## **Demartek 16Gb Fibre Channel Deployment Guide**

## **Overview**

The current generation of Fibre Channel (FC), which is 16Gb Fibre Channel (16GFC), was first introduced in the second half of calendar year 2011, and the industry is beginning to see increased interest and adoption of 16Gb Fibre Channel. Therefore, Demartek has produced this Demartek Fibre Channel Deployment Guide, one in a series of technology deployment guides. This guide can be found on our website in our <u>FC Zone</u> or by searching the Internet for "*Demartek Fibre Channel Deployment Guide*" using any well-known Internet search engine.

### **Audience**

This guide is designed for managers and technical professionals within IT departments who are exploring the benefits of deploying, or upgrading to, Fibre Channel technology in general, or 16Gb Fibre Channel specifically, or who are looking for actual deployment examples of 16Gb Fibre Channel solutions.

### **Objectives of this Guide**

This guide is designed to provide basic information about 16Gb Fibre Channel and practical guidance for planning and deploying 16Gb Fibre Channel technology and products. The focus is 16Gb Fibre Channel in primarily, but not exclusively, virtualized environments.

Because 16Gb Fibre Channel includes server adapter and switching technologies, this guide provides information and guidance in each area. A basic understanding of each of these areas is needed to successfully deploy 16Gb Fibre Channel technology.

This guide is intended to be used as a reference and is divided into sections including marketplace data, technology areas, and deployment guidance for virtual servers. There are screen shots and information from actual deployments of some products. At the time of the testing conducted for this guide, there were few true 16Gb Fibre Channel storage targets. Multiple 8Gb paths to storage targets were used to provide suitable bandwidth to demonstrate the capability of 16Gb Fibre Channel.

All of the work was performed in the Demartek lab in Colorado, USA.

### **About Demartek**

Demartek is an industry analyst organization with its own ISO 17025 accredited EPA ENERGY STAR certified testing laboratory for Data Center Storage. The vast majority of the research work we do involves hardware and software solutions tested in our lab by our staff. The Demartek lab is equipped with servers, network infrastructure, and storage, and supports multiple speeds of Ethernet, iSCSI and Fibre Channel, along with SSDs and a variety of other technologies. Many public lab validation and test reports highlighting Fibre Channel and other technologies are available on our website.

### **Demartek Videos**

Demartek produces highlight videos of public evaluations and deployment guides. Links to these videos are available on our web site in the <u>Demartek Video Library</u> and are posted on the <u>Demartek channel</u> on YouTube.

### **Demartek Lab Notes**

To be notified when new Deployment Guides and lab validation reports become available, you can subscribe to our free monthly newsletter, <u>Demartek Lab Notes</u>, available on our website. We do not give out, rent or sell our email list.

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## **Table of Contents**

Overview1
Audience1
Objectives of this Guide1
About Demartek2
Demartek Videos 2
Demartek Lab Notes 2
Table of Contents   3
Basic Storage Architectures
Direct Attached Storage (DAS)5
Network Attached Storage (NAS)5
Storage Area Network (SAN)
Unified Storage7
Demartek Storage Interface Comparison Reference Page7
Fibre Channel Marketplace
Fibre Channel History
Past and Current Versions
Generation 6 Fibre Channel – the Next Version9
16Gb Fibre Channel Specifics10
Fibre Channel Technology and Definitions11
Direct Connect11
Arbitrated Loop11
Switched Fabric11
Initiators12
Targets12
Fibre Channel Host Bus Adapters12
Fibre Channel Storage Arrays13
Fibre Channel Switches and Backbones13
World Wide Node Name and World Wide Port Name13
Switch Management Software

Fibre Channel Switch Zoning	14
Deploying 16Gb Fibre Channel in Virtualized Environments	
Microsoft Hyper-V	
Virtual Hard Disk	18
Pass-through (Raw Device Mapping)	19
NPIV	19
VMware	25
Virtual Hard Disk	26
Pass-through (Raw Device Mapping)	36
NPIV	37
Measuring 16Gb Fibre Channel Performance	
Bandwidth, IOPS, and Latency	40
Windows Perfmon	40
Linux sysstat	40
Workload Testing	
16Gb Fibre Channel Best Practices	
Multipath I/O	43
Increasing VM Density	45
Legal and Trademarks	

## Basic Storage Architectures Direct Attached Storage (DAS)

Direct Attached Storage (DAS) is probably the most well-known form of computer storage. In a DAS implementation, the host computer has a private connection to the storage and almost always has exclusive ownership of the storage. The host computer accesses the storage in a "block" fashion, which means that it directly addresses blocks on the storage device. This implementation is relatively simple and usually inexpensive. Potential disadvantages are that the distance between the host computer and the storage are frequently short, such as inside a computer chassis or within a rack or adjacent rack. Some DAS implementations require that the host computer be taken offline when adding or removing storage devices, such as a boot drive directly connected to a motherboard storage interface. SATA is a common DAS interface.

## **Network Attached Storage (NAS)**

Network Attached Storage (NAS) devices, also known as file servers, share their storage resources with clients on the network in the form of "file shares" or "mount points." The clients use network file access protocols such as SMB (formerly known as CIFS) or NFS to request files from the file server. The file server then uses block protocols to access its internal storage to satisfy the requests. Because NAS operates on a network, the storage can be very far away from the clients. Many NAS solutions provide advanced features such as snapshot technologies, global namespace, SSD caching, and more.

## **Storage Area Network (SAN)**

SAN architecture provides a way to use block access methods over a network such as Ethernet or Fibre Channel to provide storage for host computers. The storage in a SAN is not owned by one server but is accessible by all of the servers on the network. This SAN storage can be carved into logical storage pools or volumes that can be assigned to particular host servers. These logical volumes are independent of the geometries or components of the storage hardware. The storage appears to host servers and applications in the same way that DAS storage appears, but because SAN storage uses a network, storage can be a long distance away from the host servers.

SAN architectures currently use block Small Computer System Interface (SCSI) protocol for sending and receiving storage data over their respective networks. Fibre Channel (FC) SANs implement the SCSI protocol within the FC frames. Internet SCSI (iSCSI) SANs implement the same SCSI protocol within TCP/IP packets. Fibre Channel over Ethernet (FCoE) encapsulates the Fibre Channel protocol within Ethernet packets using a relatively

new technology called Data Center Bridging (DCB), which is a set of enhancements to traditional Ethernet and is currently implemented with some 10GbE infrastructure. Because each of these technologies allow applications to access storage using the same SCSI command protocol, it is possible to use all of these technologies in the same enterprise or to move from one to the other. Generally speaking, applications running on a host server cannot tell the difference between Fibre Channel SAN storage, FCoE SAN storage, and iSCSI SAN storage. In fact, applications generally cannot tell the difference between DAS storage and SAN storage.

