

# Cloud Computing Networking

Theory, Practice, and Development



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Lee Chao



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# Preface

As the IT industry advances, cloud computing represents the next big computing platform change. It is the most significant transformation since the introduction of the Internet in the early 1990s. Cloud computing along with virtualization technology will literally revolutionize the way we run a business. The cloud provides a flexible, secure, scalable, and affordable IT infrastructure. E-commerce and educational institutions can particularly benefit from cloud-based IT infrastructures.

Through the Internet, cloud-based IT infrastructures allow companies and educational institutions to subscribe to software, an IT infrastructure, or an application development platform from a cloud provider. This way, it is not necessary for subscribers to build their own IT infrastructure for supporting their computation needs. As a result, subscribers can significantly reduce the cost of IT development and management. Companies and educational institutions can also develop their own private clouds to take advantage of the flexibility, security, availability, and affordability of a cloud computing environment.

To catch up on the cutting-edge technology such as cloud computing and network virtualization, this book is designed to provide enough networking theory and concepts for readers to understand cloud computing. In addition, the book provides hands-on practice in a cloud-based computing environment.

## Motivation

More and more companies and educational institutions are planning to adopt a cloud-based IT infrastructure. Therefore, today's job market requires IT professionals to understand cloud computing and have hands-on skills for developing cloud-based IT infrastructures. Although professional development books in the cloud

computing field are available, they are usually for more experienced IT professionals. For many university students and entry-level IT professionals, there are a handful of challenges to master cloud technology. It is difficult for them to understand cloud computing without adequate knowledge of networking and system administration.

Understanding the needs of entry-level IP professionals and university students has motivated the author to write this book, which includes systematic coverage of networking and system administration for better understanding cloud computing.

### Objectives of the Book

With this motivation, this book is designed with the following objectives. First, it provides IT professionals with the necessary networking and system administration knowledge to better understand cloud computing. Second, it helps IT professionals to get a quick start in deploying cloud services. The book provides detailed instructions on establishing a cloud-based computing environment where IT professionals can carry out all the hands-on activities in this book. The cloud-based computing environment allows readers to develop cloud services collaboratively or individually. Third, it enhances readers' hands-on skills by providing lab activities. Through these lab activities, readers can develop a fully functioning cloud-based IT infrastructure with Microsoft Azure. Last, this book demonstrates how networking plays a key role in a cloud-based IT infrastructure. It helps readers understand how to set up networks for a cloud-based IT infrastructure. It also demonstrates how networks are used to construct cloud services.

### Features of the Book

This book integrates networking and cloud computing. Networking and system administration theory and concepts are used to explain cloud computing technology. Hands-on practice is conducted in the cloud computing environment. To help IT professionals catch up with the trend in cloud computing, the public cloud provider, Microsoft Azure, is used to establish a cloud computing environment. This book also illustrates the development of a private cloud with Hyper-V. After systematic coverage of networking theory and concepts such as virtual network, private network, and certification, this book leads the reader to the development of a hybrid cloud that integrates the public cloud and the private cloud.

The following are the features that make the book valuable for readers who are interested in learning about cloud-based IT infrastructures.

- *Cloud computing*: This book focuses on networking used to construct a cloud computing environment. Microsoft Azure is used to build and manage virtual networks.

- *Real-world approach:* Many hands-on activities are added to help readers develop a cloud-based IT infrastructure that can be used for a real-world business.
- *Combination of theory and hands-on practice:* This book provides adequate networking theory, enough for readers to understand cloud computing. Comprehensive lab activities are used to help readers make the connection between theory and practice.
- *Online development:* This book provides detailed instructions and resources for creating and managing online computer labs by using the Microsoft Azure academic account.
- *Instructional materials:* To help with teaching and learning, this book includes instructional materials such as an instructor's manual, PowerPoint presentations, and solutions.

The book focuses on its goal to make sure that readers learn how to develop a cloud-based network system for a real-world business. The content of the book is suitable for undergraduate and beginning graduate courses related to networking as well as for IT professionals who do self-study on cloud computing.

