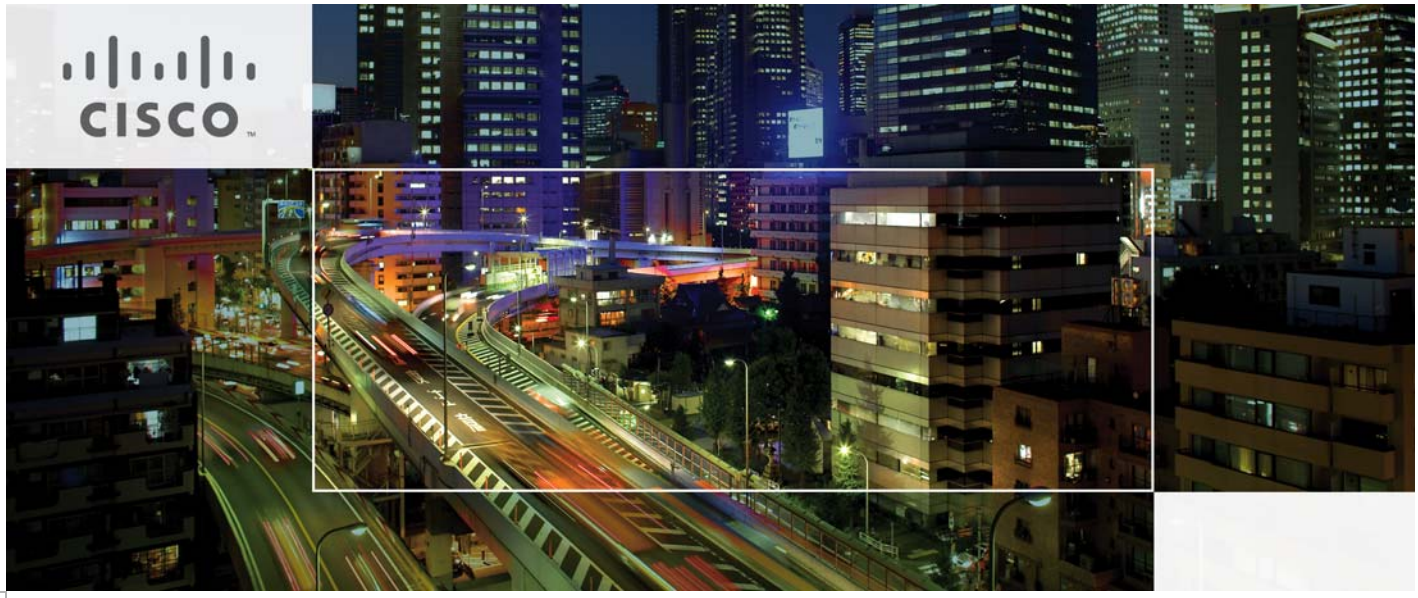

Data Center Interconnect

Implementation Guide for Virtualized Workload Mobility with Cisco, NetApp and VMware

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Cisco Validated Design

Building Architectures to Solve Business Problems

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About Cisco Validated Design (CVD) Program

The CVD program consists of systems and solutions designed, tested, and documented to facilitate faster, more reliable, and more predictable customer deployments. For more information visit http://www.cisco.com/go/designzone.

Data Center Interconnect Implementation Guide for Virtualized Workload Mobility with Cisco, NetApp and VMware

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Preface

This document provides the lab validation results of the Metro Virtualized Data Center system.

This Deployment Guide was written to be used in conjunction with two other sources: (1) The accompanying Design Guide; (2) The various best practices for the manifold technologies that were used to construct this architecture. Throughout this document, therefore, are found links to these other sources. A quick note about each follows.

Design Guide—The Design Guide was written with knowledge about the results of the lab validation effort and takes into account the various design caveats that were uncovered during the testing.

Best Practices—Where Cisco provides best practices, they were used to build the baseline validation test environments. As validation proceeded and the test team determined that these best practices needed to be adjusted for this particular system deployment, such changes were made and noted. In terms of configuration notes and user caveats, this document focuses on those differences. For reference, the best practice resources are noted throughout this document.

Refer to the follow link for Cisco Validated Designs using Data Center Interconnect.
http://www.cisco.com/en/US/netsol/ns749/networking_solutions_sub_program_home.html

Document Goals

This document focuses on three key aspects of this Data Center Interconnect system, listed below. Technology overviews and comparisons are not the focus of this document and can be found in the associated Design Guide.

1. Specific configuration guidance for recommended design deployment—While the Design Guide focuses on high-level guidance for implementing the Metro Virtualized Data Center system, this Deployment Guide will focus on showing exactly how to implement this system, drawing on configurations used in the validated environment.
2. Highlight caveats specific to validated environment—Where there are caveats to be aware of in implementing the system as validated in the test environment, these are called out in this document.
3. Compare gross system performance under various feature combinations—To arrive at the recommended system designs, many different combinations of technologies were tested. The relative performance of these particular use cases will be shown. While the focus of this document

is not a detailed characterization of scalability and performance, some high level comparisons will be made to demonstrate a summary of expectations for performance after production implementation.

Audience

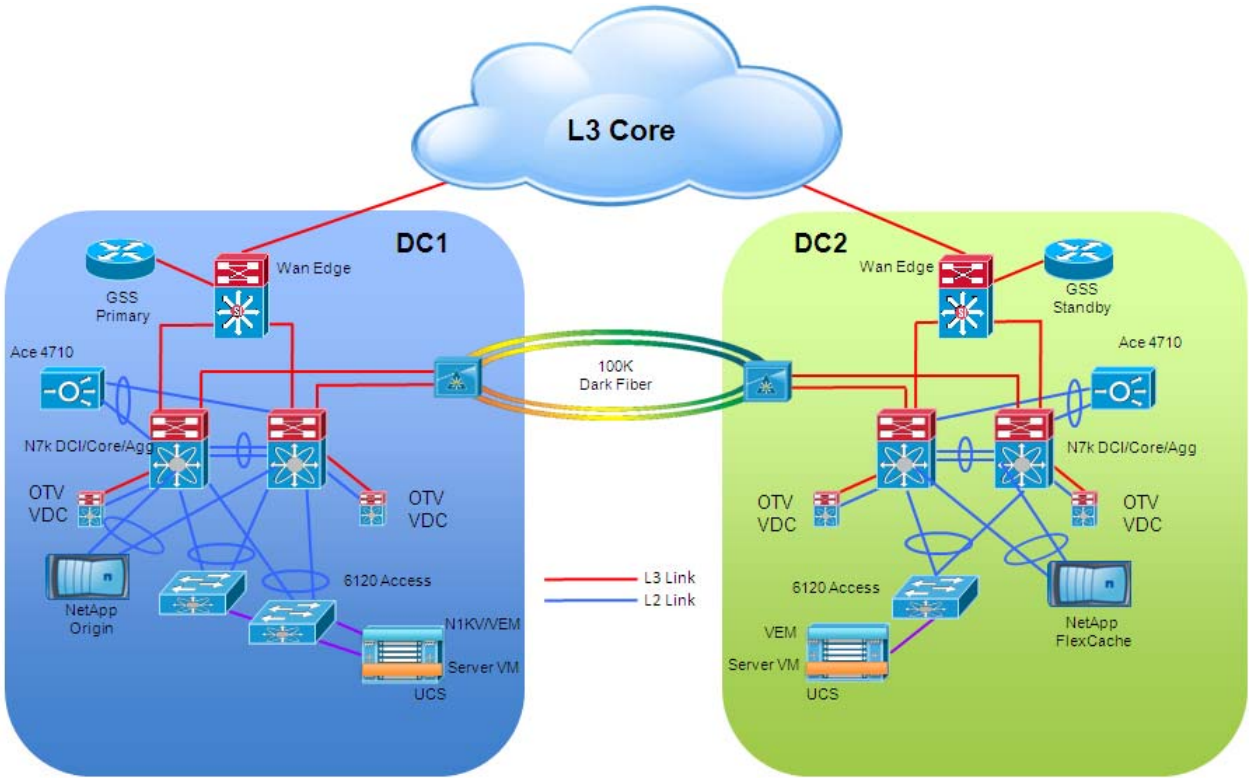
This document is intended for, but not limited to, network architects, systems engineers, field consultants, advanced services specialists, and customers who want to understand how to deploy a workload mobility solution.

CHAPTER 1

Deploying Cisco Virtualized Workload Mobility with NetApp and VMware

The validation environment used consisted of one test topology, consisting of two data centers. Figure 1-1 presents a high-level architecture view of the test topology used in validation.

Figure 1-1 Test Topology Overview



Validation Platforms

Table 1-1 provides a summary of the platforms leveraged in the validation environment as well as which specific test topologies used the technologies. Two other data points provided in Table 1-1 include the particular software versions used for each platform and any 3rd party (non-Cisco) platforms used.

Note While the software versions used during validation are provided, endorsement of any particular software release was not a goal of this document. The reader is encouraged to investigate independently the suitability of any software release for his or her own deployment.

Table 1-1 Platforms Used in Validation Environment

Platform	Software Used	Function
Nexus 7000	NX-OS 5.1(4)	Collapsed Core/Aggregation through separate Agg & OTV VDCs
Catalyst 6500	IOS 12.2(33)SXI5	WAN Edge; For testing purposes, used to provide connectivity from emulated Internet clients to data center LAN
Nexus 1000v	4.2(1)SV1(4)	Provided central management interface for managing server connectivity within and across data centers
UCS	1.4(1m)	Provided blade server-based compute resources for data centers; Worked in harmony with Nexus 1000v, VSG and Vcenter to facilitate resource deployment, VM profile assignment and resource services
ACE 4710	A3(2.7)	Advertised VIP services to Internet clients and SLB functionality to app servers; Used for multi-tier app environment for VSG validation
GSS	3.1(2)	Provided central DNS lookup functionality to Internet clients; Received triggered updates from Vcenter upon vMotion event
VSG	4.2(1)VSG1(1)	Guarded VMs against unwanted network traffic using security profiles assigned to VMs by Vcenter
VMware ESX	4.1	Provided virtual server infrastructure for validation effort; Both multiple and single cluster use cases explored; vMotion feature used extensively for workload mobility validation
NetApp FAS6080	7.3.3	Provided NFS storage to servers
NetApp FlexCache	7.3.2	Provided local file cache service to servers
ONS 15454	9.0.0	Presented optical infrastructure used to create distance between data centers; Not used directly in testing

Validation Scale

While scalability was not a focus of system validation, Table 1-2 is provided to highlight certain scale points at which the system was tested.

Table 1-2 Scale Used in System Validation

Element	Platform(s)	Scale
Nexus 1000v ESX host scale (VEM scale)	Nexus 1000v	20
VM/vNIC/VEth scale	Nexus 1000v	1000
VSM	Nexus 1000v	2

Table 1-2 Scale Used in System Validation

Element	Platform(s)	Scale
# MAC per OTV overlay	Nexus 7000	8000
# VLANs per OTV overlay	Nexus 7000	64
# VSG cluster nodes	VSG	2
# VSG-connected VEths	VSG	100

Validation Methodology

The ability of the system to enable workload migration was the focus of the validation done on the test topology. The general procedure of a given test case was as follows:

1. Initiate application traffic from Client 1
2. Initiate server workload migration (e.g. DC1 to DC2)
3. Characterize Client 1 traffic impact
4. Initiate application traffic from Client 2
5. Initiate server workload migration (e.g. DC2 to DC1)
6. Characterize Client 1 & 2 traffic impact

From these generalized steps, information was gathered to satisfy the four goals of the validation, as outlined above.

Application Traffic Profile

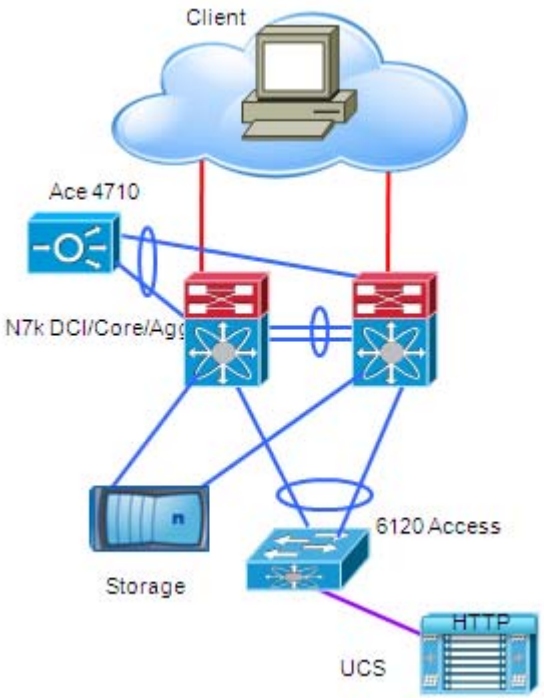
Application traffic (Layer 7) was used in all of the validation test cases. Spirent Avalanche was employed to emulate a client that would initiate requests to applications running on virtual machines on the Cisco UCS. HTTP(S), FTP (reads & writes), and SQL traffic were employed.

The application servers were set up in one of two ways: Single-tier or multi-tier.

Single Tier Application Deployment

In the single tier deployment, client requests (HTTP or FTP) would hit the ACE load balancer then be sent directly to the HTTP or FTP application server. The HTTP or FTP server would serve data from it's NFS-mounted storage back to the client (Figure 1-2).

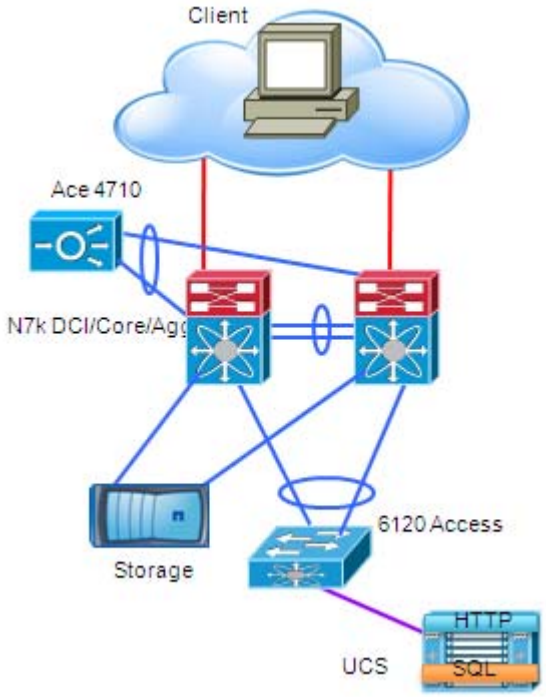
Figure 1-2 Single Tier Application Traffic Flow



Multi-Tier Application Deployment

In the multi-tier deployment, client requests would hit the ACE as HTTP requests. The first tier would be an HTTP server that would serve up an HTML form page from its NFS-mounted storage. The second tier server was an SQL database that would handle the SQL read or write requests from the HTTP tier. The HTTP server would then respond back to the client with a success or failure based on the status of the SQL action (Figure 1-3).

Figure 1-3 Multi-Tier Application Traffic Flow



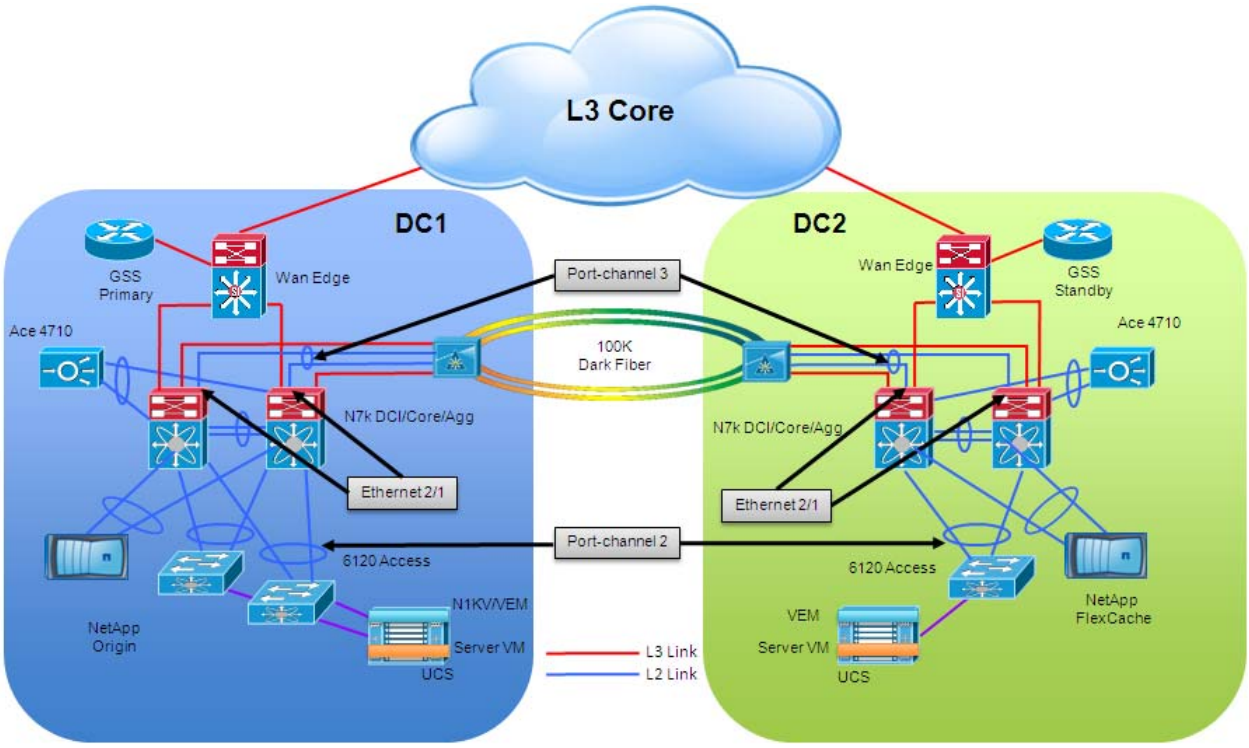
LAN Extension

LAN extension solutions are commonly used to extend subnets beyond the traditional Layer 3 boundaries of a single data center. Stretching the network space across two or more data centers can accomplish many things. Doing so also presents a challenge, since providing these LAN extension capabilities may have an impact on the overall network design. Simply allowing Layer 2 connectivity between sites that were originally connected only at Layer 3 would have the consequence of creating new traffic patterns between the sites: STP BPDUs, unicast floods, broadcasts, ARP requests, and so on. This can create issues, some of them related to attacks (ARP or flood storms), others related to stability issues (size of STP domain) or scale (ARP caches or MAC address table sizes). This section of the document discusses some of these issues and provides recommendations to alleviate them.

vPC over Dark Fiber

The virtual Port Channel (vPC) functionality allows establishing port channel distributed across two devices, allowing redundant yet loop-free topology. Compared to traditional STP-based environments, vPC allows redundant paths between a downstream device and its two upstream neighbors. With STP, the port channel is a single logical link that allows for building Layer 2 topologies that offer redundant paths without STP blocking redundant links.

Figure 1-4 vPC Topology



Spanning-Tree Configuration

The main advantage of bundling together the physical point-to-point links interconnecting the sites consist in being capable of extending VLANs without creating L2 looped topologies. As a consequence, the recommendation is to filter Spanning Tree BPDUs across the logical port-channel established between sites, so to be able to isolate the STP domains. Essentially, the idea is to replace STP with LACP as control plane protocol.

Example STP Filter

```
interface port-channel3
 description L2 VPC 3 Trunk to dc2a-agg-7k1 eth 2/1
 switchport
 switchport mode trunk
 switchport trunk allowed vlan 1,2500-2999
 spanning-tree port type edge trunk
 spanning-tree bpdufilter enable
 mtu 9216
 vpc 3
```

The **spanning-tree bpdufilter enable** command in the example above forces the interface to not send any BPDUs and drops all BPDUs that it receives. The command needs to be on all 4 Nexus 7000 aggregation switches on port channel between the data centers.

Root bridge placement is very important to ensure network stability and reachability. Typically the root bridge is located at the L2/L3 boundary in the network. In the DCI topology, this boundary exists in the Nexus 7000 at the aggregation layer.

To ensure the root is at the aggregation layer, the STP priority should be set such that the Nexus 7000 is chosen as the root in the STP calculations. There is a root for spanning tree within each isolated data center and we prevent the root from going over the DCI link to the other data center. This ensures localized STP calculations.

Example STP Priority

```
spanning-tree vlan 2500-2999,3500-3509 priority 28672
```

Note The default bridge priority is 32,768 (plus the VLAN #). The lower the value, the more likely it will become the root bridge.

The vPC peer switch feature was introduced to address performance concerns around STP convergence. This feature allows a pair of Cisco Nexus 7000 Series devices to appear as a single STP root in the Layer 2 topology. This feature eliminates the need to pin the STP root to the vPC primary switch and improves vPC convergence if the vPC primary switch fails.

The vPC peer-gateway capability allows a vPC switch to act as the active gateway for packets that are addressed to the router MAC address of the vPC peer. This feature enables local forwarding of such packets without the need to cross the vPC peer-link. In this scenario, the feature optimizes use of the peer-link and avoids potential traffic loss. Configuring the peer-gateway feature needs to be done on both primary and secondary vPC peers and is non-disruptive to the operations of the device or to the vPC traffic.

The vPC peer-switch and peer-gateway features can be configured globally under the vPC domain submode.

Example vPC Peer-Switch and Peer-Gateway

```
vpc domain 3
  peer-switch
  peer-keepalive destination 10.0.183.47 source 10.0.183.35
  peer-gateway
```

It is also recommended to use the **spanning-tree root guard** command to ensure the ports toward the access layer of the topology cannot become a root port.

```
interface port-channel2
  description vpc 2 - eth 2/25 to dc1a-acc-6k eth2/1
  switchport
  switchport mode trunk
  switchport trunk allowed vlan 1,2500-2999,3500-3509
  spanning-tree guard root
  mtu 9216
  vpc 2
```

Cisco TrustSec (CTS)

The requirement for LAN extension cryptography is increasingly prevalent, to meet federal and regulatory requirements. To accomplish this, CTS was enabled on the 4 dark fiber connections. You can manually configure Cisco TrustSec on an interface if your Cisco NX-OS device does not have access to a Cisco Secure ACS or authentication is not needed because you have the MAC address authentication bypass feature enabled. You must manually configure the interfaces on both ends of the connection. An example of the required configuration is in the example below.

Example CTS

```
   interface Ethernet2/1
```

```
ip port access-group HSRPv1_Filtering in
cts manual
sap pmk 1234
switchport
switchport mode trunk
switchport trunk allowed vlan 1,2500-2999
rate-mode dedicated force
mtu 9216
channel-group 3 mode active
no shutdown
```

The **cts manual** command configures the interface into CTS manual mode. The **sap pmk** command configures the SAP pairwise master key (PMK) and operation mode.

The *key* argument is a hexadecimal value with an even number of characters and a maximum length of 32 characters. The commands need to be on both sides of the links between the data centers.

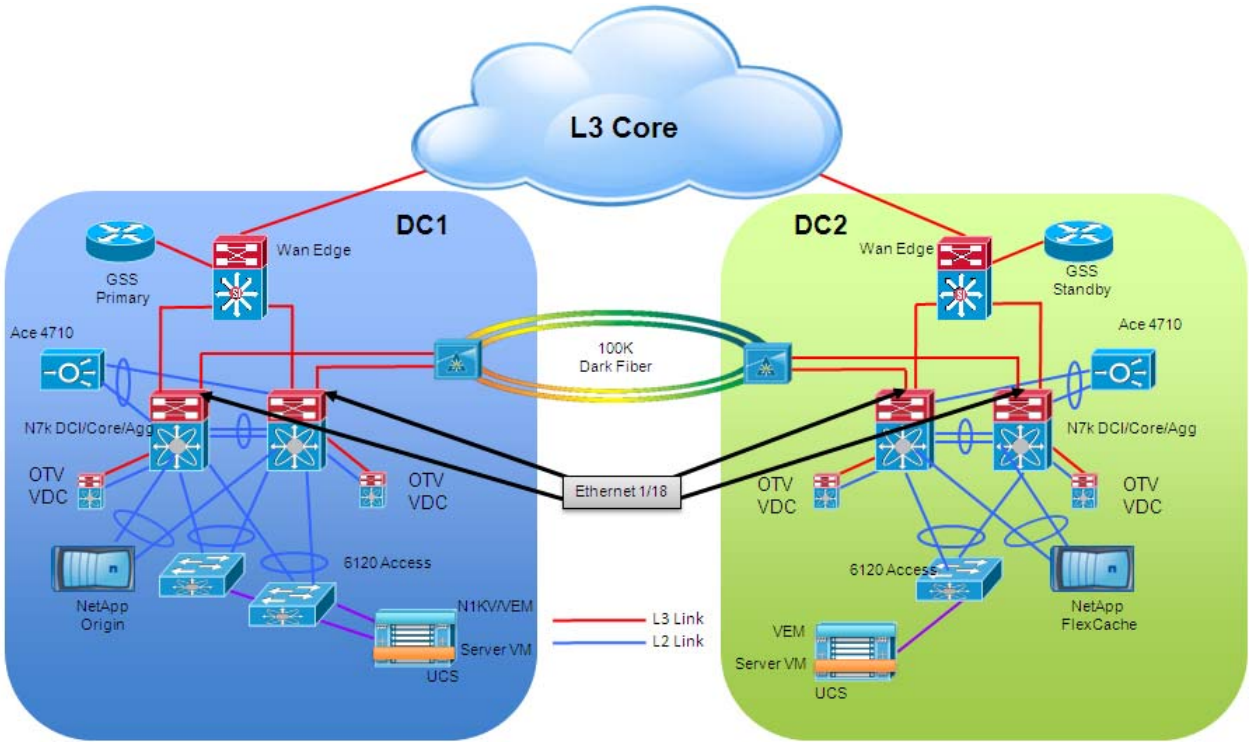
Note For more information on the Cisco TrustSec technology and for an overview of other deployment models, please refer to the following configuration guide: http://www.cisco.com/en/US/docs/switches/datacenter/sw/4_1/nx-os/security/configuration/guide/sec_trustsec.html - wp1232122

OTV over Dark Fiber

Overlay Transport Virtualization (OTV) is an IP-based functionality that has been designed from the ground up to provide Layer 2 extension capabilities over any transport infrastructure: Layer 2 based, Layer 3 based, IP switched, label switched, and so on. The only requirement from the transport infrastructure is providing IP connectivity between remote data center sites. In addition, OTV provides an overlay that enables Layer 2 connectivity between separate Layer 2 domains while keeping these domains independent and preserving the fault-isolation, resiliency, and load-balancing benefits of an IP-based interconnection.

The current implementation on the Nexus 7000 enforces the separation between SVI routing and OTV encapsulation for a given VLAN. This is an important consideration for the tested scenario, since the Nexus 7000 aggregation switches would actually have to perform both functionalities. This separation can be achieved with the traditional workaround of having two separate network devices to perform these two functions. However, a cleaner and less intrusive solution is tested here by introducing the use of Virtual Device Contexts (VDCs) available with Nexus 7000 platforms. Two VDCs would be deployed: an OTV VDC dedicated to perform the OTV functionality and a Routing VDC used to provide SVI routing support.

Figure 1-5 OTV Topology



Spanning-Tree Configuration

When using OTV, there is no need to explicitly configure BPDU filtering to prevent the creation of a larger STP domain extending between the two sites.

Just as in the case of the vPC over dark fiber, the root bridge placement is very important. Since the configuration is the same for the OTV over dark fiber use case, please reference the configuration examples in the previous section.

Cisco TrustSec (CTS)

CTS encryption has the same implications in the case of OTV over dark fiber as in vPC over dark fiber. The only difference is that there are only L3 links between the data centers that need to be protected. These L3 links, interfaces ethernet 1/18 in the OTV topology diagram, are between the routed VDCs in the Nexus 7000 in each data center. The OTV VDC has no knowledge of the CTS encryption.

Since all other considerations are similar, please refer to the vPC over dark fiber use case in the previous section.

Path Optimization

The deployment of LAN extension technologies implies that the same LAN/IP subnet gets stretched between two (or more) data center locations. As a consequence, a given IP address loses its linkage to a specific location. A mechanism is usually desired to optimize the traffic flows between any client and a

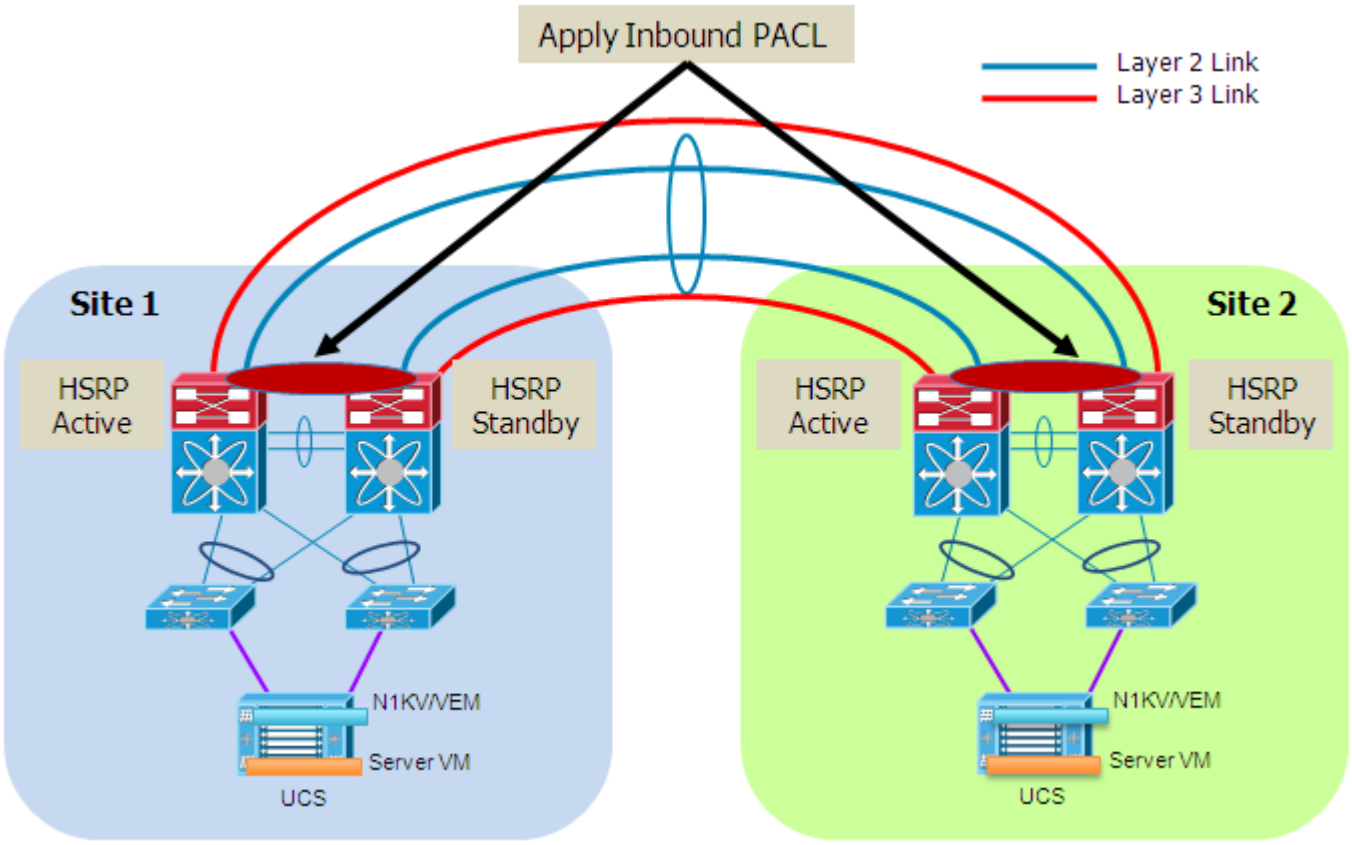
specific data center service and also between server tiers (specifically for multi-layer application deployments). This is done in order to minimize the “tromboning effect” of traffic going back and forth across the LAN extension connection established between sites.

Egress Path Optimization

In order to optimize the server-client flows and the local routing of traffic between different subnets, it is recommended to leverage First Hop Redundancy Protocol (FHRP) Isolation, which allows providing an active default gateway in each location for the VLANs that are stretched between sites. This FHRP isolation functionality can be achieved in different ways depending on the specific LAN extension technology deployed.

For the vPC over dark fiber model discussed above, inbound port access lists (PACL) are used. Figure 1-6 highlights the specific case where HSRP is used as the FHRP on the Nexus 7000 devices acting as default gateway for all the hosts.

Figure 1-6 HSRP Isolation Across the vPC Connection



Note Similar considerations apply to the use of Virtual Router Redundancy Protocol (VRRP).

The behavior shown above can be achieved by applying an inbound PACL on the DCI connection (logical vPC port-channel) so to be able to drop the incoming HSRP frame originated in the remote site. Notice that a VLAN ACL (VACL) defined on the aggregation Nexus 7000 switches could not be used for the same purpose, as it would also prevent the exchange of HSRP messages between the local aggregation devices.