There has been much debate over Fibre Channel vs. iSCSI. Some people focus on the lower entry price points available for iSCSI SANs, while others focus on high reliability, robustness and availability of Fibre Channel SANs. The conventional wisdom in this debate no longer holds true in many cases. While it is true that at the low end iSCSI tends to be less expensive than Fibre Channel, as performance, reliability, and high availability features and designs are included in iSCSI solutions, the iSCSI price advantage diminishes. Over the past few months we tested various solutions for ease of use and found that some implementations of Fibre Channel are just as easy (or easier) to use than some iSCSI implementations. We have also found several iSCSI solutions that are designed for performance, high reliability, and high availability. Much work has been done to increase performance, reliability, and ease-of-use with both of these SAN technologies. The real issues are satisfying the needs of the business or application, working with existing infrastructure and expertise, maintaining service-level agreements, and staying within budgets. Fibre Channel and iSCSI technology can meet these requirements, and there is room for both in current and future IT environments.

Most of the larger enterprises that have implemented SAN technology have implemented Fibre Channel technology. These enterprises typically demand proven technology, have the need for high bandwidth storage solutions, have the budgets to pay for more expensive hardware to meet their performance and reliability needs, and typically have full-time staff dedicated to storage management. Some of these enterprises continue to invest in Fibre Channel storage solutions and plan to do so for the foreseeable future. However, some of these enterprises are also investing in iSCSI storage solutions, especially with 10GbE technology, for their virtualized server environments.

Smaller enterprises are often attracted to iSCSI technology because of its lower entry price point, allowing them to grow their iSCSI SAN as their needs change. The lower entry price

typically uses 1GbE technology, but when 10GbE technology is used, the price for the equipment increases and it is no longer considered "entry level."

There is more to choosing a storage system than selecting the host interface. Regardless of the type of interface, several other factors need to be considered, including the number and type of disk drives, amount and type of SSD technology, management software, advanced features, support from the vendor, service level agreements (SLAs) and several other factors. Advanced features of modern storage systems may include various forms of replication, thin provisioning, compression, data de-duplication, caching, automated storage tiering, and more.

### **Unified Storage**

Unified storage combines NAS and SAN technologies into a single, integrated solution. These unified storage solutions provide both block and file access to the shared storage environment. These often provide simplified management by combining the management of all storage, regardless of the transport or "plumbing," into a single management console.

### **Demartek Storage Interface Comparison Reference Page**

We have compiled a vendor-neutral reference page on our website that provides technical information about Fibre Channel and other storage interfaces used for storage applications. We update this page periodically, and this page includes a downloadable, interactive PDF version with the same contents as the web page. Detailed information regarding history, roadmaps, transfer rates, encoding schemes, cabling, connectors and more is available on this page.

This page can be found by entering "*Storage Interface Comparison*" in any major Internet search engine or by following the link below:

www.demartek.com/Demartek Interface Comparison.html on the Demartek website.

## **Fibre Channel Marketplace**

Deployed in 90 percent of Fortune 1000 datacenters, Fibre Channel is the de facto standard for storage networking in the datacenter. There are literally millions of Fibre Channel ports installed in datacenters worldwide.

## **Fibre Channel History**

## **Past and Current Versions**

Fibre Channel is an industry standard storage solution. Development began in 1988, receiving ANSI standard approval in 1994. Fibre Channel technology was introduced to the market in 1997 at 1 gigabit per second (1Gb) and has doubled in speed every three or four years through the current 16Gb Fibre Channel technology. Although each generation of Fibre Channel was introduced to the market in the years indicated in the chart below, widespread industry adoption sometimes began later.

Generally speaking, Fibre Channel is backward compatible with the two previous generations. This means that 16GFC switches, host bus adapters (HBAs) and optics (transceivers) are backward compatible with 8GFC and 4GFC equipment.



Fibre Channel over Ethernet (FCoE) was introduced into the market in 2009, and works by tunneling Fibre Channel through Ethernet. FCoE currently runs at 10Gbps. Other than the speed and Ethernet carrier, FCoE behaves the same as native FC.

## **Generation 6 Fibre Channel – the Next Version**

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In February 2014, the Fibre Channel Industry Association (FCIA) officially announced "Gen 6" Fibre Channel. This generational naming is an effort to get away from focusing only on the speed of the interface, but to acknowledge that other important features are included with each new generation of Fibre Channel.

## From speed-based naming... 1 Gbps 2 Gbps 4 Gbps 8 Gbps 16 Gbps 32 Gbps To generation-based naming Gen 1 Gen 2 Gen 3 Gen 4 Gen 5 Gen 6

This generational naming philosophy can be found in other technologies such as mobile telephones, where the industry has moved from "1G" to "4G" today. As the mobile telephone industry has moved through its generations, the speeds have improved, but other things such as talk time, the physical size of the devices and other features have also improved. In fact, few consumers know the actual transmission speeds for these generations of mobile telephone technology.

Gen 6 Fibre Channel includes a single-lane specification running at 32Gbps and a parallel, four-lane (4 x 32Gbps) specification known as 128GFC. Products that use the new Gen 6 Fibre Channel are expected to become widely available in calendar year 2016. It is our belief that the 32GFC products will probably become available before the 128GFC products.

Gen 6 Fibre Channel includes energy efficient features that allow the optical connectors to operate in a stand-by mode (or "nap") multiple times each second.

According to the specification, Gen 6 Fibre Channel (both 32GFC and 128GFC) is backward compatible with 16GFC and 8GFC.

## **16Gb Fibre Channel Specifics**

16Gb Fibre Channel provides not only doubles the throughput from the previous generation, but has other benefits.

Some of these benefits are directly related to the speed increase, such as a reduced number of links needed to achieve the same bandwidth, reduced power consumption needed to achieve the same bandwidth and fewer cables to manage. In addition, the higher speed allows fabrics to be connected with fewer inter-switch links (ISLs), which is especially helpful in large fabrics.

16Gb Fibre Channel includes retimers in the optical modules and transmitter training, features that improve link performance characteristics, electronic dispersion compensation and backplane links.

Speed	Throughput (Mbps)	Line Rate (Gbps)	Encoding	Retimers in the module	Transmitter training
1 GFC	100	1.0625	8b/10b	No	No
2 GFC	200	2.125	8b/10b	No	No
4 GFC	400	4.25	8b/10b	No	No
8 GFC	800	8.5	8b/10b	No	No
16 GFC	1600	14.025	64b/66b	Yes	Yes

### Table 1 - Fibre Channel Speed Characteristics

#### Table 2 – Fiber Optic Cable Link Distance

Snood		Multi-	Mode		Single-Mode
Speeu	OM1	0M2	ОМЗ	OM4	051
1 GFC	300	500	860	*	10,000
2 GFC	150	300	500	*	10,000
4 GFC	50	150	380	400	10,000
8 GFC	21	50	150	190	10,000
16 GFC	15	35	100	125	10,000

\* The link distance for OM4 fiber optic cable has not been defined for these speeds.

## **Fibre Channel Technology and Definitions**

### **Direct Connect**

A Fibre Channel storage target can be connected in a point-to-point or direct fashion to a server (initiator) without needing to go through switches or an arbitrated loop.

## **Arbitrated Loop**

Fibre Channel arbitrated loop (FC-AL) is a Fibre Channel design implementation where devices are connected in a one-way loop and bandwidth is shared by all devices. When a device needs to put data on the channel, it requests control of the loop by sending an arbitration signal to the elements of the loop. This signal is used to determine which device ports are granted ownership of the bandwidth and the associated ports are opened.

