

Planning Guide

Technology for Tomorrow's Cloud

Preparing Your Virtualized Data Center for the Cloud

Why you should read this document:

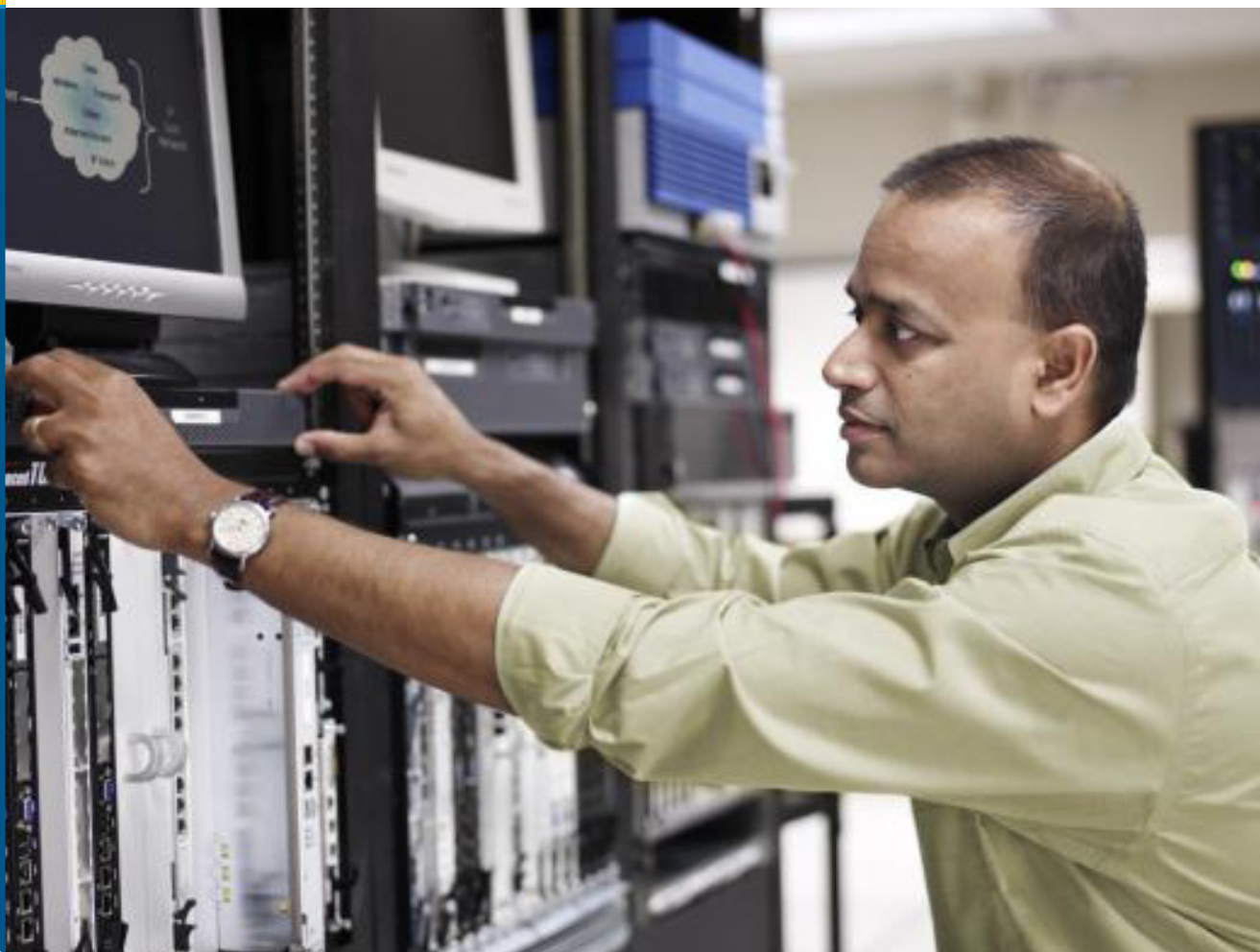
This guide provides practical information to help you prepare your data center for the cloud with:

- *Unified networking*, a new infrastructure based on 10 Gigabit Ethernet (GbE).
- *Scale-out storage* that combines software and converged storage servers to deliver high-speed access to data.
- *Trusted server pools* that demonstrate high integrity and build trust across dynamic environments.
- *Power management* that monitors and caps power in real time from server, rack, zone, and data center levels.

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Preparing Your Virtualized Data Center for the Cloud

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The Next-Generation Data Center

Virtualization is becoming the new norm for enterprise data centers. It's also a key technology that can help you get to the cloud—and these days, the cloud is top of mind for most IT managers.

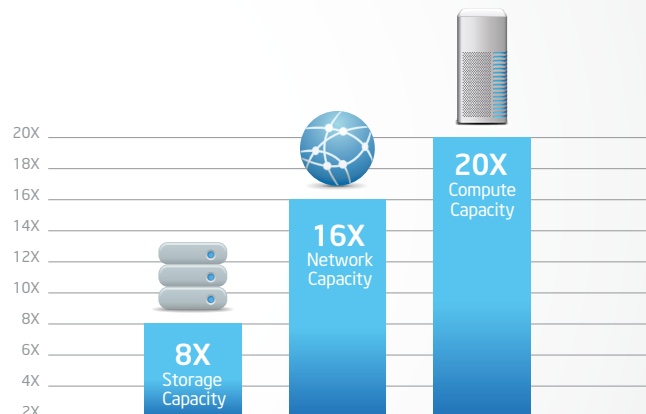
If cloud is at the top of your agenda, you're probably looking at it as a way to improve server utilization, build efficiencies in the data center, provide elastic scaling, support self-service, and provision applications faster—as well as respond better to the business. The virtualized data center is the first step and the foundation for implementing a cloud environment.

