Overview

Since the early days of computing, there has been a push to utilize compute resources as efficiently as possible. In the 1960s, IBM developed virtualization technology as a way to break a single physical mainframe computer into several logical partitions. Each partition could host a separate application, allowing the mainframe to multitask. To enable this partitioning, IBM designed the mainframe with virtualization in mind, optimizing the hardware to run a Virtual Machine Monitor (VMM) that controlled the partitions (also known as virtual machines). This VMM was originally termed a supervisor, but as it extended to control multiple machines, it became known as a hypervisor.

In the 1980s and 1990s, the client-server model along with lower prices for hardware with greater capabilities caused virtualization to become a lower priority. Customers could buy multiple inexpensive x86 machines to replace mainframes, and x86 hardware and the Windows operating system were optimized to run single applications. Eventually, cost pressures drove new demand to virtualize x86 systems as well. Virtualization gained a new life when VMWare introduced a hypervisor that could run on x86 architecture.

Virtualization has become a critical component of many corporate IT strategies and is a foundational technology in cloud computing. However, CompTIA research finds that although firms are moving rapidly into the cloud, there is less adoption and familiarity with virtualization. Understanding this underlying element of the cloud will help these firms better understand how to address issues such as cost structure and security.

![Growing Virtualization Needs](chart.png)

As physical machine shipments are growing, virtual machines are growing even more rapidly and becoming a larger part of the overall server market.
How Virtualization Works

The primary function of virtualization is to allocate resources intelligently for optimal use. This is done mainly through two pieces of hardware: the hypervisor and the management software. In a single-application environment, the operating system is installed directly on the hardware, and subsequent applications are installed in the operating system. Operating systems derive their power from the fact that they have intricate knowledge of the hardware, using a kernel that directly communicates with the processor, memory, and other devices. The hypervisor performs the same function, but instead of applications being installed on the hypervisor, complete operating systems are installed. A hypervisor directly accesses the hardware of the host system, and then presents subsets of those resources to each operating system that is installed, creating virtual machines that are completely self-contained.

[Note: the diagram shows a form of server virtualization known as bare-metal virtualization. Diagrams showing hosted virtualization and OS virtualization can be found in the appendix.]

While the hypervisor is the enabler of virtualization, the management software is the differentiator among virtualization vendors. As virtualization implementations become more and more complex, the need to manage becomes more critical. Management software provides the ability to monitor virtual machines and ensure they are operating properly. It also allows system administrators to optimize the resources that are being allocated among all virtual machines.

Server virtualization is the most common application of the technology, but storage and networks have also become candidates for virtualization. Network-Attached Storage (NAS) and Storage Area Networks (SANs) provide abstracted storage options for virtual machines to access. SANs are more expensive implementations and are typically used by large enterprises. Virtual Local Area Networks (VLANs) can group devices on a network logically rather than physically, giving administrators the ability to resegment networks without physically rearranging devices or connections. These advances are leading to the notion of a fully virtualized data center, and as all three virtualization techniques are employed, the management software becomes increasingly important.

Benefits of Virtualization

Most virtualization projects begin as an effort to consolidate resources, gaining back efficiencies that were lost as servers were underutilized by the applications running on them. As resources are consolidated, the number of physical servers or storage devices needed to maintain operations decreases. This in turn reduces the energy demands of the resource pool.
There are some benefits to be realized in managing the physical infrastructure in a virtual environment. New machine requests no longer require approval of a complete system and integration into a datacenter. Instead, a machine that is acting as a host may simply need additional memory to accommodate new requests.

In addition to the datacenter changes, the structure of an IT department will change. Management of a virtual environment is less labor-intensive, though the work itself is of a different nature. Installation and maintenance are much simpler and happen much faster in a virtual environment, and applications can more easily be moved between virtual machines. Those personnel who previously supported physical servers can be allocated to other IT work that advances the objectives of an organization.

The changes in the IT department do not end with virtual machine management, though. Virtualization opens the door for more robust features and increased flexibility. Backup and disaster recovery are implemented differently, but more simply, than in a physical environment. The ability to quickly move applications or bring up new machines brings a new level of agility. Adding in intelligence for resource utilization and dynamic allocation of those resources is what can then turn virtualization into a cloud solution.

As organizations move more of their operations into the cloud and also grapple with the implications of mobile device use within the corporation, virtualization continues to evolve. For example, IT administrators are examining new uses for virtual desktops, in which employees use their desktop, laptop, tablet, or smartphone to access to a virtual machine running on a server. Many core applications and data are accessed through this virtual desktop, giving the IT department more of an ability to control access to corporate systems.

**Issues With Virtualization**

The change to IT operations can be a benefit, but it is also an area of concern. Decoupling applications from physical machines leads to greater efficiencies, but it also requires a new knowledge of virtualization techniques and a new mindset towards compute resources. There will be a learning curve for IT administrators coming from a traditional environment, and there will also be education needed for end users.

There is also a learning curve involved in understanding the best use of virtualization. There are performance considerations in consolidating resources. Workloads have to be analyzed, and certain

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**Examples of Virtualization Savings**

- Nationwide Insurance reduced its number of physical servers from 5000 to 3500 and increased utilization rates from 10% to 65%. This reduced hardware and operating system support costs 20%-50%.
- St. Vincent’s Hospital Manhattan was able to achieve a 50% reduction in servers. In addition, the hospital found that virtualization could be used to establish development, test, and production environments without the cost of three separate infrastructures.
- The Berryessa Union School District in California consolidated 32 conventional servers to four blade servers. Desktop resources doubled from 700 to 1400 available systems, and fix time improved from weeks to minutes as onsite visits were replaced by virtual machine repair.
applications—such as SQL databases and Voice over IP (VoIP)—should be carefully examined to determine if they are virtualization candidates. Administrators will need to ensure that peak demands can be met as applications are sharing the resource pool and that applications do not suffer from being virtualized.

