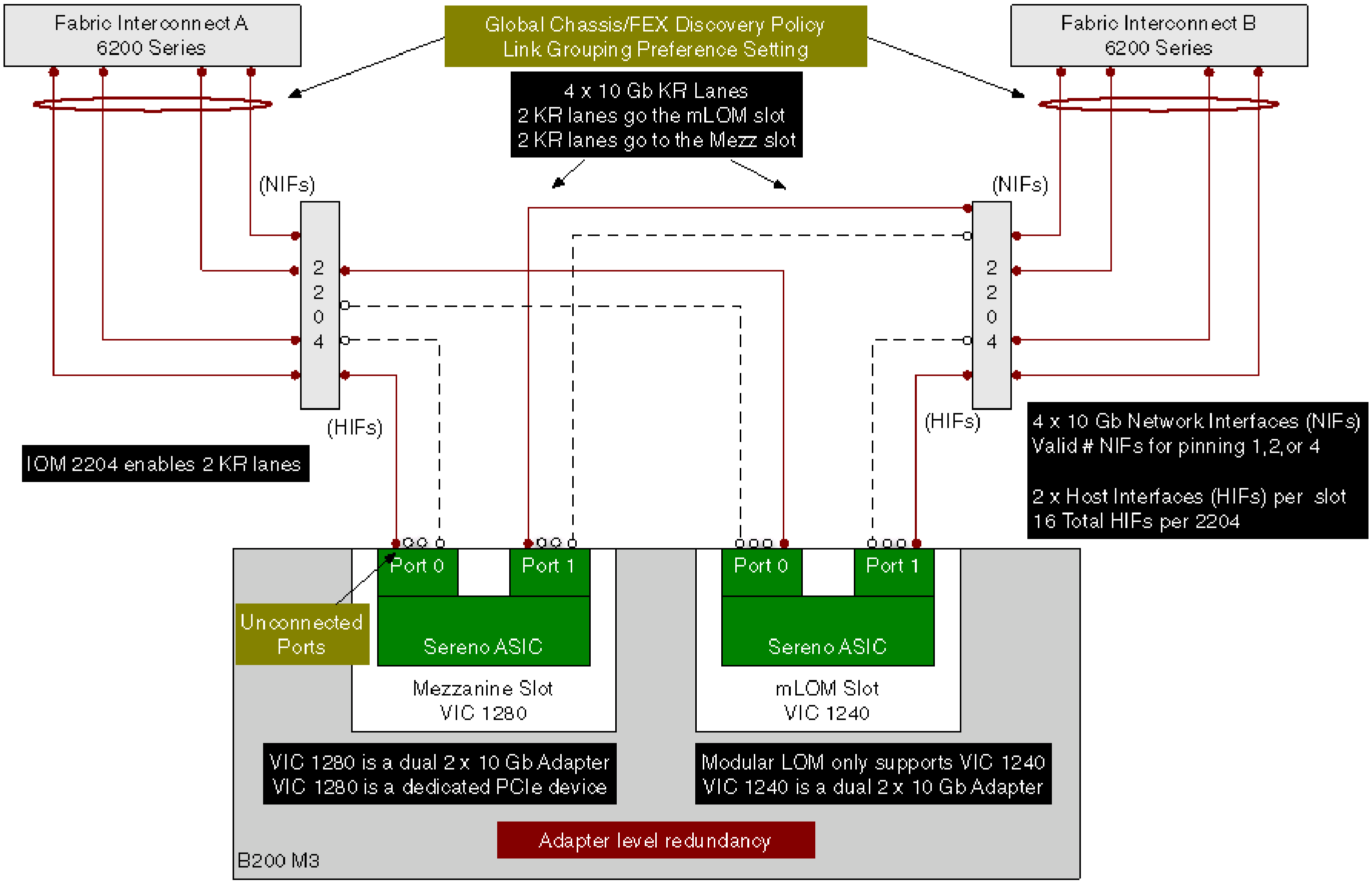

Fabric Interconnect A
6200 Series
Global Chassis/FEX Discovery Policy
Link Grouping Preference Setting
Fabric Interconnect B
6200 Series
4 x 10 Gb KR Lanes
2 KR lanes go the mLOM slot
2 KR lanes go to the Mezz slot
(NIFs)
(NIFs)
2204
2204
(HIFs)
(HIFs)
IOM 2204 enables 2 KR lanes
4 x 10 Gb Network Interfaces (NIFs)
Valid # NIFs for pinning 1,2,or 4
2 x Host Interfaces (HIFs) per slot
16 Total HIFs per 2204
Port 0
Port 1
Port 0
Port 1
Unconnected Ports
Sereno ASIC
Sereno ASIC
Mezzanine Slot
VIC 1280
mLOM Slot
VIC 1240
VIC 1280 is a dual 2 x 10 Gb Adapter
VIC 1280 is a dedicated PCIe device
Modular LOM only supports VIC 1240
VIC 1240 is a dual 2 x 10 Gb Adapter
Adapter level redundancy
B200 M3

