



Twenty-to-One Consolidation on Intel® Architecture

New Tools for Virtualization and Workload Management

Intel® architecture is challenging high-end RISC systems by enabling substantial application consolidation on affordable, industry-standard servers. The combination of IBM Enterprise X-Architecture* and VMware ESX Server*, for example, enables 20 or more operating systems and application stacks to be consolidated onto a single 8-way server—without the cost and complexity of software migration and proprietary server technologies.

Table of Contents

Executive Summary	3
Application Consolidation on Intel Architecture	4
IBM Enterprise X-Architecture— Mainframe-Inspired Technologies	5
VMware ESX Server—Logical Partitioning	6
The IBM and VMware Partnership	7
Complementary Tools for Consolidation	8
Automatic Resource Management	8
System and Lifecycle Management	9
Processing Power for Consolidated Workloads	11
Rapid Advances on Intel Architecture	12
Conclusion	13

“Intel® servers now are acquiring all of the features of high-end RISC systems and, in some cases, leading their competitors.”

Giga Information Group
Strategic Platforms—The Tipping Point
Richard Fichera, 9/3/02

Executive Summary

Consolidating multiple operating systems and applications stacks onto a single platform is one of the most challenging consolidation strategies available to the enterprise IT manager. When properly implemented, it can deliver substantial benefits, yet the costs and risks can be high—especially when it involves the expense and complexity of a migration onto a mainframe or other proprietary platform.

Intel® architecture now offers an affordable alternative for application consolidation in the middle-tier of the enterprise data center. Using VMware ESX Server*, 20 or more operating systems with associated application stacks can be hosted on an 8-way platform, and higher consolidation ratios can be achieved on 16-way or larger platforms. No software migration is required. Existing applications can be encapsulated without modification in virtual machines for security and fault isolation, and platform resources can be dynamically allocated to optimize performance and uptime based on specific business priorities.

VMware ESX Server can run on any Intel® processor-based platform. Many enterprise customers are choosing servers based on the IBM Enterprise X-Architecture* design because of the high levels of availability and scalability they offer for running consolidated applications. Together, VMware ESX Server and IBM Enterprise X-Architecture provide virtualization and workload management capabilities that are comparable with today's leading RISC-based offerings. As a result, IT organizations have affordable new options for consolidating applications, optimizing resource utilization and reducing total cost of ownership.

This paper discusses the VMware and IBM solution. It also describes several compatible products that can be used to support or extend the consolidated environment. Of course, these solutions are just the tip of the iceberg. Intel has invested over \$20 billion in enterprise computing technologies in the last two years, a rate of investment that continues to fuel unparalleled innovation. With these developments, the performance and functionality of Intel architecture will continue to advance rapidly, providing better solutions and increasing value for enterprise customers.

Consolidation: The Big Picture

Though application consolidation can deliver significant benefits, businesses should look closely at all their options, and choose those that deliver the greatest return on investment with the least risk. In general, the following options should be considered in the order listed¹.

1. **Centralization**—Moving distributed servers into centralized data centers.
2. **Data/Storage Consolidation**—Consolidating data onto large, centralized databases and storage devices.
3. **Physical Consolidation**—Consolidating servers that run the same operating system and application onto larger systems.
4. **Application Consolidation**—Consolidating diverse applications and operating systems onto large, partitioned servers or mainframes.

Unquestionably, application consolidation is the most complex consolidation strategy. Multiple applications on a single platform raise the possibility of software incompatibilities and resource contention. In addition, most of today's applications are not designed to scale well across more than two or four processors. As reported by the Giga Information Group, *"...it is very difficult to write code that is efficiently multithreaded to take advantage of more than two to four CPUs, a fact reflected by the diminishing returns seen by many applications as they are run on large SMPs²."*

Despite these challenges, it is still possible to realize significant ROI through a well-planned consolidation of applications. The use of an Intel architecture-based solution can add to the benefits by lowering upfront costs, simplifying application migration and reducing the reliance on proprietary technologies and specialized skill sets.

¹ For more information on these consolidation strategies, see the Intel white paper, Strategic Consolidation on Intel® Architecture-based Servers, available on the Intel Web site.

² Giga Information Group, The Future of the Data Center—Modularity and Virtualization, Richard Fichera, 5/8/02

Application Consolidation on Intel® Architecture

IBM is playing a major role in adapting mainframe technologies for implementation on industry-standard Intel® architecture-based servers. The IBM Enterprise X-Architecture is an integrated set of technologies that enables high-end scalability, flexibility, availability and manageability using industry-standard processors, memory and I/O. Among its advantages, Enterprise X-Architecture supports flexible physical partitioning, which empowers administrators to run multiple operating systems and application stacks on a single platform.

