CHAPTER

7

Cloud Virtualization Technology

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7.1 INTRODUCTION

Today, Cloud is a buzz word in the IT industry. The advent of powerful virtualization technology in the infrastructure domain gives us options to reap benefits of various cloud deployments. A powerful line-up of servers, blended with advanced Web technologies, provide opportunities to exploit powerful features of virtualization combined with cloud concepts. Continuous improvement means leveraging technology and expertise to do the same things more efficiently. Continuous innovation is the fusion of new business designs and next-generation technologies to do things differently, not just once, but over and over again. While virtualization sounds like a very complex and technical thought, it is in reality a simple idea.

Virtualization is a fast-growing infrastructure in the IT industry, and new technologies are being introduced on a continuous basis. As a result, technology providers and user communities have introduced a new set of terms to describe these technologies and their features for virtualization. However, some of the terms may overlap in concept, while others may be ambiguous. For example, 'Hardware-Assisted Virtualization' and 'Hardware-Based Virtual Machine' refer to the same thing, while the term 'paravirtualization' may be something new for some users.

Virtualization represents the logical view of data representation – the power to compute in a virtualized environment, storing data at different geographies, and availing various computing resources. So, virtualization removes restrictions on computing such as difficult infrastructure deployments, collocated computing resources, physical movement, and packaging of resources.

This statement can be clarified by the following two points:

1. To virtualize systems, there is a need to separate the physical from the logical, and manage and utilize IT resources as a cohesive, holistic unit that is constantly adjusting, reallocating, and responding to changes in the business environment.
2. Virtualization is a liberating technology which implies to a having a better and more responsive access to the existing information. IT management can be further simplified by instituting a policy-based response that ultimately reduces the cost of operations.

For example, in the case of storage, we can say that we have a total 30 TB of disk space when put together rather than saying that we have three different types of storage systems, and thus we can manage the 30 TB of disk space as a single type of resource. So we can now focus on how to use the resource and not how to manage it.

Virtualization is a technique that is being used in large mainframe computers for the last 30 years – not to manage each computer or resource separately – but to manage them together or we can say virtually. This technique results in huge improvements in the utilization of resources. A typical mainframe today runs between 70% and 90% of its optimum utilization and the rest of the infrastructure is probably running at less than 15% of its utilization. Raising the level of utilization across the entire infrastructure usually means one needs to manage fewer things; fewer things require fewer people and cosequently need less infrastructure expenses.

By extracting some of the administrative cost out of the infrastructure, that is, by increasing the system and resource utilization and by improving the productivity, these 'virtualized' IT

assets can help fuel the business growth we just talked about, control the cost in doing so, and increase staff productivity at the same time. Having simplified virtualization implementation as the first step, it is then easy to automate the system, which means reduced errors and streamlined business responsive systems.

7.2 VIRTUALIZATION DEFINED

Virtualization is not a vague concept – you probably are already engaged in virtualization in some fashion – but it helps to understand virtualization as a process. So, how can a virtualized environment help an organization?

Virtualization is an abstraction layer (hypervisor) that decouples the physical hardware from the operating system (OS) to deliver greater IT resource utilization and flexibility.

The virtualization platform provides the isolation of platform and allows multiple businesses to run multiple virtual machines on the same physical machine.

How can virtualization help different lines of businesses is also a big question. Following are the benefits provided by virtualization:

1. **Money saving:** With virtualization technology, the number of physical servers can be reduced; therefore, the ongoing procurement, maintenance, and ongoing operational costs will also be reduced.
2. **Dramatic increase in control:** Virtualization provides a flexible foundation to provide capacity according to the demand for an organization. New servers can be quickly deployed; therefore, services can be provided within minutes. It is also easy to ship the infrastructure when it is deployed using virtualization techniques.
3. **Simplified disaster recovery:** More efficient and cost-effective disaster recovery solutions can be realized with virtualization technologies. Servers and business on-line can be transferred to an alternate site within minutes with the help of virtualization.
4. **Business readiness assessment:** Virtualization introduces a shared computing model to an enterprise and it is easy to understand infrastructure requirements in a virtualized environment as there is no need to implement them physically.

Depending on the organizational structure, virtualization change may either impede or enable the virtualization strategy.

7.2.1 *Why Virtualization?*

Let us now look at the need for virtualization in the infrastructure domain. Virtualization can help to:

1. Reduce the cost of the existing infrastructure by reducing operational and systems management cost while maintaining the needed capacity.
2. Reduce the complexity of adding to the infrastructure.
3. Gather information and collaboration across the organization to increase both the utilization of information and its effective use.

4. Deliver on-service-level agreement (SLA) response time during spikes in production and test scenarios.
5. Build a heterogeneous infrastructure across the organization that is more responsive to the organization's needs.

Implementation of solid information management solutions in an organization does not mean to change the entire IT environment in one major re-engineering project. There is a stepped approach that is followed by most of the successful companies. Some people may focus more on automation capabilities, others may focus more on virtualization; but it is the breadth of capabilities across the spectrum of information management that truly unlocks the value of the IT infrastructure.

Initial steps in the process are to simplify the environment by consolidating similar system platforms onto fewer, more manageable resources. In the last decade, this has been one of the primary ways in which companies seek to reduce costs and increase utilization of resources.

Once similar systems are brought together into a more efficient structure, the management of these resources can be automated by adding and moving the capacity as needed, thus allowing business needs to drive resource usage rather than resources dictating the performance of the business.

Automation of tasks, such as increasing or moving capacity, can lead to the progression of task automation that are associated with a given process or sub-process, such as application testing or release management of an updated production configuration. One may look up in the information technology infrastructure library (ITIL) for guidance on IT processes, which in turn, can lead to insights into the highest-priority tasks and processes to be considered for the automation.

Another key activity at this point is to start bringing together these consolidated resources across functions performed within the company. Begin breaking down the silos of technology and sharing resources across functions within the enterprise. By doing this, a company can use its resources that may sit idle at various times of the day to perform tasks of other resources that are overburdened at that time. The ability to share these resources in a seamless fashion gives companies the ability to quickly respond to changing business needs without over-investing in the technology.

To use these resources most effectively, companies cannot allow the standard process that may be in place today to slow down the adaptation of resources to new workloads. To facilitate a fluid environment, we need tools and processes that allow the automated orchestration of resources to respond to business challenges.

As virtualization and automation capabilities improve within an organization, companies will be able to move to the enterprise-wide virtualization that is enabled by a global virtualization fabric. This fabric utilizes advanced virtualization techniques available through grid technologies and more advanced mainframe virtualization platforms to allow seamless access to resources wherever they exist within an organization. Virtualization begins to eliminate boundaries between resources that have been created by organizational silos or management processes.

Finally, we see organizations using these advanced virtualization concepts not only to access resources within their organization, but also to see these resources in demand whether they are within the company or outside at partner or vendor locations. In this state, resources are

available when needed, peak demands can be serviced without keeping unused capacity on the floor for extended periods of time, and information flows seamlessly between organizational functions, both within and outside the company.

One of the most essential ingredients for successful enterprise-wide and inter-enterprise resource sharing, application integration and business process collaboration is security management. Fundamentals of security such as authentication, authorization, and access must be in place across systems, networks, and applications. Establishing roles and using identity management will save time and money in the long run and immediately tighten the security. Having the right solution provider for security and verification between suppliers, partners, and customers will help a company to get to that 'always on' state.

All of these infrastructure management techniques are available today, but many companies find it difficult to implement them as rapidly as they would like to due to outdated IT governance and management processes. Therefore, companies must address those processes and cultures that hold them back from taking full advantage of technologies available today.

7.2.2 *Infrastructure Virtualization Evolution*

First of all, the objective is to take what is complex today and to try to consolidate it physically. Increasingly, physical consolidation is becoming easier to implement as processes deliver even greater virtualization capabilities and are more flexible. But ultimately, this is the farthest that one can go with physical consolidation. It is easy to claim that all Window servers can be moved to a mainframe Linux-based system, but it is not so easy to do so. There is a huge potential in consolidating processes, but it is more difficult to do and it also takes time. One of the key things in terms of what we are doing with virtualization is to treat things much more logically. What is desired is to develop an environment where resources that make up computer systems, local or remote, make one logical pool of resources that can be used as per needs of business applications. So, if one have got smaller servers that are capable of running additional work, it can be done automatically and dynamically rather than trying to get more value from them by physically removing them and transfering the workload onto a bigger system. However, two things are complementary: the ability to deliver logical consolidation and logical simplification, and the ability to deliver physical consolidation.

Virtualization of physical resources has been used in mainframes for production workloads for many years. Different virtual machines can run different OSs and multiple applications on the same physical computer. Each virtual machine is encapsulated and segregated, contains a complete system, including CPU, memory, and network devices to prevent conflicts, and allows a single physical machine to safely run several different OSs and applications on the same hardware.

7.3 VIRTUALIZATION BENEFITS

Traditional benefits of virtualization include:

1. Server consolidation.
2. 'Greener' IT – reduced power and cooling.
3. Reduced hardware costs.

Virtualization benefits have expanded to include:

1. Increased availability, business continuity, and disaster recovery.
2. Maximized hardware resources.
3. Reduced administration and labor costs.
4. Efficient application and desktop software deployment and maintenance.
5. Reduced time for server provisioning.
6. Increased security at the client-level desktop.
7. Dynamic and extensible infrastructure to rapidly address new business requirements.

