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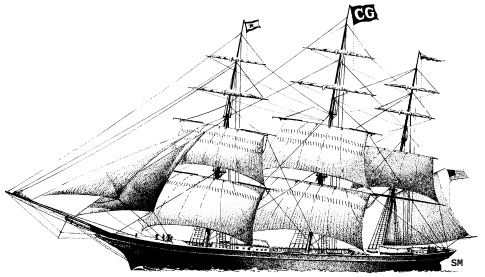

Navigating Information Technology Horizons℠

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The Problem of Application Sprawl — VMware *ESX Server* is a Solution

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Management Summary

The hundreds of small servers that many enterprises have deployed in the course of implementing e-businesses pose an ongoing problem of sprawl. The reasons for tiered environments and for multiple instances of servers have not gone away, but the multitude of their direct and associated environmental costs, servicing and support requirements, and software licensing fees, like the traffic ramifications of suburban sprawl, are compellingly onerous. Co-location gives servicing efficiencies, but is not as efficient as consolidating applications onto fewer servers. Meanwhile, new initiatives to integrate business processes and value chains, and the need for everything just-in-time, are driving a need for improved communication between applications. **Suddenly there are many cumulatively compelling reasons for server consolidation.**

Consolidation spawns issues that may remind you of your first weeks in a large college dormitory. There, the key to survival in a shared dorm room was to isolate what was not to be shared, and to cultivate illusions of separation and isolation with scheduling and headphones, and to pick a particular sink in the vast bathroom to call one's own even though it wasn't.

When enterprise applications are consolidated into similarly close quarters, electronic isolation can be achieved by mapping, masking or multiplexing at many levels. In networked storage, such isolation is done by LUN masking and mapping, so that one application does not write over another application's data. Within that application, a file system's locking mechanisms enforce data integrity by serializing the writes by different application users to a particular file, or part thereof. On mainframes and high-end servers, workload isolation is accomplished by processor partitioning, either physical or logical. This brings us to virtual machines, in which several operating systems share a physical or logical operating space. This is not new: IBM mainframes have run VM (now z/VM) as a hypervisor (supervisor of operating systems) for decades. Each virtual machine is given a "time slice" (think "percentage of available time") in which to run its applications.

Enter VMware, which does the same for Intel processors. **VMware's virtual machine software allows multiple operating systems – each with one or multiple applications – to run on each Intel processor of machines from single processor workstations to 4- and 8-way servers. Their virtual machines not only enable enterprise server consolidation on mid-range and smaller Intel servers, but also do so with measurable and substantial reductions in total cost of ownership (TCO).** For more details, read on.

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The VMware ESX Server

VMware's products were conceived to bring the benefits of the mainframe virtual machine to the Intel environment. Its first product for workstations enabled quick deployment of OS and applications instances in the dynamic and potentially treacherous environment of an academic lab. VMware enabled software developers to run multiple operating systems and instances on a single machine, facilitating the porting of applications to different platforms. By definition, each instance of operating system was isolated on a separate machine.

Last year, VMware launched its *ESX Server* software product for large enterprises, which were eager for something that would allow them to use the mainframe concept of a virtual machine on their Intel platforms. The adoption of VMware products by a variety of large enterprises, and the endorsement of VMware by IBM on its xSeries platforms, signify an acceptance of the need for this product in the enterprise.

The virtualization layer of the ESX Server enables complete server virtualization; that is, the ability to map "shares" of a CPU, memory, I/O buses, network interfaces, storage (adapters and devices) to virtual machines. An envelope isolates the workload, while a virtualization layer allows operations to be executed through the virtual layer on the CPU almost as fast as applications running natively (unconstrained by the envelope). VMware's ESX Server uses the capabilities of the underlying processor hardware for such functions as virtual-to-physical mapping, and therefore incurs significantly less of a performance hit than emulation.

The mapping of the virtual machines on the host server is done without the "knowledge" of the guest operating systems and applications running on the virtual machines. They see the resources they expect, including storage as a disk behind a SCSI controller. There is no need to install drivers or other software within the virtual machine to particularize the application for the host environment.