While IBM was developing Enterprise X-Architecture, VMware was working on a complementary technology—logical partitioning with dynamic resource allocation. Using VMware's ESX Server, IT organizations can now partition any Intel architecture-based server into multiple virtual

machines. Each virtual machine can run a separate operating system and application stack, and is fully isolated for security and fault containment. A security problem or OS failure on one virtual machine will not impact operations on any other virtual machine on the platform. IT administrators can also allocate platform resources among the virtual machines with considerable flexibility and granularity. In essence, they can carve up a single platform to match specific workload requirements for dozens of individual applications, while ensuring that critical business tasks receive top priority during peak demand.

In combination, VMware's ESX Server and IBM's Enterprise X-Architecture introduce new opportunities for consolidating mid-tier applications. Twenty or more applications can be hosted on a single 8-way or 16-way system, and hardware and software can be scaled as needs expand (Figure 1). Of course, the number of virtual machines per platform will vary depending on workloads.

Consolidating the Data Center

Non-Consolidated, 200+ Physical Servers

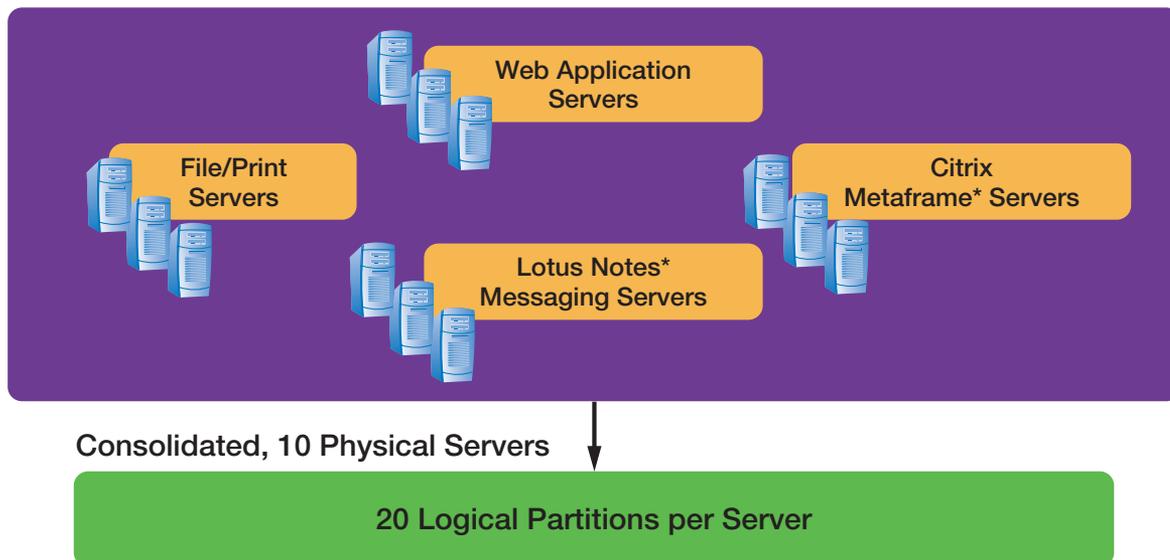


Figure 1. The combination of VMware's ESX Server* and IBM's Enterprise X-Architecture* offers flexible, cost-effective new options for application consolidation and workload management.

