EMULEX

White Paper

Emulex Enables the Virtualized Data Center
Key Building Blocks for Data Center Virtualization

AT A GLANCE

Server, storage, and fabric virtualization technologies are rapidly becoming the foundation of modern data centers as IT managers seek dramatic improvements in resource and operational efficiencies as well as responsiveness to business needs. This white paper describes how Emulex products serve as key building blocks for each of these virtualization solutions.

PRODUCTS

- Emulex LightPulse HBAs
- LightPulse Virtual HBA Technology
- Emulex AV150 Intelligent Storage Processor

APPLICATIONS

- Data Center Virtualization
- Server Virtualization
- Fabric Virtualization
- Storage Virtualization

Executive Overview

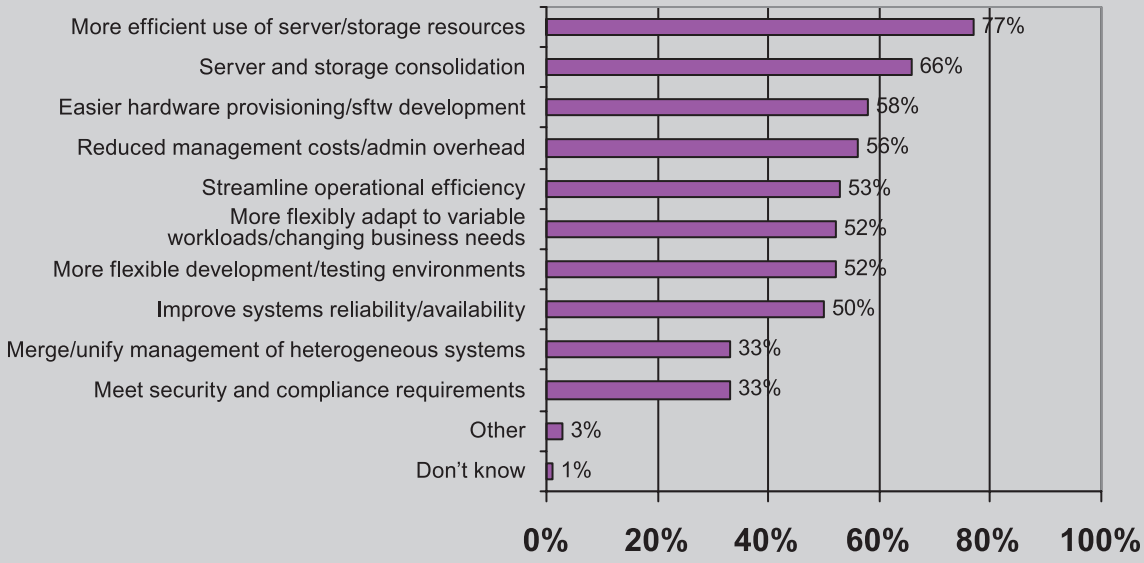
Virtualization technologies are rapidly becoming the foundation of modern data centers as IT managers seek dramatic improvements in resource and operational efficiencies as well as responsiveness to business needs. Three key technologies are significant: (i) Server Virtualization, (ii) Fabric Virtualization and (iii) Storage Virtualization. This white paper describes how Emulex products serve as key building blocks for each of these virtualization solutions. And while these are generally deployed as separate initiatives, IT managers are increasingly considering the prospect of a fully virtualized data center infrastructure – so this white paper also offers a blueprint for an end-to-end approach that incorporates all three solutions.

Data Center Virtualization

Virtualization technology is rapidly becoming the foundation of modern data centers. Whereas mainframe computing has employed virtualization technology for decades, open systems computing has been marked by a rapid expansion in the number of deployed servers, often with each dedicated to a single application or business function. At the same time, IT managers have faced an explosion of online data with a corresponding proliferation of storage devices; once again, each device is often dedicated to a single application, or line of business.

