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Choosing the Right Hardware for Server Virtualization

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IDC OPINION

Currently, virtualization is one of the most talked about new technologies in IT infrastructure. The ability to virtualize servers and reclaim, up until now, excess capacity has caught the interest of datacenter managers who are facing difficult power and cooling problems, the need to add more IT capacity to react to market changes, or a lack of significant capital resources. The server virtualization marketplace has been evolving rapidly over the past few years, and IDC has seen customer attitudes and stances toward virtualization mature rapidly as well. Virtualization is changing the landscape of the x86 IT world as we know it. Virtualization has made every vendor up and down the software and hardware stacks consider the impact on the architectural design of its product and the go-to-market model it uses. This changing marketplace has manifested itself with new requirements for virtualization products. Broadly, IDC looks at server virtualization platforms as comprising four general components:

- **Virtualization platform.** This includes both the core software and hardware platform. The software is built on the core hypervisor, basic resource controls, and application programming interfaces (APIs). Competitive differentiation includes number of sockets, number of processors in a virtual machine (VM), number of guests supported by the license, and operating system (OS) support. Competitive hardware differentiation includes CPU architecture, number and type of processors supported, chipset features, memory capacity, and hardware enhanced virtualization feature set.

- **Virtual machine management (VMM).** This includes the host-level management as well as management across virtualized servers and datacenters. Today the differentiator between vendors is whether they offer virtualization management, and at what scale.

- **Virtual machine infrastructure (VMI).** These are the value-added features that drive most customer purchasing decisions today and represent the area with the biggest gaps between vendors. They include live migration, automatic restart, and workload balancing of virtual machines across hosts.

- **Virtualization solutions.** These represent the bundling of the aforementioned technologies with some enabling workflows and process automation capabilities to meet specific business needs. These solutions are just now emerging and likely represent an important future competitive front. This category includes solutions such as VDI or disaster recovery.

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Hardware Innovations

Next-generation x86 virtualization will take advantage of hardware assistance being built into processors by chip vendors, in the form of Intel's Virtualization Technology (VT) and AMD's AMD-v CPU virtualization technology.

Neither Intel's VT nor AMD's AMD-v CPU virtualization technology eliminates the requirement for virtual machine technologies from Xen, Microsoft, SWsoft, VMware, or others; rather, these technologies make virtualization enablement robust and easier to accomplish with better performance. The processor vendors accomplish this by changing the relative privilege where the virtual machine software layer is installed, enabling the operating system layers to continue to use the privilege level normally utilized by the operating system.

SITUATION OVERVIEW: VIRTUALIZATION — A MAINSTREAM TECHNOLOGY

Virtualization in computing is a broad term that refers to the abstraction of computer resources. This includes making a single physical resource (such as a server, an operating system, an application, or a storage device) appear to function as multiple logical resources, or it can include making multiple physical resources (such as storage devices or servers) appear as a single logical resource. Early virtualization used in mainframes was primarily used to partition a single large machine/resource into multiple machines running multiple workloads or jobs, as they were frequently called. This was accomplished using both hardware and software implementations that were tightly coupled in a proprietary environment.

Virtualization Moving into the Mainstream on x86 Server Platforms

Software for implementing "virtual machines" (hypervisors) and virtual server infrastructure is technology that is now spreading rapidly on x86 platforms. x86 virtualization is also progressing in terms of use cases, technology, and maturity.

The first phase of customer adoption of virtualization is really a continuation of a trend in the industry that began in 2000. Predominantly, this phase involved IT simplification. Following the economic downturn, customers recognized that there was a need for datacenter consolidation, physical server consolidation, and asset inventory.

Physical server consolidation began to merge with virtualization, and customers began to do legacy rehosting of nonsupported operating environments, like Windows NT4, to get the benefits of the new hardware power that was available to them.

Around 2003, the market began to focus on the technology. About 70% of all deployments in 2003 were really around software development and testing — taking an emerging technology and applying it inside a sandbox of large organizations' test and development labs for consolidation purposes.

Going forward to the end of 2005, IDC saw the spending shift from consolidating the software development and testing environments toward trying to consolidate applications within the production part of the IT infrastructure. The focus was on securely encapsulating multiple applications to drive up utilization and drive down power and cooling expenses.

