



The New Enterprise Data Center Technical White Paper

Abstract: *This paper describes the technical view of the new enterprise data center through a conceptual view of the components and key elements, a staged approach and a set of patterns to guide data center transformation activities for the new enterprise data center.*

TABLE OF CONTENTS

1.0 INTRODUCTION	2
<i>1.1 Business Drivers for the Adoption of the New Enterprise Data Center</i>	2
2.0 THE NEW ENTERPRISE DATA CENTER “EVOLUTION”	3
Simplified stage	5
Shared stage	6
Dynamic stage	7
Defining characteristics mapped to each stage of adoption	8
3.0 CHARACTERISTICS OF THE NEW ENTERPRISE DATA CENTER	10
<i>3.1 Highly Virtualized Resources</i>	10
Consolidation of resources	10
Virtualization of resources	11
Ensembles	12
<i>3.2 Efficient, Green and Optimized Infrastructure and Facilities</i>	13
<i>3.3 Information Infrastructure</i>	15
<i>3.4 Security and Business Resiliency</i>	17
Security evolution	17
Risk factors and resiliency	18
Recovery planning and trusted virtual domains	19
<i>3.5 Business-driven Service Management</i>	20
IT service management	20
IT operational management	21
IT process management	22
<i>3.6 Service-Oriented IT Delivery</i>	22
Cloud computing	23
Cloud computing evolution	23
Service-oriented IT delivery transformation	24
4.0 WHY IBM?	26
5.0 NEXT STEPS	27

1.0 INTRODUCTION

Rather than simply comprising a cost to do business, information technology (IT) should link with and complement business strategy. This requires an efficient, flexible and resilient infrastructure that is primed to anticipate and respond rapidly to shifting business requirements. These requirements have driven us to the evolution of a new data center architecture—one that allows for massive scalability and dynamic responsiveness while also providing an energy efficient and resilient infrastructure.

This paper presents a technical overview of the new enterprise data center, including a description of its key characteristics, a description of the functions and capabilities of the underlying architecture and a description of an evolutionary approach to implementation through stages of adoption. The new enterprise data center strategy allows companies to focus on the services provided by the infrastructure, rather than on the underlying technology that enables these services. For example:

- Through a service-oriented approach to IT delivery, the new enterprise data center provides enterprises with greater flexibility and agility, helping them to move toward dynamic infrastructures.¹
- Forty percent of data center operators report power demand outstripping supply. The new enterprise data center improves data center energy efficiency through exploitation of virtualization-enabled consolidation, resource optimization and active energy management.²
- Cloud computing is the natural outcome of next generation data centers. By 2010, thousands of business applications across both horizontal and vertical markets will be available off the cloud, and several Application Platforms as a Service will be seen as safe for ISVs and enterprise in-house IT projects. By 2012, cloud-based business applications will be mainstream.³

The new enterprise data center strategy allows companies to focus on the services provided by the infrastructure, while streamlining the underlying technology that enables these services. Thus, it yields a more productive and satisfied user community, as well as provides better alignment between business priorities and information technology investments.

1.1 Business Drivers for the Adoption of the New Enterprise Data Center

After years of working with thousands of clients in their data center transformations, IBM has taken a holistic approach to the transformation of IT and has developed the new enterprise data center—a vision and strategy for the future of enterprise computing. The new enterprise data center enables you to leverage today's best practices and technologies to better manage costs, improve operational performance and resiliency and quickly respond to business needs. Its goal is to deliver the following:

- **Improved IT efficiency**—The new enterprise data center helps to transcend traditional operational issues in order to achieve new levels of efficiency, flexibility and responsiveness. Through virtualization, you can uncouple applications and business services from the underlying IT resources to improve their portability, as well as exploit highly optimized systems and networks to improve efficiency and

reduce overall costs.

- **Rapid service deployment**—The ability to deliver quality service is critical to businesses of all sizes. Service management enables visibility, control and automation to deliver quality service at any scale. Maintaining user satisfaction and ensuring cost efficiency and return on investment depends upon your ability to see the business (visibility), manage the business (control) and leverage automation (automate) to drive efficiency and operational agility.
- **Highly responsive and business goal driven**—A highly efficient, shared infrastructure can help businesses respond instantaneously to evolving demands. It creates opportunities to make sound business decisions based on information obtained in real time, and alignment with a service-oriented approach to IT delivery provides the framework to free up resources from more traditional operational demands and to focus them on real-time integration of transactions, information and business analytics.

2.0 THE NEW ENTERPRISE DATA CENTER “EVOLUTION”

The new enterprise data center represents an evolutionary model across three stages of adoption: *simplified, shared and dynamic*.



DRIVES IT EFFICIENCY

- Physical consolidation and optimization
- Virtualization of individual systems
- Systems, network and energy management



RAPID DEPLOYMENT OF NEW INFRASTRUCTURE AND SERVICES

- Highly virtualized resource pools—“ensembles”
- Integrated information infrastructure
- Security and business resiliency
- Green by design



HIGHLY RESPONSIVE AND BUSINESS DRIVEN

- Virtualization of IT as a service—“cloud computing”
- Business-driven service management
- Service-oriented delivery of IT

Each of these stages is realized through the implementation of one or more architectural patterns. Patterns are methods, approaches and best practices that, when implemented, strive to attain a particular goal. The architectural patterns include:

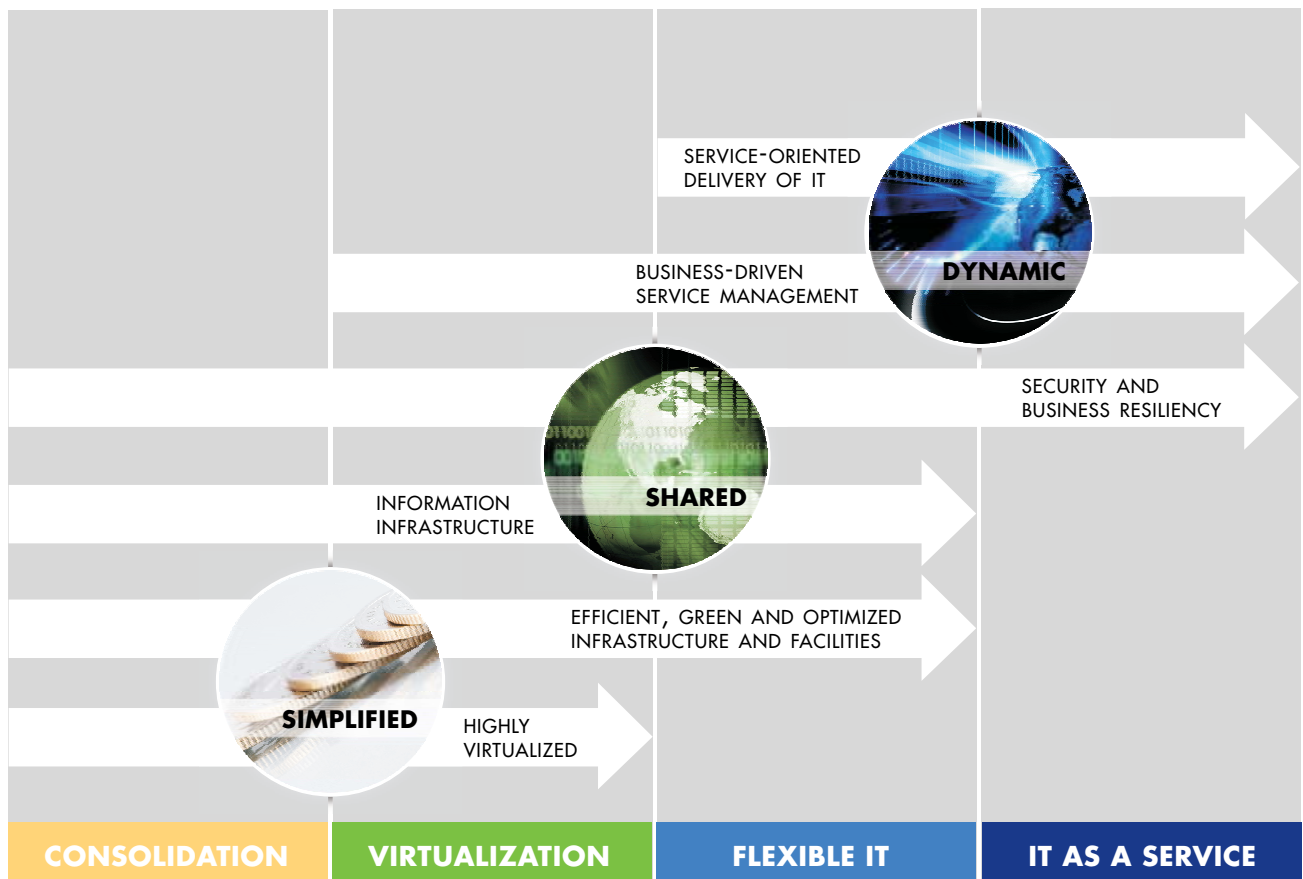
- **Consolidation pattern**—Simplifies and reduces IT and facilities assets, and standardizes IT management processes.

