HP Blades and Server Virtualization:
The Ins and Outs of I/O
The combination of blade servers and virtualization today offers a compelling solution for regaining control of their server resources, while offering benefits including space savings, reduced power and cooling, improved manageability, availability and flexibility. Initially, blade servers got a bad reputation for not being a good fit for virtualization. This was generally because early blade servers were not powerful enough, and often did not have enough I/O resources (Ethernet NICs and Fibre Channel ports) - to support multiple virtual server environments on one blade, not to mention hundreds of virtual servers in a single chassis. As a result, early blades and virtualization software have evolved to better support the high performance and high bandwidth I/O requirements that come with initiating many virtual servers.

In 2001, when server blade first emerged, they were designed to target a very narrow market portion of IT’s cries for not having enough Input/Output (I/O) resources - Ethernet NICs and Fibre Channel ports to support multiple virtual server environments on one blade, not to mention hundreds of virtual servers in a single chassis. As a result, early blades and virtualization software have evolved to better support the high performance and high bandwidth I/O requirements that come with initiating many virtual servers.

Virtualization on Blades - an architectural perspective

It’s important to address server sprawl and consolidate the plethora of distributed, undervirtualized servers, many businesses are turning to server virtualization technology on blade servers. These technologies together can revolve around low power, low cost and utilization costs and cooling and costs required for servers significantly. When these two technologies are combined, IT also gains increased server utilization rates, higher reliability, flexibility and scalability. To get the most out of these technologies, it is important to understand how the solution architectures can help or hinder these goals.

Server Virtualization Architecture

With increasing cost pressure on IT organizations and undervirtualized servers taking a space, power and administrative costs, not to mention putting out heat, it’s not surprising that many SMB and enterprise organizations have been looking for solutions outside virtualization has allowed companies to consolidate anywhere from 4:1 to 20:1 virtual servers to physical servers for many of their applications environments.

VMware was the first to deliver virtualization to industry-standard x86 servers. Their initial server virtualization engine was based on a virtualization architecture, commonly called “hosted,” as shown in Figure 1, where each virtual server talks through the native operating system to access devices. These layered architectures impose significant overhead and limitations.

For those with higher performance requirements, VMware and other vendors have developed a thin hypervisor that is hosted instead of an underlying operating system. The hypervisor then creates virtual machines which contain the operating systems (see Figure 2). The overhead reduction when using a hypervisor architecture is fairly obvious over the hosted architecture.

Virtual Layer (VMware GSX, Microsoft Virtual Server, etc)

Each virtual machine (discussed later in the section) is an environment which contains the native operating system (see Figure 2). The hypervisor software boots instead of the chosen virtualization solution provides adequate management and monitoring capabilities to easily track the performance of applications within the virtual machines looking to regaining control of their server resources. VMware, as the most mature product in the marketplace, has the most extensive management suite, including the capability to perform live migrations or movement of running VMs from one blade to another or from one server to another, and non-disruptive backup of the VM environment. VMware tools also support Dynamic Resource Scheduling (VMware DRS) which will continuously adjust the physical server loads against given thresholds and move VMs around to maximize utilization across all the physical servers.

Data Storage and Virtualization

In order to support the ability to quickly and easily move VMs from one server blade to another, VMware creates a VMware ESX Server File System (VMFS) that can be accessed by all the virtual servers (ESX servers) within a resource group as shown in Figure 3. The VMFS is a clustered file system that enables each of the VMs to have access to their data no matter which ESX server the VM is running on. The VM operating environment is given a virtual LUN (logical unit number) to send and receive SCSI commands and data. The ESX servers work in conjunction to provide data locking and access restrictions in order to prevent data from being accessed or overwritten by mistake.

VMFS allows all ESX servers to view, access and manage the data

The number of virtual machines and associated application environments can run on any given server will depend on the server configuration as well as the requirements of the distinct applications. This variability is one reason why blade servers are optimal for use with virtualized solutions. Companies have a number of applications with differing processor, memory, storage and networking options and requirements. VMware provides solutions which allow each server and blade chassis to be configured with differing processor, memory, storage and networking components to fit the requirements of the virtualized environments, while maintaining a level of standardization.