7.3.1 *Current Virtualization Initiatives*

We will now discuss new initiatives that are being used in the industry and how they help in the infrastructure domain:

1. **Virtual CPU and memory:** Physical CPUs and RAM can be dedicated or dynamically allocated to virtual machines. As there is no OS dependency on the physical hardware, with the CPU checking off, virtual machines can be seamlessly migrated to different hosts, with background changes to the physical CPU and memory resources being transparent to the guest OSs running on virtual machines.
2. **Virtual networking:** This creates a virtual 'network in a box' solution that allows the hypervisor to manage virtual machine network traffic through the physical network interface controller (NIC) and allows each of the virtual machines to have a unique identity on the network from the physical host.
3. **Virtual disk:** Storage area network (SAN)–based storage is presented as storage targets to the physical host, which in turn are then used to host virtual machines' vdisks (virtual disks).
4. **Consolidated management:** The performance and health of virtual machines and guest OSs can be monitored and 'console' access to all of the servers can be obtained via single console.
5. **Virtual motion:** Active virtual machines can be seamlessly and transparently transferred across physical hosts with no downtime and no loss of service availability or performance. The virtual machine's execution state, active memory, network identity, and active network connections are preserved across the source and destination hosts so that the guest OS and running applications are unaware of the migration.
6. **Storage virtual motion:** Vdisks of active virtual machines can be seamlessly and transparently transferred across data stores, while the execution state, active memory, and active network connections remain on the same physical host.
7. **Dynamic load balancing:** Dynamically load balances virtual machines across the most optimal physical hosts to ensure that pre-defined performance levels are met. Virtual machines can be automatically and seamlessly transferred to a less busy host if a particular host in a resource pool is in a high-utilization state. Different resource pools can be defined for different business needs. For instance, production pools can be defined with more stringent service-level requirements, while development pools can be used with more relaxed service-level requirements.

8. **Logical partitions (LPARs):** LPARs result in hardware layer logical partitioning to create two or more isolated computing domains, each with its own CPU, memory address space and I/O interface, with each domain capable of housing a separate OS environment on single physical server. LPARs can share CPUs or have dedicated physical CPUs. Likewise, an LPAR can be a dedicated physical memory address space or memory addresses can be dynamically allocated among LPARS as needed.
9. **Logical domains (LDOMs):** Operating systems running in each logical domain can be independently managed, that is, stopped, started, and rebooted without impacting other LDOMs running on the host. A Type 1 'bare-metal' hypervisor isolates computing environments from physical resources. For example, domains across distinct threads can be separated using the multi-threading technology, because the hypervisor is dynamically managing and encapsulating the allocation of physical resources.
10. **Zones:** Zone is an OS-level virtualization solution rather than a hardware-level hypervisor solution. Each zone is an encapsulated virtual server environment running within a single OS instance. As such, zones share a common kernel, through a global zone, although 'non-native' zones can emulate an OS environment other than that of the host's native OS. Zones allow virtualization across a single physical server platform, but some applications may still be limited in their ability to run within zones if they require direct manipulation of the kernel or its memory space (since the kernel is shared across zones), or if the application requires privileges that cannot be granted within a non-global zone.

7.3.2 *Virtualization Technology*

Advances in computing, especially in hardware technologies, are driving the adoption of virtualization and help in meeting the corporate demand for computing that has grown exponentially over the past decade. Success of virtualization concepts over a period of time has led to the genesis of better infrastructure optimization. Virtualization has several benefits such as live migration, hardware support, virtual machines, management of virtual datacenters, virtual networking performance, networking support, dynamic VM storage, broad OS support, and network load balancing. These benefits can be realized through a virtualization platform which allows automatic provisioning of environments and deployment of applications into those environments. In addition to setting up a virtualized infrastructure with self-service capabilities for provisioning, scaling, monitoring, and de-provisioning, the solution will also address application environment issues through best practices and automation.

A virtualized environment should enable the dynamic and repeatable process to create environments that will result in cost saving in terms of infrastructure costs and manual interventions. This platform capability for allowing backup of VM images for subsequent environment setup requests should be used for eliminating application deployment and configuration issues. This platform reduces the time required to obtain and boot new server instances, allowing upgradation of scale capacity quickly, both up and down, as computing requirements change.

An enterprise' workload is not constant and can be more during peak hours and less during off-peak hours. Therefore, computing resources have to be allocated more frequently during peak hours than off-peak hours. Downtime for a datacenter infrastructure, whether planned or unplanned, brings considerable costs with it. Downtime for higher levels of availability that have traditionally been very costly, hard to implement, and difficult to manage.

As the datacenter is virtualized, it is capable of delivering uncompromised control over all IT resources with good utilization efficiency of available resources. Virtualization of any datacenter would help to gain high performance, scalability, and flexibility. These critical underlying factors lay the foundation for adopting a hypervisor for datacenter virtualization, and for accelerating the transition of this infrastructure to a virtualized computing model in the near future.

For the purpose of virtualization, following subsections explain how various features of virtualization can be used in a virtualized datacenter. Hypervisor also acts as the foundation for virtualized computing and supports various applications that help in virtualization of critical activities of the business.

Hypervisor

Unique features of bare-metal hypervisors enable the hardware to be used efficiently. There are various memory-optimizing techniques that will make the hardware over-commit with the available resources, and also give high availability of the resources efficiently to the virtual machines running on host servers. Power-saving features also enable datacenters to 'Go Green' and save energy by powering off servers. This is done automatically as per the load of the infrastructure environment. Servers would automatically run when there is a requirement for more computing resources due to the load on the infrastructure. A bare-metal hypervisor uses high-level resource management policies to compute a target memory allocation for each virtual machine based on the current infrastructure load and parameter settings for each of the virtual machines. The computed target allocation is used to guide the dynamic adjustment of the memory allocation for each virtual machine in the infrastructure. In case the host memory is over-committed, the target allocations are achieved by invoking several lower-level mechanisms to reclaim memory from virtual machines.

Administration

To administer virtualized datacenter activities, a single console application is required. Using a centralized management software, a virtual management server manages bare-metal hypervisor environments centrally and allows IT administrator's centralized control over the virtual environment. The provisioning of VMs can be done by administrators on the basis of existing standardized templates. This ensures compliance of various policies with required hypervisor configurations and patches with automation, if required.

Various tools and software continuously monitor the virtual datacenter running on multiple hosts. So, on the basis of utilization, policies, and compute availability, VMs can be provisioned and decommissioned also. In the case of load balancing, the administrator or the managing software can dynamically move VMs from a physical host to another host without impacting the business with respect to the respective server.

7.3.3 Virtualization Use Cases

The following subsections describe the virtualization functionalities that can be used for datacenter applications and how virtualization improves the functionality of any datacenter environment.

Availability of Machines

This feature makes machines in a virtualized datacenter as 'highly available'. This feature ensures that multiple datacenter activities are carried out even in the case of hardware failures. This feature should be configured and used for all virtual machines in a virtual environment, as during a hardware failure, running virtual machines are started on another host machine and the downtime is reduced to minimal. If a server fails, the affected virtual machines are re-started on other production servers that have spare capacity. In a datacenter, this feature would give high availability to virtual machines by starting them on other servers, thus minimizing the impact of failures.

It is very useful to use the bare-metal hypervisor as it is less expensive and provides an increased level of availability for critical applications. It helps to increase the target level of availability to all application servers in a simpler and economical fashion.

By implementing the high availability (HA) feature of any datacenter, it is possible to reduce both planned and unplanned downtime. HA, a feature of bare-metal hypervisors, specifically reduces unplanned downtime by leveraging multiple hypervisor servers configured as a cluster to provide rapid recovery from outages, as well as cost-effective HA feature for applications running on virtual machines.

The HA feature protects application availability against hardware failure by restarting the virtual machines on other hosts within the cluster. Protection against OS failure is obtained by continuously monitoring a virtual machine and resetting it when an OS failure is detected. Unlike other clustering solutions, the HA feature provides the infrastructure to protect all workloads within the cluster. There is no need to install additional software within the application or on the virtual machine. This feature protects all workloads that are in the infrastructure. Once the HA feature is implemented, there is no action required to save VMs as they are protected.

Compared with traditional failover solutions, following are the advantages when we configure the HA feature:

1. Minimal setup.
2. Reduced complexity (e.g., no need for quorum disks).
3. Reduced hardware cost and setup.
4. Application availability without the investment of idle physical servers and complex identical failover servers.

A datacenter can be supported with the load balance feature as it is virtualized with a bare-metal hypervisor. The action taken by the HA feature for virtual machines running on a host when the host has lost its ability to communicate with other hosts over the management network and cannot ping the isolation addresses is called *host isolation response*. The term 'host isolation' does not necessarily mean that the virtual machine network is down, but only that the management network, and possibly others, is down. If server monitoring is in a disabled mode, restart of virtual machines in that server is also disabled on other hosts following a host failure or isolation. Essentially, a server will always perform a programmed server isolation response when it detects that it is isolated. The server monitoring setting determines whether virtual machines will be restarted in other servers in the same cluster following this event.

Fault Tolerance

Fault tolerance feature of a virtualized datacenter leverages the well-known encapsulation property of virtualization by building the HA feature directly into the bare-metal hypervisor to deliver hardware style fault tolerance to virtual machines. This feature is to be used for all virtual machines that require 100% uptime.

Dynamic Movement

Dynamic movement of virtual machines in a virtualized datacenter could give more options for load balancing and hardware maintenance. Usage of this feature does not have any impact on services offered by the virtual machine. This functionality is used by the distributed resource scheduling algorithm. Live migration of VMs is enabled by virtual dynamic motion from one physical host to another without impacting the business, with continuous availability, and tight integrity throughout the transaction. Storage dynamic movement enables to send VM files from one data store to another data store without service interruption. It is highly customizable to choose the target server that may be available at a single location with a single server, or multiple locations with multiple servers, with the required VM configuration and associated data store file disks.