- **Virtualization pattern**—Virtualizes IT assets, improves utilization, simplifies systems management and enables dynamic systems migrations.
- **Flexible IT pattern**—Responds more easily to changes and adapts the infrastructure through automated provisioning, policy-driven service level management, dynamic scheduling and movement of resources, predictive planning and task automation based on workflow execution.
- **IT-as-a-Service pattern**—Enables the highest degree of dynamic and automated IT capabilities delivered as a set of services that can be subscribed, provisioned and managed throughout their life cycle.

Aligned with the architectural patterns are a set of key characteristics outlined below that serve as the modular building blocks in the evolution of a new enterprise data center. The architectural patterns apply these characteristics to realize the proposed stages of adoption in a progressive journey—an *evolution* rather than a *revolution*. These defining characteristics include:

- **Highly virtualized resources** leverage virtualization technology and IT consolidation roadmaps to optimize physical IT resources while delivering on service-level agreements (SLAs).
- **Efficient, green and optimized infrastructure and facilities** use technologies and data center best practices that enable management of facilities and overall energy consumption in partnership with IT management.
- **Information infrastructure** helps clients meet the challenges of information explosion by improving the management of information availability, security, retention and compliance.
- **Security and business resiliency** is manifested in business continuity strategies, security technologies and a highly resilient infrastructure.
- **Business-driven service management** delivers a well-defined service management architecture and infrastructure to leverage industry standards and best practices (such as ITIL, eTOM, PRM-IT, etc.) for IT management aligned to business needs.
- **Service-oriented delivery of IT** is a new paradigm in which IT-enabled capabilities are provided as a service to customers, and are rapidly deployable with automation, quickly scaling up to meet elastic demands.

The diagram below applies the key evolutionary characteristics to illustrate how the architectural patterns are associated and aligned with adoption stages in the journey to a new enterprise data center.



Simplified stage

The *simplified* stage addresses the complexity of server sprawl, including many data center locations, disparate management tools and inconsistent processes by introducing consolidation, virtualization and standardization.

This stage begins by consolidating IT assets and data center facilities and standardizing management tools and processes. The consolidation pattern is used to help transform the data center in the following areas:

- **Infrastructure consolidation and simplification**—Reduce server footprints and disparate architectures; eliminate unneeded data copies; consolidate the application portfolio, network and storage and data centers and sites. The goal of these activities should be to reduce unnecessary complexity that does not enhance IT value.
- **Energy efficiency**—Phase out older and less efficient hardware, understand current energy use, perform thermal analysis and identify and eliminate unnecessary applications and servers.
- **IT management**—Standardize and centralize integrated systems, storage, energy and application management tool sets and processes.
- **Security and business resiliency**—Reduce operational costs associated with outages by strengthening the resiliency and security infrastructure to include appropriate levels of business continuity and integrated security. Resiliency

techniques such as active/standby and active/active configurations can be implemented across a set of infrastructure resources that support critical applications.

- **Organization alignment**—Align the organization's processes to industry best practices, such as ITIL, and garner support from business units to support application consolidation.

Following consolidation, virtualization of IT assets is the next logical step in increasing resource utilization levels and driving down management and energy costs. Virtualization enables upgrades, failovers and migrations without disruption or downtime. The virtualized infrastructure provides the agility required for the dynamic movement of workloads across resources. The virtualization pattern is used as a means to help transform data centers in the following areas:

- **Infrastructure virtualization**—Virtualize servers and storage, converge networks and perform application virtualization.
- **Energy efficiency**—Maximize effective use of low-power states in systems and implement dynamic energy management of IT resources.
- **IT management**—Unify physical and virtual system management, adapt energy management to dynamic energy needs and unify configuration and asset management.
- **Organization alignment**—Implement organizational policies necessary to support a virtual infrastructure and adapt ITIL-aligned best practices to support virtualized infrastructure.

In summary, the simplified stage provides control over the entire IT infrastructure through the reduction of complexity, while simultaneously producing cost savings, which can be used to fund activities in later stages.

Shared stage

As enterprises implement activities in the simplified stage, the inefficiencies associated with business unit-specific infrastructure designs become apparent. The shared stage involves moving from organizational and technological silos to a shared services model. This stage creates a shared IT infrastructure that can be provisioned and scaled rapidly and efficiently. Organizations can create virtualized resource pools for server platforms, storage systems, networks and applications, delivering IT and information to end users in a more fluid way. Advanced virtualization patterns and increased automation are key elements at this stage of IT transformation.

By centralizing policies and consolidating server, storage and network capacity across the enterprise, IT organizations position themselves to balance infrastructure demands across business units. Through the integration of infrastructure and the breaking down of silos, a shared view of information access that is consistent and reliable across the enterprise is achieved.

The virtualization pattern helps to scale up shared capacity through virtual infrastructure

deployment across the enterprise, thereby making more efficient use of the total capacity available. Ensembles, which expand the boundaries of virtualization across homogeneous resources to make them appear as one contiguous pool, will further help to share infrastructure for effective utilization across the enterprise. This provides the flexibility required to create logical resources of any size to meet application needs, as well as eliminates inefficiencies caused by underutilization of infrastructure at the physical layer.

The flexible IT pattern drives automation across various service management functions, providing visibility and control of the shared infrastructure performance and availability at the application level, rather than at the physical device level. Basic automation helps to reduce manual error-prone tasks, such as provisioning of infrastructure, and increases human efficiency, allowing a smaller number of IT professionals to manage a larger environment. Advanced automation implements autonomic technologies through a policy-based orchestration to dynamically adjust resource capacity or to move workloads to meet varying demands. Metering technologies track resource consumption, providing visibility into the “cost of manufacturing” for IT-enabled business services. The features of the flexible IT pattern significantly improve both business performance and the ability to meet service levels, as well as further reduce the percentage of the IT budget consumed by operational activities.

The shared stage also helps to enhance energy efficiencies through the implementation of energy management software, which can intelligently monitor power and cooling across the infrastructure and facility resources. Techniques such as hibernation turn off unneeded power and cooling sources, or move underutilized resources to low-power states.

As flexibility and automation are increased across the shared infrastructure, security and resiliency within the shared data center must also be enhanced. This stage expands resiliency to include heterogeneous environments and should provide a central point of management for multiple systems or applications. Monitoring and management should be automated, and switching should include as little human intervention as possible. The security requirements are addressed by implementing identity management solutions and by applying network-level isolation techniques to prevent intrusions and to ensure the integrity of applications and data on the shared infrastructure. Resiliency techniques, such as active/active or active/standby configurations, can be implemented across a set of infrastructure resources that support business-critical applications.

Dynamic stage

The *dynamic* stage leverages the principles of the service-oriented IT delivery model to create and deliver IT as a set of services. At this stage, the IT-as-a-service pattern utilizes the virtual infrastructure and automated service management capabilities established in the prior stage to create a layer of abstraction between the IT service and the physical infrastructure. By hiding technology complexities and making IT available as a consumable service that can be subscribed to, provisioned and managed throughout its life cycle, IT becomes a contributor, rather than an inhibitor, to business innovation.

At this stage, the IT-as-a-service pattern models the business processes, identifying

opportunities to leverage technology for business benefits and composing them into a set of service definitions. These service definitions are made available to end users in the form of a service catalog. Each of the services included in the catalog are implemented through a set of automated workflows designed to fulfill service expectations.

