White Paper

Connectivity Solutions for the Evolving Data Center

- A multi-fabric solution that integrates converged networking and 16Gb/s Fibre Channel capabilities

EMULEX

Table of contents

Data Center-driven I/O Requirements

Today's data centers are in the midst of a major transformation at every level of their infrastructure. As each business seeks operational efficiencies, business responsiveness and strategic advantage to compete in global markets, maximizing data center operations is a key stratagem. The data center of the future is being driven by consolidation, virtualization and adaptive architectures that enable flexible visions such as IT as a service, cloud computing and autonomic computing.

The data center has transitioned from a single application/server model to a virtualized server environment with shared applications on a single physical CPU. In the next phase, it will move to a fully abstracted model where all IT resources are virtualized and the physical hardware layer is easily interchanged and upgraded. Each strata of the data center is progressing through evolutionary phases of development that all lead to a fully dynamic, unified and service-oriented data center. As IT services, servers, storage and core data center infrastructure evolve into adaptive and on-demand paradigms, networking and connectivity solutions need to evolve and provide seamless integration across the global enterprise.

There are a variety of data center connectivity models being deployed today dependent on the data center size and age. For Local Area Networks (LANs), Ethernet is the standard. For Storage Area Networks (SANs), Fibre Channel is the most popular. Fibre Channel and Ethernet are predominantly both supported in virtualized and non-virtualized servers -- with the SAN enabling shared data and LANs enabling transactional communication. Additionally, convergence around iSCSI has a following in Small and Medium-sized Businesses (SMB) and department deployments. Fibre Channel over Ethernet (FCoE) is starting to be used in new data center deployments.

Emulex is one of the leading industry suppliers of network adapters. According to Crehan Research[1], Emulex is the number-one supplier of 10 Gigabit/sec Ethernet (10GbE) ports. Similarly, Emulex has well over 10 million Fibre Channel ports installed worldwide. Emulex Fibre Channel and Ethernet adapters are sold by all major server and storage providers.

I/O Has Become a Key Differentiator

The business requirements for consolidation, virtualization, compliance and convergence are driving server and storage vendors to develop flexible, high-performance, condensed I/O capability with an ever-expanding list of feature requirements. I/O has become key to product differentiation. The divide between system and switch vendor has become fuzzy as each tries to meet the complex connectivity needs of their customers.

Emulex has become a trusted partner for both server and storage vendors. Companies like HP, IBM, EMC and Cisco have turned to Emulex for Fibre Channel and Ethernet adapters and I/O

[1] Crehan Research Vendors: 10 GE (incl. FCoE) Server-Class Adapter and LOM Ports 4Q 2010. Published February 2011.

controllers. Innovation and a collaborative culture have given Emulex a unique calling card with these vendors.

Fibre Channel: The Standard for Enterprise SANs

Fibre Channel has been the defacto standard for storage area networking for over a dozen years. Its reliability, performance, security and interoperability have made it popular in the data center for mission-critical applications. With the emergence of virtual servers, IT has harnessed their Fibre Channel infrastructure as the SAN platform for their virtual server deployments.

In 2008, 8Gb/s Fibre Channel Host Bus Adapters (HBAs) were introduced. This year, 8Gb/s Fibre Channel adapters will overtake sales of 4Gb/s Fibre Channel HBAs. The key drivers for 8Gb/s HBAs, have been a wider pipe for virtualized server, the ability to keep pace with new multi-core servers and support for Peripheral Component Interconnect Express (PCIe) 2.0 bus architected servers.

For Emulex, 8Gb/s Fibre Channel was not just about performance. For example, here are just a few performance and compliance features available with Emulex 8Gb/s HBAs.

- Emulex 8Gb/s HBAs support MSI-X, allowing CPU interrupts to be processed in parallel.
- Emulex launched OneSecure, a compatible HBA with offload support for at-rest and in-flight encryption. OneSecure is OEM'd by EMC, who sells it with their Powerpath for RSA solution.
- Emulex provided BlockGuard® or T10-PI support with end-to-end protection from silent data corruption.