The result is an infrastructure that is nearly unmanageable. Many of the servers and storage devices are underutilized; floor space, power, and cooling concerns have become real limitations to data center expansion; and the sheer number of deployed devices has become almost impossible to track. Small wonder then that a technology which promises to enable consolidation of those assets on to a smaller number

Figure 1: Goals Driving Virtualization Initiatives (InfoWorld 2006)



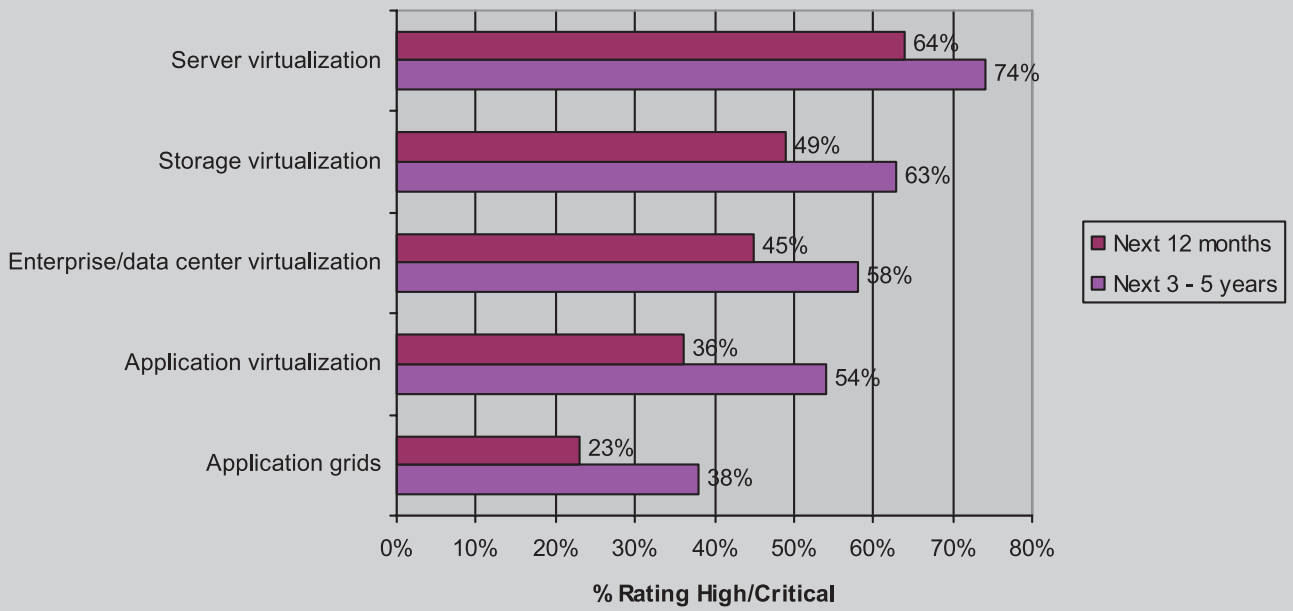
of physical devices, improve resource utilization efficiency, reduce management costs, and simplify provisioning of computer resources is front and center in the minds of IT managers (see Figure 1). These benefits translate into tangible business impacts. Simplified provisioning improves the responsiveness of IT to business needs. Hardware consolidation and improved resource utilization reduces costs and the improved manageability makes it easier to scale the IT infrastructure as the business grows.

Enterprise, or Data Center, Virtualization is the name given to the collection of key virtualization technologies: server virtualization, storage virtualization and fabric virtualization. While these are generally deployed as separate initiatives, IT managers are increasingly considering the prospect of a fully virtualized data center infrastructure.

One of the characteristics of enterprise data centers is the existence of Storage Area Networks (SANs). There is a high degree of affinity between SANs and server virtualization, because the connectivity offered by a SAN simplifies the deployment and migration of virtual machines. A virtual machine can be deployed on any physical server that has a connection to the SAN, rather than requiring its storage to be physically connected to its host server. Furthermore, a virtual machine can then, at least in theory, be migrated to any other physical server that is also connected to the SAN, and maintain the connection to its storage.