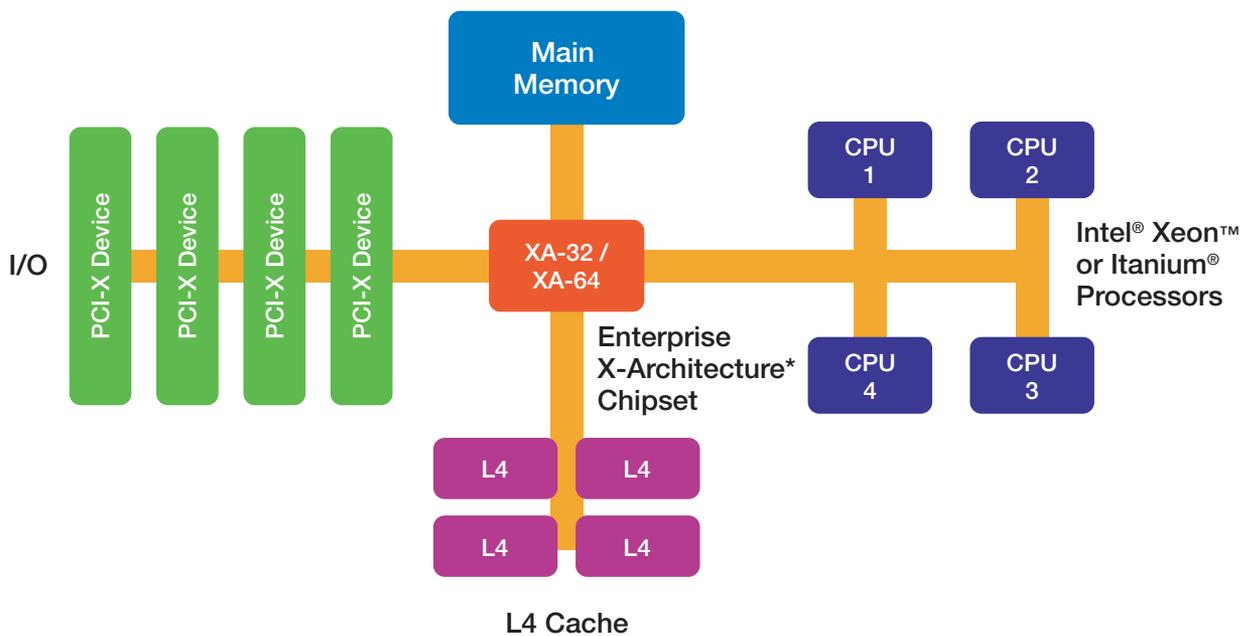


Figure 2. The IBM Enterprise X-Architecture* delivers high-end performance, scalability and availability using Intel® Xeon™ and Intel® Itanium® 2 processors, along with industry-standard memory, I/O and storage components.

IBM Enterprise X-Architecture— Mainframe-Inspired Technologies

*"We know our customers like Intel® processor-based servers, but need the expanded capabilities of a mainframe. The new IBM Enterprise X-Architecture servers have the capabilities at price points they are looking for with the ability to scale as needed. That's going to be hard to beat."*³

Michael Schmitt
Executive Vice President of Marketing
Ariba

The IBM x440⁴ is the flagship product of the xSeries server line and the standard bearer for IBM's Enterprise X-Architecture strategy. It scales from two to 16 Intel® processors, using dense 4-way expansion modules that communicate via high-speed bus-to-bus interconnects. Each expansion module adds processors, memory, high-speed cache and I/O, which helps to eliminate platform bottlenecks as processing power increases. The entire system requires only 4U of rack space in an 8-way configuration (8U in a 16-way configuration).

The IBM Enterprise X-Architecture chipset supplies the glue for this solution, enabling scalable, balanced performance using industry-standard processors, memory, storage and I/O components (Figure 2). Two versions of the chipset are available: the XA-32* chipset supports the Intel® Xeon™ processor MP, while the XA-64* chipset supports the Intel® Itanium® 2 processor. Approximately 80 percent of the internal circuitry is the same for the two chipsets, an important factor which will help to ensure parallel development for rapid and consistent innovation across both platforms.

The modular design and high-speed interconnects of the x440 enable flexible hardware partitioning and cluster configurations. For example, an x440 system can be scaled in building block fashion to create various combinations of 4-way and 8-way servers, a 12-way and a 4-way, or a single 16-way platform. Each partition can be used independently, or clustered with other partitions to support load-balancing and fail-over for business-critical applications. I/O can also be scaled easily outside the box by adding a remote I/O expansion unit. This feature has allowed IBM to maintain high rack densities while tripling the available I/O capacity for the platform⁵.

³Quoted from the IBM xSeries 440 Product Guide, available on the IBM Web site.

⁴For more information about the xSeries 440, visit the IBM x440 Web site and download the x440 Product Guide.

⁵IBM Enterprise X-Architecture technology currently supports Active™ PCI-X* and Remote I/O with the IBM RXE-100 Remote Expansion Enclosure.

The x440 offers exceptional RAS features, including its highly resilient Active Memory* subsystem, which supports IBM's Chipkill* memory, Memory ProteXion*, and high-availability memory mirroring capabilities. Other features include built-in Light Path Diagnostics*, software rejuvenation, and Predictive Failure Analysis*. The system is also built for efficient servicing, with tool-free access and redundant, hot-swap power supplies, cooling fans and I/O.

Performance, uptime and manageability are further enhanced by IBM Director. This suite of systems management tools has been optimized and extended for the IBM Enterprise X-Architecture. It helps IT administrators configure, monitor and troubleshoot system operations, and run many essential maintenance tasks without interrupting production operations.

VMware ESX Server—Logical Partitioning

VMware's ESX Server includes a small kernel that runs directly on the server hardware, plus a browser-based interface for managing virtual machines and hardware resources (Figure 3). ESX Server typically supports from one to eight virtual machines per CPU on 4-way, 8-way and 16-way servers, with a current maximum of 64 virtual machines per server.

