

WHITE PAPER

Sun Microsystems' Solutions for Virtualization Across the Enterprise

Sponsored by: Sun Microsystems

John Humphreys
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EXECUTIVE SUMMARY

Virtualization is quickly becoming an important technology across all parts of the IT environment. The technology is rapidly being deployed in server, storage, networking, as well as client environments. By far the most visible adoption of virtualization technology is happening in servers — from the largest Unix server down to the smallest volume system. Virtualization is being used as a tool for consolidation, a means to reduce space and power requirements, and more recently as a way to bring business continuity to a larger part of an organization's IT infrastructure. The key to these benefits is that virtualization software both encapsulates the software stack and decouples it from the underlying hardware. This combination means customers get both consolidation and mobility benefits — which can be used to address some of the largest challenges facing CIOs today.

Sun, a leader in the virtualization space, sees virtualization as cutting across all parts of the IT infrastructure — from servers to storage, and even clients. As such, the company is emphasizing choice in how companies virtualize their IT environments and is developing technology, partnering, and making technology available so that virtualization can evolve rapidly and deliver more value to the organization. By focusing on innovation, both through its own development and through partners, Sun is working to ensure that users have access to a portfolio of virtualization tools to address a broad base of business requirements. Sun's customer-driven approach for how companies implement a virtual environment will enable customers to choose the right virtualization tool for the job yet still maintain cohesive management of a heterogeneous environment.

Sun is taking a three-step approach to bringing more business benefits of deploying virtualization to enterprises that use x86 servers. One, Sun is emphasizing choice in how companies virtualize. Two, Sun is designing a broad range of platforms with the enterprise-class reliability, availability, and serviceability (RAS) features for which the company is known with its SPARC systems. Three, Sun is incorporating virtualization into its management offerings so that customers have a single pane of glass when managing their physical and virtual infrastructures.

The company is initially focusing on three key areas to promote the value of virtualization — pathways for a virtual enterprise, if you will. They are Eco Innovation, IT consolidation, and business continuity for server, storage, and client environments. In each of these business practices, Sun has put together a portfolio of products and services that enable customers to quickly capture the value of virtualization.

VIRTUALIZATION ACROSS THE ENTERPRISE

It has been said that everything old is new again, and nowhere is that more true than with virtualization. Virtualization and system partitioning have existed for decades aboard mainframe and Unix-based systems. What is new is the concept of bringing this virtualization technology to x86-based servers, storage arrays, and distributed client environments. This breadth of deployments allows customers to choose the infrastructure components that best meet performance, functionality, form factor, and price requirements for a large swath of the IT infrastructure.

Another major distinction of virtualization across the datacenter is that all these heterogeneous components can be virtualized across a common network. This means that virtualization decouples application software not only from the physical infrastructure but also from the physical location, freeing up IT organization resources to create more service-oriented infrastructures.