This could be achieved using the distributed power management algorithm, which will help to reduce energy consumption in the datacenter by optimizing workload placement for low power consumption with distributed power management. The algorithm consolidates workloads when distributed resource clusters need fewer resources and switches off powers of host servers to conserve energy. When resource requirements increase, the algorithm brings hosts back online to ensure that service levels are met.

In any datacenter, this feature would be effectively used while provisioning machines on demand. A distributed power management algorithm would also use this feature to save energy during off-peak hours. Migration with dynamic movement allows moving a virtual machine to a new host without any interruption in the availability of the virtual machine. However, migration with dynamic movement cannot be used to move virtual machines from one datacenter to another.

Dynamic Storage

Dynamic movement of virtual machines along with virtual hard disks in any datacenter machines could give more options to do load balancing and hardware maintenance of storage devices. This feature allows administrators to move virtual disks or configuration files of a powered-on virtual machine to a new data store. Migration of storage with dynamic movement allows moving a virtual machine's storage without any interruption in the availability of the virtual machine. Usage of this feature does not have any impact on the virtual machine.

Resource Scheduler

In a virtualized datacenter, the presence of a resource scheduler algorithm would improve resource allocation, efficiency, and power consumption in virtual infrastructures. The resource scheduler balances workloads according to the available resources in the pool, and administrators can optimize the environment on the basis of manual or automatic intervention. If workload spikes are changing very drastically, the resource scheduler can power-off some of the unused physical servers.

The resource scheduler works with virtual dynamic motion to provide automated resource optimization. This helps to migrate and place the virtual machines. The resource scheduling algorithm simplifies the job of handling new applications and adding new virtual machines, simplifies the task of extracting or removing hardware when it is no longer needed, and replacing older host machines with newer and larger-capacity hardware. Adding new resources is also straightforward as one can simply drag and drop new physical hosts into a cluster.

A resource scheduler cluster is a collection of physical bare-metal hypervisor-installed servers and associated virtual machines with shared resources. When the host is added to the cluster, it becomes a part of the pool. Thus, the resource scheduler aggregates the resources and supports all physical hosts at the cluster level. The scheduler also enforces the policies applicable to all servers available in the resource pool. This helps to provision servers dynamically to meet the compute resources demand as well as maintain service-level agreements (SLAs).

The resource scheduler algorithm places the virtual machine on available servers and can manage the automatic provisioning based on resource allocation policies and the decision-making process. It can be configured to take action based on manual intervention after reviewing the reports which are generated from monitoring or utilization tools. The concept of resource scheduler and dynamic movement provides an integrated way of achieving the redundancy and availability of compute resources to minimize the impact of a failure event.

Power Management

Usage of power management options in virtualized environment would significantly improve efficiency. Power management applications balance workloads according to the available resources, and users can configure this feature along with the resource scheduler. If a workload's needs decrease drastically, scheduling algorithms can temporarily power-down unnecessary physical servers using distributed power management algorithms. These servers are brought back online automatically when there is a requirement for more compute resources.

Provisioning and De-Provisioning

Any datacenter infrastructure can be virtualized, and the option of provisioning comes along with it for creating a virtual machine. The simplest reason for using virtual machine templates is efficiency. By using templates, many repetitive installation and configuration tasks can be avoided. It is to be noted that a datacenter can utilize the capabilities of a hypervisor and a virtual management server for the automatic provisioning and de-provisioning functionality by making the infrastructure virtualized. The outcome is a fully installed, ready-to-operate virtual machine in less time than that required for manual installation with same features and configurations as the source machine. On-demand provisioning of resources for de-duplication process and provisioning of more servers require resources on demand basis so the hypervisor should also be able to scale up and down the infrastructure as per the demand.

Moreover, the hypervisor should also be able to detect new hardware such as servers and storage that are being introduced into the existing infrastructure. It should also maintain the balance of resources in the cluster. The HA feature of machines that are hosted in the virtual infrastructure should also be guaranteed.

Dynamic Allocation and De-Allocation

A virtualized datacenter is scalable and capable of using existing resources in an efficient way. This is achieved with the bare-metal hypervisor installed on servers in the datacenter. This environment will not only be scalable but intelligent enough to understand the load on the datacenter and allocate the computing resources accordingly. Such environment would save a significant amount of energy and will also be able to use the existing computing resources in the datacenter effectively. During off-peak hours, lots of computing power would be in unusable state. The distributed power management algorithm, with the help of the distributed resource scheduler algorithm, would identify the servers with consumption of fewer resources. Using dynamic movement, virtual machines running in that server would be moved dynamically to other servers. The server is then moved to power-off state by communicating through a remote console. These servers are brought online as and when the requirement for the computing resources arises. This would save a significant amount of energy in terms of power and computing resource, thus enabling a 'Go Green' datacenter.

It is advised to balance the load based on the peak and non-peak hours. The hypervisor helps to achieve this functionality by using the bare metal. This requires creating templates as a standardization process. Administrators save time by using these templates for deploying, cloning and converting virtual machines. These templates work like a golden copy and are managed with different types of permissions and authentication. This works like a protected copy and can be used for creating new VMs. Therefore, templates are a perfect and original image of a particular VM.

By using the distributed power management algorithm along with the distributed resource scheduler, multiple datacenters could optimize power usage by moving unused physical machines to a standby mode. The challenge here could be to understand which physical machine needs to be turned off. The resource scheduler algorithm should have the ability to understand the free and used resource capacities in a cluster. Using the algorithm, the VMs running on one physical host will be moved to another to make one physical host completely offline. This is done automatically and dynamically by the resource scheduler algorithm as there is no service loss to the end user. This feature also allows an administrator to define rules and policies, according to priority, which decides how each VM should share resources and how available resources are prioritized among multiple virtual machines. It also sends a heartbeat signal to all hosts to ensure that it is up and running fine. So, this feature is capable to dynamically provision and relocate the resources that are free in the cluster quickly as and when needed.

7.4 SERVER VIRTUALIZATION

Server virtualization covers different types of virtualization, such as client, storage, and network virtualization. In this section, different implementations of virtualization, management software, constituents of virtualization platforms support, and other related topics such as appliance and cloud computing are discussed.

Server virtualization works as a masking of the server compute that comprises the count and identity of resources with servers, storage, processors and OS from the end user. Administrators actually divide the physical server into multiple isolated VMs talking to same resource pools. Virtualization of servers provides an abstraction of the physical server/s by maintaining resource pools for server users (Fig. 7.1).

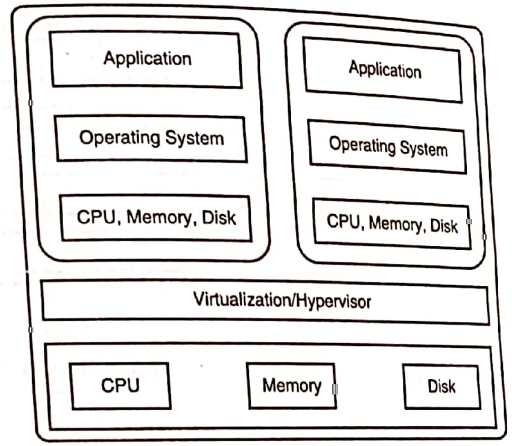

FIGURE 7.1 Server virtualization.

7.4.1 *Virtual Machine*

There are various terms to define a virtual machine. It can be termed as a virtual environment, partition, or container. In a server environment, a server that does not physically exist but is created on a different server is often called 'guest'.

The instance where a virtual machine runs is often termed as 'host'. These hosts can have multiple VMs running on the physical server. All VMs assigned to a pool of resources can be dynamically assigned to pool-based available resources.

When a user talks to this VM, he/she is privileged to use his/her VM as a physical server with all functionalities such as accessing the OSs, CPU, memory, and hard disk from the common pool. The hypervisor virtualizes multiple virtual servers based on supported architecture. Each virtual machine is bundled with an OS, CPU, hard disk, and memory.

7.4.2 *Virtualization Technologies*

Two major types of technologies are employed in server virtualization: hardware virtualization and OS virtualization. Hardware virtualization virtualizes the server hardware and OS virtualization virtualizes the application environment (e.g., file systems). These two technologies will be discussed in the following subsections.

Hardware Virtualization

Hardware virtualization is also known as hypervisor-based virtualization, bare-metal hypervisor, type 1 virtualization, or simply hypervisor. This virtualization technology has a virtualization layer running immediately on the hardware which divides the server machine into several virtual machines or partitions, with a guest OS running in each of these machines (Fig. 7.2).

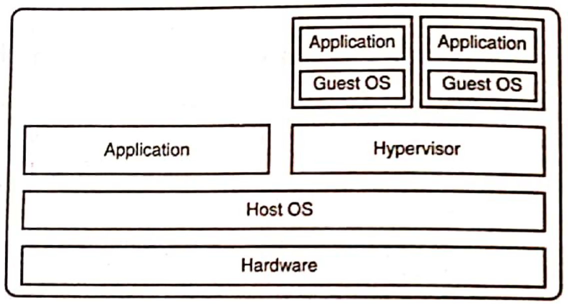

FIGURE 7.2 OS virtualization.

The binary transparency is provided by a virtualized approach and products enable the transparency for OSs, middleware, and applications.

