



A Perspective by Intel Corporation and VMware

Improving IT Management with Multi-Port NICs and a Virtual Infrastructure

Every enterprise can benefit from the improved use of information technology (IT) resources. Improved use not only helps reduce costs but also can simplify IT infrastructure, leading to improved operations. A virtual computing infrastructure allows IT staff to increase utilization, reduce cost, heighten availability of mission-critical applications and respond quickly to business needs. However, to take greatest advantage of the benefits of virtualization, IT organizations need an infrastructure element to improve reliability and performance: multi-port network interface cards (NICs).

Moving from Hardware Constraints to Virtualization

IT managers around the globe share a common challenge: keeping up with the unpredictable need for more servers and storage while addressing growing business continuity demands. Yet strategies to manage computing resources more effectively across sprawling enterprises—and amid constant new application development—have not always kept pace. The result is that many IT organizations are severely underutilizing their existing hardware resources while others are constantly reacting to business conditions instead of proactively planning for growth.

Server virtualization is a proven way to overcome this challenge by better utilizing computing resources—improving scalability, manageability and availability while lowering total cost of ownership (TCO). Virtualization software divides a single physical server into several independent virtual machines, each of which can host a separate operating system and applications in complete isolation from other virtual machines on the server (see Figure 1). Having the

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capability to run multiple virtual machines simultaneously on one physical server enables enterprises to consolidate workloads from several separate physical servers onto one server, thereby reducing the number of servers required for a given workload. Unlike physical servers, virtual machines can be created in a matter of minutes and can be moved from one physical server to another without reconfiguring the operating system or applications. As a result, services can be provisioned faster and resources allocated easily to business units when needed. In addition, virtualization enables IT administrators to proactively manage their systems to help prevent unplanned downtime and increase overall availability.

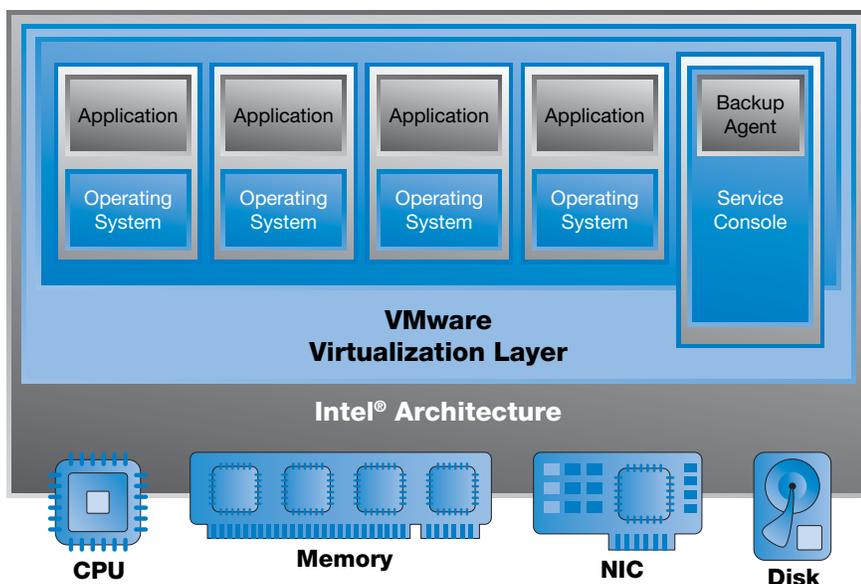


Figure 1. VMware enables enterprises to create a virtual infrastructure, which provides a layer of abstraction between the computing, storage and networking hardware and the software that operates on it. With a virtual infrastructure, users see resources as if the resources were dedicated to them. The administrator manages and optimizes resources transparently across the data center.

About This White Paper

This white paper discusses the IT benefits enterprises can gain from VMware virtualization software when using Intel® PRO/1000 Dual Port and Quad Port Server Adapters. VMware GSX Server* and ESX Server* run on Intel® Xeon™ processor-based platforms, allowing IT organizations to provision and manage virtual machines for workload consolidation across physical servers. Together with VMware VirtualCenter management software and VMotion* technology, ESX Server also enables administrators to move live, running virtual machines from server to server while maintaining continuous service availability.

High-speed Intel® Gigabit Ethernet NICs play an essential role in the virtual infrastructure model—server networking functionality is important for secure management of ESX Server, for VMotion and for meeting the network throughput requirements of multiple virtual machines. In particular, best practices for VMware ESX Server call for at least three dedicated network connections. Multi-port Intel PRO adapters are the optimum solution, providing the extra ports to support the virtual infrastructure in one server slot and freeing input/output (I/O) slots in servers that require additional ports. Intel multi-port NICs also allow IT administrators to configure redundant ports to improve throughput and reliability. With VMware server virtualization software, traffic that was once hosted on three physical servers can now be handled by three virtual machines on a single physical server—as long as that server is properly equipped with the required network connections, such as those provided by Intel multi-port NICs.