In 2006, production-level consolidation was a primary motivator for people to deploy virtualization within their organizations. IDC is beginning to see other motivations emerge, such as planned migrations taking advantage of technology like VMware's VMotion that allows the user to "VMotion" (migrate) a live, running application off of a physical host and onto another host to upgrade or address problems in the hardware and then "VMotion" it back. Depending on whose statistics you read, a large percentage of downtime, up to 80%, is associated with planned migration. Because of the large percentage of downtime associated with planned outages, IDC believes this live migration capability can really begin to impact the availability of a customer's applications.

In some cases, traditional high-availability software will be adapted to protect workloads in the virtualized IT infrastructure. And in some cases, fault-tolerant server hardware will be used to prevent hardware failures in cases where enterprise workloads or mission-critical workloads move to a virtualized IT infrastructure. IDC expects that high availability will move up in importance on the priorities list for virtualized server deployments in 2008.

The combination of multicore processors and virtualization is making it possible to consolidate workloads that have been running on underutilized servers. As we go forward, we will continue to see a diversification in the types of reasons why customers deploy virtualization software — whether it is around planned migrations or business-level, mission-critical high availability. The next phase of customer adoption will likely be centered on the concept of automation, or a utility computing environment whereby services are delivered based on policies and are moved from a fixed-cost model to a variable-cost model within the organization. While the first phase of virtualization was focused on capex, the whole next phase of virtualization will be focused on operational cost reduction.

The Benefits of Server Virtualization

Virtualization is helping companies save money using information infrastructures to better deliver services. Some of the benefits seen with virtualization are:

- The ability to rapidly save, copy, and provision a virtual machine that enables zero-downtime maintenance and supports new "go live" initiatives
- A dynamic sharing of idle resources across server platforms, resulting in improved performance and use while eliminating stovepipes
- Higher technology standardization and currency (up-to-date systems), resulting in lower operations and maintenance costs

- Seamless failover when a virtual server component fails, resulting in higher system availability
- Reduced complexity, resulting in improved logical and physical disaster recovery

Server Virtualization Usage and Adoption

More than 50% of today's virtual servers support production workloads, and 60% of all VM spending is for business processing and decision support workloads.

IDC forecasts that by 2010, customer spending on server virtualization will amount to some $20 billion, a 68% increase over five years.

Virtualization Platform Requirements

The platform requirements for virtualization in support of multiple applications in the business environment involve a mix of software and hardware considerations.

Software Requirements for Server Virtualization

In terms of the core virtualization platform, today there are more similarities between all of the software vendors than differences. All have the ability to manage CPU, memory, network, and disk resources. All have (or will soon have) support for up to 16 processor cores in a host, which covers the vast majority of x86 systems. All support both Windows and Linux operating environments.

The three intangibles that can differentiate the virtualization software offerings are channel to market, performance, and reliability. By including virtualization in the OS, the operating system vendors have had, until recently, an easier route to market because customers are/would be getting virtualization capabilities "free" with the purchase of the base OS. As of late, this advantage has been diminished as the hypervisor vendors have gone directly to the server OEMs to integrate virtualization directly with the hardware.

With this virtualization model customers can partition the server into an unlimited number of virtual machines and, more important, get this capability at a much lower price than if they were to purchase a standalone hypervisor.

Of the remaining two intangibles, IDC believes reliability matters most and will be a major driver of customer purchase decisions for some time to come (see *The Battle for the Hypervisor*, IDC #lcUS20612507, March 2007). In effect, by virtualizing their servers, customers are making a greater percentage of their datacenters "mission critical." Here incumbents such as VMware have the advantage of time. They have been in the market the longest and have a strong installed base that is vocal about the reliability of the company's platform. The other vendors are still very much demonstrating the robustness of their platforms and are challenged to create the early customer buzz to get the word out and influence others. In terms of the hypervisor platform, the differences between all of the instantiations of the technology are rapidly diminishing, and what matters more than the "speeds and feeds" are reliability, performance, ease of acquisition, and ease of deployment. This is why IDC believes there is a coming battle for real estate in the virtualization market.