Of course, storage virtualization is also highly correlated with SAN infrastructures, again because the connectivity of a SAN enables many of the benefits of virtualized storage. A SAN-based storage device can be shared between multiple servers, enabling data consolidation. Conversely, a virtual storage device can be constructed from multiple physical devices in a SAN, and be made available to one or more host servers. Not surprisingly then, not only are storage devices being virtualized, but increasingly there

Figure 2: Importance of Virtualization to Large Enterprises (InfoWorld 2006)



is interest in virtualizing the SAN fabric itself, in order to consolidate multiple physical SANs into one logical SAN, or segment one physical SAN into multiple logical storage networks.

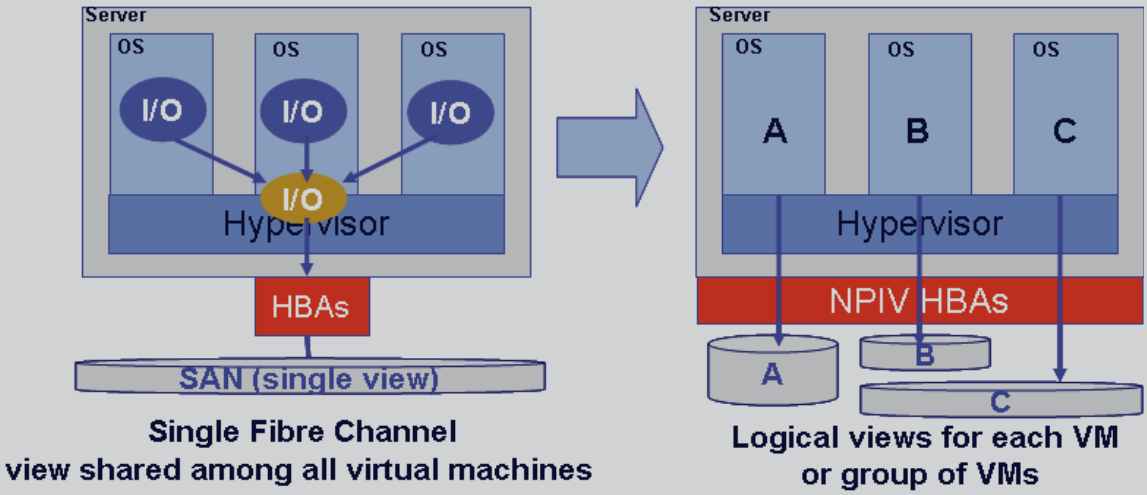
For a decade, Emulex has been a key supplier of SAN connectivity solutions. With the broadest enterprise deployment of Fibre Channel host bus adapters (HBAs), Emulex products sit at the nexus of the virtualization infrastructure. Emulex LightPulse® Virtual HBA technology contains key building blocks that enable customers to fully realize the benefits of server virtualization deployed in a SAN environment, and extends the value of fabric virtualization. Moreover, with the recent addition of intelligent storage processor products, Emulex now offers important enabling technology for partners building storage virtualization solutions.

Server Virtualization & Emulex Products

Server virtualization is the virtualization technology that has garnered the most interest and customer attention (see Figure 2). In fact, it is becoming one of the most rapidly adopted data center technologies in recent memory. Vendors like VMware and Microsoft, the Xen open source virtualization initiative, and almost every major Unix vendor are bringing virtualization technology to the server platform. Intel and AMD have announced virtualization-assist features for their processors.

Server virtualization provides the ability to deploy a discrete number of full-featured application environments called "virtual machines" or "guests", on a single, or a few, hardware platforms. Hardware resource scheduling and management is run behind the scenes by a "hypervisor", a user-invisible operating system. This promises, and is starting to deliver, benefits that meet important user needs:

Figure 3: NPIV Restores Virtual Machine Connectivity



- **Server consolidation** yielding a dramatic increase in server hardware utilization. Users report going from 15-20% up to 75 to 80% usage, with a proportional increase in server return on investment and reduction in management and maintenance overhead.
- **Faster, flexible provisioning for new applications,** as well as dynamic resizing of servers for growing applications, as well as development and test platforms.
- **Cost effective test bed deployment** of new applications
- **Easier workload balancing, incident resumption and disaster recovery,** as "virtual machines" are more readily portable to alternate hardware resources, and offer tools to automate these operations.