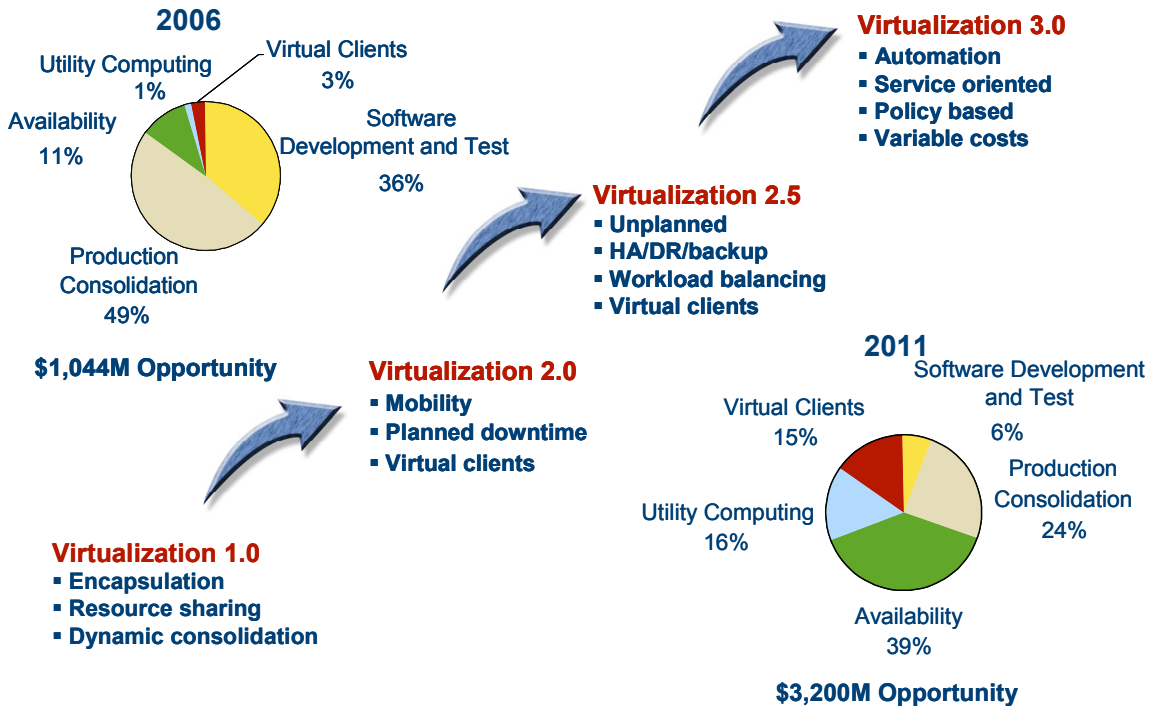
Increasingly, it is clear that IT can no longer afford to host discrete applications across discrete hardware for discrete organizations. Although the distributed IT models have helped customers lower acquisition costs, the overhead associated with unused capacity, lack of organization integration, and lack of service integration across multiple applications is driving up operational costs and thus changing the shape of the CIO agenda. Rather than viewing IT as a series of discrete silos of infrastructure, customers are increasingly viewing IT as a shared pool of resources that can be dynamically manipulated to align with application requirements. This requires the abstraction of applications and services from the physical infrastructure on which they are hosted and recognition that virtualization technologies are fundamental technology for creating more effective, economic IT.

Today, the initial implementations of virtualization focus on lowering capital costs by improving utilization and reducing the number of managed objects through resource sharing. A clear example of this phase is server virtualization, which enables the hosting of multiple operating systems (OSs) and applications on a single server. Another example is using a virtual tape library (VTL) to consolidate multiple physical tape libraries. IDC terms this phase Virtualization 1.0.

IDC believes that customers are poised to move to Virtualization 2.0, as their motivations for the employment of virtualization shift to lower operational expenses, improved service levels, and better responsiveness to changing business needs. In this phase of virtualization — which leading virtualization adopters are already achieving — the business drivers for virtualization have expanded to encompass Eco Innovation, faster provisioning, business continuity, and ultimately, policy-based automation initiatives. As these new use cases are added to the fold, the adoption of virtualization technologies is expected to grow tremendously (see Figure 1).