For the convenience of entry-level IP professionals and university students, the book is designed in the following manner:

- *Self-contained content:* For readers' convenience, the book is self-contained. It includes some necessary basic networking concepts, hands-on activities, and information about cloud-based network services.
- *Suitable for self-study:* This book provides detailed instructions that are suitable for self-study. It not only presents the theory and concepts but also explains them through examples, illustrations, and hands-on activities.
- *Designed for Microsoft Azure:* The book is specially designed for Microsoft Azure. All the hands-on activities can be conducted with the Windows Server operating system.
- *Step-by-step instructions:* For hands-on activities, the book provides step-by-step instructions and illustrations to help beginners. It also provides instructions on setting up a cloud environment for hands-on practice.

With these features, readers will be able to implement a cloud-based IT infrastructure and other cloud-based services in a short time.

### Organization of the Book

This book includes 11 chapters. Each chapter contains an introduction of its content, the main body of the chapter, a "Summary" section to summarize the discussion in the chapter, and a "Review Questions" section to help readers review the knowledge

learned from the chapter. Each chapter also includes hands-on activities to help readers practice the skills learned in the chapter.

Chapter 1 introduces networking and network operating systems. It outlines the use of network operating systems in cloud computing. This chapter gives an overview of the commonly available public cloud providers and packages used for developing private clouds. The lab activity in this chapter prepares a cloud computing environment for the lab activities in later chapters.

Chapter 2 deals with the necessary network protocols to be used in cloud computing. Three hands-on activities are used to explore the network management tools provided by the Windows Server operating system.

Chapter 3 covers the topics related to network design and IP addressing. It describes how the Internet works. It also describes other types of networks used in implementing cloud computing. The hands-on practice of this chapter creates a virtual network on Microsoft Azure. The virtual network is used to illustrate the concepts of local area networking and subnetting.

Chapter 4 introduces directory services, which are the key components of cloud computing. The chapter describes how directory services are used in enterprise-level IT infrastructure management. It provides technical details on the development and implementation of directory services. In the hands-on practice of this chapter, the Active Directory service is implemented on virtual machines hosted by Microsoft Azure.

Chapter 5 introduces network services such as the dynamic host service and name service, which are often used in cloud computing. The theory and concepts of the dynamic host service and name service are described in detail. The hands-on activity in this chapter illustrates the implementation of the dynamic host service and name service in Microsoft Azure.

Chapter 6 demonstrates how to use Windows PowerShell for network and cloud management. This chapter introduces programming units such as cmdlets, PowerShell functions, and PowerShell Scripts. During hands-on activities, readers can experiment with such units in the Microsoft Azure cloud environment. This chapter also presents the use of Microsoft Azure PowerShell for cloud service management.

Chapter 7 discusses Internet data transaction protection. In the cloud computing environment, it is necessary to protect the data transaction between a cloud provider and a cloud service subscriber. The chapter introduces network security tools such as Secure Sockets Layer (SSL) and Certificate Services. The hands-on activity in this chapter implements Certificate Services in the Microsoft Azure cloud environment.

Chapter 8 covers IP Security (IPSec), which is used in later chapters to link the virtual networks created in Microsoft Azure to the on-premises network of an enterprise. IPSec is a security protocol to secure the network protocols above the Internet layer. The hands-on activities implement IPSec in the Microsoft Azure cloud environment.

Chapter 9 explains the theory and concepts of network routing. Routers are used to connect networks. In this book, the virtual networks in the cloud and the on-premises

networks of an enterprise are connected with routers. This chapter also discusses Network Address Translation (NAT), which allows the virtual machines on a private network to share a single Internet connection. There are two activities for this chapter's hands-on practice. The first one creates a routing service with Windows Server and second one implements a NAT service.

Chapter 10 discusses the virtual private network (VPN) architecture. VPN allows an enterprise to integrate its own network with a virtual network in a cloud. This chapter gives the pros and cons of different types of VPN technologies. It focuses on the IPsec-based VPN and SSL-based VPN, which are used by Microsoft Azure to remotely access the on-premises network of a company from a virtual network in a cloud or vice versa. Two hands-on activities are included in this chapter. The first one is used to create a point-to-site connection between a local computer and Microsoft Azure. The second one creates a site-to-site connection between Microsoft Azure and an on-premises network.

Chapter 11 covers the hybrid cloud, which integrates public clouds with private clouds. It introduces hybrid cloud technology and its application in a cloud-based enterprise network. With the System Center Virtual Machine Manager (SCVMM) package, the hands-on activity of this chapter creates a hybrid cloud that integrates Microsoft Azure with a private cloud created on a local network.