OS Virtualization

This type of server virtualization is also known as OS-based virtualization, OS-level virtualization, or type 2 virtualization. OS virtualization creates virtualization environments within a single instance of an OS. Virtual environments created by OS virtualization are often called 'containers'.

Because all virtualization environments must share resources of a single OS while having a private virtual OS environment, a particular implementation of the technology may alter the file system orientation and often introduce access restrictions to global system configuration or settings.

7.5 VIRTUALIZATION FOR X86 ARCHITECTURE

Virtualization on processors encounters a set of challenges with reduced instruction set computing (RISC) processors. This is mainly because vendors or technology providers for processors, systems, virtualization technologies, and OSs are different and operate independently.

As a result, virtualization technologies and the rest of the system are available separately and on different timelines, rather than as a single integrated unit. Therefore, both forward and backward compatibilities must be considered when designing virtualization for x86. Most OSs, including those for x86, such as Windows and Linux, are designed to run directly on the bare-metal hardware, so they naturally assume that they fully 'own' the computer hardware.

7.5.1 *Paravirtualization*

Also known as OS-assisted virtualization, paravirtualization describes virtualization techniques that are used to overcome virtualization challenges on the older versions of processors. These techniques require modifying the guest OS kernel to improve the communication and performance between that kernel and the virtualization layer hypervisor. The newer versions of processors provide on-chip virtualization features called *hardware-based virtual machines* that make paravirtualization unnecessary.

Paravirtualization involves modifying the OS kernel to replace non-virtualizable instructions with hypercalls that communicate directly with the hypervisor. Paravirtualization also allows a set of kernel operations to be bypassed in favor of a hypervisor call that encapsulates the entire set. So, paravirtualization adds value beyond simple instruction emulation.

7.6 HYPERVISOR MANAGEMENT SOFTWARE

For each hypervisor, there is a companion layer of hypervisor management software that provides a range of functions, such as create VM, delete VM and move VM as hypervisor management functions controlling the hypervisor. A unique set of application programming interface (APIs) and graphical user interface (GUIs) is available for each 'hypervisor/hypervisor management software' pair that is used by the client, IT staff and by independent software vendors (ISVs) to create management services or other applications.

7.6.1 *Hypervisor*

Hypervisor is the foundation for virtualization on servers as it enables the hardware to be divided into multiple logical partitions and ensures isolation among them. It also supports Ethernet transport mechanism and Ethernet switch, which are needed for virtual local area network (VLAN). VLAN allows secure communication between logical partitions without using any physical Ethernet adapter. The hypervisor uses a virtual small computer system interface (SCSI) to provide support for virtual storage.

Hypervisor is a global firmware image located outside the partition memory in the first physical memory block at physical address zero. It takes control as soon as the system is powered on and gathers information about the memory, CPU, I/O, and other resources that are available to the system. It owns and controls all the mentioned resources and other resources that are global to the system. It performs virtual memory management using a global partition page table and manages any attempt by a partition to access outside its allocated limit. The whole physical memory is divided into blocks called physical memory blocks (PMBs). The logical memory is divided into logical memory blocks (LMBs).

PMBs are mapped to LMBs. The hypervisor has access to the entire memory space and maintains memory allocation to partitions through a global partition page table. Service partition is a partition that is allowed to update the hypervisor, which is a processor-based firmware. The hypervisor is the nerve center of the virtualization engine. It handles micro-partitioning of the CPU and the memory pool.

7.7 VIRTUAL INFRASTRUCTURE REQUIREMENTS

Virtualization products have strict requirements of back-end infrastructure components, including storage, network, backup, systems management, security, and time synchronization. Ensuring that these existing components are of a supported configuration is critical to the success of the implementation. During this engagement, an IT architect reviews and documents the current environment and, where applicable, recommends changes required to optimize the infrastructure.

Where applicable, enterprise tools are used to gain a clear understanding of the environment, and the configuration and utilization of various systems. A virtualization sizing tool is then used to accurately calculate the size of a potential virtualization platform.

7.7.1 *Server Virtualization Suitability Assessment*

One of the key advantages of virtualization is the greater utilization of physical server resources. However, achieving this advantage must not be at the cost of service to the business. It is imperative to ensure that the virtualization host server is sized such that it can deliver acceptable levels of service to all guests.

To ensure that existing servers operate in a shared environment, detailed hardware inventory and performance utilization information must be obtained, extrapolated, and analyzed for suitability and host server sizing.

At the completion of the collection phase, the architect evaluates results and provides documented recommendations on virtualization suitability across server candidates.

7.7.2 *Detailed Design*

Virtualization introduces many changes in the environment and ensures that the platform co-exists and interacts with the existing infrastructure, which is the key to a successful implementation.

The purpose of the design is to set naming and security standards, define the disk and network structure, document any required system-tuning elements, and produce a virtual infrastructure design capable of meeting specific requirements for a virtualized Intel server environment.

Detailed Design Document

Virtualization design document should include the following:

1. Security and administration model.
2. Backup methodology.

3. Host physical and virtual disk layout, specifically around file system structure, and dedication of disks to guests where applicable.
4. Virtual network topology structure/format and interconnection with the physical network.
5. Virtualization service console configuration.
6. Virtualization kernel device share factor configuration.
7. Host server hardware specifications.
8. Configuration of VM server with required database.
9. Virtual machine distribution among hosts.
10. Processes and procedures for ongoing management.
11. Implementation tables and configuration settings.

7.8 SUMMARY

This chapter focuses on server virtualization but also covers other types of virtualization. Under server virtualization, we have discussed different implementations of virtualization, management software, what constitutes support for virtualization platforms, and other related topics.

CHAPTER

8

Cloud Infrastructure: Deep Dive

CONTENTS

- Introduction
- Storage Virtualization
- Storage Area Networks
- Network-Attached Storage
- Cloud Server Virtualization
- Networking Essential to the Cloud
- Summary

8.1 INTRODUCTION

It is the need of the hour to reduce the risks and cost associated with business. At the same time, it is becoming vital to increase the agility and quality of the IT infrastructure. When we look at the compute business, it is more competitive to improve the utilization of the server and the flexibility by which hardware deployment can become an easier process and meet the changing requirements of the infrastructure market.

Virtualized IT environments and cloud computing will put new requirements on networks, both inside and to and from datacenters. Networks will require new levels of performance, availability, resiliency, security, and management while delivering cost-effectiveness and energy efficiencies expected from the rest of the infrastructure. Without the right networking infrastructure, businesses will not be able to realize the benefits of virtualization fully. These new services are designed to help networks adapt to the latest demands of virtualized infrastructure and condition the IT infrastructure for cloud computing.

What is happening in datacenters today is the adoption of virtualization. This helps businesses get better utilization out of the resources they have, makes them easier to manage, and saves money.

However, virtulization and its benefits are being adopted in multiple areas of the IT infrastructure, from different server platforms, such as x86, RISC, and mainframes, and different hypervisors, to storage and even the network. Businesses need help in understanding how the different virtualization techniques will affect their network and how they should plan and design their future network.

Multiple operating systems can run on a single physical server with the help of virtual machines (VMs) that enable various businesses to share the infrastructure. This results in effective utilization of the deployed hardware. The following varied scenarios can be deployed on the same server, where the developer and the administrator can bring in more optimization while working together:

1. Software testing and development.
2. Distributed servers and platforms testing.
3. Server consolidation.
4. Legacy application re-hosting.

The tremendous growth in data over the last decade needs lots of control mechanisms. But the IT business rule that works for an IT environment, in which computing is decentralized, does not control storage, processing, and networking requirements. This has made the system very complex, and the available data are fragmented over the legacy systems. This calls for complete lifecycle management of the cloud environment to help the cloud subscribers, which will make storage, archiving, and information dissemination easier for business operations.

Let us start with the following facts:

1. Data are growing rapidly, approximately by 50% every year.
2. Companies are running big amounts of storage, and some industries such as health and life sciences need 1 TB data per day.

3. Total IT budgets amount to around 15% because of storage.
4. Redundancies are higher.

Organizations are not able to handle the growth of the data, and this causes a lot of problems due to scarcity of efficient storage and information systems. Therefore, it adds more costs and gives rise to the problems of not meeting the service-level agreements. These problems lead to insignificant performance over legacy systems.

Indeed, there is requirement of information lifecycle management techniques to overcome these problems and meet the future high-volume data growth problems.

As company data loads continue to increase, so do the complexity and capacity of the storage environment. Storage area networks (SANs) can help overcome some of the storage challenges, but not all of them. The complexity remains. Multiple storage devices from multiple vendors can have inter-operability issues on the SAN. Storage management can be tedious and time-consuming. Also infrastructure changes can be difficult to implement.

By embracing storage virtualization, clients gain the ability to reduce storage network complexity by aggregating multiple storage devices into a common managed virtual storage pool. Storage optimization and integration services – storage virtualization service products – help businesses create an integrated, virtualized solution that aligns with their unique storage strategy, vendor choices, and environment. By gaining access to experienced, knowledgeable professionals who use proven methodologies, businesses can develop a storage virtualization solution that allows them to add storage solutions with live upgradation means, without effecting the actual servers and network. This will even help to develop a comprehensive approach to combine with varied speed-based drives according to size requirements of different vendors. It provides ease of access to storage devices across the enterprise.

8.1.1 *Value Proposition*

For organizations that need to reduce storage management complexity, increase storage capacity utilization, and enable non-disruptive hardware change, cloud vendors offer storage virtualization services. Designed to help clients reduce storage costs, centralize data management, and extend the life of their storage hardware, this service product provides experienced consultants a platform to design and build an integrated virtualization solution that aligns with clients' particular storage strategies and environments.