However, this consolidation has had its cost in fabric and storage connectivity. As multiple virtualized servers share the same Fibre Channel attachments (host bus adapters), they lose individual fabric registration, and the use of services connected to this registration, including individual zoning, array LUN masking and mapping, and fabric quality of service. A few of these services are replaced by virtual server mechanisms (resulting in two sets of processes and skills to accomplish similar tasks), while other features available on free-standing servers are simply lost once these servers get virtualized, creating major limitations in virtualizing large, mission-critical production environments.

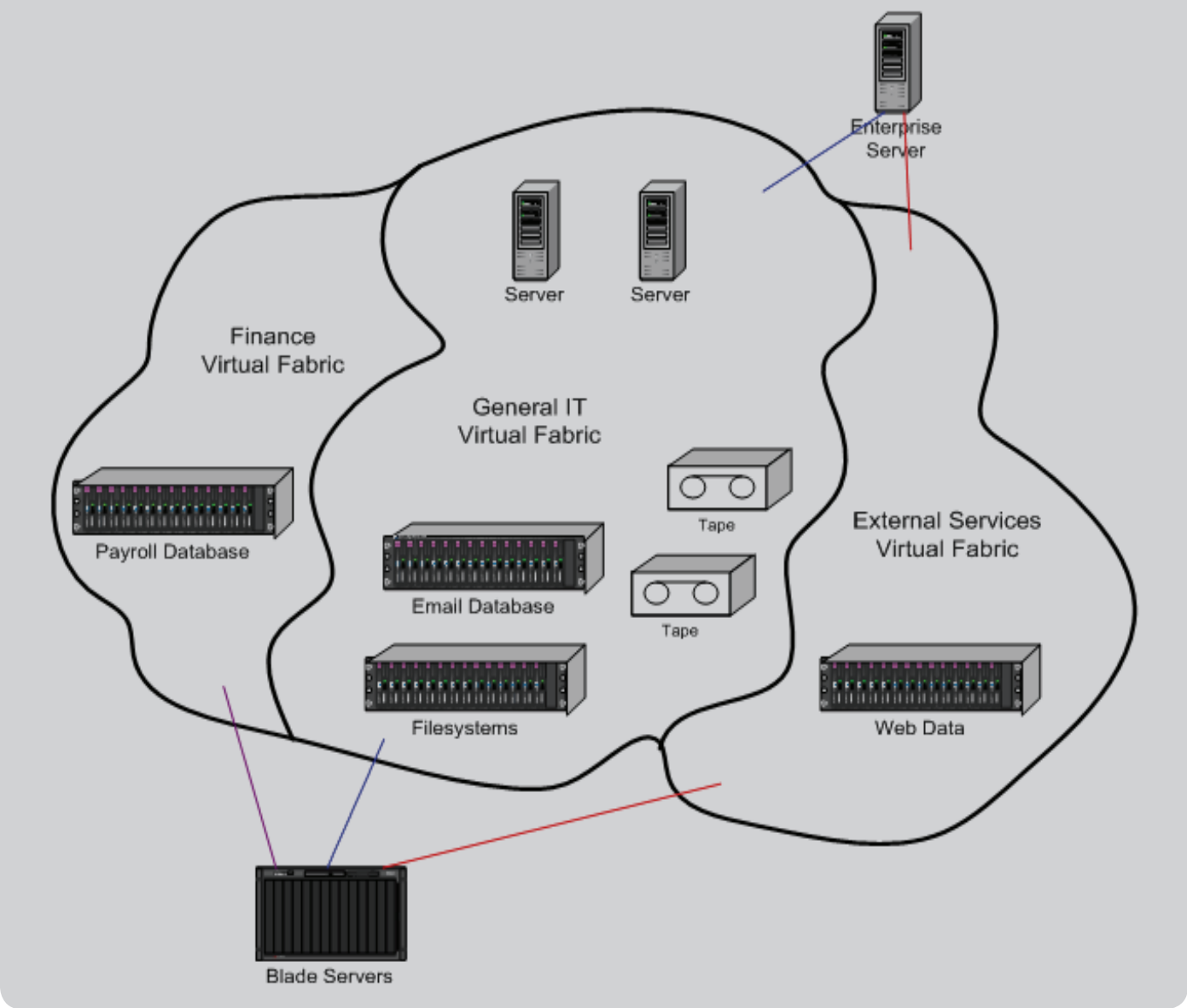
N-Port ID Virtualization (NPIV) is a key feature of Emulex's LightPulse Virtual HBA technology, that enables each Fibre Channel HBA to register multiple "virtual ports", identified by Worldwide Ports Names (WWPN) with the fabric. These virtual ports can then be assigned each virtual machine, restoring individual fabric registration (see Figure 3). NPIV is part of the Fibre Channel protocol standard published by the ANSI T11 committee and implemented by leading fabric switch vendors as part of their standard offering. The first vendor to provide NPIV Fibre Channel support as part of its standard product, Emulex provides an NPIV implementation that conforms to the T11 standard and readily interoperates with existing fabric switches, transparently to storage devices.