It is worth noticing how the specific Nexus 7000 hardware implementation would cause the aggregation switches to learn the HSRP vMAC from the messages received on the DCI connection before these packets can actually be dropped by the applied PACL. In the validated topology, this does not represent a problem, since information for this vMAC is already known locally (static entry), so the dynamic entry learned via the DCI connection is never added to the table. This is true for both HSRP Active and Standby devices, when vPC is used to connect these to the rest of the switch (HSRP behavior is improved when integrated with vPC to provide active-active data plane first-hop routing capabilities).

The PACL configuration denies the HSRP control packets from entering the Nexus 7000, but the control packets are still on the DCI link. The configuration required to deny HSRP control packets from entering the Nexus 7000 is below.

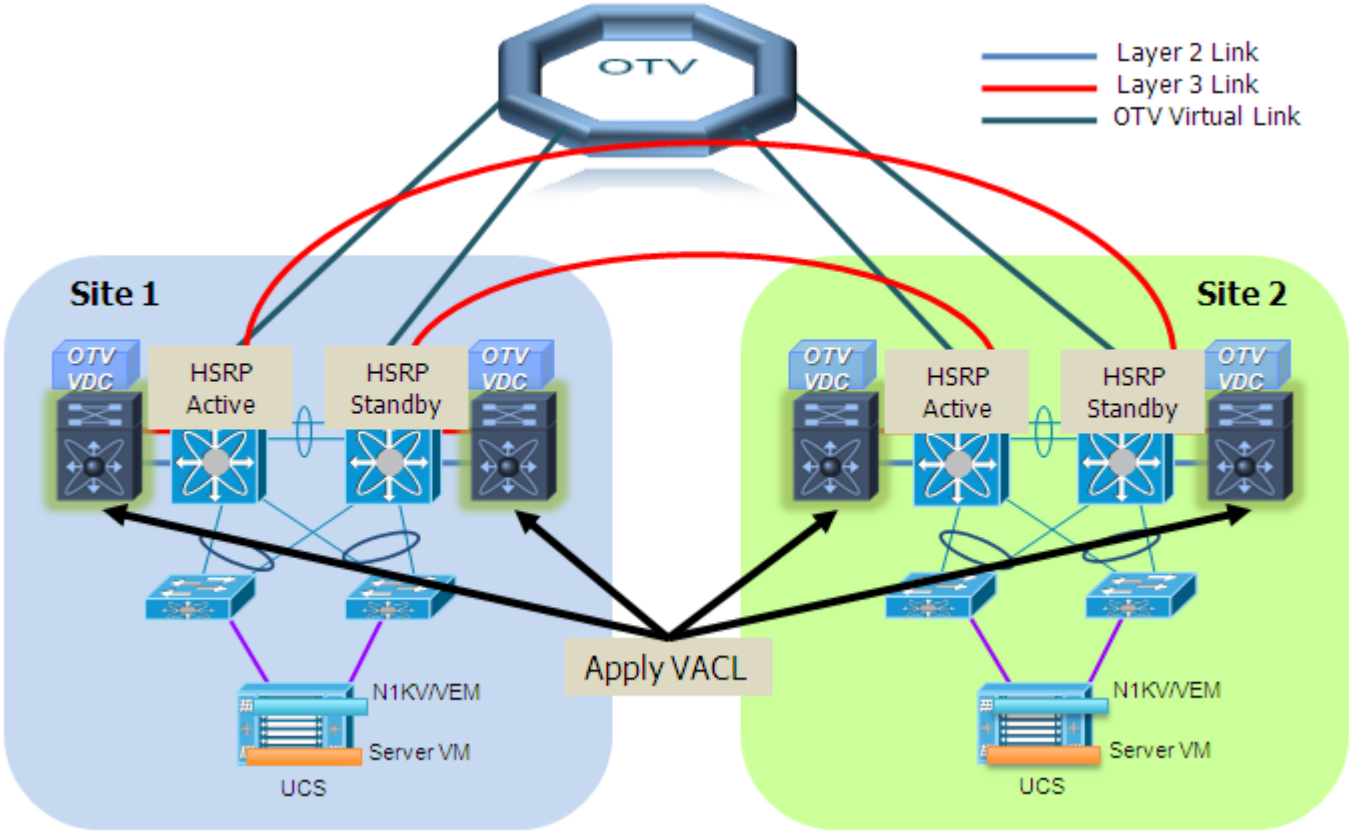
Example HSRP Port ACL (PACL)

```
ip access-list HSRPv1_Filtering
  10 deny udp any 224.0.0.2/32 eq 1985
  20 permit ip any any
interface port-channel3
  description L2 VPC 3 Trunk to dc2a-agg-7k1 eth 2/1
  shutdown
  switchport
  switchport mode trunk
  switchport trunk allowed vlan 1,2500-2999
  ip port access-group HSRPv1_Filtering in
  spanning-tree port type edge trunk
  spanning-tree bpdufilter enable
  mtu 9216
  vpc 3
```

Forcing the localization of the HSRP prevents the server from having to go to the remote data center for default gateway routing. This will keep the DCI link from being crossed twice when a server is sending traffic to another server in the same data center but on a different VLAN. It will also optimize the server-to-client traffic flows.

Similarly to what was discussed for the vPC–based approach, it is possible to provide a specific configuration to filter HSRP messages and prevent them to be exchanged across the logical OTV overlay. The recommended approach in this case consists in defining a VLAN ACL on the OTV VDC and applying it to the set of VLANs that need to be extended, which is different from the PACL approach discussed in the vPC scenario above.

Figure 1-7 HSRP Isolation Across the OTV Overlay



A couple of additional considerations are required in this case:

- The filtering of HSRP happens now before the messages are sent to the other site. This is due to the application of a VACL instead than a PACL (as already mentioned a PACL can only be applied in the inbound direction).
- Because of a specific Nexus 7000 HW implementation, even if the HSRP messages are dropped by the VACL once they get to the OTV VDC, this does not prevent the OTV device from learning the HSRP vMAC from the received frame. As a consequence, an OTV control protocol update is created for that vMAC and sent to the other OTV devices connected to the same overlay. Even if this behavior should not have functional impact on the solution, it is recommended to apply a simple configuration (route-map) to the OTV control plane to avoid sending this specific update.

Note In a future software release, OTV will provide a single CLI knob to enable the FHRP filtering functionality across the overlay, removing the need for a VACL configuration and further simplifying the solution.

Example HSRP VACL Filters

```
AGG-A-OTV-VDC#
ip access-list HSRPv1
  10 permit udp any 224.0.0.2/32 eq 1985
ip access-list IP_ALL
  10 permit ip any any
vlan access-map HSRPv1_Filtering 10
        match ip address HSRPv1
```

```
        action drop
vlan access-map HSRPv1_Filtering 20
        match ip address IP_ALL
        action forward
vlan filter HSRPv1_Filtering vlan-list 2500-2563
```

The **vlan access-map** command creates the filter that is then applied to the VLANs where we do not want to forward the HSRP control packets. This filter is applied to the VLANs using the **vlan filter** command.

Note For further information on VLAN access-map and VLAN filter, please refer to the command reference guide: http://www.cisco.com/en/US/docs/switches/datacenter/sw/4_0/nx-os/security/command/reference/sec_cmds_v.html#wp1037226

Example HSRP route-map

```
mac-list HSRPv1_vMAC seq 10 deny 0000.0c07.ac00 ffff.ffff.ff00
mac-list HSRPv1_vMAC seq 20 permit 0000.0000.0000 0000.0000.0000
route-map HSRPv1_Filtering permit 10
  match mac-list HSRPv1_vMAC
otv-isis default
  vpn Overlay200
    redistribute filter route-map HSRPv1_Filtering
```

The mac-list consists of the well-known HSRP virtual MAC (vMAC) of 0000.0c07.acxx. The first 5 bytes of the MAC address are always the same regardless of the HSRP group. The last byte of the MAC address are determined by the HSRP group. Using a mask of ffff.ffff.ff00 means to match the first 5 bytes exactly and the last byte can be any value. This will ensure you filter all HSRP virtual MAC addresses.

The otv-isis is the control protocol for OTV. To prevent the OTV device from sending the learned HSRP vMAC, a route-map that specifically blocks the vMAC address is applied to the OTV control protocol using the **redistribute filter** command. All other MAC addresses are allowed.

Ingress Path Optimization

For client-server flows optimization (inbound direction), an additional level of intelligence is required to provide information on which specific location the service is available and avoid a sub-optimal traffic path across the L2 connection established between sites. As previously mentioned, this may cause an asymmetric traffic path that would break once stateful devices (FW, load balancers, etc.) are deployed as part of the solution. If only FHRP isolation is used, this will be the case, therefore an additional optimization must be used.

The following section presents a specific DNS based ingress path optimization solution based on the integration of Cisco Application Control Engine (ACE), Cisco Global Site Selector (GSS) and VMware vCenter.

DNS Based Functionality with GSS, ACE, and vCenter Integration

The specific approach validated and discussed in this document to optimize the inbound client to server traffic flows is DNS based and leverage the following components:

- Cisco Global Site Selector (GSS)
- Cisco Application Control Engine (ACE), deployed as an appliance

- VMware vCenter

GSS

A GSS system comprises of between one and eight GSS devices, each independently answering DNS queries.

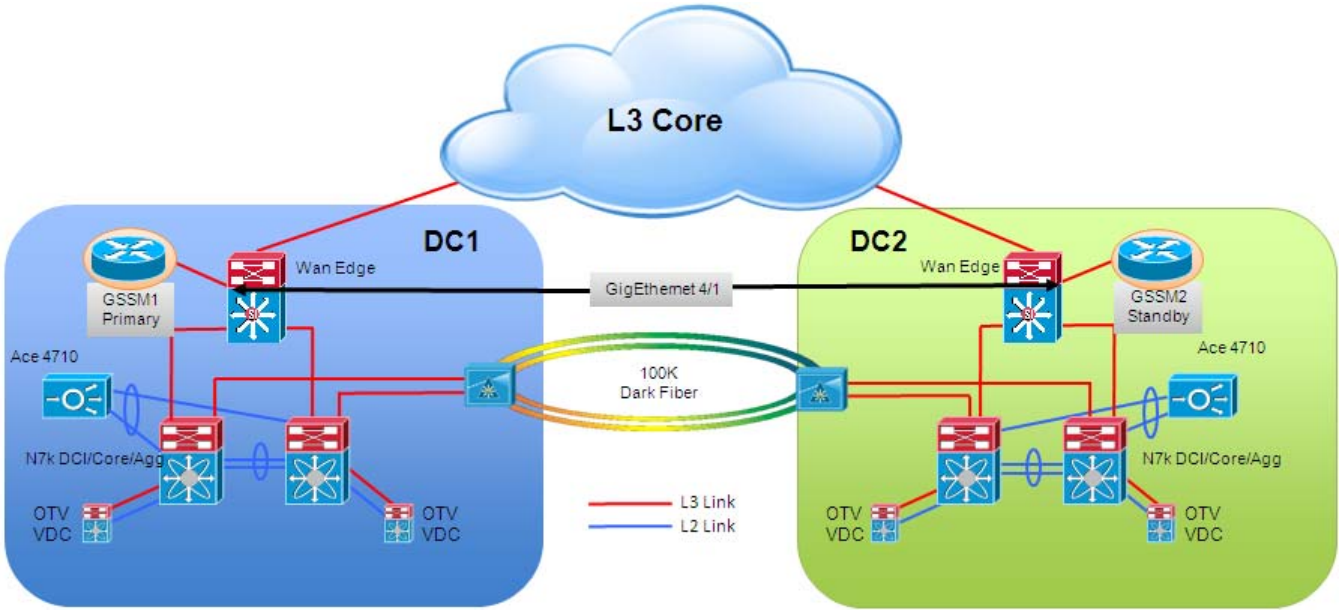
A GSS can run in one of three modes;

- **Primary GSS Manager (GSSM)**—Performs DNS functions as normal, along with providing a centralized GUI for configuration and statistics gathering for the GSS system
- **Standby GSSM**—Performs DNS functions as well as acting as a backup to the Primary GSSM, in the event of failure of that device. All changes to the GSS database, made on the Primary GSSM, are synchronized with the Standby GSSM.
- **GSS—**Performs DNS functions according to the configurations made on the Primary GSSM.

In this phase of testing, two GSS devices were used; one configured as the primary GSSM (gssm1) and the other as the secondary GSSM (gssm2).

Each data center has a GSS 4492 connected to the WAN edge of the network. One of the gigabit ethernet interfaces is connected to the out-of-band management network and the other gigabit ethernet interface, Gig Ethernet 4/1, is L3 connected in-band to the WAN edge device of the local data center.

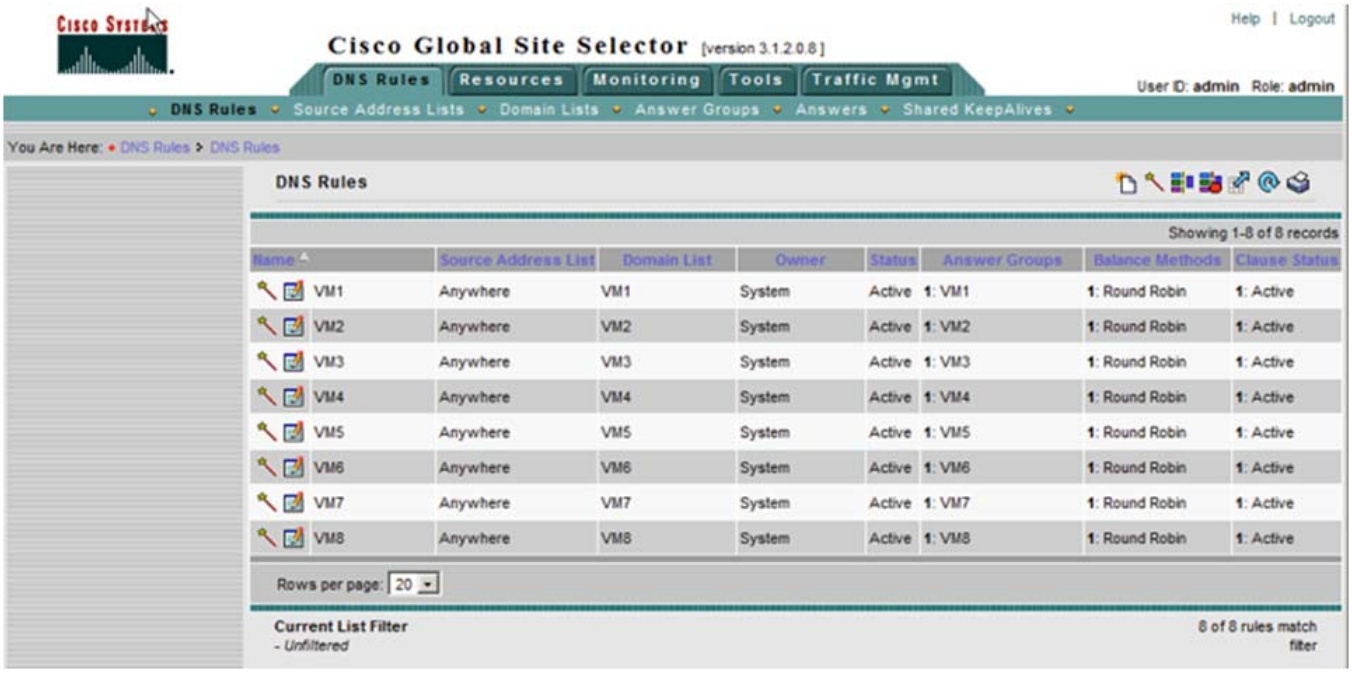
Figure 1-8 GSS Deployment



The two GSS are also configured in a Primary/Standby GSSM pair and are able to respond to queries regardless of their primary or standby role.

The primary GSSM performs content routing as well as centralized management functions for the GSS network. The primary GSSM serves as the organizing point of the GSS network, hosting the embedded GSS database that contains configuration information for all of your GSS resources, such as individual GSS devices and DNS rules. Other GSS devices report their status to the primary GSSM. The primary GSSM offers a single, centralized GUI for monitoring and administering your entire GSS network.

Figure 1-9 Primary GSSM GUI



Before you configure request routing or add GSS devices to your GSS network, first configure and enable a primary GSSM. From privileged EXEC mode on the CLI of your primary GSSM GSS device, enter the **gss enable gssm-primary** command to configure your GSS device as the primary GSSM in the GSS network.

Example Configure Primary GSSM

```
gssm1.example.com# gss enable gssm-primary
```

The standby GSSM performs GSLB functions for the GSS network even while operating in standby mode. In addition, the standby GSSM can be configured to act as the primary GSSM should the primary GSSM need to go offline for repair or maintenance, or becomes unavailable to communicate with other GSS devices. As with the primary GSSM, the standby GSSM is configured to run the GSSM GUI and contains a duplicate copy of the embedded GSS database that is currently installed on the primary GSSM. Any configuration or network changes affecting the GSS network are synchronized between the primary and the standby GSSM. The GSSM sends DNS application configuration changes to all GSS's in the network over TCP ports 2001 - 2009 using a secure session (RMI over SSL). These configuration changes only include IP addresses and DNS names.

To configure the standby GSS device as a standby GSSM, enter the **gss enable gssm-standby** command from privileged EXEC mode to enable your standby GSSM device and direct it to the primary GSSM in your GSS network. This command registers the standby GSSM with the primary GSSM.

Example Configure Secondary GSSM

```
gssm2.example.com# gss enable gssm-standby gssm1.example.com
```

The GSS (Global Site Selector) performs routing of DNS queries based on DNS rules and conditions configured using the primary GSSM. Each GSS is known to and synchronized with the GSSM, but individual GSS devices do not report their presence or status to the other. Each GSS on your network delegates authority to the GSS devices that serve DNS requests.

To configure the GSSMs to also serve DNS requests, use the **gss enable** command from privileged EXEC mode to enable your GSS device as a GSS and direct it to the primary GSSM in your GSS network.

Example Configure GSS

```
gssm1.example.com# gss enable gss gssm1.example.com
```

Once the configuration above is completed, the GSS device must be activated. This is done from the primary GSSM.

After you log in to the CLI and enable privileged EXEC mode, you enter the **gslb** command to access the global server load-balancing configuration mode. From this mode, you must activate the GSS using the **gss-device activate** command.

Example Activate GSS DNS Requests

```
gssm1(config-gslb)# gss-device gssm1.cisco.com activate
```

After the GSS devices in the network have been activated, the Global Server Load Balancing (GSLB) configuration can be put into place.

The ACE in each data center associates a different Virtual IP (VIP) address to each given workload (1:1 mapping). This implies that when the workload is deployed in DC1, external clients can access it by connecting to VIP_1 address, whereas VIP_2 is used once the workload is moved to DC2.

These VIP addresses need to be configured on the GSS so that when a client does a DNS query to the DNS server and the DNS server queries the GSS as authoritative for that domain, the GSS will return the correct response.

To accomplish this, both addresses (VIP_1 and VIP_2) are configured in the GSLB, but only one is active at a time.

Example GSLB VIP configuration

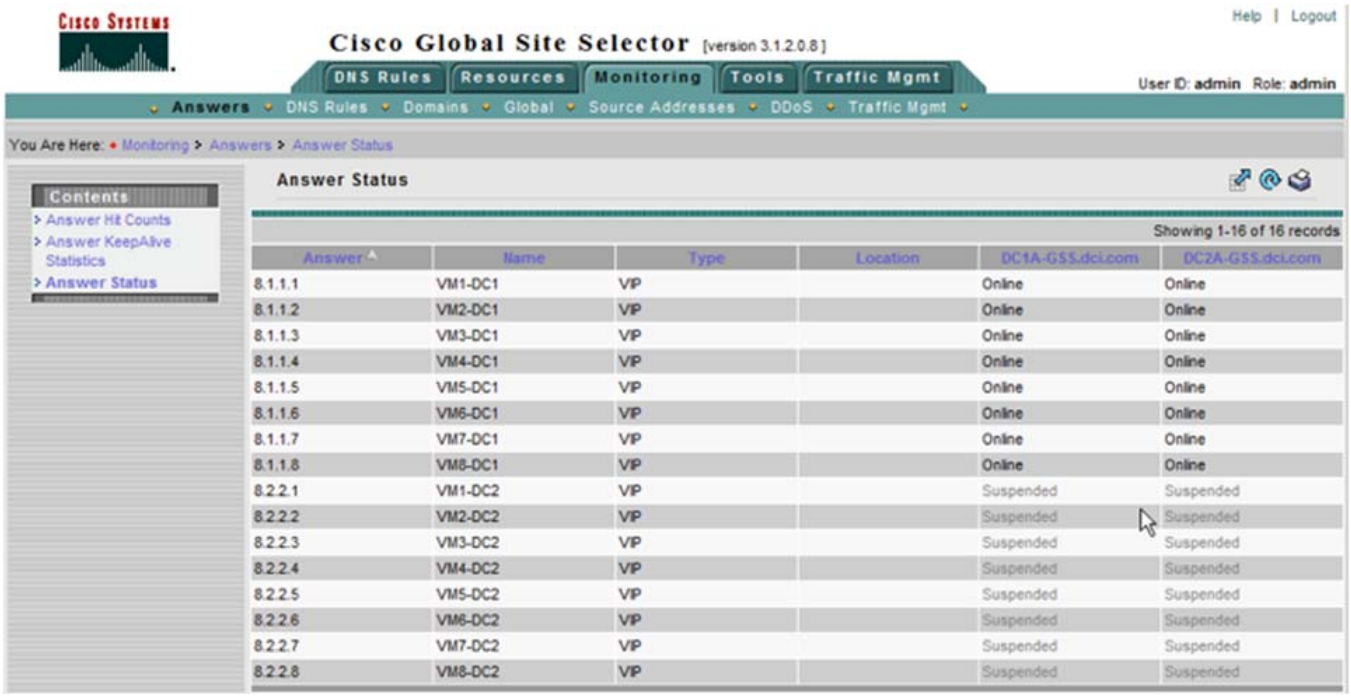
```
gssm1.example.com(config-gslb)#
domain-list VM1 owner System
  domain vm1.ph4dci.com
answer vip 8.1.1.1 name VM1-DC1 manual-reactivation disable activate
answer vip 8.2.2.1 name VM1-DC2 manual-reactivation disable suspend
answer-group VM1 owner System type vip
  answer-add 8.1.1.1 name VM1-DC1 weight 1 order 0 load-threshold 254 activate
  answer-add 8.2.2.1 name VM1-DC2 weight 1 order 0 load-threshold 254 suspend
dns rule VM1 owner System source-address-list Anywhere domain-list VM1 query a activate
  clause 1 vip-group VM1 method round-robin ttl 20 count 1 sticky disable
  manual-reactivation disable activate
```

Note Caveat: CSCtn18346 - GSS 4492 running version 3.1(2) fails to boot up to "Normal Operation" or [runmode=5] and may be stuck in [runmode=0] when the “ip name-server” command is missing from the non-gslb configuration.

The *answer vip* configuration lines determine which answer the GSS will respond with when queried. As can be seen here, one is active and the other is suspended. The active entry is the one the GSS will respond with. The **manual-reactivation disable** command ensures the GSS automatically reverts to using the active answer when it returns to an online state.

From the GUI, the active and suspended entries can be monitored for both the primary and standby GSSM.

Figure 1-10 GSSM Monitoring



Note Further information about configuring the GSS device can be found in the following paper: http://www.cisco.com/en/US/docs/app_ntwk_services/data_center_app_services/gss4400series/v3.1/getting/started/guide/gss_gsgd.html

ACE

A separate ACE is deployed in each data center site. The ACE is connected to the aggregation layer devices leveraging a vPC connection.

Since the intent was not to test the load balancing aspect of the ACE module, the 8 server farms are configured with one VM per server farm. There is also one VIP per server farm as mentioned in the design guide document.

The example below represents a single VIP workflow when the VIP is located in DC1. The external VIP address for server 1 is 8.1.1.1. The GSS will resolve the DNS query to this address when the VM is in DC1. The internal address of the VM is 10.25.1.111, in this example. When the ACE receives traffic destined to the external address, it will change the destination address to the internal address based on the policy-maps defined for the type of traffic that you want to be handled by the ACE.

Example DC1 ACE VIP & Server Farm

```
rserver host VM1
  ip address 10.25.1.111
  inservice
serverfarm host SRV1
  rserver VM1
    inservice
class-map match-all VIP-SRV1
  2 match virtual-address 8.1.1.1 tcp any
policy-map type loadbalance first-match L4-POL-SRV1
```

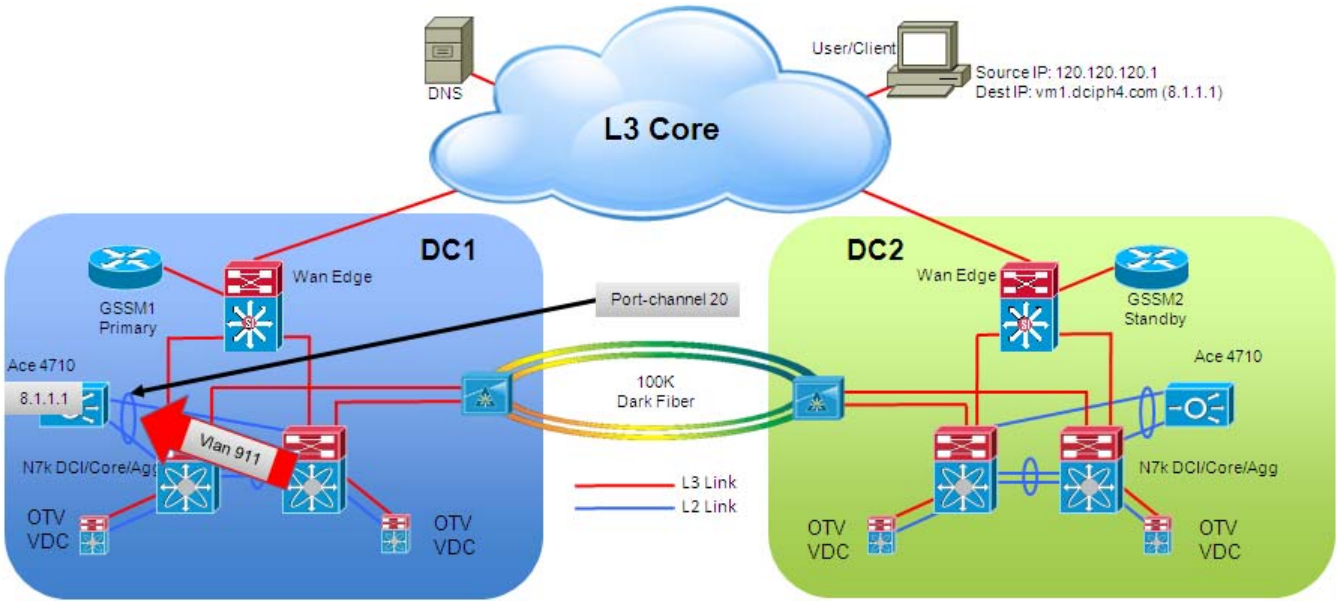
```
  class class-default
    serverfarm SRV1
policy-map multi-match VIP-MM-SRV
  class VIP-SRV1
    loadbalance vip inservice
    loadbalance policy L4-POL-SRV1
    loadbalance vip icmp-reply
    nat dynamic 1 vlan 2501
        inspect ftp
```

The ACE in DC1 is configured for L3 routing between the ACE and the Nexus 7000 aggregation switches for the client side flows. Since there is a port channel between the Nexus 7000 and the ACE to extend the server VLANs to the ACE, another VLAN is extended and configured for L3. The port-channel 20 and VLAN 911 are shown in Figure 1-11. A static default route on the N7K is used to send all server to client traffic across this VLAN. The service-policy is used on the client to server traffic so that the VIP addressing can be taken care of in the ACE.

Example DC1 ACE L3 Client Side VLAN

```
access-list ANY line 8 extended permit ip any any
interface vlan 911
  description Client side VLAN
  ip address 9.1.1.251 255.255.255.0
  access-group input ANY
  service-policy input VIP-MM-SRV
  no shutdown
ip route 0.0.0.0 0.0.0.0 9.1.1.254
```

Figure 1-11 ACE DC1 Client Side



In regards to the Nexus 7000 aggregation devices, the vPC is configured to trunk the server VLANs as well as the L3 VLAN to the ACE. The L3 VLAN is configured to have hsrp to allow for failover in case of a device failure. The VIP addresses are statically routed across the L3 VLAN interface.

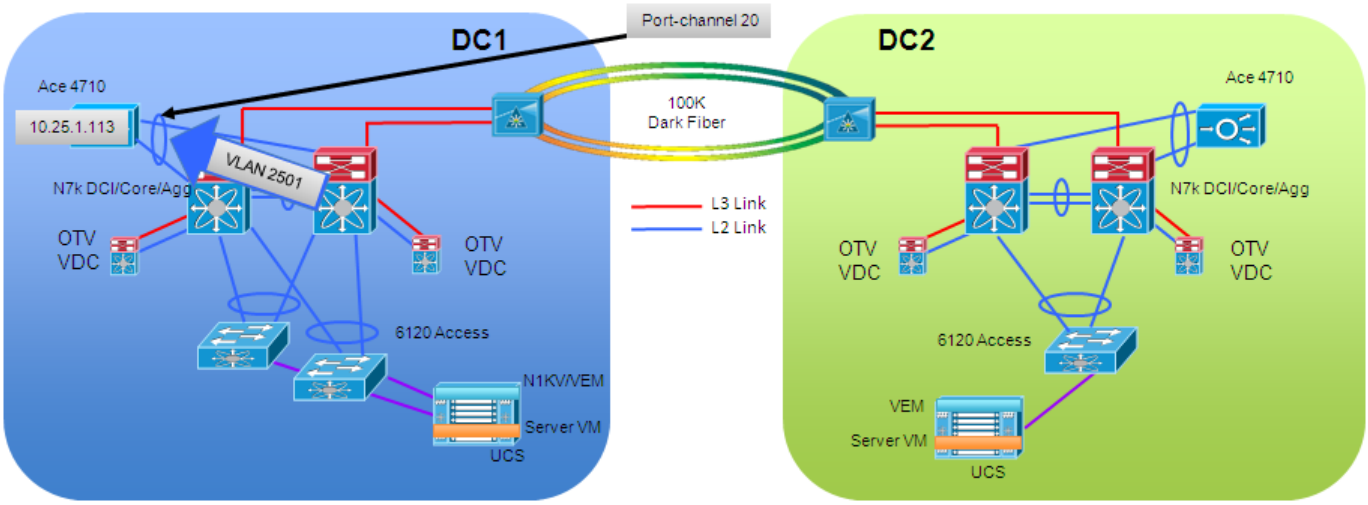
Example DC1 Nexus 7000 Client Side

```
interface port-channel20
```

```
  switchport
  switchport mode trunk
  switchport trunk allowed vlan 911,2501-2508
  spanning-tree port type normal
  spanning-tree guard root
  mtu 9216
  vpc 20
interface Vlan911
  no shutdown
  mtu 9216
  no ip redirects
  ip address 9.1.1.253/24
  ip ospf passive-interface
  ip router ospf 200 area 0.0.0.0
  ip pim sparse-mode
  hsrp 1
    preempt delay minimum 180 reload 300
    priority 253
    timers  1  3
    ip 9.1.1.254
ip route 8.1.1.0/24 9.1.1.251
```

Source NAT (S-NAT) functionality has been validated in the solution, to ensure stitching of egress traffic back to the ACE that received the original ingress flow.

Figure 1-12 ACE Server Side



The source IP is changed to an address identifying the ACE itself (10.25.1.113 in the example below) as the source of the traffic and the destination IP address, which was changed from the VIP address to the internal address in the example above, is left unchanged.

Example DC1 ACE Server Side VLAN

```
interface vlan 2501
  description Server side VLAN
  ip address 10.25.1.112 255.255.255.0
  access-group input ANY
  nat-pool 1 10.25.1.113 10.25.1.113 netmask 255.255.255.0 pat
  no shutdown
```

The ACE in DC2 is configured similarly. The server internal IP addresses are the same in the server farm since we are using OTV to L2 extend the server VLANs between DC1 and DC2. However the other IP addresses in the ACE need to be changed since they are specific to the ACE in each data center.

The VIP address needs to be different so a more direct path can be established to the site, avoiding the sub-optimal path across the DCI connection. In the example below is highlighted the change that needs to be made in the VIP configuration. The remainder of the configuration in the DC1 example is the same.