FIGURE 1

Virtualization Milestones

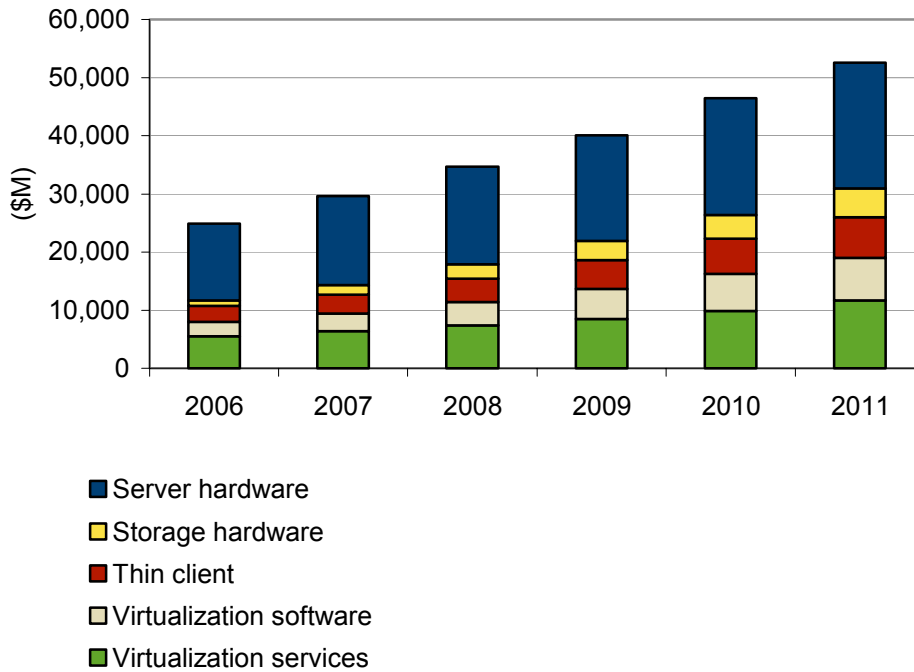


Source: IDC, 2007

The key to these new use cases is the decoupling of application services and data services from the physical infrastructure, which allows these services to be provisioned, migrated, and scaled more transparently. Much of the focus today has been on Virtualization 1.0 and its characteristic static consolidation, as applications running on an operating system supported by a virtual machine (VM) become more portable, but increasing emphasis is being placed on the storage and client infrastructure to be virtualized as well. This combination of storage, server, and client virtualization and the ability to dynamically align these virtualized resources represents a foundation of the next generation datacenter and is a key in the successful implementation of a service oriented architecture. As virtualization across all of these areas is forecast to grow dramatically over the next few years (see Figure 2), customers are encouraged to continue examining virtualization solutions for a variety of business issues.

FIGURE 2

Customer Investment in Virtualization Across the Enterprise



Source: IDC, 2007

The following sections examine Eco Innovation, IT consolidation, and business continuity as drivers for employing virtualization as well as Sun Microsystems' offerings for each practice area.

Eco Innovation

Increasingly, the operational costs associated with powering IT are becoming a major source of cost and pain for organizations. Not only is the price of energy skyrocketing, but the amount of power an individual device consumes (for direct power and cooling of the device) has jumped dramatically as well.

Fundamentally, this increase in utility expenses is being driven by three key factors. The first factor is the increased need for technology to support the business because IT underlies nearly every business process in most organizations. Technology has evolved to the point of becoming ubiquitous and core to any company's ability to compete. The second factor is the dramatic increase in the number of devices supporting a business. This growth is being driven by pressures to lower the cost of acquisition and by the best practice of deploying a single application per system. As a result, businesses end up purchasing large volumes of low-cost hardware, which is exemplified by a server installed base that has grown over 700% in the past 15 years. The third factor is that the drive for ever better performance has led to dramatic

increases in the power any single device consumes. In the past decade alone, server hardware power consumption has increased approximately 400% as processor speeds have increased and memory footprints have expanded.

Taken together, these trends result in organizations that are paying a significant and growing percentage of their IT budgets to literally keeping the systems powered and cooled (for many customers, power consumption has grown by a factor of 10 in the past few years). Worse still, other customers are reaching a critical mass and have outstripped their ability to power and cool the equipment in their datacenters. These companies face the prospect of spending millions of dollars to design, build, and outfit new datacenters to handle their IT needs.

By moving to virtualization, customers are able to consolidate servers while maintaining service levels and drastically reducing space, power, and cooling needs not only to make the organization more green but to reduce costs in the process. In addition, virtual tape technologies allow for a broader use of tape libraries in the datacenter, which, unlike disk arrays, do not require energy to power and cool data at rest.

Sun is investing in a host of technologies, ranging from the processor to the system to rack-level and datacenter improvements, that will allow customers to both reduce electricity consumption and extend the life of their organizations' current datacenters. These technologies, which span systems, storage, software, and services, are covered in greater detail in the following sections.

IT Consolidation

Consolidation has been a major initiative in the market over the past six or seven years. Initially, the focus on consolidation followed the downturn in the economy in 2000 and involved reducing both the number of datacenters an organization employed and the number of physical systems in those datacenters by taking advantage of more powerful server hardware.

What never seemed to change was the de facto customer best practice of deploying one application per server. Concerns around application compatibility and uptime have kept customers fully leveraging the capacity of their server installed bases. In fact, widely cited averages have server utilization in the 10–15% range, meaning that upwards of 90% of all capacity and hardware spending is wasted. IDC estimates that today roughly a three-year supply of idle capacity is currently deployed in the market.

Virtualization has begun to change the one-application-per-server paradigm and, for some users, is becoming the standard way to deploy new applications in the organization. In addition, virtualization is not just for development and test anymore — over half of companies that are virtualizing reported having virtualized servers hosting production applications — in some cases, some of the most mission-critical applications are being hosted on virtualized or partitioned servers.

The benefits from a business perspective primarily include the ability to increase efficiency and utilization as a means to reduce server/storage sprawl. The reduction in server/storage footprints helps in a multitude of ways, including reducing power and cooling costs, reducing capital costs, as well as shrinking the time it takes to back up the datacenter.