As FC switches became more affordable in the late 2000s, use of FC-AL between storage and servers declined. However, some FC target devices may use the FC-AL designs internally. Dual loops are often used inside of these storage devices to provide redundancy.

## **Switched Fabric**

A network of Fibre Channel devices and switches is referred to as a fabric. Switched fabric is the general design implementation that most people today associate with Fibre Channel deployments. With this general design, SAN devices are found on the edge of the network, various configurations of switches are found in the core of the network, and fiber optic cabling is used to connect these components together.

The term topology describes how the switches are interconnected, such as core-edge, edge-core-edge or fully meshed. The goal of these topologies is to provide good performance for all of the edge devices, good resiliency of the network, while minimizing the number of interconnections between switches.



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The placement of the devices and the associated traffic flows are the key differences between the four scenarios.

- Scenario A has localized traffic, which has no extra hops between switches, providing a slight performance advantage but does not provide scalability or resilience features.
- Scenario B is an edge-core switch configuration, separating the server and storage and introducing one switch hop. This topology provides increased scalability opportunities.
- Scenario C is an edge-core-edge configuration, with two hops between switches, and provides large scalability opportunities.
- Scenario D is a full-mesh topology and uses inter-switch connections so that there is no more than one hop between the edge devices such as servers and storage. These configurations can grow to thousands of device ports.

Inter-switch connections are sometimes called inter-switch links (ISLs) or inter-chassis links (ICLs).

### Initiators

Initiators are typically host servers that need access to storage resources. This is in keeping with the standard SCSI protocol where initiators issue commands to storage devices and wait for replies. Fibre Channel initiators are usually implemented in a hardware host bus adapter, but are sometimes implemented in software. Fibre Channel initiators can access multiple Fibre Channel targets simultaneously.

### **Targets**

Targets are devices that provide storage resources for Fibre Channel initiators. These follow the SCSI protocol for targets by responding to requests from initiators. Targets can be implemented as dedicated hardware devices such as disk arrays or as combination hardware and software in a server or appliance solution. Fibre Channel targets can respond to multiple Fibre Channel initiators simultaneously.

### **Fibre Channel Host Bus Adapters**

Fibre Channel Host Bus Adapters (HBAs) connect a device such as a server or storage device to the Fibre Channel network or another FC device. Due to the architecture of Fibre Channel HBAs, most of the processing of the I/O requests is performed by the HBA itself, and is "offloaded" from the host CPU. As a result, Fibre Channel I/O traffic tends to be

very host CPU efficient when compared to other interfaces that do not offload the I/O processing.

### **Fibre Channel Storage Arrays**

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Many storage vendors sell storage array products configured for the Fibre Channel protocol. FC storage arrays can be composed of hard disk drives (HDDs), solid state drives (SSDs) or a combination of the two. These arrays have target mode Fibre Channel HBAs present. An FC array can be connected to a host via direct connect, arbitrated loop, or switched fabric.

We are beginning to see products from storage vendors that have 16Gb Fibre Channel host ports. The performance of 16Gb Fibre Channel can be approximated by utilizing multiple 8Gb ports (or slower ports). However, using 16Gb Fibre Channel components requires fewer cables, optics and switch ports than it would to achieve equivalent performance with 8Gb Fibre Channel or 4Gb Fibre Channel.

### **Fibre Channel Switches and Backbones**

The switches are designed to run stand-alone or as edge switches for part of a larger SAN fabric. The Backbones, also known as Directors, form the central core of an enterprise Fibre Channel fabric and provide reliable, scalable, high-performance switching infrastructure for mission-critical storage. There are also embedded Fibre Channel switches designed for the blade server market and Fibre Channel encryption solutions for protecting data-at-rest. Fibre Channel extension solutions provide ESCON, FICON and FCIP (Fibre Channel over IP). FCIP is often used to transmit Fibre Channel protocol over a WAN.

### World Wide Node Name and World Wide Port Name

IEEE provides FC device vendors with unique identities called World Wide Names (WWN) in the form of a 64-bit address, not unlike a MAC address for Ethernet devices. The World Wide Node Name (WWPN) identifies the endpoint, such as an HBA, while the World Wide Port Name identifies individual ports on a device (for example, the single or dual ports of an HBA).

#### **Switch Management Software**

Software management tools are available that support full lifecycle management of all switches in the network to ensure network availability and optimal performance and available for use on most versions of Windows, Linux, VMware and Microsoft Hyper-V.

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### **Fibre Channel Switch Zoning**

Zoning is a service in Fibre Channel SANs that groups together servers and storage that need to communicate with each other. Elements of a zone can only communicate with other elements within the same zone. This prevents unauthorized access of storage. Servers and storage can be members of multiple zones.

Web interface management tools are available to zone switches, such as the example screenshots shown below.



Aliasing allows the administrator to assign logical names to switch ports or WWNs for simpler management. Though not necessary for Fibre Channel zoning, aliasing can improve the ease of zoning administration.

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Selecting WWNs as alias members tends be more portable than using switch ports because the WWNN and WWPN can move from one switch port to another if the fiber optic cables are moved. However, if the Fibre Channel HBAs are moved from one server or storage target to another, it's possible that an alias or zone based on WWNs may have unexpected members, which can be a security concern.

The same ports, WWNs, and aliases can be members of more than one zone. A zone must include both storage clients (initiators) and storage targets to be effective.

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After a zone is created, it must be enabled before storage traffic will run across it. A zone configuration is a collection of zones that will be active at one time. After a zone configuration is created, a name for this zone configuration can be assigned.



Coning Modes	Basic Zones		
Basic Zones	Print Edit View Zoning Actions		
Traffic Isolation Zones	🖲 New 🔻 Resource View 🔻 🍫 Refre	esh ▼ Enable Config Save Config Clear All	
	Alias Zone Zone Config		
	Name COMBINED	▼ New Zone Config Delete Rename Clone	
	Member Selection List	Zone Config Members	
	Zones (© Zones)     Asyudu [Datastores(& Members)     Asyudu [Datastores(& Members)     As DB gerv     Ms_CLUSTER(6 Members)     Ms_CLUSTER(6 Members)     MMBUS_SRVR_((10 Members)     MMBUS_SRVR_((10 Members)	S Zones. FAS3240_SRVR_I MS_CLUSTER NIMBUS_SRVR_I	
			B really the contract course
	Current view: Fabric view		Effective zone config: COMBINED
vitch Commit Messages: ne Admin opened at Thu May	09 2013 21:39:03 GMT+00:00		

Zones are then added to the zone configuration, and then the entire configuration should be saved to preserve aliases, zones, and zone configurations if the switch is powered off or rebooted.

oning Modes	Basic Zones	
Basic Zones	Print Edit View Zoning Actions	
Traffic Isolation Zones	🕒 New 🔻 Resource View 🔻 🍫 Refresh 🔻	Enable Config Save Config Clear All
	Alias Zone Zone Config	
	Name COMBINED	lew Zone Config Delete Rename Clone
	Member Selection List	Zone Config Members
	Cones (6 Zones)     Sones (7 Zones)     Analyze (6 Members)     Analyze (7 Zones)     Monte (7 Zones)	A Zones.
	Current View: Fabric View	🔒 Effective Zone Confia: COMBIN
annaisteann astroite 🕩		
ch Commit Messages:	09 2013 21:39:03 GMT+00:00	
rianini opened at the may	00 E010 E1.00.00 OH1100.00	

## **Deploying 16Gb Fibre Channel in Virtualized Environments**

Fibre Channel is supported by all the common virtualization platforms such as VMware vSphere, Microsoft Hyper-V, and others. Fibre Channel LUNs are suitable to host both guest operating systems and as application space within guests. Provisioning storage can be accomplished with either virtual disks managed by the hypervisor or by passing the raw LUNs directly through to the guest OS.