Running multiple virtual servers works the same way on a blade server as on any other server. First, a hypervisor is booted on the server that contains the base functionality needed to interact with the device and map each virtual machine there. VMware provides management software called VirtualCenter in which virtual machines are configured and initiated. It is important that the chosen virtualization solution provides adequate management and monitoring capabilities to easily track the performance of applications within the virtual machines looking to regaining control of their server resources. VMware, as the most mature product in the marketplace, has the most extensive management suite, including the capability to perform live migrations or movement of running VMs from one blade to another, and non-disruptive backup of the VM environment. VMware tools also support Dynamic Resource Scheduling (VMware DRS) which will continuously adjust the physical server loads against given thresholds and move VMs around to maximize utilization across all the physical servers.

Blade Architecture

Much of the value of server blade systems comes from the shared components within the blade chassis, making them an excellent partner for virtualization — further consolidating server space and sharing components. In a blade chassis, the backplane, the power supplies, the cooling fans, the I/O modules and the management, are shared by all the server blades held in the chassis. For example, the HP BladeSystem c7000 chassis holds up to sixteen full-height or eight half-height server blades sharing the rest of the chassis components (see Figure 4).

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Virtualization on Blades – an architectural perspective

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Together, server blades and virtualization are addressing many of IT’s cries. “My servers run at 5% utilization rates and I’m being asked to provide another ten servers each running their own applications. I’m out of space; I’m out of power and I can’t stretch my budget or my administrators any thinner. How can this be good for business?” However, the question arises; “Can the system architecture scale? How can virtual environments be designed for a server running one application translate to support multiple virtual servers and their applications?”

Today, the answer to this question is a resounding “Yes!” for many application environments and workloads. As with any technology, early blade and virtualization solutions experienced a lot of growing pains, both real and rumored. In particular, I/O throughput, provisioning, and ongoing management presented challenges in the beginning. Over the past two years, chip, blade and server virtualization vendors made important changes to improve data movement into and out of the servers. This paper discusses the architectural and operating environment improvements that allow for faster data handling in server blades and server virtualization technologies. It will provide tips on how to determine if blades and virtualization can meet or exceed your business needs.

Virtualization on Blades – an architectural perspective

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The redundant, shared components ensure high reliability, and both the blade and interconnect options provide increased flexibility of configuration. The fact that all these components are hot-swappable creates a highly serviceable solution.

I/O Options

The combinations of options for storing and moving data through a blade are numerous. Each blade can be configured with or without local on-blade storage. The blade design allows for connecting to networked storage (SAN or NAS). In addition, HP users have the option of adding local storage through storage blades. For SAN connections, mezzanine cards can be added for additional network ports, Fibre Channel SAN ports, or Infiband connections. On the other side of the midplane, Ethernet, Fibre Channel, and InfiniBand can be incorporated into Pass-Thru modules. The HP c-Class blade design can also support two or four (depending on the blade) small form factor (SFF) disks with various hard drive controllers for connecting to networked storage (SAN or NAS). However, HP users have the option of adding local storage through storage blades. For SAN connections, mezzanine cards can be added for additional network ports, Fibre Channel SAN ports, or Infiband connections. On the other side of the midplane, Ethernet, Fibre Channel, and InfiniBand can be incorporated into Pass-Thru modules. Some server blades have the option to be configured with on-blade storage or without it (called diskless). The HP c-Class blade supports two or four (depending on the blade) small form factor (SFF) disks with various hard drive controllers for connecting to networked storage (SAN or NAS). However, HP users have the option of adding local storage through storage blades. For SAN connections, mezzanine cards can be added for additional network ports, Fibre Channel SAN ports, or infiband connections. On the other side of the midplane, Ethernet, Fibre Channel, and InfiniBand can be incorporated into Pass-Thru modules.

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Blade Networking Options

Blades support a number of networking options for IP-based networking via Ethernet, Fibre Channel (FC) based networking, and high speed low latency InfiniBand. Ethernet comes with at least one 1-gigabit Ethernet (1GbE) network interface card (NIC) standard for management and lights-out operations and some number of expansion slots for additional networking capabilities. These networking options are supported primarily through mezzanine (or daughter) cards that attach to the blade. Each blade supports for some number of PCI express ports on expansion slots, e.g., the HP ProLiant BL460C blade server supports three expansion slots. The network signals are carried through the midplane to switch modules, pass them through a switch module on the other side of the midplane (see Figure 5 on page 6).