By restoring virtual machine level SAN connectivity, NPIV enables administrators to manage storage on behalf of the virtual machine in much the same way they manage storage attached to physical machines, leveraging familiar best practices and existing SAN management tools. This provides users with essential capabilities to optimize, scale up and protect their virtualized environment:

- Optimization of storage connectivity to the need of the individual application or line of business, is provided by WWPN-based fabric quality of service and zoning tools offered by fabric switch vendors, as well as storage masking, mapping or quality (drive speed, mirroring, etc) provided by storage array vendors.
- Advanced provisioning, with seamless SAN reattachment of migrated workloads, and possible server and storage pre-provisioning.
- Compliance with corporate storage processes and utilization of corporate storage tools and skillsets.
- Enhanced incident resilience upon loss of server, storage or HBA resources, or upon resource overload.

N-Port ID virtualization is built into Emulex LightPulse 4Gb/s host bus adapters, with driver and user interface support announced or planned for all major operating systems.

General IT Virtual Fabric



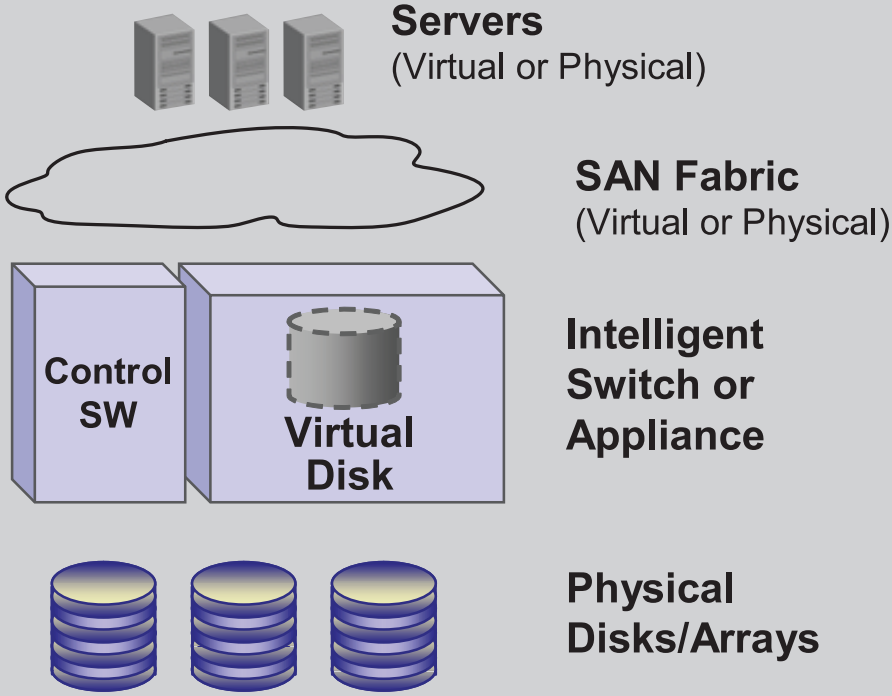
Fabric Virtualization & Emulex Products

As large enterprise users deploy extensive storage networks, they are confronted with a number of limitations. Some of them are hard limitations, such as the maximum of 239 switches in a given fabric implemented in the Fibre Channel protocol and switches. Others appear progressively, such as decreased fabric service level as device discoveries and fabric reconfigurations take more time and affect more users. In addition, resources are deployed and managed based on locations, as opposed to business needs.

In response to these challenges, the Fibre Channel industry devised virtual fabrics, which overcome these limits by enabling configuration of logical, or "virtual" SANs, which can be sized, tailored and managed to business needs, and effectively isolate potentially disruptive fabric events.

Emulex host bus adapters transparently support connection into virtual fabrics, enabling co-hosted applications to be configured and operate within separate virtual fabrics. The latest generation LightPulse Virtual HBAs bring virtual fabric integration to the next level, by enabling

Figure 5: Fabric-based Storage Virtualization



a single adapter to connect into multiple virtual fabrics, by tagging each individual frame for fabric routing. This capability, embedded in standard adapter firmware, will be activated by upcoming Emulex drivers and fabric switch firmware versions, as part of ongoing partnerships with leaders such as Cisco.