A feature of 16Gb Fibre Channel that is particularly attractive to virtualization managers is the speed at which datastores or virtual machines can be migrated from one device to another.

### **Microsoft Hyper-V**

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Hyper-V requires no special configuration to connect to FC LUNs once the Windows Server operating system has the device drivers loaded. Microsoft Hyper-V supports two methods of configuring Fibre Channel LUNs for use by guest virtual machines—Virtual Hard Disk method and Pass-through method.

### **Virtual Hard Disk**

In the VHD method, a Fibre Channel volume is allocated to the parent (Hyper-V) partition in the usual manner. This Fibre Channel volume is brought online, initialized, and formatted, and folders may be created if desired.

In the Hyper-V management role, we created a new hard disk using the "Actions" pane. There are three choices for the type of VHD: Fixed size, Dynamically expanding and Differencing.

The new VHD onto the FC volume that was just attached, and storage space allocated.

In the Hyper-V management role, select a virtual machine that is not running, and open "Settings." Add a hard drive under the IDE Controller, and specify the location of the VHD just created on the new FC volume.

After starting that virtual machine, the new volume appears in Disk Manager for that virtual machine.

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### Pass-through (Raw Device Mapping)

The pass-through method for allocating Fibre Channel LUNs to guest virtual machines requires that the LUN be allocated on the parent partition in the usual manner, similar to the VHD method. The difference is that the FC LUN is assigned to the guest by using the "settings" function for the guest VM in the Hyper-V management role, while the guest is not running.

The LUN is given to the guest by the "Add Hardware" function and selecting the "SCSI Controller". In the SCSI Controller section, select "Hard Drive", then "Add". Choose "Physical hard disk." Create a hard disk of appropriate size.

After starting that virtual machine, the new volume appears in Disk Manager for that virtual machine.

### NPIV

NPIV, essentially virtualizes the FC HBA. With Microsoft Hyper-V, a virtual machine can be configured to use a Virtual Storage Area Network with N\_Port ID Virtualization (NPIV) as long as it has a compatible FC HBA

Once a VM has booted in the hypervisor machine, the VM can use the Virtual SAN to connect to a Fibre Channel LUN. From Hyper-V, the Virtual SAN Manager is selected and a new Virtual Fibre Channel SAN created

#### Demartek 16Gb Fibre Channel Deployment Guide June 2014 Page 20 of 46



🛃 Virtu	ual SAN Manager for DMRTK-SRVR-K
<ul> <li>★ Virtual Fibre Channel SANs</li> <li>♦ Rew Fibre Channel SAN</li> <li>★ Global Fibre Channel Settings</li> <li>₩ World Wide Names</li> <li>C003FFDABASF0000 to C003FFDA</li> </ul>	Image: Second Storage Area Network         Click Create to add a virtual Fibre Channel storage area network (SAN).         Image: Second Storage Area Network (SAN)         Image: Second Storage Area Network (SAN)
	Create A virtual Fibre Channel SAN groups physical HBA ports together. You can add a virtual Fibre Channel adapter to a virtual machine and connect it to a virtual SAN.
	OK Cancel Apply

🛃 Virt	ual SAN Manager for DM	RTK-SRVR-K	_ □ ×
<ul> <li>Virtual Fibre Channel SANs</li> <li>New Fibre Channel SAN</li> <li>FC-1</li> <li>Global Fibre Channel Settings</li> <li>World Wide Names</li> <li>C003FFDABASF0000 to C003FFDA</li> </ul>	New Fibre Channel SAN – Name: FC-1 Notes:		
	WWNN         ✓       20008C7CFF0B8E81         □       20000051E0F8521         □       200000051E0F8520	WWPN 10008C7CFF0B8E81 10008C7CFF0B8E80 10000051E0F8521 100000051E0F8520	Status 'New Fibre Channel SAN' Available Available Remove virtual SAN
		ОК	Cancel Apply

After the Virtual SAN is created, the settings for the VM are edited. Select Add Hardware. "Fibre Channel Adapter" should be listed as one of the hardware devices that can be added. A list of Virtual SANs will be displayed.

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E Set	tings for Win Server 2012 on DMRTK-SRVR-K
Win Server 2012	
<ul> <li>★ Hardware</li> <li>M Add Hardware</li> <li>BIOS Boot from CD</li> <li>Memory</li> <li>512 MB</li> <li>Processor</li> <li>1 Virtual processor</li> <li>IDE Controller 0</li> <li>Hard Drive HD 1.vhdx</li> <li>IDE Controller 1</li> <li>DVD Drive None</li> </ul>	Fibre Channel Adapter     You can review and edit the World Wide Names (WWNs) assigned to the Fibre Channel     adapter, and connect the adapter to a virtual storage area network (SAN).     Virtual SAN:     Not connected     V     Not connected     FC-1     Edit Addresses     Address set A:     World Wide Node Name (WWNN):     C003FF0000FFFF00
SCSI Controller Fibre Channel Adapter Not connected Not connected COM 1 None COM 2	World Wide Port Name (WWPN):       C003FFDABA5F0002         Address set B:       World Wide Node Name (WWNN):         World Wide Port Name (WWNN):       C003FF0000FFFF00         World Wide Port Name (WWPN):       C003FFDABA5F0003         Create Addresses       Create Addresses
None Diskette Drive None Management Name Win7 Integration Services All services offered Snapshot File Location C:\ProgramData\Vicrosoft\Win Smart Paging File Location C:\ProgramData\Vicrosoft\Win	Click Copy to copy the addresses to the dipboard. Copy To remove the adapter from this virtual machine, click Remove. Remove
	OK Cancel Apply