In May 2011, Emulex began sampling the Emulex Engine™ (XE) XE201 I/O Controller that provides 16Gb/s Fibre Channel, 10GbE, and 40 Gigabit/sec. (40GbE). 16Gb/s Fibre Channel HBAs using the XE201 will become available the second half of 2011. These new adapters double the data throughput from 800 Megabytes per second to 1,600 Megabytes per second and will likely be paired with Intel Romley servers supporting the next-generation PCIe 3.0 bus architecture. During 2011, the ecosystem will be developing with a plugfest commencing in the fall. A real market for 16Gb/s Fibre Channel will emerge in 2012.

The need for more Fibre Channel capacity is being driven by requirements for greater virtual machine (VM) ratios and high-bandwidth applications, advancements in server designs such as multi-core processors, larger system memories, faster PCIe buses and faster disk arrays leveraging solid state disks (SSDs).

In a recent virtualization study by ESG[2], there was a clear correlation that as data centers become more experienced and sophisticated in their deployment of virtual servers, their VM ratios increase. The figure below shows that VM ratios are on the rise with greater than 30% of the respondents planning on increasing VM ratios to more than 25 VMs/per server over the next few years.

[2] Mark Bowker and Jon Oltsik, "ESG Research Report: The Evolution of Server Virtualization", November 2011.

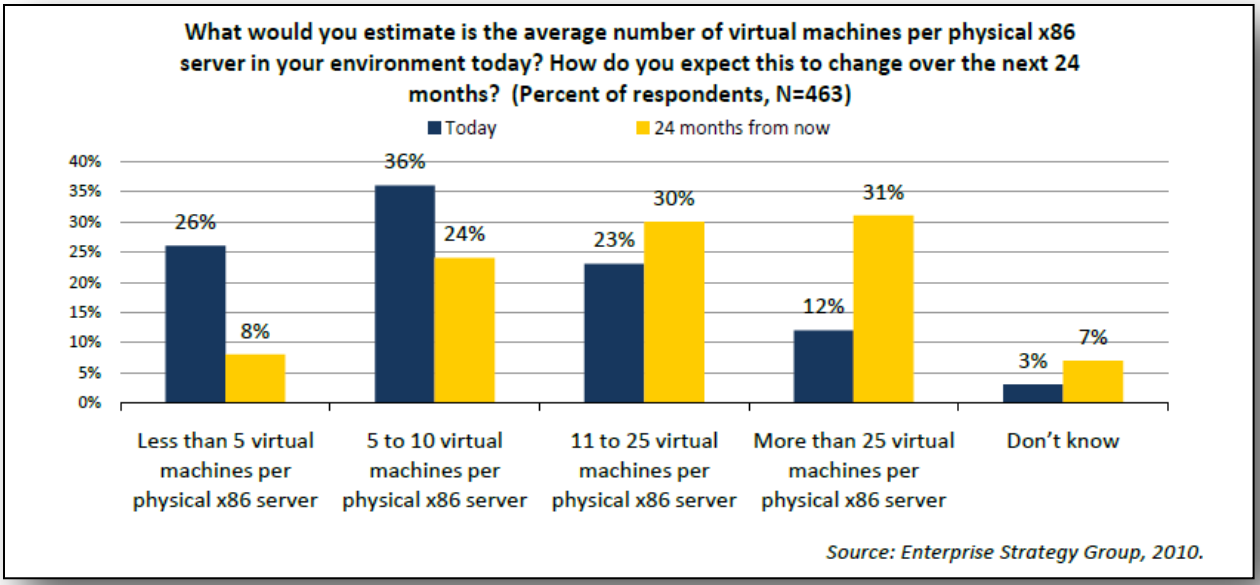


Figure 1: Average number of virtual machines per x86 server. Source: ESG Research Report, "The Evolution of Server Virtualization", November 2010.

