

Choosing HBAs for Linux Environments

QLogic Linux FC HBAs – The #1 Choice for Mission-Critical Applications in Enterprise Datacenters



Executive Summary

Linux-based servers are being deployed in significant numbers in enterprise datacenters while Linux adoption for mission-critical systems is on the rise. Key reasons for Linux becoming a popular choice include the need for cost reduction, increasing blade server deployments, and the move toward server virtualization and consolidation.

One of the key challenges for IT administrators deploying Linux solutions in the datacenter is the assortment of component solutions that need to be integrated for seamless implementations. These component solutions include hardware, software drivers, management software, high availability software, configuration and troubleshooting tools, and solutions for emerging technologies such as virtualization. The growing popularity of Linux in datacenters demand that datacenter managers choose Linux HBA solutions that provide superior reliability, scalability, and continuous innovation enabling deployment flexibility.

This paper discusses QLogic Linux FC HBA solutions and how they help address the challenges faced by IT managers in implementing a reliable, scalable integrated Linux solution for mission-critical applications.

Key Findings

QLogic, the #1 choice for FC HBAs in Linux environments provides IT managers with superior benefits by:

- **Lowering TCO for Storage Connectivity:** QLogic enables IT managers to deploy a stable, highly reliable and interoperable Linux solution that leads to higher availability of mission-critical application and lower storage connectivity operational costs.
- **Boosting Deployment Flexibility:** QLogic's broad product portfolio and extensive Linux solution choices enable deployment flexibility and performance scalability for low latency applications.
- **Maximizing Investment Protection through Innovation:** Continuous innovation and leadership support for advanced technologies like server virtualization facilitates leveraging current infrastructure to build long term value and lowering datacenter costs.

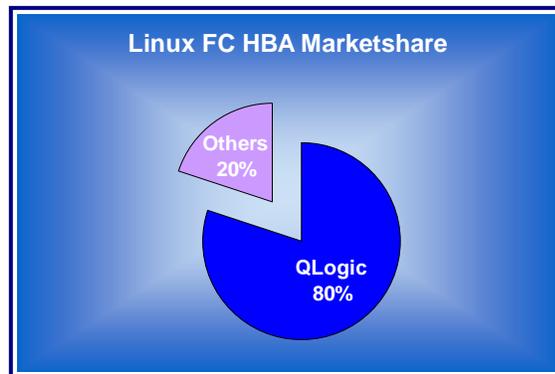
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Introduction

With the increasing penetration of Linux deployments into mission-critical systems in the datacenter, it is imperative that IT managers deploy a Linux FC HBA that offers them a mature, reliable, and scalable solution. Challenges for successful datacenter I/O deployments in mission-critical Linux environments include:

- Selecting a reliable solution with proven interoperability.
- Leveraging flexibility and choice in Linux solutions to enable superior deployment scalability.
- Choosing a vendor who can offer solutions for a broad spectrum of technology solutions.

QLogic has been shipping Linux solutions for FC HBAs since 1999. Early adoption and deployments by OEMs and end users, robust solutions and continuous innovation of QLogic Linux solutions have led to QLogic leading the market in Linux-based FC HBA solutions with an estimated 80% market share. 5+ years of field-hardened interoperability, close partnership with the Linux community, flexibility and choice in software solutions have all contributed to the maturity of the solutions. QLogic offers the industry's most extensive portfolio for Linux solutions including Fibre Channel / iSCSI HBAs and Infiniband HCAs.



QLogic Linux FC HBAs are the proven choice for enterprise datacenters for the following reasons:

- **Proven reliability**
 - Mature Linux solutions
 - OEM and ecosystem partnerships
 - Pervasive interoperability
- **Superior scalability**
 - Flexibility and choice
- **Broad hardware portfolio**
- **Investment protection through continuous innovation**