Along with the promise of significant benefits, the cloud also places greater demands on the data center. IT managers are seeing increases in virtual machine (VM) density per server and running into bottlenecks with existing storage and networking architectures. This has led to greater capacity demands, increased complexity, and more and more massive interconnections. Although this setup may work for a while, IT managers are finding that it doesn't scale—reducing the flexibility and efficiency benefits associated with cloud environments.

More Pressure on the Data Center

IDC projects that more than 2.5 billion users will connect to the Internet over the next five years, with more than 10 billion devices.¹ Intel has estimated that this will require 8 times the amount of storage capacity, 16 times the network capacity, and more than 20 times the current compute capacity by 2015.²

- 1 IDC, *ICT Outlook: Recovering Into a New World*, Doc # DR2010_GS2_JG, Mar 2010.
- 2 Intel Market Projections, 2009 to 2010. For eight times the network capacity: 800 terabytes per second of IP traffic estimated on internal Intel analysis, *Network Supply/Demand 2010-2020* forecast. For 16 times the storage capacity: 60 exabytes of data stored from Barclays *Capital Storage Bits*, September 2009, extrapolation by Intel for 2015. For 20 times the compute capacity: Intel internal long-range planning forecast extrapolated to 1 billion virtual servers using one virtual machine per core.



Next-Generation Data Center Is ...

- Leveraging the virtualized data center to achieve operational efficiency and elastic scaling and to support self-service, rapid deployment, and the ability to cloud burst.
- Capable of handling *big* data across the networking, computing, and storage infrastructure. The trend is for users to retain more data for longer periods—often unstructured—and some applications, including medical, engineering, and financial, present significant challenges to data center services.
- Able to optimize performance through simplification. Rather than continuing to add storage and server ports, innovative new technology can be put in place to intelligently manage and simplify your IT environment.
- Able to build trust and compliance into cloud implementations at the basic hardware level. Trusted server pools protect the most sensitive workloads and provide data from system integrity checks for use by dashboards for audit purposes.

Based on an open and interoperable approach, the next-generation data center provides the right infrastructure for your cloud. It enables you to simplify deployments and increase IT efficiencies. And while networking and storage bottlenecks may be at the heart of the challenges that next-generation data centers address, issues such as power management and security represent other very real problems.

Our recommendations are based on our experience working with IT managers, cloud providers, and security and power-management solution vendors—as well as the experience of our own Intel IT in building and deploying cloud technology. In addition, our

Next-Generation Data Center Isn't ...

- A set of technologies that replace virtualization. Combining virtualized servers with innovative networking, storage, security, and power-management technologies gives you a foundation for achieving the benefits of cloud computing, including reduced operational costs, flexibility, elasticity, and scalability.
- A way to address all pain points in the data center. Usage models for networking and storage capacity, security, and power management are just the beginning of the conversation about innovative new technologies that simplify the data center environment and support cloud computing.
- A prescriptive, step-by-step set of technologies to deploy in a specific order or configuration. By thinking through the cloud-usage models that make the most sense for your organization, you can plan how to best prepare your data center for the cloud.
- Based on proprietary systems with closed interfaces that don't integrate with other solutions and also include high switching costs.

recommendations align with solutions and guidelines that industry-leading OEMs and ISVs have been publishing on the Intel® Cloud Builders³ program site. Our Intel Cloud Builders program continues to yield in-depth guidance that you can use, including reference architectures, education, and a forum for discussion of technical issues.

The purpose of this guide is to introduce you to data center technologies that address challenges of networking, storage, security, and power management. We will walk you through a series of suggestions and recommendations for the best way to evaluate and implement these technologies in your data center.

³ [Intel Cloud Builders](#) is a cross-industry initiative to help enterprises, telecommunications companies, and service providers build, enhance, and operate secure cloud infrastructures.

Technology Big Bets: Cloud-Ready Infrastructure

Making the right infrastructure investments on data center technology will help ready your data center for the cloud. Evaluate each of the four technologies in this guide from the perspective of your current data center capabilities and your future goals for cloud computing. Then, choose which to utilize in your own data centers or use them to evaluate vendors from which you plan to buy. Keep in mind, though, that while individually these technologies can contribute specific improvements to data center efficiency, collectively they present new synergies that arise as computing, networking, and storage converge.

The remainder of this guide provides considerations and recommendations for the following technologies for tomorrow's cloud:

- Unified networking
- Scale-out storage
- Trusted server pools
- Policy-based power management

Intel Experience with Cloud-Ready Infrastructure

Intel IT has embarked on a multiyear project to move to a new enterprise architecture for cloud computing.⁴ The plan calls for a highly efficient, automated, and virtualized infrastructure to support a private enterprise cloud for office and enterprise computing—and also provide the foundation for further development and innovation.