One or more hands-on activities are included in each of the chapters. It is recommended that readers complete the activities in the previous chapters before starting the hands-on activity in the next chapter because some of the hands-on activities may depend on the ones in the previous chapters.





## Acknowledgments

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**Lee Chao, PhD**, is currently a professor in the Science, Technology, Engineering, and Mathematics Division at the University of Houston, Victoria, Texas. He earned his PhD from the University of Wyoming, Laramie, Wyoming. He has been teaching IT courses for over 20 years. His current research interests are database system development and cloud computing. Dr. Chao is also the author of more than a dozen research articles and books in various areas of IT.



# OVERVIEW ON CLOUD AND NETWORKING

## Objectives

- Draw an overview of network servers.
- Understand the role of network servers in networking.
- Learn about the process of implementing networks.
- Set up a cloud-based lab for hands-on practice.

## 1.1 Introduction

In an enterprise, IT infrastructure is needed to provide employees with the necessary hardware and software to do their job. The key component of the IT infrastructure is the network that connects servers, desktop computers, and mobile devices. The IT infrastructure in an enterprise is a high-cost and high-maintenance unit. It requires expensive hardware and software and skilled IT service staff members to keep it running.

Cloud computing is a technology that can be used to support online IT infrastructure. Cloud computing has become the new trend in delivering business applications and services. The cloud is a cost-effective, flexible, reliable IT infrastructure to support e-commerce and e-learning. With the cloud, employees across the world are able to access the hardware and software provided by an enterprise. In addition, an enterprise can allow its contractors to create their own virtual IT infrastructures on the cloud. Cloud computing can also provide a collaboration platform for developers to participate in an application development project anywhere and anytime. When an enterprise develops a cloud for its own use, this type of cloud is called a private cloud. When a cloud provides cloud services for the public to subscribe, this type of cloud is called a public cloud. When a cloud integrates both the public and private clouds, it is called a hybrid cloud. A large enterprise usually has its IT infrastructure created on a hybrid cloud.

Since a cloud can be considered an online IT infrastructure, the network is also a key component of the cloud. Networking theories and practice have been widely used in cloud computing. To understand the usage of the cloud in an enterprise, one has to have a thorough understanding of networking theories and practice. At the end of this book, a hybrid cloud will be developed. To get there, the reader needs to be familiar with the cloud-related networking theories and practice.

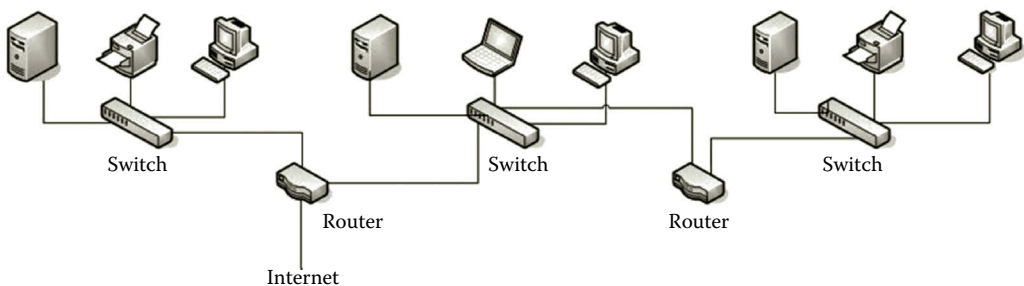
As networks play a key role in today's IT industry, networking has become a required subject in the computer science and information systems curricula. Networking theories and practice are taught at different levels in high schools and higher education institutions. Students majoring in IT-related fields are required to have networking knowledge and skills.

This chapter will first introduce the types of networks. Then, it will introduce the operating systems that are able to provide network services and manage network devices. It will analyze the functionalities of these operating systems and present their functionalities through network architecture. This chapter will explain how cloud computing is supported by the operating systems. It will discuss the networking process and illustrate how to implement a network system. At the end of the chapter, instructions will be provided on how to develop a cloud-based lab environment for conducting hands-on activities in later chapters.

## 1.2 Networks

To transmit data from one computer to another computer, the two computers need to be connected via network hardware and software. Computers, printers, copiers, or storage devices linked by a network are called hosts. Each host has a network interface card (NIC) to which a network cable or another connection medium is connected. The network cable or connection medium carries binary electronic signals back and forth between two hosts. When there are multiple hosts on a network, these hosts are connected to a network device called a switch through which electronic signals are distributed to other hosts. The network device, router, is used to connect two different networks. In the IT industry, it is known that a switch is used to construct a network and a router is used to connect networks.