Multiple fabric integration will provide expanded flexibility in connecting large enterprise servers to virtual fabrics, without dedicating adapter resources to each fabric, or implementing resource-intensive, overhead-prone inter-SAN links. Furthermore, in combination with N-Port ID Virtualization, it will allow individual virtual machines or applications to be mapped to a specific virtual fabric, thereby providing each line of business or mission-critical application with optimized fabric services and storage resources.

Emulex's LightPulse Virtual capabilities enable convergence of virtual fabrics and server virtualization to provide a resilient, scalable, flexible and business-optimized environment as part of the Virtualized Data Center.

Storage Virtualization & Emulex Products

After great initial excitement, network-based storage virtualization adoption has lagged behind that of server virtualization. However, the first wave of storage virtualization solutions was offered primarily by start-ups, which made data center managers cautious in their investments. More recently, established vendors like EMC, IBM, HP, Hitachi, and others have entered the market with their own technologies, or by partnering with other vendors – which will further catalyze the adoption of this technology.

Application	Description	IT Benefit
Non Disruptive Data Migration	A popular Disaster Recovery (DR) strategy consists of taking periodic Point-in-Time images of primary storage and then migrating those images to the DR site.	LOB Availability IT administration costs Resource efficiency
	During scheduled array "lease replacements", this is the ability to move data from an old array to a new array while the hosts/servers continue to operate on the data .	
	Used to migrate live data between different storage tiers (e.g. primary vs. nearline storage) in the implementation of an ILM strategy.	
Heterogeneous Volume Management	The ability to allocate Virtual LUNs without regard to where the actual data resides – potentially across different vendors' arrays.	Storage resource utilization
	The ability to overprovision large LUNs to all applications without having that much back-end physical storage. The back-end physical storage can then be purchased "just-in-time" when storage utilization starts to hit a pre-defined high watermark.	
Data Replication	Invisible to the host, a virtual LUN is transparently mirrored – either locally or to a remote replication facility.	LOB Availability/ Disaster Recovery IT administration costs

