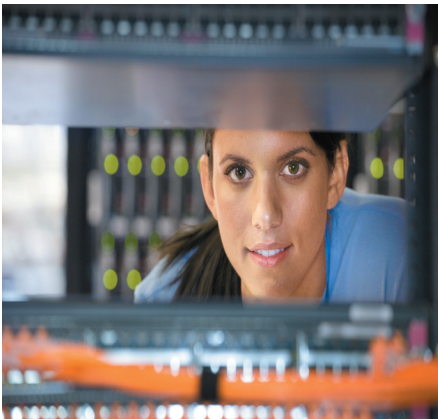


Consolidating Enterprise Routing and Network Services on Intel® Architecture

Service-rich software routing on a single architecture – Intel® architecture delivers more flexibility, greater scalability and lower overall cost than purpose-built routers and appliances.



Software-based network components easily incorporate new functions, services and applications.

Yesterday's routers are typically optimized for high packet throughput, often at the expense of flexibility. But in the enterprise space, there is a need to expand the functionality of routers to include security, voice, video and other functions, blurring the line between routers and network appliances. IT professionals and Internet service providers (ISPs) are trying to keep pace with changing network requirements by supporting more sophisticated functionality and services. However, implementing new functions on mixed architecture systems often requires costly add-in hardware. Conversely, a single architecture - Intel® architecture - allows these requirements to be met with software-based networking components (i.e., routing, firewall, VPN and IPS) that are highly adaptable and capable of running nearly any workload, allowing enterprises to easily incorporate new features, services and applications.

A software-based networking component can be based on off-the-shelf, general-purpose server processors that for many classes of routers have closed the performance gap relative to network requirements. Technological advances, per Moore's Law, are producing impressive performance improvements, evidenced by the Intel® Xeon® processor E5645 (circa Q1'2010) delivering over ten times greater L3 IP forwarding throughput than its predecessor that launched just two years earlier. Furthermore, developers can differentiate their product offerings by leveraging complimentary technologies from the server industry, like virtualization, power management and security.

This paper describes the benefits enterprises can derive from software-based networking components with respect to flexibility, scalability and low overall cost. Various usage models are discussed, some of which are made possible through the use of advanced Intel® technologies. Routing performance benchmarks of an Intel®-based HP* server, running example technologies and use cases from software networking vendor Vyatta*, are also presented.

The Expanding Role of Routers in the Enterprise

In the enterprise, many devices support both routing and security, as well as providing other functionality. The diversity of workloads has increased as enterprises seek to incorporate a mix of QoS, firewall, application acceleration, VPN and intrusion prevention, among other services.

The classic router role is expanding in the enterprise, where the advantages of executing a full suite of networking and communications applications in software are substantial.

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Moving forward, routers need to be more adaptable, thereby simplifying the integration of additional workloads and ultimately lowering overall equipment cost and management effort. A major issue today is that most routers are based on a mix of specialized hardware and are therefore fixed function and not very adaptable. Moreover, augmenting networks with individual, fixed function appliances increases the need for load balancers and interconnect switches and can be difficult to manage. In contrast, devices designed to support diverse software networking workloads offer enterprises far more flexibility and opportunity for consolidation.

Consolidating Workloads on Intel® Architecture

The exceptional performance gains of Intel® Xeon® processors, driven in part by a higher level of architectural parallelism, enable networking equipment to consolidate diverse workloads, similar to the way servers are used in datacenters. In both cases, consolidation provides equipment developers and end users more flexibility, as well as lower overall cost since systems are built with high-volume, cost-effective server processors. By choosing Intel® architecture processors to run routing and network services, equipment manufacturers benefit from commodity server economics and a very large ecosystem of ready-made software and hardware building blocks. End users benefit from reduced

operating expenses (OPEX) since consolidated workloads are more efficient with respect to energy consumption, datacenter footprint and equipment support.