Sun has long been a leader in promoting the benefits of consolidation and has developed a deep portfolio of products and services that can be leveraged to help customers achieve their consolidation goals. These technologies are covered further in the following sections of the paper.

Business Continuity

More recently, virtualization is being employed as a means to increase business continuity — both high availability and disaster recovery — to applications that have historically gone unprotected in the datacenter.

Depending on which study is cited, somewhere between 10% and 20% of applications are protected using "traditional" high availability and disaster recovery software. Thus, approximately 80% of the application portfolio is subject to outages and downtime associated with a failure or disaster. Whether key employees are without the right tools to do their jobs or a portion of an n-tier architecture goes down, as organizations increasingly integrate IT and data sources, it is becoming apparent that outages of even "noncore" assets can have an impact on employee productivity or the ability of a company to continue operating.

As a result, customers have been placing greater emphasis on technologies that can deliver greater levels of availability and resiliency within a smaller economic envelope. These lower-cost solutions are a means to protect a much larger part of customers' IT environments without the added complexity and expense of traditional measures.

Virtualization has quickly become a leading technology in the race to protect those "business-critical" applications because it not only encapsulates applications but also decouples the application stack from the underlying hardware. This capability enables customers to treat and manage their infrastructures more like a pool of resources and manage systems from different vendors through a single console — whether those systems are server, storage, or even remote clients.

Whether it means resizing partitions to ease capacity planning concerns, automatically restarting down nodes or virtual machines, or load balancing across multiple hosts or shrinking backup windows, virtualization technology has a strong role in helping customers increase service levels and application availability.

THE IMPORTANCE OF CHOICE

As the operational and business benefits delivered by virtualization have been realized, implementing virtualization has become a major initiative for organizations. There is growing recognition among customers of the need for diversity in how they virtualize or decouple the application stack from the underlying hardware. This need for diversity stems directly from the application because different applications have different requirements in terms of isolation, flexibility, and performance. Having the right virtualization tool for the job is as critical as choosing a hardware platform or vendor.

These expanding use cases for virtualization are what make the technology so compelling to customers and, in turn, are why Sun, its partners, and other leading virtualization providers are working together to create a robust portfolio of hardware, software, storage, and services needed to virtualize the enterprise. This collaborative approach is critical if the challenges of virtualization are to be overcome and the full potential of the technology is to be realized.

A strong portfolio of products and services will be required so that customers can continue to choose not only the application that best meets their needs but also the virtualization software, operating system, and storage that will support those needs. It should also be noted that although the following technologies are presented independently, they can be combined to enhance the capabilities and counteract some of the challenges of each standalone option.

Systems

From a systems perspective, Sun is taking a three-pronged approach to delivering virtualization to customers. Sun continues to deliver hard partitioning in its SPARC systems. In hard partitions, workload isolation goes down to the hardware level and is based on the specific number of processor boards.

This technology has long been used in support of running multiple mission-critical applications on the same host, yet with complete software isolation. It enables the user to take down (for maintenance or upgrades) one partition while ensuring the other partitions on the machine continue to operate. This approach to partitioning is a staple in the RISC Unix world and continues to advance in terms of the granularity of the partitions and the degree of flexibility with which the customer can manage them.

In the volume systems space, Sun strives to build the engines that run the virtualization software the customer chooses; for example, the Sun Fire x4600. This box provides the heavy processing and memory footprint needed to deliver the most effective virtualization platform. The Sun Blade 8000, which also is designed around rich memory and I/O footprint, is another platform that is a great virtualization candidate.

Sun is also focused on delivering a hybrid approach to virtualization in the Sun Fire T1000 and T2000 products (and all future chip multithreading [CMT] systems) as well as x86 systems. These systems, with CMT, will also come embedded with Logical Domains (LDoms). LDoms are a highly optimized hypervisor in firmware in

which Solaris will act as the control OS. This hypervisor will allow users to create isolated full virtual machine domains to consolidate multiple applications on a single server. Initially, Sun will enable Solaris, Linux, and FreeBSD software stacks to run in LDoms. Users will be able to manage the virtual machines independently, including the ability to start, stop, and reboot a VM. In Solaris 10, users will be able to dynamically add and remove virtual CPUs while the OS is still running. This will enable customers to resize a VM on the fly.