Unlike many of their competitors, cloud vendors are multi-vendor suppliers and integrators who use a comprehensive consulting approach and can provide the expertise, techniques, and broad product portfolio needed by clients to create an efficient virtualized storage environment.

8.2 STORAGE VIRTUALIZATION

Storage utilization is improved by storage virtualization. It provides the common pool of storage in a self-service manner with access to and management of the resources among the various tenants of the organization, which may not be directly looking for physical location of storage (Fig. 8.1).

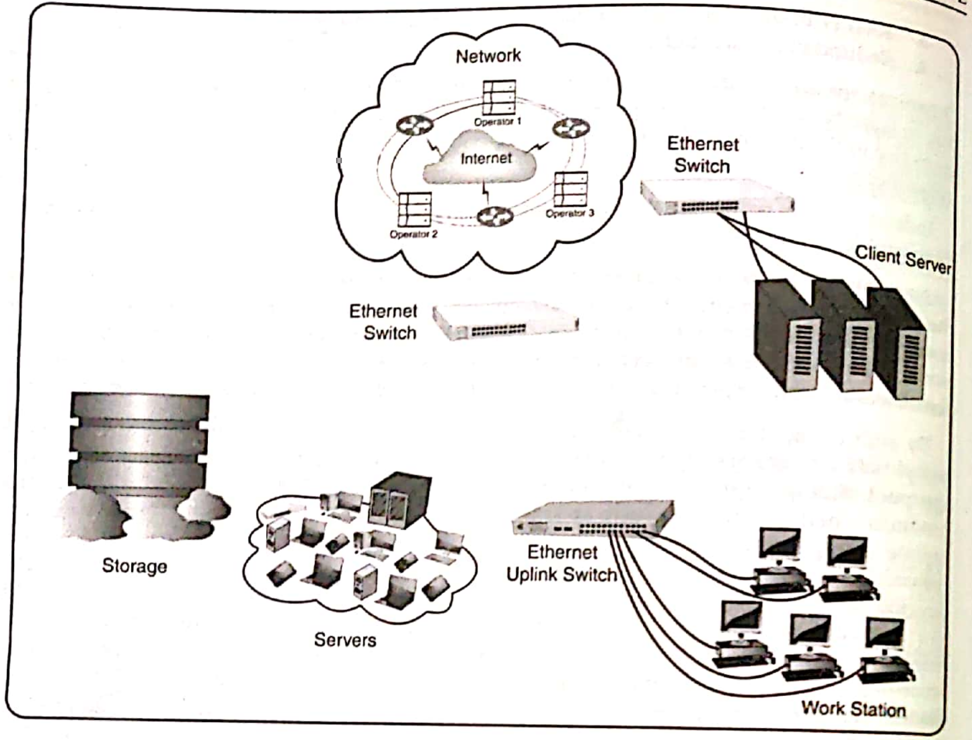

FIGURE 8.1 Storage cloud.

1. **Benefits:**
   - Make storage simpler.
   - Make storage more heterogeneous.
   - Make storage more manageable.
2. **Why the cloud?**
   - The cloud can assess, design, develop, optimize, and support on-demand infrastructure that is integrated, virtualized, autonomic, and built on open standards.
3. **The storage challenge**: Storage is a top priority for every business, mission-critical as well as challenging to manage. What makes it challenging?
   - Growth in storage demand and, therefore, growth in storage management costs due to digital content, e-mail, Internet-based applications, and emerging technology are one of the reasons.
   - Threats to business continuity posed by disaster or human errors as causes of 40% of outages are yet other reasons. Also, dealing with storage management strains your budget.
   - Pressure to retain data for compliance with regulations has increased worldwide.
   - Complexity of storage networks with devices from different manufacturers resulting in separate islands of storage is on the rise.

A single point of management over your entire storage network, using your storage and data resources to their full potential, among others, enables excellent productivity of storage administrators and increases the potential to reduce errors. Typical structural client savings of 30–70% on storage management costs are possible.

8.2.1 *Storage Cost Drivers*

Storage is growing rapidly. Although the cost of storage hardware is decreasing (halving every 12 months), the overall storage cost is increasing as a result of increased demand for storage (nearly doubling every 12 months) and complex storage management:

1. Only 14% of the total cost of ownership (TCO) is hardware cost.
2. Studies indicate that storage-related cost (hardware and software) will peak to 23% of the total IT budget.
3. Today storage administrations are islands of point solutions, which increases the management cost.
4. While the purchasing cost per GB goes down by 20%–40% yearly, the cost of managing storage may rise high with the growth in traditional storage environments.

8.3 STORAGE AREA NETWORKS

Storage area network (SAN) is a method of provisioning by locally attaching the device to the operating system, and to the servers. With the SAN architecture, we can connect different types of disk arrays, tapes, and other storage devices (Fig. 8.2).

Network-attached storage (NAS) is different from SAN as it uses file-based protocols such as Network File System (NFS). In this architecture, it is evident that the storage is available remotely and can be accessed as a file and not as the disk block.

SANs are becoming a pervasive technology. The following list shows their evolution through several stages:

1. **Direct-attach storage:** Hosts can only use storage that is directly attached through point-to-point small computer system interface (SCSI) connections. The disk storage is physically separate and cannot be configured to attach to multiple hosts.
2. **Centralized but still direct-attach storage:** The storage is physically centralized in one unit. The disk controller is connected to multiple hosts with point-to-point connections. Re-assigning storage to different hosts requires re-cabling.
3. **Shared storage:** A SAN enables point-to-point connections between any host and the disk controller. Disk volumes can be dynamically assigned to different hosts, without requiring re-cabling. SANs have enabled several benefits, including:
   - Better connectivity (avoidance of re-cabling).
   - Improved performance (through higher-bandwidth connections).
   - Distance flexibility (overcoming SCSI limitations).
   - Scalability (enabling storage capacity to be increased with less disruption).
   - More vendor/product choice (by separating the disk storage from the host server and using open-standard Fibre Channel connections).

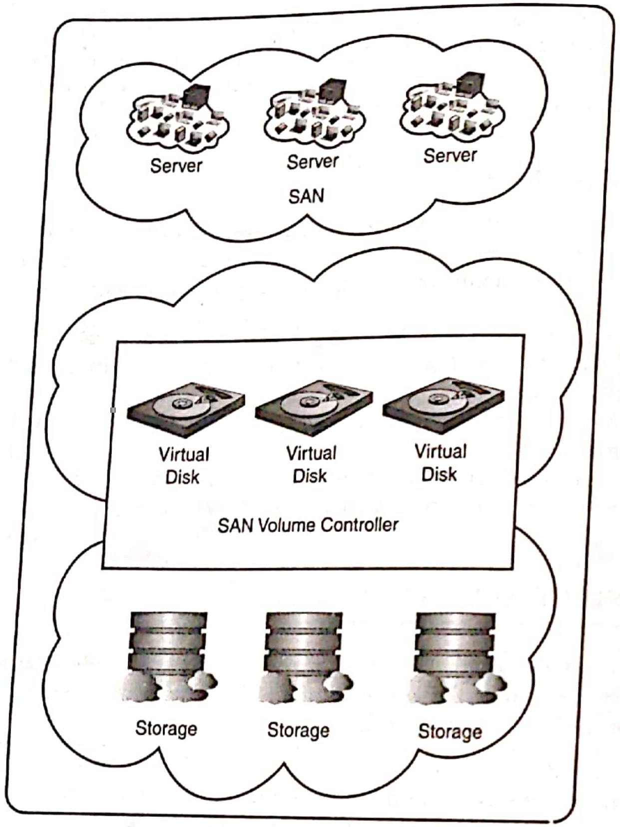

FIGURE 8.2 SAN.

However, these benefits have also resulted in new issues and increased complexity. Let us see what this means:

1. **Complexity case A:** Enterprises have a SAN with many UNIX/Windows servers attached.
2. **Complexity case B:** Within the SAN, there are many different types of storage. In some cases, customers made this choice to stay vendor-neutral; while in others, it was a result of mergers or consolidations. The storage administrator has to configure logical unit numbers (LUNs) to servers and keep track of which servers have what storage. Surprisingly, most customers admit that they are keeping track of all this with spreadsheets, as SAN managers are not as prevalent as we would have thought. You can imagine the complexity of reallocating LUNs to different servers as the need for storage shifts from one server to another.

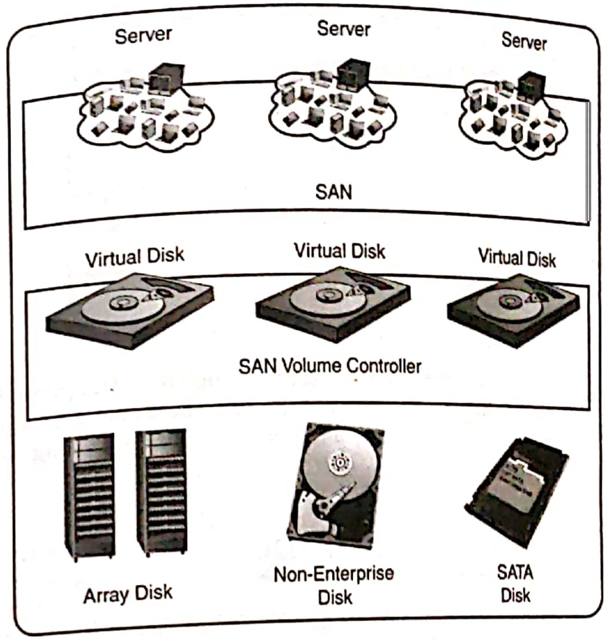

FIGURE 8.3 Virtual storage infrastructure.