Rapid technological advancement in high-end CPUs is delivering the necessary IP packet forwarding throughput while allowing the addition of other workloads to the software stack without changing the hardware. With purpose-built platforms, deploying new services may require developers to add a computing module and then architect a way to get packets to/from that module for services processing. This approach isn't very scalable since the computing architectures are usually different for packet and applications processing. Alternatively, Intel Xeon processor-based systems are very scalable because all the workloads execute on the same computing architecture, so it's possible to repartition hardware resources in response to changing traffic and service demand. These systems can also incorporate a wide range of advanced technologies first developed for general purpose servers, like virtualization, power management and hardware-based security.

End users don't typically delve into router hardware details, but given the added flexibility offered by Intel-based platforms, there are some benefits well worth noting, as shown in Table 1.

Features	Value
Best of breed applications	Consolidate essentially any application, such as security, VoIP, video and encoding/transrating, onto the basic platform.
Easy performance upgrade	Increase packet and application processing capacity by simply purchasing the latest generation server processor or by upgrading with readily available off-the-shelf memory and components.
Equipment Re-Use	Increase throughput at the largest sites as needed and cascade legacy systems to upgrade throughput at smaller sites.

Table 1. Intel®-based Platform Benefits

Developing a Flexible Networking Services Platform

As the name implies, purpose-built routers are based on custom hardware that often requires the design of separate, proprietary computing systems to add services. On the other hand, working with Intel Xeon processors is a much simpler job because developers can leverage standard server processors and other off-the-shelf components. This approach eliminates the time and effort of hardware development and allows an increased focus on the value-add applications. In addition, server and appliance hardware manufacturers can follow the CPU technology cadence, offering the latest Intel Xeon processors as soon as they become available. Incorporating server-oriented virtualization technology, Intel Xeon processors provide developers more software flexibility, which is discussed in the following section.

Increasing Flexibility with Virtualization

Virtualization technology has been around for many years, most notably used in datacenters where many applications are consolidated onto a single physical server, thereby saving cost and floor space. This is achieved by creating secure partitions, called virtual machines (VMs), which are execution environments for the operating systems (OSes) and applications they house. Multiple VMs run on the same physical board, whose hardware resources, including processing cores, memory and peripheral devices, are abstracted. This is achieved by adding a new software layer, called a virtual machine monitor (VMM), that manages the execution of “guest OSes” in much the same way that OSes manage the execution of applications. A guest OS does not have absolute control over platform resources as it would with-

out virtualization, but it acts as though it does. This enables efficient and secure sharing of system resources without any modification to proven applications, as well as a great deal of flexibility in the way hardware resources are partitioned across multiple software applications.

Intel has enhanced the capabilities of virtualization technology with a complementary hardware-assist technology called Intel® Virtualization Technology (Intel® VT).¹ Intel VT performs various virtualization tasks, like hardware-based memory address translation, which reduces the overhead and footprint of virtualization software and improves its performance. In addition, Intel VT increases the robustness of virtualized environments by using hardware to protect the software running in one VM from interfering with the software running in another VM. The following describes four of the many usage models enabled by virtualization.

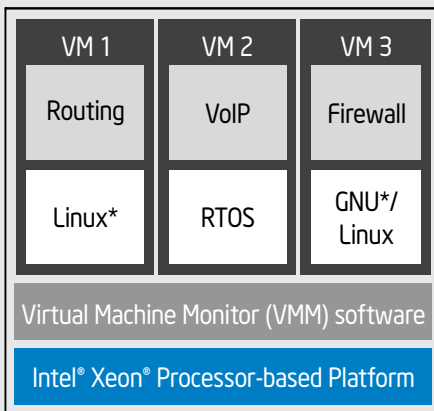


Figure 1A. Consolidating Best of Breed Applications

Scenario 1: Consolidating Best of Breed Applications

Situation:

An IT department wants the flexibility to choose the best VoIP and security software on the market for a system that is also running routing functions.