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Proven Reliability

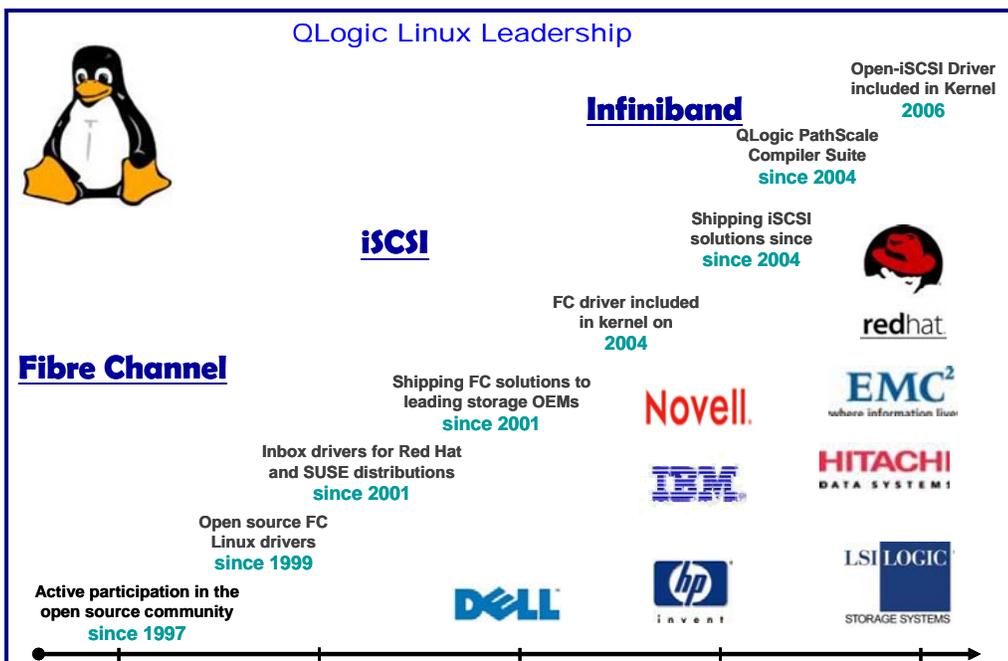
Enterprise datacenters demand the solutions they deploy have been through rigorous testing – not only in lab environments but also in successful real-life deployments over a long period of time. QLogic Linux FC solutions have been tried and true-tested in thousands of mission-critical customer deployments since 1999. Acceptance of QLogic’s solutions by the collaborative Linux community model have ensured that QLogic’s Linux solutions have been validated to meet the requirements of even the most demanding IT environments.

Mature Linux Solutions

QLogic is a pioneer for delivering Linux solutions for HBAs. **QLogic was the first HBA vendor to ship:**

- Open source FC Linux drivers
- Inbox drivers for Red Hat and SUSE/SLES distributions
- iSCSI Linux drivers

The following figure illustrates the successful progression of QLogic’s Linux leadership.



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QLogic has 5+ years of field-hardened interoperability with thousands of successful customer deployments of Linux FC HBAs across numerous Fortune 1000 enterprises. During these years, QLogic has contributed immensely to the open source Linux kernel in terms of FC HBA drivers and enabled the acceptance of Linux HBA drivers in enterprise datacenters.



The research firms IDC and The Dell'Oro Group have ranked QLogic as the clear leader in Fibre Channel HBA market share (revenue and unit shipments). According to both, QLogic was the #1 FC HBA vendor with:

- IDC: 44.5% revenue and 44.5% unit market share
- Dell'Oro Group: 43.5% revenue and 46.1% unit market share

OEM and Ecosystem Partnerships

Key OEM partners who have qualified and distributed QLogic FC Linux drivers include Dell, IBM, EMC, Fujitsu, Hitachi Data Systems, Hewlett Packard, and Network Appliance. QLogic also works closely with key technology partners like AMD, Cisco, Intel, NVIDIA, and Oracle to ensure compatibility and superior performance.

Rigorous testing across OEM platforms, ecosystem partners, and a variety of test suites enable QLogic FC Linux solutions to be more mature and robust.

Pervasive Interoperability

QLogic works closely with the OS distributions to obtain certifications for its standard drivers, as applicable. QLogic's SLES 9 and SLES 10 standard FC drivers are **Novell YES certified**. QLogic's Standard FC/iSCSI Linux Drivers are also compatible with Red Hat's RHEL 3 and RHEL 4 distributions.