3. **Complexity case C:** Complexity of different file systems. Now the storage administrator needs to know the different commands to be used depending on the file system being dealt with.
4. **Complexity case D:** On top of all of this, each of these storage devices has to be configured and installed. But because there are no common standards, each storage device has its own procedures and user interfaces for doing this. Now imagine that you are in production and the storage administrator is faced with the task of replicating all of these devices across all servers and managing the performance and capacity of each device. Again, they each have their own separate interfaces and procedures to do this.
5. **Complexity case E:** Last but not least, because the file systems are tied to each of the hundreds of servers, all of the storage management functions have to be run on these hundreds of servers. If you ask businesses what percentage of their storage is actually being utilized, most of them will not know the answer.

So, this is what businesses mean when they say they have inter-operability and manageability problems with their storage. No wonder, if you think about the many permutations and combinations of 'x' servers/operating systems times 'y' device types, you know that the complexity is daunting.

8.3.1 *Storage Virtualization Benefits*

Storage virtualization makes storage simpler, more heterogeneous and more manageable. It creates a logical view of storage that simplifies management and makes physical changes to the infrastructure transparent to the user (Fig. 8.3).

1. **Make it simpler:**
   - Effective use of capacity.
   - Effective management of capacity.
   - Lower cost of ownership.
2. **Make it more heterogeneous:**
   - Any-to-any attachment.
   - Data migration.
   - Security.
   - Investment protection.
3. **Make it more manageable:**
   - Scalable.
   - Quality of service management.

This gives the options to control the storage volumes through a central point. It even reduces the server down-time for different predicted outages, maintenance, and support activities. This helps in effective resource utilization and sets the storage management tools in a cost-effective fashion.

8.4 NETWORK-ATTACHED STORAGE

Network-attached storage (NAS), based on its network address, is a hard drive storage. It is not directly connected to the server that actually serves the workstations connected to the network applications.

It is advantageous to separate the storage from the server. This makes the process faster because both the application and the files are not challenging the same resources on the network. NAS works on local area network, based on Ethernet switch with the IP address. There exists a mapping between the main server and the file server.

NAS comprises Redundant Array of Independent Disks (RAID) systems, hard disk storage and configuration, and file mapping with network-attached device management device. It works on file-based protocols. This can comprise NFS, Common Internet File System (CIFS), etc.

8.4.1 NAS Basics

NAS is different from the file server based on the operating system. These file servers are based on the offerings of the file servers such as UNIX, Novell, Linux, Windows, and OS/2. NAS does not have the features of the application or directory server; rather it is based on the specific Storage function (Fig. 8.4).

NAS uses a plug-and-play feature of the Ethernet network and makes it available in a fraction of a second. It delivers the fully loaded performance-based application environment to serve the files available on the network systems. These systems can be connected to the non-Windows–based environments to attach to file systems such as NFS and serve the large ports.

Implementation of NAS architecture is not difficult, but the administrator should know the gamut of its components such as the interconnection points and NAS protocols.

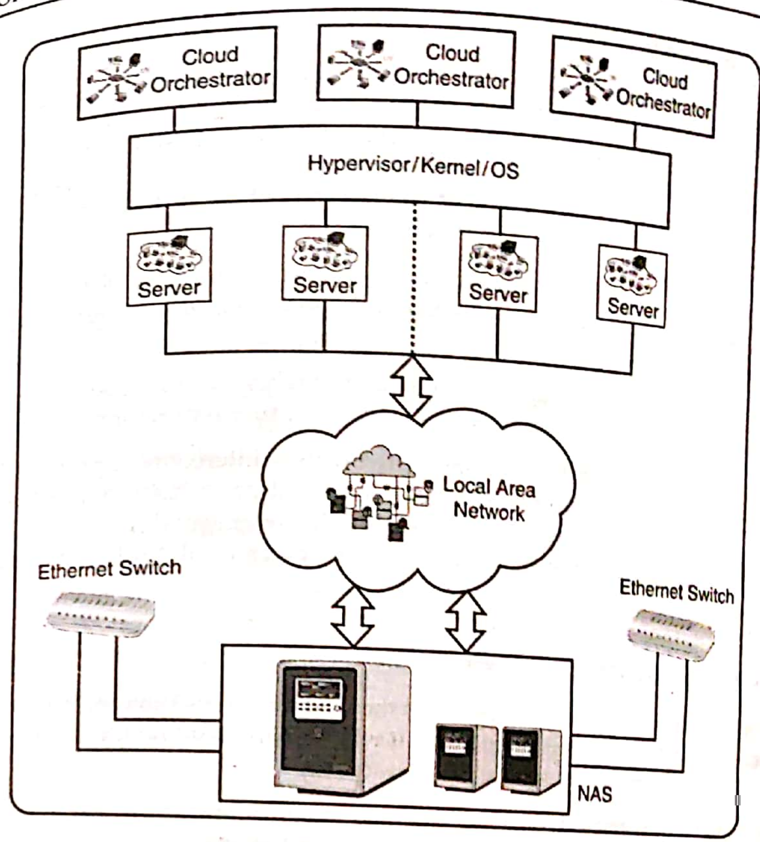

FIGURE 8.4 NAS.

8.4.2 NAS Protocols

We need a language to talk to the NAS interconnects. It is important to have knowledge of the protocol that is the key for NAS implementation. CIFS started as the project outcome of server messaging block protocol and was later renamed as CIFS. CIFS is the most common protocol for windows environment.

Another protocol for the NAS is NFS. The combined power of virtualization and performance gives an upper hand to use NFS as a preferred protocol among NAS vendors. This helps in storing the data at the file level, rather than at the block level.

Internet small computer system interface (iSCSI) is another protocol stack for NAS and gives the option to access the data at block level. This is an inexpensive protocol compared to the other two as it works without using expensive adapters and sophisticated software.

Fibre Channel over Ethernet (FCoE) is another NAS protocol. It is a combination of Fibre Channel and Ethernet, but it is difficult to determine its success as there are few Fibre Channel over Ethernet deployments.

8.4.3 NAS Interconnects

To integrate NAS devices, we need NAS interconnects. The more we understand the NAS interconnects, the easier it will be to take better storage decisions for NAS systems. Fast Ethernet is one of the best among all interconnect architecture. It is very easy to understand and not expensive. It is important to note that it works slowly at basic file levels. It is good for transfer of up to 10 MB of data within a small group of people. The enhanced and more advanced level of interconnect after Fast Ethernet is Gigabit Ethernet.

Gigabit Ethernet serves a larger group of people, with file transfer of more than 10 MB. This can easily accommodate 100 people accessing the same server at a very good speed and relatively good performance.

Gigabit Ethernet is a good interconnect protocol, but when we increase our group size, to say 500, we can face some performance issues. It may also cause issues for block-level accesses.

In order to overcome these problems, the relatively new interconnect protocol 10 GE is of help. This is the fastest interconnect protocol currently and provides very good performance when there is demand for huge-sized file transfers with more speed. Enterprises use hybrid interconnect protocols as per their requirements. Price plays a vital role while choosing the interconnect protocol.

8.4.4 NAS Requirements

NAS requirements need some basic steps to get the best out of a situation. It will help you to define the success for the NAS implementation. It will help to maintain the most suitable set of vendors based on the requirements of the NAS systems.

It is a good idea to understand NAS implementation before starting it. All the vendors have different devices available over different deployments, so having a clear idea of the same gives an edge to the best fit of the NAS system. It will be good to evaluate the different options available by distributing the requirements among the vendors and outlining the different extremities of the situation.

Listing of the requirements required for the device can be the easiest step. The primary requirements can be connecting to the multiple servers without any performance loss, the amount of the storage to handle the file use, etc. This will require little bit of research on the current offerings available to handle these requirements. The requirements that are technical necessity of the NAS systems can be maintained as a list to match up with real-world deployment and budget management to buy them.

8.4.5 High-Performance NAS

NAS works with file-based systems that help companies to work with distributed file systems such as NFS and CIFS. This consolidates the distributed file system into different, small file-based storage systems. There were some problems associated with NAS such as reliability, connectivity, and scalability with the enterprise storage. But now, the new-generation NAS systems have overcome it and promise higher value in the same file-based storage systems.

In order to differentiate the high-performance from regular NAS, there is no common single point of agreement. But we can have some distinction at least, such as high-performance NAS provides more ports on the interface level. Connectivity is an important factor for performance and more the number of ports, more reliable the NAS implementation.

High-performance NAS systems operate with the Serial Advanced Technology Attachment (SATA) or serial-attached SCSI. As a result, we get higher scalability with the disk controller engines available within the system. High-performance NAS systems work with various heads that can access various disks, and at the same time, improve performance. It is also possible to analyze the input/output operations per second (IOPS) to optimize the high-performance NAS system. We can have the concurrent file access in the high-performance NAS platform or access to multiple metadata points at the same time.

Clustering also plays an important role in increasing the throughput of NAS systems other than having a single pool of storage. It also offers resiliency as even if one of the cluster is not working, the other will not be affected and the workload of the failed one can be transferred to the working and free cluster.

The unique feature of high-performance NAS is Global File System (GFS). It is very helpful in the clustered environment where all the clusters share a single pool. GFS can be added with the operating system or as a separate layer on top of the high-performance NAS. GFS helps the cluster to work independently or as the same entity while sharing the same pool. High-performance NAS has an upper and helping edge over the deployment challenges. It helps to

1. Perform more work in less time.
2. Reduce the number of file servers.
3. Simplify NAS storage infrastructure.
4. Save energy.