Solution:

Put three workloads in separate VMs, allowing them to run independently on their native OSes. As a result, IT can make application selections that are relatively independent of other software running on the system.

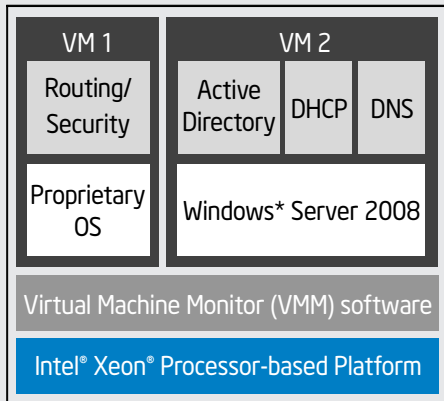


Figure 1B. Migrating Applications without OS Porting

Scenario 2: Migrating Applications without OS Porting

Situation:

An equipment manufacturer wants to design a branch office device that integrates Windows® Server 2008 applications, such as Microsoft® Domain Name System Server.

Solution:

Use virtualization to enable Windows Server 2008 to run unmodified on its own in a VM.

Scenario 3: Provisioning Workloads

Situation:

A service provider experiences changes in traffic mix as more and more customers are streaming video content, which demands a higher level of quality of service (QoS) than typical Internet traffic.

Solution:

Assign more Intel architecture processing cores from the standard routing application to the video routing application, which performs Integrated Services (IntServ)² as defined by the Internet Engineering Task Force (IETF) to improve QoS. The Internet integrated services framework provides an end-to-end QoS solution with the ability for applications to choose among multiple, controlled levels of delivery service for their data packets.

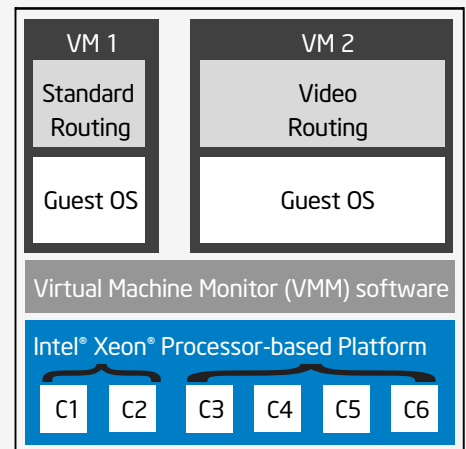


Figure 1C. Provisioning Workloads

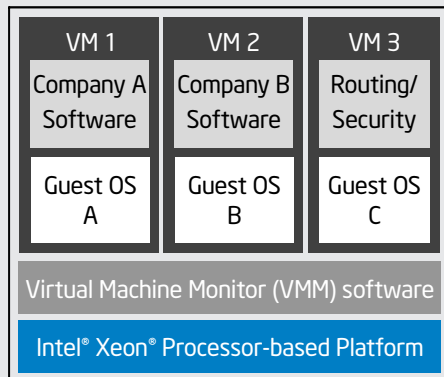


Figure 1D. Protecting Software in the Cloud

Scenario 4: Protecting Software in the Cloud

Situation:

Customers of a cloud-based service provider are concerned their data is at risk when their application software shares a server with other companies.

Solution:

Put each company’s software into dedicated VMs, thereby isolating every execution environment and associated data since all memory spaces are protected in hardware by Intel VT. VMs are secure partitions that can help prevent unintended software interactions. For example, some virtualization software products have achieved Common Criteria Evaluation Assurance Level 4 (EAL4+). The Common Criteria is an international set of guidelines that provides a common framework for evaluating security features and capabilities of Information Technology (IT) security products, and EAL4+ is the highest assurance level that is recognized globally by all signatories under the Common Criteria Recognition Agreement (CCRA).³

ENABLING CLOUD-BASED SERVICES



Cloud computing has the potential to spark innovation by providing a natural place to merge services. For instance, an online retailer and a cell phone provider may collaborate in the cloud to enable the purchase of items over the phone. Such transactions require information sharing, such as the subscriber status (e.g., prepaid, active) and how much to charge the customer's phone bill. Quality of service information may also be exchanged between the parties in order to guarantee swift response to the transaction.