Underlying Intel's private cloud strategy is a plan to implement the right technology to support these efforts. For example, Intel IT has upgraded network architecture to optimize the data center infrastructure and be able to respond faster to business needs.⁵ Another example: Intel IT has built protection into the hardware in its server clusters to enhance security software solutions and support compliance.⁶

4 Chalal, Sudip, et al. *An Enterprise Private Cloud Architecture and Implementation Roadmap*. IT@Intel (June 2010).

[intel.com/content/www/us/en/cloud-computing/cloud-computing-private-cloud-roadmap-paper.html](https://www.intel.com/content/www/us/en/cloud-computing/cloud-computing-private-cloud-roadmap-paper.html) (PDF)

5 Ammann, Matt, et al. *Upgrading Data Center Network Architecture to 10 Gigabit Ethernet*. IT@Intel (January 2011).

[intel.com/content/www/us/en/data-center-efficiency/intel-it-data-center-efficiency-upgrading-data-center-network-architecture-to-10-gigabit-ethernet-practices.html](https://www.intel.com/content/www/us/en/data-center-efficiency/intel-it-data-center-efficiency-upgrading-data-center-network-architecture-to-10-gigabit-ethernet-practices.html) (PDF)

6 *Evolution of Integrity Checking with Intel® Trusted Execution Technology: An Intel IT Perspective*. IT@Intel (2010).

[intel.com/content/www/us/en/pc-security/intel-it-security-trusted-execution-technology-paper.html](https://www.intel.com/content/www/us/en/pc-security/intel-it-security-trusted-execution-technology-paper.html) (PDF)

Unified Networking

As server virtualization grows to support cloud environments, LAN and storage networks face heightened pressure to manage more and more traffic. As an IT manager, this means you must manage an increasingly complex data center environment with higher VM densities and physical servers that look like spaghetti at the back. Plus, as volumes grow, it's difficult to maintain availability without degradation of performance, and it's costly to manage and scale separate network and storage fabrics.

A new infrastructure is emerging for the next-generation data center—based on 10 gigabit Ethernet (GbE)—that scales to handle large traffic volumes and simplifies networking while improving performance and keeping costs low. A 10 GbE solution delivers an ideal fabric for cloud infrastructure because it offers:

- Ubiquity, with Ethernet connectivity as the standard on almost all servers
- Advanced virtualization support that enables dynamic resource allocation, 10 GbE throughput, and support for platform virtualization enhancements
- A unified networking fabric that consolidates LAN and storage area network (SAN) traffic

The Road to 10 GbE Solutions

Moving to a 10 gigabit Ethernet (GbE) solution can address large traffic volumes and data center complexity through:

- Port consolidation—simplifying the ports connecting to the network
- Fabric consolidation—combining multiple data center fabrics into a single 10 GbE fabric
- Low-latency Ethernet—providing more bandwidth between nodes in a computer cluster
- Bigger pipe—providing more bandwidth to applications

Simplify, Simplify, Simplify

Evolution toward 10 GbE solutions offers new opportunities for data centers to simplify their networks by optimizing for virtualization, taking a different approach to storage, decreasing cabling, and converging multiple network types into one unified Ethernet network.

Consolidate Ports

One way 10 GbE solutions help simplify data center complexity is by enabling you to consolidate ports. Consider that most virtualized servers contain eight to ten GbE LAN ports and two dedicated SAN ports, typically Fibre Channel. Virtualization demands connectivity to every server in the data center, and as virtualization increases, connection and cabling complexity can stretch your ability to provide reliable service at an acceptable level.

With 10 GbE solutions, traffic from multiple GbE ports can be consolidated into a pair of 10 GbE ports, lowering equipment costs and reducing cabling while still meeting the needs of virtualized servers and bandwidth-hungry applications.

No More Spaghetti Cabling



GbE Server Connections



10 GbE Server Connections

Consolidate Fabrics

Most data centers today deploy separate LAN and storage networks, with storage often divided between network attached storage (NAS) for file-based applications and SANs for block-based applications using Fibre Channel and Internet small computer system interface (iSCSI) over IP protocols.

Although Fibre Channel offers enterprise-class performance and is widely deployed, it is also very expensive, requiring a separate infrastructure from SANs with separate switches, cables, and expensive host bus adapters for each connection. You might justify the cost when connecting a handful of physical servers, but increasing virtualization drives the need for even more Fibre Channel equipment. Maintaining two separate, growing fabrics with the

connectivity required in a highly virtualized environment is costly and complicated.

Unified networking solutions over 10 GbE make it possible for storage and LAN traffic to share a single 10 GbE fabric that carries all these disparate types of traffic, plus traffic over Fibre Channel over Ethernet (FCoE) that connects servers to Fibre Channel SANs. This reduces requirements for SAN-specific hardware, including adapters, switches, and cabling, decreasing costs and complexity. Plus, recent Ethernet enhancements ensure lossless connectivity and quality of service (QoS) for critical traffic, which is especially important for storage.

Unified Networking at Intel

Intel IT recently upgraded its network architecture to a 10 GbE fabric for its 90 data centers to accommodate current growth and meet anticipated network demand in the future.⁷ Key drivers included server virtualization and consolidation in the Intel office and enterprise computing environments, rapid growth in high-performance-demanding design-computing applications, and an ongoing 40 percent per year growth in Internet connection requirements.