Administrators should evaluate the prospective high-performance NAS system for

1. Underlying NAS systems management requirements.
2. Expectation of NAS systems management efficiency.
3. High-performance and -throughput issues.
4. Demand of special host software or drivers.
5. Expense of added software maintenance issues.
6. Tuning and load balancing.
7. Appropriate system for data workload.
8. Management and interoperation with storage vendors to ease compatibility concerns.

The most important step for better performance results is to optimize the workload and understand the data workload with the inner depth of application. We can find out what type of application it is and how it works – sequentially, or by storing transactional data with the known IOPS. High-performance NAS systems require the following to accommodate high-performance systems:

1. New switching.
2. Network architecture changes.
3. Additional LAN bandwidth.

High-performance NAS is evolving fast, but still many features of traditional NAS are not available in it as yet, such as

1. Snapshots.
2. Replication.
3. Point-in-time (PIT) copies.
4. Finer management granularity.
5. Better load balancing and data migration.

High-performance NAS has also renewed interest in the following:

1. Storage virtualization.
2. VMs used throughout.
3. Storage virtualization aggregation.
4. Live storage mobility.
5. High-capacity storage systems.

8.4.6 Network Infrastructure

Network infrastructure helps organizations in understanding their networks and their network usage better, addressing specific networking issues or problems, and reducing networking costs. The service provides relevant recommendations based on the analysis of data from the client's network and networking environment, industry insights, and leading practices in networking. The service is composed of three activities from which the client may choose one or more activities to engage:

1. **Network infrastructure assessment:** It focuses on helping clients understand the components that are deployed in their networks and includes reviews of their network designs, devices, service-level agreements (SLAs), readiness reviews for deployments or refreshes with new technologies.
2. **Network performance analysis:** Network performance analysis and capacity planning focuses on helping businesses understand how the performance of their network is being affected by business critical applications and background traffic, and to determine or predict the network sizing requirements to optimize the usage by applications.
3. **Network diagnostic assessment:** Network diagnostic assessment focuses on helping businesses with problem determination, problem source identification, and root cause analysis of network performance problems.

Network infrastructure services can be appropriate any time your network is experiencing performance problems, you are under pressure to do more with fewer resources, or you have other networking issues to address. These services are also beneficial when you are planning to deploy important new business applications, bring in significant new traffic driven by organic growth or a merger or acquisition, introduce a new and network-dependent business model, or deploy a new technology such as voice or video over IP (VoIP), wireless communications, or radio frequency identification (RFID).

Network infrastructure assessments, network performance and capacity planning studies, and root cause analysis of infrastructure performance problems help to prepare for new initiatives or to repair the current networking environment.

8.5 CLOUD SERVER VIRTUALIZATION

This section provides an overview of the architecture, features, and benefits of server virtualization solutions that provide a cost-effective VM solution for OS platforms. VMs help to run various OS concurrently on the single server. This helps to cater various scenarios such as consolidation, automation, test and development environments, migrating from x86 to non-x86 env, workload management (Fig. 8.5)

8.5.1 *Datacenter Virtualization*

The primary requirements of the datacenter with respect to datacenter virtualization are as follows:

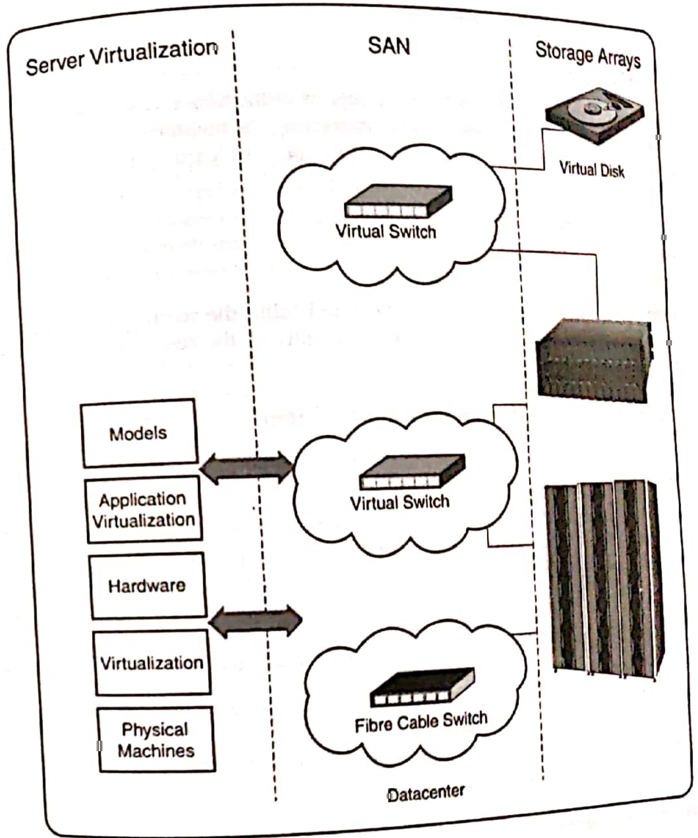

FIGURE 8.5 Server virtualization.

1. Virtual servers.
2. Storage.
3. Networking.
4. Unmodified operating systems.

These servers help to run independently the application on the VMs by sharing same pool of resources. They enable

1. Comprehensive virtualization.
2. Management.
3. SAN.
4. Resource optimization.
5. Application availability.
6. Operational automation capabilities.

8.5.2 *Virtual Datacenter*

Organizations are always in need of higher levels of utilization and flexibility of hardware resources. Virtual servers help achieve this by abstracting the memory, processor, storage, etc. available in the form of virtual resources. The most important feature of virtual servers is that it provides

1. High level of performance.
2. Scalability.
3. Flexibility.

These virtual servers work like a complete server and fulfill the requirements of processors. The advance virtualization techniques ensure availability of the resources when there is an acute need of resources.

8.5.3 *Virtual Datacenter Management and Control*

Virtual datacenters provide all management and control functions of the environment under the same umbrella. These functions offer the following benefits:

1. They use a very simple provisioning method to allocate the virtual servers with the easy-to-use interface and templates to deploy the virtual server.
2. Businesses need special attention at different intervals; virtual servers help to automate the operational needs of the deployment and set the alerts when they are required the most.
3. They help to schedule and alert the different management, control, and support functions with scheduled automated tasks.
4. They act as a very good tool for metering the utilization of processor memory and IOPS requirements with detail reports.
5. They help to set the customized roles based on the type of work as well as access permission to the resources using different tiers.

8.5.4 *Dynamic Resource*

In the virtual datacenter, resource requirements are not same every time. They have different spikes to meet the dynamic nature of the environment. Dynamic resources adhere to the

requirements and allocate the computing resources dynamically to meet the business goals. This helps in

1. Monitoring utilization.
2. Common resource pool maintenance.
3. Matching the business needs and changing priorities.
4. Making additional capacity available.
5. Migrating live VMs.
6. Dynamically allocating IT resources.
7. Creating rules and policies to prioritize resource allocation.
8. Granting IT autonomy to business organizations.
9. Providing dedicated IT infrastructure to business unit by higher utilization achievement.
10. Having centralized IT control over hardware resources.

8.5.5 *High Availability*

A virtual datacenter requires the features of high availability to provide cost-effective failover options. It should not be based on related operating systems and virtualization technologies. The following features for high availability make a datacenter more robust and reliable:

1. Failover options to protect applications.
2. Consistent defense mechanism for IT infrastructure.
3. Live workload transfer in case of failover.
4. Alerting the administrator for stringent situation.
5. Zero down-time to meet SLAs.

8.5.6 *Live Migration*

Similar to the high availability option we have already discussed, live migration helps the environment to run and gives unparalleled availability and flexibility to meet the requirements of the business goals. It monitors the utilization of servers, storage, and networking and leverages the virtualization technology to move the VM from one server to another at unprecedented situations. This is maintained by a set of files managed by shared storage-based file systems to access the VM at different periods of intervals or simultaneously. Even the network is virtualized, which ensures smooth migration. The main features/benefits it has are that it

1. Balances the workloads by transferring the under-performing servers.
2. Ensures live migration within no time and not even traced by the end-user.
3. Maintains, manages, and supports the resource pools automatically.
4. Provides ease of hardware maintenance with failover alerts and scheduled maintenance activities.

8.6 NETWORKING ESSENTIAL TO THE CLOUD

Network plays a vital role in infrastructure management to:

1. Reduce costs.
2. Improve service.
3. Manage risk.

It is important to focus on infrastructure initiatives essential for reaping benefits such as:

1. Server.
2. Storage hardware optimization.
3. Technology enhancements.
4. Service management improvement.
5. Security.
6. Resiliency.
7. Optimization of the network (hardware, software, management).

Highly virtualized infrastructure-based clouds meet with demanding network requirements that can restrict the growth of the infrastructure management activities. There is a need of the following features:

1. More stringent network performance.
2. Fast reliable access to virtualized resources.
3. Flexible and adaptable networks.
4. Application workload mobility.
5. Response to variable capacity requirements.
6. Security to support multi-tenancy.

8.6.1 *Datacenter Network*

To get the dynamic and self-service based environments, networking is very essential for initiatives such as datacenter consolidation and virtualization. Networking is very pivotal to the success of transforming the infrastructure to improve services and risk management. Though only server and storage are more in focus for virtualization and provisioning, network optimization is also essential to ensure the overall benefits of networking. To support these networking requirements, businesses will need the following:

1. Expertise to assess, plan, design, and implement networks with holistic consideration of servers, storage, application performance, and manageability.
2. Different options of cost and different ranges of performance to match their needs.
3. Technological expertise to design and deploy security policies.
4. Simple operational software to lower the cost and to integrate the network and manage it.