Example DC2 ACE VIP & Server Farm

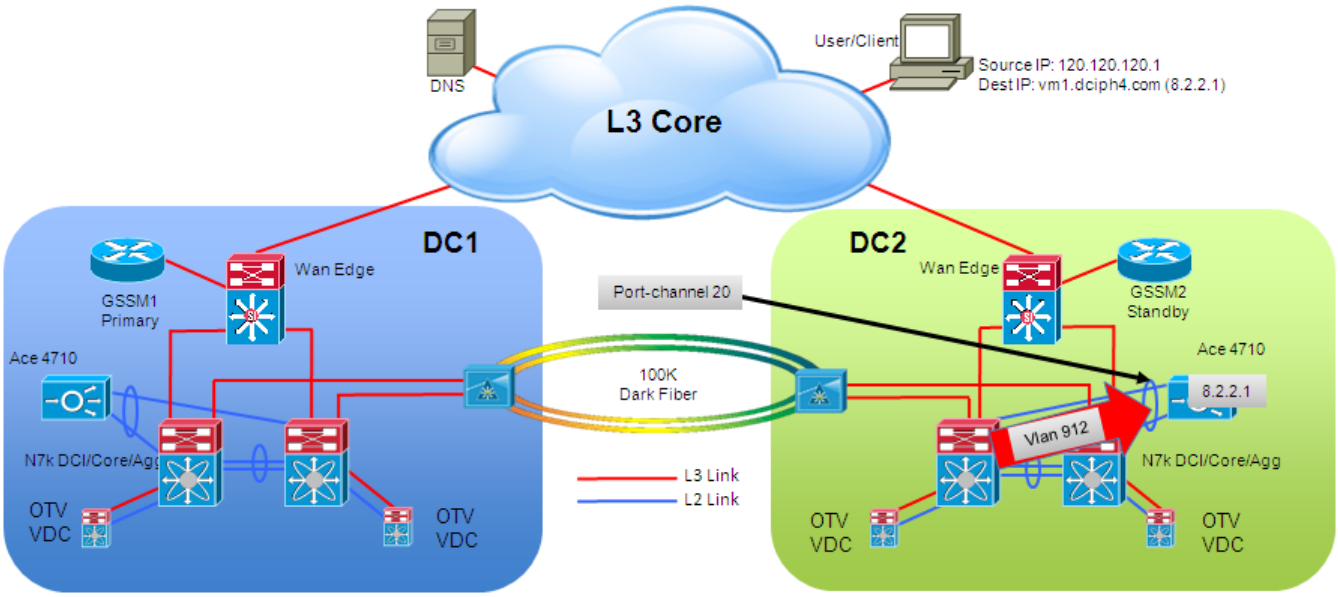
```
class-map match-all VIP-SRV1
  2 match virtual-address 8.2.2.1 tcp any
```

The ACE in DC2 is also configured for L3 routing between the ACE and the Nexus 7000 aggregation switches for the client side flows. A port-channel and static route, just as in DC1, are similarly configured.

Example DC2 ACE L3 Client Side VLAN

```
access-list ANY line 8 extended permit ip any any
interface vlan 921
  description Client side VLAN
  ip address 9.2.1.251 255.255.255.0
  access-group input ANY
  service-policy input VIP-MM-SRV
  no shutdown
ip route 0.0.0.0 0.0.0.0 9.2.1.254
```

Figure 1-13 ACE DC2 Client Side



The Nexus 7000 aggregations devices are also configured as in DC1, with the changes to the VIP address.

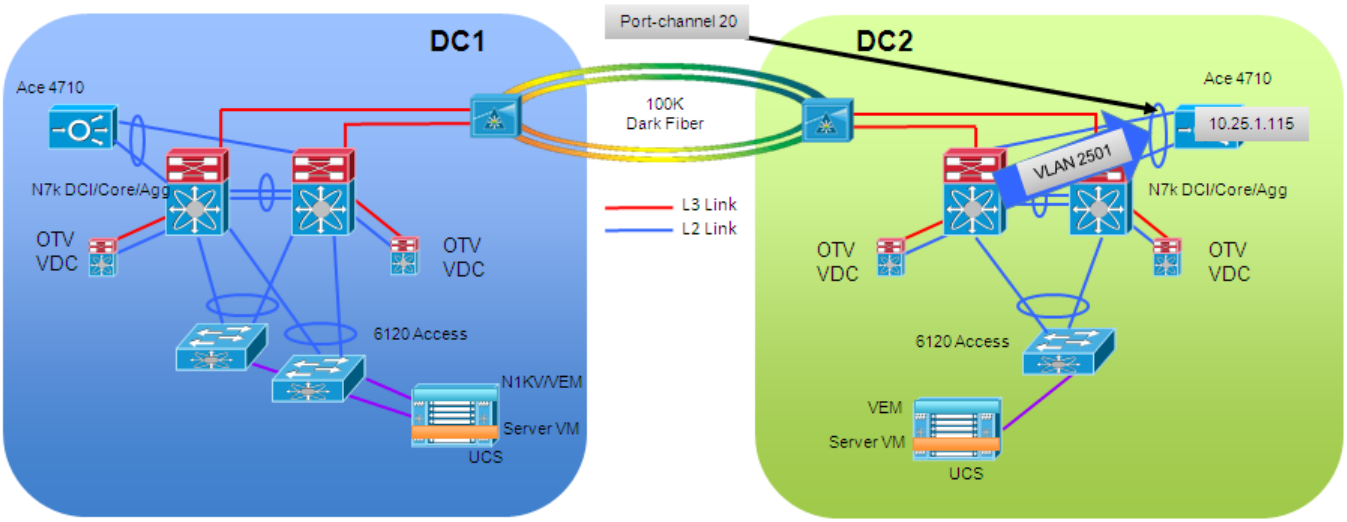
Example DC2 Nexus 7000 L3 Client Side VLAN

```
interface Vlan921
  no shutdown
  mtu 9216
```

```
  no ip redirects
  ip address 9.2.1.253/24
  ip ospf passive-interface
  ip router ospf 200 area 0.0.0.0
  ip pim sparse-mode
  hsrp 1
    preempt delay minimum 180 reload 300
    priority 253
    timers  1  3
    ip 9.2.1.254
ip route 8.2.2.0/24 9.2.1.251
```

The SNAT configuration for the DC2 ACE is slightly different from the DC1 ACE. As in the case of the DC1 ACE, the source IP address is changed to the address identifying the ACE itself.

Figure 1-14 ACE DC2 Server Side



Since the ACE in DC1 is being identified as 10.25.1.113, in the example, a different address needs to be chosen for the ACE in DC2. In the example below, 10.25.1.115 is being used.

Example DC2 ACE Server Side VLAN

```
interface vlan 2501
  description Server side VLAN
  ip address 10.25.1.114 255.255.255.0
  access-group input ANY
  nat-pool 1 10.25.1.115 10.25.1.115 netmask 255.255.255.0 pat
  no shutdown
```

The default load balancing method for the ACE is src-dest-port. To simplify the flows for troubleshooting purposes, the method was changed to src-dest-ip. This matches the method on the Nexus 7000.

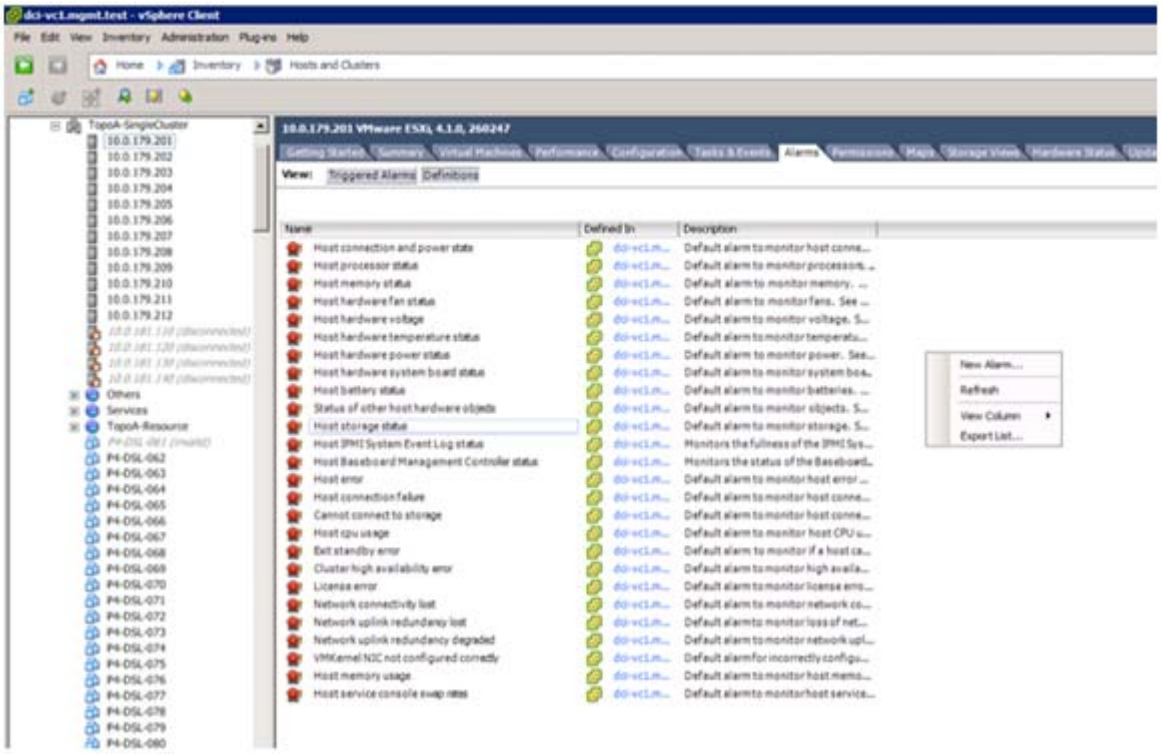
vCenter integration

vCenter is intimately involved in the vMotion process for the servers. When a workload mobility event is required, it is initiated from the vCenter GUI or via API calls to the vCenter via scripts.

Once the vCenter completes the vMotion event for each server, vCenter needs to change the GSS GSLB configuration such that the GSS answers the DNS queries with the new location of the VM. This is accomplished by configuring an alarm for each VM to be triggered once the vMotion completes in vCenter. This alarm then runs a TCL script that updates the GSS device.

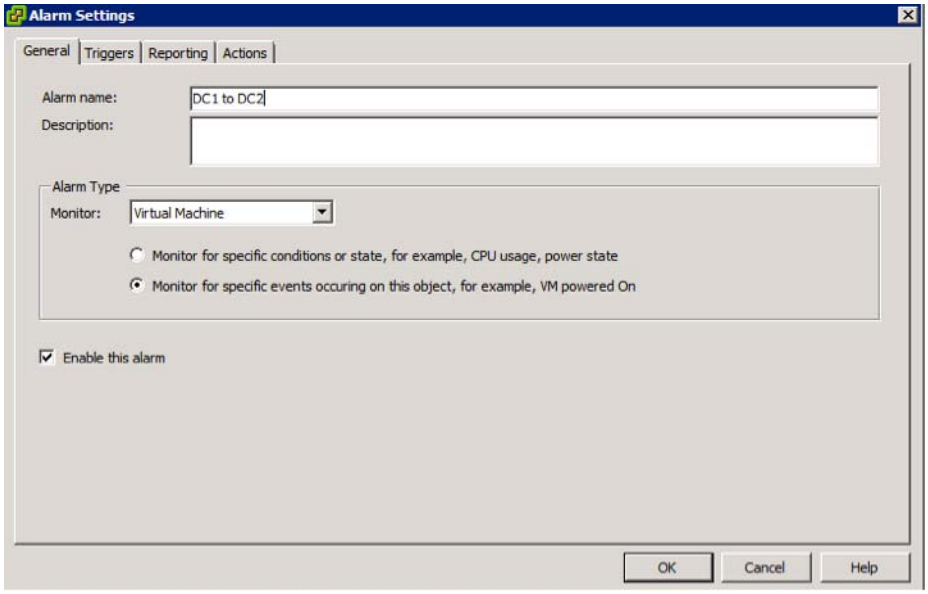
The alarms must be configured for each VM and for each direction, DC1 to DC2 and DC2 to DC1. Starting on the alarms tab definitions view for the VM in vCenter, right click in the window and select *New Alarm*.

Figure 1-15 vCenter New Alarm



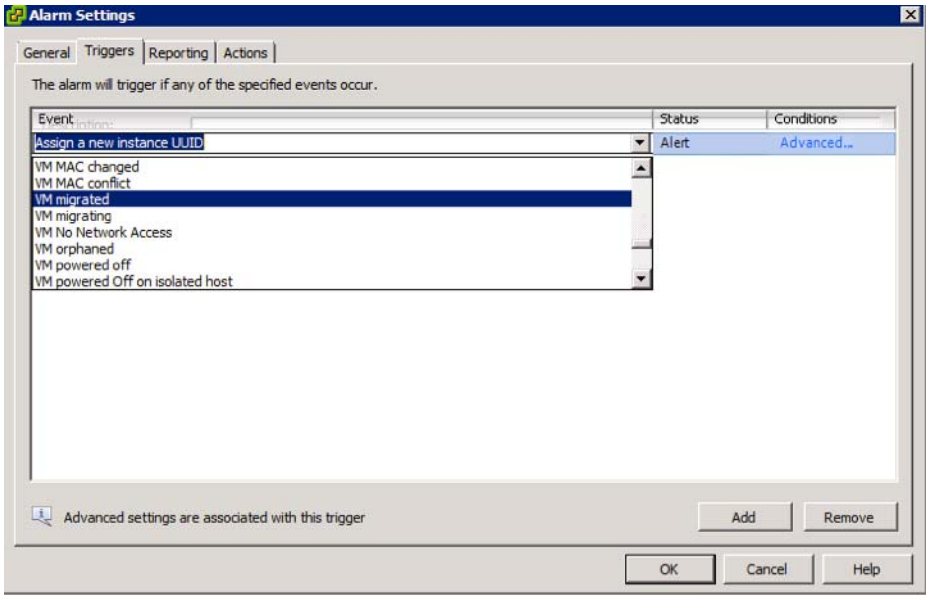
In the alarm settings dialog box on the general tab, type an alarm name and select alarm type *Monitor for specific events occurring on this object*.

Figure 1-16 Settings General Tab



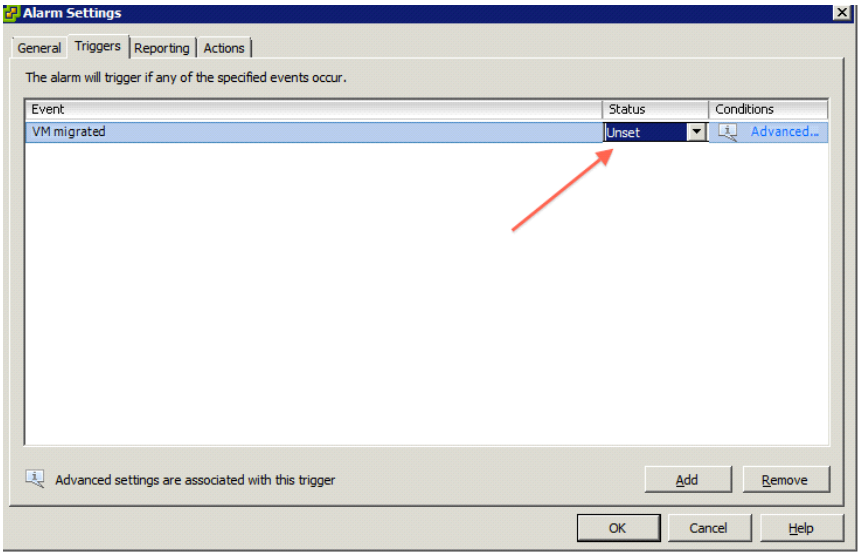
Click the *Triggers* tab and add a trigger. Initially it will be *Assign a new instance UUID* (in vCenter 4.1). Click twice on the event name and a drop down box will appear. Change the event to *VM migrated*.

Figure 1-17 Alarm Settings Triggers



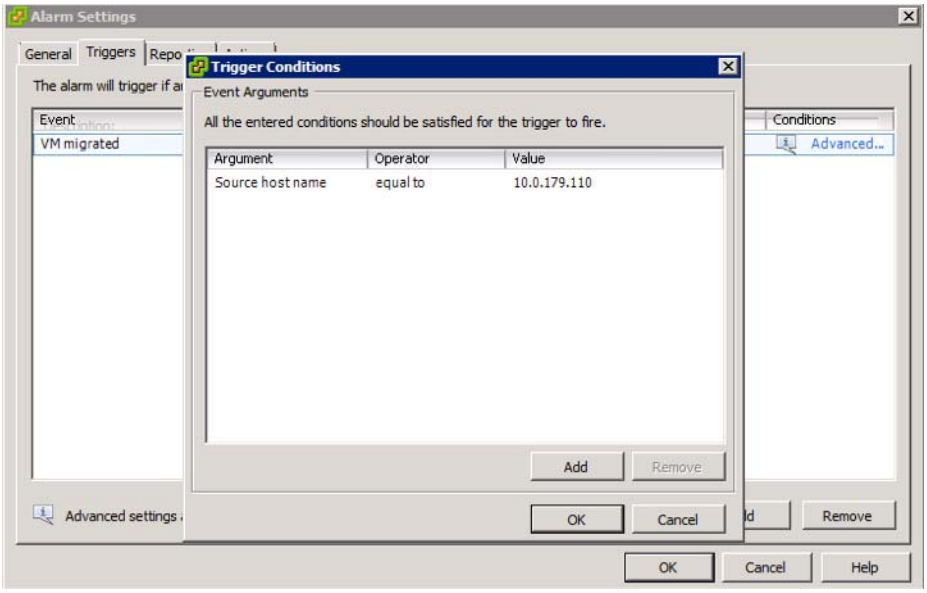
When configuring the triggers under the alarms settings, for the VM migrated event, you should configure the status to *Unset*. Without this setting, the event will not be triggered on a second migration, unless the user acknowledges the first alarm.

Figure 1-18 vCenter Alarm Unset



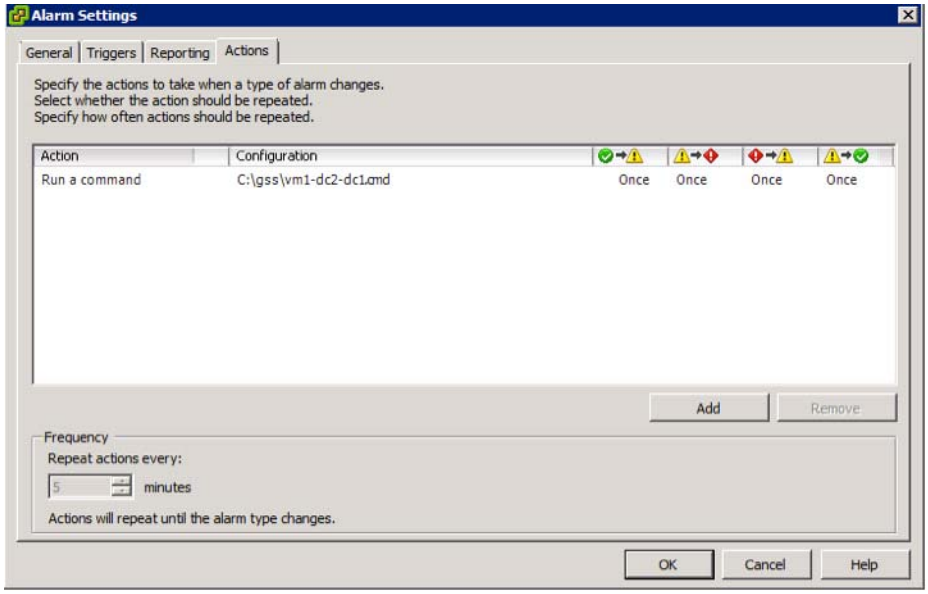
Since each alarm has to be directional, we must configure an advanced condition for the source host name, ie the ESXi host the VM is moving from. Click the Advanced link on the condition column to bring up the Trigger Conditions dialog box. Add a trigger condition and select *Source host name* and put in the ESXi host name the VM will be on when it starts the vMotion process.

Figure 1-19 Trigger Conditions



Next the action must be configured. Click the *Actions* tab and then add an action. Using the dropdown, change the action to *Run a command*. When the alarm is triggered, the action *run a command* is initiated on the vCenter machine. The command configuration is a local command file on the vCenter. This was required because the command call in vCenter does not allow parameters to be passed to the script being called. Therefore a specific command file is required for each VM and direction.

Figure 1-20 Alarm Actions



The command file is located in a directory on the vCenter server and contains a call to the tclsh application to read and evaluate the TCL script to change which VIP address is active in the GSS.

Example Command File Contents

```
C:\Tcl\bin\tclsh.exe c:\gss\gss.tcl P4-SQL-Server-1 DC1-2
```

The TCL script is also located on the vCenter server. The TCL script accepts the arguments of vmName and data center. The vmName is used to determine which lines of the GSS GSLB to change so that the GSS will answer the DNS query with the correct IP address once moved. The data center argument is used to specify direction of the move. The script can be changed to handle multiple VM servers. Only 2 servers are shown in the example for simplicity.

Example TCL script

```
# load the Expect package into Tcl
package require Expect
if {$argc != 2} {
    puts "Usage: tclsh85 $argv0 <vmName> <datacenter>"
    puts "Datacenter options are: DC1-2 DC2-1"
    exit 0
}
#### Configuration Options ########################################
set gssIP "10.0.183.39"
set gssUser "admin"
set gssPass "default"
set gssEnable "default"
array set serverIP {
    P4-SQL-Server-1,DC1 "8.1.1.1"
    P4-SQL-Server-1,DC2 "8.2.2.1"
    P4-SQL-Server-2,DC1 "8.1.1.2"
    P4-SQL-Server-2,DC2 "8.2.2.2"
}
      array set vipName {
    P4-SQL-Server-1,DC1 "VM1-DC1"
    P4-SQL-Server-1,DC2 "VM1-DC2"
    P4-SQL-Server-2,DC1 "VM2-DC1"
```

```
    P4-SQL-Server-2,DC2 "VM2-DC2"
}
#### End Configuration Options ######################################
set vm [lindex $argv 0]
set dc [lindex $argv 1]
set killscript 0
set varList [list serverIP($vm,DC1) serverIP($vm,DC2) vipName($vm,DC1) vipName($vm,DC2)]
foreach var $varList {
    if {![info exists $var]} {
        set $killscript 1
        puts "ERROR: Variable \"$var\" does not exist."
    }
}
if {$killscript} {
    exit 1
}
# telnet into GSS
spawn telnet $gssIP
expect "Cisco GSS"
expect "login:"
send "$gssUser\r"
expect "Password:"
send "$gssPass\r"
expect ">"
send "enable\r"
expect "Password:"
send "$gssEnable\r"
expect "#"
send "config term\r"
expect "#"
send "gslb\r"
if {[string equal $dc "DC1-2"]} {
     send "answer vip $serverIP($vm,DC1) name $vipName($vm,DC1) manual-reactivation
disable suspend\r"
     expect "#"
     send "answer vip $serverIP($vm,DC2) name $vipName($vm,DC2) manual-reactivation
disable activate\r"
     expect "#"
} elseif {[string equal $dc "DC2-1"]} {
     send "answer vip $serverIP($vm,DC2) name $vipName($vm,DC2) manual-reactivation
disable suspend\r"
     expect "#"
     send "answer vip $serverIP($vm,DC1) name $vipName($vm,DC1) manual-reactivation
disable activate\r"
     expect "#"
} else {
    puts "ERROR: Invalid argument for datacenter. Expect \"DC1-2\" or \"DC2-1\"."
}
send "end\r"
expect "#"
send "exit\r"
expect ">"
send "exit\r"
expect eof
exit 0
```

Server Virtualization

Server virtualization decouples applications deployment from physical server purchases. When servers are configured into virtualization pools, a data center becomes a dynamic entity in which resources are used efficiently, and the allocation of virtual machines to physical servers can be adjusted dynamically to best balance efficiency and performance. And when these virtual machines need to be moved, network persistence, security and storage compliance need to be considered.

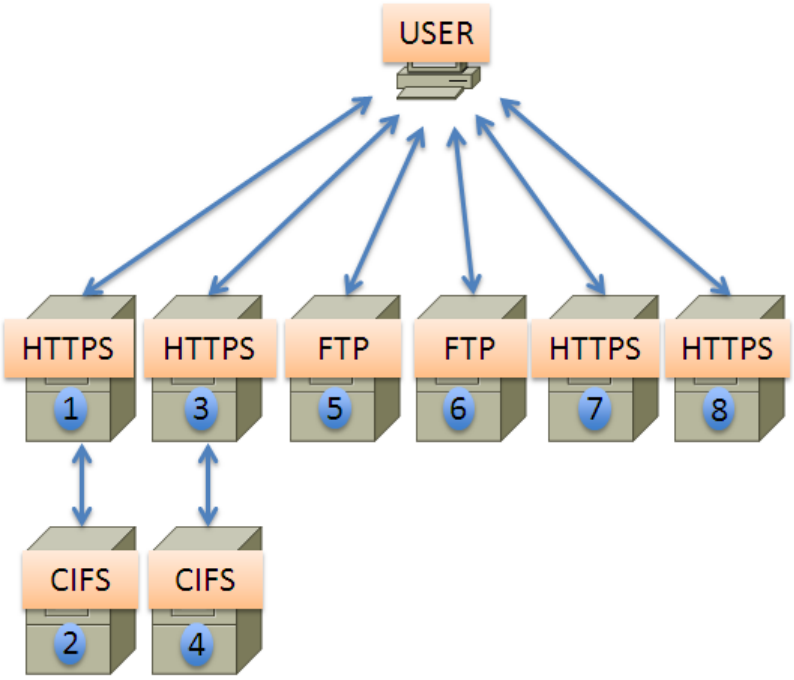
Virtual Machine Deployment

The applications servers used in the testing were deployed across multiple ESXi hosts in the data center. The test topology consisted of one UCS Chassis in DC1 with 4 blade servers and another UCS chassis in DC2 with 4 blade servers. There was also 12 other non-UCS ESXi servers deployed in DC2 to give a total of 20 ESXi hosts for the topology.

FTP, HTTPS, and CIFS were used as applications for testing purposes. VM server pairs 1-2 and 3-4 were configured in a 2-tier model. VM servers 1 and 3 were configured as web servers for HTTPS traffic. VM servers 2 and 4 were configured to provide CIFS file sharing to servers 1 and 3, respectively. When the client requests a file from server 1, it would need to use the CIFS file-share to get the actual file on server 2 and then send the file to the client. The same setup was used for servers 3 and 4.

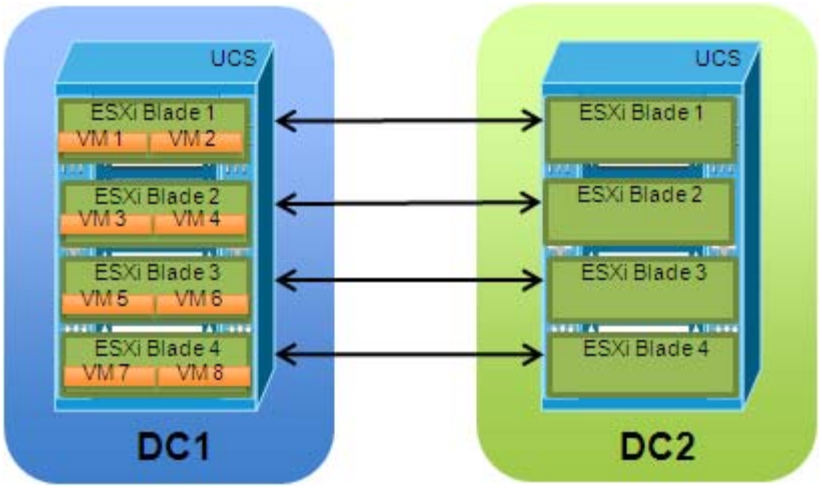
VM Servers 5 thru 8 were deployed in a single tier model. VM servers 5 and 6 were configured as FTP servers. VM servers 7 and 8 were configured as webservers for HTTPS without using the CIFS file-share.

Figure 1-21 VM server Tiers



These 8 servers were deployed in pairs on each of the 4 UCS server blades in DC1, initially. When moving the servers to DC2, they would be moved to the corresponding UCS blade in DC2 while maintaining the same deployment model. The same was true for DC2 to DC1 operations as well.

Figure 1-22 ESXi VM Server Placement and Movement



There were 32 Windows XP VMs and 960 Linux VMs also on the network during testing and were mostly used to create vethernet ports on the Nexus 1000V. The 992 VMs were deployed between the 20 ESX servers and were not directly used for the workload mobility tests.

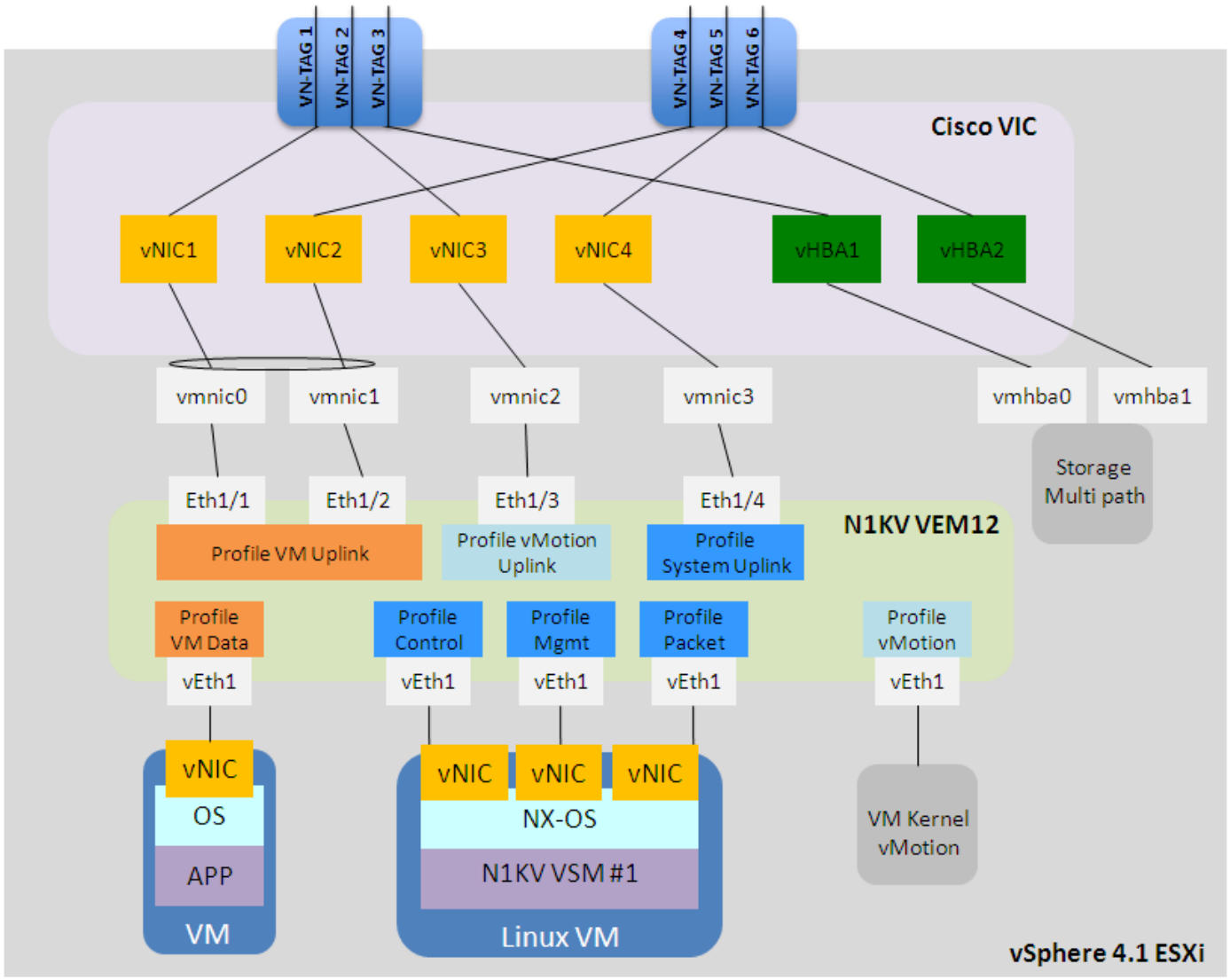
Nexus 1000V

Nexus 1000V allows the policy configuration to move with a virtual machine during live migration, ensuring persistent network, security, and storage compliance, resulting in improved business continuance, performance management, and security compliance. Another goal of the testing is to allow the deployment of the Nexus 1000V Distributed Virtual Switch (DVS) in a stretched fashion between physical data center sites. This can be achieved independently from the specific ESXi cluster deployment. This means that the VEM modules forming a given Nexus 1000V switch can be deployed on ESXi hosts belonging to separate ESXi clusters or to a single stretched cluster.

The Nexus 1000V is deployed in a stretched fashion between the physical data centers. When deploying the VSMs, it is required that the active and standby VSM be deployed into the same physical data center. It is also recommended to deploy them on separate ESXi hosts, to enhance the redundancy.