Figure 29 shows a Cisco UCS VIC 1240 connecting to a pair of Cisco UCS 2208 Fabric Extenders forming two 20 Gbps port channels from the Cisco UCS B200 M3 half-width blade server.

Figure 29 Connectivity Illustration with FEX model 2208 and VIC 1240

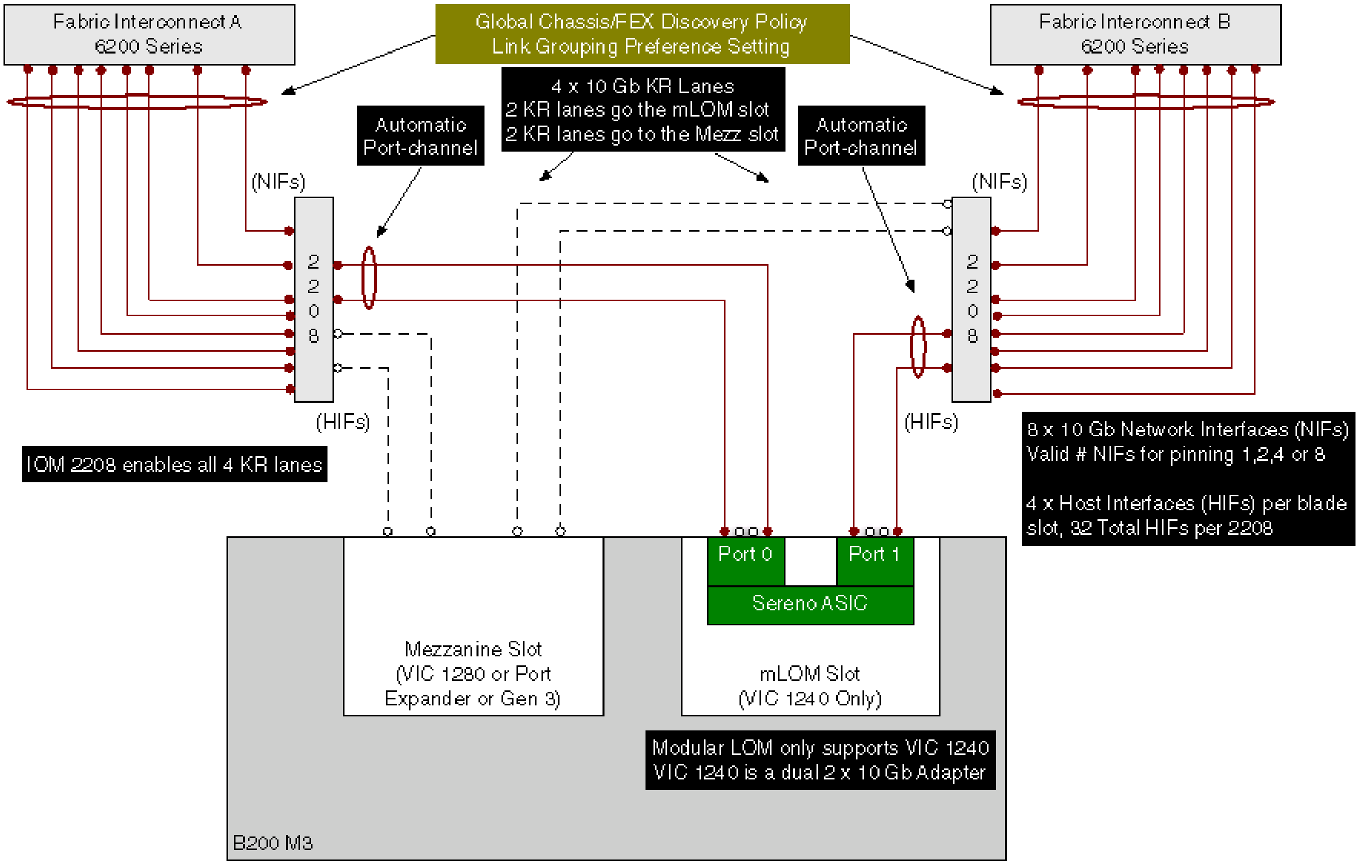

Fabric Interconnect A
6200 Series
Global Chassis/FEX Discovery Policy
Link Grouping Preference Setting
Fabric Interconnect B
6200 Series
4 x 10 Gb KR Lanes
2 KR lanes go the mLOM slot
2 KR lanes go to the Mezz slot
Automatic
Port-channel
Automatic
Port-channel
(NIFs)
(NIFs)
2208
2208
(HIFs)
(HIFs)
IOM 2208 enables all 4 KR lanes
8 x 10 Gb Network Interfaces (NIFs)
Valid # NIFs for pinning 1,2,4 or 8
4 x Host Interfaces (HIFs) per blade slot, 32 Total HIFs per 2208
Port 0
Port 1
Sereno ASIC
Mezzanine Slot
(VIC 1280 or Port Expander or Gen 3)
mLOM Slot
(VIC 1240 Only)
Modular LOM only supports VIC 1240
VIC 1240 is a dual 2 x 10 Gb Adapter
B200 M3

Figure 30 shows a Cisco UCS VIC 1240 with port expander card connecting to a pair of Cisco UCS 2208 Fabric Extenders. This configuration allows for two 40 Gbps capable port channels.