Facilitating greater service collaboration, platforms that consolidate routing and network services can simplify the task of combining services since all of the software can run on the same hardware. Besides enabling consolidation, virtualization is the basis for securing proprietary data in the cloud. In addition, platforms based on general-purpose processors, like the Intel® Xeon® processor, are relatively easy to code, which speeds up application development.

Improving Scalability with Multi-core Technology

Over time, the demand for individual workloads changes, and when a throughput limit is reached, an end user may need to scale the computing resources supporting certain workloads. Device manufacturers can make this a relatively straightforward process when systems are designed with a single architecture, such as Intel architecture, since practically any platform resource can be assigned to a particular workload. As a result, an IT administrator has the ability to re-provision the platform resources available to an application by letting it run with more threads or on more cores when demand increases. Overall system performance also scales higher by deploying processors with more cores.

Lowering Power Consumption with Power Management

In the enterprise environment, there are times when network traffic may fall off considerably, such as when workers go home or on holidays. Yet, most network devices continue to run full throttle and needlessly waste energy. Helping to

minimize power consumption, Intel is focused on power management at all levels of processor design: transistor, circuit, microarchitecture and architecture. Two innovations in this area are more flexible power states and Intel® Turbo Boost Technology.⁴

- **Flexible power states:** In addition to controlling the processor state (e.g., active, idle, sleep), application software can now control the power state of individual cores. During off-peak periods, a device can consolidate applications onto fewer cores and then power down the unused cores in order to save power.

- **Intel® Turbo Boost Technology:** When the networking device is experiencing high demand, this technology allows the processor cores to run faster than the base operating frequency, thermal conditions permitting. This is akin to getting an extra speed bump or two. Power savings can be realized because the highest peak demand is handled by Intel Turbo Boost Technology, potentially reducing the need for computing headroom or over provisioning.

Protecting Against Malware with Trusted Execution

Routers and network appliances are common targets of cyber attacks because they are often a major line of defense for other IT systems. Malicious software infiltrating a device can wreak havoc by accessing sensitive information, stealing identities or committing other illegal actions. While anti-virus, encryption, firewall and other security products offer protection, these software solutions can be neutralized by malware that has the same or higher privileges.

Designed to help protect against software-based attacks, Intel® Trusted Execution Technology (Intel® TXT)⁵ integrates new security capabilities into the processor, chipset and other platform components. Unalterable by rogue software, these hardware-based security features run mission-critical applications in a safe partition, protect crucial platform data and keep malware from launching in the first place. Intel TXT ensures all system software components are in a known state, referred to as “trusted,” before launching, which provides even greater protection for operating systems and applications.

Packet Processing Performance Data

Intel® processor performance and energy-efficiency have improved many-fold in recent years, making a single architecture approach a reality for networking devices. For instance, Figure 2 shows the L3 IP forwarding performance for five Intel Xeon processors released over a two year period; the performance per core increased by over ten times – up to 10 gigabits per second (Gbps).⁶ Intel’s processor roadmap provides users with an annual opportunity to increase performance and lower cost with minimal or no software modifications. Platform configuration details for Figure 2 are listed in Appendix A.

In addition to silicon architecture improvements, these performance gains have been made possible in part through software and driver optimizations architected by Intel’s Communications Infrastructure Division (CID). Intel’s CID is specifically focused on delivering the technology and products that will enable network equipment providers to consolidate processing on a single CPU architecture – Intel architecture. The division also provides hardware offload to boost performance per watt for selected processing workloads such as cryptography for IPSEC.