Each operating system and application stack is fully isolated within its own virtual machine. This isolation is essential for security and availability in a multiple application environment. It enables diverse operating systems (Microsoft Windows*, Linux*, etc.) as well as different versions of the same operating system, to be hosted on a single platform. This solves the traditional problems of application incompatibility and resource contention. It also allows applications that do not scale well across multiple processors to run efficiently on a large SMP platform.

Multiple virtual machines can be assigned to each physical CPU, and reassigned as needed to balance workloads. Currently, a virtual machine cannot utilize more than one CPU at a time. However, support for dual-processor virtual machines is expected in 2003, with larger SMP support to come in the future. In the meantime, ESX Server is ideal for consolidating multiple, heterogeneous applications that are currently running on smaller, underutilized machines. For many businesses, this accounts for a large percentage of their total software environment.

Key benefits of VMware ESX Server include:

- **Twenty-to-one server consolidation (typical)**—Especially suitable for relatively small applications that do not scale well across multiple processors.
- **Faster application deployment**—A virtual machine can be configured in about an hour, versus about eight hours for a physical server.
- **Better resource utilization**—VMware supports both static and dynamic allocation of processor, memory and I/O per virtual machine.
- **Simplified management**—The combination of software encapsulation, browser-based management and application consolidation can substantially simplify the computing environment.
- **Improved flexibility/scalability**—Virtual machines can be added as needed to take advantage of hardware capacity. They can also be clustered for load-balancing and automatic fail-over.
- **More efficient development environment**—Virtual machines make it easy to run multiple software iterations, including the production version, on the same machine.

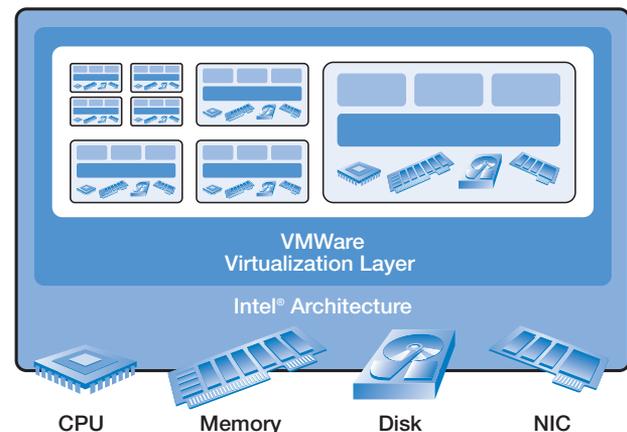


Figure 3. VMware's ESX Server* creates virtual machines that enable multiple operating systems and application stacks to run efficiently, reliably and securely on a single, Intel® architecture-based server.

The IBM and VMware Partnership

Recognizing the strong potential for consolidating applications using ESX Server on the x440, IBM and VMware have formed a partnership to certify and optimize performance, coordinate product development, and provide customers with unified support for the combined platform. IBM is currently a reseller of ESX Server and offers full support for Microsoft Windows, Red Hat Linux*, SuSE Linux and VMware ESX Server running together on the x440, x360, x255 and x330 platforms⁶.

As Enterprise X-Architecture expands to include more features and larger SMP platforms, and as VMware evolves to support multiple CPUs per virtual machine, the scalability and flexibility of the platform will make it increasingly well-suited for consolidating a wide variety of enterprise applications. Currently, the best applications for consolidation on the x440 running ESX Server include (Figure 4):

- Web and application services, such as Microsoft Internet Information Services (IIS), Apache, Lotus* Domino, xAllaire* ColdFusion* and BEA WebLogic* Application Server
- Remote Session Access solutions, such as Citrix MetaFrame and Windows Terminal Services
- File and print
- Lotus Notes*
- Visual Basic
- Financial (CRM) applications
- Imaging servers
- Network Services, such as Microsoft Active Directory, iPlanet Directory Server, DHCP and DNS
- Small databases
- Custom developed applications
- Any applications currently running on small, underutilized servers
- Development environments (test and production versions can be run side-by-side)