There are different types of networks such as the local area network (LAN), wide area network (WAN), Internet, and cloud-based network. A LAN is a type of network that exists within a room or a building as shown in Figure 1.1. A WAN is a type of network that is highly scalable and may cover a large geographic area (Figure 1.2). The Internet is a worldwide network system formed by interconnecting LANs and



**Figure 1.1** Local area network.

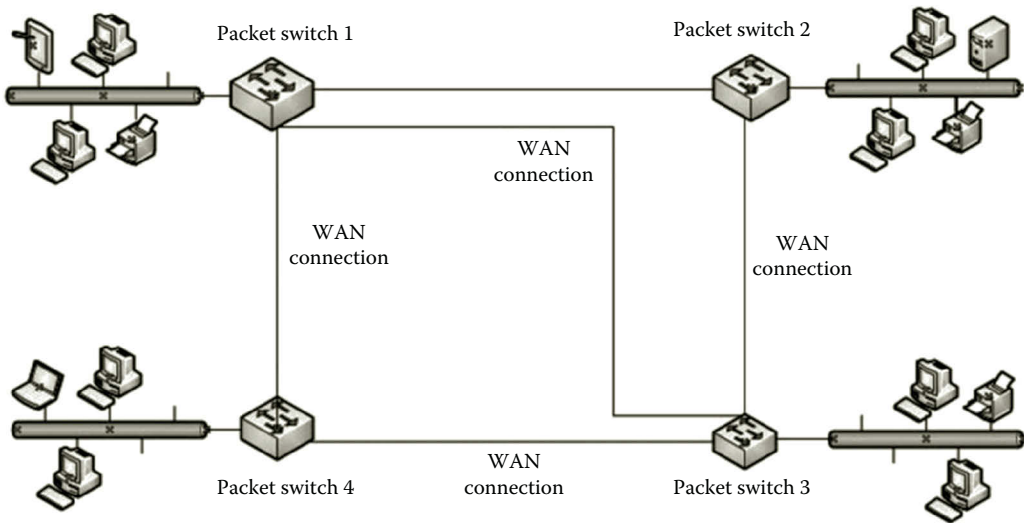


Figure 1.2 Wide area network.

WANs as shown in Figure 1.3. The LAN is connected to the Internet through one of the Internet Service Providers (ISPs). The ISP communicates with the regional network through an access point called a point of presence (POP). It can be a telecommunication facility rented by an ISP for accessing the global network, or it can be any facility used to access the Internet such as a dial-up server, router, or ATM switch. ISPs are connected through a network access point (NAP), which is a major Internet interconnection point.