For testing, the VSMs are deployed in DC1 on separate ESXi hosts. L3 is the chosen transport mode for the control traffic between the VSM and VEMs.

Figure 1-23 ESXi 4.1 Deployment with Nexus 1000V on Cisco UCS



To configure the Nexus 1000V into L3 transport mode, the *svs mode* must be set to L3 under the *svs-domain*. The control and packet VLAN that is configured under the svs-domain is then ignored. Once configured, the system creates a control0 interface. The IP address on this interface is the IP address of the VSM. It needs to be on one of the l3 control VLANs described later in this section.

Example L3 Transport Mode

```
svs-domain
  domain id 1
  control vlan 1
  packet vlan 1
  svs mode L3 interface control0
interface control0
  ip address 10.0.181.10/24
```

Since there are 2 data centers, you need 2 separate VLANs trunked on the system uplink ports for this purpose. It is worth noticing that the VSM used to manage the various VEMs was deployed as a virtual machine connected to the same VEM module it needs to manage. Since that is the case, these VLANs

must be configured as system VLANs under the system uplink port-profile, SystemMgmt in the example below. On initial booting of the ESXi hosts, the VEM will bring up and forward on those system VLANs before it has the full configuration downloaded from the VSM, thus preventing a potential "chicken-and-egg" situation.

Example System uplinks

```
port-profile type ethernet SystemMgmt
  vmware port-group
  switchport mode trunk
  switchport trunk allowed vlan 179,181,2562-2563
  no shutdown
  system vlan 179,181
  state enabled
```

During testing, VLAN 179 is used in DC2 and VLAN 181 is used in DC1 for the L3 control VLANs. This means that the VSMs and VEMs that reside in DC1 will be on VLAN 181 and the VEMs that are in DC2 will be on VLAN 179.On the port profiles of these VLANs, you must configure *capability l3control*. This informs the Nexus 1000V which profile to use for L3 control traffic. You must also configure **system vlan** under these port profiles as well.

Example L3 Control

```
port-profile type vethernet l3control_179
  capability l3control
  vmware port-group
  switchport access vlan 179
  switchport mode access
  no shutdown
  system vlan 179
  description DC1 L3 Control Vlan 179
  state enabled
port-profile type vethernet l3control_181
  capability l3control
  vmware port-group
  switchport access vlan 181
  switchport mode access
  no shutdown
  system vlan 181
  description DC2 L3 Control Vlan 181
  state enabled
```

It is important to keep in mind that VLAN 181 where the active/standby VSMs are deployed in DC1 needs to be extended across the DCI connection to exist also in DC2. This is to allow these virtual machines network connectivity once the vMotion process is completed, in the case of a VSM migration event. This is required independently from the transport type (L2 or L3) used for control plane communication between the active VSM and the distributed VEMs.

The interfaces part of the "VM Uplink" port profile is configured as part of a port-channel. The interesting point is that each virtual interface part of this bundle is actually connected to an independent upstream Fabric Interconnect device. In order for this to work, it is required to configure the Nexus 1000V to operate in vPC Host Mode (vPC-HM). To configure the Nexus 1000V, the *mac-pinning* option should be used on the *channel-group* configuration. Refer to the following example.

Example Nexus 1000V vPC-HM

```
port-profile type ethernet VMtraffic
  vmware port-group
  switchport mode trunk
  switchport trunk allowed vlan 2501-2556
  channel-group auto mode on mac-pinning
```

```
  no shutdown
  description all vm traffic
  state enabled
```

Another aspect of the workload mobility use case is the ability of the Nexus 1000V to move the port profiles when the VMs are moved from one data center to another. Comparing the configuration before and after the moves, we are able to see that the port profiles are moved, including any of the features enabled on them.

To determine which virtual ethernet interface is assigned to which VM, use the **show interface virtual** command. Looking at P4-SQL-Server-5 for example, we see that the vethernet is 10 and the module is 5. The module is the Virtual Ethernet Module (VEM) that is configured on the ESXi host when the N1KV is deployed and represents a virtual linecard to the Nexus 1000V. The module number 5 was assigned to 10.0.182.130 when the VEM was powered on and registered with the VSM.

Example Show Virtual Interface Before vMotion

```
--------------------------------------------------------------------------------
Port        Adapter        Owner                     Mod Host
--------------------------------------------------------------------------------
Veth1       vmk1           VMware VMkernel           5   10.0.182.130
Veth2       vmk1           VMware VMkernel           4   10.0.182.140
Veth3       vmk2           VMware VMkernel           5   10.0.182.130
Veth4       vmk0           VMware VMkernel           3   10.0.182.120
Veth5       vmk1           VMware VMkernel           3   10.0.182.120
Veth6       vmk0           VMware VMkernel           5   10.0.182.130
Veth7       vmk2           VMware VMkernel           3   10.0.182.120
Veth8       vmk0           VMware VMkernel           4   10.0.182.140
Veth9       vmk2           VMware VMkernel           4   10.0.182.140
Veth10      Net Adapter 1  P4-SQL-Server-5           5   10.0.182.130
Veth11      Net Adapter 1  P4-Other-017              5   10.0.182.130
Veth12      Net Adapter 1  P4-Other-018              5   10.0.182.130
Veth13      Net Adapter 1  P4-Other-019              5   10.0.182.130
Veth14      Net Adapter 1  P4-Other-020              5   10.0.182.130
Veth15      Net Adapter 2  P4-SQL-Server-5           5   10.0.182.130
Veth16      Net Adapter 2  P4-SQL-Server-6           5   10.0.182.130
```

Note VM names > 27 characters will be truncated when sent to the Nexus 1000V. For more information, consult the VMware web site http://www.vmware.com

Taking a look at the **show port-profile** command before the workload mobility, the port-profile VMNetwork_2505_isolated is where vethernet 10 assigned.

Example Show Port-Profile Before vMotion

```
port-profile VMNetwork_2505_isolated
 type: Vethernet
 description: VLAN2505 isolation ports
 status: enabled
 max-ports: 32
 inherit:
 config attributes:
  switchport mode private-vlan host
  ip port access-group vm-acl in
  service-policy output vm-qos
  switchport private-vlan host-association 2505 1505
  switchport port-security
  switchport port-security violation protect
  no shutdown
 evaluated config attributes:
  switchport mode private-vlan host
```

```
  ip port access-group vm-acl in
  service-policy output vm-qos
  switchport private-vlan host-association 2505 1505
  switchport port-security
  switchport port-security violation protect
  no shutdown
 assigned interfaces:
  Vethernet10
 port-group: VMNetwork_2505_isolated
 system vlans: none
 capability l3control: no
 capability iscsi-multipath: no
 port-profile role: none
 port-binding: static
```

This output verifies that the features enabled on this port profile govern the server attached to vethernet 10.

One of the features tested was private-vlans. Using the **show vlan private-vlan** command, it is shown that vethernet 10 is using 2505 isolated.

Example Show vlan private-vlan Before vMotion

```
Primary  Secondary  Type             Ports
-------  ---------  ---------------  ----------------------------------
2505     1505       isolated         Po1, Po2, Po3, Po4,
                                     Po5, Po6, Po7, Po8,
                                     Po9, Po10, Po11, Po12,
                                     Po13, Po14, Po15, Po16,
                                     Po17, Po18, Po19, Po20,
                                     Veth10, Eth3/4, Eth3/5, Eth4/4,
                                     Eth4/5, Eth5/4, Eth5/5, Eth6/4,
                                     Eth6/5, Eth7/4, Eth7/5, Eth8/4,
                                     Eth8/5, Eth9/4, Eth9/5, Eth10/4,
                                     Eth10/5, Eth11/2, Eth12/2, Eth13/2,
                                     Eth15/2, Eth16/2, Eth17/2, Eth18/2,
                                     Eth19/2, Eth20/2, Eth21/2, Eth22/2,
                                     Eth23/2
```

Once the workload mobility has completed, notice that vethernet 10 is now located on module 9.

Example Show Virtual Interface After vMotion

```
--------------------------------------------------------------------------
Port         Adapter         Owner                     Mod Host
--------------------------------------------------------------------------
Veth1        vmk1            VMware VMkernel           5   10.0.182.130
Veth2        vmk1            VMware VMkernel           4   10.0.182.140
Veth3        vmk2            VMware VMkernel           5   10.0.182.130
Veth4        vmk0            VMware VMkernel           3   10.0.182.120
Veth5        vmk1            VMware VMkernel           3   10.0.182.120
Veth6        vmk0            VMware VMkernel           5   10.0.182.130
Veth7        vmk2            VMware VMkernel           3   10.0.182.120
Veth8        vmk0            VMware VMkernel           4   10.0.182.140
Veth9        vmk2            VMware VMkernel           4   10.0.182.140
Veth10       Net Adapter 1   P4-SQL-Server-5           9   10.0.180.130
Veth11       Net Adapter 1   P4-Other-017              5   10.0.182.130
Veth12       Net Adapter 1   P4-Other-018              5   10.0.182.130
Veth13       Net Adapter 1   P4-Other-019              5   10.0.182.130
Veth14       Net Adapter 1   P4-Other-020              5   10.0.182.130
Veth15       Net Adapter 2   P4-SQL-Server-5           9   10.0.180.130
Veth16       Net Adapter 2   P4-SQL-Server-6           9   10.0.180.130
```

Module 9 is what was assigned to 10.0.180.130 when the VEM was powered on and registered with the VSM.

Checking the **show port-profile** command once again, verify that vethernet 10 is still associated.

Example Show Port-Profile After vMotion

```
port-profile VMNetwork_2505_isolated
 type: Vethernet
 description: VLAN2505 isolation ports
 status: enabled
 max-ports: 32
 inherit:
 config attributes:
  switchport mode private-vlan host
  ip port access-group vm-acl in
  service-policy output vm-qos
  switchport private-vlan host-association 2505 1505
  switchport port-security
  switchport port-security violation protect
  no shutdown
 evaluated config attributes:
  switchport mode private-vlan host
  ip port access-group vm-acl in
  service-policy output vm-qos
  switchport private-vlan host-association 2505 1505
  switchport port-security
  switchport port-security violation protect
  no shutdown
 assigned interfaces:
  Vethernet10
 port-group: VMNetwork_2505_isolated
 system vlans: none
 capability l3control: no
 capability iscsi-multipath: no
 port-profile role: none
 port-binding: static
```

Verifying the **show vlan private-vlan** command, it is shown that vethernet 10 is still using 2505 isolated.

Example Show vlan private-vlan After vMotion

```
Primary  Secondary  Type              Ports
-------  ---------  ---------------   ----------------------------------
2505     1505       isolated          Po1, Po2, Po3, Po4,
                                      Po5, Po6, Po7, Po8,
                                      Po9, Po10, Po11, Po12,
                                      Po13, Po14, Po15, Po16,
                                      Po17, Po18, Po19, Po20,
                                      Veth10, Eth3/4, Eth3/5, Eth4/4,
                                      Eth4/5, Eth5/4, Eth5/5, Eth6/4,
                                      Eth6/5, Eth7/4, Eth7/5, Eth8/4,
                                      Eth8/5, Eth9/4, Eth9/5, Eth10/4,
                                      Eth10/5, Eth11/2, Eth12/2, Eth13/2,
                                      Eth15/2, Eth16/2, Eth17/2, Eth18/2,
                                      Eth19/2, Eth20/2, Eth21/2, Eth22/2,
                                      Eth23/2
```

During testing with port-security configured on the Nexus 1000V, there were occasional problems with traffic being blocked after a vMotion on some of the Microsoft Windows 2008 servers. It was found that on occasion, the Windows server would report the incorrect MAC address to the Nexus 1000V in the form of 0000.0000.MACA as seen in this example:

Example MAC Issue

```
TopoB-N1kv# show port-security address int vethernet 19
                    Secure Mac Address Table
------------------------------------------------------------------------
Vlan    Mac Address             Type             Ports      Configured Age
                                                                (mins)
----    -----------             ------           -----      ---------------
1506    0000.0000.0408          DYNAMIC          Vethernet19       0
1506    0050.56A9.0408          DYNAMIC          Vethernet19       0
------------------------------------------------------------------------
```

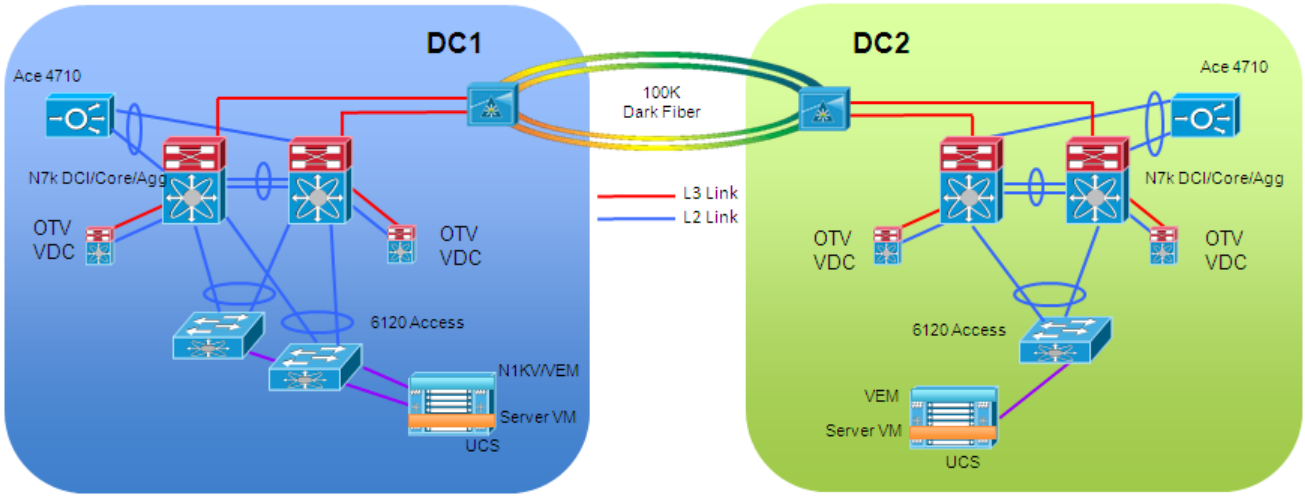
Notice how the last section is the same as the "real" MAC address. Because the default port-security max secure address list is set to 1, the Nexus 1000V does not allow the "real" MAC address to register itself in the secure address list after the bogus one already has registered. After this occurs, that Windows 2008 server cannot communicate with the outside world thus interrupting traffic.

A defect (CSCto11322) points to a possible problem with the Windows 2000 driver in conjunction with the E1000 network adapter used on the VMs. The problem is mostly sporadic; the defect mentioned numerous power cycles before the issue could be reproduced. To alleviate this issue in testing, the number of allowed port-security MAC addresses was raised to 2.

UCS 6100 to Nexus 7000 connectivity

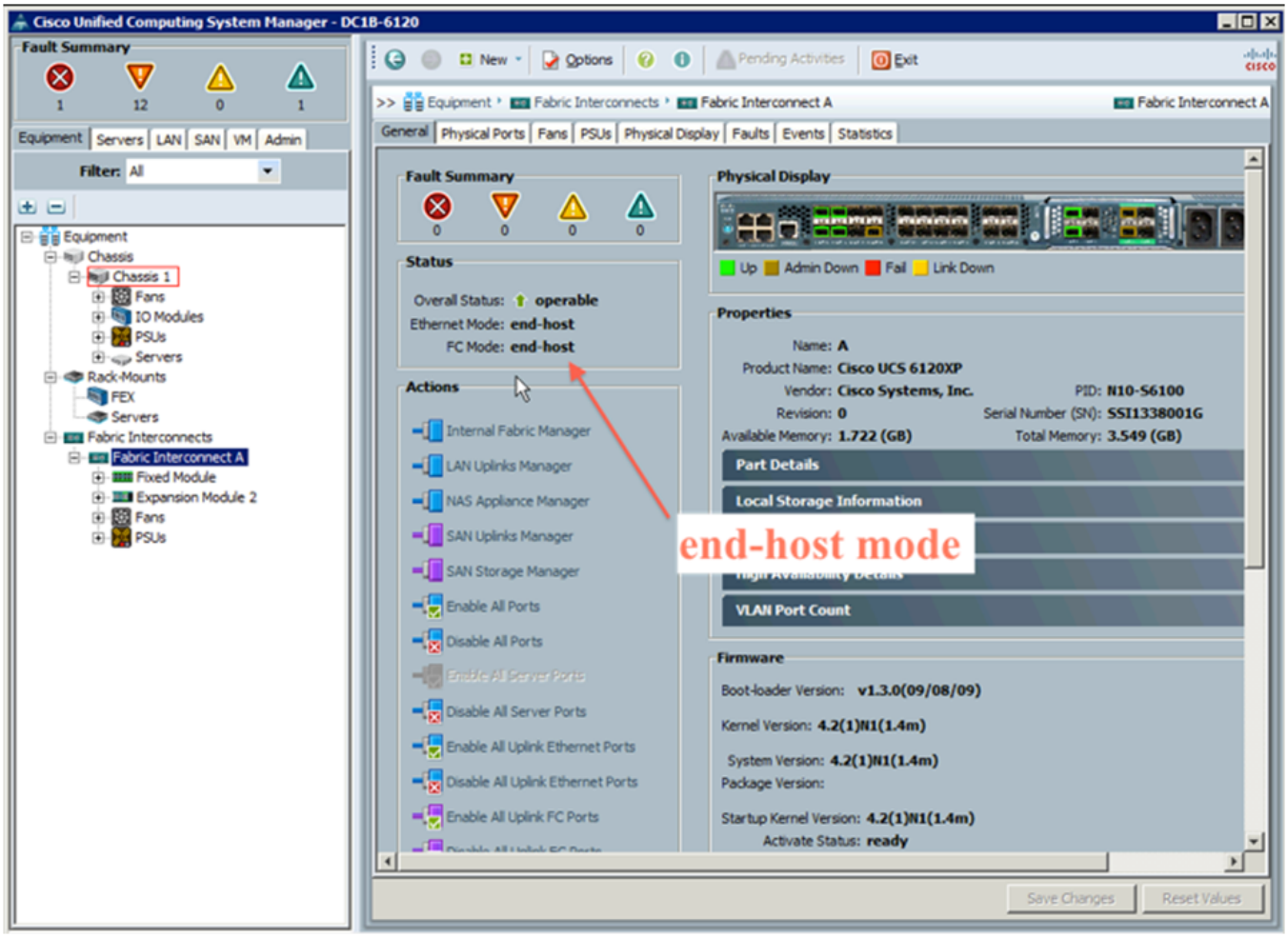
The Cisco Unified Computing System (UCS) allows for the establishment of a server farm architecture that enables system resources to be allocated dynamically and flexibly to meet individual virtual machine requirements within a common, consistent resource pool.

Figure 1-24 6100 to Nexus 7000 Connections



The 6100 Fabric Interconnect devices are deployed in end-host mode, which represents the recommended option when compared to the switch mode of operation. The 6100 is connected to the pair of Nexus 7000 using a vPC configuration. This provides load balancing and redundancy from the 6100 to the rest of the network.

Figure 1-25 6100 End Host Mode



Initially the topology was configured to have one interface from the 6100 to the management network and another interface the test topology. While testing, however, it was noticed that some MAC addresses were not being learned on the Nexus 1000V.

It was determined that the topology configuration was creating a disjointed L2 domain. In the tested release of code (4.2(1)N1(1.4m)), disjointed L2 domains are not supported.

Note Use the following white paper to explore 6100 connectivity options: http://www.cisco.com/en/US/prod/collateral/switches/ps9441/ps9402/white_paper_c11-623265.html - wp9000099

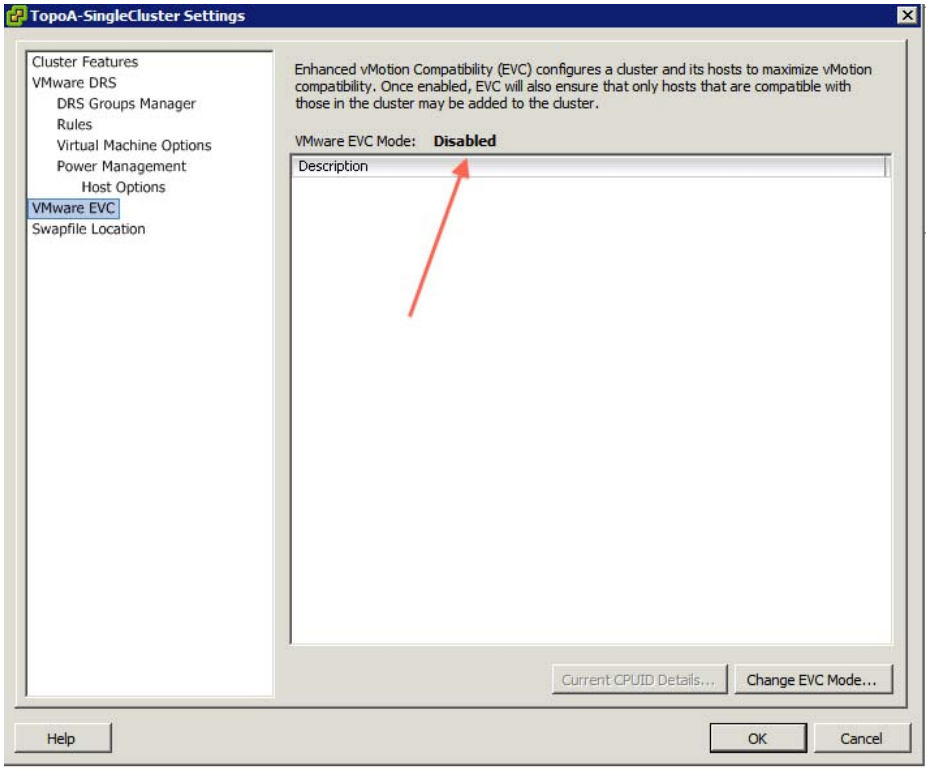
vCenter/ESXi

Each ESXi host that is managed by vCenter that is to be used for workload VMs should have a VMKernel interface configured for vMotion traffic. This interface is configured on a VLAN that is also extended between the data centers. Even though vMotion traffic is TCP based and a vMotion over L3 will work, VMware currently only supports L2 based vMotion events.

Enhanced vMotion Compatibility (EVC) simplifies vMotion compatibility issues across CPU generations. EVC automatically configures server CPUs with Intel FlexMigration or AMD-V Extended Migration technologies to be compatible with older servers.

After EVC is enabled for a cluster in the vCenter inventory, all hosts in that cluster are configured to present identical CPU features and ensure CPU compatibility for vMotion. The features presented by each host are determined by selecting a predefined EVC baseline. vCenter does not permit the addition of hosts that cannot be automatically configured to be compatible with the EVC baseline. For testing purposes, there was a mix of Intel-based and AMD-based ESXi hosts in the same cluster. However, some of these hosts were not compatible with the EVC baseline. When this is the case, you must have Enhanced vMotion Compatibility (EVC) disabled for the cluster.

Figure 1-26 EVC Disabled



Note For more information about Enhanced vMotion Compatibility, refer to VMware's website. http://kb.vmware.com/selfservice/microsites/search.do?language=en_US&cmd=displayKC&externalId=1003212

During testing, a script was used to schedule the workload mobility events in vCenter. After the daylight savings time change, we noticed that the scheduling was off by about 1 hour.

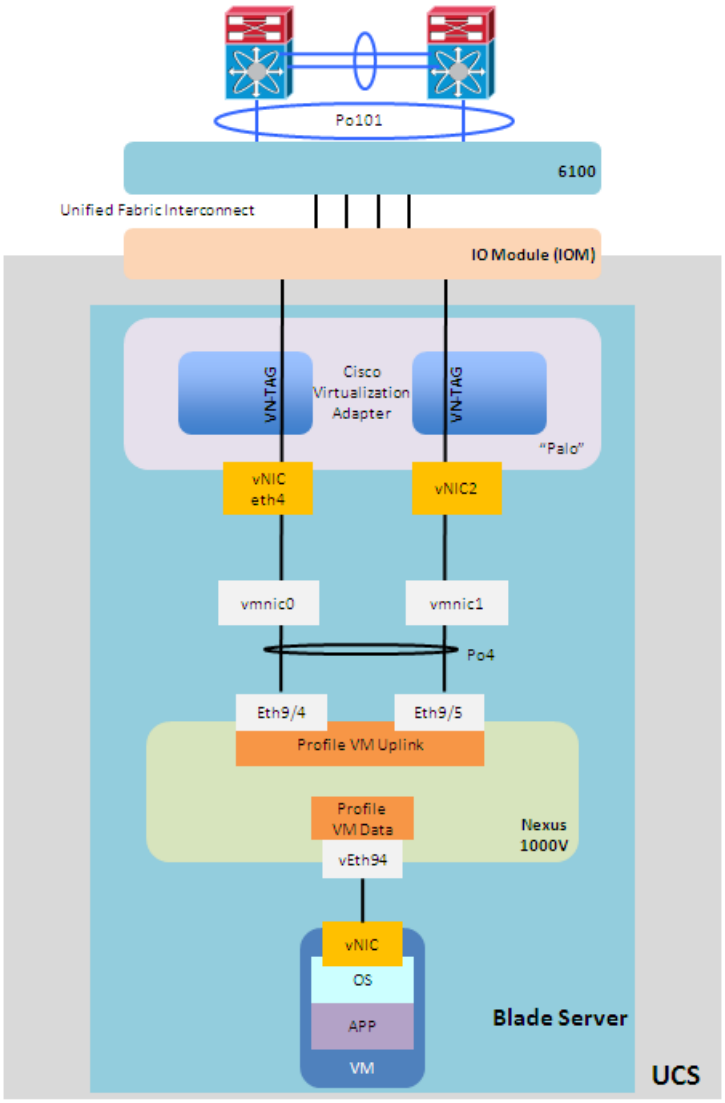
The issue is caused by vCenter Server storing and processing scheduled task times in UTC. vCenter Server uses UTC to preserve a reference time for clients and hosts that are running on different time zones. UTC does not have daylight savings advancements, so after the DST change; scheduled tasks run one hour earlier or later.

Note Further information about this issue can be found on VMware's website: http://kb.vmware.com/selfservice/microsites/search.do?language=en_US&cmd=displayKC&externalId=1034554

Path of a packet from Nexus 7000 to Virtual Machine

Traffic flows from the Nexus 7000 to the 6100 via the port channel (Po101) between them.

Figure 1-27 Path of a Packet Nexus 7000 to VM



Once in the 6100, it sends the traffic to the UCS via the unified fabric interconnect links between the 6100 and the UCS into the IO Module on the UCS. This traffic is tagged with a specific identifier tag assigned by the UCS manager to each vNIC deployed on the Cisco virtualization adapter. From here the

traffic is forwarded to the VMware ESXi kernel. The ESXi kernel passes the packet to the Nexus 1000V VEM module that handles the software switching decisions to get the packet to the correct virtual ethernet (vEth94 above) toward the VM.

Virtual Security Gateway (VSG)

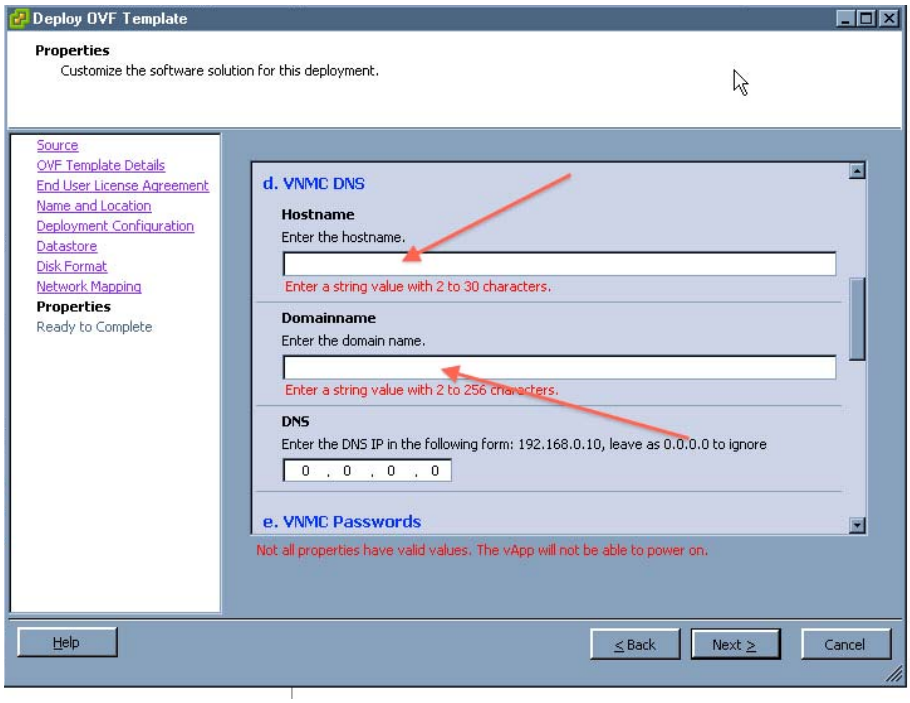
Cisco Virtual Security Gateway (VSG) is a virtual firewall for Cisco Nexus 1000V Series Switches that delivers security and compliance for virtual computing environments. Cisco VSG uses virtual network service data path (vPath) technology embedded in the Cisco Nexus 1000V Series Virtual Ethernet Module (VEM), offering transparent insertion and efficient deployment. VSG also introduces the Cisco Virtual Network Management Center (VNMC), which is used to manage VSG(s).

The VNMC is a virtual appliance that provides centralized device and security policy management for the VSG. VNMC uses security profiles for template-based configuration of security policies. A security profile is a collection of security policies that can be predefined and applied on an on-demand basis at the time of virtual machine instantiation.

The VNMC should be deployed in the management area of the data center, typically where the vCenter Servers are deployed.

When installing VNMC by deploying the Open Virtualization Format (OVF) template, under the "VNMC DNS" area on the Properties page, both the Hostname and the Domain name must be entered. If either option is not configured, the deployment settings do get validated and the VM gets deployed but the VM will fail to power up with the error message as to “hostname not configured” or “Domain name not configured”. The only workaround is to delete the VM and redeploy.

Figure 1-28 VNMC Hostname and Domain Name



This issue has been resolved in VNMC version 1.2 that will be release later this year.

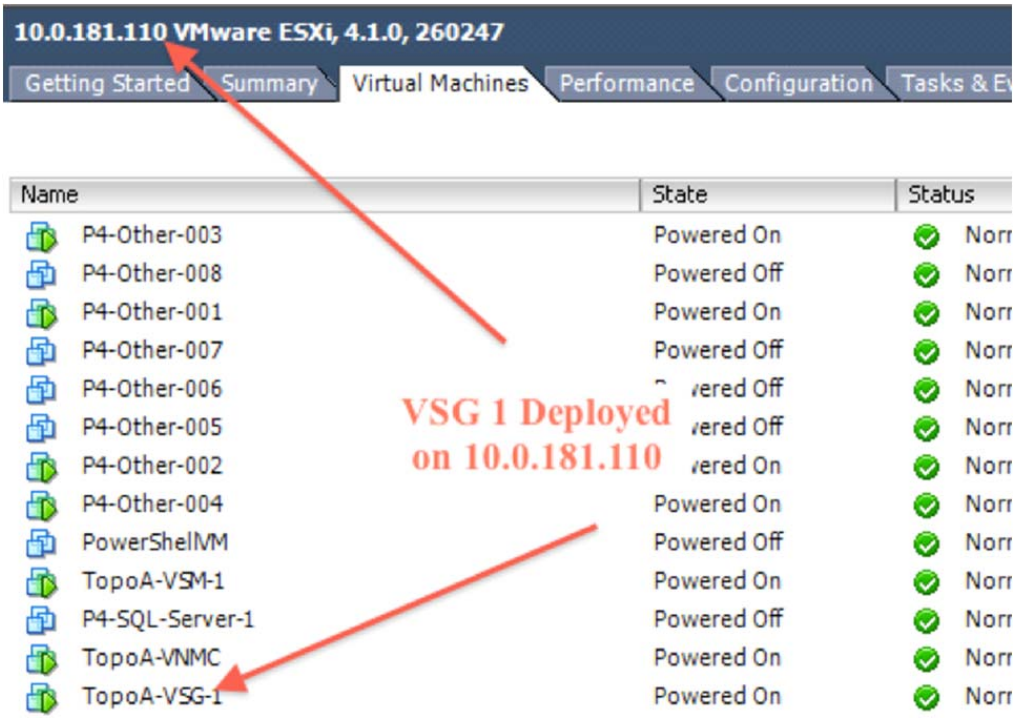
Note For more information on the specifics of deploying the VMNC appliance, refer to http://www.cisco.com/en/US/docs/switches/datacenter/vsg/sw/4_2_1_VSG_1_1/vnmc_and_vsg_qi/guide/vnmc_vsg_install_Aadden.pdf

When deploying the stretched VSG model, similarly to how discussed for the VSMs, both active and standby VSGs are deployed in DC1. It is recommended to deploy each VSG in an active-standby pair on a separate VMware ESXi host in the same data center.