The emergence of cloud computing, in which IT services are delivered over a network, makes this stage more dynamic. Essentially, cloud-enabled infrastructures are built based on a service-oriented delivery model and allow for massive scaling and rapid delivery of IT services. This process can be further accelerated through the use of ensembles, enabling IT staff to view and access infrastructure pools as one contiguous capacity. These dynamic characteristics encourage the adoption of cloud computing, which can deliver IT services as true “cloud experiences” to users. The latest technology innovations facilitated by cloud computing and ensembles will also help to accelerate dynamic stage adoption.

The rapid deployment of development and test environments to support the dynamic release cycles of an application life cycle is an example of a simple IT service available at this stage. These environments can be rapidly created and decommissioned, leveraging a dynamic infrastructure that is truly economical, highly integrated, agile and responsive. Another example is the massive scaling of production infrastructure to add capacity on the fly, as demands continue to grow. The true dynamic nature at this stage will allow workloads to be moved across the infrastructure to eliminate the downtime for planned maintenance, thus increasing the business continuity and SLAs for the IT services being delivered.

Defining characteristics mapped to each stage of adoption

The following table depicts a summary mapping of each of the six defining characteristics to the corresponding stages of adoption:

DEFINING CHARACTERISTICS	SIMPLIFIED	SHARED	DYNAMIC
HIGHLY VIRTUALIZED RESOURCES	<p>Physical consolidation and optimization</p> <ul style="list-style-type: none"> • Server, storage and data center facility consolidation • Network convergence <p>Virtualization of individual systems</p> <ul style="list-style-type: none"> • Server, storage, application, network and desktop virtualization 	<ul style="list-style-type: none"> • Highly virtualized “ensembles” • Creation of a management layer to view the entire shared capacity as a contiguous linear system 	<ul style="list-style-type: none"> • Advanced virtualization that supports cloud computing
EFFICIENT, GREEN AND OPTIMIZED INFRASTRUCTURE AND FACILITIES	<p>Energy efficiency through consolidation</p> <ul style="list-style-type: none"> • Eliminates unused applications and servers • Implements energy management of IT resources • Upgrades to new, more efficient technology 	<p>Green by design</p> <ul style="list-style-type: none"> • Intelligent power and cooling algorithms • Hibernation and low-power mode switching of underutilized resources • Standard and modular facilities building blocks, such as high density zones, to evolve a green data center 	<ul style="list-style-type: none"> • Automatic workload distribution to low-power systems • Scheduling of infrastructure load to eliminate data center “hotspots” • Climate and time of day considered during execution of jobs
INFORMATION INFRASTRUCTURE	<ul style="list-style-type: none"> • Reduces multiple copies of data into a single consistent architecture for information access 	<p>Shared view of information across enterprise</p> <p>Integrated and shared infrastructure provides:</p> <ul style="list-style-type: none"> • Information availability • Information retention • Information security and compliance 	<ul style="list-style-type: none"> • Information on demand leverages service-oriented delivery of IT
SECURITY AND BUSINESS RESILIENCY	<ul style="list-style-type: none"> • Secured infrastructure with network isolation and encryption • Authentication and authorization • Active/active and active/standby configurations to meet required service levels 	<p>Enterprise security</p> <ul style="list-style-type: none"> • User identity management and single sign on across shared infrastructures and applications • Increased availability with a single point of control using automated management and monitoring 	<p>Business resiliency</p> <ul style="list-style-type: none"> • Policy-based access • Matured process governance • Resiliency through self-healing, autonomic components and applications that switch without interruption to the user
BUSINESS-DRIVEN SERVICE MANAGEMENT	<p>Standardized management processes</p> <ul style="list-style-type: none"> • Centralizes management systems • Aligns organization to ITIL best practices • Integrated physical and virtual systems management 	<p>Central management and automation</p> <ul style="list-style-type: none"> • IT metering and cost allocation • Automated discovery and configuration management • Manage availability at the service levels and business priorities 	<ul style="list-style-type: none"> • Highly automated management functions to deliver IT services • Predictive capacity planning • Management of the full services life cycle • Continuous process improvement
SERVICE-ORIENTED DELIVERY OF IT	<ul style="list-style-type: none"> • Virtualization across IT infrastructure sets the stage and serves as the foundation for this new model of IT delivery 	<ul style="list-style-type: none"> • Dynamic workload management • Automation across multiple service management functions, including provisioning 	<p>IT as a service through cloud computing</p> <ul style="list-style-type: none"> • Subscription-based IT services • Rapid deployment of infrastructures • Integration of real-time data and analytics

3.0 CHARACTERISTICS OF THE NEW ENTERPRISE DATA CENTER

The sections below describe the technology aspects in support of achieving the desired characteristics of the new enterprise data center—highly virtualized, energy efficiency, information integration, security, business resiliency, service management and service-oriented delivery of IT. Each characteristic is backed by IBM's reference architecture, which can be leveraged to form the basis of an enterprise-specific IT architecture.

3.1 Highly Virtualized Resources

A key attribute of the new enterprise data center is its ability to deliver IT services in a highly virtualized manner that integrates the overall enterprise business goals and objectives into the IT framework. The distributed, scale-out IT model that was prominent in the 1990s can no longer sustain itself in the 21st century; the pendulum is swinging back towards a centralized, highly-integrated and business-friendly IT model.

The sheer growth of deployed IT components, be they server, storage or networking entities, coupled with the associated management costs and surrounded by ever-increasing electricity costs, makes this a challenging environment for data center managers and IT executives.

Creating a highly-virtualized IT environment requires the use of resource consolidation and virtualization technologies. These form the core building blocks for advancement toward higher levels of optimization and improvement of IT efficiency.

Consolidation of resources

As mentioned above, IT consolidation serves as an initial step toward achieving higher levels of virtualization. Consolidation typically spans servers, storage, networks and data center facilities, and leads to greater IT efficiency. Sweeping up distributed servers with underutilized capacities and consolidating them into fewer, more efficient and better managed servers offers significant benefits. It is not uncommon for distributed servers to run, on average, at 10 percent of their full utilization capabilities. When you consider the fact that many enterprises may have hundreds or thousands of servers deployed, it's easy to appreciate the value that server consolidation can provide.

Rationalizing silos of storage and incorporating them into an enterprise-wide storage-area network (SAN) offers not only immediate cost efficiencies, but also strategic alignment for future information management initiatives.

Network consolidation leads to standardization on a single, enterprise-wide network architecture that provides access to information anytime, anywhere, thereby supporting the needs of today's global enterprises. It also offers cost efficiencies by bridging voice and data network investments, while also enabling higher levels of productivity through advanced communications and collaboration applications.

Lastly, any consolidation initiative must take into account a data center strategy and the potential benefits associated with consolidating facilities. The same attributes of cost, efficiencies and return on investment that apply to servers, storage and networks also apply to data center facilities. In fact, they likely offer the most significant opportunities

for cost savings.

IBM offers the industry's most scalable servers, as well as storage products that are ideal platforms for consolidation. We have years of experience working with clients to address their data center strategies for consolidation, and have harnessed unique intellectual capital that is included in our technology services. Our products and services are tailored to help clients assess, plan, design and implement the right consolidation solutions for their needs.

Virtualization of resources

Virtualization is another important building block in the process of becoming a highly optimized IT provider. IBM is no stranger to virtualization technologies, having built these capabilities into its mainframe servers as early as the 1970s, and having continued to enhance these capabilities and offer them across its complete server and storage product lines. This practical experience has allowed IBM to offer valuable virtualization points of entry through hardware logical partitioning; dynamic and scalable virtual guest hosting; virtualized I/O; industry-leading, finer-grain virtualization; more comprehensive management capabilities; and seamless integration with other virtualization layers that exist in the marketplace.

Gartner predicts that:

- The installed base of virtual machines will grow more than tenfold between 2007 and 2011.
- One out of every four x86 workloads deployed or redeployed during 2008 will be installed in virtual machines, and by 2012, the majority of x86 server workloads will be running in a virtual machine. ⁴

IBM's experience is based on more than 30,000 enterprise clients who have deployed system-level virtualization capabilities with IBM offerings. Our IBM System x™ customers are deploying over 1,000 virtual servers a day, and we have more than 2,000 customers using storage virtualization. IBM typically expects that 80 percent of a client's infrastructure can be virtualized.