The new data center fabric design has reduced data center complexity, with fewer physical servers and switches, increased throughput and reduced network latency, and improved adaptability to meet future requirements, such as additional storage capacity. Although server costs increased by 12 percent, overall total cost of ownership (TCO) for 10 GbE as compared to the 1 GbE fabric was reduced by 18 to 25 percent per server (cable infrastructure, 48 percent cost reduction; LAN infrastructure per port, 50 percent cost reduction).

Intel offers 10 GbE solutions with Intel Xeon® processor servers and the Intel Ethernet Server Adapter X520. The Intel Ethernet Server Adapter X520 supports LAN and storage traffic with standard adapters rather than expensive, proprietary converged network adapters (CNAs). Plus, this removes a potential performance limitation⁸ and enables easy scaling. Intel Ethernet Server Adapter X520 uses native FCoE and iSCSI initiators integrated into the operating system or hypervisor to enable the Intel Xeon CPUs to process storage protocols. Intelligent hardware offloads increase throughput for unified networking and I/O virtualization and help reduce system latency.

⁷ Ammann, Matt, et al. *Upgrading Data Center Network Architecture to 10 Gigabit Ethernet*. IT@Intel (January 2011).

[intel.com/content/www/us/en/data-center-efficiency/intel-it-data-center-efficiency-upgrading-data-center-network-architecture-to-10-gigabit-ethernet-practices.html](https://www.intel.com/content/www/us/en/data-center-efficiency/intel-it-data-center-efficiency-upgrading-data-center-network-architecture-to-10-gigabit-ethernet-practices.html) (PDF)

⁸ CNAs rely on proprietary offload engines to process storage traffic. Storage traffic throughput is tied to that hardware engine, meaning performance will not improve as server platforms improve. Intel's approach scales with server advancements, meaning performance will improve as servers do.

Scale-out Storage

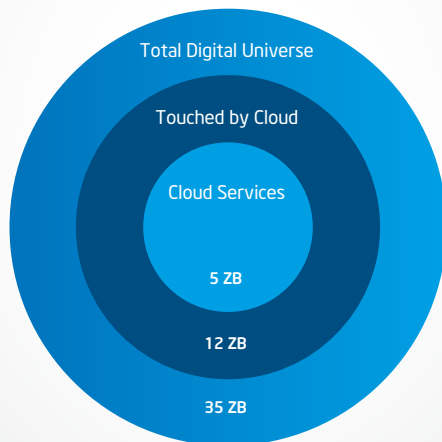
The availability of increasingly dense attached storage devices has paved the way for exponential growth in digital content. In fact, content volumes are expected to increase by more than 40 percent each year over the course of the next decade. And according to a study by IDC, by 2020, 15 percent of digital information could be created in the cloud, delivered to the cloud, or stored and manipulated in the cloud.⁹

The bottom line is that data is increasing at a furious rate, creating significant storage challenges for data center managers. In the enterprise, unstructured data is growing the fastest—data that is highly variable and not easily managed without an understanding of its content and context. Most of what used to be collected on paper, film, DVDs, and CDs has now moved online in diverse formats—for example, e-mail, instant messages, documents, spreadsheets, images, and video. According to an IDC study in 2009, 95 percent of the growth in digital information in the coming years will be from unstructured data; the remaining 5 percent will be driven by traditional structured data, such as financial or supply chain information.¹⁰

More efficient data storage has become an imperative for the next-generation data center. Along with the need to manage increased volume, data—much of it unstructured—must be readily accessible for business, regulatory, and compliance needs. Traditional file storage management systems such as NAS are proving to be too costly and inefficient to cope with demand.

Digital Information in Clouds, 2020

Potential Available Share



ZB=zettabyte

Source: IDC Digital Universe Study, sponsored by EMC, May 2010.

9 *The Digital Universe Decade—Are You Ready?* IDC Digital Universe Study, sponsored by EMC, May 2010. viewer.media.bitpipe.com/938044859_264/1287663101_75/Digital-Universe.pdf (PDF)

10 *As the Economy Contracts, the Digital Universe Expands.* IDC Digital Universe Study, sponsored by EMC, May 2009. emc.com/collateral/leadership/digital-universe/2009DU_final.pdf (PDF)

Storage Inefficiencies in Virtualized Environments

In highly virtualized environments, existing storage inefficiencies are compounded. Why?

- **Overallocation:** The tendency to allocate capacity based on worst-case scenarios, called fat (or thick) provisioning, is done to ensure that business units avoid capacity constraints. What emerges, however, is a growing collection of underutilized storage volumes, each far exceeding its actual requirements. Eventually, all the capacity is provisioned, even though much of it isn't used. The result: an abundance of waste while at the same time a shortage of capacity for new workloads.
- **Full-copy snapshots/cloning:** The waste is multiplied whenever fat-provisioned volumes are copied or archived on traditional arrays. Redundant data is copied and archived, and unused space within each volume is backed up as well, making offline storage a major culprit in the misallocation of storage resources.
- **Performance degradation:** An array of storage and networking fabrics come into play when data moves to the cloud. And the sheer physical distances covered can raise substantial concerns about latency. How realistic is it to expect high-performance access to storage resources that may be housed hundreds of miles away? And assuming that high-performance technologies do exist, is the cost justified for anything besides mission-critical applications?