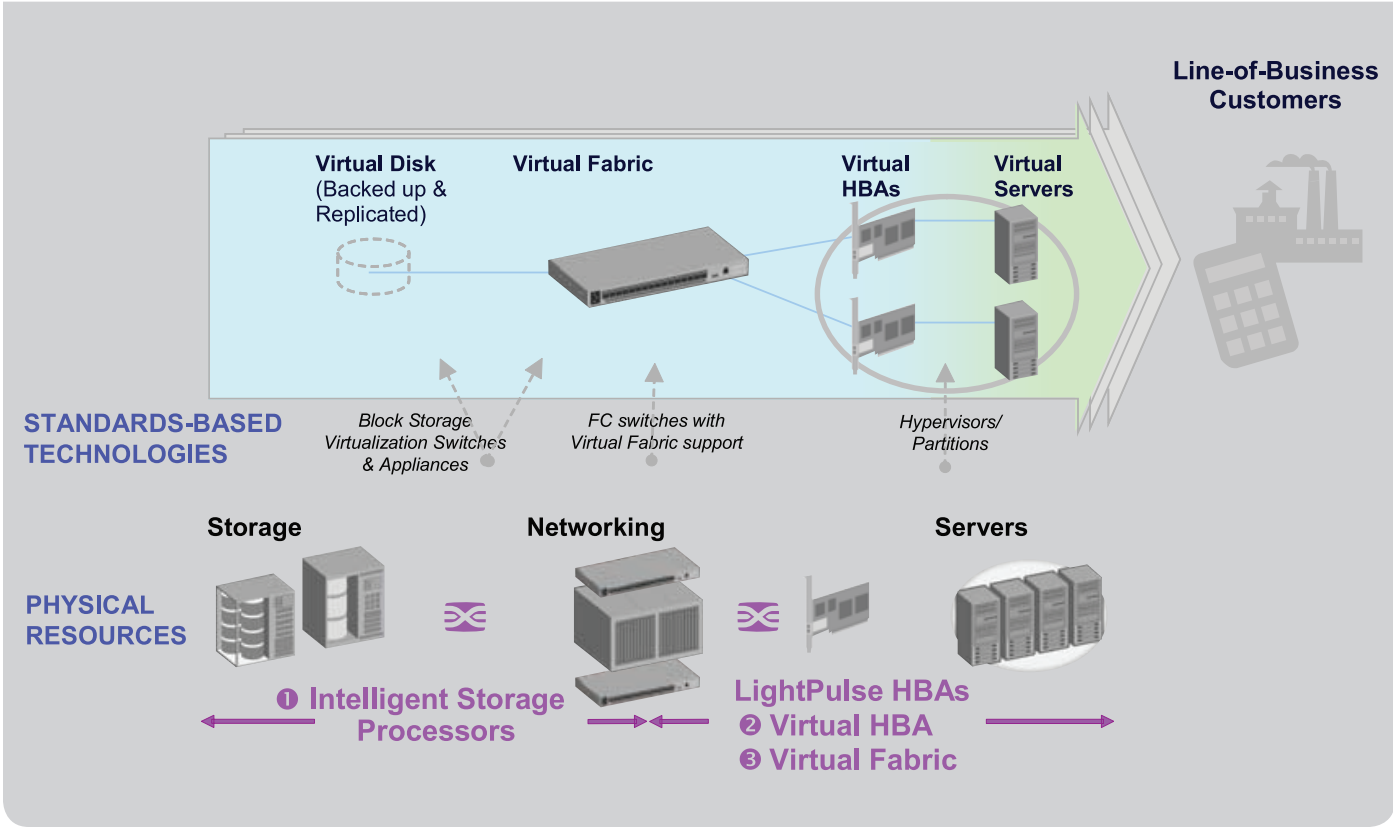
Table 1. Benefits of Storage Virtualization

While a lot has been written to describe this technology and its different variants, the industry is trending towards a "network-based" approach. This essentially boils down to an intelligent switch or appliance that resides "in the fabric" and appears to the hosts/servers as a virtual disk (or disks) – whereas the actual storage resides on a physical array or arrays that are hidden from the hosts/servers (see Figure 5).

Storage virtualization technology in and of itself does not offer IT benefits. It's really about the storage applications that the technology enables. Table 1 describes a few examples of storage applications and their benefits.