So, how do you begin? While you can consolidate similar IT resources to gain simple efficiencies, such as by moving a SAP R/3 distributed three-tier server environment into a two-tier environment based on fewer yet more powerful servers, virtualization offers additional capabilities that address inefficiencies across a more disparate set of environments, while offering similar and compelling benefits. Using the SAP R/3 example, virtualization might allow for additional application workloads to be executed on the same servers to take advantage of available capacity. By consolidating multiple applications onto a single server running multiple virtual servers, a significant reduction in the number of physical servers—and a corresponding improvement in server utilization rates—is obtainable. With our IBM POWER System servers, fine-grain virtualization can support a more effective allocation of resources by dynamically allowing for as little as one-tenth of a processor to be virtualized.

A recent Forrester report indicates that 65 percent of enterprise decision makers expect to use server virtualization by 2009.⁵ Not surprisingly, IBM's market research confirms that virtualization implementation continues across the industry. IBM's strategy for the new enterprise data center positions virtualization as a key element in assisting data center managers seeking to simplify the integration of complex server, storage and networking architectures. Virtualization removes barriers that inhibit the increased use of IT resources, maximizes the use of existing IT investments, helps improve productivity by fostering an environment that supports composite applications and aligns the performance of the IT infrastructure with an organization's business goals.

Ensembles

Growing business demands are causing customers to look for ways to extend the characteristics of virtualization that can scale up horizontally across a pool of similar systems. This leads to the evolution of ensembles aimed at reducing complexity and management overhead by creating large pools of like resources that are managed as one.

Ensembles simplify and improve the planning, deployment, configuration, operations and management of the new enterprise data center. Ensembles can scale from a few to many thousands of systems while maintaining management complexity and costs essentially independent of their size and similar to those of a single system. Ensembles can be classified into four types:

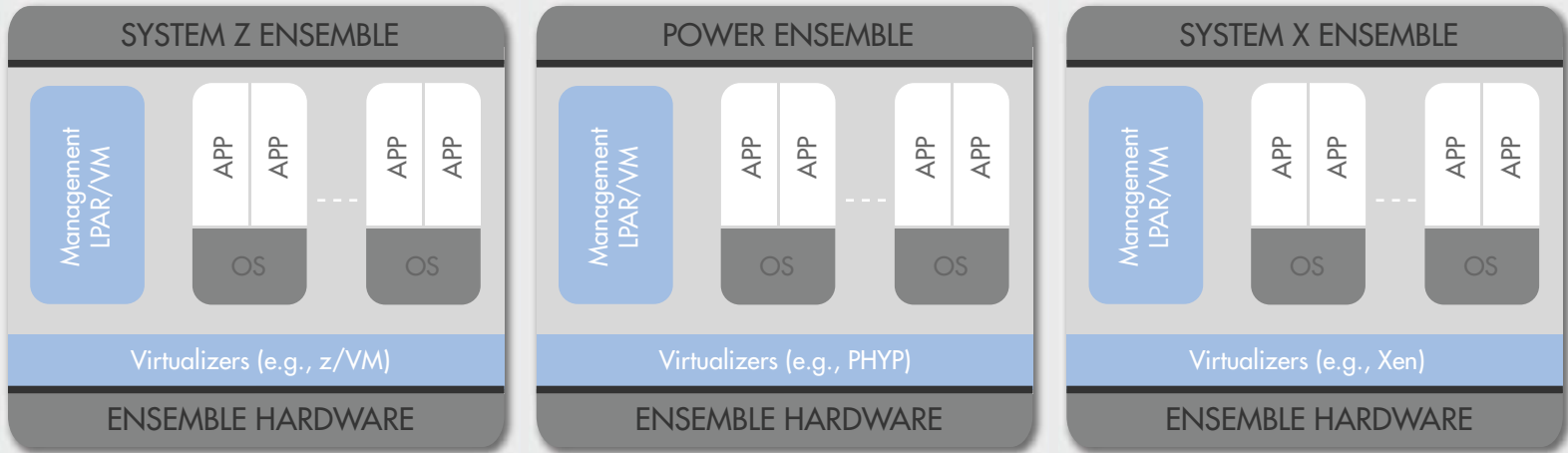
- A **server ensemble** is a collection of servers that are managed as a homogenous pool of compute resources, and it includes the software to manage itself. It has an integrated virtualization stack, and all of the resources in the ensemble are virtualized. Each ensemble contains a set of compatible servers typically consisting of a single processor architecture (e.g., POWER™, x86, AMD, z/Architecture®).
- A **storage ensemble** is a set of storage resources designed to be managed as a single unit that offers services to other systems or ensembles within a highly virtualized environment. These storage services could include raw block devices (e.g., LUNs or iSCSI) and access to shared storage (e.g., NAS, GPFS/SOFS, iSCSI), or virtual storage (e.g., SVC).
- A **network ensemble** is a collection of network resources structured to deliver a set of network services and characteristics that support applications directly connected to the ensemble. Each network ensemble contains access and aggregation switches in a layer 2 OSI stack with IP routing for external connectivity, and may include a set of network services, such as filtering, load balancing, offload or monitoring.
- A **solution ensemble** is a pool of machines, typically in the form of a server ensemble and possibly attached to a storage ensemble, that are richly interconnected through a network ensemble, which enables a cooperating group of software applications to be provisioned one or multiple times within a server ensemble.

An *ensemble manager* is a key component of all ensembles, and is responsible for the systems management aspects of an ensemble, such as workload optimization, availability,

restart, recovery and ability to change software. It also has hardware resource management responsibilities, including functions such as heat production and power consumption.

SYSTEMS DIRECTOR—Manages ensembles and individual servers

ENSEMBLE MANAGER—With extensions as needed per ensemble type



STORAGE SERVER ENSEMBLES

INDIVIDUAL SERVERS

As described in the diagram above, an ensemble manager provides all of the external interfaces and states of the ensemble, as well as the capabilities and behaviors inherent to the ensemble. The ensemble manager will serve as an extension of IBM Systems Director to manage multiple ensembles in an ecosystem. The ensemble manager provides an aggregated view of how the ensemble is running (health monitoring, metering, utilization, etc.), encapsulating the individual components that make up the ensemble and appearing to the rest of the data center as a single, continually available, dynamically scalable virtualized server.

3.2 Efficient, Green and Optimized Infrastructure and Facilities

After conducting an intensive study of server and data center energy efficiency for the U.S. Congress, the Environmental Protection Agency (EPA) reported that the U.S. data center industry is in the midst of a major expansion period spurred by increased demand for IT capacity to support business growth. The EPA listed several trends that are stimulating this demand, including:

- Increased use of online banking and electronic stock trading;
- Adoption of Internet-based communications and entertainment;
- A shift toward using electronic medical records for healthcare;

- Globalization of competition; and
- Government regulations requiring digital records retention.⁶

To satisfy this robust demand for computing capacity, IT executives are increasing both the numbers and the density of their servers and storage devices. IBM and consultant studies project that the server installed base will increase by a factor of six between 2000 and 2010, while storage is expected to grow even more significantly.⁷

Rising energy costs affect businesses of all sizes. IBM surveyed more than 1,100 executives from small and mid-size businesses across ten markets in Europe, Asia and the Americas. Nearly half of those surveyed reported that energy represented one of their largest cost increases over the past two years.⁸

Increased demand for IT capacity to support business growth, increased energy use by the data center, rising energy costs and environmental concerns are coming together to define a new field of competition for the enterprise—data center energy efficiency. The more energy efficient your data center, the more prepared your company will be to compete in a business environment where energy is becoming increasingly expensive.

IBM Systems lead the way to higher efficiencies and improve the ratio of compute capacity per kilowatt consumed. Further, IBM's leadership in virtualization helps IBM servers achieve a higher level of utilization, thus significantly reducing the number of servers and, consequently, the space, power and cooling required. IBM systems also provide technology that allows the power associated with a system to be monitored, managed and capped.

According to Gartner, "Traditionally, the power required for non-IT equipment in the data center (such as that for cooling, fans, pumps and UPS systems) represented on average about 60 percent of total annual energy consumption."⁹ Based on the data center energy-efficiency assessments that it conducts for clients around the world, IBM has learned that it can implement effective solutions to reduce such high consumption by 15 to 40 percent annually.¹⁰ This means that the payback on investment can be achieved in as little as two years, thereby covering the cost of the assessment in the first year.

The data center energy challenge affects both the physical data center and the IT infrastructure. IBM assessments provide insight into not only the data center's energy efficiency, but also the potential for gaining efficiencies through server and storage consolidation. These assessments of the current state of your data center can be compared to industry benchmarks, and they provide a fact-based business case for making improvements.