Scale-out Storage: Intelligent Solutions

The explosion of digital content and the emergence of cloud computing have driven the development of capacity-based scale-out storage cloud architecture. These *intelligent* storage solutions offer compelling benefits and a way for the next-generation data center to address three major storage challenges: increasing volume, inefficient management, and cost. While traditional approaches to storage are built around extremely powerful, costly, and custom hardware, intelligent storage solutions combine software and converged storage servers to deliver high-speed access in a much more modular and scalable solution. Multiple vendors are now offering these innovative, cost-effective solutions based on industry-standard x86 architecture.

There's no one-size-fits-all solution for scale-out storage.

Depending on your organizational needs, you can design your solution to support three basic usage models that are critical to cloud computing:

- **Application data store:** Data collected and stored as part of business operations that needs to be available for further manipulation (for example, data analysis)
- **Large object store:** Photos, videos, thumbnails, and documents in diverse formats stored and managed with applications such as Microsoft SharePoint* and EMC* Documentum*
- **Backup and archiving:** Scheduled backups that transfer data to storage—typically a private cloud in most enterprises, but potentially to software-as-a-service (SaaS) cloud storage, or even first to a private cloud and then to the SaaS cloud

Advantages of Intelligent Storage Solutions

Capabilities	Description	Benefit
Thin provisioning	Space is allocated only when data is written to disk (essentially as needed and how much is needed).	<ul style="list-style-type: none"> ▪ Maximizes available capacity ▪ Minimizes overallocation and underutilization ▪ Reduces costs
Data de-duplication	All redundant and duplicate data is indexed and replaced with pointers to a single copy of that data.	<ul style="list-style-type: none"> ▪ Reduces backup volume and wasted offline storage ▪ Reduces costs
Automated data tiering	Dynamic tiering of enterprise data based on application demand: Frequently accessed data is moved to a storage tier running high-performance drives, while vast amounts of less frequently accessed, unstructured data are directed to a lower-cost tier.	<ul style="list-style-type: none"> ▪ Aligns data storage to application demand ▪ Reduces costs
Erasure coding/ RAID over nodes	Use of erasure codes (a forward error correction code) is coupled with data storage across nodes and even geographies.	<ul style="list-style-type: none"> ▪ Provides high reliability to survive disk or node failures ▪ Low bit-error rates

Intel Xeon processors are providing the compute power for next-generation storage solutions that can meet growing cloud demands. As a well-proven data center building block, Intel Xeon processors deliver leading performance along with massive scalability and efficiency at reduced cost. Increasingly, Intel Xeon processors provide performance within storage solutions that enable next-generation capabilities like thin provisioning, automated tiering

of data, data de-duplication, and erasure coding/RAID over nodes. Unlike storage solutions that were built around custom application-specific integrated circuits, Intel Xeon processor-based storage solutions free up storage vendors to innovate and deliver new products to market faster, cut down on the number of proprietary interfaces, and offer scale-out storage solutions for a lower TCO.

Trusted Server Pools

If you've hesitated to implement cloud computing because of security concerns, you are not alone. Security is one of the major barriers for most organizations considering cloud initiatives.

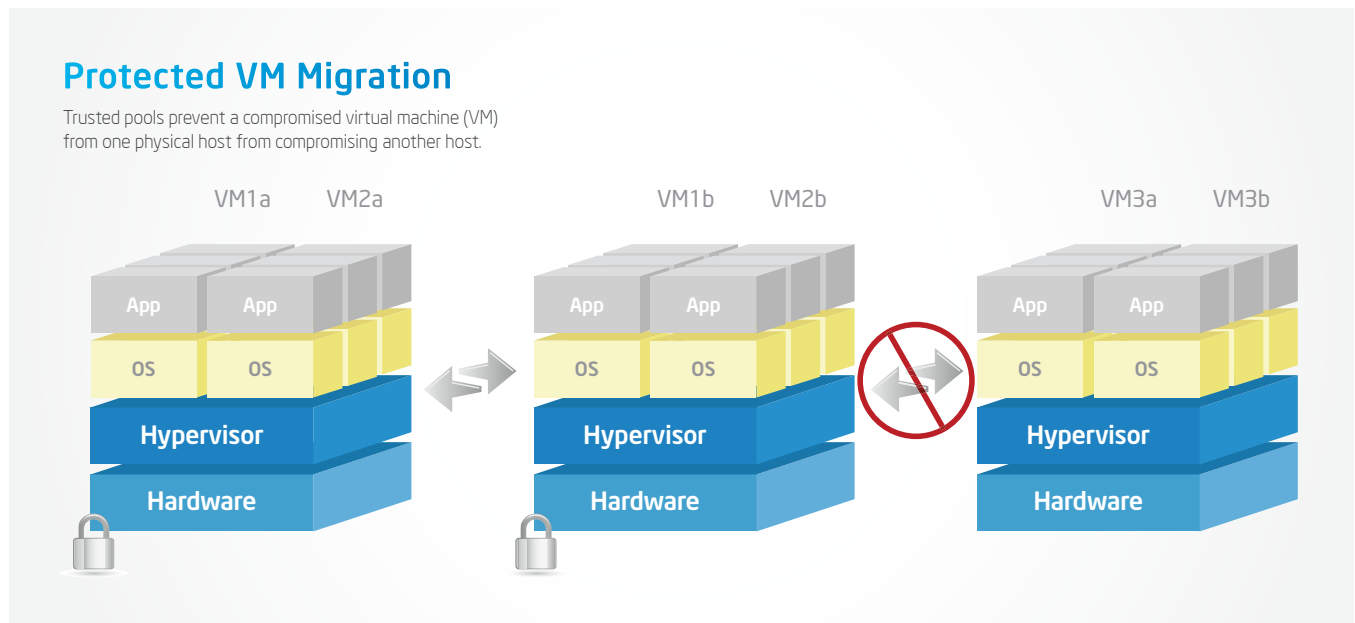
With its heavy dependence on virtualization, cloud computing has elastic boundaries that can push the perimeter of the enterprise far

beyond the data center. The traditional perimeter behind which data and platform are constrained and protected—typically by firewalls, physical separation, and isolation—doesn't work well for dynamic cloud architecture models.