Building Virtual Infrastructure with VMware

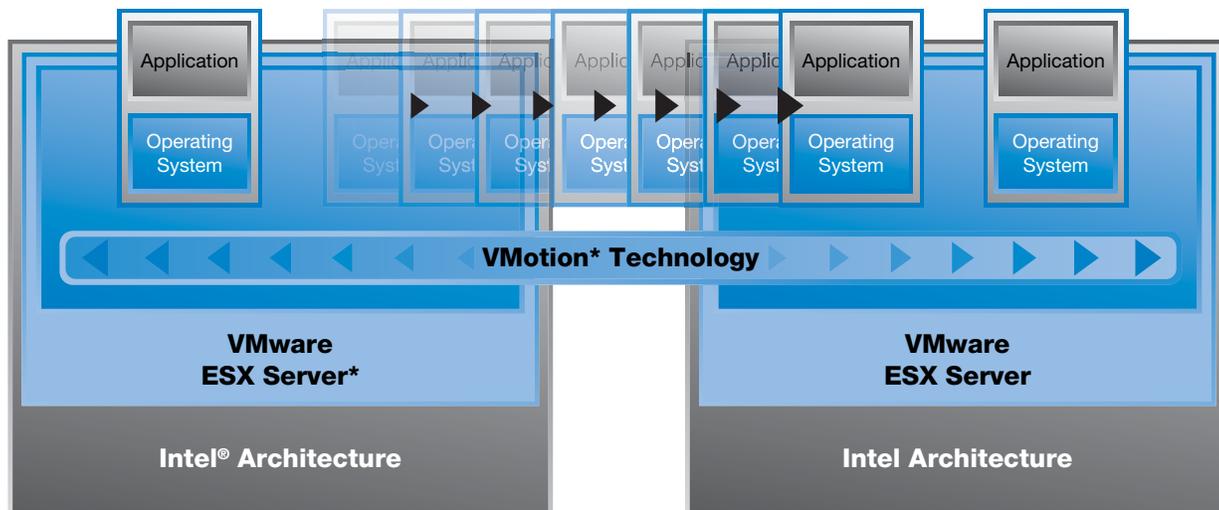
Today, approximately 80 percent of Fortune 100 companies are VMware customers.¹ No matter how large or small the enterprise, adopting a virtual infrastructure enables IT departments to be responsive to business needs while controlling costs.

The primary building blocks of the VMware virtual infrastructure include VMware GSX Server and ESX Server in conjunction with VMware VirtualCenter management software.

VMware GSX Server and ESX Server provide a virtualization layer that allows multiple virtual machines to operate simultaneously on a single physical server. ESX Server provides IT administrators with additional capabilities that give them complete control over the server resources allocated to each virtual machine. GSX Server and ESX Server software typically enable organizations to run one to eight virtual machines per processor on 2-way, 4-way, 8-way and 16-way servers, up to a maximum of 64 virtual machines per physical server with GSX Server and 80 virtual machines per server with ESX Server.

VMware VirtualCenter management software is used by system administrators to manage virtual machines across many physical systems. VirtualCenter simplifies the management of virtualized Intel® architecture-based environments, whether they use Microsoft Windows*, Novell NetWare* or Linux* operating systems. In addition, VMware VMotion technology allows administrators using VirtualCenter to migrate a live

Figure 2. VMware VMotion* technology moves live, operating virtual machines from one physical system to another while maintaining continuous service availability. VMotion allows fast reconfiguration and optimization of resources across the virtual infrastructure.



virtual machine to a different physical server without service interruption, making dynamic workload balancing and zero-downtime hardware maintenance possible (see Figure 2).