Compounding the financial challenges that occur when the rising demand for IT capacity meets the rising cost of energy, data centers themselves are often out of sync with the information technologies they support. A study conducted by Gartner found that "36 percent of respondents indicated that their organizations' newest data centers are seven or more years old."¹¹ By contrast, IBM's client experience has indicated that the IT equipment in those data centers typically turns over every two to four years. As a result, the

older data centers may not be able to power and cool the newer IT equipment—especially blade servers—in an energy-efficient manner.

Cooling new IT equipment has become a major problem in many data centers. According to Gartner, “High-density equipment, such as blade servers, demand enormous equipment power and air conditioning power. Rack enclosures can accommodate 60 to 70 (IU) units, equating to 20,000 watts to 25,000 watts of power per rack. In addition, for every watt of equipment power, there is a need for another 50 percent to 60 percent for air conditioning equipment.”¹² Innovative cooling technologies can help you beat the heat in high-density computing facilities, and they can enable and accelerate the growth of IT capacity by making it possible for the data center to increase its use of blade servers.

IBM’s active energy management software includes a new monitoring and management function that integrates geospatial visualization, device monitoring and the ability to “take action” to manage energy efficiently. This enables administrators and/or autonomic software to correlate IT equipment power/thermal events with IT performance events, and to more quickly identify root cause problems and solutions. For example, from a single interface, a system administrator can drill down into the power, temperature and performance of a selected device and resolve a temperature-over-threshold alert by capping or reducing the power consumed by the device, as long as a lower power state can still achieve the defined service level agreement.

Autonomic management of the power consumption in the new enterprise data center is not restricted to adjustments of the IT equipment. Government Computing News (GCN) reported in June of 2007 that “instead of separate data, building, access, physical security, elevator, HVAC, fire and energy systems—with separate control environments and their own console and monitoring programs—the goal is to use IP to centrally manage everything.”¹³ IBM management software will be a leader in integrating the automation of building automation systems with IT infrastructures, providing a holistic solution for managing energy consumption in the new enterprise data center.

IBM’s software balances and adjusts the workloads across a virtualized infrastructure, aligns the power and cooling consumption with business processing requirements and provides the means to fairly allocate energy costs to users based on the energy they consume. As a result, energy demands are balanced to avoid high peak energy use and the associated higher energy billing rates, while still meeting service level agreements aligned with business priorities.

By working with partners, IBM can provide its customers with comprehensive green data center implementations that bridge modularized facilities’ building blocks, and provide energy-efficient IT and cooling solutions. These services help to unlock additional power and cooling capacity by identifying and resolving problems with air management, utilization of water cooling, advanced stored cooling technology and over-provisioned power budgets.

3.3 Information Infrastructure

Information infrastructure is a critical element in planning the new enterprise data center

and mapping its design to the business needs of the enterprise. Historically, the practice of managing data through its life cycle while providing the requisite availability and security characteristics has been an operational consideration that trails the selection of major infrastructure components.

According to an IDC report on data centers, the enterprise data center of the future will be much more interested and focused on the business value of data and information services, on leveraging storage infrastructure efficiency through policy-based software and on true automation.¹⁴

The scale of data growth, regulations for data retention and formal compliance requirements present new challenges. In the era of the new enterprise data center, the requirements for information infrastructure will be identified early on, and will address both the selection of specific virtualization technologies and the flexibility offered through service-oriented delivery of IT. When properly mapped to the operational requirements, the information infrastructure provides the enterprise with information on demand.

There are four basic roles of information infrastructure for which business requirements must be understood: *availability*, *security*, *retention* and *compliance*. These are discussed in order:

- **Availability**—The information infrastructure must maintain availability of data as required by applications and business processes. Availability includes data placement to maintain the right level of performance, access controls and obtain protection from accidental deletion or local disaster. Server and storage virtualization eliminates the complexities of equipment incompatibilities and allows for easy migration of data between storage tiers. As data capacities grow, there will be a heavy premium on automated management.
- **Retention**—Enterprises must establish policies to retain data according to content type, and enforce these policies in infrastructure processes. Content management software must be used to classify data and assign its treatment throughout its life cycle. Some data must be retained for long periods of time because there is business value attached to it; other data should be discarded according to a specific schedule. Large data capacities require a high degree of automation, as do attempts to eliminate human error in data handling.
- **Compliance**—Content management-based retention processes must also conform to the regulatory compliance obligations of the business. Users may need to conform to a number of regulations governing length of retention, time-to-data retrieval and proof of deletion. Again, automation plays a critical role, as operations personnel should not be able to tamper with the correct operation of compliance processes.
- **Security**—As more sensitive data is preserved, there becomes an increased liability risk in this data's unauthorized or unintended disclosure. Information security is now a necessary element of information infrastructure. Enterprises must maintain confidentiality of sensitive data or risk severe financial consequences. Encryption of storage media, encryption of network transmissions,

encryption of associated key management, data leakage prevention and secure access control are crucial security building blocks.

The functional attributes of information infrastructure are key elements of NEDC operations, and will be planned as overlays on the physical infrastructure. Integrated management, which combines physical management with information management, will be a vital element of NEDC deployments.

3.4 SECURITY AND BUSINESS RESILIENCY

IBM customers and industry analysts continually identify security and resiliency as top business requirements. The ability to provide a secure infrastructure that incorporates recovery and resiliency at all layers, from hardware to the business as a whole, is a necessity in today's global, 24/7 economy. Increasingly, customers, shareholders, regulatory bodies, insurers and supply chains are driving the highest levels of availability, recovery and security. This challenge is exacerbated by an increasing need to share infrastructure resources among applications. With the shift from a customized IT environment to a flexible, shared and highly optimized one, the trade off between redundancy and optimal sharing can be better managed in an integrated manner.

IT continues to face both internal and external security threats. In a highly shared environment, isolation management is a critical additional security requirement. Customers wish to see familiar and intuitive notions of physical isolation mirrored in the shared environment. As services and applications are provisioned in a shared, virtual environment, isolation policies can be consistently managed through all layers of the IT stack.

Security evolution

Security requires many capabilities, and enterprise IT must be armed with these capabilities. Among these security functions, authentication, authorization and distribution of security policies are the foundational capabilities.

Every user must be authenticated before using any of the services provided. If a user does not belong to an authentication domain, the user's identity must be verified through ID federation.

After a user is authenticated, the user can access resources based on his or her credentials. As multiple services and resources exist in every data center, access capability for the user should be appropriately determined. This is not an easy task, as services are often packed in ensembles or application images and may be ported anywhere, while access decisions usually vary depending on the exact instance of the services. Naturally, this configuration leads to the separation of access enforcement functions embedded in the application image from access decision functions.

In order to achieve synchronized access decisions, it is crucial to implement access control policies (and other security policies) to all related servers. To make such access control and policy enforcement accountable, it is also important to distribute and enable policies at appropriate times.

Intrusion prevention and detection become more difficult when virtual server images are separated from physical devices. For example, in cloud computing, a physical server may exist in a faraway place where there also resides an additional network vulnerable to exploitation by hackers. Thus, protection based on physical network topology alone is inadequate.

Additional mechanisms are needed to detect information leakage in a modern data center. Implementing only a single choke point, such as the traditional DMZ, to provide monitoring is insufficient because commonly used applications may leak unauthorized information. Therefore, an information leakage protection mechanism must be implemented in every key component.

These challenges can be addressed through a common best practices-based security management system whereby communication channels, servers and data are all placed under a single management framework. To provide isolation, as well as to prevent intrusions, virtual resource regions in which policy mechanisms prevent unauthorized accesses can be established. Capabilities exist in the new enterprise data center to establish such individual regions of trust domains.