Storage

Like customers in the systems space, customers in the storage space need a variety of devices and virtualization technologies to drive up storage utilization, maximize their storage dollars, and ensure that the right data is associated with the right storage device. There are two major drivers of storage virtualization. The first major driver is the need to tier the storage according to value of data to primary disk, modular disk, low-cost disk (SATA), virtual tape, or tape archive. By better matching the data with the right device, customers can expect to drive down storage hardware costs as well as conserve energy without inhibiting performance.

The second major driver is the need to create a common pool of storage capacity. In this manner, virtualization in the storage space is more about aggregating capacity than partitioning. Customers can use virtualization technologies to mask a variety of storage arrays and devices they currently employ in their datacenters. This ability to create a large pool of virtualized storage not only enables customers to drive up storage utilization but also complements their server virtualization investments because a virtual pool of storage makes application migration in the server realm more streamlined.

Sun is bringing to bear a host of different technologies and devices from the StorageTek acquisition in storage virtualization. Specifically, with respect to information life-cycle management, Sun is delivering the StorageTek Virtual Tape Library (VTL) and the StorageTek Virtual Storage Manager (VSM). These solutions work to speed, stage, and manage the migration of data from primary storage to second-tier disk storage to tape. They can also help to shrink the backup window, as organizations are finding backup windows using traditional tape products can exceed the time available. These solutions are useful in creating a tiered storage strategy by the segmentation of storage options from simply online and offline by adding the near-line tier in between.

To deliver on the customer need of creating a common pool of storage, Sun has brought to market both the StorageTek 9900V and StorageTek Shared Virtual Array (SVA). The SVA product works to provide synchronous mirroring and snapshot capabilities to ensure that the data on primary storage devices is protected and the organization has a business continuity and disaster recovery process in place. The 9900V works to virtualize the different arrays in a company's datacenter. This allows customers to aggregate heterogeneous storage systems under a single point of control, which not only helps to drive storage utilization but also enables single-console management to reduce time and costs associated with storage management. Both systems have thin provisioning to reduce the amount of capacity overhead normally required when deploying a disk array.

Software

Clearly, at the end of the day, the magic of virtualization comes down to software. Although Sun is often thought of as a hardware vendor and is bundling virtualization software into its servers and storage systems, it also has made significant and broad investments in standalone virtualization software. These investments run the gamut from servers to storage to client environments and help to give Sun one of the broadest virtualization product portfolios around today. The major standalone virtualization software offerings from Sun include those mentioned in the following sections.

Solaris Resource Manager

As a well-established and mature technology, resource management software allows for the allocation of system resources across multiple applications. Solaris Resource Manager provides customers with a way to schedule and dynamically allocate resources within a single OS instance. Unlike hard partitions, resource management involves the installation of only a single image of the operating system with multiple applications installed on top of the OS. A resource scheduler controls access to all the system resources. The technology is very flexible and granular, but the applications are not truly isolated from each other; therefore, contention issues can come into play and all the applications must ultimately run on the same OS. Sun makes this type of solution available on both its RISC and x86 systems. Resource management is recommended in environments in which contention issues, between physical resources, have been vetted via testing and the ability to dynamically shift capacity is of primary importance.

Solaris Containers

This virtualization option isolates applications in a single OS, which helps customers address concerns around virtual machine or OS sprawl. It also allows administrators to manage more applications than they can with the "one server, one application" approach so typical today.

Essentially, Solaris Containers combine the isolation benefits of Solaris Zones with the flexibility benefits of Solaris Resource Manager. Containers are freely available to customers with an upgrade to Solaris 10. With OS virtualization, the virtualization is instrumented in the OS and the applications reside in isolated containers in a single copy of the operating system. This type of virtualization is very lightweight and requires almost no system or application overhead. Any application faults are isolated in the container and do not impact the other zones (though if the OS or server fails, so do all the containers, illustrating the importance of having a robust operating environment and hardware). OS virtualization also scales with the operating system and can run on the entire line of Sun servers (both x86 and SPARC). Like resource management, each container can access all the resources on the system so that applications have burst capacity to handle spikes in demand. This approach also helps consolidate OS images so that changes and upgrades to core operating environments are greatly streamlined. Container technology is a good option for a Solaris environment in which isolation and security are critical.

Because containers run in Solaris 10, customers also can leverage the security of Solaris Trusted Extensions to ensure applications and data are isolated even when they reside on the same OS. With Solaris 10, users are able to label containers and control access at the kernel level to ensure a secure and solid access method even when public and private data is on the same host.