In addition to working closely with the Linux community, QLogic's HBA solutions are continually tested for interoperability with previous generation products, as well as with the latest servers, storage and networking products from major manufacturers including: ADIC, Brocade, Computer Associates, Dell, EMC, HDS, HP, IBM, LSI Logic, Quantum, StorageTek, Sun, Symantec (Veritas). **QLogic's Interoperability Guide is updated monthly with the latest interoperability information.**



QLogic has invested more than \$100M in SAN and equipment to test and certify for best-in-class interoperability expected by QLogic's enterprise-class customers. SAN administrators can enjoy peace of mind when deploying a QLogic FC HBA knowing that it will work not only with their existing SAN infrastructure, but with equipment added to the SAN at a later

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date. QLogic's *SANtrack™ Partner Program* ensures that QLogic HBAs are interoperable with the most extensive list of equipment in the SAN marketplace.

Superior Scalability

Enterprise datacenters build their infrastructures to meet not only immediate needs, but also to plan for future scalability. Major considerations for SAN administrators deploying Linux solutions include flexibility and choice of the vendor/partner's technology in key areas such as software drivers, high availability solutions, and easy to use tools for device installation, configuration and management, all designed to enable deployment flexibility.

Flexibility and Choice

QLogic offers the most flexible Linux solutions providing the end user a variety of options to choose from. QLogic Linux solutions provide flexibility and choice in:

1. Operating system drivers and technology
2. High availability (failover) solutions
3. Device management tools
4. Ease of use in installation, configuration, and diagnostics
5. Performance enhancing compiler suite

1. Operating System Drivers and Technology

- **Inbox (in-kernel) and Standard drivers:** QLogic offers end users the ultimate flexibility in choosing the HBA OS drivers they deploy. QLogic not only supports open source Inbox drivers in Red Hat and Novell distributions, but also offers QLogic Standard drivers. QLogic Standard drivers are developed and supported by QLogic and are currently supported on Red Hat RHEL 2.x/3/4 and Novell SLES 8/9/10 environments. QLogic has engaged in close partnerships with the leading OS distributions to ensure the Inbox drivers are tested rigorously early in development cycle to ensure best-in-class compatibility.
- **Integration with Linux kernel:** QLogic works very closely with the Linux community to submit drivers to the upstream kernel. QLogic has been proactively submitting FC drivers to the open source community since 1999. Early Linux distributions from Red Hat (up to RHEL 4) and Novell (up to SLES 9) shipped a version of QLogic's Standard FC HBA drivers. With SLES 10 and moving forward with RHEL 5 and beyond, a version of QLogic's FC upstream driver will ship with the RHEL/SLES distributions.

Some of the key contributions QLogic has made to the Linux kernel include:

- Upstream engineering support via Linux-SCSI and Linux-kernel mailing lists since 2004.
- Extensive in-house testing with numerous OEM storage and platform configurations that have helped solidify the upstream FC drivers.

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- Worked with Red Hat and the open-source community to include the Open-iSCSI qla4xxx driver upstream. This involved iSCSI transport definition and design.
- Contributions in design of FC transport class.
- **Innovation and leadership in iSCSI:** QLogic is the only HBA vendor shipping open source drivers for iSCSI HBAs. QLogic has worked very closely with the Linux community and has received acceptance from the kernel community for the QLogic Open-iSCSI driver. Open-iSCSI project is a high performance, transport independent, multi-platform implementation of RFC3720. RFC3720 describes a transport protocol for iSCSI that works on top of TCP. QLogic is leading the industry and has worked in close partnership with Red Hat and the Linux community to receive acceptance of its Open-iSCSI driver greatly benefiting users of both software and hardware initiators.
- **Boot from SAN support:** QLogic supports Boot from SAN implementations and provides Device Update Disks (DD-Kits) to support FC/iSCSI HBAs that are not yet supported in the Inbox drivers that ship with the Linux distributions.
- **Infiniband drivers:** QLogic's InfiniPath™ Infiniband HCAs and drivers deliver industry-leading OpenIB performance, allowing applications using OpenIB protocols, such as IPoIB and SDP to achieve maximum scalability. QLogic is an active member driving innovation as part of the Open Fabrics Alliance.
- **APIs:** QLogic provides industry standard SNIA-based HBA APIs and also SNIA SMI-S APIs to enable ISV/OEM software applications to seamlessly interoperate with QLogic HBAs.

2. High Availability (failover) Solutions

QLogic supports three types of high availability (failover/multipathing) solutions.

