



A Perspective by Intel Corporation and VMware

**Virtual Infrastructure: Multi-Port NICs Are
Critical When Consolidating Servers and
Improving IT Management Through
Virtualisation**

Every enterprise can benefit from improving the utilisation of information technology (IT) resources. Increased utilisation not only helps reduce costs but can also simplify IT infrastructure, leading to improved operations. A virtual computing infrastructure provides IT staff with the capabilities necessary to increase utilisation as well as to reduce cost, heighten availability of mission-critical applications and respond quickly to business needs. However, to take greatest advantage of the benefits of virtualisation, IT organisations require a critical infrastructure element that is designed to ensure reliability and improve performance: multi-port network interface cards (NICs).

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Moving from Hardware Constraints to Virtualisation

IT managers around the globe share a common challenge: keeping up with unpredictable needs 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 organisations are severely underutilising their existing hardware resources while others are constantly reacting to business conditions instead of proactively planning for growth.

Server virtualisation is a proven way to better utilise 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 (VMs), each of which can host a separate operating system and applications in complete isolation from other VMs on the server (see Figure 1).

Having the capability to run multiple VMs 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, VMs 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, virtualisation enables IT administrators to proactively manage their systems to help prevent unplanned downtime and increase overall availability.

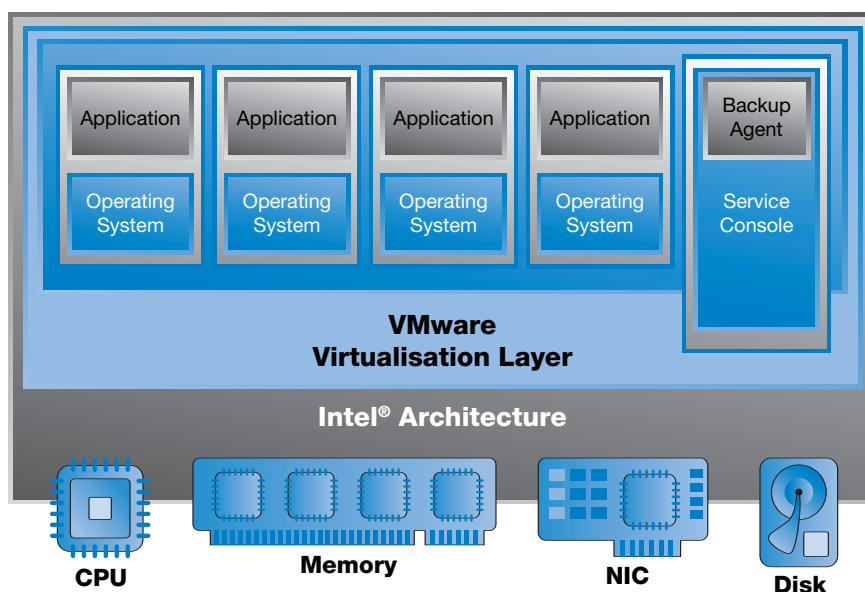


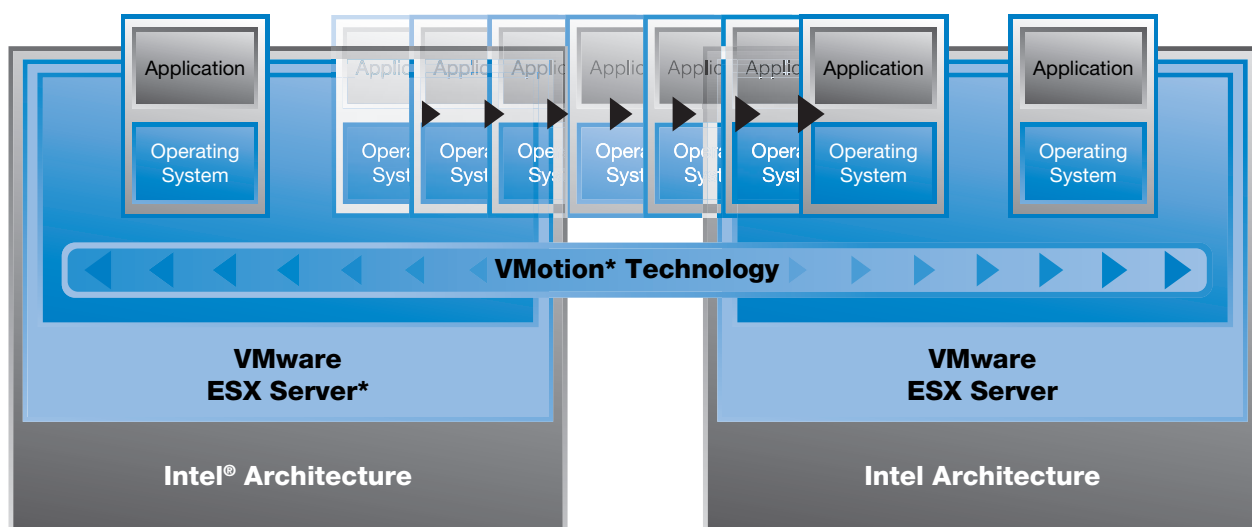
Figure 1. VMware enables enterprises to create a virtual infrastructure, which provides a layer of abstraction between the computing, storage and networking hardware and the software that runs on it. With a virtual infrastructure, users see resources as if they were dedicated to them. The administrator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