Risk factors and resiliency

A study conducted by Forrester Research reveals that customers are reacting to disasters and spending more money to recover from them than to pro-actively consider a data center resiliency strategy to prevent them.¹⁵

Through its service orientation and service management focus, the new enterprise data center affords enterprises the opportunity to consider resiliency in an integrated manner. Resiliency risks are complex, as they can be business-driven, data-driven or event-driven. Business-driven risks include compliance, governance and mergers. Data-driven risks include data corruption, viruses and system failures. Event-driven risks include natural disasters, pandemics and fires. If not mitigated through careful management, these risks will manifest themselves in the facilities, technologies, processes, applications and data, organization and strategy. The following are key resiliency requirements:

- Facilities require physical security to help protect critical information, systems and personnel, as well as to protect a facility's redundant power supplies and backup power generation.
- Technology resiliency should be implemented in current and future systems and applications, and it requires automatic failover of components to a backup system. Likewise, all technology in the facility should be recoverable to a location that is outside the potential risk zone of the primary facility. Additionally, components, systems and applications should be monitored for performance and availability to ensure that resources can meet changing and fluctuating demands and allow for on-demand provisioning.
- Process resiliency should include proper documentation that clearly outlines both the functional process and the owners of the process, which may include the use of standards such as ITIL. While documentation is critical, the process must be flexible and dynamic in regard to the changing surrounding environment.

- Applications and data should be designed for resiliency as well as functionality. Quite often, proper testing of changes is the ultimate determinant of a company's business availability.
- Organizational resiliency includes the ability to replace key resources, should they become unavailable for any reason. Ensuring that critical resources have access to the systems and information they need to perform their jobs is just as crucial, and may require creating work area recovery capabilities away from the data center.
- While not specifically physical in nature, the strategy and vision of the corporation should be designed in a way that ensures the overall resiliency of the company. For the new enterprise data center, this may involve the use of a multi-site architecture of data centers with a balance achieved between rapid communication and separation of risks.

Recovery planning and trusted virtual domains

IBM recognizes the importance of monitoring and surveillance in helping companies to stay on top of decisions, and in alerting them to exceptions to the documented processes or architecture. Use of a resilient and reliable shared infrastructure helps to minimize downtime by using self-healing and scalable technology, as well as by using recoverability capabilities outside the data center. Implementation of flexible and efficient integrated processes allows for improved communications and responsiveness. Such integrated processes also protect and ensure the contingency capabilities during and after failure. Only through proper analysis and design of the new enterprise data center and its recovery capabilities can a company achieve the level of resiliency needed in today's fast-paced global economy.

IBM innovations that address isolation and security requirements are aimed at creating both virtual appliances running on ensembles of resources and trusted virtual domains.

Virtual appliances are preassembled application (or application component) stacks that can be replicated easily for both scalability and reliability. They run on ensembles that are homogeneous nodes, meaning that the software versions are either identical or nearly identical on all of the nodes. Virtual appliances have simplified capabilities for workload optimization, availability, restart and recovery, as well as the ability to change software. This allows for the development of application architectures that can easily take advantage of the similarity of resources to build higher-level applications and business process continuity.

A *trusted virtual domain* is an example of virtual regions of trusted domains. IBM has extensive research activity in this area, and has designed many advanced technologies to implement trusted virtual domains. A trusted virtual domain can be created dynamically based on request, or, alternatively, it can be a permanent subset of the new enterprise data center. All components (server, virtual guest machine, connections and clients) are mutually trusted by authenticating themselves. Further, it can be assumed that operations within a trusted virtual domain are safe from malicious parties, as security protection mechanisms are embedded in every key component of virtual environments.

3.5 Business-driven service management

As infrastructure becomes increasingly automated and autonomic, IT responsibilities will shift from managing complex technical operations to managing complex service operations. Operational complexity, process compliance, speed of change and costs are driving the need for business-driven service management.

According to a report conducted by Gartner, through 2012, only 5 percent of large enterprises will achieve operational and infrastructural management excellence.¹⁶

The new enterprise data center helps businesses meet these challenges with an integrated service management framework that enables the fusion of people, processes and technology. The new enterprise data center service management framework is comprised of:

- An IT service management platform.
- IT operational management.
- IT process management.

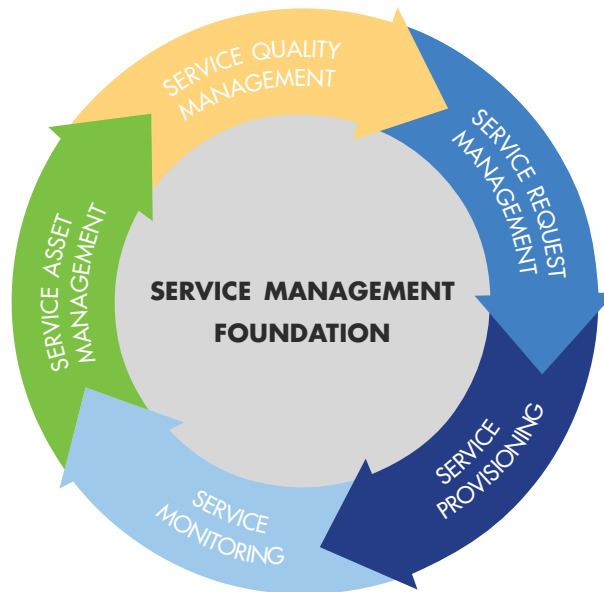
IT service management

The IBM IT Service Management Platform, as depicted in the diagram below, is an open, standards-based platform for data, workflow and policy integration across IT management processes. The platform includes automated, pre-configured and customizable process workflows for the change and configuration management processes. The IBM Change and Configuration Management Database (CCMDB) includes an open, federated CMDB designed to automate process execution, simplify architectural complexity and help reduce incident and problem management costs. The CCMDB solution:

- Enables open sharing of all configuration items, regardless of location.
- Provides fully automated, agentless application discovery for a unified view of configuration items/assets and their dependencies.
- Manages the change process and provides a record of change, which is useful for problem solving as well as audit and compliance.
- Serves as an integration point for other service management processes and management data.

The IBM IT Service Management Platform can help you to:

- Ensure cost-effective and successful implementation of your IT Service Management initiatives.
- Better anticipate the impact of provisioning changes prior to deployment.
- Lower the business risks of service failures and inconsistencies.
- Ensure compliance to technology and regulatory standards.
- Reduce time to problem resolution.



IT operational management

The IBM IT Operational Management solution automates tasks to address application or business service operational management challenges. This solution helps to optimize the performance and availability of business-critical applications, along with supporting IT infrastructure. It also helps to ensure the confidentiality and data integrity of information assets, while protecting and maximizing the data utility and availability.

The IBM IT Operational Management solution can be grouped into the following areas:

- **Business application management** helps to ensure the availability and performance of business-critical applications.
- **Server, network and device management** helps to optimize the availability and performance of the underlying IT infrastructure upon which applications and customers rely.
- **Security management** helps to ensure the confidentiality and data integrity of information assets.
- **Storage management** helps to protect and maximize data utility and availability.
- **Energy management** helps to ensure the optimization and efficiency of the data center.
- **IT Asset Management** with Service Desk provides customers with the information required to track, manage and service IT assets efficiently throughout their entire life cycle by combining the inventory, financial and contract management of IT hardware and software assets.
- **Usage management** provides cost management, usage-based accounting and charging for IT system resources. The goal is to aid businesses in determining IT infrastructure costs. This capability accurately measures, analyzes, reports and bills the utilization and costs of computing resources, such as servers, storage, networks, databases, messaging and other shared services.
- **Virtualization management** provides management at the operations layer level

to understand the relationships across interconnected virtual and physical systems that support all functions of an IT life cycle management.

- **Facilities management** provides management of the data center environment.

IT process management

The IBM IT Process Management solution, which employs innovative and self-managing technology, automates tasks down to the execution layer. Since the solution uses standards-based API interfaces, it is easily customizable, and can enable you to standardize information across tasks and tools for consistent policy administration, thus bridging organizational silos and integrating IT management processes for rapid responsiveness and greater flexibility. The IT Process Management solution for the new enterprise data center can help you to:

- Identify bottlenecks as processes are executed.
- Monitor and dynamically adjust actual workloads.
- Automate specific tasks in a process utilizing existing IT operational management.
- Deploy autonomic technology at the right pace for your business.

The IBM IT Process Management solution also includes predefined implemented processes based on IBM's best practices and IBM's extensive experience applying standards, including the Information Technology Infrastructure Library (ITIL), enhanced Telecom Operations Map (eTOM), Control Objectives for Information and Related Technology (CoBIT), Capacity Maturity Model Integrated (CMMI), Process Reference Model for IT (PRM-IT) and other standards in customer environments.