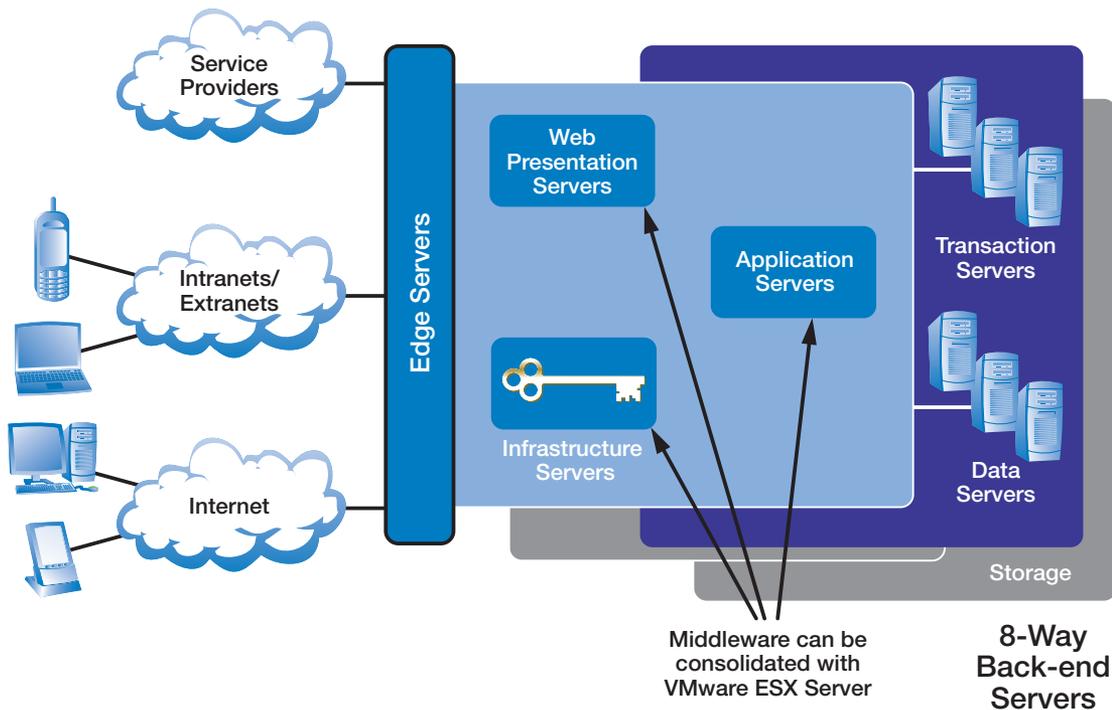


Figure 4. VMware* software running on Intel® processor-based servers is currently best suited for middle-tier applications. Larger platforms and support for multi-CPU virtual machines will soon extend its utility into the back-end of the enterprise datacenter.

⁶ Microsoft also supports issues that arise in the Windows OS when it is running on top of ESX Server, as long as it is determined that those issues can be reproduced outside of the virtual machine environment. (Source: Microsoft Knowledge Base Article—273508; available on the Microsoft Web site.)

Consolidation in Action: Gap, Inc.

- **Applications:** BEA WebLogic*, Microsoft IIS*, Tivoli*, Lotus Notes* (and many others, including custom applications and business objects)
- **Consolidation Ratio:** Better than 30:1
- **Key benefit:** Nearly \$2M savings over three years, with better than 40 percent ROI

For several years, rapid business growth at Gap, Inc. was accompanied by rapid growth in its Intel processor-based server infrastructure. The company began in 1999 with only 50 servers; by 2002 it had 450. Average utilization was only 5 percent and the maintenance costs were set to quadruple for each server as its life cycle passed the three-year mark.

In conjunction with Intel® Solution Services, Gap, Inc. worked out a consolidation strategy using VMware ESX Server running on IBM x440 platforms. Tests were performed using workloads that closely modeled the resource consumption of Gap's real-world applications. It was determined that more than 30 virtual machines could be configured in each server, without exceeding 60 percent utilization. Using this approach, Gap will greatly reduce its server count, while retaining plenty of headroom for continued growth and unanticipated loads. It will also lower its total cost of ownership by nearly 50 percent, by reducing management costs and freeing existing staff for other IT initiatives.

Complementary Tools for Consolidation

A wide variety of third-party solutions are already available to extend the value of ESX Server running on Intel processor-based servers, and to provide comparable consolidation opportunities for different application environments. The following are two of the most important categories.

Automatic Resource Management

Automatic Resource Management (ARM) is similar to the dynamic resource allocation made possible by VMware ESX Server, yet different in a critical respect. ESX Server partitions a platform to run multiple OS images. ARM applications, on the other hand, dynamically allocate hardware resources among multiple applications running on a single OS image.

For the most part, these two approaches furnish very similar advantages—but for different software environments. Virtual machines are best suited for general-purpose

consolidation, especially for small applications and for applications that are not designed to run as multiple images on a single OS (e.g., Citrix Metaframe, Microsoft IIS). Applications can be consolidated quickly and easily, without modification to either the application itself or its operating system.