<u>2</u>	Settings for Win Server 2012 on DMRTK-SRVR-K
Win Server 2012	
<ul> <li>★ Hardware</li> <li>▲ Add Hardware</li> <li>▲ BIOS Boot from CD</li> <li>➡ Memory 512 MB</li> <li>➡ Processor 1 Virtual processor</li> <li>➡ IDE Controller 0</li> <li>➡ Hard Drive HD1.vhdx</li> <li>➡ IDE Controller 1</li> <li>♠ DVD Drive None</li> <li>SCSI Controller</li> <li>➡ Fibre Channel Adapter</li> </ul>	Fibre Channel Adapter You can review and edit the World Wide Names (WWNs) assigned to the Fibre Channel adapter, and connect the adapter to a virtual storage area network (SAN). Virtual SAN: FC-1 Click Edit Addresses to edit the port addresses. Edit Addresses Port addresses Address set A: World Wide Node Name (WWNN): C003FF00000FFFF00 World Wide Port Name (WWPN): C003FFDABA5F0000 Address est B:
FC-1 Network Adapter Not connected COM 1 None COM 2 None Diskette Drive None Management Name Win7 Integration Services	Address set B:         World Wide Node Name (WWNN):         C003FF0000FFFF00         World Wide Port Name (WWPN):         C003FFDABA5F0001         Create Addresses         Click Copy to copy the addresses to the clipboard.         Copy         To remove the adapter from this virtual machine, click Remove.         Remove
All services offered Snapshot File Location C: \ProgramData\Vicrosoft\Wi Smart Paging File Location C: \ProgramData\Vicrosoft\Wi	n v

Windows can generate WWNs, or the user can enter their own based on their own needs. When the VM boots, the VM will obtain its LUN using the Virtual SAN in the same way a bare metal installation would use an HBA to access a physical SAN.

If another hypervisor host with a 16Gb FC HBA is available, the VMs can be migrated to it without detaching their storage. Migration can be accomplished while VMs are running, with Virtual Fibre Channel LUNs connected and being subjected to I/O

If two hypervisor hosts are clustered, a Fibre Channel LUN can be configured as a Cluster Shared Volume (CSV). This volume will be seen by both machines. Provided the VHD that stores the VM is on the CSV instead of local storage, the time required for the VM to migrate is drastically reduced as the corresponding VHD does not have to be transferred over the network to the new machine.



### **VMware**

VMware vSphere drivers need to be installed on the vSphere host

```
/tmp # esxcli software vib install --depot=/tmp/BCD-bfa-3.2.0.0-00000-offline_bundle-
943825.zip
Installation Result
Message: The update completed successfully, but the system needs to be rebooted for
the changes to be effective.
Reboot Required: true
VIBS Installed: Brocade_bootbank_scsi-bfa_3.2.0.0-10EM.500.0.0.472560
VIBS Removed:
VIBS Skipped:
```

A system reboot is required to complete the installation. The ESX/ESXi host is then ready to accept 16Gb Fibre Channel traffic over the HBA. After LUNs are created on the storage and the switch(es) are zoned appropriately, open the Configuration tab and navigate to the Storage adapters page. Rescan the storage adapters to recognize the LUNS.



VMware ESX/ESXi supports two methods of configuring Fibre Channel LUNs for use by guest virtual machines. These methods are:

1. Virtual Hard Disk method

2. Pass-through method

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#### Virtual Hard Disk

Using the virtual hard disk method, a Fibre Channel LUN is provisioned as a datastore via the vSphere client by accessing the Configuration tab for our ESX/ESXi host, Selecting "Storage" and then clicking on "Add Storage" on the right hand side of the screen.

dit View Inventory Administration Plug-ins Help							
A Hone > A Shventory > ( Inventory							
e							
dmtk-srvr-i VHware E	5Xi, 5.1.0, 799733   Evaluation (60 days re	maining)					
Getting Started Summa	Yirtusi Machines Resource Allocation	Performance Configuration Loca	d Users & Groups Events Permissions				
Hardware	Wew: Datastores Dev	rices					
Health Statuo	Datastores	Destas	Bala Tara Casada	Para Trans. Land Indaha	Mark and Incoloration	Refresh Delete Add Stori	ige Rescan Al
Memory	Local_datastorett		Add Storage		Unknown		
Storage	Uccal_datastorel2	Select Storage Type			Unknown		
Storage Adapters		Specify if you want to for	mat a new volume or use a shared folder over the network.				
Network Adapters			_		-		
Power Management		Select Disk/LUN	Storage Type				
Software		File System Version Current Disk Lavour	Create a datastore on a Pibre Channel, ISCSE, or local Si	CSI disk, or mount an existing VMPS volume.			
Licensed Features		Properties	C Betwork Elle Sustem				
Time Configuration		Ready to Complete	Choose this option if you want to create a Network File :	System.			
Authentication Service	es						
Virtual Machine Startu	p/Shutdown						
Virtual Machine Swapt Security Profile	ReLocation		Adding a datastore on Piore Channel or ISCSI will add th to the storage media.	is datastore to all hosts that have access			
Host Cache Configura	Datastore Details						Dromerties
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Select Disk/LUN Select a LUN to create a	datastore or expand the	current one	lage				
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Select Disk/LUN Select a LUN to create a Disk/LUN Select Disk/LUN	datastore or expand the Name, Identifier,	e current one Path ID, LUN, Cape	acity, Expandable or VMFS Label	c •	Clear		
Select Disk/LUN Select a LUN to create a Disk/LUN Select Disk/LUN File System Version	datastore or expand the Name, Identifier, Name	e current one Path ID, LUN, Cap	acity, Expandable or VMFS Label	c ▼	Clear Capacity		
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Ø	Add Storage - 🗆 🗙
File System Version Specify the version of the VM	IFS for the datastore
Disk/LUN     Select Disk/LUN     File System Version     Current Disk Layout     Properties     Formatting     Ready to Complete	File System Version            • VMFS-5         Select this option to enable additional capabilities, such as 2TB + support.         VMFS-5 is not supported by hosts with an ESX version older than 5.0.             • VMFS-3          Select this option if the datastore will be accessed by legacy hosts.
Help	< Back Next > Cancel
Ø	Add Storage – 🗆 🗙
	······································
Current Disk Layout You can partition and form	at the entire device, all free space, or a single block of free space.
Current Disk Layout You can partition and form	at the entire device, all free space, or a single block of free space.
Current Disk Layout You can partition and form: Disk/LUN Select Disk/LUN File System Version Current Disk Layout Properties Formatting Ready to Complete	at the entire device, all free space, or a single block of free space.          Review the current disk layout:         Device       Drive Type       Capacity       Available       LUN         NETAPP Fibre Channel Disk       Non-SSD       2.00 TB       547.87 GB       100         Location       /vmfs/devices/disks/naa.60a98000375339453224435943383643       Partition Format       GPT         Primary Partitions       Capacity       Legacy MBR (NETAPP Fibre Cha       129.00 MB          Legacy MBR (NETAPP Fibre Cha       500.00 GB           Image: Comparison of the current disk layout, only the following configurations may be used. It is recommended that the entire disk/LUN be dedicated to a single VMFS. Additional file systems deployed to this device will only be supported if they are used exclusively by the Service Console.
Current Disk Layout You can partition and form: Select Disk/LUN File System Version Current Disk Layout Properties Formatting Ready to Complete	at the entire device, all free space, or a single block of free space.          Review the current disk layout:         Device       Drive Type       Capacity       Available       LUN         NETAPP Fibre Channel Disk Non-SSD       2.00 TB       547.87 GB       100         Netation       /vmfs/devices/disks/naa.60a98000375339453224435943383643       100       100         Partition Format       GPT       GPT       129.00 MB       129.00 MB       129.00 MB       129.00 MB       100       100         Capacity       Legacy MBR (NETAPP Fibre Cha       129.00 MB       100       100       100       100         Coreany       GPT       Given the current disk layout, only the following configurations may be used. It is recommended that the entire disk/LUN be dedicated to a single VMFS. Additional file systems deployed to this device will only be supported if they are used exclusively by the Service Console.       >         C       Use 'Free space'       Use all available partitions       This configuration will delete the current disk layout. All file systems and data will be permanently lost.