As in the case of the VSM deployment, the VSG virtual machines are connected to the same VEM that is hosting the virtual machine. However, there is no requirement for a special system VLAN to be used. There is also no special consideration in regards to separate or stretched ESXi cluster models.

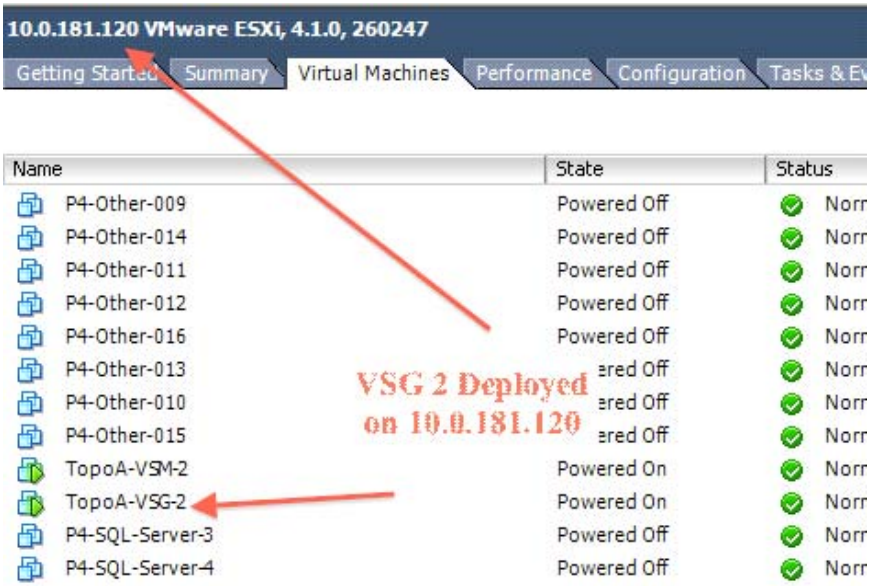
As can be seen in Figure 1-29, the active VSG (VSG1) is deployed in DC1 on ESXi host 10.0.181.110.

Figure 1-29 VSG1 Deployment



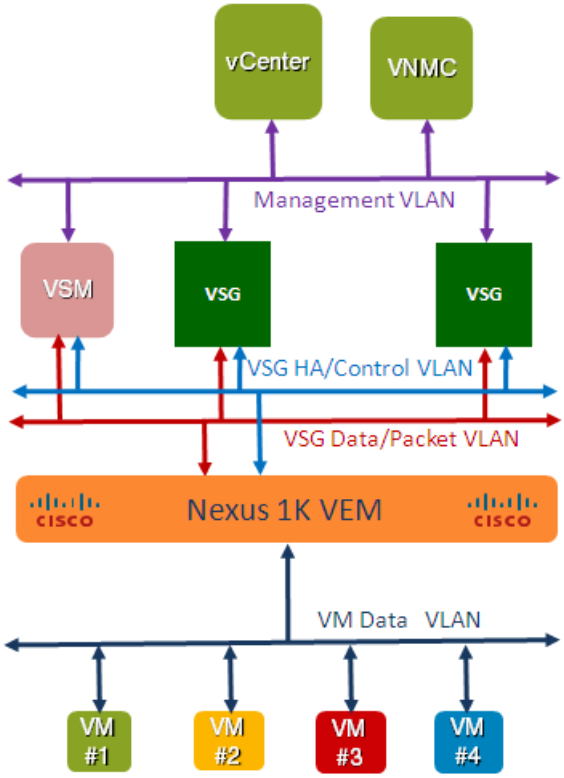
The standby VSG (VSG2) is deployed on 10.0.181.120 which is also in DC1. Deploying the VSG VMs on separate ESXi hosts is recommended to enhance the redundancy of the firewall should one of the ESXi hosts have a problem.

Figure 1-30 VSG 2 Deployment



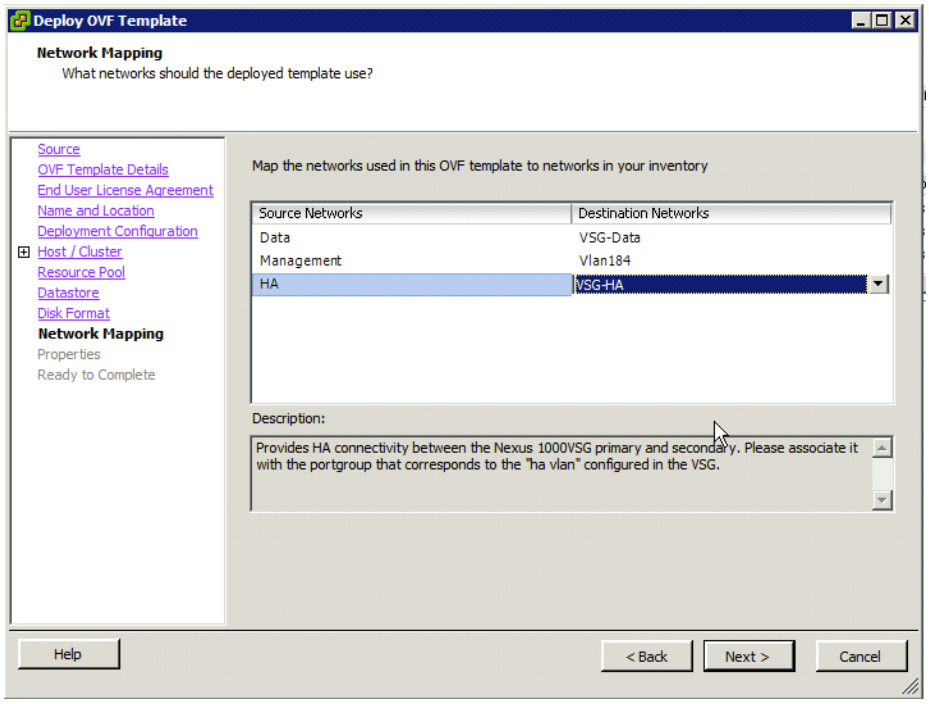
Three vNICs/networks are required for the VSG within the data center - Management, Data, and HA/Control. In Figure 1-31, the management VLAN is between the VSG, VSM, vCenter and VNMC. The Data and HA VLAN is between the VSG, VSM and VEMs.

Figure 1-31 VSG vNICs



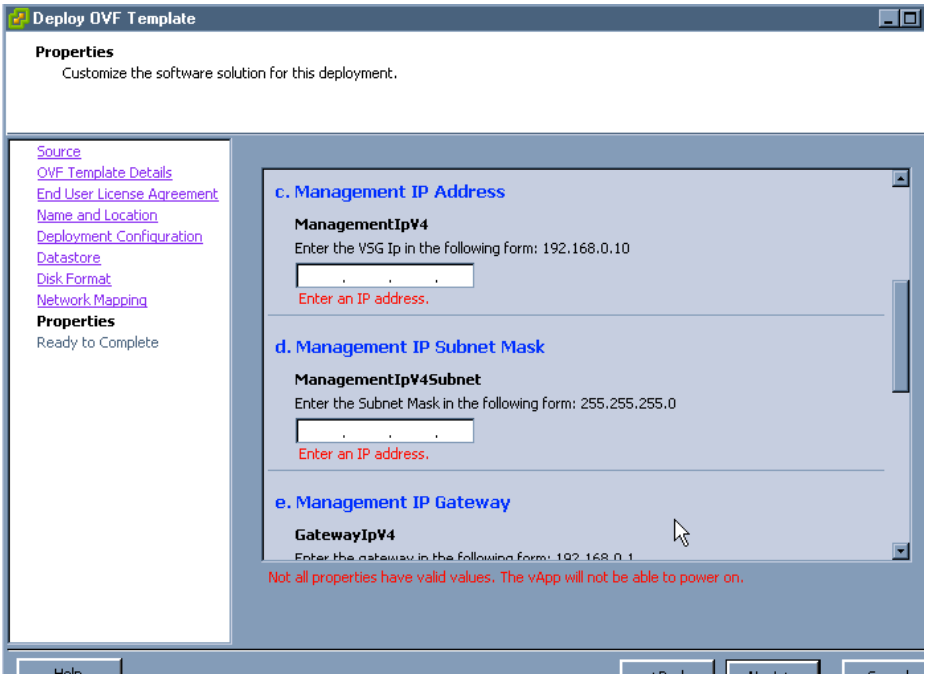
Prior to deploying the VSG OVA, it is suggested to have the Nexus 1000V port-profiles defined for these three networks so that the destination networks can be associated with the VSG during the deployment of the OVA.

Figure 1-32 VSG Network Mapping



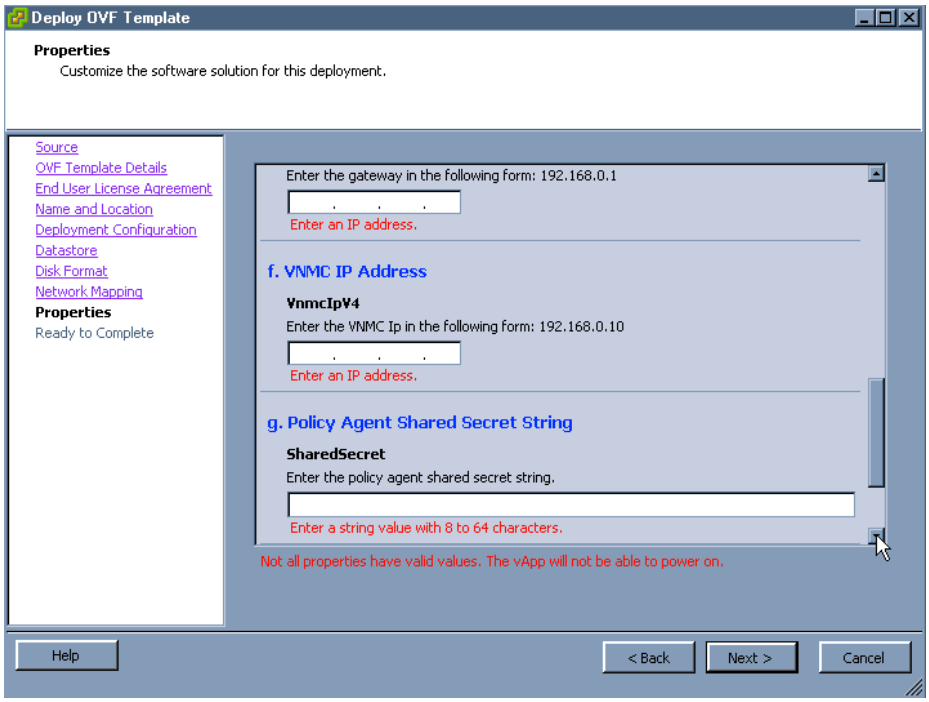
Since the VNMC communicates with vCenter, VSM, and the VSG over the management VLAN, Vlan184 was used for the VSG deployment. This interface is configured during the VSG OVA deployment in vCenter.

Figure 1-33 VSG Management Interface Configuration



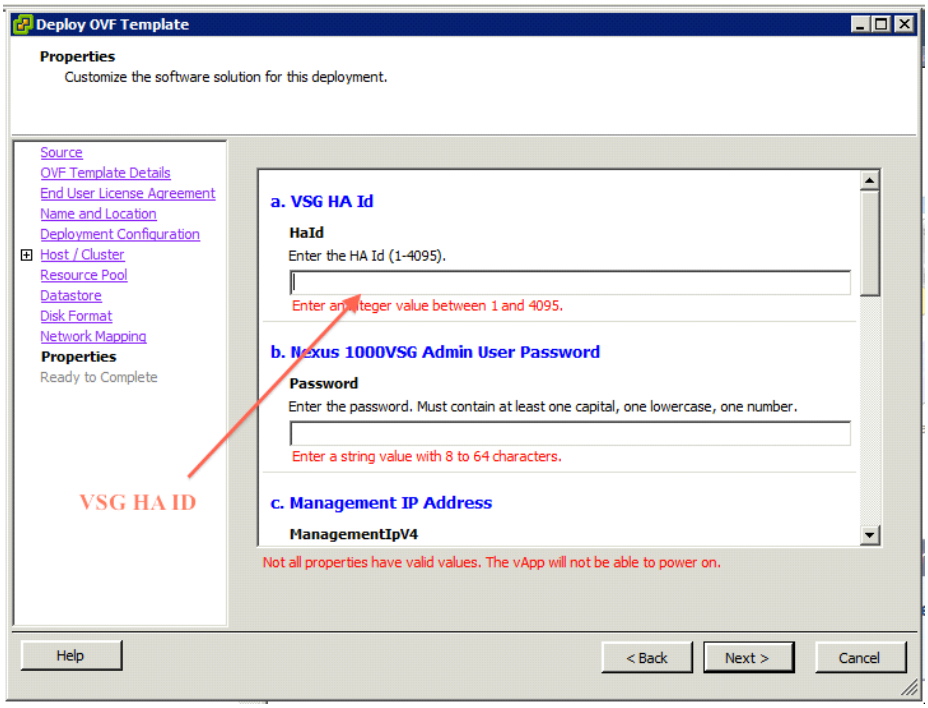
In addition to the management interface configurations, the VNMC IP address is also configured on the VSG during the OVA deployment.

Figure 1-34 VSG VNMC IP address



The HA, or high availability vNIC is for communication and synchronization between the active and standby VSGs. Only the configuration is synchronized between the active and standby VSG. The HA ID is configured during the VSG OVA installation. This ID will not conflict with the domain ID of the Nexus 1000V.

Figure 1-35 VSG HA ID



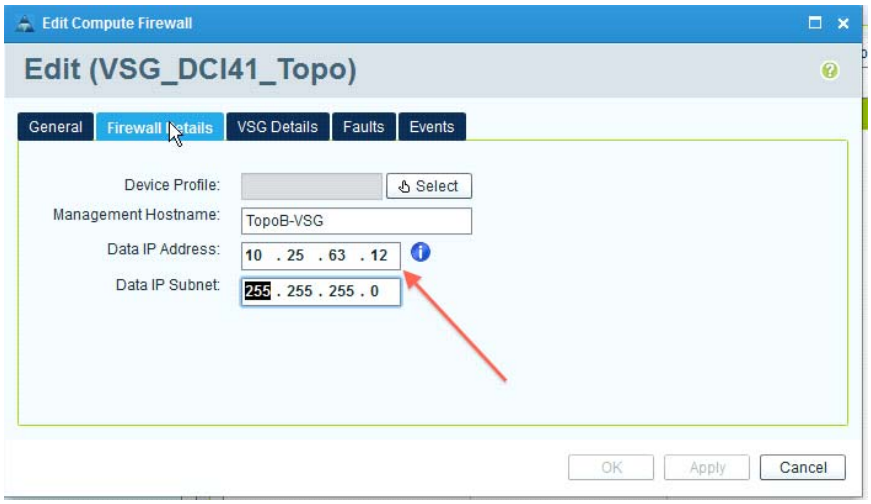
The data path vNIC is used for packets that are redirected from the VEMs vPath to the VSG for policy evaluation. The Nexus 1000V port-profile for the data interface was configured as displayed in the following example.

Example VSG Data Interface Port-profile

```
port-profile type vethernet VSG-Data
  vmware port-group
  switchport mode access
  switchport access vlan 2563
  no shutdown
  state enabled
```

The data interface on the VSG is configured on the VNMC.

Figure 1-36 VSG Data Path Interface



When the vPath on the VEM intercepts a packet that needs to be sent to the VSG for evaluation, it encapsulates the original packet with an outer L2 header and sends it to the MAC address of the VSG. Since this is a L2 packet, a L2 adjacency is required between the VEM and VSG, even though an IP address is assigned to the data interface. This means that the VLAN (VLAN 2563) that is used for the data path needs to be extended between the data centers.

When the VSG receives the packet and checks the security policy configured on the port-profile of the incoming packet, described later in this section, it returns whether the packet should be allowed or dropped. The vPath on the VEM is then programmed with this information and no longer needs to communicate with the VSG for that specific traffic flow.

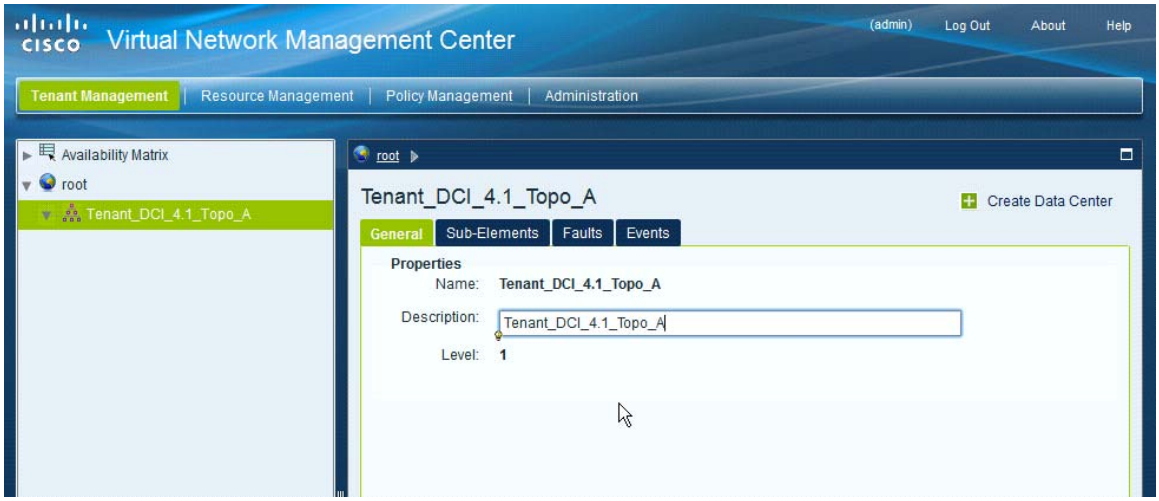
It is important to highlight that vPath tracks Layer 4 information for all the traffic flows (sequence numbers, TCP flags, etc.). This is the type of information referred to as the “state” information later in this document. However, there are some stateful applications that require dynamic opening of additional TCP/UDP sessions as part of the application communication. Support for application level protocol fixup is required to dynamically allow additional connections by doing packet inspection. In the first release of VSG, this capability is limited to FTP, RSH and TFTP, with a plan to add more in future releases.

The VSG-VEM interaction is critical to ensure that the security policies can be applied when new flows are intercepted by the vPath functionality in the VEM. Since the active/standby VSGs would most likely be deployed in a single site, it is expected that the failure of the DCI connection would cause the impossibility for vPath to forward to the active VSG the first packet of new flows established to/from VMs belonging to the VEMs in the remote site. Under these circumstances, it is possible to configure what should be the policy enforcement behavior: if the “fail open” option is selected, new flows to/from these VMs will be allowed bypassing the security policy. If the “fail close” option is chosen, then new flows will not be allowed and communication to/from the VMs will be prevented. Existing flows will continue to flow without interruption, independently from the chosen mode of operation.

Note The “fail open” and “fail close” modes are set at the port profile level. However, currently there is no support for a mixed mode configuration in a given VSG, which means the same mode is used for all the port profiles associated to that policy node.

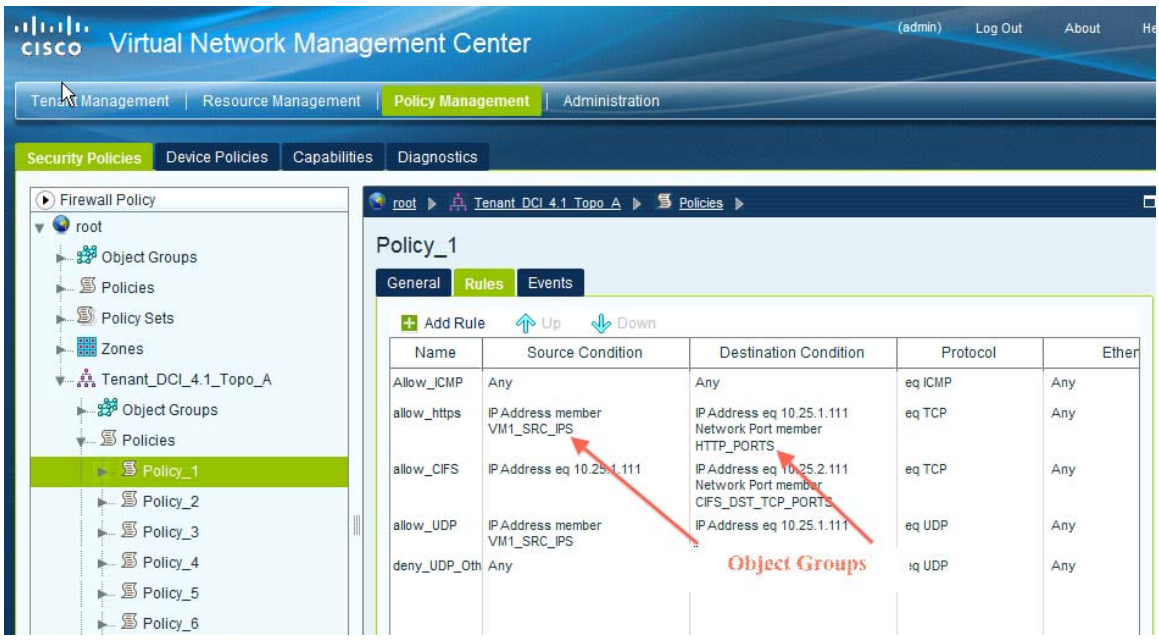
The security policy configurations are done on the VNMC GUI. The first item to configure is the tenant.

Figure 1-37 VNMC Tenant Configuration



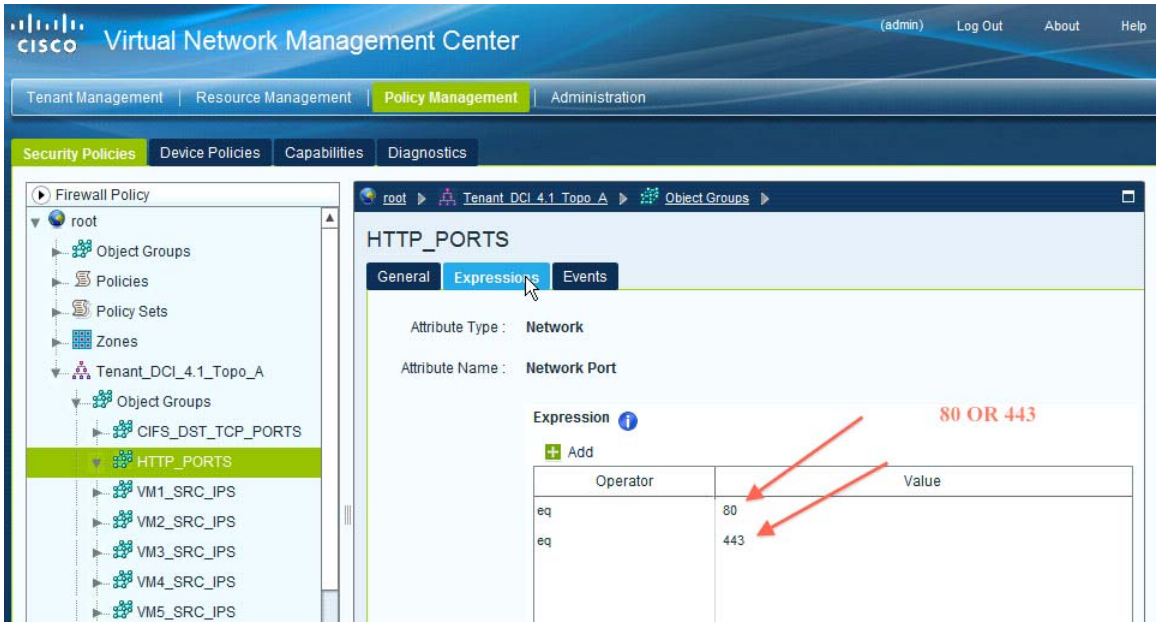
Once the tenant is configured, the security profiles can be configured. When configuring the security profiles, a number of rules can be added to a single policy. These policies are evaluated in the order listed in the GUI.

Figure 1-38 VNMC Security Policy



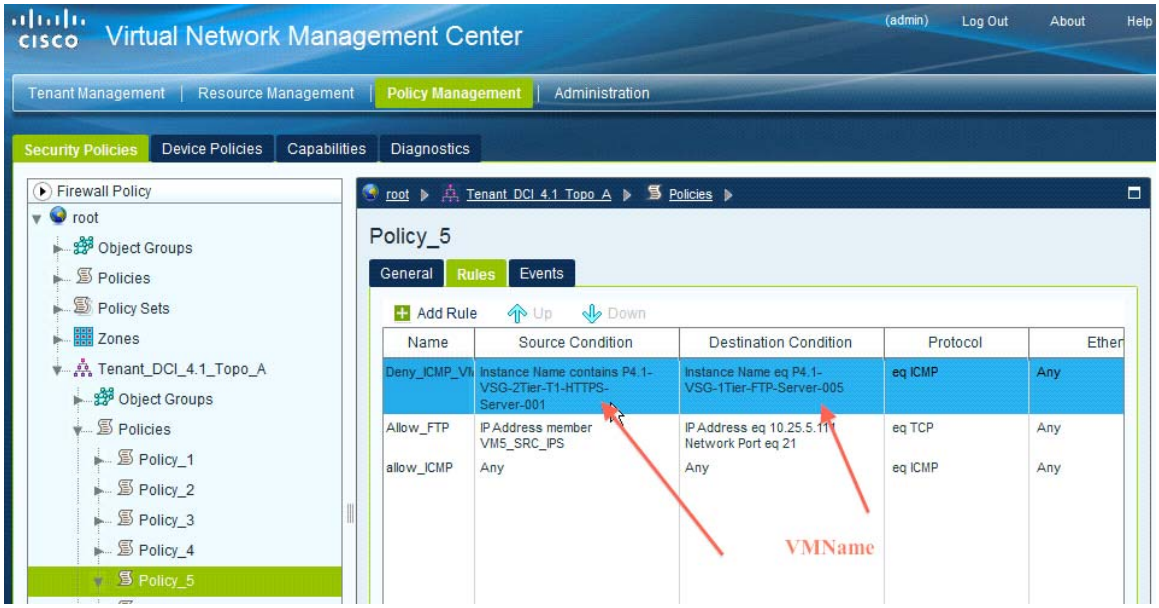
The condition in a each rule definition is done in an “and” fashion. For example, the destination condition in the allow_https rule will match is the ip address 10.25.1.111 and network port number that is a member of the HTTP_PORTS group. If the rule also wants to have an A or B type condition as well, the “or” conditions must be deployed in object groups. In the example above, and shown in more detail below, HTTP_PORTS is an object group that contains TCP port 80 and 443. These are evaluated in the rule, as the TCP port can be 80 or 443. Other options are available in the object groups’ configurations.

Figure 1-39 VNMC Object Group HTTP_PORTS



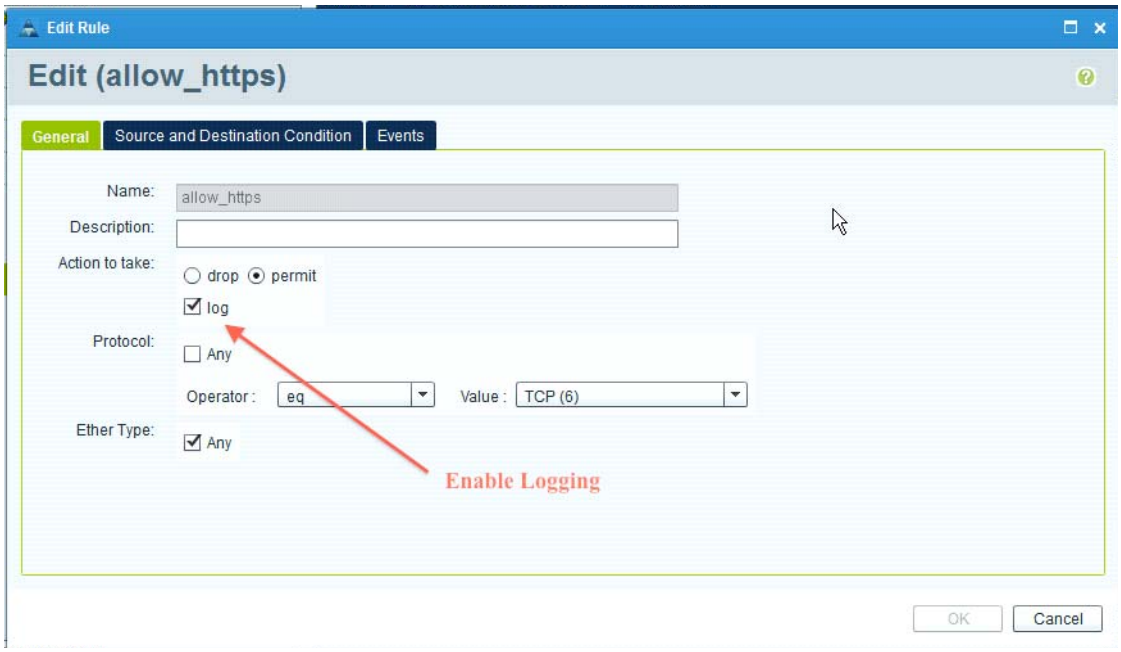
Another option for security policy rules is the ability to use VM attributes in the rule conditions. An example of using the VM attribute VMName is shown below.

Figure 1-40 VNMC VM Attribute



For testing and tracking purposes, the logging function was enabled on each rule.

Figure 1-41 Enable Logging



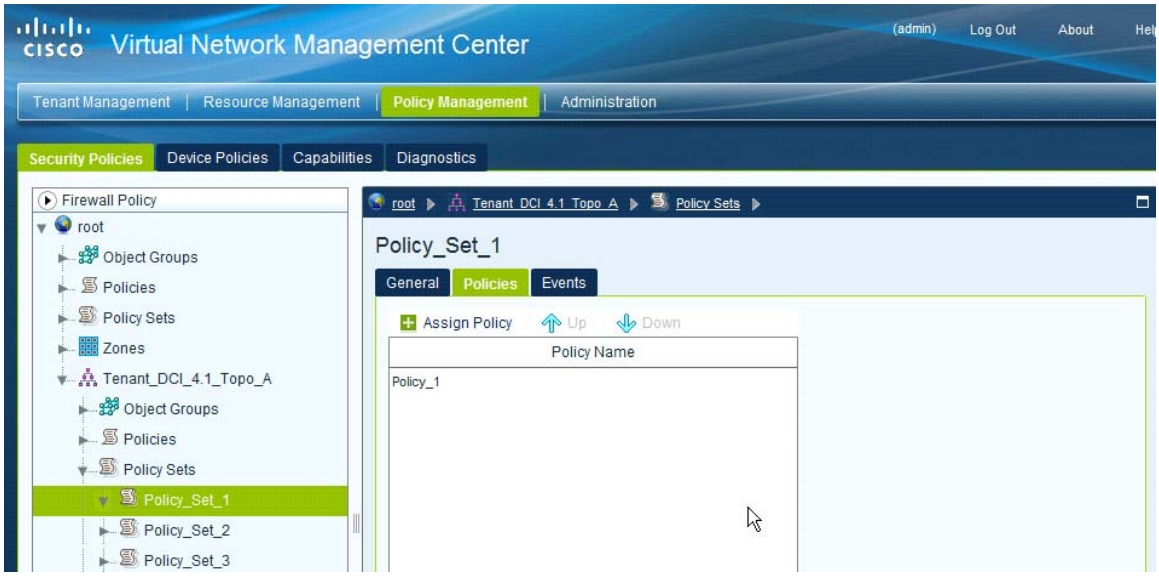
When enabled, each packet that corresponds to the rule creates a log message on the VSG and to the syslog server, if configured.

Example Logging Output

```
2011 Jul  6 15:34:48 TopoB-VSG %POLICY_ENGINE-6-POLICY_LOOKUP_EVENT:
policy=Policy_Set_2@root/Tenant_DCI_4.1_Topo_A
rule=Policy_2/deny_CIFS_other@root/Tenant_DCI_4.1_Topo_A action=Drop direction=egress
src.net.ip-address=10.25.2.115 src.net.port=25137 dst.net.ip-address=10.25.2.111
dst.net.port=445 net.protocol=6 net.ethertype=800
2011 Jul  6 15:34:48 TopoB-VSG %POLICY_ENGINE-6-POLICY_LOOKUP_EVENT:
policy=Policy_Set_2@root/Tenant_DCI_4.1_Topo_A
rule=Policy_2/deny_CIFS_other@root/Tenant_DCI_4.1_Topo_A action=Drop direction=egress
src.net.ip-address=10.25.2.115 src.net.port=25138 dst.net.ip-address=10.25.2.111
dst.net.port=445 net.protocol=6 net.ethertype=800
```

Once the rules and policies are configured, they are then grouped into policy sets. These policy sets are what is used to configure the security profile on the Nexus 1000V.