Hardware Requirements for Server Virtualization

While the purpose of virtualization software is to effectively divide and use the hardware to run multiple applications and increase the usage of the computing resources, it is limited to the capabilities of the system or systems on which it is running. Looking at the major components the virtualization software controls — CPU, memory, network, and disk resources — it becomes easy to see the importance of having the right balance of resources.

As system loads increase from between 5% and 20% to between 40% and 50% or more, there is an equal or greater demand for balanced systems with higher levels of CPU performance, increased memory capacity and speeds, expanded I/O capabilities, sufficient network bandwidth, and accessibility to adequate storage resources. IDC is seeing customers virtualize while moving to new servers that contain these attributes. Virtualization not only increases the workload but also segments the workload into multiple pieces that increase the demand for more resources running at the same time.

Choosing the Right Hardware Platform

Choosing the right hardware platform for server virtualization is just as important as choosing the right virtualization software. To make the proper choice, one must consider the following:

- **Performance.** Increased workloads require more system performance to maintain desired service levels and application response times. More performance and throughput can be achieved by using new processor architectures with multiple cores per processor and systems designed to utilize this additional performance and functionality. In addition to the increase in performance needed to run more workloads in native mode is the added resource requirement for running the VMs. The hardware assist features in processors and chipsets play a key role in minimizing this overhead.

- **Energy efficiency and space.** Power and cooling are most understood when cost or physical constraints affect an end user's ability to function normally; for example, when costs exceed budget or power requirements exceed available resources. Floor space can be a huge issue when an expanding IT footprint results in building out datacenter or IT space. Virtualization and consolidation help reduce hardware footprint and energy utilization. More energy-efficient systems further reduce power requirements, both saving power and lowering operating costs. Systems with reduced power requirements and or higher performance per watt aid IT in controlling energy and space requirements.

- **TCO/ROI.** Since the mass adoption of x86 servers, systems management costs have grown significantly. The increasing operating costs have resulted in diverting resources and capital from initiatives aimed at driving innovation and increasing the value of IT. Using a virtualized environment has the potential to increase system utilization, lower power and cooling requirements, decrease space requirements, and simplify operations, reducing system management requirements.

- **Optimized platform features.** Component and systems vendors are increasingly adding features that are optimized for virtualization. For example, both Intel and AMD have added virtualization capabilities to their processors. These capabilities both ease the design of robust virtualization software and reduce the performance overhead typically seen by applications running in a virtualized environment.

- **Industry collaboration.** Virtualization on x86 is best characterized by looking at the industrywide collaboration that has occurred. Because virtualization involves multiple levels of hardware and software, hardware component and systems vendors, operating system and application vendors, and virtualization vendors have collaborated to create first working solutions. Now the industry players are optimizing for virtualization on their new platforms.

- **Compatibility.** Maintaining compatibility across platform generations is a key attribute for future systems. Moving VMs from one server to another requires architectural considerations so that IT does not create islands of virtual resources but actually maximizes flexibility within its infrastructure.

FUTURE OUTLOOK: x86 PLATFORMS AND VIRTUALIZATION ADOPTION

Virtualization brings a set of capabilities to the x86 platform that were originally developed in mainframes and then added to RISC-based machines. These capabilities have now become available on mainstream servers.

The worldwide server market has undergone significant technology shifts over the past two years, which have led to marked changes in customer buying behavior. During this time, both multicore technology and server virtualization capabilities were introduced to the x86 server segment, and they are now well established in IT organizations in the United States and throughout the rest of the world.

Impact of Virtualization and Multicore

Each of these technologies is impactful to the market in their own right. However, the use of multicore technology in conjunction with server virtualization tools has a compounding impact on server configurations and accelerates the ability of IT organizations to exploit the benefits of multicore technology.

- The introduction of multicore processing and virtualization into the x86 server segment will significantly disrupt the worldwide server industry. Multicore will increase the effective processing capacity in the market through relatively fewer systems.

- Virtualization enables customers to raise system utilization rates, consolidating servers within their IT infrastructures. Based on IDC's 2007 virtualization study, overall x86 utilization, recorded at 35% before virtualization, is currently at 52% with virtualization. The planned increase with virtualization will take utilization to 61% over the next two years. This projection is in line with growth prospects for virtualized servers.