Ethernet

As with Ethernet, blades support mezzanine Fibre Channel adapters (also known as host bus adapters or HBAs). For reliability and redundancy, each HBA should have at least two ports. Fibre Channel HBAs can be run in 2Gb, 4Gb, and 8Gb bandwidths with the bulk of implementations using 4Gb HBAs. These HBAs are made by the same industry-leaders that provide the PCI bus HBAs. Either Fibre Channel switch modules or Fibre Channel Pass-Thru modules are placed on the back side of the midplane to move the FC data to external connectors. Like the Ethernet switch module, the FC switch module is the last expansion option and reduces cabling significantly. These switch modules are made by industry leaders such as Brocade and Cisco for compatibility across your storage network. These modules support a minimum of 12 FC ports and can expand up to 24 ports with aggregate switch bandwidth of 152 gigabits per second (Gbps). A Fibre Channel Pass-Thru module avoids having to purchase and configure an embedded FC switch that may be managed and configured differently than your current environment. However, depending on how many spare ports are available on your SAN, there may be additional FC switches purchased, along with cables, to connect into your SAN.

InfiniBand

The InfiniBand Switch Module for the HP c-Class enclosure has 16 downlinks to connect to 16 server blades and 8 external uplinks. When using an InfiniBand fabric, a subnet manager is required. For high performance computing (HPC) configurations, HP supports Voltaire Grid Switch family of products. OpenSM from OpenFabric Enterprise Distribution can also be used. HP does not support an Infiband Pass-Thru module today.

HP Virtual Connect

A new interconnect option between the server blades and external networks in c-Class BladeSystem is through HP’s new virtual I/O offering called Virtual Connect (VIRTUAL CONNECT). Today, there are two Virtual Connect modules that can be ordered from HP, the Virtual Connect Ethernet Module and the Virtual Connect Fibre Channel Module. The Virtual Connect module(s) slide into the back of the c-Class chassis, just like the FC and Ethernet switch or Pass-Thru modules. The Virtual Connect module presents MAC and IP addresses, for the Ethernet Module, or world-wide names (WWN) for the FC Module on the external ports. Without Virtual Connect, every time a new blade is added to the chassis, a new blade configuration change is made with no effect on the external LAN or SAN. This allows the BladeSystem administrator to add new blades, replace failing blades or move blades around within the chassis without having to reconfigure the network external to the c-Class BladeSystem chassis. The Virtual Connect interface to the outside world remains the same allowing the blades to be fungible. All management of connection changes is done through the Virtual Connect Manager, included with every module. The recently released Virtual Connect Ethernet module supports two 10GbE CX-4 uplinks and eight 1GbE uplink ports externally. Internally, 16 1GbE downlinks connect to up to 8 blades through redundant mezzanine paths. Management features include external to the c-Class chassis, RAC support for PXE, WOL, (wake on LAN), port VLAN, VLAN Tagging, VLAN pass through, NIC Trimming and port aggregation.

The Virtual Connect Fibre module supports four external 4Gb FC uplink ports with HBA Aggregation using Network Port for Virtualization
The redundant, shared components ensure high reliability, and both the blade and interconnect options provide increased flexibility of configuration. The fact that all these components are hot-swappable creates a highly serviceable solution.

I/O Options

The combinations of options for storing and moving data through a blade are numerous. Each blade can be configured with or without local hard drives, independent of the server blades connected to it for connecting to networked storage (SAN or NAS). In addition, HP users have the option of adding local storage through storage blades. For SAN connections, mezzanine cards can be added for additional network ports, Fibre Channel SAN ports, or InfiniBand connections. On the other side of the midplane, Ethernet, Fibre Channel, and InfiniBand interconnects can be incorporated in Pass-Thru modules to be used. HP is also now making great strides in virtualizing I/O within the HP BladeSystem, with its new Virtual Connect technology.