## 

Ø	Add Storage	_ □	×
Properties Specify the properties for	r the datatore		
Disk/LUN     Select Disk/LUN     File System Version     Current Disk Layout     Properties     Formatting     Ready to Complete	Enter a datastore name		
Help		< Back Next > Canc	el
Ø	Add Storage	- • ×	
Disk/LUN - Formatting Specify the maximum file size	e and capacity of the datastore		
DiskAUN     Select DiskAUN     File System Version     Current Disk Layout     Properties     Formatting     Ready to Complete	Capacity Maximum available space Custom space setting 547.87 GB of 547.87 GB available space		
1			

## 

Ø	Add Storage	- 🗆 🗙
Ready to Complete Review the disk layout	and click Finish to add storage	
<u>Disk/LUN</u>	Disk layout:	
Ready to Complete	Device     Drive Type     Capacity       NETAPP Fibre Channel Disk (na Non-SSD     2.00 TB       Location     /vmfs/devices/disks/naa.60a98000375339453224435943383643       Partition Format     GPT       Primary Partitions     Capacity       Legacy MBR (NETAPP Fibre Cha     129.00 MB        Elsestem:	LUN 100
Help	< Back Finish	Cancel
Ø	dmrtie-unr-i-vSphere Client	- 0 ×
File Edit View Inventory Administration Plug-ins Help		
dinitikaniri	i   (valuation (of days remaining) an "annumentation", Tablemarka (Section 2011), Tablemarka (Section 2011), Tablemarka (Section 2011), Tablemarka	
Kennen (M. Karlen, M. Karlen, M. Kennen (M. Karlen, M. Karlen, M. Karlen, K. Karlen	New Billing Andread (1994) (1	Alf torge - face id

Then we created a new hard disk for the DB-VM01 VM by using the settings dialog box and clicking "Add" from the top left of the hardware tab.

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Device Type Select a Disk Create a Disk Advanced Options Ready to Complete	Choose the type of device you Serial Port Parallel Port CD/DVD Drive CD/DVD Drive USB Controller USB Device (unavailable) CSB Device (unavailable) Ethernet Adapter Hard Disk CSI Device	u wish to add.
Help		< Back Next > C

There are three choices for the type of VHD: Thick Provision Lazy Zeroed, Thick Provision Eager Zeroed, or Thin Provision.

Ø	Add Hardware ×			
Select a Disk				
Device Type Select a Disk Create a Disk Advanced Options Ready to Complete	A virtual disk is composed of one or more files on the host file system. Together these files appear as a single hard disk to the guest operating system. Select the type of disk to use. Disk Create a new virtual disk C Use an existing virtual disk Reuse a previously configured virtual disk. C Raw Device Mappings Give your virtual machine direct access to SAN. This option allows you to use existing SAN commands to manage the storage and continue to access it using a datastore.			
Help	< Back Next > Cancel			

A datastore location can be selected. Using the Browse button brings up a list of datastores including our recently configured FC\_datastore01.

Colliso	remissions	close tab X			Ø	S	elect a datastore or da	itastore cluster		
					Select a datastore or data	astore duster:				
Ø		DB-VM01 - Virtu	al Machine Properti	ies	Name	Drive Type	Capacity Provisione	Free Type	Thin Provisi Supported	oning
Hard	dware Options Resources			Virtual f	Local_datastor	Non-SSD	1.16 TB 354.07 GB	922.25 GB VMFS5	Supported	
Е	Ø	Add	Hardware		FC_datastore01	Non-SSD	547.75 GB 973.00 MB	546.80 GB VMFS5	Supported	
EH.	Create a Disk									
	Specify the virtual disk size	and provisioning policy			1					
					Disable Storage DRS	S for this virtual	Imachine			
Ē	Device Type Select a Disk	Capacity			Select a datastore:					
C C	Create a Disk	Disk Size: 40	E GB 👤		Name	Drive Type	Capacity Provisioned	Free Type	Thin Provisio	ning
E	Advanced Options Ready to Complete	Disk Provisioning								
E		C Thick Provision La	zy Zeroed							
, i		C Thick Provision Ea	ger Zeroed							
ę		(• Thin Provision							ОК	Cancel
		Location								
		C Store with the virt	ual machine							
		Specify a datastor	e or datastore cluster:	Results	- I					
		1		Browse						
					Cruzi I					
<u> </u>	Нер			< Dack Next >						
	Help			ок	Cancel					
_										
	7)									~
Ľ	<b>9</b>			Add Ha	rdware					^
	Advanced Opt	ions								
	These advan	iced options do	o not usually ne	eed to be chang	ed.					
	Device Type				e	1.6.1				
	Select a Disk		Specify the	e advanced opti	ons for this virti	ual disk.	These options of	o not normal	ly need	
	Select a Disk		to be chan	igea.						
	Create a Disk			evice Node						
	Advanced Opt	ions	vii tuur D	CVICE NOUC			_			
	Ready to Comple	ete	•	SCSI (0:3)			<u> </u>			
							_			
			0	IDE (0:0)			<b>T</b>			
			-Mode -							
			Thouse							
			1 Indep	pendent						
			Indep	endent disks ar	e not affected b	by snaps	shots.			
			O Pr	ersistent						
			d	nanges are imme	diately and per	manent	v written to the	diek		
			u u	langes are infine	culately and per	manenu	y written to the	UISK.		
			<b>C</b>							
			C No	onpersistent						
			Ch	hanges to this di	sk are discarde	d when y	you power off o	revert to th	e	
			sn	apshot.						
	,						1.			_
	Help					<	< Back	lext >	Cancel	

# 

Ø	Add Hardware ×				
Ready to Complete Review the selected optio	is and click Finish to add the hard	vare.			
Device Type Select a Disk Create a Disk Advanced Options Ready to Complete	Options: Hardware type: Hard Dis Create disk: New virt Disk capacity: 40 GB Disk provisioning: Thin Pro Datastore: FC_data Virtual Device Node: SCSI (0: Disk mode: Persiste	k ual disk vision store01 3) nt			
Help		< Back	Finish Cancel		

Ø	DB-VM01 - Virtual M	lachine Properties – 🗖 🗙
Hardware Options Resources   Hardware   Hardware   Memory   CPUs   Video card   VMCI device   SCSI controller 0   Hard disk 1   Hard disk 2   Hard disk 3   Hard disk 4   CD/DVD drive 1	DB-VM01 - Virtual M         Add       Remove         Summary       32768 MB         32768 MB       8         Video card       Restricted         LSI Logic SAS       Virtual Disk         Virtual Disk       Virtual Disk         Virtual Disk       Client Device	Image: Stress stres
Hard disk3 Hard disk4 CD/DVD drive 1 Network adapter 1 Floppy drive 1	Virtual Disk Virtual Disk Client Device VM Network Client Device	Mode Independent Independent Independent disks are not affected by snapshots. C Persistent C hanges are immediately and permanently written to the disk. C Nonpersistent C Changes to this disk are discarded when you power off or revert to the snapshot.
Help	U	OK Cancel

After starting that virtual machine, the new volume appears in Disk Manager for that virtual machine.