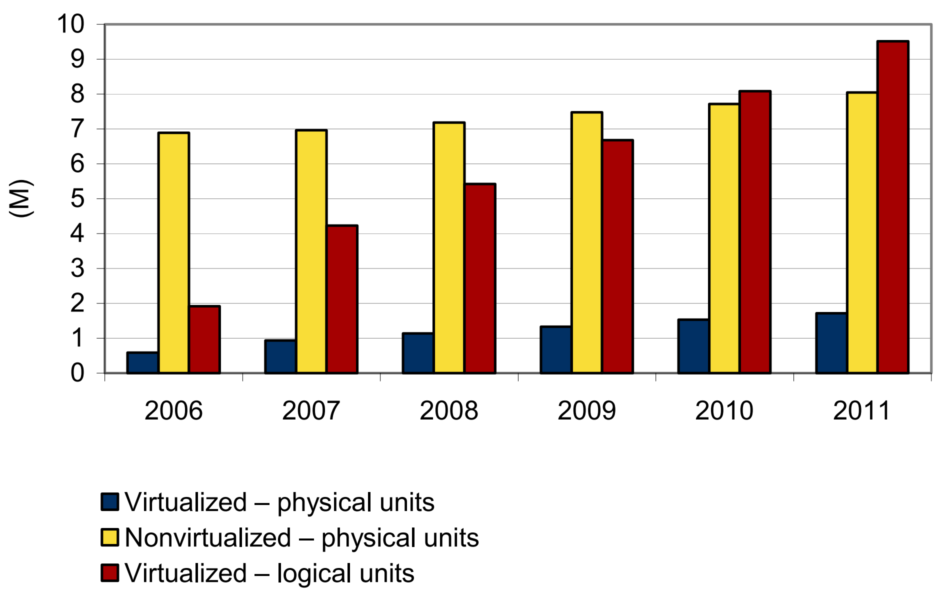
- Customers are buying richer configurations in servers with quadcore processors and when virtualizing. This includes more memory, I/O, and storage.

- While most customers are using virtual machines as part of their production and test environments, more than half use VMs as part of their high-availability strategies and another 47% are using VMs in their disaster recovery environments.

Figure 1 shows the rapid growth of both virtualized servers and logical server units. The share of physical virtualized servers is projected to grow from 8% in 2006 to 18% in 2011. The share of virtualized logical units will increase from 22% of total logical units in 2006 at a 38% CAGR to reach 54% in 2011. This compares with a projected CAGR of 6% for physical server units. The number of logical servers generated on virtualized servers will surpass the number of nonvirtualized physical server units in 2010.

FIGURE 1

Virtualized Versus Nonvirtualized Servers Installed Base Forecast, 2006–2011

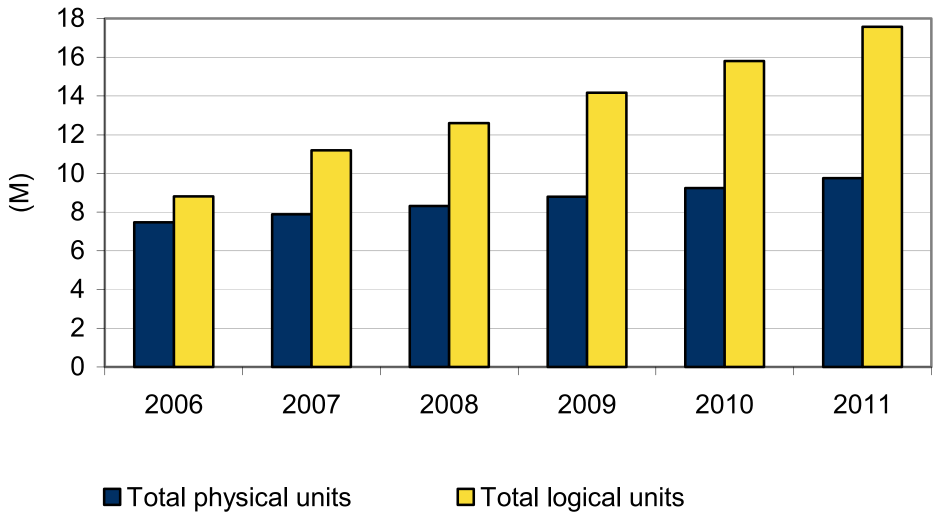


Source: IDC, 2007

Figure 2 compares the projected growth of total physical server units with the projected growth of total logical server units. Physical servers are expected to increase at a 6% CAGR from 2006 to 2011, and logical servers are expected to increase at a 15% CAGR.