Blade Storage Options

Most server blades have the option to be configured with on-blade storage or without it (called diskless). The HP c-Class blades support two or four (depending on the blade) small form factor (SFF) disks with a hardware RAID controller for reliability and speed. The disks drives are located at the front of the blade. This gives users easy access and hot-plug capabilities in the event of a disk failure. Simply pop the bad disk out and pop a new one in, without ever removing the blade from the chassis or stopping your application processing. It’s important to note that not all vendors support hardware RAID on the server blades; all are blades architectured to support drive hot-swap capabilities. While still not the standard configuration, the idea of having diskless server blades is becoming more popular. There are two primary drivers for removing local storage. The first is that the disk is the only moving component on the blade, which makes it less likely to fail. If you remove the disks, the mean time between failures (MTBF) on a blade is increased. That card, with the HP c-Class blade design and easy access for repair, becomes less of a driver and leads to the second reason for moving to diskless blades, which is ease of provisioning and reprovisioning. When no local data is stored on the blade, it takes much less time to replace and configure, and it is essentially stateless. Without on-board data, users can begin to manage their blades as a pool of processing resources rather than as distinct individual servers. This also makes a blade expendable if there is a hardware failure — there is no local data to recover. The administrator can walk up to the front of the chassis, see which blade has failed, pull the failed blade, without affecting the processing on any of the other blades, replace the blade and walk away. If you are running VMware v3 with high availability (HA), (discussed in more detail later), then when the failure was detected, the processing would have been handed over to the failed blade that had been replaced, processing would move back over to the new blade automatically. This is the beginning of true utility computing.

Diskless blades get their boot environment over the network and off the SAN using a protocol called Preboot Execution Environment (PXE). When a server blade is booted, it will send out a request, not unlike a DHCP request, for a boot server. A boot server will respond with the file path to a network bootstrap program (NBP) which the blade will download into memory and begin to boot. Depending on the network, this process could take a few minutes, though hopefully, booting is not a process that is performed very often. Using diskless blades has the added advantage that it allows you to configure, update, and manage all of their operating environments on the storage area network (SAN).

There may also be reasons to use local storage, for example, operations where a SAN would not be used, or environments that require a lower storage cost than SAN storage. To support these and other environments where larger amount of direct-attach storage is required, HP has recently created a specialized Storage Blade, the SPSR, which is placed in the blade chassis slot adjacent to the server blade(s) the blade chassis has been pre-wired with PCI express channels between adjacent slots. To access the storage blade, a PCI express pass-thru card is placed on the server blade to provide connectivity over to the storage blade. Today each storage blade can hold up to six hot-swap SFF SAS (Serial Attached SCSI) drives for up to 876 gigabytes (GB) of storage in a half-height bay. They also support up to six GB SAS (Serial ATA) drives.

In addition to the above options, most blade systems also are attached to a SAN or network attached storage (NAS). HP estimates roughly a 70% SAN rate attach for blade systems.

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Ethernet

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Either Fibre Channel switch modules or Fibre Channel Pass-Thru modules are placed on the back side of the midplane to move the PCI device to external connectors. Like the Ethernet switch module, the FC switch module is the last expensive option and reduces cabling significantly. These switch modules are made by industry leaders such as Brocade and QLogic.

Fibre Channel pass-through modules support a minimum of 12 FC ports and can expand up to 24 ports with aggregate switch bandwidth of 150 gigabits per second (Gbps).

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This allows the BlackSystem administrator to add new blades, replace failing blades or move blades around within the chassis without having to reconfigure the entire BladeSystem chassis. The Virtual Connect interface to the outside world remains the same allowing the blades to be fungible. All management of connection changes is done through the Virtual Connect Manager, included with every module.

The recently released Virtual Connect Ethernet module supports two 10GBE CX-4 uplinks and eight 1Gbe uplinks ports externally. Internally, 16 1Gbe downlinks connect up to 8 blades through redundant midplane paths. Management features include external to the c-Class chassis pass support for PXE, WDI, (wake on LAN), port VLAN, VLAN Tagging, VLAN pass through, NIC teaming and port aggregation.

The Virtual Connect FC module supports four external 4G FC uplink ports with HBA Aggregation using Network Port 0 Virtualization.
The Plan

As with any implementation plan, the challenge can be in the details. It is, of course, possible to overtune the capabilities of any system, blade or otherwise, by not understanding your applications and biasing too many virtual environments with the same or similar usage profiles onto one server. Fortunately, with a little planning this can be avoided.