Ø	dmrtk-srvr-i - vSphere Client	- 🗆 🗙
File Edit View Inventory Administration Plug-ins Help		
🔄 🔂 🏠 Home 🕨 🏭 Inventory 👂 🗊 Inventory		
Image: Construction of the second	Consol Remissions  Performance Events Consol Remissions  Disk Management Volume Layout Type File System Status  (C:) Simple Basic NTFS Healthy (Boot, Page File, Consol Remissions)  New Volume (F:) Simple Basic NTFS Healthy (Primary Partition) System Reserved Simple Basic NTFS Healthy (System, Active, F  Disk 3 Unknown Net Initialized Unalcoated Unal	Actions Disk Hanagement More Actions



#### **Pass-through (Raw Device Mapping)**

A Fibre Channel LUN was made available to the hypervisor via the vSphere console in the usual manner. The LUN is then passed directly to the virtual machine. This process is similar to the virtual hard disk method above, except that this LUN will be allocated using "raw device mappings" and is mapped with physical device mappings that are stored with the virtual machine. Selected screenshots from this process are shown below.

Ø	Add Hardware
Select a Disk	
Device Type Select 3 Disk Select Target LIN Select Datastore Compatibility Mode Advanced Options Ready to Complete	A virtual disk is composed of one or more files on the host file system. Together these files appear as a single hard disk to the guest operating system. Select the type of disk to use. Disk Create a new virtual disk View an existing virtual disk Reve are previously configured virtual disk. Reve are previously configured virtual disk.
Help	< Back Next > Cancel
Ø	Add Hardware
Ready to Complete Review the selected option	s and click Finish to add the herdware. Options:
Select Tardet LLM Select Tardet Mode Advanced Cotones Ready to Complete	rranowie type: Hard Dak Create dak: Use mapped system LUN Wrbal Device Node: SCS (0:1) Dak mode: Persistent Target LUN: NETPAP Före Channel Disk (naa.60a98000375339453224435943383 Changed datastore: Store with W
Help	< Back Finish Cancel

The LUN is now available to the virtual machine and is described as a "Mapped Raw LUN".

Demartek 16Gb Fibre Channel Deployment Guide
June 2014
Page 37 of 4

Ø	DB-VM02 - Virtual N	Machine Properties – 🗆 🗙
Hardware Options Resources		Virtual Machine Version: 8
		Physical LUN and Datastore Mapping File
Show All Devices	Add Remove	/vmfs/devices/disks/naa.60a9800037533945322443594338:
Hardware	Summary	
Memory	2048 MB	1
CPUs	1	Virtual Device Node
Video card	Video card	SCGT (0,1)
VMCI device	Restricted	[3C31 (0.1)
SCSI controller 0	Paravirtual	Compatibility Mode
Hard disk I	Virtual Disk Cliegh Davies	C Victual C Physical
Natwork adapter 1	VM Natwork	
Eleppy drive 1	Client Device	
New Hard Disk (adding)	Mapped Raw LUN	
1		Manage Paths
Help		OK Cancel

#### NPIV

NPIV features can be used in VMWare, enabling a virtual machine to use a virtual Fibre Channel port as long as the ESX/ESXi machine has a compatible FC HBA.

The host ESX/ESXi machine should be able to access the LUN that will eventually be assigned to your VM. The VM that will be using the virtual FC must first be given a RDM (Raw Device Mapped) Hard Drive using the instructions in the previous section. After this, access the settings for your VM by right clicking on the VM and accessing "Edit Settings."



The Virtual Machine Properties screen will open with the Hardware tab open. Click on the "Options" tab, and "Fibre Channel NPIV" will be listed as one of the settings that can be modified.

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	vivit - viitu	
arroware Options Resources Settings General Options VMware Tools	Summary VM1 Shut Down	Fibre Channel Virtual WWNs     Virtual machines running on hosts with Fibre Channel hardware that supports NPIV can be assigned virtual WWNs for advanced features. These WWNs are normally assigned by the host or by
Advanced General CPUID Mask Memory/CPU Hotplug Boot Options Fibre Channel NPTV	Normal Expose Nx flag to Disabled/Disabled Normal Boot	vCenter. I ✓ Temporarily Disable NPIV for this virtual machine No WWNs are currently assigned.
CPU/MMU Virtualization Swapfile Location	Automatic Use default settings	Number of WWNNs: 1 Number of WWPNs: 1 WWN Assignments: No WWNs currently assigned
Help		OK Cancel

Clicking on the Fibre Channel NPIV will show a menu that tells us that NPIV is Temporarily Disabled. Click on the checkbox to enable it. Then click on the radio button next to Generate New WWNs so that the machine gets WWNs to use. Click ok to generate the numbers and the Virtual Machine Properties box will close.

🤣 VM1 - Virtual Machine Properties – 🗆 🗙				
Hardware Options Resources		Virtual Machine Version: 8		
Settings General Options VMware Tools Power Management Advanced General CPUID Mask Memory/CPU Hotplug Boot Options Fibre Channel NPIV CPU/MMU Virtualization Swapfile Location	Summary VM1 Shut Down Standby Normal Expose Nx flag to Disabled/Disabled Normal Boot Generating Automatic Use default settings	Fibre Channel Virtual WWNs         Virtual machines running on hosts with Fibre Channel hardware that supports NFIV con be assigned withal WWNs for advanced features. These WWNs are normally assigned by the host or by vCenter. <ul> <li>Temporarily Disable NPIV for this virtual machine</li> <li>No WWNs are currently assigned.</li> <li>C Leave unchanged</li> <li>G Generate new WWNs</li> <li>Number of WWNs:</li> <li>Number of WWNs:</li> <li>Temporarily</li> <li>WWN Assignments:</li> <li>No WWNs currently assigned</li> <li> <ul> <li>Mo WWNs currently assigned</li> <li> <ul> <li>Very transmitting the structure of t</li></ul></li></ul></li></ul>		
Help		OK Cancel		

Re-access the same menu again to find out what WWNs were generated for Target

### configuration.

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🤣 VM1 - Virtual Machine Properties – 🗖 🗙				
Hardware Options Resources		Virtual Machine Version: 8		
Settings General Options VMware Tools Power Management Advanced General CPUID Mask Memory/CPU Hotplug Boot Options Fibre Channel NPIV CPU/MNU Virtualization Swapfile Location	Summary VM1 Shut Down Standby Normal Expose Nx flag to Disabled/Disabled Normal Boot Automatic Use default settings	Fibre Channel Virtual WWNs         Wrtual machines running on hosts with Fibre Channel hardware that supports NPIY can be assigned virtual WWNs for advanced features. These WWNs are normally assigned by the host or by vCenter.         Temporarily Disable NPIV for this virtual machine         The current WWN assignments were created by ESX Server.         Leave unchanged         Generate new WWNs         Number of WWNNs:         Number of WWNNs:         Number of WWNNs:         Remove WWN assignment         WWN Assignments:         Node WWN:         25:1:e100:01:29:00:01:73         Port WWN:         25:1:e100:01:29:00:02:73		
Help		OK Cancel		

Once the target is configured, the VM can be booted and will obtain its LUN using the virtual port in the same way a bare metal installation would use an HBA to access a physical SAN.