In addition to virtualization, traditional high-bandwidth applications such as databases, backup and disaster recovery will benefit from support for faster data transfers enabled by 16Gb/s Fibre Channel.

The next generation of Intel servers will continue to move up the level of performance through the use of multi-core processors, which can drive bandwidth in excess of 50Gb/s. These servers will use denser memory modules and support terabytes of data. Simultaneously, the industry will move to PCIe 3.0, supporting up to 64Gb/s of bandwidth or four ports of 16Gb/s Fibre Channel. Technological advances in SSDs will also remove the disk array as a bottleneck.

Ethernet: The Standard for LANs

Ethernet is clearly the predominate technology for networking servers and users together. Standards for 10GbE were approved in 2002, but adoption was slow as prices remained relatively high. The growth curve for 10GbE is expected to accelerate rapidly as prices drop and virtualized, multi-core servers demand much higher I/O bandwidths. The transition to even faster next-generation deployments is underway as standards for 40GbE and 100 Gigabit/sec Ethernet (100GbE) have been approved and vendors are beginning to introduce products.

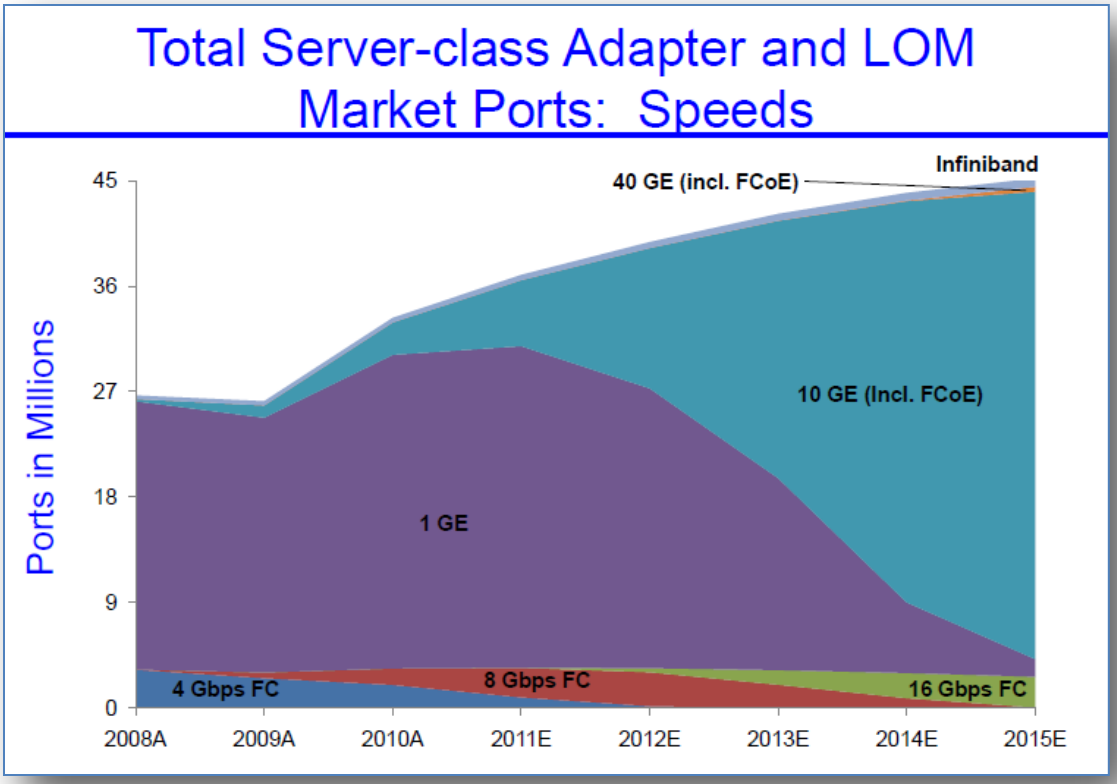


Figure 2: Total server-class adapter and LOM market ports: Speeds. Source: Crehan Research Feb. 2011.