Figure 1-42 VNMC Policy Set



To prepare the traffic VM's port-profile for firewall protection, the following information is needed: VSG Data vNIC IP and VLAN-ID, security policy set name, and organization name. Using the **org** and **vn-service** commands, the security policy is applied to the port-profile on the Nexus 1000V.

Example Apply security policy to port-profile on the Nexus 1000V

```
port-profile type vethernet VMNetwork_2501
  vmware port-group
  switchport mode access
  switchport access vlan 2501
  vn-service ip-address 10.25.63.12 vlan 2563 security-profile Policy_Set_1
  org root/Tenant_DCI_4.1_Topo_A
  no shutdown
  description VLAN2501 Access Ports
  state enabled
```

In the above example, the organization name always starts at the root level and then includes the tenant name as configured on the VNMC.

Once this is configured on the Nexus 1000V, any vEthernet that is included in this port-profile will have the security policy applied to it.

Example Output show port-profile name VMNetwork_2501

```
# sh port-profile name VMNetwork_2501
port-profile VMNetwork_2501
 type: Vethernet
 description: VLAN2501 Access Ports
 status: enabled
 max-ports: 32
 inherit:
 config attributes:
  switchport mode access
  service-policy output vm-qos
  switchport access vlan 2501
  ip port access-group vm-acl in
  vn-service ip-address 10.25.63.12 vlan 2563 security-profile Policy_Set_1
  org root/Tenant_DCI_4.1_Topo_A
```

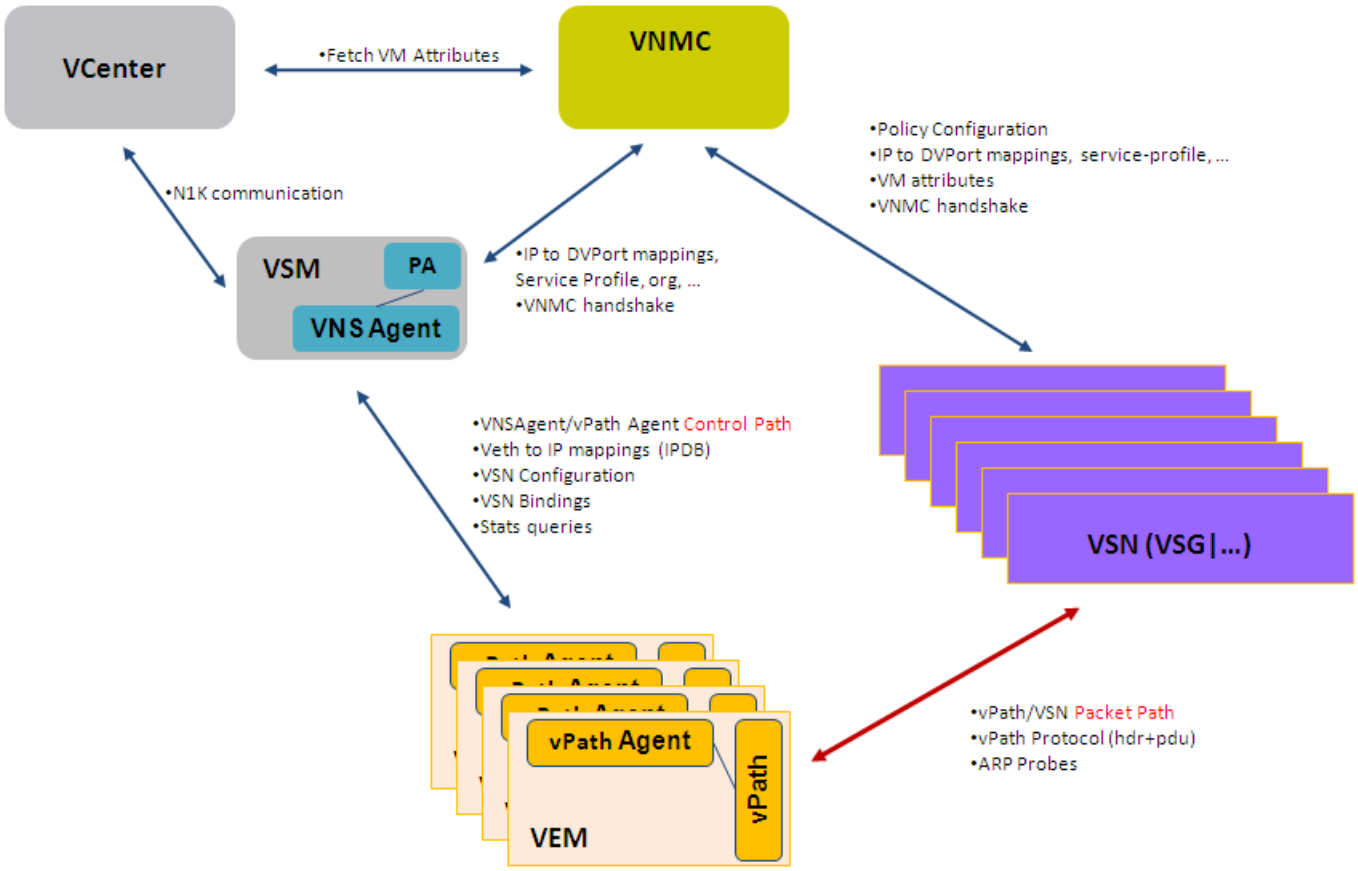
```
  no shutdown
 evaluated config attributes:
  switchport mode access
  service-policy output vm-qos
  switchport access vlan 2501
  ip port access-group vm-acl in
vn-service ip-address 10.25.63.12 vlan 2563 security-profile
Policy_Set_1
  org root/Tenant_DCI_4.1_Topo_A
  no shutdown
 assigned interfaces:
  Vethernet43
  Vethernet44
  Vethernet45
  Vethernet46
  Vethernet113
 port-group: VMNetwork_2501
 system vlans: none
 capability l3control: no
 capability iscsi-multipath: no
 port-profile role: none
 port-binding: static
```

When the VNMC is initially configured, it contacts the vCenter to gather the VM attributes so that it can be used in defining security policies. If the attributes change, the vCenter notifies the VNMC directly.

The VNMC is also in contact with the VSM to know what IP to DVPort mappings, service profiles, etc are used on the VSM.

The VSM is in contact with the VEM for control path information. The VSM configures the VEM with the VSG connection information and bindings that are to be used for the profiles it is using.

Figure 1-43 VSG System Path



The VEM is in direct contact with the VSG for packet path information. For port profiles that have a vn-service profile configured, the vPath Flow Manager determines what action to take when a packet is received. When the first packet of a flow is received, the flow manager encapsulates the packet MAC-in-MAC and redirects it to the VSG for evaluation. The VSG evaluates the packet and sends back the packet with a permit or deny action.

The flow manager receives the packet from the VSG and it extracts the policy decision and programs it into the flow. The detoured packet is now subjected to the new policy on the flow and is permitted or denied based on the evaluation the flow manager received from the VSG. The rest of the stream is evaluated by the cached policy until it ages out or is over-ridden with a later policy decision.

Storage Elasticity

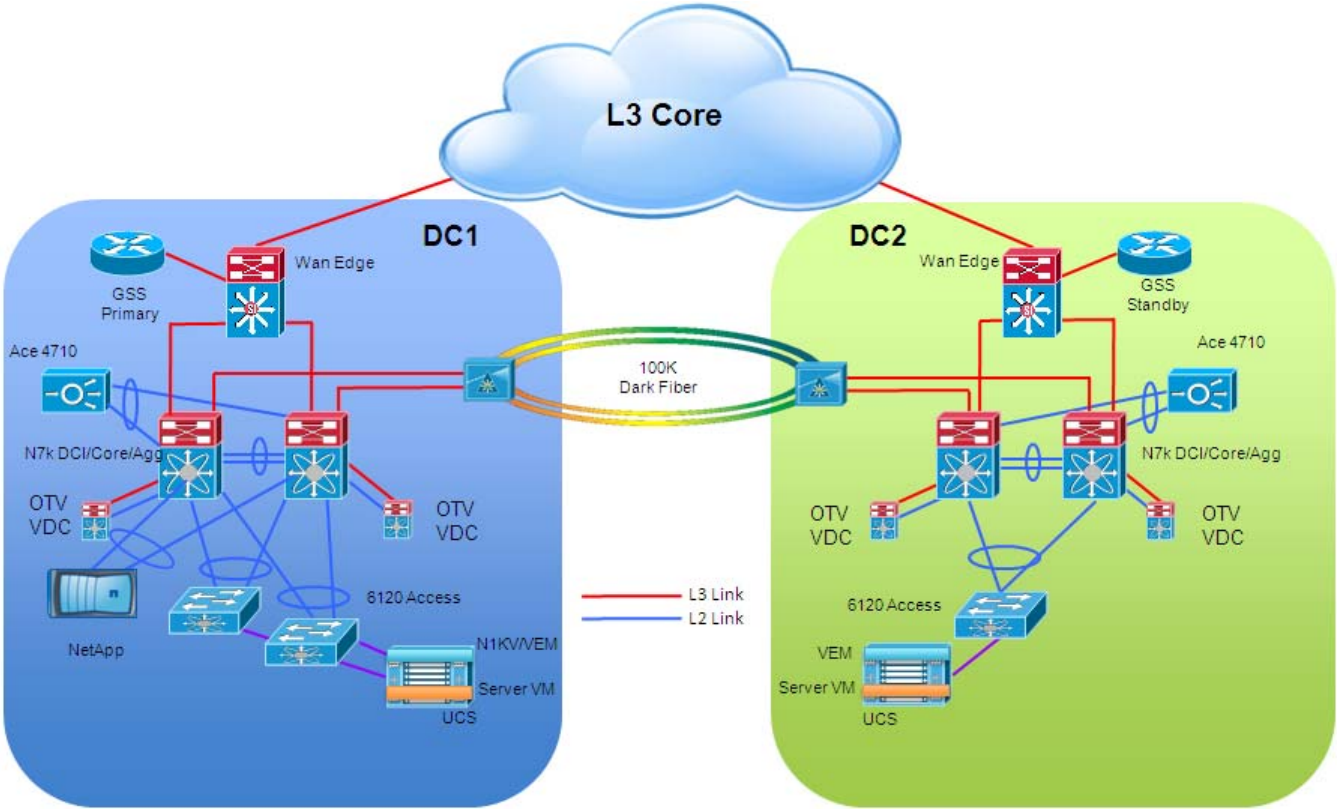
One of the most underrated components of a holistic DCI solution is the storage deployment. This becomes specifically relevant in the workload mobility scenario, where in order to be able to move VMs across data center sites, it is critical to ensure a consistent access to the storage for the ESXi hosts where the VMs reside.

Shared Storage Model

The shared storage model is conceptually the simplest: all the ESXi hosts deployed in both data center sites have access to the same disk array, which is physically available in DC1. When deploying this approach in the context of a virtualized workload mobility solution, some restrictions in terms of distance and latency between sites become suddenly apparent, considering that hosts located in remote sites will have to perform all their I/O operations (read and write) to the centralized disk array. This model may be deployable in scenarios where workload mobility is deployed between sites in close proximity to each other (few Kms) like it would be the case for example when the data centers are connected to a common Campus network. For comparison purposes, the shared storage model was tested at 100Km.

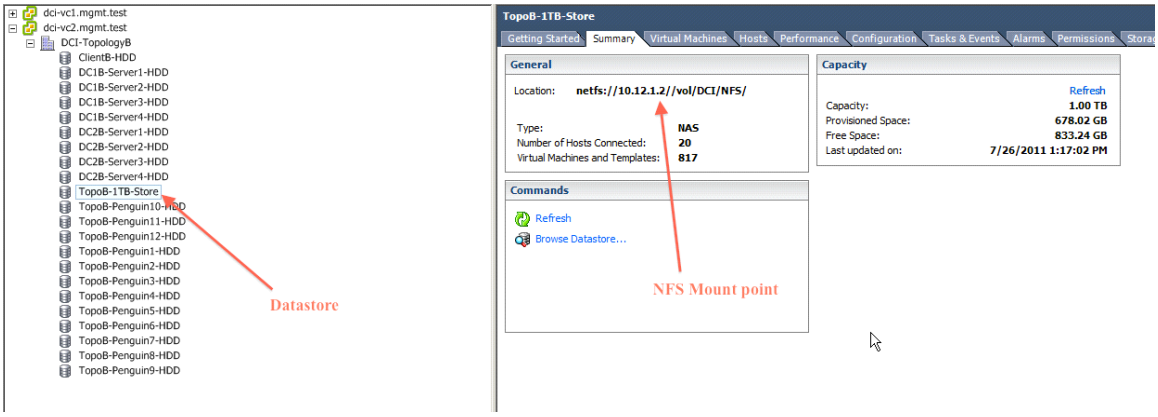
Another consideration is that the NFS traffic will be sharing the bandwidth on the DCI links with the other flows between the data centers, thus classification and rate limiting of traffic may be required, depending on the traffic profiles in the network.

Figure 1-44 NAS Access to Shared Storage Model



In the shared storage model, the NFS volume is L3 connected to the ESXi servers.

Figure 1-45 NFS Volume on vCenter



A vpc port channel is created between the Nexus 7000 in DC1 and the NetApp system. VLAN 1201 is trunked to the NetApp and used to bring the NFS traffic into the network. The NetApp is configured for IP address 10.12.1.2.

On the Nexus 7000s in DC1, a VLAN 1201 SVI is created and HSRP is configured between the two Nexus 7000s for redundancy. The 10.12.1.0/24 network is injected into the ospf routing table so that servers in DC2 also have access to the same NFS volume.

Example VLAN 1201 OSPF Routing

```
interface Vlan1201
  no shutdown
  mtu 9000
  no ip redirects
  ip address 10.12.1.253/24
  ip ospf passive-interface
  ip router ospf 200 area 0.0.0.0
  hsrp 1
    preempt delay minimum 180 reload 300
    priority 253
    timers  1  3
    ip 10.12.1.254
```

When configuring the VLAN, the MTU must be set to 9000 or less. This is due to the NetApp only accepting MTU values of 9000 or less when configuring the network interface when using OnTAP 7.3.3.

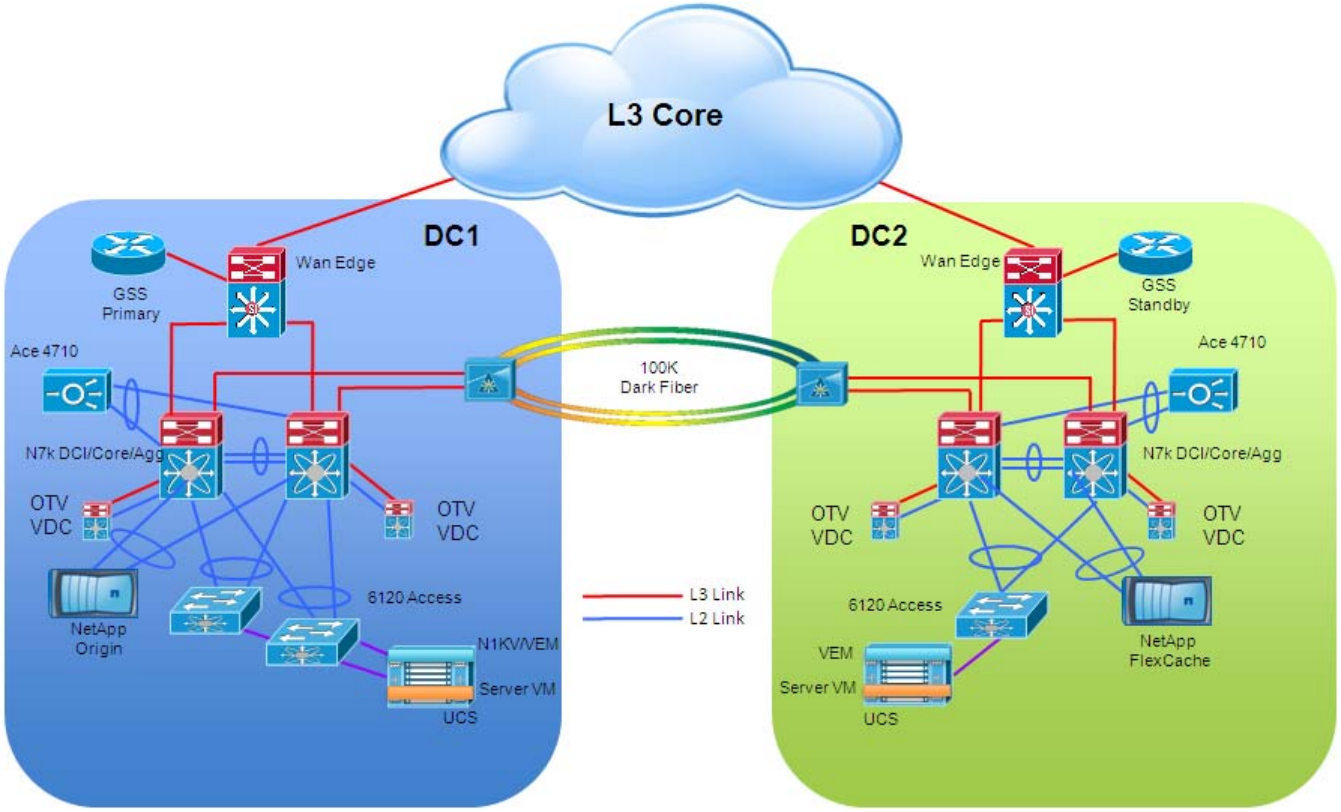
Figure 1-46 NetApp MTU Error

Since the storage traffic is carried across the DCI connection to DC2, the 802.1AE encryption described in a previous section will encrypt the storage traffic as well. No additional encryption should be required for the NetApp NFS traffic.

NetApp FlexCache

FlexCache is a caching technology that improves storage access performance; similarly to the way a cache in the memory architecture of a compute system improves performance. FlexCache improves performance in NFS environments by scaling out cache volumes for increased IOPs, bringing data closer to the hosts for decreased latencies, off-loading overburdened storage controllers, or a combination of all of these.

Figure 1-47 NetApp FlexCache Topology Overview



In the FlexCache setup there is an origin volume and a FlexCache volume. The origin volume is where the data is actually stored. The FlexCache volume represents the cache that is used to store the frequently accessed portions of the data.

As pictured above, in the workload mobility use case, the origin volume is deployed in DC1 and the FlexCache volume is deployed in DC2.

VLAN 1201 is used across the vPC to the NetApp to access the NFS export on the filer.

NRV is the NetApp proprietary protocol used to establish communications between the FlexCache volume and the origin volume. NRV is similar to NFS and it is transported over a TCP session (port 2050) established between the origin and the FlexCache systems.

The origin volume is configured to use VLAN 1313 for the NPV connection, which is trunked across the same vPC as 1201.

Example VLAN 1313 NPV

```
interface Vlan1313
  no shutdown
  mtu 9000
  no ip redirects
  ip address 10.13.13.253/24
  ip ospf passive-interface
  ip router ospf 200 area 0.0.0.0
  hsrp 1
    preempt delay minimum 180 reload 300
    priority 253
    timers  1  3
    ip 10.13.13.254
```

Note that the 10.13.13.0 network is injected into the ospf routing table. This is allow the FlexCache and Origin systems communicate over the L3 network.

ESXi servers located in DC1 are pointed to the IP address of the origin volume, whereas ESXi servers in DC2 are pointed to the same IP address that identifies the FlexCache volume. It is important to note how both FlexCache and Origin volumes are accessed via the same IP address. This is critical; since one of the requirements to support vMotion is that both the source and the destination ESXi servers have access to a common storage. From the point of view of the ESXi hosts in DC2, they are accessing the same volume as the ESXi hosts in DC1, despite the fact that in DC2 only a cache is actually available. It is also important that the routing information for the volume IP address not be shared between the data centers. This is to ensure localization of the NFS traffic destined to the Origin or the FlexCache volumes.

The 10.12.1.0 network was removed from the routing table in DC1 by removing the *ip route ospf* command under the interface Vlan1201 configurations in both Nexus 7000s.

Example VLAN 1201 Remove Routing

```
interface Vlan1201
  no shutdown
  mtu 9000
  no ip redirects
  ip address 10.12.1.253/24
  ip ospf passive-interface
  ip router ospf 200 area 0.0.0.0   ßRemove
  hsrp 1
    preempt delay minimum 180 reload 300
    priority 253
    timers  1  3
    ip 10.12.1.254
```

Once the routing is removed, the same interface VLAN 1201 configurations are added to the Nexus 7000 switches in DC2. A VPC is created between the Nexus 7000 and the FlexCache system and VLAN 1201 is trunked. For the NPV connection, VLAN 1314 was created and trunked to the FlexCache system.

Example DC2 Nexus 7000 FlexCache Configuration

```
interface Vlan1201
  no shutdown
  mtu 9000
  no ip redirects
  ip address 10.12.1.253/24
  ip ospf passive-interface
  hsrp 1
    preempt delay minimum 180 reload 300
    priority 253
    timers  1  3
    ip 10.12.1.254
interface Vlan1314
  no shutdown
  mtu 9000
  no ip redirects
  ip address 10.13.14.253/24
  ip ospf passive-interface
  ip router ospf 200 area 0.0.0.0
  hsrp 1
    preempt delay minimum 180 reload 300
    priority 253
    timers  1  3
    ip 10.13.14.254
interface port-channel1201
  switchport
```

```
switchport mode trunk
switchport trunk allowed vlan 1201,1314
mtu 9216
vpc 1201
```

Workload Mobility Results

Below are the results of the validation of the above deployment of EMC VPLEX Metro with stretched Nexus 1000V, OTV and ESXi clustering. Where appropriate, a comparison with the shared storage model will be presented.

Traffic Profile

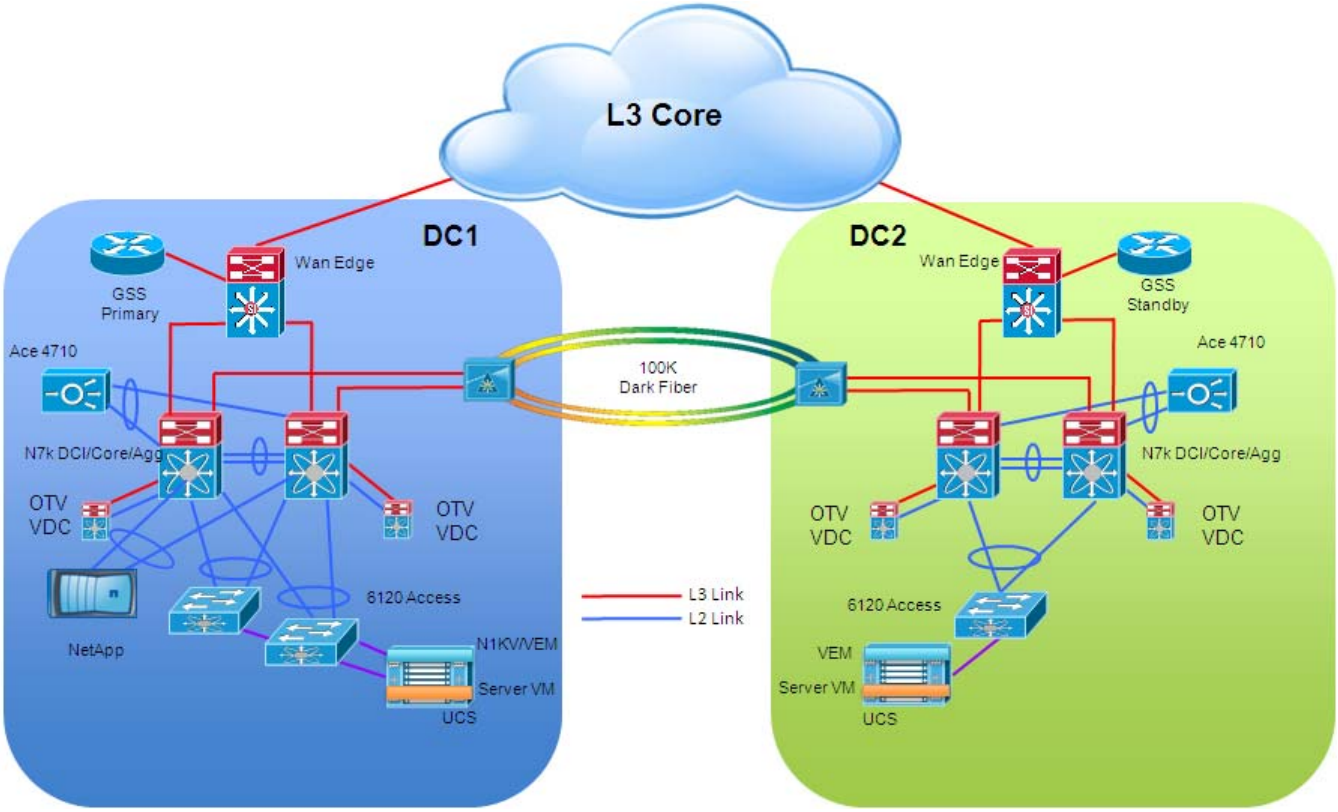
Traffic for the test topology was created using FTP and HTTPS test tools as well as other packet generation tools such as Spirent TestCenter. These test tools are able to show transfer rates, outage times and successful transactions before, during and after the workload mobility is performed. Even though the results information provided in each use case is a subset of the overall information that was collected during testing, it is a representation of how the system performed for the particular use case.

Shared Storage

Shared storage was used initially for the storage model to provide a comparison to the NetApp FlexCache. The ESXi cluster deployment model had no bearing on the shared storage model when tested, as the traffic results were similar in both the separate and stretched ESXi cluster setups. All other aspects of the network, Nexus 1000V, OTV LAN extension, etc. were the same as in the Separate and Stretched ESXi clusters described in later sections.

As shown in the storage elasticity section above, in the shared storage model, the storage is physically located in DC1 and configured so that the ESXi hosts in DC1 and DC2 can utilize the same NAS storage.

Figure 1-48 NAS Access to Shared Storage Model



Once the traffic is started, issuing the **show conn** command on the ACE in DC1 shows that the connections are traversing the DC1 ACE to get to the servers in DC1.

Example DC1 ACE show conn output Before vMotion

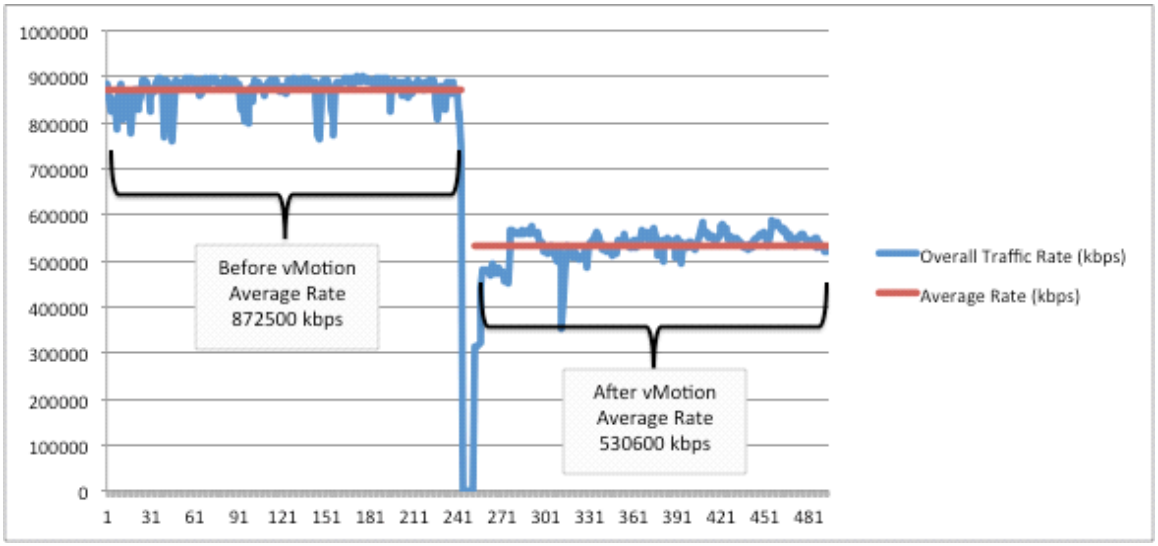
```
total current connections: 48
conn-id    np dir proto vlan source                destination           state
----------+--+---+-----+----+---------------------+---------------------+------+
1278357    1  in  TCP   911  120.120.120.18:39324  8.1.1.8:443           ESTAB
1278345    1  out TCP   2508 10.25.8.111:443       10.25.8.113:21695     CLOSED
1297632    1  in  TCP   911  120.120.120.13:12813  8.1.1.3:18979         ESTAB
1293558    1  out TCP   2503 10.25.3.111:49727     10.25.3.113:47898     ESTAB
1297586    1  in  TCP   911  120.120.120.13:12812  8.1.1.3:21            ESTAB
1297562    1  out TCP   2503 10.25.3.111:21        10.25.3.113:47897     ESTAB
1298267    1  in  TCP   911  120.120.120.13:12814  8.1.1.3:21            ESTAB
1298303    1  out TCP   2503 10.25.3.111:21        10.25.3.113:47899     ESTAB
1298295    1  in  TCP   911  120.120.120.13:12815  8.1.1.3:18980         ESTAB
1298319    1  out TCP   2503 10.25.3.111:49728     10.25.3.113:47900     ESTAB
```

Application traffic performance before and after the VMs were moved between data centers was recorded.

When using shared storage, the servers must use the FC extension over the dark fiber to get to the storage array when moved to DC2.

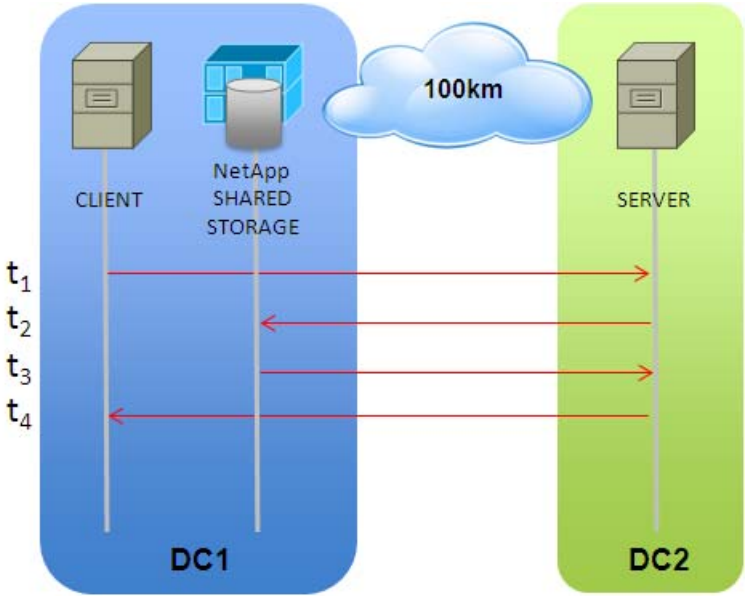
Figure 1-49 shows the cumulative rate of the VM servers' throughput rates, in kbps, before and after the vMotion occurs. Notice that before the vMotion occurred, the application traffic was at an average rate of 872500 kbps, however after the vMotion occurred, the rate decreased to an average of 530600 kbps which is a decrease of 39.2% in performance.

Figure 1-49 Original Client Shared Storage Read Application Traffic Performance



Remember that the original traffic streams are still entering the network at DC1. They are then traversing the OTV LAN extension over to DC2, which is 100km away, to the server. The server then must read the data from the storage array back in DC1 across the DCI link, another 100km. The crossing of the DCI link for storage and of the OTV LAN extension attributes to 4 trips across the 100km distance and thus causes the rate reduction seen above. Below is a graphical representation of this crossing of the 100km.

Figure 1-50 Shared Storage Original Client Traffic Flow



After each vMotion is complete, the vCenter uses an alarm trigger to initiate the script to change the GSS entries to point to DC2. This configuration was described earlier in the path optimization section.

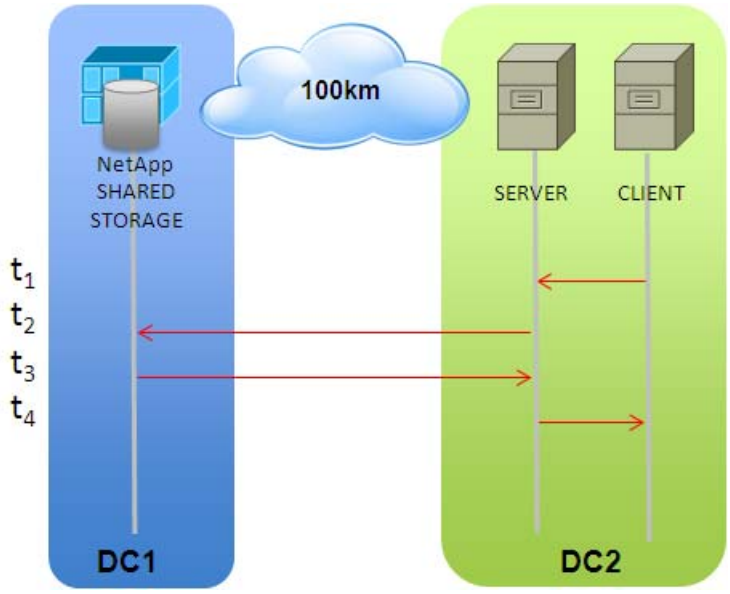
Once the GSS has been updated, new traffic flows enter the network at DC2. Issuing the *show conn* command on the ACE in DC2 shows that the connections are now traversing the DC2 ACE.