8.6.2 *Market Opportunity*

1. **Cost control, high availability and performance, and robust security are business imperatives:**
   - Businesses are looking for cost containment and reduction in the datacenter - while addressing challenges in responding quickly to rapidly changing business requirements.
2. **Datacenter networking technologies are changing fast and in-house staff does not always have adequate time and experience to take appropriate actions:**
   - Businesses need help, especially in new areas such as infrastructure virtualization, private optical networking, and converged data and storage networking.

3. **Datacenter consolidations as well as server and storage virtualization impact the network in terms of new requirements for flexibility, performance, and security:**
   - A near-capacity and often difficult-to-manage datacenter networking infrastructure resulting from years of ad hoc changes and updates that can impede plans for server and storage virtualization.

First, especially in today's economic environment, cost control, and cost savings are key considerations. Cloud vendors can help businesses save money by optimizing their current network through consolidation and virtualization of network devices, while helping them plan for the future. With the rapid changes occurring in IT infrastructure technologies, many businesses do not have the time or experience to understand how the network will be impacted. Most of the focus is on consolidating and virtualizing servers and storage without thinking long term about the supporting network.

8.6.3 *Datacenter Network Services*

Network services help to model, design, and architect solution for the organization to:

1. Develop the network infrastructure to work for the initiatives such as compute, storage, network consolidation, and energy optimization.
2. Integrate services of infrastructure.
3. Improve facility management for energy, cooling, and space optimization by adopting new and transformed networking devices.
4. Prepare for new technologies while maintaining security and resiliency.
5. Provide greater freedom to focus internal resources on critical operational concerns.
6. Help reduce datacenter sprawl.
7. Help build differentiating advantage through improved efficiency and business innovation.

8.6.4 *Data and Storage Network Convergence*

The convergence of the data network and storage network into a single physical infrastructure will be attractive to businesses that want to lower costs and complexity in their datacenters without forfeiting high availability and performance. Data and storage network convergence eliminates duplicate infrastructure, reducing the required hardware components – adapters, cables, and switches – and resulting in savings on hardware expenditures, power, cooling, and space. At the same time, with a single physical infrastructure, deployment, upgrades, and management will be simplified, contributing to lower total cost of ownership.

The services include the following:

1. Developing the network design.
2. Selecting vendors and preparing a detailed design.
3. Creating a roadmap for migration.
4. Carrying procurement, logistics site preparation.
5. Deployment, testing the network.
6. Providing on-going maintenance support.

Comprehensive network infrastructure solutions are designed to meet the changing requirements driven by consolidation and virtualization in support of dynamic infrastructures and cloud computing. The service product consists of the following components:

1. **Consolidation and virtualization:** These help to consolidate the datacenter by designing and deploying the virtualized IT environments. Convergence of data and storage networking helps to design and deploy a converged data and storage infrastructure that allows quick achievement of the financial benefits of Fibre Channel over Ethernet technology.
2. **Private networking:** This helps in establishing the private network and design and deploy the connectivity between the resources of different datacenters.
3. **Security/firewalls:** This helps to design and deploy network firewall technology to support the security requirements in today's datacenter network.

8.6.5 Network Infrastructure

Network infrastructure engagements are assessments that look at the performance, availability, resiliency, and cost of the network. A major target audience for these services is clients who are facing pressure to do more with less or who are or experiencing network performance or availability problems. Another important target audience is clients who are planning changes such as the deployment of a new application that may require network redesign, anticipation of increased network traffic from organic growth or acquisitions or new network traffic flows driven by datacenter consolidation, green datacenter migrations, and server relocations.

Network infrastructure optimization includes four components: network infrastructure assessment, network performance analysis and capacity planning, network infrastructure for consolidation and virtualization, and network diagnostic assessment.

Network infrastructure assessments are designed to help organizations provide an in-depth view of an existing network infrastructure and identify gaps between the client's current and desired capabilities. These assessments are designed to determine if there are resources that are underutilized or untapped and if more value can be extracted from the investments a client has already made. They can also include reviews of network designs, devices, configurations, and service level agreements (including service level objectives) as well as an assessment of the readiness to deploy a new technology or upgrade the infrastructure.

Network performance analysis and capacity planning helps clients understand how overall network performance is affected by applications and background traffic, whether current or new. It also demonstrates how the network may react to failures or changes in configurations. It captures the traffic flows across the infrastructure to establish baselines and trends, including usage patterns to provide inputs for simulation modeling or virtual testing of proposed changes in the infrastructure. Outputs of network performance and capacity planning can be used as inputs to make immediate changes to improve performance and capacity as well as determine network sizing requirements for a planned environment change or for setting appropriate SLAs with carriers.

Network infrastructure for consolidation and virtualization is a service component that helps clients address the increasingly complex networking aspects of a virtualized IT environment by identifying cost savings and delivering an optimized networking infrastructure. The service can also help to plan, design, and build a networking infrastructure that contributes fully to a dynamic infrastructure – one that adapts quickly and effectively to business opportunities and rapidly changing demands.

A network diagnostic assessment helps clients identify problems, pinpoint sources, and analyze root causes of specific performance issues. This type of assessment can uncover problems such as traffic congestion, latency, suboptimal configurations, or the impact of application behavior on the performance of the network. For converged networking environments network diagnostic can determine the issues around VoIP and video real-time protocol issues so that additional drill down can be identified. The objective is to recommend approaches and corrective actions that help the client maintain business-critical application performance a levels that support their business goals.

All engagements result in actionable recommendations for optimizing the networkin infrastructure like given below:

1. **Main points:**
   - Rising costs and challenges in responding quickly to rapidly changing busine opportunities.
   - Critical business processes jeopardized by down-time, security breaches, or poor performance of the networking infrastructure.
   - Determining the networking alternatives that address immediate challenges a protect future flexibility.
2. **Network infrastructure provides the following benefits:**
   - Identifying areas to cut costs through consolidation and virtualization.
   - Planning a network that fully contributes to a responsive IT environment.
   - Removing network as a bottleneck to meeting availability, security, and pe mance requirements.
   - Leveraging expertise to plan and justify a dynamic networking infrastructur directly to business needs.
   - Achieving the optimal balance of business needs, network enhancements, an savings using a proven, structured, and robust approach.
3. **Business impact:**
   - Increasing costs for a proliferation of hardware.
   - Business constrained by IT infrastructure.
   - Lost returns because of customer displeasure and reduced employee produ
   - Poor business image, fines, and investigations due to security breaches.
   - Risk of inexperienced staff making poor long-term, strategic decisions.
   - Inability to achieve the right balance of business, cost, and network benefit

The technique provides a structured approach for deploying business applications in with IT capabilities.

8.6.6 *Datacenter Networking Services Enhancements*

There are three service products under networking strategy and optimization services:

1. Organization network strategy and planning.
2. Network application optimization.
3. Network infrastructure.

The following are four service components available under network integration services datacenter networks:

1. Consolidation and virtualization.
2. Data and storage network convergence.
3. Private optical networking.
4. Security and firewalls.

8.6.7 *Network Integration – Consolidation and Virtualization*

The consolidation and virtualization component helps clients understand, plan for, and meet the new demands of virtualized servers and storage while also addressing consolidation and virtualization of the network itself to further reduce infrastructure costs. It is designed to

1. Address the new demands that virtualized servers and storage devices place on the network *and* the benefits of consolidating and virtualizing the network itself.
2. Deliver cost-effective, optimized networking infrastructures that support and fully contribute to a responsive, consolidated, and virtualized IT environment.

Cloud vendors can help businesses migrate from a traditional, isolated, static network design for the datacenter to one that is integrated with other IT resources to provide dynamic, scalable network resources. Regardless of the brands of technology in their environment, network consolidation and virtualization services are designed to offer guidance throughout the process – from developing the strategy and assessing the current infrastructure to designing and implementing a networking infrastructure that comprehensively supports a dynamic infrastructure.

In the big picture, IT infrastructure is moving left to right – servers, storage, and networking are becoming more and more interdependent, leading ultimately to a set of resources that are provisioned together to deliver services:

1. **Legacy environment:** Static, endpoint agnostic, strict, limited change windows, proliferation of special-purpose devices (firewalls, load balancers, IPS).
2. **Device virtualization:** Physical consolidation and optimization, basic virtualization of servers, storage, and network, simply network management.
3. **System virtualization:** Connecting virtualized servers and storage, support platform-specific network requirements and multiple layers of network virtualization.
4. **Cloud computing:** Architect responsive, secure network; support automated provisioning of servers, storage, and network; increase operational savings.

8.6.8 *Datacenter Network Thinking has to Change*

Static, secure datacenter networks that meet their non-functional requirements through limited, controlled changes are no longer adequate. Datacenter networks must become significantly

more flexible and responsive, capable of dynamic change. The datacenter network is a critical success factor for storage and server virtualization initiatives – ignore it at your peril. Consolidation and virtualization in the datacenter is increasing demands on the network in terms of throughput and traffic patterns, upending traditional performance and capacity 'rules of thumb'. VM mobility and mixed-platform environments will require the network to be much more dynamic in terms of scaling and services provided, to transfer workloads without disruption to end-users and business processes. The network must be integrated into the overall IT systems management environment to provide dynamic services in response to automated provisioning.

8.7 SUMMARY

This chapter provides an overview of the architectures, features, and benefits of cloud infrastructure solutions which provide a cost-effective solution for any datacenter cloud implementation.