Trust across Dynamic Virtualized Environments

You can build trust across dynamic environments with trusted compute pools of virtualized servers that can be validated or attested by external entities based on known, trustworthy signatures. This pool of resources can provide a level of security for virtual machines before movement to the platform and enable the dynamic migration of VMs from one trusted pool to another.

A trusted compute pool is built from servers that can demonstrate high integrity grouped together by creating policies. The pool substantially reduces the security risks of using a remote or virtualized infrastructure. With a more secure platform, you can add tenants and restrict sensitive workloads to the trusted compute pools to enhance the protection of these workloads.



Trusted pools are an important part of cloud security practices—in your own private cloud, but also as part of the data center operations and security provided by cloud service providers. You need to be able to trust that public clouds are built on this same level of technology.

A Root of Trust

The best way to secure your platform is to enable a trusted foundation that protects your virtualized server environment. The trusted foundation starts with a root of trust at the platform level and extends a chain of trust through measured firmware, BIOS, and hypervisor virtualization—providing protection against a growing set of attacks (rootkit attacks) on the hypervisor and below. A root of trust hardens the platform against attack and is extremely difficult to defeat or subvert. Essentially, you build protection into your hardware to protect your software.

In addition, a root of trust helps ensure system integrity within each system. Intel Trusted Execution Technology (Intel TXT) checks hypervisor integrity at start-up by measuring the code of the hypervisor and comparing it to a known good value. Launch can be blocked if the measurements do not match. It also provides a mechanism for the attestation of platform measurement credentials to local and remote systems to complete the trust verification process and support compliance and audit activities.

Intel TXT builds trust into each server at the most basic level—the hardware. When multiple trusted servers are aggregated into trusted pools, you can protect highly virtualized environments by:

- Creating a policy that restricts the migration of VMs so that only those on trusted platforms can be migrated to other trusted platforms. Trusted pools should always be specified for your most sensitive workloads.

- Proving host software is good by using integrity-checking data for audit purposes with Governance, Risk Management, and Compliance (GRC) or security information and event manager (SIEM) dashboards.
- Responding and recovering better by detecting attacks more quickly, containing the spread of malware, and reducing the need to rebuild hypervisors if a compromise is detected.

Intel's own private cloud architecture is a multitenant environment on virtualized infrastructure as a service (IaaS) running on clusters of Intel Xeon processor-based servers with Intel TXT.¹¹ Management of the clusters is automated and policy driven. The clusters enable live migration of VMs with applications running in them to be moved between servers with no downtime. One-time integrity checks are performed at system or hypervisor start-up. Workloads can be relocated to enable individual servers to be rebooted without interruption to applications—generating frequent system integrity checks as each server reboots and maintaining the trust level in the server pool.

In this usage model, trusted pools built with hardware-based security mechanisms can better protect against software-based attacks and enable you to enforce strict policies that provide a foundation of trust for your services and platforms.

¹¹ *Evolution of Integrity Checking with Intel® Trusted Execution Technology: An Intel IT Perspective*. IT@Intel (2010). intel.com/content/www/us/en/pc-security/intel-it-security-trusted-execution-technology-paper.html (PDF)

Policy-Based Power Management

Imagine this scenario: Your data center architecture has been deliberately oversized to exceed periodic peak loads, but most servers never approach their theoretical power and cooling requirements. Those that do likely run hot at periodic intervals, while rows of underutilized servers draw only a fraction of their allocated resources.

Virtualization has helped mitigate this inefficiency by reducing the number of physical servers required in the data center. However, significant additional savings are possible through an array of

optimization techniques that reduce energy consumption by better balancing resource requirements against workloads and address environmental concerns for greenhouse emissions. After all, power accounts for some 25 percent of typical data center operational costs, and McKinsey estimates that, combined, today's data centers emit as much carbon dioxide as all of Argentina.¹² For large, highly virtualized data centers, policy-based power management schemes can pay off quickly.

Five Approaches to Policy-Based Power Management

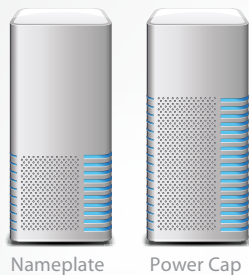
The following five usage scenarios optimize productivity per watt to reduce TCO in highly virtualized data centers. Together they monitor and cap power in real time at server, rack, zone, and data center levels to manage aggregated power consumption and load migration on available power and cooling resources.