In summation, the new enterprise data center service management framework, which consists of comprehensive service management, operational management and process management components, can help you to:

- Establish a foundation for delivering processes as responsive services.
- Achieve efficiencies through process innovation and integration.
- Realize new value from existing IT assets by applying tools and models.
- Reduce IT maintenance costs through self-managing deployment capabilities.
- Improve staff productivity by automating key IT tasks.
- Increase the speed and quality of change and configuration management.

3.6 Service-oriented IT delivery

The complexities and fragility of distributed IT have not allowed IT organizations to meet the dynamic and growing needs of current business environments in a timely and cost-effective manner, which has led enterprises to seek more agile IT environments that can respond at the speed of business. The service-orientation paradigm is the answer to this problem. Based on the concepts and principles of service-oriented architecture, the service-oriented IT delivery model transforms IT infrastructure into a collection of service components with common standards and interfaces that are flexible in adapting to business demands. The emergence of Cloud computing style architectures will become

mainstream in the adoption of Service-oriented IT delivery.

Cloud computing

Enterprises are beginning to look to turn-key models in an effort to offer new services and run new applications and business processes in a flexible and expeditious manner. This results in an emerging data center architecture that offers massive scaling but simplified administration and optimized operations. Cloud computing is a term used to describe both a platform and a type of application. A cloud computing platform dynamically provisions, configures, reconfigures and de-provisions servers as needed. Servers in the cloud can be physical machines or virtual machines. Advanced clouds typically include other computing resources, such as storage area networks (SANs), network equipment, firewalls or other security devices.

Cloud, as an IT service delivered to users, boasts the following features:

- A service management platform.
- A simplified user interface that makes the underlying infrastructure totally transparent and irrelevant to the user.
- Near-zero incremental management costs when additional IT resources are added to the service.

Cloud computing is generating new excitement in the information technology (IT) industry. If you can envision optimization around consolidation and virtualization of IT resources, then you might view cloud computing as the ability to seamlessly connect these capabilities across your entire enterprise. The cloud computing model is based on a shared infrastructure in which large pools of systems are linked to provide dynamic and cost-efficient IT services. The need for cloud computing is justified not only by the growth of traditional IT environments, but also by dramatic growth in connected devices and real-time data streams, as well as the adoption of service-oriented architecture and Web 2.0 applications, such as mash-ups, open collaboration, social networking and mobile commerce. By delivering appropriate resources only when those resources are needed, cloud computing has enabled teams and organizations to streamline lengthy procurement processes and drive down overall costs.

Cloud computing forms the foundation for a new way of delivering IT capabilities, which is similar to the way utility companies deliver water or electrical services. Consumers rely on electric companies to provide electricity when and where it is needed; people generally don't worry about where the resource is generated. Likewise, a cloud computing platform dynamically provisions, configures, reconfigures and de-provisions IT capability as needed, transparently and seamlessly, thus allowing IT consumers to focus on their value proposition. A cloud computing infrastructure conforms to a set of well-defined specifications for data, application and services life cycle management.

Cloud computing evolution

In the new enterprise data center, cloud computing is targeted toward both existing workloads and emerging, massively scalable workloads. With a collection of IT capacities,

image management tools and governance components that make up its cloud offerings, IBM is paving the way for cloud computing evolution.

IBM has established the first cloud computing center for software companies in China. The center will allow Chinese software companies to support their development activities by providing them with the ability to tap into a virtual computing environment. In addition, Google and IBM recently announced a partnership with six universities (Stanford University, University of Washington, MIT, CMU, UC Berkeley, and University of Maryland) to foster research and development in parallel programming techniques for cloud computing.

Internally, IBM Research has built and deployed the Research Computing Cloud in order to offer cloud computing services to a broader community. To help clients take advantage of cloud computing, IBM is also developing Blue Cloud, which includes a feature that allows cloud applications to integrate with their existing IT infrastructures through SOA-based Web services. The design of Blue Cloud is particularly focused on breakthroughs in IT management simplification to ensure security, privacy and reliability, as well as high utilization and efficiency.

Advanced virtualization techniques provided by ensembles will further accelerate the adoption of cloud computing.

Service-oriented IT delivery transformation

Service-oriented IT delivery provides a foundation for creating and delivering infrastructure capabilities as a service to applications, giving businesses the flexibility to decouple applications from physical infrastructures. Service-oriented IT delivery components may include infrastructure resources (such as servers, storage and networks), operating systems, middleware, databases and associated management software (process workflow, provisioning, monitoring and workload management). This delivery model leverages virtualization and automation as the foundational building blocks to enable the delivery of IT services.

Service-oriented IT delivery is made up of a common set of reusable infrastructure components that are set up as shared services within the environment. These reusable infrastructure components provide a framework for the application portfolio and eliminate the need to build multiple infrastructures that support different applications.

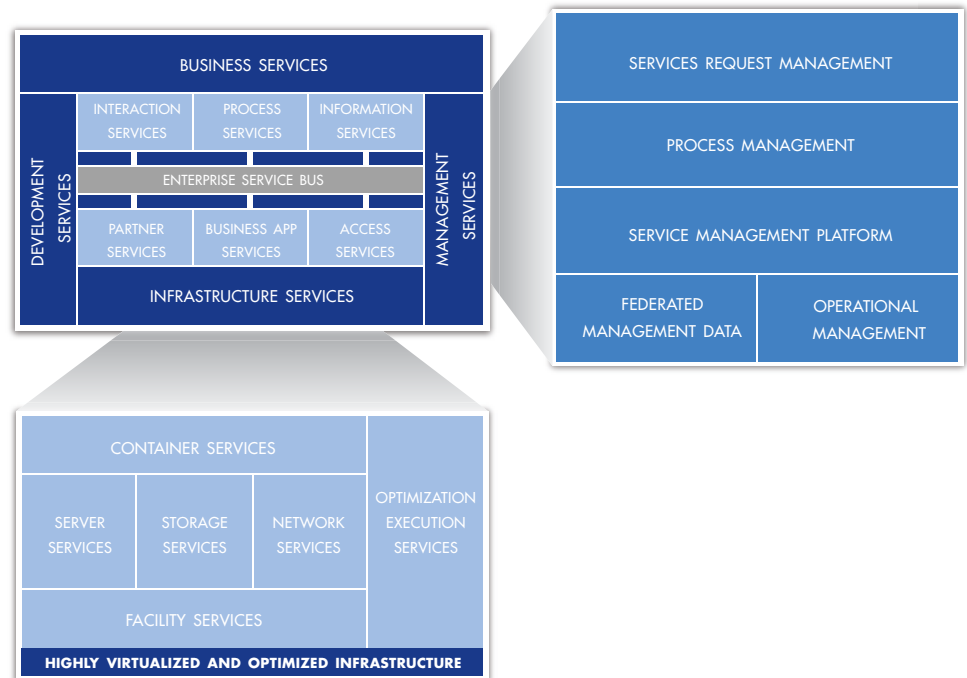
This new model of IT delivery will help to deliver infrastructural services by:

- Hiding the technology complexities of multiple physical layers of technology and exposing IT capabilities as a portfolio of services.
- Providing the flexibility to compose services across a multitude of IT assets (server, storage, network, middleware, etc.).
- Simplifying service delivery, leading to improved SLAs.

Major industry analysts view service orientation as a key IT ingredient in the achievement of business agility. IT virtualization and IT automation are two vital elements in the ability

of service orientation to deliver IT as a service. IT virtualization is viewed as a technological aspect of service-oriented IT delivery, creating a pool of infrastructure resources, such as computing power and data storage, in order to mask the physical nature of the boundaries from users. IT automation, on the other hand, is viewed as a way to better govern IT services, enabling policy-based, service-oriented, dynamic management of underlying virtualized resources.

Based on the principles of IBM's service-oriented architecture framework, a new class of IT operating environments (ITOE) can be built to support service-oriented IT delivery in the new enterprise data center. As shown in the figure below, the standardized components of infrastructure services at the bottom layer are integrated with the highly automated IT management services shown on the right, leading to the realization of service-oriented IT delivery transformation in an enterprise.