In restructuring an IT department to handle virtual machines, the policies will also have to be addressed. Virtual machines are simpler to bring up than physical machines, but this can lead to a proliferation of machines that is hard to manage. Some companies store images for starting up virtual machines to save the time involved in configuring the machine for specific applications. These images also must be tracked and maintained.

Security is one of the most important policies to address. The hypervisor adds a layer of software to the operational stack, which in turn adds vulnerabilities. There must be a plan for the security of each machine—including the host machine and all virtual machines. Communications between machines also must be monitored, and in the case of virtual machines on a single host talking to each other, this communication does not have external components that can be monitored. Existing security policies will need to be modified to handle these issues, and additional tools may be required to secure the virtual infrastructure.

Compliance must also be monitored in a virtual environment. A single host may have a virtual machine with PCI or HIPAA information and other virtual machines without that information. This is allowed by the regulations, but additional care is needed to ensure that data does not cross the virtual machine boundaries.

Finally, a new focus on virtualization techniques should not come at the cost of managing the physical infrastructure. There are benefits to consolidation, but it also means that host machines become more critical as they support multiple applications. It is worthwhile to revisit policy related to monitoring physical resources and ensuring redundancy.

These issues are not insurmountable. There are a wide variety of vendors and service providers who can assist with these areas. However, dealing with these issues adds to the cost of virtualization. It may be simple to calculate how many physical servers can be removed by virtualizing or how much energy is saved, but the additional costs of training and policy changes must be taken into account. For this reason, calculating ROI on virtualization is not a trivial matter. In a general sense, the economics of virtualization are a net benefit to companies. But it is up to individual firms to assess their virtualization strategy and lay out the proper investment plan.

**Getting Started With Virtualization**

For those companies who have not yet virtualized their compute resource, virtualization may still be a good step to take prior to considering cloud solutions. This will give some experience with virtual environments that may prove beneficial when dealing with cloud issues. As with all IT projects, a thorough plan is the best path for success.

1. **Understand your workloads.** Server consolidation will only be effective if there are a sufficient number of underutilized servers running similar workloads. Administrators can start by monitoring performance loads to understand the peak demand for resources. Next, applications should be examined. Applications that require very low latency are still in the early stages of
being virtualized and may not be ideal candidates. There is no exact formula for determining how to virtualize, but best practices can guide administrators who are examining their data center. Whether the virtualization initiative is being driven from within the IT department or from the executive level, this initial step is critical in assessing the feasibility of virtualization.

2. **Build the business case.** This may be less critical if the push for virtualization is coming from executives, but IT administrators hoping to convince management to invest will need to have a thorough analysis. All costs should be carefully considered, from hardware and software to training and time. Less tangible items such as organizational flexibility should be included in the list of benefits.

3. **Train the staff.** Once the plan is approved, IT staff will need to begin building their knowledge and skills. Many vendors offer training modules, and there are also a wide range of consultative resources to consider. Certification in virtualization can ensure that staff members are up to speed on the most recent trends and best practices.

4. **Examine IT policies and plans.** Policies surrounding security and compliance will have to be modified for a virtual environment. Even policies related to the physical machines will have to be addressed, since there is now a greater dependence on a host running several virtual machines. In addition, plans such as disaster recovery and business continuity will now take advantage of the virtual infrastructure. This is a good time to involve other lines of business in the virtualization planning.

5. **Start small.** Attempting to virtualize as much infrastructure as possible in the first iteration is likely to lead to mistakes and higher costs. Virtualization can be approached in stages, which will give time for any issues to be resolved, support structures to be put in place, and familiarity with management tools to be built. Small implementations of less critical applications provide learning opportunities for larger implementations in the future.

6. **Monitor and adjust as needed.** Virtualization is not a project with a defined end date. Instead, it is a new way of operating IT, and as such it will be constantly adjusted as with any business process. In addition to becoming more adept at the technical aspects of virtualization, the IT department can continue to learn more about the various lines of business and how they use IT. This will give insight as to how to optimize the virtual environment.

Though not every customer has sufficient computer resources to benefit from a virtualization transition, knowing more about the technology, the benefits, and the drawbacks will help customers make educated decisions. As virtualization continues to extend beyond servers into other functions, solution providers and end users both will continue to find innovative ways of operating in a virtual environment.

**Taking Virtualization Knowledge Into the Cloud**

- Those IT departments who maintain responsibility for server maintenance can eventually move towards a private cloud environment as automated resource management and self-service provisioning are added to the virtualized solution.
- Public cloud users can ask their cloud providers about the details of the virtual environment. Issues such as security and restoration of service will depend on the virtualization implementation, and users of Infrastructure as a Service (IaaS) and Platform as a Service (PaaS) will be provisioning and working on virtual machines.
Appendix

A virtualization layer allows virtual machines, possibly with different operating systems, to be created within the operating system running on the host machine.

The OS virtualization layer creates separate containers, all running the same operating system. These environments run on the same base OS and hardware, but allow for individual processes and users.
References

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