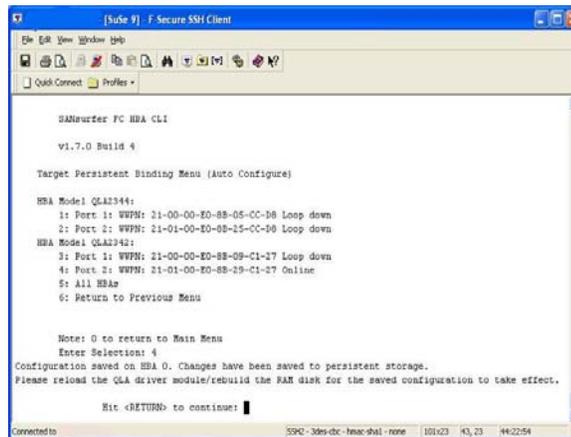
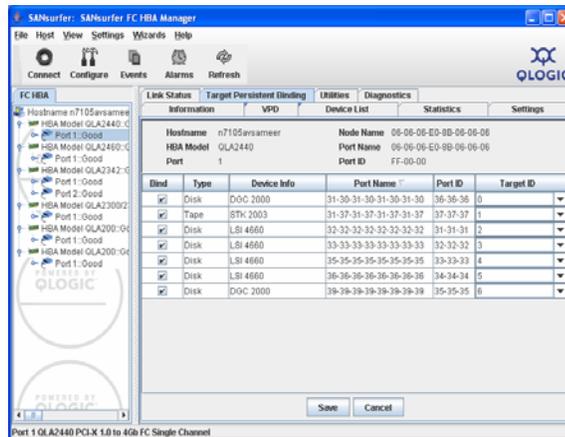
- **Device Mapper (FC HBAs):** QLogic fully supports the **Device Mapper (DM)** Multipathing offered by Red Hat and Novell. QLogic has been supporting DM starting with RHEL 4 and SLES 9 releases.
- **QLogic failover solution:** QLogic offers failover drivers for all its FC HBAs. QLogic was the first vendor to support failover in its HBA Linux drivers. QLogic failover drivers have been shipping for over four years and tested and supported with multiple models of HP, IBM, and LSI Logic storage arrays. **QLogic is the only leading FC HBA vendor to provide a failover solution for the 2.4 Linux kernel.** QLogic's FC HBA Manager device management tool provides wizards to simplify configuring failover on specified target devices at time of installation.
- **Third-party failover solutions:** QLogic's FC Linux drivers are compatible with leading 3rd party failover solutions such as EMC PowerPath®, LSI Logic RDAC, and VERITAS Dynamic Multipathing (DMP).

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3. Device Management Tools

QLogic offers a comprehensive device management and installation tool. SANsurfer HBA Manager Graphical User Interface (GUI) and Command Line Interface (CLI) enable end-users to configure and manage their QLogic FC/iSCSI HBAs with significant ease of use.

- The **HBA Manager** is a GUI-based tool that helps configure and manage local and remote HBAs in the SAN. SAN administrators can quickly install, configure, monitor, upgrade, and diagnose QLogic FC/iSCSI HBAs using this tool.
- **Configuration Wizards:** The FC HBA Manager provides easy-to-use wizards for configuring failover, persistent binding, and LUN masking and updating HBA parameters during HBA installation. Support of hosts with Linux and other leading operating systems enables HBA management in heterogeneous SAN environments.
- The **HBA CLI** is a simplified version of the HBA Manager GUI. The CLI provides SAN administrators with two modes of operation:
 - Easy-to-use Interactive
 - Versatile ScriptableThe CLI supports both FC and iSCSI HBAs and it supports Linux and other leading operating systems.



4. Ease of Use in Installation, Configuration, and Diagnostics

QLogic offers the ultimate ease-of-use to enable end users to seamlessly install and diagnose FC HBAs. QLogic provides the following solutions:

- **Linux tools:** QLogic provides various tools for FC HBAs to accomplish tasks like *HBA Snapshot*, *Dynamic Target and LUN Discovery*, *LUN Transition- offline to online* and *Modifying SCSI Command Timeout Value*.