Multi-fabric Support

With the emergence of rack and blade architectures, the requirement for greater functionality in a smaller, power-efficient footprint has been a key focus for innovation. Emulex has applied these requirements in the realm of I/O connectivity by consolidating industry I/O requirements into one I/O Controller (IOC).

The XE201 I/O Controller is a multi-core ASIC that provides up to four 8Gb/s Fibre Channel, two 16Gb/s Fibre Channel, four 10GbE and one 40GbE ports. A variety of Ethernet and Fibre Channel port configurations are possible. The XE201's ability to support both Fibre Channel and Ethernet gives server vendors the ultimate in flexibility -- lowering design costs and simplifying board options. For storage array and appliance vendors, this flexibility enables them to meet evolving connectivity needs with one design.

Additionally, the XE201 supports converged networking, with the ability to run multiple protocols (FCOE, iSCSI, TCP/IP and RDMA over Converged Ethernet [RoCE]) over a single wire. Convergence lowers data center cost for adapters, switches and cabling. The XE201 takes convergence to a new level, both adding new transports, such as support for Fibre Channel, as

well as enhancing wire-speed support with the capability to run 16Gb/s Fibre Channel as well as 40GbE.

Ultimate Performance and Scalability

The XE201 is a powerful multi-fabric I/O ASIC that offers the ultimate scalability in terms of virtualization and I/O resources. The multi-core ASIC features eight separate cores, and runs a combination of standard protocols and specialized functions. This multi-core architecture implements in hardware what was previously designed into firmware and allows dynamic scaling to meet horsepower requirements for a particular workload.

The XE201 leverages the Emulex vEngine™ technology, offloading more I/O onto the XE201 chipset and lowering the CPU burden on the host server so that it can support more VMs.

The XE201 supports pooling of resources so that they may be dynamically allocated to multiple protocols. Dynamic resource management providing flexibility in the implementation of interrupts, how interrupts are assigned, virtual functions, simultaneous TCP/IP connections, logins per initiator port, completion queues, exchanges, N_Port ID Virtualization (NPIV) and XRI ports with provides a quantum jump in terms of multiprotocol scale-out with support for up to 256 VMs.

Powerful and Interoperable I/O Virtualization Platform

I/O virtualization standards are evolving with a number of use cases and variety of implementation strategies varying by server and switch vendors. The XE201 supports a wide array of I/O virtualization constructs by implementing the following (evolving) standards and features, including Single Root IO Virtualization (SR-IOV), Virtual Ethernet Bridge (VEB) and Virtual Ethernet Port Aggregator (VEPA), which define the fundamental architecture moving from traditional I/O functions implementations to a Physical Function (PF) and Virtual Function (VF) implementation.

I/O virtualization has a variety of usages, including the ability to partition an Ethernet pipe, implement Quality of Service (QoS) requirements and facilitate I/O mapping between the network and the VMs running on a hypervisor.

To support I/O virtualization, the XE201 features a powerful and flexible internal switch. The internal switch is optimized for multi-tenant implementations, ensuring robustness and traffic isolation across protocols and VMs. In virtual servers, the internal switch allows data to be forwarded between VMs, which are co-located on the same server, without travelling to an external switch. The benefit is a reduction in the number of CPU cycles and network traffic required for data to reach its destination.

Emulex Connectivity Solutions (Chip and Board-level Solutions)

As Emulex works with leading server and storage OEMs, we understand that one size does not fit all. Server vendors have a range of servers -- high-volume x86 rack servers, blade servers and traditional UNIX servers. Emulex offers a variety of solutions meeting the I/O connectivity needs for each platform. These products include I/O controllers/LAN on Motherboard (LOM), I/O adapters and custom I/O solutions. Emulex has a roadmap of solutions mapping 10GbE, 40GbE and 100GbE and 8Gb/s, 16Gb/s and 32Gb/s Fibre Channel.