In addition, Sun added container mobility and cloning to Solaris 10. This capability, which has proved so compelling for VMware users, will allow a container to be moved from one physical host to another. It will allow containers to quickly attach and detach from hosts, allow containers to be cloned, and offer a streamlined means of backing up and restoring.

Sun recently released BrandZ as an extension to Solaris Containers technology. BrandZ, productized as Solaris Containers for Linux applications, enables containers to run different Solaris and Linux applications unmodified. This approach will allow customers to consolidate multiple operating environments into a container while still running a single OS. It also will allow Linux users to take advantage of Solaris tools such as DTrace.

Additionally, Sun is investing in container technology so that customers receive more fine-grained resource management, including capping of CPU resources and controlling memory. The company is working to offer greater flexibility in container security so that privileges can be adjusted per container.

Virtual Machines

Virtual machines allow a customer to partition a server by installing a hypervisor on the machine. The hypervisor is a thin layer of software that sits between the hardware and the OS and enables a customer to run multiple identical or different operating systems and applications in isolation from each other. Like containers, a "virtual machine" can isolate faults so that the surrounding VMs can continue to run. Unlike containers, each VM requires a separate operating system so that while hardware consolidation is possible, there is no reduction in the number of OS images. Additionally, some overhead is associated with running the virtualization software. This overhead is negligible for many applications, but for I/O-intensive applications, it can become a significant concern. This option works best for companies that need to run different operating systems on a single server.

In terms of hypervisor-based partitioning, Sun x64 systems can support major virtualization software solutions, including those from VMware (ESX Server and VMware Server [formerly GSX Server]), Microsoft (Microsoft Virtual Server), XenSource, and Virtual Iron.

Additionally, Sun is working to get Xen into Solaris. The company has an alpha version of Xen with OpenSolaris today and plans to have a "production-ready" version in OpenSolaris soon. The work with Xen also extends to LDOMs, where Sun is working to leverage the Xen hypervisor as the partitioning technology and use Solaris as the Control/Host Domain. This work is still in the early stages, but it is ongoing.

Secure Global Desktop Software

Sun's Secure Global Desktop (SGD) Software provides users with the ability to virtualize and deliver remote access capabilities for either an individual application or an entire desktop. This software, which was obtained during an acquisition of Tarantella, can help customers address some of the major issues of a distributed desktop environment — primarily data security, desk-side support costs, and lost user productivity stemming from PC outages.

The software works by virtualizing the keyboard, video, and mouse connection to a remote computer that is managed inside a datacenter environment. In this way, data that once resided on a desktop is now under lock and key in the datacenter. Additionally, the support time and costs and productivity loss associated with PC downtime are minimized as the resources themselves are managed like any other datacenter resource, and if coupled with virtual machines in the datacenter, the VMs are automatically restarted on another host if the original host device goes down — turning hours of downtime into minutes.

Sun's Secure Global Desktop Software also works with both SPARC and x86 machines to virtualize the connections to the desktop device, which can be anything from a thin client to a full PC, depending on customer needs and depth of virtualization (a single application versus the full desktop). The software also allows the user to be mobile — logging into a machine from any terminal with a Web browser and allowing access back to the dedicated resources in the datacenter. Sun's Secure Global Desktop Software is a good option for customers that need access to computing from a variety of client devices.

Sun Ray Software

Sun also brings a whole line of Sun Ray thin clients to the market. These systems, which run on a fraction of the energy of a full PC, are driven by Sun Ray Software. This software delivers many of the same capabilities as Sun's SGD Software — better security, lower cost of ownership, higher system uptimes that lead to increased worker productivity — the only caveat is that the customer must run Sun Ray devices as client-side devices.

Sun Ray Software virtualizes the connection between a desktop that resides on a server (or virtual machine) in the datacenter and the Sun Ray thin-client device. Sun delivers Sun Ray as a "system" — from client device to software and even back-end servers if necessary — which means that Sun can offer enhanced capabilities, features, and performance. In terms of capabilities, the most compelling is desktop mobility — specifically the ability to maintain session state as the employee moves from one location to the next, whether that is locally at a campus, from home to the office, or at company sites across the globe. Sun calls this "hotdesking," and this ability combined with the reduced client management requirements and the ability to deliver Windows, Linux, and Unix desktops from a single platform is the major driver for customers' moving to a Sun Ray implementation.