Figure 30 B-200 M3 Illustration with FEX model 2208, VIC 1240 and Port Expander

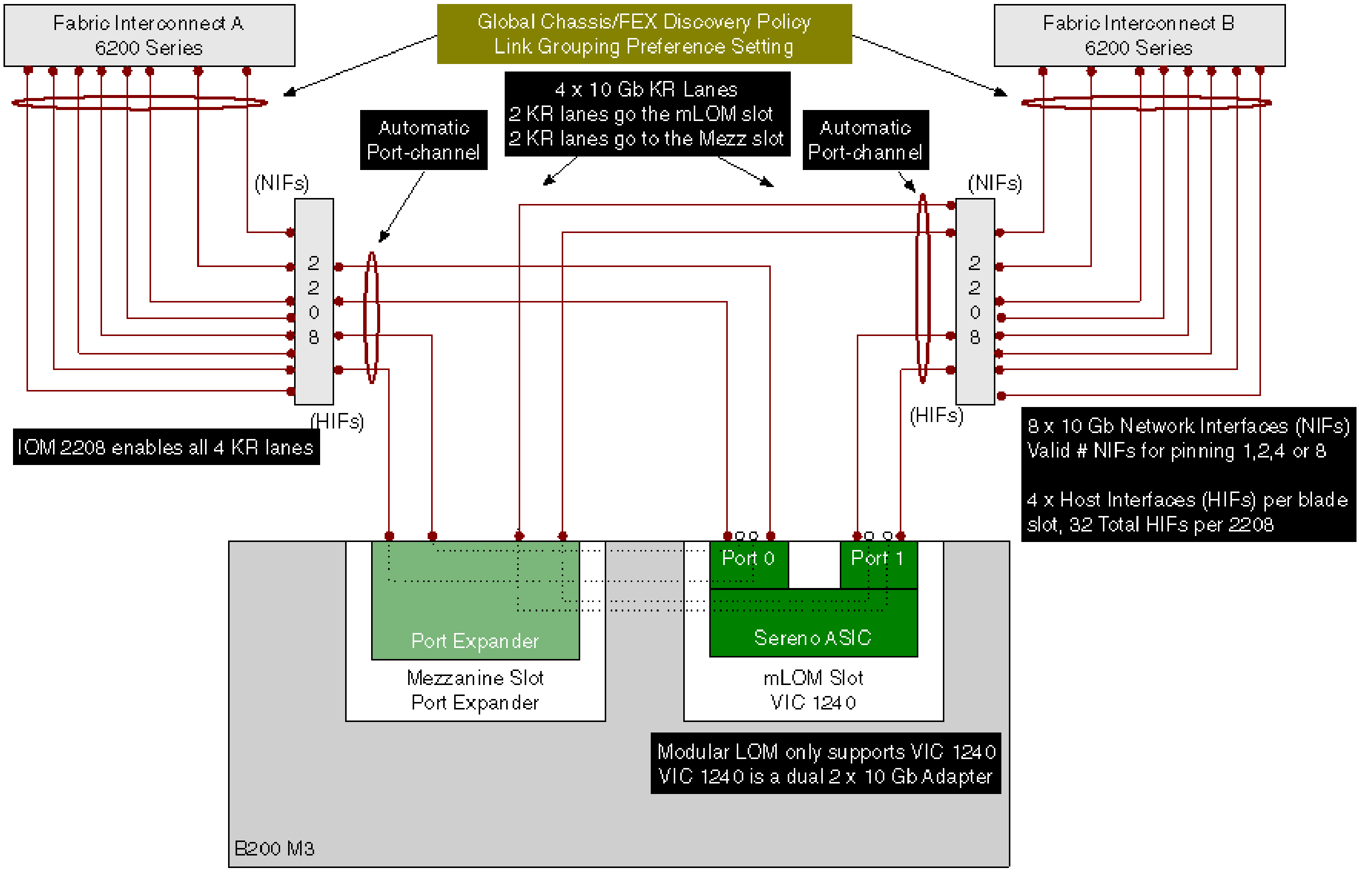
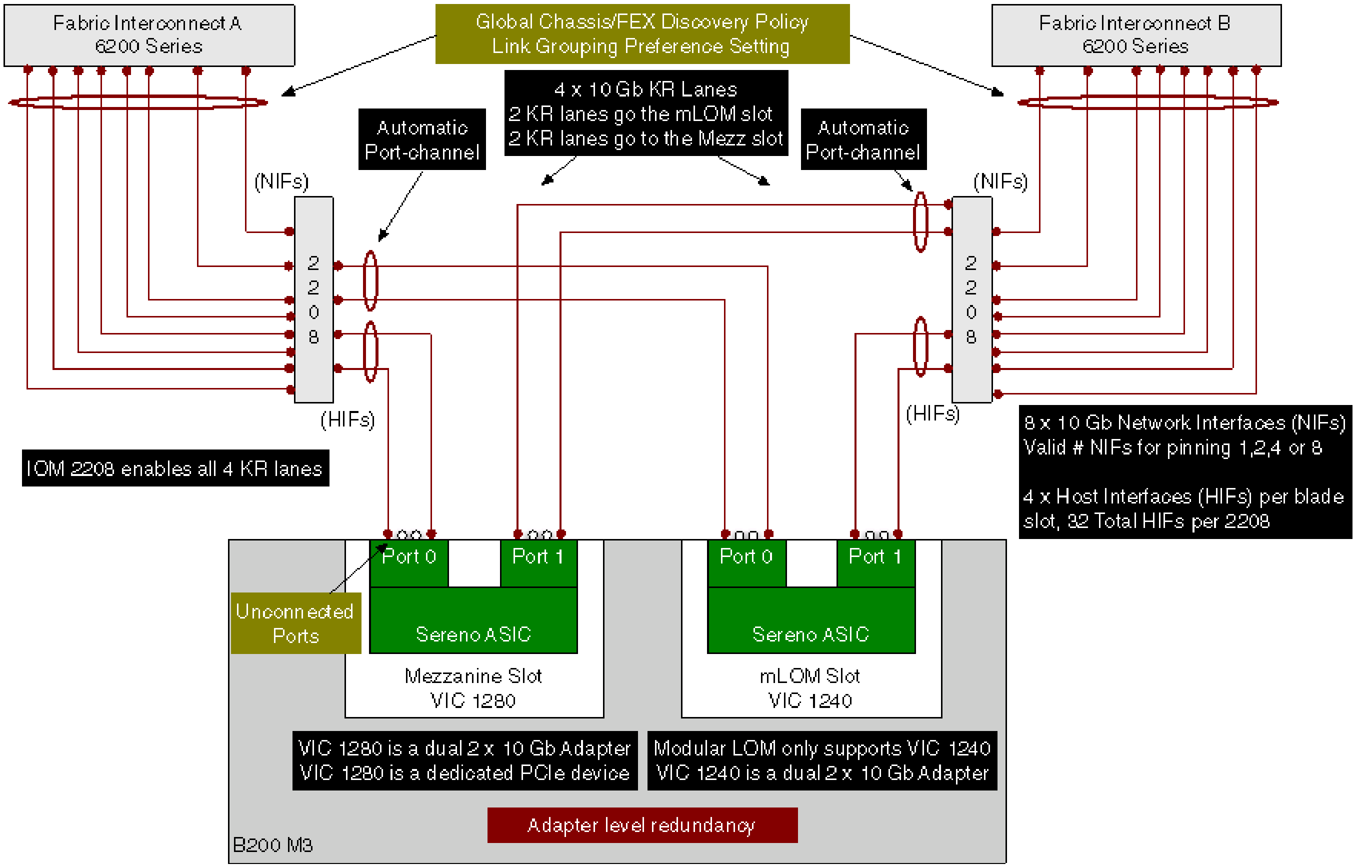