ARM applications, such as Aurema's Active Resource Management Technology (ARMTech*) and Hewlett-Packard's Resource Partitioning Manager*, are better suited for core business applications running on larger SMP platforms, where optimized application performance and availability are key concerns. Although ARM implementations may be more complex, requiring more sophisticated skills to efficiently manage OS and hardware resources, they are generally more effective for larger applications that can run on multiple CPUs. Likely candidates for ARM include major ERP and CRM applications, database management systems and decision support software. It can also be used effectively to consolidate multiple Java*-based Web servers, or to run a three-tier environment on a single operating system.

System and Life Cycle Management

Though server and application consolidation offer strong potential for cost reduction, most companies will derive even greater benefit from consolidating and upgrading their existing management tools. A new generation of applications are automating and streamlining key functions. Microsoft Operations Manager (MOM) and NetIQ* are important examples. Both offer a new level of automated, intelligent and proactive system monitoring for Microsoft Windows environments. Many OEMs and ISVs have developed modules that extend the functionality of these management solutions for specific systems and applications.

Other management tools are helping IT organizations simplify and automate their processes for provisioning and change management. PlateSpin Operations Management Center*, for example, deploys agents that enable IT organizations to quickly inventory and assess their current

hardware and software environment. It then allows them to create “service disks” that encapsulate key components for standard configurations using VMware virtual machine technology. These service disks can be used to provision new systems far more quickly, and to automate software distribution for upgrades, patches, security updates, etc.

PlateSpin, MOM and NetIQ are part of a new generation of management applications that deliver a high level of off-the-shelf functionality for quick ROI, and can also be mined for steady cost improvements as IT organizations take advantage of more sophisticated capabilities. These tools can substantially reduce operating costs in both distributed and consolidated environments. As a result, solution architects have more choice in balancing the advantages of consolidation against the superior performance, scalability and availability that is often possible in a distributed or clustered architecture.

Consolidation in Action: GEHIS

- **Applications:** Microsoft Exchange*, Lotus Domino*, Windows Domain Controller, Squid Proxy Server*, several proprietary applications.
- **Consolidation Ratio:** ~ 10:1 (includes a standby server for disaster recovery)
- **Key benefit:** Better availability/scalability with lower TCO

“The combination of VMware ESX Server and IBM xSeries hardware was the ideal solution for GEHIS. Different servers can now run on stable and scalable hardware. This simplifies backup and recovery, because we can store image files of the virtual machines and deploy them instantly.”

Michael Lutschewitz
Infrastructure Manager
GEHIS

GEHIS manages all IT investments and services for GEHE Pharma Handel GmbH, subsidiary of GEHE AG, Europe’s largest pharmaceutical distributor. Given its complex retail and wholesale distribution network, which covers 11 countries with up to five deliveries per day, the performance and availability of its computing resources are essential to GEHE’s business productivity. Like many IT organizations, GEHIS was striving to simplify its environment, reduce total costs and improve agility. The use of VMware ESX server to consolidate multiple and diverse applications has become an important part of that effort.

Although GEHIS could have consolidated all 20 of their initially targeted applications onto a single 4-way IBM x440 server, they chose to deploy a second x440 for disaster recovery. ESX Server plays an important role in this strategy, since it allows image files of the virtual machines to be stored on the backup server for nearly instantaneous failover. The high availability of the virtual machines running on the x440 servers complements this failover capability, providing exceptional support for business-critical applications using affordable, industry-standard technologies.

Consolidation in Action: T. Rowe Price

- **Applications:** A wide variety of off-the-shelf and custom applications
- **Consolidation Ratio:** ~ 26:7 (moving toward 10:1)
- **Key benefits:** Server consolidation with faster ROI, reduced server and storage costs, rapid recovery, improved manageability, greater flexibility

T. Rowe Price is one of the largest and most successful investment management firms in the world, with over \$140 billion in managed assets.⁷ To reduce server and storage costs and improve management efficiency, the company recently consolidated twenty-six 2- and 4-way Intel processor-based servers onto two 6-way servers and five 4-way servers using VMware GSX server and Aurema's ARMTech. This consolidation ratio was chosen to ensure quick payback for the consolidation project. It also provides substantial headroom for future growth.

Because existing hardware was redeployed to support the majority of the VMware consolidation project, the expected ROI will be realized after deploying only five applications per platform host. To date, the environment is running 41 applications on the seven servers. Since performance tests have shown that each server can ultimately host about 10 applications, T. Rowe Price will be able to reduce new hardware purchases, which will result in significant future savings.

The company chose to use GSX Server, rather than ESX Server, because GSX Server runs on top of the operating system. ARMTech is used to provide allocation, management and control of system resources. To date, the consolidated platforms have surpassed all expectations. In conjunction with their current use of NetIQ, T. Rowe Price has found the environment much easier to manage. Changes are easily implemented right up to application landing dates, and the support staff has not experienced even a single customer complaint. Development teams can quickly test and deploy new applications and support multiple versions as each application evolves. They can also restore configurations almost instantly, for a quick recovery in the event of a production problem.