VMware ESX Server maps virtual machines to the network card on the host server. Each virtual machine may have up to four virtual network cards (and four MAC addresses). In addition, VMware ESX Server can run a VMNet, a private network segment implemented in memory but unconnected to the external network, allowing secure communication between the virtual machines. This allows enterprises to create virtual

Exhibit 1: Beneficial Characteristics

Hardware independence	Once set up, a VMware virtual machine can be run on any Intel machine regardless of the underlying hardware.
Fault Isolation	If one applications operating system should unexpectedly cease to operate, the others do not, nor does the host server.
Instant application capacity on demand, and near instant restore	Achieved by invoking dormant virtual machines. Some applications are moving toward pricing tailored for virtual machines.
Ease of deployment	With VMware's virtual machines, pre-integrated applications and operating system instances can be transmitted to satellite locations for installation, greatly simplifying remote deployment.
Completeness of de-installation	If something on a virtual machine is de-installed from a server, there is no garbage left behind. The envelope, which has contained everything, is gone.

networks in a single box - for instance, a firewall – web server – firewall – application server – database server, all on a single machine. For enterprise processes with a need for tightly integrated, end-to-end functionality, this is a useful feature.

With the recent release of ESX Server 1.5, VMware has added resource management features that enable quality-of-service levels to be enforced for each virtual machine. Administrators can set separate controls for four variables: I/O bandwidth, CPU utilization, RAM, and network access. These resources may be reallocated dynamically, so that even allocated but unused resources do not sit idle. Details of the advanced memory features, CPU allocation alternatives, and I/O management are beyond the scope of this paper. In general, the ESX Server has the ability to dynamically adjust virtual machine shares according to the activity and resource needs of the applications in the virtual machines at that point in time. This allows the server to do much more with its assets. When one virtual machine is temporarily idle, its server assets can be used by other virtual machines on the same processor. The only parameter that is not dynamically adjustable is the network configuration, which requires a reboot.

ESX Server's console authenticates users, implements SNMP alerts and traps, and can host agents from management frameworks, such as IBM's *Director* and HP/Compaq's *Insight Manager*.

Pricing for the new ESX Server 1.5 ranges from $3750/server for a 1-2 processor server, up to $10,000 for an 8-way server.

The Savings

The operational savings an enterprise will get from VMware ESX Server depends on the workloads to be consolidated on a particular server and how synergistic their workloads are, in terms of resource needs and patterns of use. In a VMware TCO study by five of their customers, the greatest savings came from operations (more than 70% in the four enterprises that measured it). Hardware and software savings ran from over 25% to over 50%, and downtime decreased 24%, in the instance where those savings were calculated.

A Reusable Methodology

An ideal scenario for fully using all VMware's load-balancing features would be a data center for global operations (forget latency for a moment), where the virtual machines' activity would bloom and shrink as the sunset circled the globe, evenly using the server cycles 24 hours a day. Actual operations vary from that ideal, but it illustrates the flexibility of virtual machines that will be useful in the emerging world of grids[1]. The ability to provision (and to de-install) operating systems and applications in remote locations securely is what will be needed to outsource workloads for processing on other servers. As one balances virtual machines on a single server by their workload characteristics, one could balance workloads across a grid on an ongoing basis.

Conclusion

VMware's ESX Server virtualization capabilities can help in all Intel environments where servers are under-utilized, and where the workloads are predictable. It is an infrastructure tool that can wring more use out of existing IT assets, and potentially reduce the cost of managing a large number of servers. As a useful tool for server consolidation, it also shows great promise, both for enhancing corporate agility in times of rapid expansion and as a tool to enable utility-style deployment of IT resources in the future.

[1] In grids, organizations can call on an extended environment of servers to process workloads beyond the capabilities of a single organization. Within organizations, the emerging concept of grids offers the opportunity for dynamic allocation of workloads to better use of underutilized assets.

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