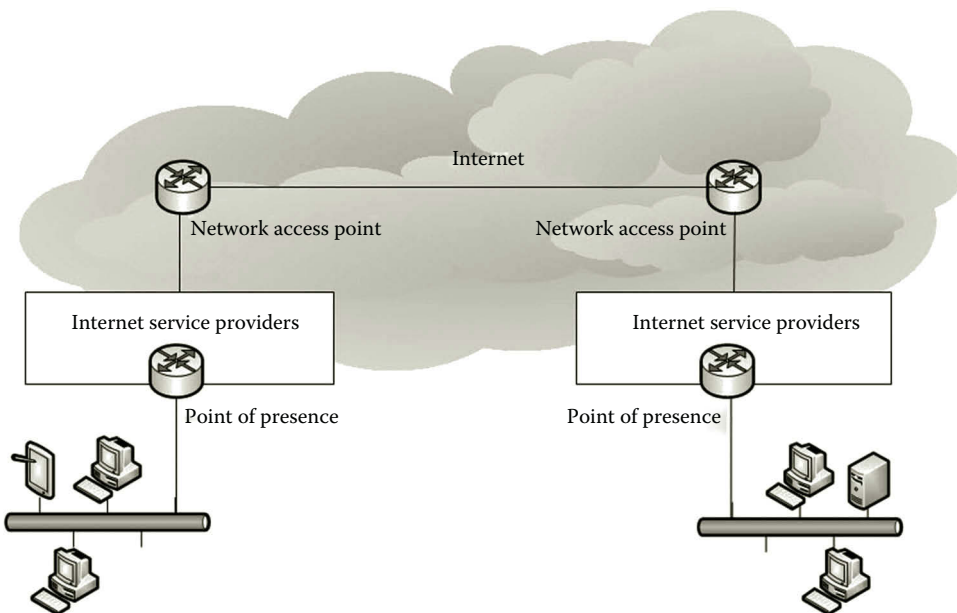
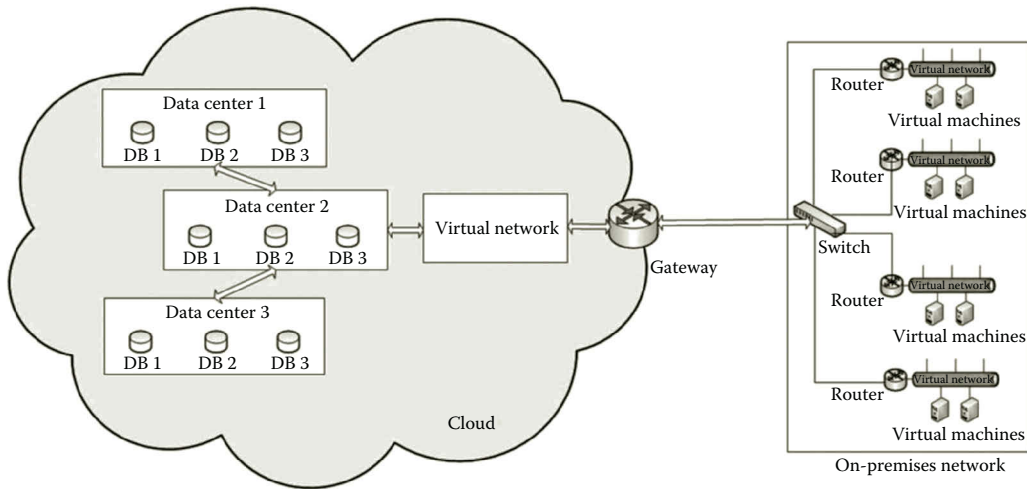


Figure 1.3 Internet.



**Figure 1.4** Cloud-based network.

A cloud-based network is an enterprise network that can be extended to the cloud shown in Figure 1.4. The cloud-based network allows an enterprise to distribute its network around the world. The cloud significantly simplifies the development of an enterprise network system. In the cloud, the underlying network is constructed by a cloud provider. All an enterprise needs to do is to connect its on-premises network to the network built in the cloud to form a global enterprise-class network system. There is no initial capital investment in this type of global network system.

Unlike the Internet, the cloud-based network provides centralized control over network visibility. Through the cloud-based network, the enterprise is able to provide a multitenant application, which is a software application that serves multiple tenants. Each tenant subscribes an instance of the application. Each tenant's data are isolated and remain invisible to other tenants. On the other hand, the maintenance and update of the application can be greatly simplified. The cloud-based network enables the enterprise to deploy IT infrastructures to remote locations in minutes (Figure 1.4).

The cloud-based network targets organizations with a large number of sites around the world. There could be a couple of hundred to ten thousand employees working in multiple sites such as branch offices, schools in a school district, clinics, manufacturing facilities, or retail stores. Through the management tools deployed in the cloud, network administrators are able to manage the enterprise-distributed networks anywhere and anytime. The management tools can be used to manage cloud-hosted virtual machines and mobile services. They are used to accomplish tasks such as centralized management, remote monitoring, remote software and app installation, remote wiping, and security auditing.



### 1.3 Network Operating Systems

Operating systems can be categorized as a server edition, desktop edition, and mobile edition based on the tasks performed by them. The server edition can be used to manage networks and is capable of providing network services. Here, our focus is on server edition operating systems. In the following, we will discuss several commonly available server edition operating systems that are capable of networking.

Most of the low-cost network server operating systems are developed to run on the x86 platform, which is powered with the microprocessors from Intel and AMD. The x86 platform was originally created for personal computers. Today's x86 platform is built on multicore x86 microprocessors, which can handle large-scale networking tasks. Popular operating systems such as Linux, Windows, and some versions of the UNIX operating system are all supported by the x86 platform.