⁷ As of December 2002

Processing Power for Consolidated Workloads

Powerful processors play an essential role in application consolidation, especially when multiple virtual machines are being supported by each CPU. The new Intel Xeon processor MP, based on the Intel® NetBurst™ microarchitecture, delivers about 30 percent better performance than its predecessor, providing substantial headroom for consolidating workloads. It continues a long history of processor advances that will continue to push the upper limits of performance and value for business servers (Figure 5).

"There's always excess horsepower and memory utilization. If I can share the memory, CPU and I/O, I can drive average utilization to the area of 85 percent, up from an average of 50 percent [®]."

Chris Schuttger
IT Infrastructure Architect
TXU Corporation

Performance-boosting features include improved memory bandwidth, faster clock frequencies, Intel® Hyper-Threading

Technology and three levels of integrated cache. Hyper-Threading Technology allows the processor to support two simultaneous software threads. This improves the efficiency of CPU sharing for many applications, since the processor can actively process one thread while it is waiting for data or input for the other thread.

Integrated, multi-level cache is especially important in a multi-application environment. In older architectures, third level cache is provided on a separate chip on the server motherboard. Integrated cache is faster, which reduces memory latency for data-intensive workloads. This complements the large, high-speed, level four cache supplied by the IBM Enterprise X-Architecture, ensuring exceptionally fast memory retrieval.

The higher level of performance afforded by the Intel Xeon processor MP provides a high-capacity foundation for application consolidation. ESX Server's ability to allocate hardware resources efficiently adds to the overall platform capacity, resulting in the twenty-to-one and higher consolidation results typically achieved on 8-way and 16-way Intel Xeon processor MP-based servers.

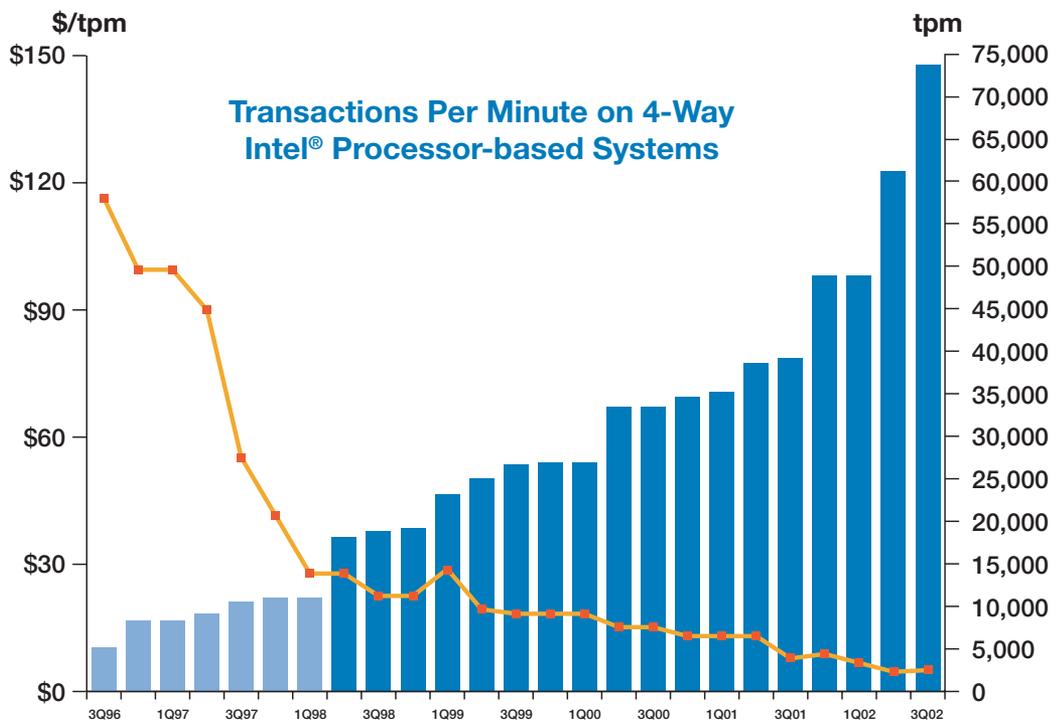


Figure 5. Intel® processor advances continue to drive new levels of performance and value on affordable, industry-standard servers.

[®]Source: Easy Partitioning, by Larry Greenemeier, *Information Week*, 11/18/02: <http://www.informationweek.com/story/IWK20021114S0017>

Consolidation in Action: Gannett Co., Inc.