FIGURE 2

Physical Server Versus Logical Server Installed Base Forecast, 2006–2011



Source: IDC, 2007

PLATFORM CHOICE: SYSTEM SCALING FOR VIRTUALIZATION AND INCREASED UTILIZATION

IDC conducts ongoing research to look at how systems have been deployed. IDC has seen virtualization drive more robust systems, increasing the number of processors and the amount of memory, I/O, and disk capacity.

IDC believes this change is driven by the higher workload activity running on each system. This generally occurs through consolidation of multiple applications or increasing individual application workloads. For example, a system that was running at 10% of capacity may have been upgraded to run at 50% of capacity. Maintaining a balanced system with adequate resources may require additional processors, memory, I/O, and disk storage capacity. The increase may occur in only one of the mentioned areas, or it may occur in several or all of the areas.

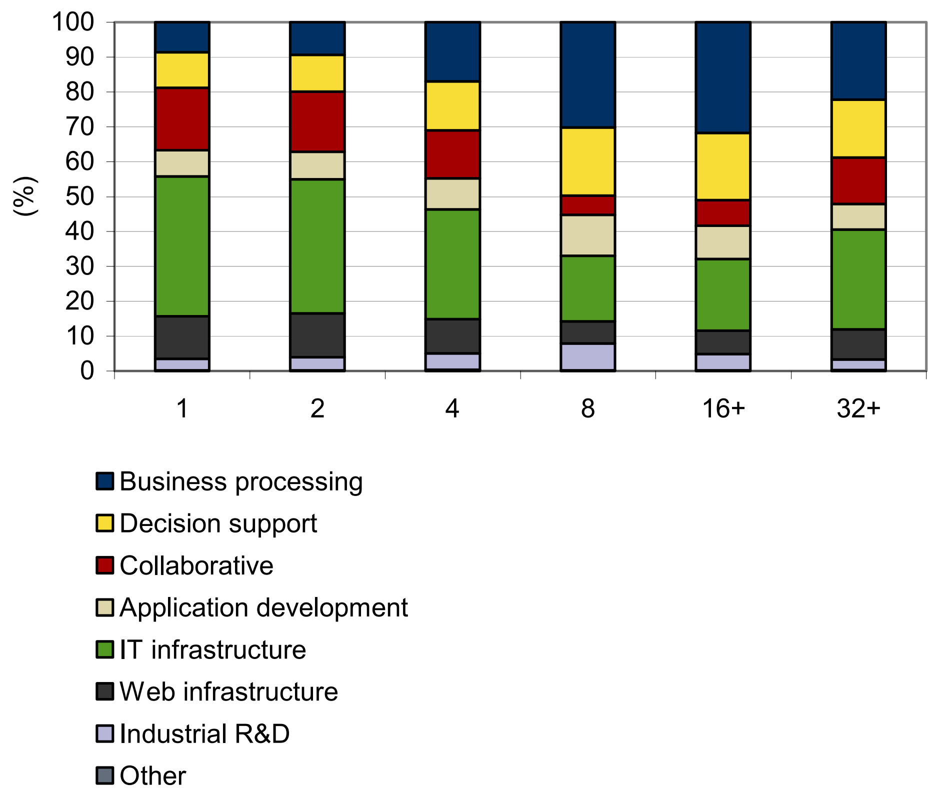
The change is also driven by increased compute capability provided by multicore processors and the need to add more memory to fully utilize this added compute resource. Virtualization becomes a key tool on the software side to leverage this added capability as well.

In short IDC is seeing end users buy more fully configured systems to balance the amount of work that can be done and efficiently utilize the systems' capabilities. Virtualization has become a major tool to maximize the utilization of these resources. It is also driving the purchase of larger systems, even with new, more powerful systems coming on the market.