VMware virtual infrastructure software allows IT administrators to:

- Manage Intel processor-based hardware as a single logical pool of computing resources
- Streamline server provisioning and management
- Monitor system availability and performance
- Move workloads dynamically across distributed servers without service interruption
- Eliminate scheduled downtime by enabling zero-downtime maintenance
- Secure the environment with robust access control

Increasing Efficiency, Flexibility and Responsiveness

VMware virtual infrastructure software offers numerous benefits that increase the efficiency, flexibility and responsiveness of IT infrastructure:²

- **Respond faster to business needs.** With VMware VirtualCenter management capabilities, server-provisioning time is reduced from weeks to minutes. Virtual machines can be added as needed, allowing IT administrators to quickly respond to a variety of situations, including increased demand for capacity, new requests for IT services and the need for hardware and performance. Using VMware, administrators can create server templates to ensure that server configurations for newly added virtual machines are consistent with departmental policies.
- **Lower TCO through server consolidation and streamlined systems management.** In a large data center, VMware software can enable significant hardware and operating cost savings through server consolidation. For example, with VMware ESX Server, more than 20 separate servers (operating systems and associated applications) can be hosted on one 8-way server. Higher consolidation ratios can be achieved on 16-way and larger server platforms. No software migration is required, making the process very straightforward. This approach enables enterprises to consolidate mission-critical applications and services running on various operating systems onto fewer,

more scalable and reliable enterprise-class servers, including blade servers. As a result, IT managers can streamline data center operations, reduce hardware requirements and minimize unused capacity while maintaining application service-level agreements simply by balancing workloads and adjusting the resources dedicated to each virtual machine. The end result: a lower cost to acquire, deploy, manage and operate needed IT resources.

- **Develop and test software more efficiently.** By consolidating multiple test and development servers onto fewer physical servers, IT developers can test new enterprise applications in large-scale test configurations without incurring the cost or resource burden of provisioning and configuring a large number of physical servers.
 - **Create cost-effective business continuity and disaster recovery solutions.** Business continuity means maintaining the availability of mission-critical applications in the face of maintenance needs, hardware failures and adverse events. VMotion technology allows administrators to move live applications on a virtual machine from one physical server to another physical server before bringing the primary server down for maintenance. In this way, VMware virtualization software can dramatically improve application availability and make updates to business-critical servers possible without a disruption in service. In addition, virtual machines can be clustered to further increase application availability by providing automatic failover.
- VMware software can also help administrators implement a cost-effective disaster recovery solution. In the event of a disaster, multiple production workloads that were running on virtual machines on physical servers can be recovered in minutes simply by copying the virtual machine images to a physical server at the disaster recovery site and then restarting the virtual machines on that server. Using virtual infrastructure in this way can provide business continuity while eliminating the need to maintain identical hardware at both the production and disaster recovery sites.
- **Migrate legacy and custom applications.** Migrating customized enterprise applications can be problematic, so many organizations require their legacy systems to remain operational at least until the transition is complete. Because virtual machines operate independently of physical hardware and multiple virtual machines can run on a single physical server, IT administrators can protect critical data and maintain new and old systems

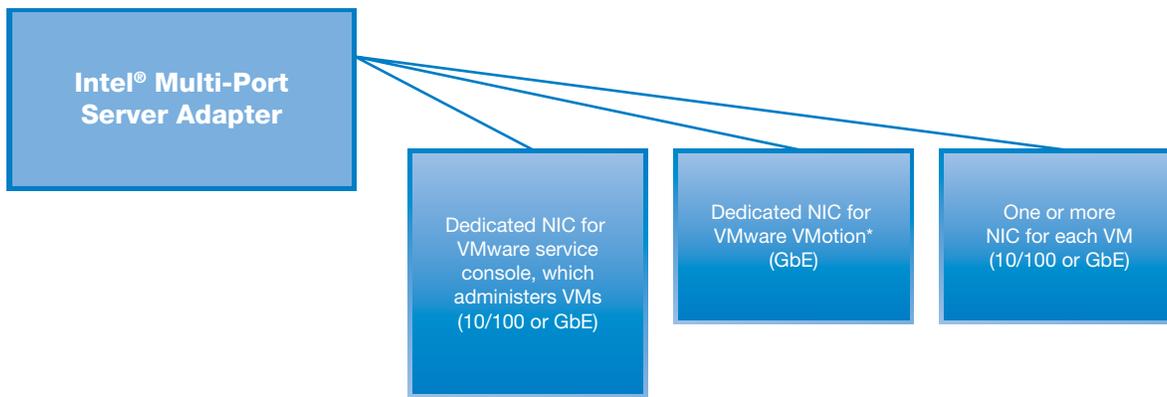


Figure 3. VMware network best practices recommend the creation of network labels for each virtual NIC through VMware ESX Server*. Network labels should be global across server farms, and VMware VMotion* automatically maps virtual machines (VMs) to appropriate virtual NICs based on network labels. Virtual machines must have access to the necessary subnets on the target ESX Server. VMware recommends a Gigabit Ethernet connection between the ESX Server-based platform, the VMware service console and VMotion. Intel® multi-port NICs can provide the necessary number of ports to meet this requirement, in addition to dedicated ports for each virtual machine on a server.

simultaneously. This can be accomplished by running these systems in secure virtual machines at near-native performance levels on standard, Intel Xeon processor-based servers.