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- **Installers and Device Update Disks (DUDs/DD-Kits) packages:** QLogic offers easy to use Linux Installers (FC/iSCSI HBAs) which help to build, install, and load the appropriate driver for a particular distribution, kernel version, and hardware platform without any user intervention. QLogic also offers Device Update Disks for enabling boot-from-SAN capabilities for HBAs that are not yet included in the Inbox drivers.
- **Single driver for 2Gb and 4Gb FC HBAs:** QLogic ships a single driver (Inbox and Standard drivers) for all 2Gb and 4Gb FC HBAs. This simplifies the install process for end users.
- **Unified driver and firmware:** QLogic's Standard drivers (Fibre Channel) have the firmware embedded in the drivers. Embedding the firmware in the driver reduces the number of software loads and ensures that both the driver and the firmware have been thoroughly tested. A unified firmware/driver eliminates the need to guess which combination of firmware and OS driver have been tested for compatibility. For Inbox drivers, firmware modules are loaded via hot plug.
- **Diagnostics:** Diagnosing and debugging an FC HBA in the SAN is of key value. QLogic offers loop back tests, read/write buffer tests, and link status tests. Newer technologies like the ANSI SFF-8472 Diagnostic Monitoring Interface (DMI) for Optical Transceivers Specification are also supported. Support for this feature provides SAN administrators with real time information on the optical transceiver's status information that helps to aid in predicting any system failure issues that might arise out of the transceiver component of the HBA. All the required parameter values are available in an easy-to-read GUI display.

5. Performance Enhancing Compiler Suite

QLogic's goal is to make it easier to develop and deploy 64-bit applications into clustered environments. QLogic has developed the world's highest-performance 64-bit Linux compiler with complete GNU tool chain compatibility.

The QLogic PathScale Compiler Suite shares its heritage with the well-known and mature SGI compiler suite. The Compiler Suite has been optimized for both the AMD64 and EM64T architectures and has the world's most sophisticated optimization infrastructure. Unlike other compilers, the QLogic PathScale Compiler Suite provides superior performance across both floating-point and integer-intensive applications. Application developers targeting 64-bit Linux servers will see immediate performance benefits from compiling with the PathScale compilers.



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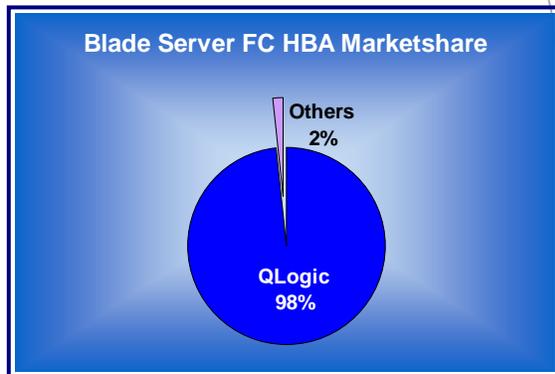
Broad Hardware Portfolio

As Linux deployments increase in enterprise data centers, end users are looking to vendors who offer a wide portfolio of solutions that they can leverage. QLogic offers the broadest portfolio of HBAs and HCAs for enterprise datacenters. The portfolio includes standard form factor HBAs, Mezzanine card HBAs for blade servers, and the new ExpressModule form factor. Technologies supported in hardware include:

- Fibre Channel HBAs
- iSCSI HBAs
- Infiniband HCAs

Linux adoption is more prevalent in bladed server environments than traditional rack or tower mount servers. QLogic developed the world's first embedded SAN infrastructure for bladed servers and is the leading supplier of Fibre Channel embedded switches and HBAs for bladed servers. In 2005, QLogic shipped its 500,000th blade server HBA port and 20,000th blade server switch. Based on results published by The Dell'Oro Group, QLogic is the clear leader in the 4Gb FC HBA (Mezzanine Cards) for blade servers

QLogic has worked with all major OEMs over three generations of blade-servers and has developed over 20 HBAs and embedded Fibre Channel Switch modules for blade servers. This wide exposure across systems and products enables QLogic to deliver the most reliable products for this rapidly growing market segment. In addition, QLogic HBAs offer Linux solutions that work across hardware architectures including IA32, x64, IA64, and PowerPC platforms.



Investment Protection through Continuous Innovation

IT datacenters like to keep abreast of new technologies and deploy solutions that enable them to become more efficient, while saving costs by leveraging existing investments.