About This White Paper

This white paper discusses the IT benefits that enterprises can gain from VMware virtualisation software when utilising 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 organisations to provision and manage VMs for workload consolidation across physical servers. Together with VMware VirtualCenter management software and VMotion* technology, ESX Server also enables administrators to move live, running VMs from server to server while maintaining continuous service availability.

High-speed Intel® Gigabit Ethernet NICs play an essential role in the virtual infrastructure model—running multiple VMs on one physical server creates a need for multiple server ports in a small form factor. 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 virtualisation software, traffic that was once hosted on three physical servers can now be handled by three VMs on the same physical server—as long as that server is properly equipped with the required network connections provided by Intel multi-port NICs.

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



Building Virtual Infrastructure with VMware

Today, 80 percent of Fortune 100 companies are VMware customers.¹ No matter how large or small the enterprise, adopting 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 virtualisation layer that allows multiple VMs to run 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 VM. GSX Server and ESX Server software typically enable organisations to run from one to eight VMs per processor on 2-way, 4-way, 8-way and 16-way servers, up to a maximum of 64 VMs per physical server with GSX Server and 80 VMs per server with ESX Server.

VMware VirtualCenter management software is used by system administrators to manage VMs across many physical systems. VirtualCenter simplifies the management of virtualised 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 VM 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 providing 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. VMware customers² have seen how VMware software enables them to:

- **Respond faster to business needs.** With VMware VirtualCenter's management capabilities, server-provisioning time is reduced from weeks to minutes. VMs 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 VMs 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 minimise unused capacity while maintaining application service-level agreements simply by balancing workloads and adjusting the resources dedicated to each VM. 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 VM from one physical server to another physical server before bringing the primary server down for maintenance. In this way, VMware virtualisation software can dramatically improve application availability and make updates to business-critical servers possible without a disruption in service. In addition, VMs 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 VMs on physical servers can be recovered in minutes simply by copying the VM images to a physical server at the disaster recovery site and then restarting the VMs 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 customised enterprise applications can be problematic, so many organisations require their legacy systems to remain operational at least until the transition is complete. Because VMs operate independently of physical hardware and multiple VMs can run on a single physical server, IT administrators can protect critical data and maintain new and old systems simultaneously. This can be accomplished by running these systems in secure VMs at near-native performance levels on standard, Intel Xeon processor-based servers.

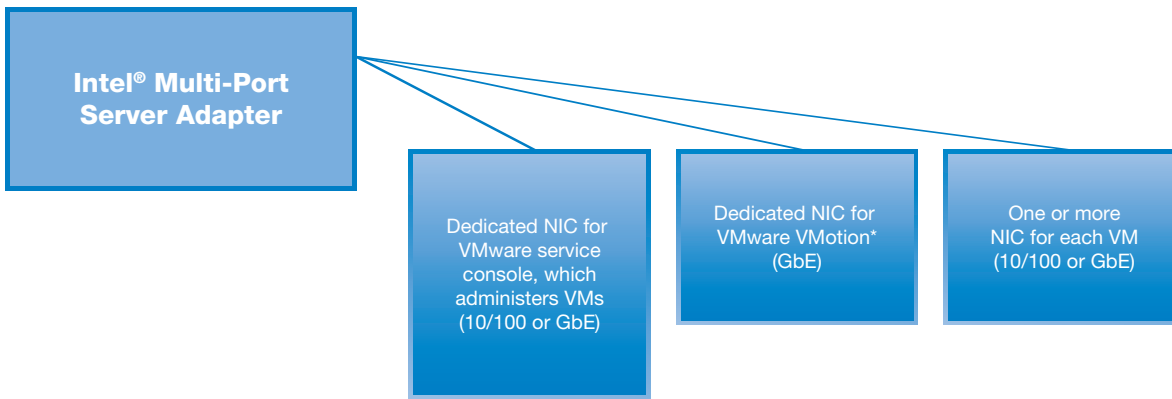


Figure 3. VMware network best practices require the creation of network labels for each virtual NIC through VMware ESX Server*. Network labels are global across server farms, and VMware VMotion* automatically maps VMs to appropriate virtual NICs based on network labels. VMs must have access to the necessary subnets on the target ESX Server. VMware requires 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 VM on a server.