Intel® NICs: Providing the Glue for VMware Virtual Machines

Often taken for granted in servers, the NIC capacity must be carefully maintained on servers hosting multiple virtual machines. Best practices for VMware ESX Server recommend a minimum of three network adapters:

- One for the virtual machine and its applications
- One for the VMware service console to handle system administration
- One for VMotion to enable dynamic workload balancing

This can be challenging if servers are Peripheral Component Interconnect (PCI) slot-constrained.

Every IT administrator also needs to mitigate reliability risks. On a server that is operating multiple applications on multiple virtual machines, a connection failure can be a costly business interruption that is time-consuming to fix. If redundant network connections are desired to enhance the reliability of servers hosting many applications, the issue intensifies—up to four ports could be required per server.

In addition, IT administrators must be able to segment traffic to maintain a flexible and secure network. The flexibility to assign NICs to servers and virtual machines enables administrators to increase performance quickly

during peak times. Server workloads are always growing in size as well, which means that enterprises need multiple network connections that provide the throughput to respond immediately to employee and customer requests for data.

All of these requirements consume server ports. For that reason, Intel created the Intel PRO/1000 MT Dual Port and Quad Port Server Adapters, which are optimized for Intel Xeon processor-based servers. They provide the foundation for a flexible and reliable virtual infrastructure.

Intel dual- and quad-port adapters conserve valuable PCI slots in servers while helping to eliminate network bottlenecks—especially in a connection-dense virtual machine environment. Migration to high-speed Gigabit Ethernet can also be achieved easily and cost-effectively using Intel multi-port NICs.

Dedicated ports for virtualization. Intel PRO/1000 MT Dual Port and Quad Port Server Adapters have two or four Gigabit Ethernet connections in a single PCI card, delivering increased port density for slot-constrained servers. A single, integrated, dual-port Gigabit Ethernet controller chip provides high performance and reliability along with low power consumption. For servers running VMware server virtualization software, ESX Server best practices strongly recommend extra ports to establish separate physical networks for application production traffic, for management and for VMotion virtual machine migration (see Figure 3).

High performance. Multi-port Intel Gigabit Ethernet adapters can reduce network downtime and increase processor utilization. Intel multi-port adapters include support for advanced server features, including adapter

fault tolerance to provide redundant network links for server failover; adaptive load balancing and link aggregation for increased scalability and throughput; PCI Hot Plug and ActivePCI for increased uptime; and interrupt moderation for significantly enhanced processor utilization.

Extensive compatibility. With a flexible design that fits almost any type of PCI bus, dual- and quad-port Intel adapters include standards-based management features and wide network operating system support to help ensure extensive compatibility with the latest server and networking environments. Intel adapters are compatible with full-height and low-profile PCI slots. The standard, full-height bracket can be easily swapped out and replaced by the shorter, low-profile bracket for installation in high-density servers that feature low-profile PCI slots.

Increased reliability. Intel® Advanced Network Services (ANS) software allows administrators to increase uptime with redundant, teamed connections. Switch fault tolerance and test switch configuration features help test compatibility and further increase uptime. Intel multi-port adapters can be configured to automatically switch to a secondary link when a server's primary link fails. Server performance can be further enhanced by teaming connections on adapters with each other, with connections on other Intel PRO Server Adapters or with LAN on Motherboard (LOM) components using Intel ANS features to achieve multi-gigabit scalability and redundancy for server failover capability. Advanced cable diagnostics can dynamically test and report network problems such as interrupts and automatically compensate for cable issues.

Server expandability and business continuity. Proactively including an Intel multi-port NIC at time of server purchase or installation of VMware ESX Server ensures server expandability by helping avoid the cost of taking a server offline to install a new NIC when adding servers or virtual machines. Intel multi-port adapters also enable business continuity by allowing IT administrators to dedicate ports for remote storage and management, including storage area network/network attached storage (SAN/NAS) and direct attached storage (DAS).

Network segmentation. To help ensure that IT organizations can support unpredictable network demands, such as heavy

traffic on Web servers and intranets, IT departments are increasingly segmenting enterprise networks. Segmentation helps provide better data security and uptime for each network. Within dedicated subsystems, hardware and software operating environments cannot be modified without proper authentication. Employing multi-port network adapters can provide the platform flexibility to respond to evolving needs for segmentation and enable the connection to multiple switches to segment traffic on a network.