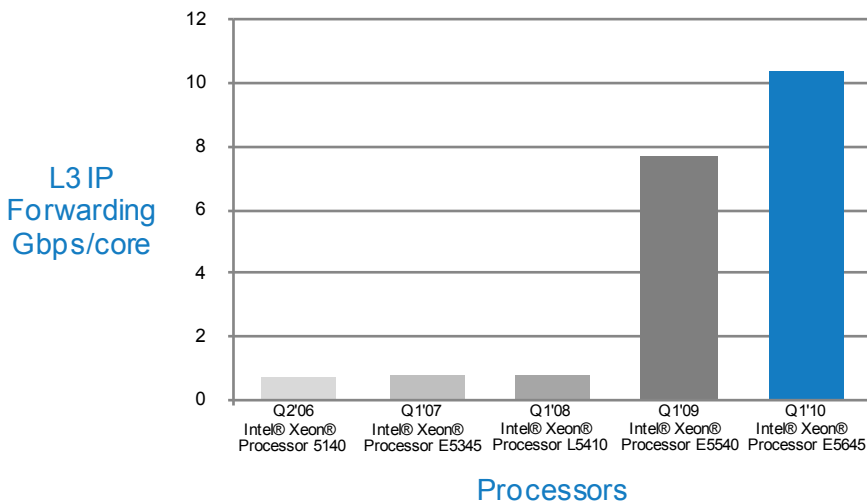


Figure 2. L3 IP Forwarding Performance for Five Intel® Xeon™ Processors

HEMC* Broadband Case Study

HEMC* Broadband, one of the largest ISPs in Northeastern Georgia, provides dial-up and high-speed Internet connections for Habersham EMC* members and others, plus fiber access to the Internet for business customers.

As the HEMC Broadband customer base and requirements grew, they recognized the need to redesign the network beyond a single core router with just one node of connection (NoC) to the Internet. To provide higher availability, a second NoC was needed in a different city. However, deploying a primary and backup router in two different locations would cost nearly \$100,000 (USD) if purchased from a traditional proprietary router vendor.

Solution

Seeking a flexible, affordable core routing solution, HEMC Broadband found Vyatta*. Its solutions combine enterprise-class routing and security with the performance and economics of open systems, giving network administrators the ability to innovate, scale and grow in ways that were previously unavailable. Encouraged by their research, HEMC set up a virtual test environment that mirrored the production network using Network OS from Vyatta. “I was able to test everything imaginable,” says Daniel Stickel, System Administrator for Habersham EMC, who was impressed with Vyatta’s cost, flexibility and ease of use. “All the protocols I could possibly need were right there, whether I needed clustering, VRRP, OSPF or BGP.”

Convinced that Vyatta was the right solution, Stickel deployed the routing software on two standard servers running dual quad-core processors with 8 Gigabits of RAM at a Habersham EMC location in Cleveland, Georgia. A month later, he set up a similar configuration at the second NOC and designed an architecture using Virtual Router Redundancy Protocol (VRRP) at both sites, where the two devices are connected via Open Shortest Path First (OSPF).