Services

Sun has also developed a series of workshops and assessment and implementation services to help customers quickly capture the value of virtualization. These consulting, education, and support services run the gamut of the virtualization life cycle and are designed to help improve system utilization, reduce power and cooling costs, simplify management, and increase service levels. The spectrum of offerings includes the following:

- ☒ **Sun Solution Workshop.** This workshop is a two-day collaborative effort with the customer to identify business goals and develop an action plan. Sun professionals in the areas of virtualization, environmental, and eco-assessment services co-lead the workshop.
- ☒ **Sun Justification Review Service.** This is a 10- to 14-day engagement to develop an in-depth justification and total cost of ownership (TCO) analysis for Sun's offerings, helping IT managers create the justification for the investment in IT infrastructure for their organizations.
- ☒ **Sun Solution Architecture Service.** This is a two- to three-month engagement to design an enterprisewide virtualization solution to deliver consolidation, business continuity, and reduced power and cooling to the datacenter.
- ☒ **Sun Solution Implementation Service.** This service offering involves the deployment of a new virtualized architecture, including new management processes, training, and other services, to IT managers.

Sun has also set up an online Virtualization Learning Center where customers can view demos of the technology, familiarize themselves with the spectrum of virtualization offerings, and access technical briefs that are designed to help customers get the most out of a virtualization deployment.

The life-cycle approach Sun is taking enables customers to mix and match services based on their core competency. It also allows customers to set the scope and pace of transformation that best fits their needs.

CHALLENGES/OPPORTUNITIES

Sun and other vendors must continue to engage customers in industrywide educational discussions that articulate how to map IT requirements to the different virtualization, operating environment, and server platform choices available as well as what virtualization tools work best with specific applications or for certain business solutions. Having a broad set of choices is only the first step in full coverage of customer requirements.

Customers and vendors must also not overlook the importance of robust, scalable, and balanced systems in a virtual world. Virtualization can concentrate risk as more applications are placed on fewer systems. As such, enterprise features and design become increasingly important. Sun will need to continue to draw from the technologies and capabilities of its high-end systems and incorporate them in the volume system line if it is to continue to differentiate itself in the hardware layer.

As virtualization increasingly affects more than just the server, it will also be critical to have tools that enable customers to coordinate across server, storage, network, and client resource pools. Data migration, for example, will need to be intelligently linked with virtual machine migration to ensure not only that the application continues to run but also that the data the application requires is appropriately located and relevant. The cross-silo coordination will be an area of increased future development and differentiation in the vendor community.

Moreover, Sun will need to stay ahead of the curve as virtualization moves beyond being simply a tool for consolidation. IDC and customers will look for the company to continue to develop deeper assessment, implementation, and support expertise, which we understand it is in the process of developing, to help customers take advantage of the new emerging use cases for virtualization technologies. Vendors in the market will need to differentiate themselves through these services as customers begin to look to transform and incorporate virtualization across their IT environments.

CONCLUSION

Virtualization is shaping up to be one of the major trends that affects the server, storage, and client markets as well as customer datacenters in general. The technology has already found a broad set of usages, ranging from improved hardware utilization in test and development, to Eco Innovation, to high availability and disaster recovery. The expansion in use cases shows no sign of slowing.

As the technology becomes more mainstream and pervasive, the ability not only to offer customers choices in terms of how they virtualize their systems but also to provide systems that have the scalability, RAS, and manageability to ensure that increased utilization does not come at the expense of application availability or business performance becomes even more critical and is an area of focus for Sun.

But as with any broadly accepted technology, users require choices to make sure they have the right tool for the job. With virtualization, users must consider the degree of isolation, the breadth of operating systems they plan to support, the goals of the organization (e.g., is server consolidation the only goal or is a reduction in OS instances important?), the degree of mobility and flexibility the solution necessitates, the applications the organization plans to support, and the level of performance required.

Sun's software investments in Solaris Containers, Solaris Resource Management, Xen, Secure Global Desktop Software, and Sun Ray Software, as well as its partnerships with key software virtualization vendors, illustrate how the company is making choice in virtualization a top priority in the software layer. Sun has also worked to incorporate virtualization capabilities directly into the hardware for its storage and RISC-based server systems. All these technologies, combined with Sun's assessment and implementation programs, are designed to help customers navigate the litany of virtualization choices and emerge with a highly successful, custom implementation that meets their specific business, application, and datacenter requirements.

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