Example DC2 ACE show conn output

```
total current connections: 16
conn-id    np dir proto vlan source                destination           state
----------+--+---+-----+----+---------------------+---------------------+------+
1038027    1  in  TCP   921  120.120.120.24:59065  8.2.2.4:21            ESTAB
1037995    1  out TCP   2504 10.25.4.111:21        10.25.4.115:20387     ESTAB
1038040    1  in  TCP   921  120.120.120.24:59066  8.2.2.4:8626          ESTAB
1038018    1  out TCP   2504 10.25.4.111:49696     10.25.4.115:20388     ESTAB
1038403    1  in  TCP   921  120.120.120.28:52134  8.2.2.8:443           ESTAB
1038381    1  out TCP   2508 10.25.8.111:443       10.25.8.115:9832      ESTAB
1038471    1  in  TCP   921  120.120.120.26:7282   8.2.2.6:443           ESTAB
1038459    1  out TCP   2506 10.25.6.111:443       10.25.6.115:5988      ESTAB
1038462    1  in  TCP   921  120.120.120.25:56681  8.2.2.5:443           ESTAB
1038472    1  out TCP   2505 10.25.5.111:443       10.25.5.115:10222     ESTAB
1038477    1  in  TCP   921  120.120.120.27:14654  8.2.2.7:443           ESTAB
1038470    1  out TCP   2507 10.25.7.111:443       10.25.7.115:10645     ESTAB
1038607    1  in  TCP   921  120.120.120.23:18670  8.2.2.3:21            ESTAB
1038510    1  out TCP   2503 10.25.3.111:21        10.25.3.115:30092     ESTAB
1038611    1  in  TCP   921  120.120.120.23:18671  8.2.2.3:11882         ESTAB
1038622    1  out TCP   2503 10.25.3.111:49737     10.25.3.115:30093     ESTAB
```

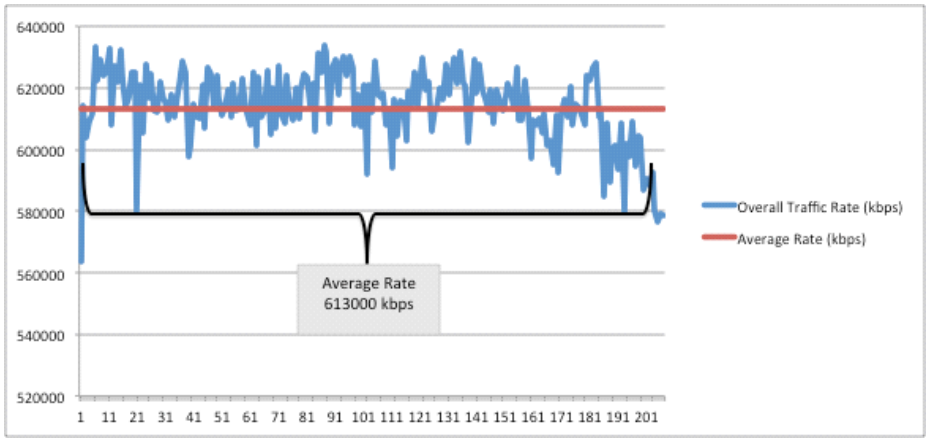
This removes the OTV LAN extension 100km part of the delay, however the storage extension delay is still relevant.

Figure 1-51 Client-Server Optimization Only



This means that the number of trips across the 100km is lowered to 2. The rate is expected to be between the two extremes of zero crossings (which was 872500 kbps) and 4 crossings (530600 kbps). In Figure 1-52, notice that the average transfer rate is 613000 kbps.

Figure 1-52 New Client Shared Storage Read Application Performance



To verify the original traffic flows are continuing via DC1, compare the output of the **c** command on the DC1 ACE before and after the vMotion is complete. In the output below, you can see that total current connections are less than before the vMotion occurred. This is due to the connections finishing the transfer and closing.

Example DC1 ACE show conn Output After vMotion

```
total current connections: 42
conn-id    np dir proto vlan source                destination           state
----------+--+---+-----+----+---------------------+---------------------+------+
1322106    1  in  TCP   911  120.120.120.17:62019  8.1.1.7:443           ESTAB
1287151    1  out TCP   2507 10.25.7.111:443       10.25.7.113:51163     ESTAB
1304858    1  in  TCP   911  120.120.120.13:12817  8.1.1.3:18981         ESTAB
1304860    1  out TCP   2503 10.25.3.111:49729     10.25.3.113:47902     ESTAB
1304875    1  in  TCP   911  120.120.120.13:12816  8.1.1.3:21            ESTAB
1304866    1  out TCP   2503 10.25.3.111:21        10.25.3.113:47901     ESTAB
1307459    1  in  TCP   911  120.120.120.13:12818  8.1.1.3:21            ESTAB
1307410    1  out TCP   2503 10.25.3.111:21        10.25.3.113:47903     ESTAB
1307466    1  in  TCP   911  120.120.120.13:12820  8.1.1.3:21            ESTAB
1307490    1  out TCP   2503 10.25.3.111:21        10.25.3.113:47905     ESTAB
1307475    1  in  TCP   911  120.120.120.13:12819  8.1.1.3:18982         ESTAB
```

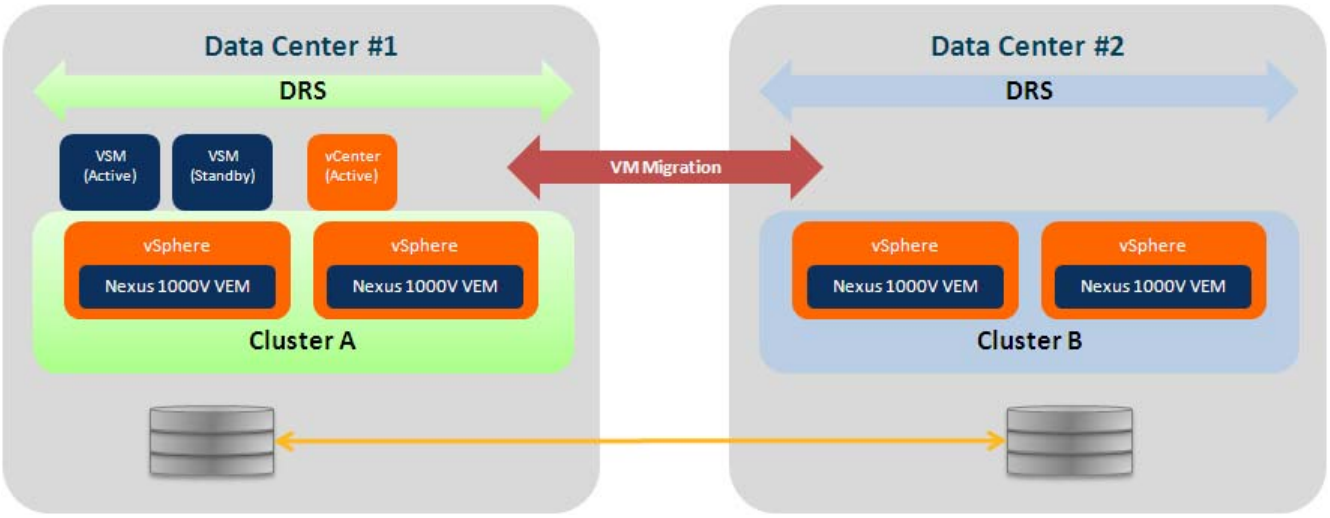
This will also help to verify that the movement of the VMs from DC1 to DC2 disconnected none of the connections.

For a write operation, the number of times across the 100 km distance is the same as in the read scenario.

Separate VMware ESXi Clusters

The NetApp FlexCache with Nexus 1000V and OTV use case was done with two different methods of VMware ESXi clustering. Separate clusters were used for the first iteration of the use case.

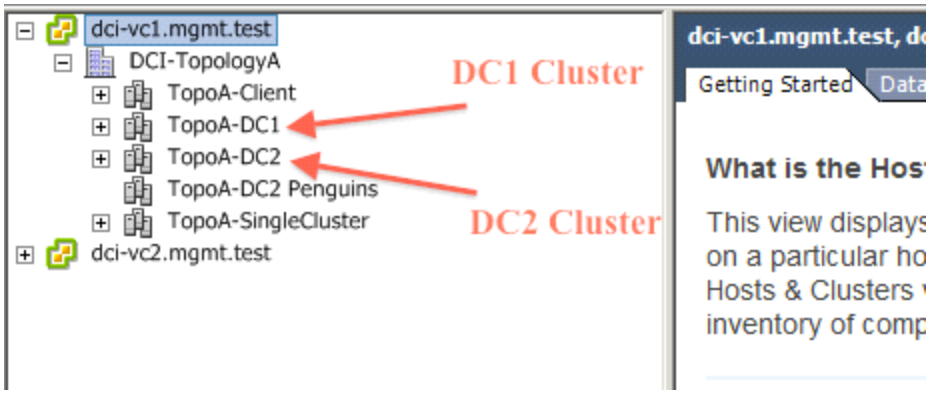
Figure 1-53 ESXi Separate Cluster



The ESXi hosts in the topology are configured so that there is one ESXi cluster in DC1 and one ESXi cluster in DC2. With 2 separate clusters, all vMotion operations are done sequentially. As described previously, there are 4 ESXi hosts in DC1 and 16 ESXi hosts in DC2. Initially the VMs are deployed so that the 8 test VMS are on DC1 hosts 1-4 with 2 on each host and the Windows XP VMs are deployed with 8 on each host in DC1. All the Linux VMs are deployed in DC2. There are 20 VMs on each of the 12 non-UCS ESXi hosts, and 180 VMs on each of the UCS ESXi hosts.

With this configuration, there are 40 VMs in DC1 cluster and 960 in DC2 cluster.

Figure 1-54 ESXi Separate Cluster vCenter



A vMotion is initiated for the 8 VM servers. All vMotions are scheduled to occur at the same time, however since the network is in the separate ESXi cluster configuration, all the servers will move sequentially.

The time it takes each VM to move between data centers varies depending on the amount of used memory in the VM. In testing, the times varied between 24 and 204 seconds with the average being 101 seconds from start to finish.

Table 1-3 Separate Cluster vMotion Times Per VM

Server	vMotion Time DC1 -> DC2 (sec)	vMotion Time DC2 -> DC1 (sec)
VM 1	178	162
VM 2	50	77
VM 3	99	133
VM 4	122	60
VM 5	152	117
VM 6	28	42
VM 7	76	24
VM 8	204	95

During the vMotion, there is a period of time that the servers must be offline to change ownership from one ESXi host to another. To measure how applications would be affected by this downtime, FTP and HTTPS transfers were initiated before the vMotion was to occur, and allowed to continue to run during the move to the other data center. The downtime of the client to server traffic varied from 3 to 7 seconds with the average being 4.75 seconds of actual outage time.

Table 1-4 Separate Cluster vMotion Outage Time Per VM

Server	vMotion Time DC1 -> DC2 (sec)	vMotion Time DC2 -> DC1 (sec)
VM 1	3	6
VM 2	*	*
VM 3	3	6
VM 4	*	*
VM 5	5	7
VM 6	3	4
VM 7	6	4
VM 8	6	4

Note VM2 and VM4 were the second tier for the 2 tier model and thus the outage measured for those servers was included as part of VM1 and VM3, respectively.

Overall, the entire vMotion of 8 VMs took 710 to 909 seconds from start to finish with an average of 810 seconds. This is due to all the servers needing to vMotion in sequential order.

Table 1-5 **Separate Cluster Overall vMotion Times**

Test Runs	Overall vMotion Time (sec)
DC1->DC2 #1	909
DC2->DC1 #1	710

Since the same storage is presented to the ESXi hosts in both data centers for both shared storage and FlexCache, storage vMotion is not required.

The application performance before and after the VMs were moved between data centers was recorded.

When the server is located in DC1 and the client enters DC1, none of the traffic traverses the 100km distance between the data centers since the server and storage are both located in the same data center.

Figure 1-55 Separate DC1 NetApp FlexCache Server-Storage Communication

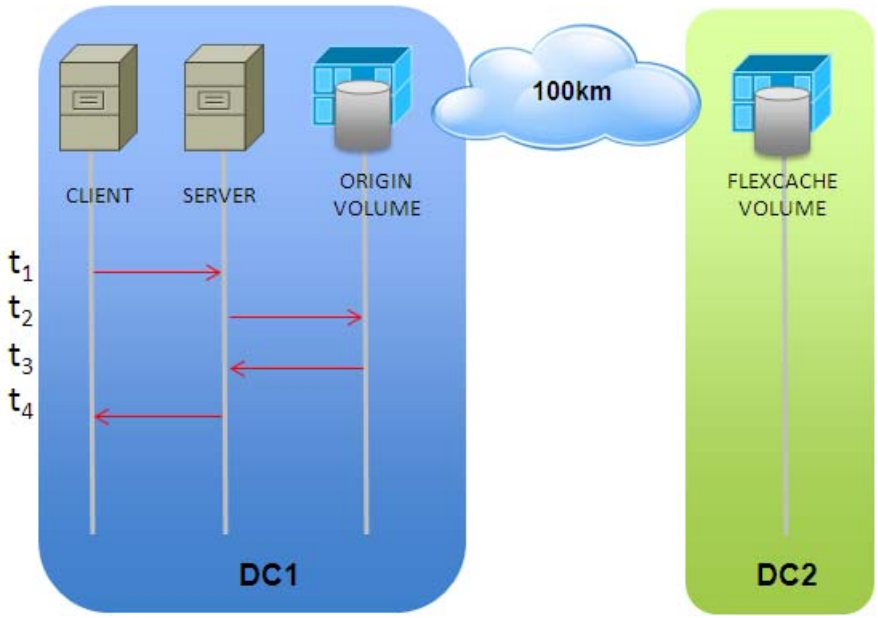
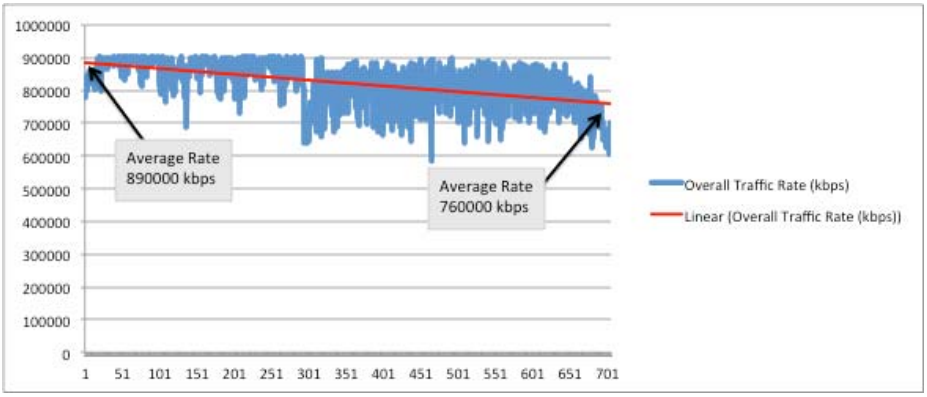


Figure 1-56 shows the cumulative rate of the VM servers' throughput rates, in kbps, before and after the vMotion occurs. Notice that before the vMotion occurred, the application traffic was at an average rate of 890000 kbps, however after the vMotion occurred, the rate decreased to an average of 760000 kbps which is a decrease of 14.6% in performance. This is an improvement of 24.6% over the shared storage deployment.

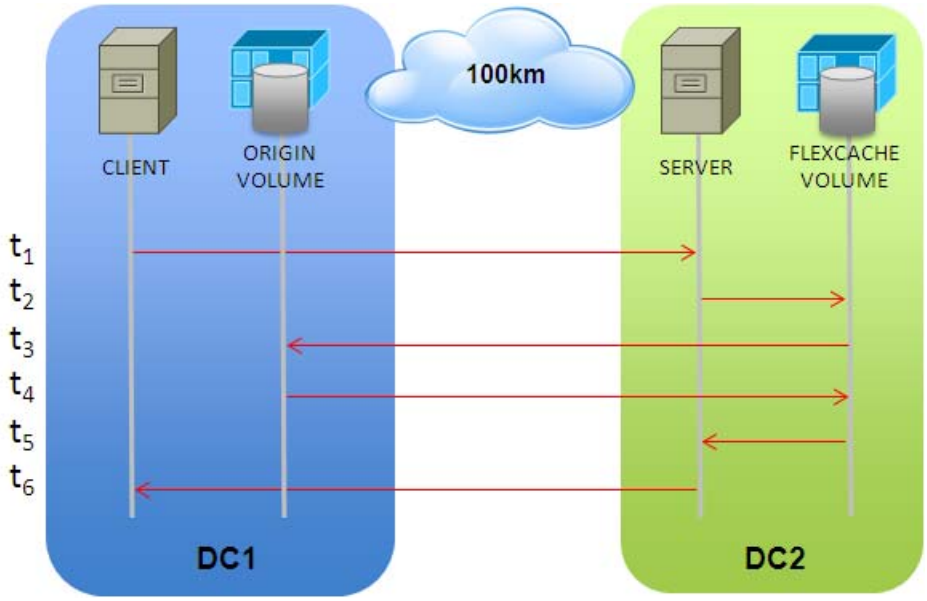
Figure 1-56 Original Client NetApp FlexCache Read Application Traffic Performance



Remember that the original traffic streams are still entering the network at DC1. They are then traversing the OTV LAN extension over to DC2, which is 100km away, to the server. However, instead of the server having read the data from the storage array back in DC1 across the DCI link, another 100km, the server reads the data from the local FlexCache, thus eliminating the need to traverse the DCI link.

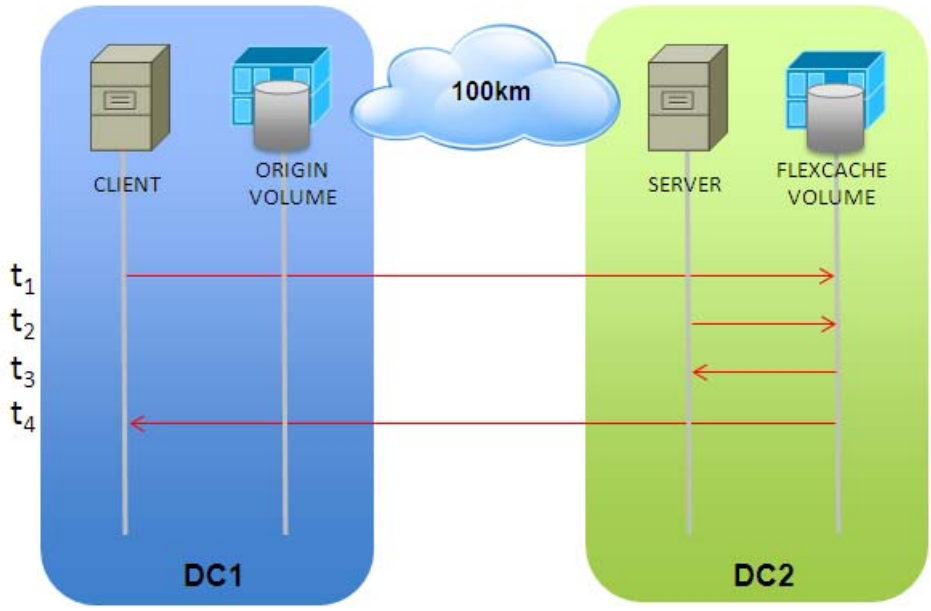
The NetApp FlexCache initially does not have the files in the cache, which results in a cache miss and therefore must go back to DC1 to retrieve the files the first time. This will give performance similar to shared storage since the DCI link must be traversed 4 times.

Figure 1-57 NetApp FlexCache Miss



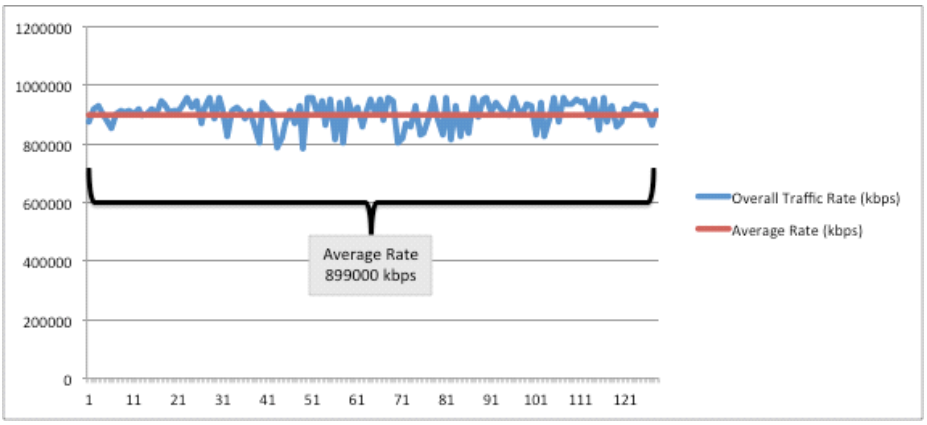
However once the cache is populated, this enables the server to access a local copy of the data from the cache instead of having to traverse the DCI link to retrieve the data.

Figure 1-58 NetApp FlexCache Populated



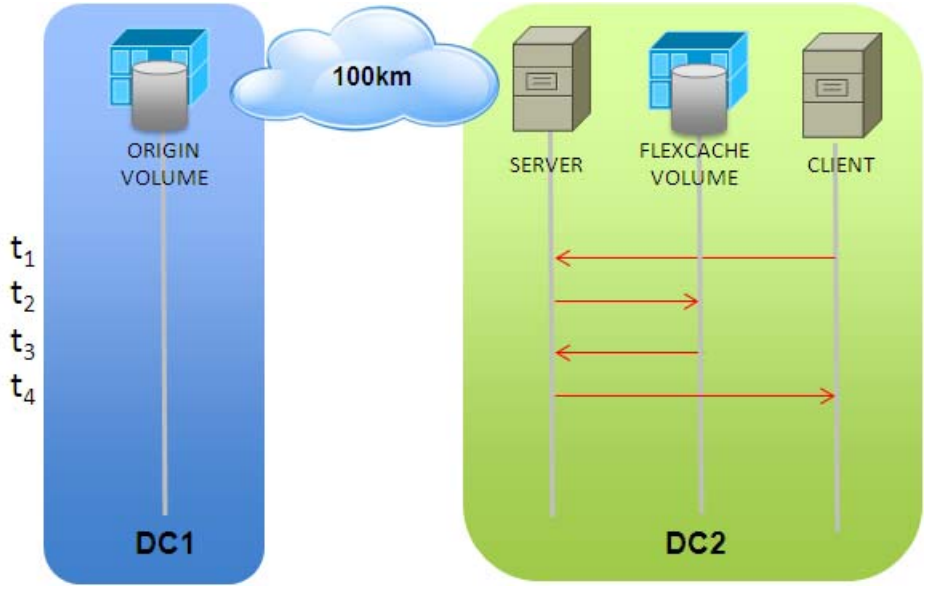
Since the GSS is updated after the vMotion of the server completes, all new flows to the server enter DC2 directly. This removes the need to traverse the OTV LAN extension. The new traffic streams that entered via DC2 had no noticeable traffic degradation as compared to when the VMs were in DC1.

Figure 1-59 Separate New Client FlexCache Read Application Performance



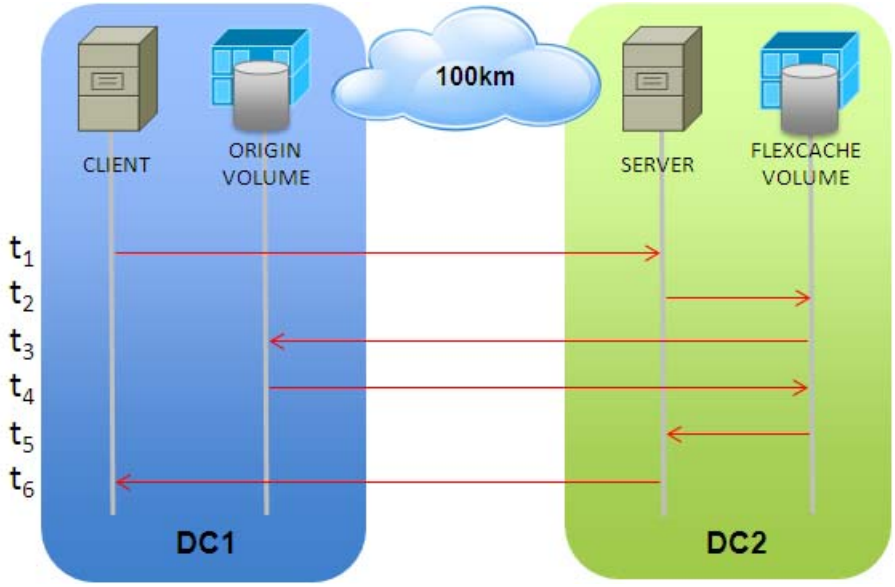
Note for the new client, the client to server communication and the server to storage communication are optimized, providing equivalent application performance when the server was in DC1 and the client was entering the data center via DC1.

Figure 1-60 Optimization of Client-Server and Server-Storage Communication



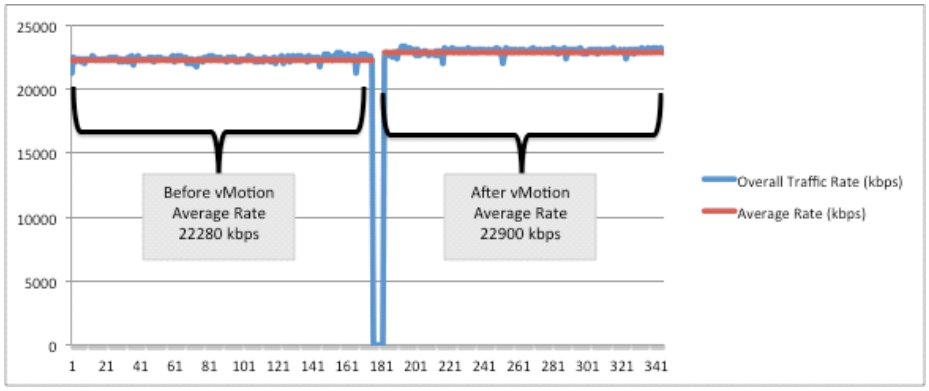
The traffic profiles for NetApp FlexCache during write operations is different than during read operations. As described in the design guide document, in a FlexCache system, all writes from a host are passed directly through the cache volume to the origin volume. The origin volume responds to the FlexCache volume when it assumes responsibility for the new or changed data and only then does the FlexCache volume acknowledges the result of the write to the host. This specific behavior is called a write-through cache.

Figure 1-61 NetApp FlexCache Write-Through Cache



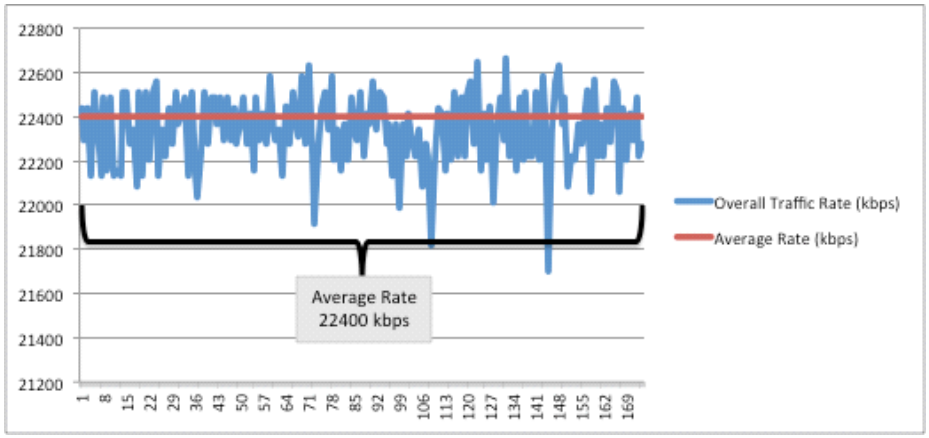
Once the vMotion is complete, the write operations will utilize the OTV LAN extension as well. Before the vMotion occurred, the traffic rate was 22280 kbps on average and after the vMotion occurred, it was 22900 kbps on average, virtually unchanged.

Figure 1-62 Separate Original Client NetApp FlexCache Write Application Performance



The new write traffic streams that entered via DC2 also had no degradation when compared to the client via DC1 streams.

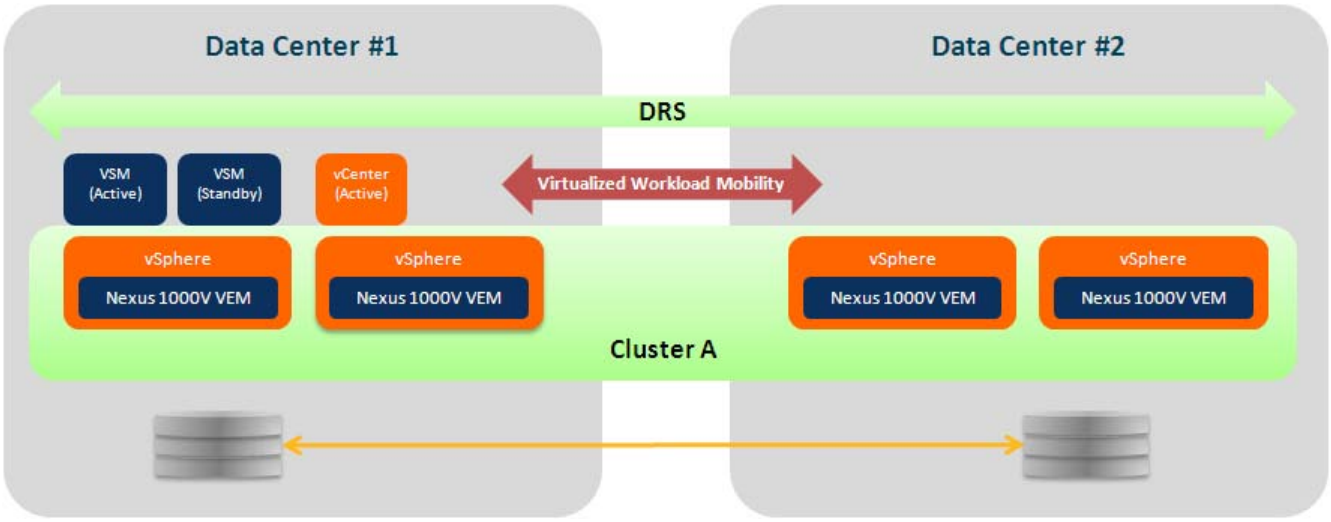
Figure 1-63 Separate New Client FlexCache Write Application Performance



Stretched VMware ESXi Clusters

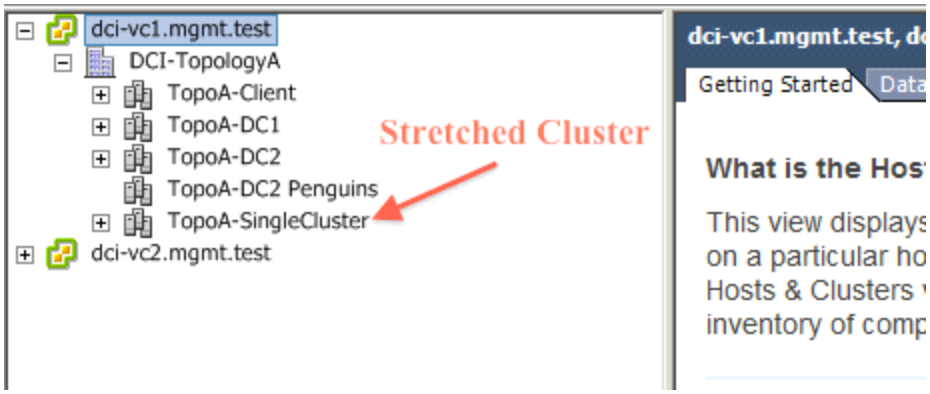
The second method for configuring the ESXi clustering is via a stretched cluster.

Figure 1-64 ESXi Stretched Cluster



The ESXi hosts in the topology are configured so that there is one ESXi cluster including all the ESXi hosts in DC1 and DC2. As described previously, there are 4 ESXi hosts in DC1 and 16 ESXi hosts in DC2. Initially the VMs are deployed so that the 8 test VMs are on DC1 hosts 1-4 with 2 on each host and the Windows XP VMs are deployed with 8 on each host in DC1. All the Linux VMs are deployed in DC2. There are 20 Linux VMs on each of the 12 non-UCS ESXi hosts, and 180 Linux VMs on each of the UCS ESXi hosts. With this configuration, there are 1000 VMs in the cluster.