Usage Scenario	Description	Power Consumption Benefits
1. Real-time server power awareness	Provides insight into how much power is consumed, so HVAC output can be scaled to the specific need or heat load rather than cooling to a theoretical maximum. Virtual machines (VMs) can be relocated from power-constrained systems to unconstrained systems within the cluster or across different clusters.	<ul style="list-style-type: none">Manage data center hotspots.Reduce chances of hardware failure.
2. Rack density optimization	Maximize available compute resources for increased server density at the same overall power envelope per rack.	<ul style="list-style-type: none">Reduce tendency to overprovision power and cooling.Optimize rack utilization in host data centers with customer power allocation.
3. Power load balancing	Dynamically balance resources by building workload profiles and setting performance loss targets. You can match actual performance against service level agreements (SLAs).	<ul style="list-style-type: none">Utilize existing power more efficiently.Meet SLA requirements more precisely.

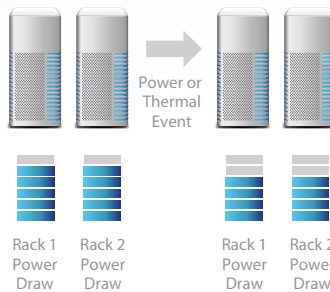
¹² Kaplan, James M., et al. *Revolutionizing Data Center Energy Efficiency* (July 2008). mckinsey.com/client-service/bto/pointofview/pdf/Revolutionizing_Data_Center_Efficiency.pdf (PDF)

Usage Scenario	Description	Power Consumption Benefits
4. Disaster recovery/ business continuity policies	Prioritize business-critical workloads to continue to run normally, while power capping less critical workloads and allowing total power and cooling requirements to fit within diminished capacity during HVAC malfunction or power excursion.	<ul style="list-style-type: none"> ▪ Maintain business continuity for most business-critical workloads.
5. Data center energy reduction	Gain power-aware support for multiple service classes to enforce multiple SLAs across different populations of users with different priority workloads.	<ul style="list-style-type: none"> ▪ Meet different SLAs for different users or different workloads.

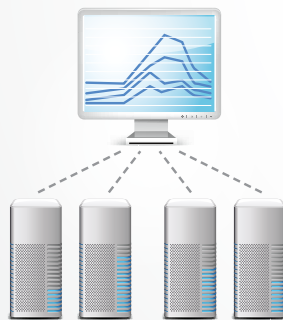
Policy-Based Power Management at a Glance



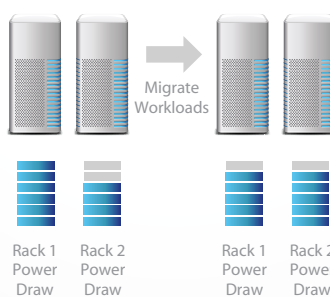
Rack Density Optimization



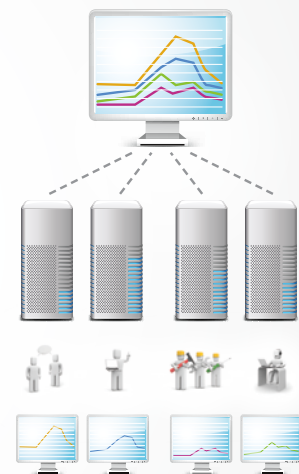
Disaster Recovery/Business Continuity Policies



Real-Time Server Power Monitoring



Power Load Balancing



Power-Aware Support
for Multiple Server Classes

Intel Intelligent Power Technology provides policy-based power management that covers all five usage scenarios for significant energy cost savings. Intel Intelligent Power Node Manager is built into Intel Xeon processor-based servers and reports individual system-level power for use in management consoles and higher-level policy tools to manage server consumption. With Intel Data Center Manager (Intel DCM)—software technology that provides power management up to the data center level for groups of servers—you can increase power conservation for servers, racks, groups of servers, and data centers.

Intel IT has successfully monitored and capped power consumption across individual servers and groups of servers with Intel Intelligent Power Node Manager and Intel DCM. Tests showed that server power consumption was reduced by approximately 20 percent when running an I/O-intensive workload without affecting performance. At that reduced level of power consumption, Intel Intelligent Power Node Manager was able to dynamically balance power requirements so that overall performance was maintained, demonstrating that capping can help maintain business continuity.¹³

¹³ *Data Center Energy Efficiency with Intel® Power Management Technologies*. IT@Intel (February 2010). software.intel.com/sites/datacentermanager/power_mgmt_tech.pdf (PDF)

Intel Resources for Learning More

Intel Cloud Builders Guide: Cloud Design and Deployment on Intel Platforms

The following reference architectures are part of the *Intel Cloud Builders Guide: Cloud Design and Deployment on Intel Platforms* series. They are based on real-world IT requirements and give detailed instructions on how to install and configure a particular cloud solution using Intel Xeon processor-based servers and other Intel and Intel partner technologies.