These product lines include both adapters and I/O controllers:

Emulex OneConnect™: OneConnect is a product family of 10GbE PCIe 2.0 adapters and blade mezzanine adapters based on the Emulex BladeEngine™ 3 (BE3) controller. OneConnect was the first Universal Converged Network Adapter (UCNA) with high-performance TCP/IP, TOE, FCoE and iSCSI protocol offloads. There are over 60 OEM design wins for OneConnect by leading vendors such as HP, IBM, Dell and EMC. HP includes a BE3 chip as a Universal LOM on their new G7 line of ProLiant servers. The new OCe11000 adapters feature an unsurpassed IOPS/watt capability with excellent performance, broad protocol and operating system support. BE3 and OneConnect are targeted at providing 10Gb/s Ethernet connectivity for high-end UNIX and high-volume x86-based servers.

Emulex LightPulse®: Emulex LightPulse is a product family of HBAs and multi-fabric converged adapters. In its ninth generation, over 10 million LightPulse HBA ports have been shipped with availability from all major system manufacturers for all operating systems. Emulex LightPulse adapters are known for their line-speed performance and field-proven reliability. Emulex LightPulse 16Gb/s Fibre Channel HBAs will be leveraging the new XE201 Controller, offering excellent performance and driver and management compatibility with prior generations of LightPulse adapters.

Additionally, the roadmap for LightPulse includes converged fabric adapters as a new line of adapters with support for both 16Gb/s Fibre Channel and 10GbE based on the new Emulex Engine XE201 controller. Several Tier 1 OEMs have chosen this architecture for their high-end UNIX servers and for traditional 16Gb/s Fibre Channel implementations. These new adapters will feature TCP/IP, TOE and FCoE offload, 16Gb/s Fibre Channel support, as well as a broad range of enterprise features, BlockGuard® T10-PI data integrity and support for PCIe Generation 3 servers and storage devices.

System Software and Management Capabilities Enable a Complete Solution

From a management perspective, the OneCommand™ Manager application provides robust converged network management with extensive diagnostics, installation, discovery and cross-firmware and parameter management. The ability to control an entire enterprise from a single

desktop, regardless of operating system, or networking protocol makes OneCommand Manager the most powerful adapter tool. In fact, OneCommand Manager provides twice the functionality in half the time when compared to competitive adapter management applications.

All Emulex adapters and I/O controllers are matched by a comprehensive set of field-proven drivers and supported with the OneCommand Management application. For example, Emulex is introducing the fourth generation of the Service Level Interface (SLI). SLI 4 provides a software abstraction to preserve a common driver architecture. The common driver architecture means that the same device drivers work across all generations of Emulex adapters and ensures in-box and in-distribution driver support for Emulex adapters with leading OS vendors. For the user, this means that they only need to qualify a single software stack for their entire data center.

Emulex adapters also support the most extensive set of server boot code implementations, including support for network, iSCSI[3], FCoE protocols and UEFI x64/IA64 UNDI and PXE Boot implementations. Emulex Universal boot support simplifies the boot process by allowing for proper selection of the relevant image.