Figure 1-65 ESXi Stretched Cluster vCenter



The ESXi hosts in the topology are configured so that there is only one ESXi cluster across DC1 and DC2. In a single cluster, vSphere 4.1 can support 8 concurrent vMotions when the bandwidth between the ESXi hosts is 10Gbps.

Note Further information about the number of concurrent vMotions can be found in the following document: http://kb.vmware.com/selfservice/microsites/search.do?language=en_US&cmd=displayKC&externalId=1022851

A workload mobility operation is initiated for the 8 VM servers. Since the network is in the stretched ESXi cluster configuration, all the servers will move in parallel.

Just as in the separate ESXi cluster configuration, after each vMotion is complete, the vCenter uses an alarm trigger to initiate the script to change the GSS entries to point to DC2. This was described earlier in the path optimization section.

The time it takes each VM to move between data centers varies depending on the amount of used memory in the VM. In testing, the times varied between 28 and 43 seconds with the average being 36.2 seconds from start to finish.

Table 1-6 Stretched Cluster vMotion Times Per VM

Server	vMotion Time DC1 -> DC2 (sec)	vMotion Time DC2 -> DC1 (sec)
VM 1	42	31
VM 2	31	34
VM 3	39	42
VM 4	34	41
VM 5	43	28
VM 6	41	30
VM 7	39	31
VM 8	39	34

As in the separate cluster case, traffic was started before the vMotions were to occur to be able to measure the impact of the event on the application. The downtime of the client to server traffic varied from 4 to 17 seconds with the average being 8.4 seconds of actual outage time.

Table 1-7 Stretched Cluster vMotion Outage Time Per VM

Server	vMotion Outage Time DC1 -> DC2 (sec)	vMotion Outage Time DC2 -> DC1 (sec)
VM 1	6	5
VM 2	*	*
VM 3	17	8
VM 4	*	*
VM 5	6	12
VM 6	7	8
VM 7	4	6
VM 8	12	10

Note VM2 and VM4 were the second tier for the 2 tier model and thus the outage measured for those servers was included as part of VM1 and VM3, respectively

Overall, the entire vMotion of 8 VMs took 42 to 43 seconds from start to finish with an average of 42.5 seconds. Notice how this is a much shorter time than in the case of separate ESXi clusters. This is because the moves are all happening in parallel.

Table 1-8 Stretched Cluster Overall vMotion Times

Test Runs	Overall vMotion Time (sec)
DC1->DC2 #1	43
DC2->DC1 #1	42

Since the network is the same except for the ESXi cluster configuration, when tested, the shared storage model had similar performance characteristics as the separate cluster model. These were described in the shared storage results in the previous section.

When the server is located in DC1 and the client enters DC1, none of the traffic traverses the 100km distance between the data centers since the server and storage are both located in the same data center.

Figure 1-66 Stretched DC1 NetApp FlexCache Server-Storage Communication

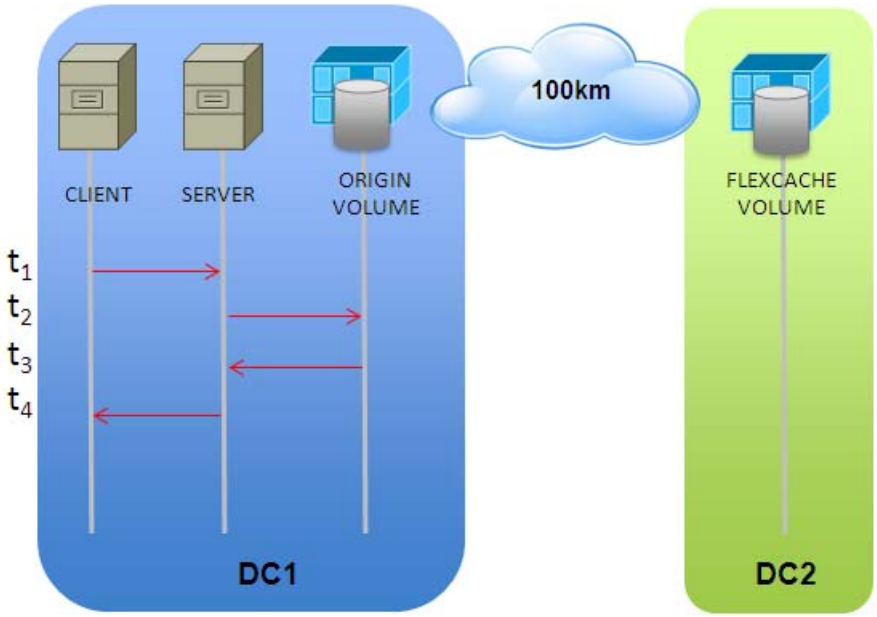
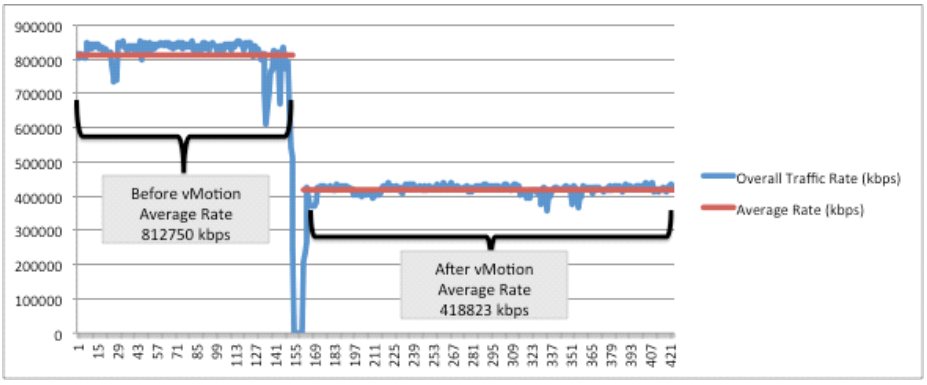


Figure 1-67 shows the cumulative rate of the VM servers' throughput rates, in kbps, before and after the vMotion occurs. Notice that before the vMotion occurred, the application traffic was at an average rate of 812750 kbps, however after the vMotion occurred, the rate decreased to an average of 418823 kbps which is a decrease of 48.5% in performance.

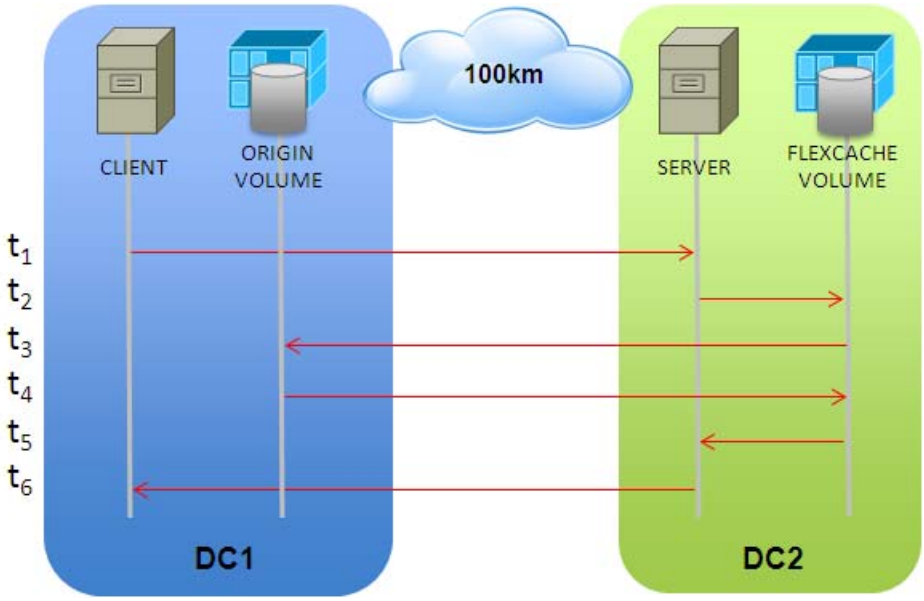
Figure 1-67 Stretched Original Client NetApp FlexCache Read Application Traffic Performance



Remember that the original traffic streams are still entering the network at DC1. They are then traversing the OTV LAN extension over to DC2, which is 100km away, to the server. However, instead of the server having read the data from the storage array back in DC1 across the DCI link, another 100km, the server reads the data from the local NetApp FlexCache.

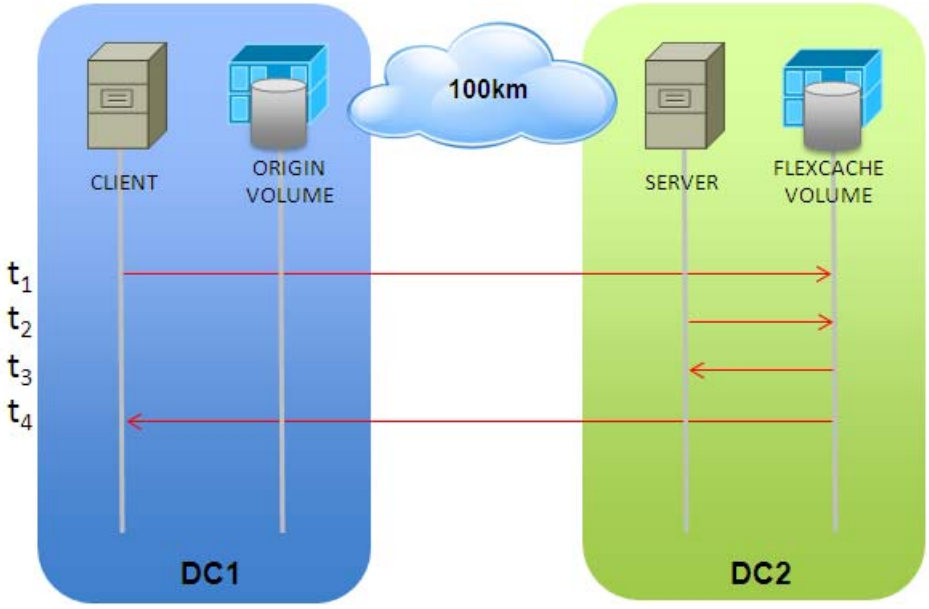
The NetApp FlexCache initially does not have the files in the cache, which results in a cache miss and therefore must go back to DC1 to retrieve the files the first time. This will give performance similar to shared storage since the DCI link must be traversed 4 times.

Figure 1-68 NetApp FlexCache Miss



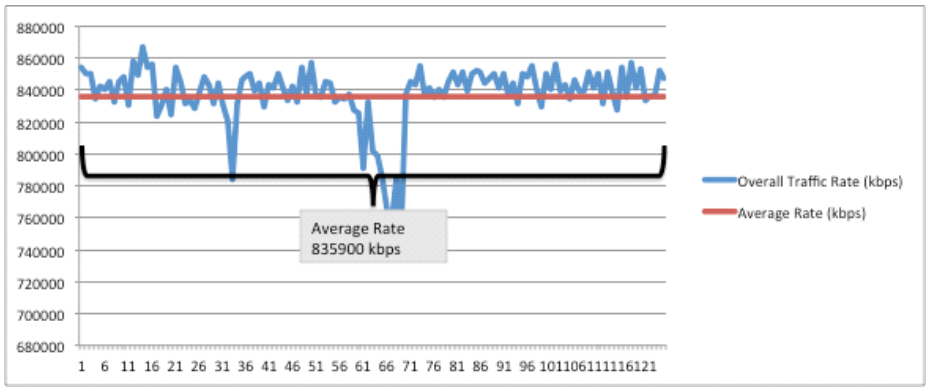
However once the cache is populated, this enables the server to access a local copy of the data from the cache instead of having to traverse the DCI link to retrieve the data.

Figure 1-69 NetApp FlexCache Populated



Since the GSS is updated after the vMotion of the server completes, all new flows to the server enter DC2 directly. This removes the need to traverse the OTV LAN extension. The new traffic streams that entered via DC2 had no noticeable traffic degradation as compared to when the VMs were in DC1.

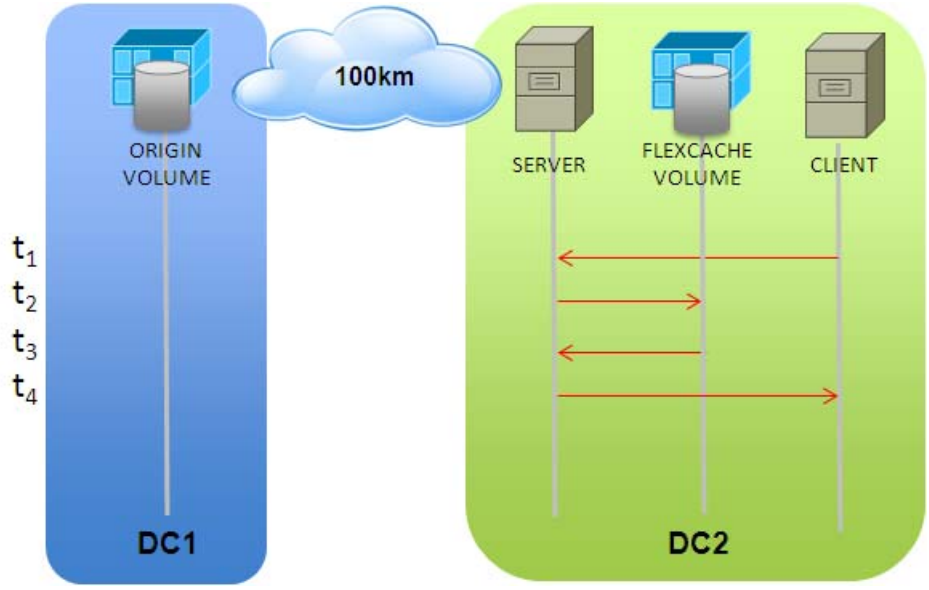
Figure 1-70 Stretched New Client FlexCache Read Application Performance



Note for the new client, the client to server communication and the server to storage communication are optimized, providing equivalent application performance when the server was in DC1 and the client was entering the data center via DC1.

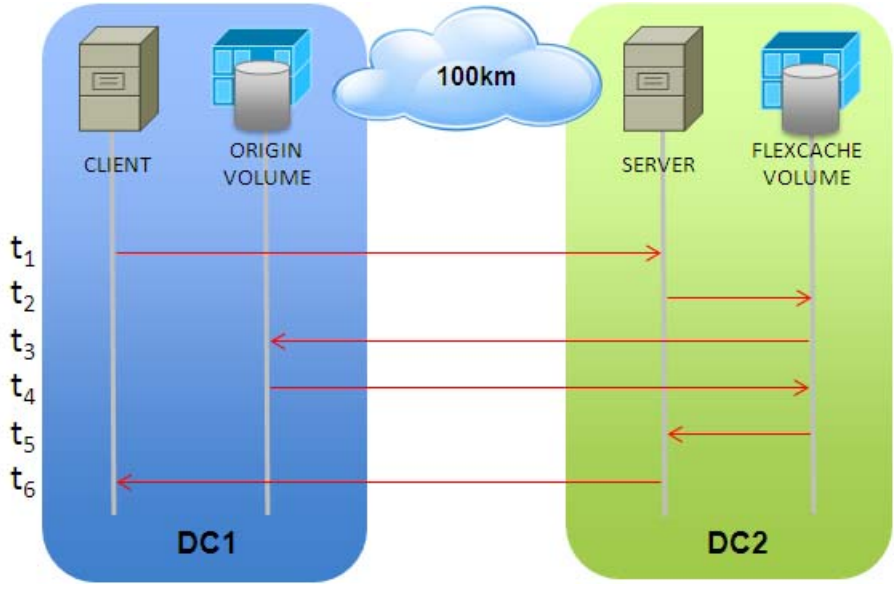
As in the separate ESXi cluster configuration, for traffic streams that are writing traffic to the server, the performance is slightly different than in the read scenario.

Figure 1-71 Optimization of Client-Server and Server-Storage Communication



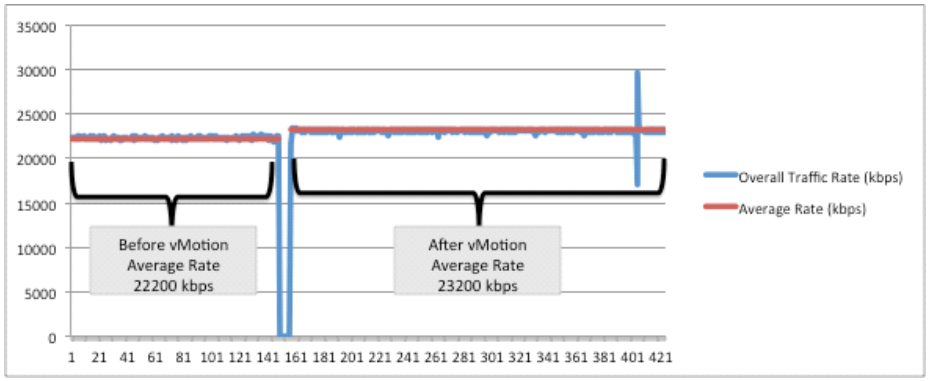
The traffic profiles for NetApp FlexCache during write operations is different than during read operations. As described in the design guide document, in a FlexCache system, all writes from a host are passed directly through the cache volume to the origin volume. The origin volume responds to the FlexCache volume when it assumes responsibility for the new or changed data and only then does the FlexCache volume acknowledges the result of the write to the host. This specific behavior is called a write-through cache.

Figure 1-72 NetApp FlexCache Write-Through Cache



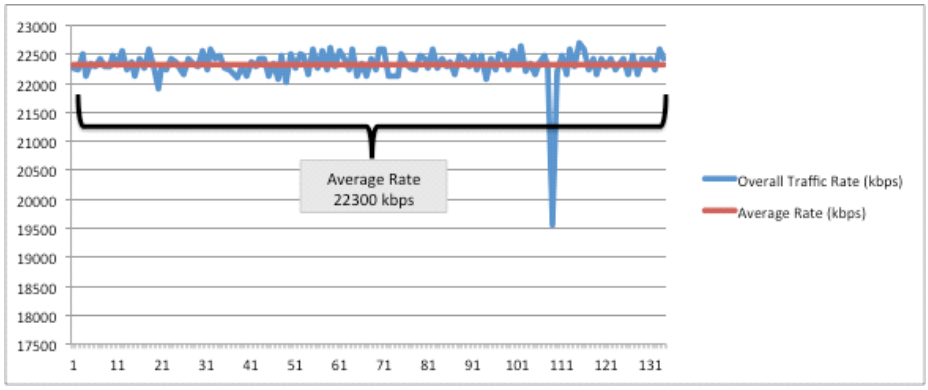
Once the vMotion is complete, the write operations will utilize the OTV LAN extension as well. The original client to server write traffic had no noticeable performance change after the VM was moved to DC2.

Figure 1-73 Stretched Original Client FlexCache Write Application Performance



The new write traffic streams that entered via DC2 also had no degradation when compared to the client via DC1 streams.

Figure 1-74 Stretched New Client FlexCache Write Application Performance



Summary of Deployment Recommendations

The Virtualized Workload Mobility solution allows for live migration of virtual machines between data centers located 100Km apart. Various functional components of the solution were considered.

LAN Extension

The deployment of OTV over dark fiber brings up several design advantages when compared to the vPC-based solution.

- Provisioning of Layer 2 and Layer 3 connectivity leveraging the same dark fiber connections reduces the number of dark fiber required between the data centers.
- Native failure domain isolation: there is no need to explicitly configure BPDU filtering to prevent the creation of a larger STP domain extending between the two sites. Also, ARP optimization is also provided in order to limit the amount of ARP broadcast frames exchanged between data center locations.

- Improved Layer 2 data plane isolation: The required storm-control configuration is simplified in the OTV deployment scenario because of the native suppression of unknown unicast frames and for the broadcast containment capabilities of the protocol (broadcast containment is a roadmap item at the time of writing of this document).
- Native multi-homing LAN extension capabilities, which would allow extending the service to additional remote sites in a very simple fashion.

The deployment of OTV implies that the same LAN/IP subnet gets stretched between two (or more) data center locations. While removing the need to re-IP the VM once it is moved, a given IP address loses its linkage to a specific location. A mechanism is usually desired to optimize the traffic flows between any client and a specific data center service.

Path Optimization

In order to optimize the server to client (egress) traffic flows, it is required to deploy a local active default gateway for all the hosts belonging to a given extended VLAN. Notice that doing so, not only ensure to optimize traffic directed toward a given client, but avoid also tromboning of traffic for inter-subnet routing inside each data center location. When deploying egress path optimization in the context of a virtualized workload mobility deployment, it is also important to ensure that the same virtual MAC (vMAC) and virtual IP (vIP) are associated to the default gateway active in each location.

In this way, a workload moved between DC1 and DC2 (for example leveraging VMware vMotion) would maintain in the ARP cache the information it had before moving, so the same (vMAC, vIP) combination can be used to route traffic outside its own subnet once migrated to the new location.

The recommended solution to achieve this goal consist in defining the same FHRP (HSRP) group in each site and filter the FHRP messaging across the LAN extension connection. This prevents the HSRP nodes in the local Data Center from communicating with the HSRP nodes in the remote Data Center and allows each HSRP group to operating independently from one another. The virtual machine IP default gateway is configured for the HSRP Virtual IP address, and since the HSRP VIP is the same in each Data Center (together with the vMAC, since the same HSRP group is configured), the VM IP default gateway does not need to change, and remains active, as the VM moves from one Data Center to another.

The optimization of egress traffic flows represents only half of the challenge. In many scenarios it is highly desirable to ensure optimization also for the ingress traffic flows (client to server), in order to avoid asymmetric routing scenarios where traffic directed to the client exits from DC2 and the return flows directed to the server enters through DC1. This becomes mandatory when deploying stateful services (like firewall and load balancer services). In order to avoid breaking established sessions once the workload is moved to the new location, the ACE and GSS are utilized to provide a DNS based ingress path optimization.

To achieve this, the following network elements are deployed:

- A separate ACE is deployed in each data center site. The ACE is connected to the aggregation layer devices leveraging a vPC connection. Traffic from the client enters the ACE via a L3 VLAN across the vPC.
- The ACE in each data center associates a different Virtual IP (VIP) address to each given workload (1:1 mapping). This implies that when the workload is deployed in DC1, external clients can access it by connecting to VIP_1 address, whereas VIP_2 is used once the workload is moved to DC2. This is the basic assumption of every DNS based ingress optimization technique, since the use of a unique VIP per site is what allows the GSS to redirect traffic to the right location where the workload is deployed.

- The ACE then used source network address translation (SNAT) to send the traffic via L2 to the destination server. This is to ensure stitching of egress traffic back to the ACE that received the original ingress flow.
- At least one GSS per DC should be deployed to provide redundancy. Each GSS is connected to one WAN edge device. These two GSS are configured as an Active/Standby GSSM (Global Site Selector Manager) pair and are able to respond to queries regardless of their active or standby role. It is possible to deploy additional GSS nodes simply operating as peers of the GSSM pair.
- VMware vCenter is required to take an action (i.e. update the entry in GSS associated to a given workload), once the vMotion for the workload is completed. In the simplest fashion, this can be done only on a single VM level. As a consequence, this solution only addresses where a single VM is used to represent a specific application.

Server Virtualization

The Cisco Nexus 1000V switch is a software switch on a server that delivers Cisco VN-Link services to virtual machines hosted on that server. It takes advantage of the VMware vSphere framework to offer tight integration between server and network environments and help ensure consistent, policy-based network capabilities to all servers in the data center.

Nexus 1000V allows policy to move with a virtual machine during live migration, ensuring persistent network, security, and storage compliance, resulting in improved business continuance, performance management, and security compliance. A single Nexus 1000V should be deployed between the data centers to allow for the policy profiles to migrate with the VM. This removes the need to any rebuilding of policy definitions by the user and thus increases the speed and efficiency of the workload move. The active and standby VSM for the Nexus 1000V should be deployed in the same data center.

Cisco Virtual Security Gateway (VSG) is a virtual firewall for Cisco Nexus 1000V Series Switches that delivers security and compliance for virtual computing environments. Cisco VSG uses virtual network service data path (vPath) technology embedded in the Cisco Nexus 1000V Series Virtual Ethernet Module (VEM), offering transparent insertion and efficient deployment. Utilizing the VSG allows the security policies to move with the VM when a workload is moved.

Storage Elasticity

NetApp FlexCache is a caching technology that improves storage access performance, similarly to the way a cache in the memory architecture of a compute system improves performance. FlexCache improves performance in an NFS environments by scaling out cache volumes for increased IOPs, bringing data closer to the hosts for decreased latencies, off-loading overburdened storage controllers, or a combination of all of these.

A cache is a temporary storage location that resides between a host and a source of data. The main objective of a cache is to store frequently accessed portions of a source of data in a way that allows the data to be served faster and/or more efficiently than it would be by fetching the data from the source. Caches are beneficial in read-intensive environments in which data is accessed more than once and/or is shared by multiple hosts.

The deployment of FlexCache does not provide any support for data replication between sites, since the actual data is only stored on the Origin Volume located in DC1. In order to address scenarios where a disaster could strike and put DC1 offline, it is recommended to provide data replication (for example leveraging NetApp SnapMirror) toward a DR location (which could also be the same DC2 site where the FlexCache System is deployed). Specifics about disaster recovery were beyond the scope of this phase of testing.

Workload Mobility Results

In summary, the ESXi cluster model used determines the time it will take for the entire workload mobility event to occur. Having the ability to move 8 VMs concurrently decreases the overall time needed on average by 65 seconds, or 64%. When considered with the number of VMs that may need to be moved, this greater than 50% reduction in time can be critical. The NetApp FlexCache configuration provided local active-cache storage in DC2 which improved application performance after workload mobility of 25% on average as compared to shared storage at 100km.

Summary of Deployment Caveats

Below is a summary of the deployment caveats discussed in this document.

- CSCtn18346 - GSS 4492 running version 3.1(2) fails to boot up to "Normal Operation" or [runmode=5] and may be stuck in [runmode=0] when the “ip name-server” command is missing from the non-gslb configuration.
- Data store deployment tuning and provisioning is essential for optimized VM migration with low application impact. Please contact EMC and VMware to discuss the options.
- A defect (CSCto11322) points to a possible problem with the Windows 2000 driver in conjunction with the E1000 network adapter used on the VMs. The problem is mostly sporadic; the defect mentioned numerous power cycles before the issue could be reproduced. To alleviate this issue in testing, the number of allowed port-security MAC addresses was raised to 2.
- Disjoined L2 domains are not supported on the current release of 6100 software.
- Enhanced vMotion Compatibility (EVC) needs to be disabled for the ESXi cluster when there are a mix of Intel and AMD based in the same cluster.
- vCenter stores and processes scheduled tasks times in UTC and thus does not have daylight savings time. Due to this scheduled tasks will run one hour earlier after the DST change.
- During the VNMC configuration, you must configure the hostname and domain name or the VNMC will not power up. This is resolved in VNMC release 1.2.
- The “fail open” and “fail close” modes of the VSG are set at the port profile level. However, currently there is no support for a mixed mode configuration in a given VSG, which means the same mode is used for all the port profiles associated to that policy node.

APPENDIX A

Bill of Materials as Validated

Table A-1 presents the product part numbers for the components required to build out the network infrastructure used to validate the Virtualized Workload Mobility solution.

Table A-1 Cisco Virtualized Workload Mobility Solution Components

Part Number	Description	Quantity
Cisco Nexus 7010		
N7K-C7010-BUN	Nexus7000 C7010 (10 Slot) Chassis	8
N7K-M132XP-12	10 Gbps Ethernet Module	16
N7K-SUP1	Supervisor module-1X	14
N7K-C7010-FAB-1	Fabric Module 1	24
N7K-M148GT-11	10/100/1000 Mbps Ethernet Module	8
Cisco Nexus 5000		
N5K-C5020P-BF	40x10GE/Supervisor	4
N10-FAN2	Chassis fan module	20
N5K-PAC-750W	AC power supply	8
Cisco Nexus 2000		
N2K-C2148T-1GE	N2K-C2148T-1GE CHASSIS	12
N2K-C2148-FAN	Fabric Extender Fan module	4
N2K-PAC-200W	Fabric Extender AC power supply	4
Cisco Catalyst 6500		
WS-C6504-E	Cisco 6500 4-slot Chassis System	8
WS-SUP720-3BXL	Supervisor Engine 720	4
WS-F6K-PFC3BXL	Policy Feature Card 3	4
WS-X6704-10GE	CEF720 4 port 10-Gigabit Ethernet	16
WS-X6748-GE-TX	CEF720 48 port 10/100/1000mb Ethernet	7
WS-SUP720-BASE	Supervisor Engine 720	1
WS-F6K-PFC3A	Policy Feature Card 3	1
WS-SUP720	Supervisor Engine 720	8
WS-X6148A-GE-45AF	48-port 10/100/1000 RJ45 EtherModule	1

Table A-1 Cisco Virtualized Workload Mobility Solution Components

Part Number	Description	Quantity
WS-SUP720-3B	Supervisor Engine 720	2
WS-F6K-PFC3B	Policy Feature Card 3	3
Cisco Global Site Selector (GSS)		
GSS-4492-k9	Global Site Selector 4492	4
Cisco Application Control Engine (ACE)		
ACE-4710-K9	ACE 4710 Application Control Engine Appliance	4
Cisco MDS 9500		
DS-C9509	MDS 9509 (9 Slot) Chassis	2
DS-X9224-96K9	1/2/4/8 Gbps FC Module	6
DS-X9316-SSNK9	16x1GE, Storage Services Node	2
DS-X9304-18K	4x1GE IPS, 18x1/2/4Gbps FC Modul	2
DS-X9530-SF2-K9	Supervisor/Fabric-2	4
DS-CAC-2500W	MDS 9509 (9 Slot) Chassis Power Supply	2
DS-9SLOT-FAN	MDS 9509 (9 Slot) Chassis Fan Module	2
WS-CAC-6000W	MDS 9509 (9 Slot) Chassis Power Supply	2
Cisco UCS Chassis		
N20-C6508	UCS 5108 Blade Server Chassis/0 PSU/8 fans/0 fabric extender	4
SC IO OPT	I/O Module Addons	4
N20-I6584	UCS 2104XP Fabric Extender/4 external 10Gb ports	5
N20-PAC5-2500W	2500W power supply unit for UCS 5108	11
SC PWR CAB OPT	Power Cables	11
N20-FAN5	Fan module for UCS 5108	32
N20-FW001	UCS 5108 Blade Server Chassis FW package/DO NOT PUBLISH	4
N20-B6620-1	UCS B200 M1 Blade Server w/o CPU, memory, HDD, mezzanine	4
N20-B6620-2	UCS B250 M1 Blade Server w/o CPU, memory, HDD, mezzanine	12
Cisco UCS 6100 Fabric Interconnect		
N10-S6100	UCS 6100 Series Fabric Interconnect	5
N10-S6100-SUP	20x10GE/Supervisor	5
N10-E0440	4x10GE + 4x1/2/4G FC Module	5
N10-FAN1	Chassis fan module	10
N10-PAC1-550W	AC power supply	10
NetApp (Network Attached Storage)		
FAS6080A-IB-BS2-R5	FAS6080A,IB,ACT,ACT,HW/SW, 220V,R5	1
X1107A-R6-C	NIC 2-PORT BARE CAGE SFP+ 10GbE SFP+ PCIe, -c	2
DS4243-0724-12A-R5-C	DSK SHLF, 12x2.0TB,7.2K,SATA, IOM3,-C,45	2

APPENDIX B

Acronyms

Table B-1 provides key terminology acronyms used in Data Center Interconnect technologies.

Table B-1 Acronyms

ACE	Application Control Engine
DCI	Data Center Interconnect
DWDM	Dense Wave Division Multiplexing
FC	Fibre Channel
FCP	Fiber Channel Protocol
FCIP	Fibre Channel over IP
FHRP	First Hop Redundancy Protocol
FW	Firewall
GSS	Global Site Selector
HSRP	Hot Standby Routing Protocol
LAN	Local Area Network
MAC	Media Access Controller
MAN	Metro Area Network
Nexus 1000v	Nexus 1000 virtual switch
Nexus 7K	Nexus 7000 Data Center switch
OTV	Overlay Transport Virtualization
SAN	Storage Area Network
STP	Spanning Tree Protocol
UCS	Unified Computing System
VDC	Virtual Device Context
VEM	Virtual Ethernet Module
VSM	Virtual Switch Module
VIP	Virtual IP address
VSG	Virtual Security Gateway
VLAN	Virtual Local Area Network
VM	Virtual Machine

Table B-1 Acronyms

VNMC	Virtual Network Management Center
vPC	Virtual Port Channel
VPN	Virtual Private Network
VWM	Virtualized Workload Mobility