Before anything else, it must profile the application environments to determine what the systems requirements are, across the processing life of the application. Some applications have daily, even yearly spikes in activity. Some spikes are not predictable, caused by some external event. However, it’s important to come up with a best guess for day-to-day operations and deal with anomalies as they arise. Be sure to look at processor, memory, network and storage access patterns.

If the environment being evaluated doesn’t already have tools to profile applications environments, many vendors provide consulting services that can help with this process (for example, VMware’s Capacity Planner Assessment Service). Once the applications environments have been profiled, a set a target for how many environments will run concurrently on the same server. Current users have implemented anywhere from 1 VM per server to 20 VMs per server (an average around 5-6 VMs per server), depending on the environment. With this in mind, choose which applications would be compatible sharing resources; try not to combine applications which have similar workload profiles as these are the more likely to experience performance degradation due to resource conflicts.

When asked what advice they would give to someone just beginning to look at blades and virtualization, one respondent says “I’m a big fan of VMware and I have changed my mind on blades. I would like to switch everything to blades and virtualize it all.”

One example of this can be seen over the lifetime of the HP BladeSystem c7000. Initial blades had limited network bandwidth support. As such, these blades would not have made good candidates for multiple virtual environments, especially environments with high levels of network access. As customers required more bandwidth, HP developed new p-Class blades with greater bandwidth. Additionally, even more bandwidth is supported in the latest c-Class blades and chassis. Many new advances have been made in the i/O bandwidth, power, cooling, and now in virtual i/O through Virtual Connect.

When the first release of VMware ESX became available, neither Intel nor AMD had virtual-assist technologies to help with a hypervisor’s privileged status like they do today. With every release of ESX, VMware works to improve overhead of the virtual environment, especially with regard to I/O. Before implementing VMware, it is imperative that the compatibility of both the system and the storage is verified by checking the VMware website.

Cost Justification

As part of the strategic decision to move to blades and virtualization, the ROI and probably the CFO will look for the financial justification. To assist in this process, CIO has tools, including an ROI analysis tool and a TCO analysis tool. The outputs from these tools help show the bottom-line value of moving to blades and virtualization.

Today, it is required to provide cost-effective services to an environment that is make up of hundreds to thousands consuming power, creating heat, requiring cooling, cabling, security server, storage, data, and software management, with servers running less than 10% utilization and generally running only one application.

Virtualization and blades offer a reliable, flexible and substantially more cost effective alternative. Customers will consolidate their users are consolidating up to 100 servers into a single rack with up to sixteen blades sharing processor, cooling, i/o network, SAN network cabling, disk storage, creating up to 80% or more server utilization rates at 80% or above. The combination of VMware’s Virtual Infrastructure 3 (VI3) and HP’s c-Class BladeSystem offer significant value for IT today and into the future.

About the Authors

Anna Skamarock, advisory analyst with Focus Consulting, has spent nearly 30 years in high-tech fields in various positions, including end user, systems administrator, scientific programmer, NFS software engineer, backup and recovery software engineer, including end user, systems administrator, scientific programmer, NFS software engineer, backup and recovery software engineer, including end user, systems administrator, scientific programmer, and more recently with the Sun American Supercomputing Compatibility Guide (http://www.vmware.com/pdf/v3_vsan_ guide.pdf to get the most up-to-date compatibility information, go to the VMware website www.vmware.com and search for "SAN compatibility.”

When an application is moved from a physical server to a virtual server using VMware’s Convert, the application environment including the application data will be moved from the physical server over to the ESX Server and written to the VMFS associated with the current disk space over to the disk space associated with the VMFS server using VMware’s Converter, the application environment including the application data will be moved from the physical server to the ESX Server and written to the VMFS associated with the current disk space over to the disk space associated with the VMFS. The markets for both technologies have seen significant change over this time. Change in capacities, change in leadership among the top vendors and change in how users implement and manage these technologies within their infrastructure. It also means added capabilities for increased performance, bandwidth, and ease of management.

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She also co-authored Storage environments required for server virtualization and blades goes hand-in-hand with planning for server virtualization. When asked what advice they would give to someone just beginning to look at blades and virtualization, her response was: “I’m a big fan of VMware and I have changed my mind on blades. I would like to switch everything to blades and virtualize it all.”