System size and configuration are driven by the size, type, and number of workloads running on a system or set of systems (see Figure 3).

FIGURE 3

Server Shipment Share by Number of Sockets and by Workload, 2006



Source: IDC, 2007

Systems with four or more sockets have a higher percentage of business processing and decision support workloads than one- and two-socket systems. More than 50% of today's virtual servers support production workloads, and 60% of all VM spending is for business processing and decision support workloads. Virtualization tends to drive larger systems with richer configurations, and these workloads generally run on larger systems.

SERVER VIRTUALIZATION USAGE TODAY

For much of the industry, the most exciting story around virtualization software has been mostly focused on server consolidation and reducing physical footprints and the resulting hardware acquisition cost reductions, resulting in lower power and cooling costs.

Current Server Virtualization Trends

During 2008, watch for customers to begin leveling their virtualization road maps from a relatively simplistic technology play to a more comprehensive and longer-term end-to-end adoption road map that will impact servers, clients, storage, and even network architectures over the next decade. Simply stated, virtualization begins a process that will extend this technology phenomenon far beyond its current general role as a tool for server consolidation.

Among the bigger-picture benefits CIOs and IT managers will demand are an integrated approach to business continuity, fault-resistant (and -tolerant) and high-availability architecture designs, a reduction in unplanned downtime, and vastly increased business agility that allows companies to become better able to address emerging market opportunities and to do so more quickly than less agile competitors.

Live migration, or the ability to move virtual servers to alternate computing resources while running, was popularized by VMware with its VMotion product. Used most often for planned downtime scenarios, applying upgrades and security patches, or repairing the physical server on which the VM resides, live migration is being embraced by customers as a useful and important element of improving high availability for their virtualized x86 environments. IDC believes that live migration will be further improved over time by the reduction in any "gap" in processing time so that workloads will be moved from resource to resource in a seamless way, with no perceptible interruption for end users accessing the migrating virtual machine.

Virtualized Platform Characteristics: A Review of Intel Features

The software on x86 platforms generally runs regardless of system size, so the focus here is on some differing capabilities in the hardware system.

Size matters — larger systems run larger workloads and/or more VMs. This gives IT not only the ability to run larger and more workloads but also more flexibility to manage its systems to meet changing needs and scalability.

Hardware is being optimized to run virtualization better and provide more control and easier management of VMs and workloads. Some examples of the features added by Intel that reduce software overhead and/or simplify virtualization software are:

- **VT-x.** Baseline virtualization capability in the processor simplifies software and enables mixed 32- and 64-bit operating environments
- **FlexMigration.** Eases migration between multigenerational platforms
- **FlexPriority.** Interrupt virtualization (reduces interrupt overhead)
- **VT-d.** I/O virtualization (reliability and protection through device isolation and performance through direct assignment of devices thereby reducing the I/O overheads in the VMM)
- **VMDq.** Optimization in the NIC to improve LAN performance in a virtualized environment (reduces hypervisor overhead associated with network processing)
- **I/O Acceleration Technology (IOAT).** Hardware assists in the NIC and chipset that improve the processing of data in TCP-IP or iSCSI stack/protocol and offload the CPU, making more cycles available for more guest OSs
- **Extended Page Tables (EPT).** Memory/page table virtualization (reduces memory/page table overhead) (EPT is not currently available on any shipping processors but will be available later in 2008.)
- **Virtual Processor ID (VPID).** Ability to assign a VM ID to tag CPU hardware structures (e.g., TLBs); can help avoid complete TLB flushes on VM transitions to give a lower-cost VM transition time (VPID is not currently available on any shipping processors but will be available later in 2008.)
- **CPU architecture enhancements.**
  - Core architecture: four instructions per cycle versus three (in prior generations)
  - Core architecture: Smart Cache — larger cache and prefetching
  - 45nm high-k: faster entry/exit times for virtualization (25–75%)
  - Next-generation 45nm: hardware-assisted page tables, VT-d, etc.

The key to these added features is a platform that runs virtualized workloads close to the speed of native workloads running on the machine. In short, these features are designed to eliminate overhead and increase efficiency.