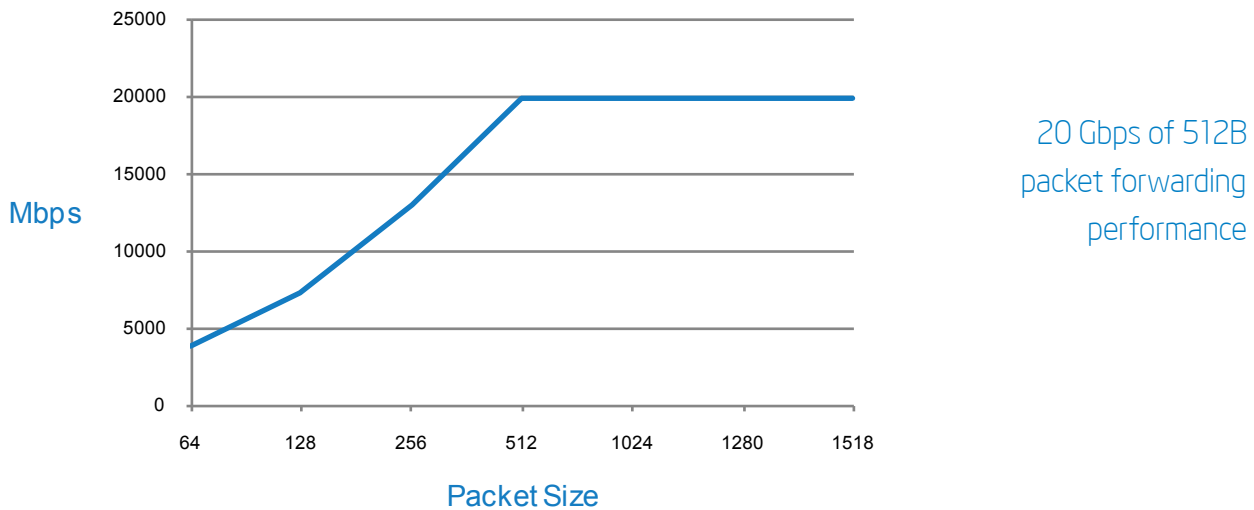


Figure 3. Uni-directional RFC2544 IP Forwarding Test Result

In other benchmark testing, HP engineers assembled a router platform using the HP ProLiant* DL360 G6 Server and Vyatta’s Network OS, a software-based routing and security solution. Based on uni-directional RFC2544 IP forwarding tests, two Intel® Xeon® processor E5530 achieved 20 Gbps⁵ when forwarding 512 byte packets (or larger), as shown in Figure 3. Intel® Hyper-Threading Technology (Intel® HT Technology)⁷ was enabled to create two logical cores for each physical core, and processing was distributed across the eight logical cores. Configuration information is listed in Appendix B.

For several years, Intel and other industry leaders have been optimizing packet forwarding performance of Intel® platforms. Intel is committed to deliver faster packet processing with new product releases, including the second generation Intel® Core™ microarchitecture, code-named “Sandy Bridge”, which is supported by the software and driver optimizations in the Intel® Data Plane Development Kit (Intel® DPDK). Please contact your Intel field sales representative for more information about the kit.

Simplifying the Deployment of New Services

Many enterprises want more flexibility to address changing network requirements, some of which include implementing new services for security, video and mobility. When the network uses purpose-built routers, the options for running new services are usually to add more hardware, such as a compute module, a dedicated network appliance or a server.

It is now possible to consolidate routing and network services on to a single processor architecture, which saves hardware and operating cost, eases application development and improves agility, thanks to the exceptional performance gains of the Intel Xeon processor. In addition, this approach leverages many of the advanced computing technologies developed for datacenters, thereby increasing the flexibility, scalability, power-efficiency and security of the networking infrastructure. Network platforms based on Intel architecture are supported by industry-leading development tools, which reduces engineering effort and risk when deploying software-based networking components.

Consolidating Enterprise Routing and Network Services on Intel® Architecture

Appendix A: Test Platform Configurations

1. Dual-Core Intel® Xeon® processor 5140, 2.33GHz, 1333MHz FSB, 4MB shared L2 cache

Intel® 5100 chipset, FBDIMM DDR2-667MHz, 4 x 1GB (total 4GB), 3 x Intel® 82571GB Gigabit Ethernet Controllers with quad-port PCI-Express* x4

2. Quad-Core Intel® Xeon® processor E5345, 2.33GHz, 1333MHz FSB, 4MB shared L2 cache

Intel 5100 chipset MCH (A0 pre-release stepping) DDR2 667MHz, 4 x dual rank 1GB (total 4GB), Dual Channel Configuration, 3 x Intel 82571GB Gigabit Ethernet Controllers with quad-port PCI-Express x4