Fabric Interconnect A
6200 Series
Global Chassis/FEX Discovery Policy
Link Grouping Preference Setting
Fabric Interconnect B
6200 Series
4 x 10 Gb KR Lanes
2 KR lanes go the mLOM slot
2 KR lanes go to the Mezz slot
Automatic
Port-channel
Automatic
Port-channel
(NIFs)
(NIFs)
2208
2208
(HIFs)
(HIFs)
IOM 2208 enables all 4 KR lanes
8 x 10 Gb Network Interfaces (NIFs)
Valid # NIFs for pinning 1,2,4 or 8
4 x Host Interfaces (HIFs) per blade slot, 32 Total HIFs per 2208
Port Expander
Mezzanine Slot
Port Expander
Port 0
Port 1
Sereno ASIC
mLOM Slot
VIC 1240
Modular LOM only supports VIC 1240
VIC 1240 is a dual 2 x 10 Gb Adapter
B200 M3

Figure 31 shows a half-width blade using the Cisco UCS VIC 1240 and 1280 in the mLOM and mezzanine slot respectively. This configuration combined with the Cisco UCS 2208 Fabric Extender results in four 20 Gbps aggregate port channels.

Figure 31 B200 M3 Connectivity Illustration with FEX model 2208, VIC 1240 and VIC 1280


Fabric Interconnect A
6200 Series
Global Chassis/FEX Discovery Policy
Link Grouping Preference Setting
Fabric Interconnect B
6200 Series
4 x 10 Gb KR Lanes
2 KR lanes go the mLOM slot
2 KR lanes go to the Mezz slot
Automatic
Port-channel
Automatic
Port-channel
(NIFs)
(NIFs)
2208
2208
(HIFs)
(HIFs)
IOM 2208 enables all 4 KR lanes
8 x 10 Gb Network Interfaces (NIFs)
Valid # NIFs for pinning 1,2,4 or 8
4 x Host Interfaces (HIFs) per blade slot, 32 Total HIFs per 2208
Port 0
Port 1
Port 0
Port 1
Unconnected
Ports
Sereno ASIC
Sereno ASIC
Mezzanine Slot
VIC 1280
mLOM Slot
VIC 1240
VIC 1280 is a dual 2 x 10 Gb Adapter
VIC 1280 is a dedicated PCIe device
Modular LOM only supports VIC 1240
VIC 1240 is a dual 2 x 10 Gb Adapter
Adapter level redundancy
B200 M3

References

This section provides references that can be helpful during FlexPod design implementation:

- Cisco Unified Computing System:

  http://www.cisco.com/en/US/products/ps10265/index.html
- Cisco UCS 6200 Series Fabric Interconnects:

  http://www.cisco.com/en/US/products/ps11544/index.html
- Cisco UCS 5100 Series Blade Server Chassis:

  http://www.cisco.com/en/US/products/ps10279/index.html
- Cisco UCS B-Series Blade Servers:

  http://www.cisco.com/en/US/partner/products/ps10280/index.html
- Cisco UCS Adapters:

  http://www.cisco.com/en/US/products/ps10277/prod_module_series_home.html
- Cisco UCS Manager:

  http://www.cisco.com/en/US/products/ps10281/index.html
- Cisco Nexus 7000 Series Switches:

http://www.cisco.com/en/US/products/ps9402/index.html

- Cisco Nexus 1000v:

  http://www.cisco.com/en/US/products/ps9902/index.html
- Cisco Prime Data Center Manager:

  http://www.cisco.com/en/US/products/ps9369/index.html
- VMware vCenter Server

  http://www.vmware.com/products/vcenter-server/overview.html
- VMware vSphere:

  http://www.vmware.com/products/datacenter-virtualization/vsphere/index.html
- Interoperability Matrix:
  - NetApp Interoperability Matrix Tool

    http://support.netapp.com/matrix/
  - Cisco UCS Hardware and Software Interoperability Tool

    http://www.cisco.com/web/techdoc/ucs/interoperability/matrix/matrix.html
  - VMware Compatibility Guide

    http://www.vmware.com/resources/compatibility/search.php
- NetApp Data ONTAP 8 Operating System

  http://www.netapp.com/us/products/platform-os/data-ontap-8/index.aspx