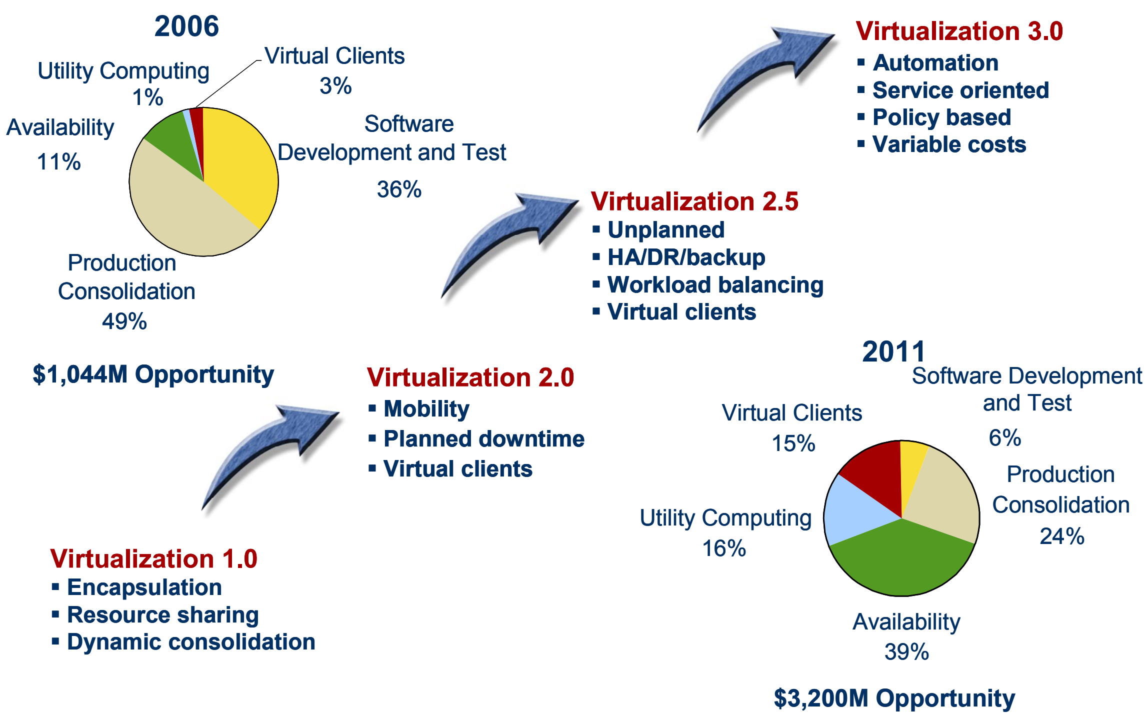
The addition of these features, combined with new Xeon 7300 quadcore processors, has allowed Intel to produce numbers on virtualization benchmarks that show current generation systems outperforming the Xeon 7100 dual-core processors by more than 150%. From another perspective, a four-socket system will support 2.5 times the number of VMs that a two-socket system can support. This illustrates the scalability gained by a four-socket system.

The Future of Virtualization

As the market moves toward Virtualization 2.5 and 3.0 (see Figure 4), higher-level capabilities such as high availability, disaster recover, workload balancing, and automation are gaining more attention. IDC is seeing more companies move into or at least toward 3.0 capabilities and requirements. The previously mentioned hardware capabilities are becoming a baseline requirement.