- **Applications:** All kinds, including infrastructure, vertical applications, custom finance, etc.
- **Consolidation Ratio:** ~ 7:1 (increasing to 15–30:1)
- **Key benefit:** Hardware and maintenance cost reduction

Gannett Co., Inc. is a diversified, international media company that operates 110 daily newspapers—including *USA Today*—with a total average daily circulation of over 8 million. It also owns and operates 22 television stations and more than 100 Web sites. Gannett's IT organization is currently finalizing plans to deploy a pair of IBM x440 servers configured with VMware ESX Server to consolidate a variety of existing and future applications.

Early tests confirmed that each 4-way server would be able to host 15–30 applications, and that the breakeven point for hardware costs is reached with only 6–7 applications per server. Gannett has therefore planned a strategy that will attain the breakeven point early in the deployment. Additional savings will be realized for several years via reduced maintenance costs, and by eliminating the need to purchase several additional servers each year. The replaced systems will be reused in non-production environments, adding another dimension to the overall ROI for the consolidation project.

Gannett sees significant potential for virtual machine technology on Intel Architecture. In time, they believe it may completely change the way they purchase and manage their Intel-based server infrastructure. Instead of purchasing servers based on individual application requirements, they may rely primarily on standardized 4-way and 8-way systems, using virtual machine technology to optimize utilization and resource allocation based on specific application and business priorities.

Rapid Advances on Intel® Architecture

“Current investment in Intel-related technology is probably an order of magnitude or more greater than that of RISC, and the gap will probably widen over time.”

Giga Information Group
Strategic Platforms—The Tipping Point
Richard Fichera, 9/3/02

With its open architecture and leading price/performance, Intel architecture now accounts for approximately 88 percent of all servers sold worldwide⁹. This has made it the platform of choice for major ISVs, platform manufacturers and third-party developers, and has led to enormous combined investment in research and development. Over time, this investment has borne fruit in a wide variety of product categories, and continues to drive performance and price/performance in all areas of the datacenter.

As already discussed in this paper, Intel architecture is now delivering many of the core capabilities that have previously

been available only on mainframes or other large, RISC-based systems. Other processor, platform and software advances are having an equally strong impact on the corporate datacenter. Innovations such as high-density blade servers, grid computing, networked storage, remote I/O, advanced management tools, and self-healing hardware and software solutions, are all evolving rapidly on Intel architecture. As with Enterprise X-Architecture and ESX Server, these developments are leading toward more agile, modular, reliable and cost-effective computing solutions that will continue to help IT organizations “do more with less.”

Due to the massive, industry-wide investment in Intel architecture-based solutions, many of these new developments are showing up first, and advancing most rapidly, on Intel processor-based servers. This rate of innovation will continue, and most likely accelerate, in the months and years to come. As companies take advantage of today's leading solutions, such as Enterprise X-Architecture and ESX Server, they will be building a flexible, industry-standard infrastructure, and will be better positioned to take advantage of the world's most rapidly advancing computing architecture.

⁹ IDC Quarterly Server Tracker, 3rd Quarter, 2002.

Conclusion

Intel architecture has come of age for application consolidation. Using VMware ESX Server running on the IBM eServer xSeries 440 and other Intel architecture-based platforms, IT organizations are realizing twenty-to-one and higher consolidation ratios. Each OS and application stack is fully isolated in its own virtual machine, and resources are dynamically allocated based on specific application priorities.

Today's ARM applications, such as Aurema ARMTech and HP Resource Partitioning Manager, offer similar advantages for consolidating multiple applications onto a single OS. Though somewhat more complex to deploy and manage,

they can be used to improve availability and performance for core ERP, CRM and database applications, enabling high-end implementations on affordable, industry-standards platforms.

In conjunction with high-quality management tools, these solutions offer exceptional new opportunities for driving down total costs in complex, enterprise environments. Yet they are just the tip of the iceberg. The enormous investment in Intel architecture-based solutions continues to drive innovation at an unparalleled rate, delivering better and more affordable solutions across a wide range of enterprise needs.



This document and related materials and information are provided "as is" with no warranties, express or implied, including but not limited to any implied warranty of merchantability, fitness for a particular purpose, non-infringement of intellectual property rights, or any warranty otherwise arising out of any proposal, specification, or sample. Intel assumes no responsibility for any errors contained in this document and has no liabilities or obligations for any damages arising from or in connection with the use of this document.

Intel, the Intel logo, Intel Xeon, Itanium, Pentium and NetBurst are trademarks or registered trademarks of the Intel Corporation or its subsidiaries in the United States and other countries. *Other names and brands may be claimed as the property of others.

Copyright © 2003 Intel Corporation. All rights reserved.

0203/ASI/KR/PDF