The Plan

As with any implementation plan, the challenge can be in the details. It is, of course, possible to overrun the capabilities of any single server, blade or otherwise, by not understanding your applications and planning two or more virtual environments with the same or similar usage profiles onto one server. Fortunately, with a little planning this can be avoided.

It is also important to state that not all application environments do well virtualized but may still do well on blades. Specifically, large database applications continue to perform best on their own server. Some companies have moved their large database applications to blades for the technology and management benefits that blades provide but do not use virtualization on that blade. For example, Oracle 10g RAC customers find blades ideal for increased performance as well as space savings.

Before anything else, IT must profile the application environments to determine what the systems requirements are, over the processing life of the application. Some applications have daily, even yearly spikes in activity. Some spikes are not predictable, caused by resource conflicts per server, depending on the environment. With this in mind, choose a set a target for how many environments will run concurrently on the server, depending on the environment.

Migrating from p-Class to c-Class

For users who implemented the HP p-Class BladeSystem chassis previously, and are now implementing a new architecture, it is a good time to migrate to the c-Class. The features of the c-Class BladeSystem and blades are more advanced, in a variety of ways, that of the p-Class, enabling support for more complex machines per blade. However, this will invoke a migration process rather than a simple swap-out upgrade. The advantages of the c-Class infrastructure, which you can expect to leverage over the coming years, are well worth the trouble and HP has services to ease such a transition. If VMware is already running on the p-Class blades and is decided to upgrade to c-Class, there still will be a migration process but it will not include the additional migration from physical servers to virtual servers.

Migrating from physical to virtual (P2V)

Don’t let the job of migrating your environment from the physical to virtual servers be daunting. With a little up-front planning and understanding of the environment, the transition can move quickly.

First of all, one must decide if the VMware ESX Server VMFS will be created on a SAN or on local disks. Today, over 75% of VMware customers use a SAN for the VMFS. If a SAN will be used, verify that the SAN storage and HBAs are supported by checking the VMware SAN Compatibility Guide (http://www.vmware.com/pdf/vsv3_san_guide.pdf) to get the most up-to-date compatibility information, go to the VMware website www.vmware.com and search for “SAN compatibility.”

When an application is moved from a physical server to a virtual server using VMware’s Converter, the application environment including the application data will be moved from the physical server over to the ESX server. In order to apply the changes within the current disk space over to the disk space associated with the VMFS. Because of this, while the application data is being transitioned, twice the amount of storage will be required. The good news is that once the data has been moved for that application environment, the precious storage can be reclaimed and used again.

About the Authors

Anna Samarakoon, advisory analyst with Focus Consulting, has spent nearly 30 years in high-tech fields in various positions, including end user, systems administrator, scientific programmer, NAS software and technology advisor, NAS software engineer, technical sales, marketing, and product management, and industry analyst at HPC International, Sun Microsystems, VMware, IBM, StorageTek, and Enterprise Management Associates (EMA). She is co-author of “Blades Server and Virtualization: Transcending Enterprise Computing While Cutting Costs.”

Barb Goldworm, president of Focus Consulting, has spent thirty years in the computer industry, in various technical, marketing, sales, senior management, and information technology positions with the companies including IBM, Novell, StorageTek, Enterprise Management Associates, and multiple successful startups. A frequent speaker at events, Barb currently chairs the ‘Server Blade Summit Conference’ and is a regular speaker and expert columnist for TechTarget SearchServerVirtualization, having also written regularly for ComputerWorld SoftwareNow, and NetworkWorld. She also co-authored “Blades Servers and Virtualization: Transcending Enterprise Computing While Cutting Costs.”

Focus Consulting (www.focusonsystems.com) is a research, analysis, and consulting firm focused on systems, software, and storage. Focus offers a family of hybrid industry-vendor combining decades of experience in systems, software, storage, data, and management with years of experience in Research and SMR markets. Focus analysts bring expertise from technical, marketing, business, and executive roles; have extensive experience in market research and analysis, and are frequent speakers and educators at industry events. The Focus team brings a comprehensive yet focused view of how to meet demanding business needs in this world of ever changing technology, while keeping an eye on ROI, TCO and bottom line value.

Tip: Planning for server virtualization and blades goes hand-in-hand. When implementation plans call for server virtualization on blades, order blade configurations that will best support the multiple application environments required.
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