Cabling advantages. Intel offers dual- and quad-port adapters with both copper and fiber-optic connections. Both types of adapters use a common driver technology—Intel® SingleDriver™ technology—for Gigabit Ethernet, which helps reduce IT complexity. These Intel network adapters support cost-effective 10/100/1000 transmission rates over existing Category 5 (Cat 5) cabling and gigabit connection rates over existing fiber-optic cabling. IT administrators can upgrade Fast Ethernet connections to Gigabit Ethernet using Intel PRO NICs. This added flexibility reduces training costs associated with the upgrade and expedites the Gigabit Ethernet rollout.

Centralized remote management. Dual- and quad-port Intel adapters support standard management protocols to further reduce TCO. These protocols include Wired for Management (WfM), Microsoft Remote Installation Service (RIS), Simple Network Management Protocol (SNMP) and Desktop Management Interface (DMI).

Virtualization: Making the Connection

To improve return on investment (ROI) and reduce TCO, organizations need to make the most of what is already in place. Virtual IT infrastructure has become a powerful enabler for consolidating servers, for running applications in multiple operating-system environments, for simplifying administration and for lowering operating costs. VMware software on Intel Xeon processor-based servers provides a robust virtualization platform, and Intel NICs provide the connections to make the virtual IT infrastructure a reality. Together, VMware and Intel help IT managers reach their common goal: serving enterprise needs in the most efficient and responsive way possible.

Key Terminology

Network interface card (NIC) is a computer circuit board that is installed in a computer to connect the computer to a network. Network interface cards provide a dedicated, full-time network connection for enterprise desktop PCs or servers.

Virtual infrastructure is the basis for flexible, scalable and low-cost enterprise IT that has the capability to respond immediately to changing business needs. Virtual infrastructure decouples application workloads completely from underlying physical hardware. This allows applications to be deployed across a pool of physical servers to improve hardware utilization and management flexibility. The key building block of virtual infrastructure is a platform that

abstracts the physical resources of an industry-standard server to provide a set of virtual resources to an application. VMware ESX Server provides that virtualization platform, and VMware VirtualCenter manages the virtual machines on physical servers running ESX Server. VMware VMotion permits the migration of applications running on virtual machines across this pool of virtual resources without service interruption.

Virtual machine is a virtualized Intel Xeon processor-based server environment on which a guest operating system and associated application software can run. Multiple virtual machines can operate on the same host machine concurrently.

Intel® PRO/1000 Multi-Port Adapter Product Features

- Intel® SingleDriver™ technology
- Backward compatibility with previous generations of Intel® PRO/1000 network adapters
- Remote management support (WfM, RIS, SNMP/DMI)
- Full-height and low-profile screw-on brackets included with each adapter
- Interrupt moderation
- Large send offload/TCP segmentation offload
- RJ-45 connectors
- Plug and Play specification support: standard
- Auto-negotiation, full-duplex capable
- Copper cable distances up to 100 m and fiber distances up to 1,000 m
- Adapter fault tolerance
- Switch fault tolerance
- Adaptive load balancing
- Fast EtherChannel^a
- Gigabit EtherChannel^a
- Test switch configuration
- 802.1Q VLANs
- 802.3x flow control
- TCP checksum offload
- IEEE 802.1p*

^aAvailable only when used with a capable switch.

VMware Compatibility with Intel PRO/1000 Dual and Quad Port Adapters

VMware supports Intel PRO/100 Fast Ethernet and Intel PRO/1000 Gigabit Ethernet network adapters. For a representative list of VMware-qualified adapters, see the VMware ESX Server 2 I/O Compatibility Guide at www.vmware.com/pdf/esx_io_guide.pdf. VMware may add support for drivers and devices between product releases. Check the VMware Web site for current information at www.vmware.com/support/esx2.

Learn More About This Virtual Infrastructure Solution

For more information about the products described in this white paper, visit www.vmware.com or www.intel.com/network/connectivity.

About VMware

VMware is the global leader in virtual infrastructure software for industry-standard systems. Some of the world's largest companies use VMware solutions to simplify their IT, fully leverage their existing computing investments and respond faster to changing business demands.

VMware is based in Palo Alto, California. For more information, visit www.vmware.com or call 650-475-5000.



About Intel

Intel (NASDAQ "INTC"), the world's largest chip maker, is also a leading manufacturer of computer, networking and communications products.

Additional information about Intel is available at www.intel.com.



¹ VMware Inc., internal research, February 3, 2003.

² Leading enterprises have realized significant benefits using VMware virtual infrastructure software. For more information, visit www.vmware.com/customers/stories.

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