3. Intel® Xeon® processor L5410 2.33 GHz,

Intel® Chipset: Intel 5100 chipset, number of CPUs: 2 x 4 core (6 cores used), 12MB L2 cache, 1333 FSB, PCI-Express: 3 x4, MEMORY: 6GB – DDR2 667, 2 Channels, 3 DIMM / Channel, NIC: 3 x quad-port Intel® 82571EB Gigabit Ethernet Controller (Ophir) Software – OS: Linux* 2.6.15

4. Intel® Xeon® processor E5540 2.53 GHz,

Intel® Chipset: Intel® 5520 Chipset, number of CPUs: 2 x 4 core x 2 thread (16 threads), L3 CACHE: 8 MB per Socket, Intel® QuickPath Interconnect (Intel® QPI) : 5.86 GT/s, PCI-Express: x4, x4, MEMORY: 6GB - DDR3 1066, 3 Channels, 1 DIMM / Channel, NIC: 4 x quad-port Intel 82571EB Gigabit Ethernet Controller (Kawela) PCI-Express x8 Software – LinuxCent OS 5.2 with Lincoln Tunnel driver

5. Intel® Xeon® processor E5645 2.40GHz, Uni - Processor configuration,

Intel 5520 Chipset (C2 stepping), number of CPUs: 1 x 4 core x 2 thread (8 threads), 12MB L3 cache, Intel QPI : 5.86 GT/s, DDR3 1066MHz, 3 x dual rank 2GB (total 6GB), Triple-Channel Configuration, 4 x Hex-port Intel® 82576EB Gigabit Ethernet Controller (Kawela) PCI-Express x8 BIOS version S5500.86B.01.00.0048, Operating system: LWRT* 6.03

Appendix B: Test Platform Configuration

HP* ProLiant* DL360 G6 Server Configuration

Processors	2 x Intel® Xeon® processor L5530 (quad-core)
Chipset	Intel® 5520 Chipset
Memory	6GB DDR3 @ 1333MHz
Networking	Intel® Ethernet Server Adapter X520-SR2
Operating system	Red Hat* Enterprise Linux* 5.2 x64
Routing software	Vyatta* Community Edition software
Tester	Spirent* TestCenter*

For more information on Vyatta software-based network operating system, visit www.vyatta.com

For more information about the HP ProLiant DL360 G6 Server, visit http://h10010.www1.hp.com/wwpc/us/en/sm/WFO5a/15351-15351-3328412-241644-241475-3884319.html?jumpid=reg_R1002_USEN

For more information on Intel® products and technologies, visit www.intel.com/technology/advanced_comm

1 Intel® Virtualization Technology (Intel® VT) requires a computer system with an enabled Intel® processor, BIOS, virtual machine monitor (VMM) and, for some uses, certain platform software enabled for it. Functionality, performance or other benefits will vary depending on hardware and software configurations and may require a BIOS update. Software applications may not be compatible with all operating systems. Please check with your application vendor.

2 Source: <http://tools.ieff.org/html/rfc2210>

3 Source: <http://virtualization.info/en/news/2010/11/vmware-vsphere-4-0-receives-common-criteria-eal4-certification.html>

4 Intel® Turbo Boost Technology requires a system with Intel Turbo Boost Technology capability. Consult your PC manufacturer. Performance varies depending on hardware, software, and system configuration. For more information, visit www.intel.com/technology/turboboost/.

5 No computer system can provide absolute security under all conditions. Intel® Trusted Execution Technology (Intel® TXT) requires a computer system with Intel® Virtualization Technology, an Intel TXT-enabled processor, chipset, BIOS, Authenticated Code Modules and an Intel TXT-compatible measured launched environment (MLE). The MLE could consist of a virtual.

6 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, visit <http://www.intel.com/performance/resources/limits.htm>.

7 Requires an Intel® Hyper-Threading Technology (Intel® HT Technology)-enabled system, check with your PC manufacturer. Performance will vary depending on the specific hardware and software used. Not available on the Intel® Core™ i5-750 processor. For more information, including details on which processors support Intel HT technology, visit www.intel.com/technology/platform-technology/hyper-threading/index.htm

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