For Target Mode applications, Emulex offers the TargetConnect™ Software Development Kit (SDK). TargetConnect supports two development models:

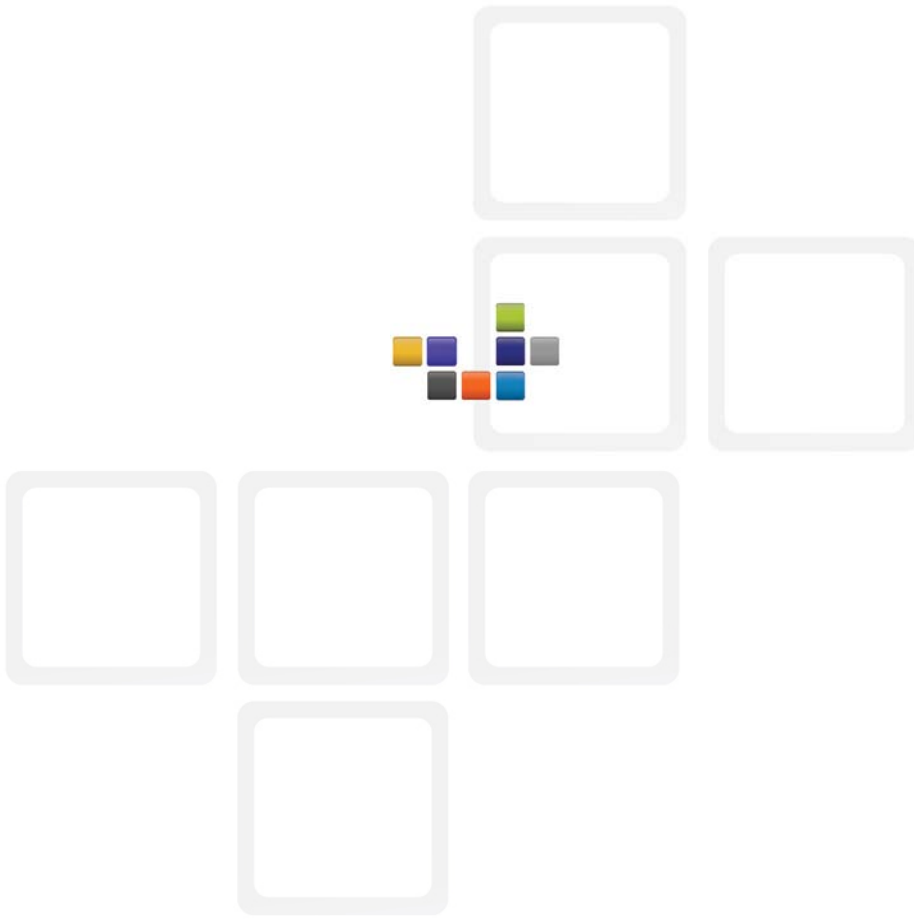
- SCSI Target Mode Driver for Proprietary Functionality, where developers are provided with sample code and write directly to the Emulex target mode API, creating custom SCSI target mode driver
- Emulex SCST Subsystem for Open Source Functionality, for developers who want to leverage the Open Source community SCST architecture in designing Linux-based storage solutions.

Conclusion

Network I/O has been important to data centers for decades. Virtualization has made the network part of the server delivery model and has made networking a differentiator for server vendors. Emulex is a leading provider of network adapters (both Fibre Channel and Ethernet) to server vendors – providing adapters and LOMs for blade and rack servers. Emulex is the leader in 10Gb/s ports and has over 10 million Fibre Channel ports worldwide.

Emulex has led the industry with the first Universal Converged Network 10GbE Adapter supporting multiprotocol offload. Emulex is taking the next step with a multi-fabric solution that integrates CNA and 16Gb/s Fibre Channel capabilities. With leadership in both Ethernet and Fibre Channel, Emulex has emerged as a strategic partner for tier-one server and storage providers.

[3] Available on OneConnect Adapters and BladeEngine (BE) implementations.



www.emulex.com

World Headquarters 3333 Susan Street, Costa Mesa, California 92626 +1 714 662 5600
Bangalore, India +91 80 40156789 | Beijing, China +86 10 68499547
Dublin, Ireland+35 3 (0)1 652 1700 | Munich, Germany +49 (0) 89 97007 177
Paris, France +33 (0) 158 580 022 | Tokyo, Japan +81 3 5322 1348
Wokingham, United Kingdom +44 (0) 118 977 2929