One of the key areas that are gaining rapid traction is server virtualization. Server virtualization technologies are rapidly gaining traction as they deliver significant cost savings through better utilization and management of hardware resources. Multiple vendors have rolled out products that incorporate the open source Linux-based Xen™ hypervisor that enables multiple operating systems to run simultaneously on the same server.

QLogic is a leader in supporting server and storage virtualization initiatives and the industry's leading Linux FC HBA that will help enterprises scale their operations, provide

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the lowest cost of ownership and maximize hardware and software investments. QLogic engaged early with Novell and Red Hat to ensure compatibility with OS distributions like SLES 10 and RHEL 5 which support integrated Xen-based virtualization.

QLogic is also working closely with next generation initiatives from Intel and AMD with respect to processor technology, virtualization software providers such as Cisco, Virtual Iron, VMware, and XenSource, to develop solutions that address:

- Virtualization in Linux
- Provisioning of Virtual Machines
- Securing Virtualized Networks

Virtualization in Linux

Server Virtualization is enabled with a key piece of technology called hypervisor or Virtual Machine Monitor (VMM). QLogic provides support for both the open source Xen hypervisor and VMware® ESX Server. QLogic provides FC Inbox drivers that are included as part of leading Xen hypervisor-based virtualization platform vendors such as Virtual Iron and XenSource.

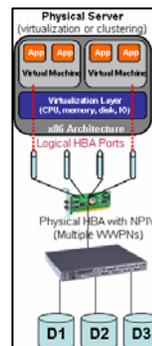
In addition, QLogic worked closely in early testing efforts with Novell and Red Hat to ensure hypervisor supports this key technology. QLogic's proven FC Linux drivers also served as the foundation for VMware ESX Server QLogic FC HBA drivers. QLogic drivers are embedded in the ESX Server 3.x / 2.x kernel.

QLogic FC HBA drivers combined with the virtualization-enabled OSs will offer end users the means to establish a fully integrated, reliable virtual server environment and reap the benefits of dramatically increased server efficiency.

The QLogic FC HBA drivers include technology for the virtualization of physical HBA ports that work seamlessly with the Xen hypervisor and Linux OS kernel. QLogic Standard FC Linux drivers already support SLES 10 and will support RHEL 5 when it is generally available. Both these Linux distributions support the Xen hypervisor and associated requirement for supporting multiple guest OSes running on top of the Xen hypervisor.

Provisioning of Virtual Machines

One of the key needs in a server virtualized Linux environment is the capability to support live migration of virtual machines from one physical server to another physical server. Server virtualization solutions abstract the underlying hardware components, allowing multiple virtual machines to run on a single physical server. In these virtualized environments, several mission-critical applications now operate simultaneously on their own virtual server, sharing the same physical server resources, I/O data path, and network infrastructure. As server virtualization becomes more widely deployed, storage administrators need to "dynamically provision"



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the underlying physical server components to ensure maximum server utilization and network performance, while maintaining hardware and software isolation.

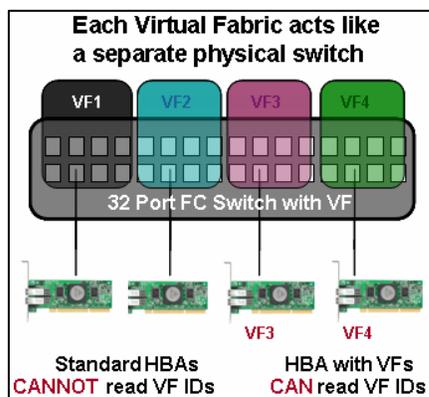
In the Linux environment, QLogic is actively engaged with Linux distributions from Novell and Red Hat, virtualization platform vendors such as VMware, Virtual Iron and XenSource to extend virtualization technologies to the FC HBA. N_Port ID Virtualization (NPIV) is one such HBA virtualization technology that allows a single physical FC HBA port to function as multiple logical ports, each with its own identity. With NPIV-enabled HBAs, each virtual machine can attach to its own logical HBA port and respective World Wide Port Name (WWPN). During a live migration of a virtual machine to a new physical server, storage administrators no longer have to reconfigure their network settings (for example, zoning, masking, binding) since they are maintained in the logical port configuration.