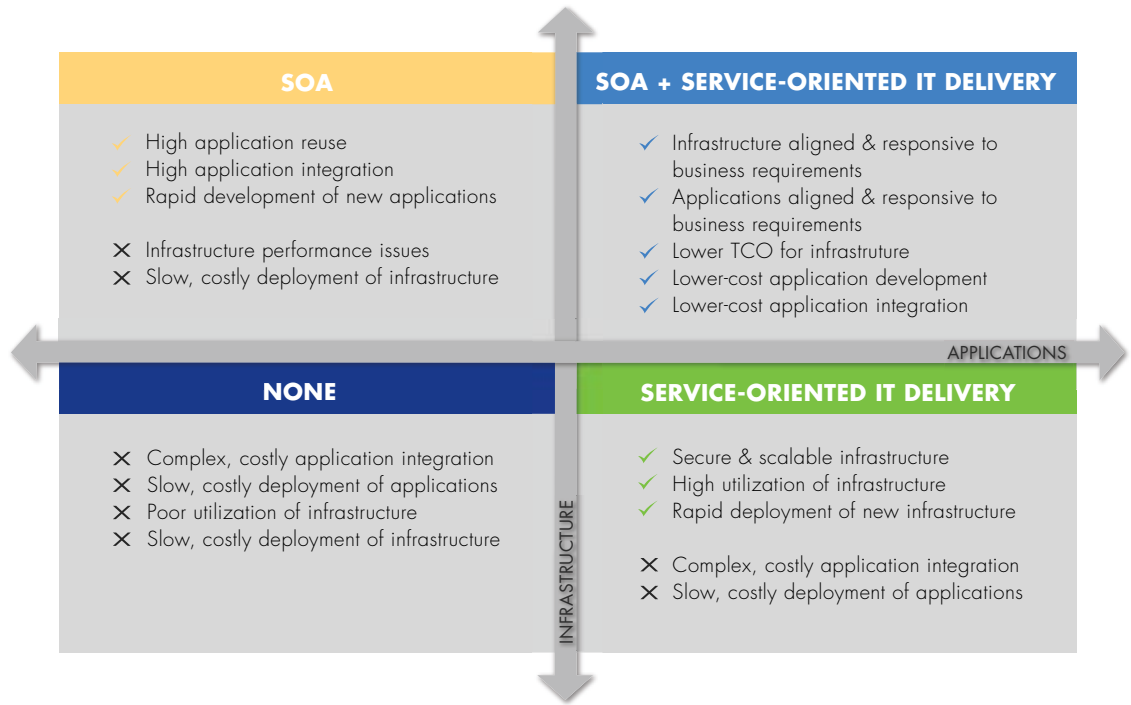


By leveraging IBM's broad technology portfolio and deep solution integration expertise, clients can build IT services on this foundation. These IT services can be built at different layers of abstraction, ranging from simple infrastructure services, such as server services, storage services and network services, to a more complex composition of these capabilities.

IT service management components represented on the right side of the figure above help to create and manage the delivery of IT services. Service request management consists of a front-end service catalog, making these services accessible to end users. Process management contains a set of task-based workflows designed to orchestrate the delivery of IT services. Federated management components discover asset data and store resource configurations. During the run time, operational management components take actions based on federated management data to proactively rebalance traffic,

resize virtual machines, move resources and schedule the provisioning/de-provisioning of resources accordingly.

The service-oriented IT delivery framework is used to design and build infrastructure services to support any class of application architectures, ranging from legacy to SOA-based. Enterprises that have adopted SOA can further maximize their benefits from service-oriented IT enablement across the infrastructure.



In summation, the service-oriented IT delivery framework simplifies management complexity and increases asset utilization/ human resource productivity, allowing for dynamic infrastructure responsiveness to business processes. Therefore, this characteristic enables a company to attain higher levels of business and IT agility, thus enhancing speed-to-market business services.

4.0 WHY IBM?

Transforming a data center requires cutting-edge technology and a wealth of IT skills. With IBM as your partner, you have access to the most comprehensive IT skill sets and advanced technologies available anywhere in the world. IBM offers a broad range of data center service products and the highly skilled IT architects and IT specialists required to evolve and transform all aspects of your IT infrastructure.

IBM software has the broadest array of service management software, dynamic middleware and IT tools of any company in the world. IBM's server and storage products and services provide industry-leading technologies for virtualization, high-volume computing, energy management, cooling and massive scalability.

Our combination of skills and technology is unmatched in the industry. Combine these attributes with our advanced research capabilities and exceptional focus on customer satisfaction, and you get the industry leader in data center transformations.

5.0 NEXT STEPS

There are a number of ways to get started on your journey toward evolving to a new enterprise data center. Start by reviewing the wealth of information on all of the topics discussed in this white paper. For more information about the new enterprise data center, visit <http://ibm.com/datacenter/>.

You should also talk to your IBM client representative about our new enterprise data center assessment. For a limited time, IBM is offering a no-cost enterprise evaluation on a nomination basis to help you pinpoint problem areas in your data center and recommend a roadmap for evolution.

Finally, be on the lookout for more new enterprise data center technical white papers. IBM is producing a series of deep-dive technical papers on the key technologies outlined in this overview.

-
- 1 Gartner, "Stepping Up to the Challenge," Gartner Summit Report, 2007.
 - 2 Gartner, "Data Center Power and Cooling Challenge," 2007.
 - 3 Gartner, "Cloud Computing Trends and Directions," David Cearley, Tom Bittman, and Yefim Natis, June 13, 2008.
 - 4 Ibid.
 - 5 Forrester Research, "Forrester Recommendations for IBM IT Optimization Programs," Frank E. Gillett and James Staten, November 12, 2007.
 - 6 U.S. Environmental Protection Agency, Report to Congress on Server and Blade Center Energy Efficiency Public Law 109-431, August 2, 2007, http://www.energystar.gov/index.cfm?c=prod_development.server_efficiency_study.
 - 7 IBM, CIO Leadership Exchange, October 2007.
 - 8 IBM, "IT Energy Efficiency for Small and Mid-Size Businesses: Good for Business and the Environment," December 2007.
 - 9 Gartner, "The Data Center Power and Cooling Challenge," David Cappuccio and Lynne Craver, November 2007.
 - 10 IBM, "The Green Data Center: Cutting Energy Costs for a Powerful Competitive Advantage," April 2008.
 - 11 Gartner, "Gartner Survey Suggests Extensive Data Center Expansion Plans Are on the Horizon," Mike Chuba, February 11, 2008.
 - 12 Gartner, "The Data Center Power and Cooling Challenge," David Cappuccio and Lynne Craver, November 2007.
 - 13 Government Computing News, "GSA Paves Way for IT-based Buildings," Drew Robb, June 4, 2007.
 - 14 IDC, "The Data Center of the Future: An IDC Report," Michelle Bailey, Lucinda Borovick, Matthew Eastwood, Vernon Turner, Tim Grieser, and Robert C. Gray, 2006.
 - 15 Forrester Research, Enterprise and SMB Hardware Survey, North America and Europe, Q3, June 2007.
 - 16 Gartner, "Stepping Up to the Challenge: Creating the Future of Infrastructure and Operations," Thomas Bittman, Gartner IT Infrastructure, Operations and Management Summit 2007.



Copyright IBM Corporation 2008
IBM Corporation
New Orchard Road
Armonk, NY 10504
Printed in the United States of America, 05/2008
All Rights Reserved

IBM, IBM logo, POWER, System p, System x and z/Architecture are trademarks or registered trademarks of the International Business Machines Corporation.

Adobe, the Adobe logo, PostScript and the PostScript logo are either registered trademarks or trademarks of Adobe Systems Incorporated in the United States, other countries, or both.

Java and all Java-based trademarks are trademarks of Sun Microsystems, Inc. in the United States, other countries or both.

Microsoft, Windows, Windows NT and the Windows logo are trademarks of Microsoft Corporation in the United States, other countries, or both.

Intel, Intel logo, Intel Inside, Intel Inside logo, Intel Centrino, Intel Centrino logo, Celeron, Intel Xeon, Intel SpeedStep, Itanium and Pentium are trademarks or registered trademarks of Intel Corporation or its subsidiaries in the United States and other countries.

UNIX is a registered trademark of The Open Group in the United States and other countries.

Linux is a registered trademark of Linus Torvalds in the United States, other countries, or both.

ITIL is a registered trademark and a registered community trademark of the Office of Government Commerce, and is registered in the U.S. Patent and Trademark Office.

IT Infrastructure Library is a registered trademark of the Central Computer and Telecommunications Agency, which is now part of the Office of Government Commerce.

All statements regarding IBM's future direction and intent are subject to change or withdrawal without notice, and represent goals and objectives only.

OIW03013-USEN-00