Intel® NICs: Providing the Glue for VMware Virtual Machines

Often taken for granted in 2-way servers—the majority of servers on the market—NIC capacity must be carefully maintained on servers hosting multiple VMs. Best practices for VMware ESX Server recommend a minimum of three network adapters—one for the VM and its applications, one for the VMware service console to handle system administration and 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 running multiple applications on multiple VMs, 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 six 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 VMs 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 optimised 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 VM environment. Migration to high-speed Gigabit Ethernet can also be achieved easily and cost-effectively using Intel multi-port NICs.

Dedicated ports for virtualisation. 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 utilising VMware server virtualisation software, ESX Server best practices strongly recommend extra ports to establish separate physical networks for each application's production traffic, for management and for VMotion VM migration (see Figure 3).

High performance. Multi-port Intel Gigabit Ethernet adapters can reduce network downtime and increase processor utilisation. 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 utilisation.

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 your first VM ensures server expandability by helping avoid the cost of taking a server offline to install a new NIC when adding servers or VMs. 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 ensure that IT organisations 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 for both copper and Fibre Channel networks. Both 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. 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.

Centralised 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).

Virtualisation: Making the Connection

To improve return on investment (ROI) and reduce TCO, organisations 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 virtualisation 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 most 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 utilisation 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 virtualisation platform and VMware VirtualCenter manages the VMs on physical servers running ESX Server. VMware VMotion permits the migration of applications running on VMs across this pool of virtual resources without service interruption.

Virtual machine is a virtualised Intel Xeon processor-based server environment on which a guest operating system and associated application software can run. Multiple VMs 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
- Cable distance: 100 m
- Adapter fault tolerance
- Switch fault tolerance
- Adaptive load balancing
- Fast EtherChannel**
- Gigabit EtherChannel**
- Test switch configuration
- 802.1Q VLANs
- 802.3x flow control
- TCP checksum offload
- IEEE 802.1p*

Technical Features	Intel® PRO/1000 MT Dual Port Server Adapter	Intel® PRO/1000 MT Quad Port Server Adapter
NOS Software Support	<ul style="list-style-type: none"> • Microsoft Windows Server* 2003 and Microsoft Windows* 2000 • Microsoft Windows XP 32- and 64-bit Editions • Microsoft Windows NT* 4.0 • Linux* 2.4.x or later (32- and 64-bit) • FreeBSD* 4.x or later • Novell NetWare* 4.11, 4.2, 5.0, 5.1, 6.0 • SunSoft Solaris* 7, 8 • UnixWare* 7.x, OpenUNIX* 8.0 (ddi8) • SCO5* 	<ul style="list-style-type: none"> • Microsoft Windows Server 2003 and Microsoft Windows 2000 • Microsoft Windows XP 32- and 64-bit Editions • Linux 2.4.x or later (32- and 64-bit) • FreeBSD 4.x or later • Novell NetWare 5.1, 6.0, 6.5 • SunSoft Solaris 7, 8 • UnixWare 7.x, OpenUNIX 8.0 (ddi8)
Data Rate(s) Supported per Port	10, 100 and 1,000 Mbps	10, 100 and 1,000 Mbps
Bus Type	PCI/PCI-X	PCI/PCI-X
Bus Width	32- or 64-bit	64-bit
Bus Speed	33/66/100/133 MHz	33/66/100/133 MHz
Onboard Memory	128 KB	128 KB
Interrupt Levels	INTA	INTA, INTB, INTC, INTD
IEEE Support	802.3ab*	802.3ab
Hardware Certifications	FCC Class A, CE	FCC Class A, CE, GOST, AS/NZ 3548, BSMI, ICES-003, VCCI
Data Transfer Mode	Bus-master DMA	Bus-master DMA
Controller—Processor	Intel® 82546	Intel® 82546EB
Typical Power Consumption	1 A at +5 VDC	16.8 W at +3.3 VDC
Operating Temperature	0–55° C	0–55° C
Operating Humidity	85% at +55° C	85% at +55° C

*Available only when used with a capable switch.

Learn More About This Innovative Solution

For general 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/pressroom.



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

² Leading enterprises have realised significant benefits using VMware virtual infrastructure software. For more information, visit www.vmware.com/customers/stories. Performance tests and ratings are measured using specific computer systems and/or components and reflect the approximate performance of Intel® products as measured by those tests. Any difference in system hardware or software design or configuration may affect actual performance. Buyers should consult other sources of information to evaluate the performance of systems or components they are considering purchasing. For more information on performance tests and on the performance of Intel products, reference www.intel.com.

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