Securing Virtualized Networks

In large enterprise SAN environments, several Linux mission critical applications operate simultaneously, almost always sharing the same physical network infrastructure. Although complex fabric zoning algorithms create “minimal” network isolation, storage administrators require a more “flexible” method to ensure “complete” isolation of applications, storage devices, hardware components, and services in a SAN fabric. QLogic Linux drivers enable virtual fabric support along with support for NPIV to enable seamless migration of virtual machines as well as provide the isolation and security in virtualized networks.

VSAN is a standard that was pioneered by Cisco. In November 2004, the T11 committee of the International Committee for Information Technology Standards selected Cisco's Virtual SAN (VSAN) technology for approval by the American National Standard Institute (ANSI) as the industry standard for deploying **Virtual Fabrics (VF)**, defined as the ability to segment a single, physical SAN fabric into many logical, completely independent SANs.

Virtual Fabrics provide the ability to create completely isolated network islands, each with its own set of fabric services (for example, name server, zone server, login server). A switch supporting virtual fabric technology appends a special virtual fabric ID to each Fibre Channel (FC) frame, essentially dividing its ports into groups that function like separate physical switches. QLogic is the first FC HBA vendor to extend virtual fabric capabilities to the HBA level, thereby tagging each frame at the HBA port with virtual fabric IDs and creating completely isolated virtual fabrics.



Summary and Conclusion

IT managers know that choosing the right Linux HBA for their datacenter infrastructure can have a significant impact on the reliability and scalability of their mission-critical systems. Enterprises should choose a Linux HBA that is a proven solution and QLogic is the #1 choice for HBA solutions in the Linux environment that delivers:

- **Proven reliability**
- **Superior scalability for flexibility and choice**
- **Broad hardware portfolio (FC, iSCSI and Infiniband)**
- **Leadership in the supporting the Linux Community**
- **Advanced virtualization support to enable key technologies**

QLogic offers enterprise datacenters deploying mission-critical applications a proven solution with superior performance scalability and choice. Support for high availability solutions and key emerging technologies such as server virtualization enable IT administrators to deploy solutions that enable them to become more efficient, while saving costs by leveraging existing investments. Deploying and standardizing on QLogic Linux HBAs translates to clear and tangible benefits, enabling enterprises to drive more value from their SAN infrastructure investments.

Appendix: QLogic HBAs – Linux Specifications* (December 2006)

Supported Hardware Adapters
<ul style="list-style-type: none"> • Fibre Channel (FC) • iSCSI • Infiniband
Supported Driver Types
<ul style="list-style-type: none"> • Upstream • Inbox Drivers • QLogic Standard Drivers
Supported Distributions
<ul style="list-style-type: none"> • Novell SLES <ul style="list-style-type: none"> ○ FC: SLES 8, SLES 9, and SLES 10 ○ iSCSI: SLES 8, SLES 9 and SLES 10 ○ Infiniband: SUSE 9.3, SLES 10 • Red Hat RHEL <ul style="list-style-type: none"> ○ FC: RHEL 3 and RHEL 4 ○ iSCSI: RHEL 3 and RHEL 4 ○ Infiniband: Fedora Core 3 & 4, RHEL 4 • Other <ul style="list-style-type: none"> ○ Asianux ○ CentOS 4.0-4.3 (Rocks 4.0-4.3)
Supported Hardware Platforms
<ul style="list-style-type: none"> • IA32, x64, IA64, and PowerPC
Linux Tools
<ul style="list-style-type: none"> • Driver Installers • Dynamic Kernel Module Support (DKMS) • Driver Update Disk Kits (DUD) for Boot from SAN support • Tools to automate: <ul style="list-style-type: none"> ○ HBA Snapshot ○ Dynamic Target and LUN discovery ○ LUN Transition – Offline to online ○ Modify SCSI command timeout value
Device Management Tools / APIs
<ul style="list-style-type: none"> • Management Tools <ul style="list-style-type: none"> ○ SANsurfer FC/iSCSI HBA Manager GUI and CLI • Boot Support <ul style="list-style-type: none"> ○ BIOS, EFI (FC), and FCode • APIs <ul style="list-style-type: none"> ○ FC: SNIA HBA APIs, SMI-S APIs, FDMI ○ iSCSI: SNIA IMA ○ Infiniband: MPI, OFED

***Note:** Support for Driver Types/OS Distributions/Tools/Hardware Platforms varies by technologies and specific Host Adapters.

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