A well designed virtualization solution must be "invisible to the SAN" environment from a performance, latency and scalability perspective. In other words, it's unacceptable to compromise SAN performance in the pursuit of the virtualization benefits described above. Whether it's in a switch or appliance implementation, any virtualization solution consists of two core components – (i) the storage management application that sets up the virtual volumes and administers them (the "control path") and (ii) the virtualization engine that does the actual work of translating I/Os to virtual volumes into I/Os to physical disks (the "data path"). The latter introduces a potential performance bottleneck into the entire virtualized SAN.

Figure 6: A Virtualized Data Center Blueprint



To avoid this bottleneck, the data path must be capable of processing millions of I/O operations/sec with low latency and high throughput. Emulex supplies a next-generation, intelligent storage processor optimized for storage virtualization that is unique in its ability to provide low latency, high performance and scalability – the net result being a solution that is "invisible to the SAN".

The availability of Emulex's intelligent storage processor for switches and appliances has an interesting impact on the ongoing debate between switches versus appliances. There is a perception that intelligent switches provide superior performance and scalability compared to appliances - that have traditionally been software-based. The use of the Emulex AV150 Intelligent Storage processors largely eliminates this debate – as it provides the same high-performance virtualization engine for the switch or appliance into which it is designed.

In their evaluation and deployment of storage virtualization solutions, IT managers should ensure that their solutions are "invisible to the SAN." Emulex has and continues to work with its partners to address this requirement via the use of its intelligent storage processor.

A Blueprint for the Fully Virtualized Data Center

While each of the three aforementioned virtualization technologies offer their own benefits, a further increase in flexibility, operational and resource efficiency can be gained by combining them into an end-to-end approach. Figure 6 illustrates how an IT manager can supply all the elements of a storage service to her customers completely via "soft provisioning". In other words, for a given customer, Storage Service = Virtual Server + Virtual HBA + Virtual Fabric + Virtual Disk.

This fully virtualized approach to storage provisioning maximizes flexibility, operational and resource efficiency. The following example goes further to describe how this approach would operate:

Operation	Console View
IT Task: Provision a new server with 10TB of storage for Marketing, and another new server with 5TB of storage for Manufacturing – on their respective departments' fabrics	
Provision virtual disks with parameters matching department needs - 10TB for Marketing RAID 5, 5TB for Manufacturing RAID 10 with replication. Set up appropriate access control.	Storage virtualization console
Provision virtual servers on hypervisor – either from scratch or using guest migration tools – WinXP for Marketing, Linux for Manufacturing	Server virtualization console- virtual server provisioning view
Create two virtual fabrics – Virtual Fabric #1 for Marketing and Virtual Fabric #2 for Manufacturing	SAN management console
Create multiple Fibre Channel HBA ports – a set for the Marketing virtual server and another set for Manufacturing virtual server	Server virtualization console – HBA configuration view
Assign Marketing ports on Fibre Channel HBA to Virtual Fabric #1 and Manufacturing ports to Virtual Fabric #2	Server virtualization console – HBA configuration view
Mount appropriate volume onto each virtual server OS	Virtual server consoles
Both departments are up & running on completely virtual resources!	

Conclusion

This white paper has described three important data center technologies: server, fabric and storage virtualization. It has also described a blueprint for how all three technologies can be utilized together to realize maximum benefits - flexibility, operational and resource efficiencies - in a fully virtualized data center. Emulex products - LightPulse HBAs and Intelligent Storage Processors - act as core building blocks for each of these three virtualization technologies. With the Fully Virtualized Data Center blueprint above in mind, only Emulex is working closely with its partners to ensure these products work seamlessly together in a robust, interoperable and integrated fashion.

While possible, it's unlikely that an IT manager will deploy all three of these virtualization technologies in one fell swoop. Instead, IT managers should carefully analyze and determine their own phased deployment approach – and ensure that each step is compatible with the next. IT managers should ensure that future purchases of HBAs and intelligent switches/appliances meet the requirements for building towards the Fully Virtualized Data Center. Working from the above blueprint, Emulex current and future products will clearly support this phased implementation approach.

EMULEX®

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