Policy-Based Power Management with Dell* and VMware*

intel.com/content/www/us/en/cloud-computing/cloud-computing-policy-based-power-management-with-dell-and-vmware-reference-architecture.html

NetApp* Unified Networking and Storage: 10 GbE FCoE and iSCSI

intel.com/content/www/us/en/cloud-computing/cloud-computing-netapp-unified-networking-guide.html

Enhancing Server Platform Security with VMware

intel.com/content/www/us/en/cloud-computing/cloud-computing-xeon-server-platform-security-vmware-guide.html

Scale-out Storage with EMC Atmos*

intel.com/content/www/us/en/cloud-computing/cloud-computing-scale-out-storage-with-emc-atmos-architecture.html

Data Center Design

An Enterprise Private Cloud Architecture and Implementation Roadmap

In this white paper, Intel IT defines a path for building and implementing a private cloud for the enterprise. This is a significant shift to a new enterprise architecture based on a cloud computing approach. Cloud computing is a shared, multitenant environment built on a highly efficient, automated, virtualized infrastructure.

intel.com/content/www/us/en/cloud-computing/cloud-computing-private-cloud-roadmap-paper.html

An IT Cloud Computing Roadmap from Intel IT

A video (length: 4:30) featuring Intel IT experts who talk about building and implementing the private cloud at Intel.

connectedsocialmedia.com/5269/an-it-cloud-computing-roadmap-from-intel-it/

Unified Networking

The following papers highlight the benefits of unified networking, approaches to enabling it, and the ways that Intel and three of its partners are helping to bring important consolidation-driving technologies to enterprise data center customers.

Simplifying the Network with 10 Gigabit Ethernet Unified Networking: An Intel and EMC Perspective

intel.com/content/www/us/en/ethernet-controllers/ethernet-software-compatible-with-emc-storage-systems-paper.html

The Transition to 10 Gigabit Ethernet Unified Networking: Cisco and Intel Lead the Way

[intel.com/content/www/us/en/network-adapters/10-gigabit-network-adapters/10-gigabit-ethernet-unified-networking-cisco-paper.html?wapkw=the transition to 10 gigabit ethernet unified](http://intel.com/content/www/us/en/network-adapters/10-gigabit-network-adapters/10-gigabit-ethernet-unified-networking-cisco-paper.html?wapkw=the%20transition%20to%2010%20gigabit%20ethernet%20unified)

Unified Networking on 10 Gigabit Ethernet: Intel and NetApp Provide a Simple and Flexible Path to Cost-Effective Performance of Next-Generation Storage Networks

intel.com/content/www/us/en/network-adapters/10-gigabit-network-adapters/10-gigabit-ethernet-unified-networking.html

Upgrading Data Center Network Architecture to 10 Gigabit Ethernet

Data center trends like server virtualization and consolidation, along with rapid growth in design computing, have put a strain on Intel's network. While high-performance Intel processors and clustering technologies are rapidly improving server performance, the Intel network has become the limiting factor in supporting faster throughput. This white paper discusses how Intel IT upgraded our data center network architecture to 10 GbE to accommodate these increasing demands.

intel.com/content/www/us/en/data-center-efficiency/intel-it-data-center-efficiency-upgrading-data-center-network-architecture-to-10-gigabit-ethernet-practices.html

Scale-out Storage

Ready for Cloud Storage? Key Considerations and Lessons Learned (BrightTalk Webcast)

This webcast of a panel discussion moderated by the Storage Networking Industry Association (SNIA) Cloud Storage Initiative includes an overview of data based on a recent research report. A lively discussion focuses on overcoming barriers to adoption and key considerations for companies weighing pros and cons of the cloud. Panel members are end users, including Ajay Chandramouly from Intel, and discuss their experiences with cloud storage.

brighttalk.com/webcast/679/27865

Trusted Server Pools

Evolution of Integrity Checking with Intel® Trusted Execution Technology: an Intel IT Perspective

Intel IT is transitioning to an enterprise private cloud to support enterprise computing applications. This multiyear initiative is designed to enable greater agility and efficiency and involves a phased implementation that progressively moves more important applications to the cloud. The highly virtualized multitenant environment creates new security challenges, including those presented by emerging threats such as rootkit attacks.

intel.com/content/www/us/en/pc-security/intel-it-security-trusted-execution-technology-paper.html

Policy-Based Power Management

Data Center Energy Efficiency with Intel® Power Management Technologies

This IT@Intel brief describes the evaluation of Intel Intelligent Power Node Manager and Intel Data Center Manager. The tests assessed the potential for these Intel power management technologies to increase data center energy efficiency and validate potential usage models.

software.intel.com/sites/datacentermanager/power_mgmt_tech.pdf

The Efficient Data Center: Using Data Center Instrumentation and Server Refresh to Optimize Compute Performance in Constrained Environments

This paper describes the challenges facing IT managers, such as limited power, increasing cooling demands, and space constraints, and describes the importance of managing power and cooling challenges to reduce costs.

intel.com/Assets/PDF/The-Efficient-Data-Center-Server-Instrumentation-and-Refresh.PDF

Additional Resources

The Digital Universe Decade—Are You Ready?, IDC Digital Universe Study, sponsored by EMC, May 2010.

This study explores the explosive growth of digital information, with projections through 2020. It describes how the consumerization of IT (consumer technologies in the workplace) will create stresses on organizations that must handle all this electronic content and discusses emerging technologies that can help them cope.

http://viewer.media.bitpipe.com/938044859_264/1287663101_75/Digital-Universe.pdf

Revolutionizing Data Center Energy Efficiency

This report describes part of McKinsey's ongoing body of research on data center management and is designed to help organizations improve data center energy efficiency in terms of cost and greenhouse gas emissions.

http://mckinsey.com/client-service/bto/pointofview/pdf/Revolutionizing_Data_Center_Efficiency.pdf

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No computer system can provide absolute security under all conditions. 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). Intel TXT also requires the system to contain a TPM v1.s. For more information, visit intel.com/content/www/us/en/data-security/security-overview-general-technology.html.

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