## **Measuring 16Gb Fibre Channel Performance**

Storage system performance can be measured by a variety of tools that are either included in the operating system or easily installable. Workload performance data in this guide was generated using readily available measuring and monitoring tools such as Windows Perfmon, Linux iostat and switch monitoring utilities. Additional open source and third party tools are also available, but beyond the scope of this guide.

### **Bandwidth, IOPS, and Latency**

Bandwidth, IOPS and latency are the standard industry measurements for storage performance. Bandwidth is often expressed in units of data transferred (read or written) over a period of time, such as MB/s.

IOPS, inputs and outputs per second, is the total number of read and write requests serviced by the storage or interface during each second.

Latency is the time taken to service the I/O requests. Latency is commonly expressed in milliseconds, however, as solid state storage continues to improve, it is becoming more common to see sub-millisecond latency measurements. In our lab testing, we have found that Fibre Channel solutions generally have low latency (lower is better).

### **Windows Perfmon**

Windows Performance Monitor (Perfmon) is a very granular measurement tool that is provided with the Windows operating system. The user can define performance counters for the measurements desired and either execute measurement s in real-time or batch measurements to coincide with workloads. There is a staggering array of performance counters available for metering system performance in Perfmon.

### Linux sysstat

Linux sysstat is an add-on Linux package that can be installed into most Linux distributions. It contains a collection of individual command-line utilities such as "iostat" that provide various performance statistics for CPU, I/O devices, filesystems and more.

## **Workload Testing**

A variety of synthetic I/O benchmarks exist to push I/O through the storage infrastructure. Open source tools like IOmeter and vdbench can be configured to drive multiple I/O patterns to simulate recognizable workload profiles or just force maximum bandwidth and IOPS. Several industry associations and companies also produce industry recognized benchmark kits that can be obtained in varying price ranges from free to several thousands of dollars.

Real-world applications may more closely align with actual use cases and are the workloads used for this guide. The following graph is from a workload application which produces database "data warehousing" I/O in a virtualized environment. The purpose of this workload is not to show that we can achieve line rate across 16Gb Fibre Channel, which can be easily done with any synthetic benchmark, but to instead demonstrate the limitation of the 8Gb Fibre Channel in a real-world I/O intensive environment.

Here we see the same database workload executed across 8 virtual machines. We can see that the dual channel, 8Gb Fibre Channel is frequently saturated by this workload as the bandwidth often plateaus around 1600 MBps.



Simply switching the interface to dual channel, 16Gb Fibre Channel demonstrates this environment is capable of more work with the same compute resources. The bottleneck generated by the storage interface is gone and there is capacity for additional I/O if more compute resources are added to the environment, such as additional VMs running the workload, or more CPU and memory to the existing VMs.

The higher bandwidth and IOPS attainable by 16Gb FC compared to 8Gb FC has the potential to identify new performance bottlenecks. These could include a back-end storage system that may be incapable of generating 16Gbps performance. On the other hand, the higher bandwidth may allow the system to achieve its maximum processing capacity by fully utilizing the CPU or memory through the reduction of I/O waits from the storage system.

## **16Gb Fibre Channel Best Practices**

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Like all technology, proper deployment of 16Gb Fibre Channel is essential to achieving the best performance and reliability that can be delivered.

## Multipath I/O

Single path I/O may be appropriate for non-production, non-critical functions, or environments in which redundancy is provided by some mechanism other than multipath I/O (MPIO). However, most production environments will want to take advantage of the redundancy and performance benefits provided by having more than one I/O channel.

Multiple paths can be configured at several points in the environment. However, if at any point in the system architecture a single path is introduced (including the use of a single 16Gb FC switch, even if multiple switch ports are zoned), then there is a single point of failure and overall redundancy cannot be guaranteed.

The simplest multipath configuration is to bypass the SAN altogether. For fully redundant multipath, two HBAs must be present in both the server and the storage target, regardless of whether they are single port or dual port adapters. A 16Gb FC port from each HBA on the server connects to corresponding ports on the two target HBAs. This deploys the FC target as direct attached storage, but does provide redundancy in case of FC port or HBA

failures in both the server and the storage target. So long as all paths remain operational, multipathing can be configured to take advantage of both paths in an active-active fashion, essentially doubling the potential bandwidth.



To enhance the robustness of this configuration, dual port HBAs can be used to further increase both redundancy and bandwidth. In theory, as many HBAs as are supported by the server and storage can be deployed in this fashion, though there will be a point of diminishing returns if the server, storage and workloads are not able to drive the aggregated FC bandwidth.

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More likely, the intent will be to deploy FC storage in a 16Gb FC SAN, rather than directly attaching it to individual servers. The server and storage side configuration remains unchanged, however, two or more 16Gb FC switches are placed between them. Each separate HBA, on both the server and the storage, needs a port connected to each switch. If multiple ports are in use, it is best never to connect ports on the same HBA to the same switch in order to eliminate single points of failure.

An operating system will initially see multiple "copies" of each LUN or virtual disk provisioned to the server, one for each path. Each operating system has its own mechanism for enabling and configuring multipath management, usually a multipath driver, which resolves the multiple copies situation and which is outside the scope of this Deployment Guide. Detailed documentation is available from your operating system vendor.

Note that in the diagram on the right, each HBA is connected to each switch, and that there is no single point of failure from a SAN fabric perspective.

This deployment model allows for the addition of more servers and storage targets to the same SAN fabric by connecting them to available ports on the switches in a similar fashion.



## **Increasing VM Density**

Deploying 16Gb Fibre Channel in virtualized environments provides additional opportunities and considerations. VM density is a phrase that refers to the number of VMs supported by a hypervisor host or cluster. Density is governed by the amount and performance of compute power (CPU and memory), network resources (Ethernet and SAN), and backend storage available to the VM environment. When any component is utilized to its maximum capacity, the number of VMs that can be deployed is capped at that point.

In the case of a storage I/O bottleneck, such as was demonstrated earlier in this guide, the hypervisor host is not able to fully utilize the compute power available to it. Therefore, removing that constraint by deploying 16Gb FC allows the environment to use more of its compute resources. Theoretically, more VMs could be deployed to take advantage of the additional bandwidth increasing the VM density.

However, removing one bottleneck can highlight another. By removing storage I/O constraints, the processors and memory are able to do more work, potentially enough to fully utilize those resources without the addition of more VMs.



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## Legal and Trademarks

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