FIGURE 4

Virtualization Milestones



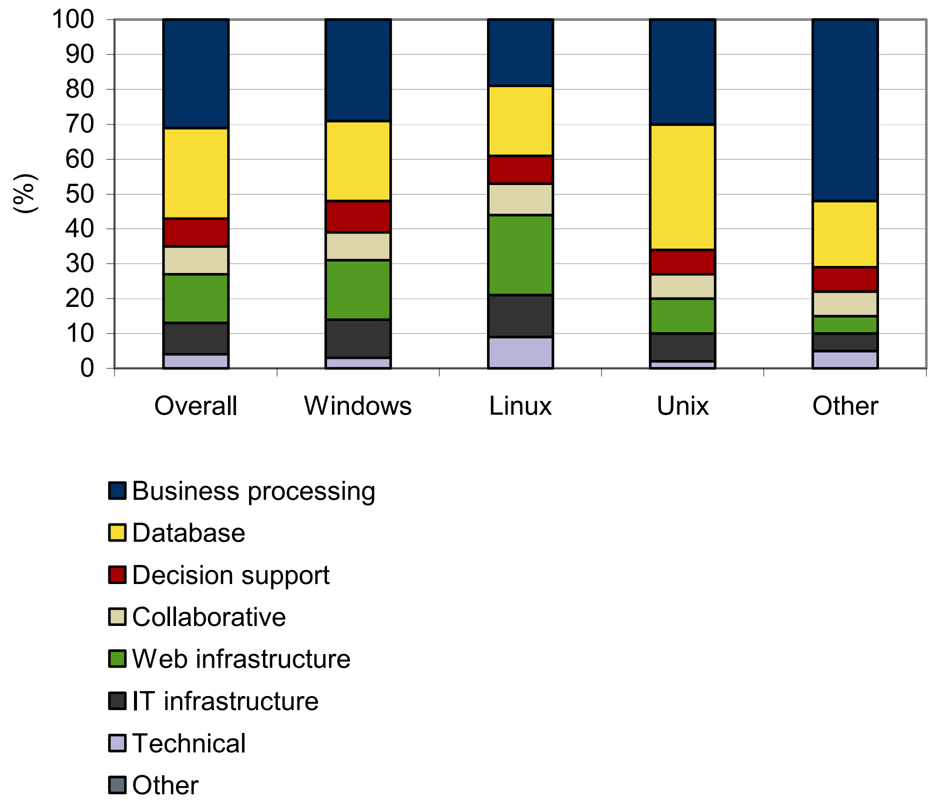
Source: IDC, 2007

WORKLOADS THAT BENEFIT FROM VIRTUALIZATION

In IDC's annual survey of end users regarding workloads, virtualization was used to support all workload segments. Interestingly, server virtualization is primarily used to support the most important applications — business processing, database, and decision support. More than half of all virtualized servers are deployed in support of these applications (see Figure 5). This number increases for Unix and other platforms. Web applications are more likely to be virtualized on Linux platforms relative to other operating environments.

FIGURE 5

Server Workloads by Operating Environment, 2006



Source: IDC, 2007

CHALLENGES/OPPORTUNITIES

While virtualization is now considered a mainstream technology in servers, it is still a mystery to many IT shops. This is slowing down adoption, especially in the midmarket. Intel, VMware, and others engaged in the market still need to educate end users and provide guidance on adoption strategies.

The mix of workloads and the usage model for running those applications are different for every IT shop. Standardizing environments and operations is on most IT leaders' lists. This is both an opportunity and a challenge. It is a challenge to create a working plan and execute on that plan. It is an opportunity to increase the market for x86-based systems as a foundation for standardization in virtualized environments.

Virtualization is still a hot topic and a growing market where leadership platforms are valued. Virtualization is accelerating purchases and driving transitions to newer systems. Intel needs to continue educating the market on its capability and ability to lead with innovations that will help to enhance the market.

CONCLUSION

Virtualization technology is on a roll, driven by adoption on x86-based servers. Today VMware has a leading software product that is being chased by a number of other vendors. While the software market is heating up, hardware vendors are leveraging that momentum and creating platforms that are optimized for virtualization.

IT shops are the beneficiary of this rapid change and increase in functionality and performance. This market change occurred at the same time that multicore processors arrived, creating even more need and opportunity for server virtualization solutions. In addition, the rapid buildup of x86-based systems in the datacenter over the past decade created a need to drive more efficient use of systems and a need to control energy and space consumption.

Intel has responded to market requirements and has delivered a breadth of multicore processors, chipsets, and other platform technologies that are designed to meet the unique and challenging needs of virtualization. The multicore processors provide the necessary performance and flexibility desired by IT. Other Intel technologies address the need for better control over memory and I/O when running multiple VMs, network optimization, and so forth. All of this adds up to systems optimized for the increased workload caused by virtualization. Also worth noting is the excellent scaling in four-socket Intel systems, compared with that of two-socket systems, when running multiple VMs that will be of interest to IT shops looking for scalability and flexibility in their datacenters.