#### 1.3.1 Windows Server 2012

For networking, Windows Server 2012 provides tools to accomplish the following tasks:

- *Network management*: The tasks may include network performance management, network device management, system backup and restoration, troubleshooting, and so on.
- *Network services*: The tasks may include developing and managing network services such as IP address management service, dynamic IP address assignment, name service, Web service, email service, VOIP service, and so on.
- *Network security*: The tasks may include user authentication, certification service, data encryption, network monitoring, setting up firewalls, virus protection, and so on.
- *Remote access and routing*: The tasks may include sharing network resources through VPN and DirectAccess. Windows Server 2012 can also accomplish tasks such as routing network traffic from one network to another network.
- *Cloud communication management*: The tasks may include extending a private cloud to a public cloud by securely connecting the private cloud to the public cloud. The public cloud can also be used to extend the data center located on the private cloud.
- *Virtualization*: Windows Server 2012 includes the virtualization tool, Hyper-V. With Hyper-V, we are able to accomplish the tasks of creating virtual machines, virtual networks, and virtual network devices such as virtual switches.

Compared with the older version of Windows Server, Windows Server 2012 was designed with the cloud concept in mind. New networking features have been added

mainly to support cloud computing. The new features such as failover clustering, virtualization, and file services have all been added for this purpose. The virtualization tool Hyper-V has been modified so that it can help set up environments in the cloud.

Hyper-V is broadly used to create and manage virtual machines and virtual network devices such as virtual switches. With Hyper-V, one can create virtual networks that are independent of the underlying physical network. For network security management, the virtual networks created with Hyper-V can be isolated from each other. For example, the virtual network for hands-on practice in a networking class can be made to isolate itself from that of the Admissions office. Also, deploying the workload to multiple virtual networks can improve the performance of a large project such as a datacenter.

Hyper-V has a feature called live migration; that is, virtual machines hosted by virtual networks can live migrate anywhere without service disruption. These virtual networks can be migrated to a cloud while preserving their existing IP addresses. With the IP addresses preserved, the virtual networks on the cloud can emerge into the on-premises network. All the services provided by these migrated virtual networks can continue to function without knowing where the underlying physical network is. With Hyper-V, a true hybrid cloud can be established by seamlessly integrating a public cloud and a private cloud running on an on-premises network.

In Windows Server 2012, most of the management tasks can be done through the Server Manager interface shown in Figure 1.5. Networking tasks such as active directory administration, dynamic IP addressing, name service, virtualization, and remote access can all be handled in Server Manager.

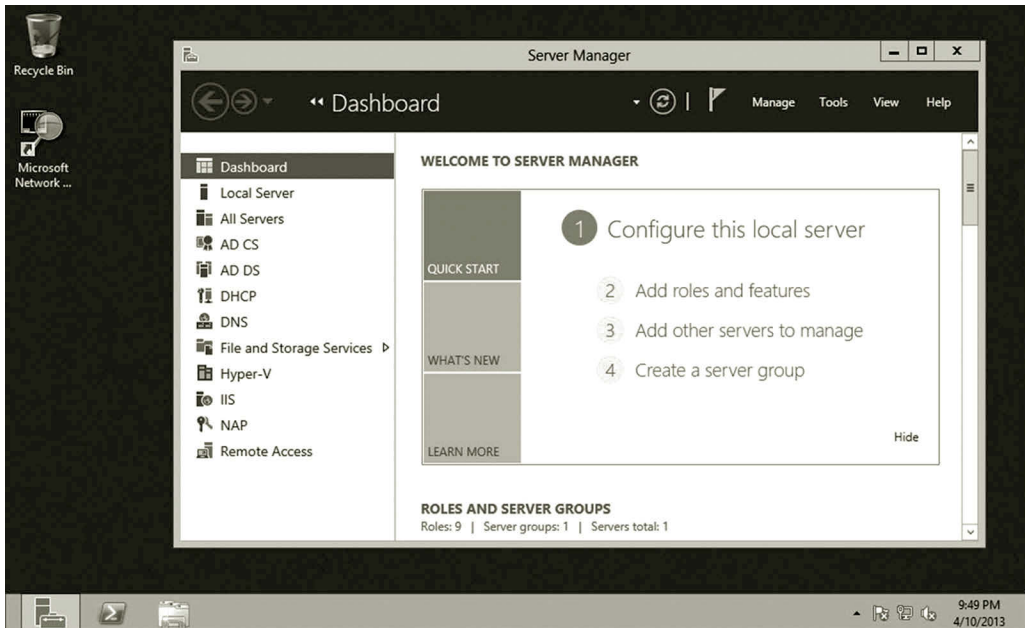
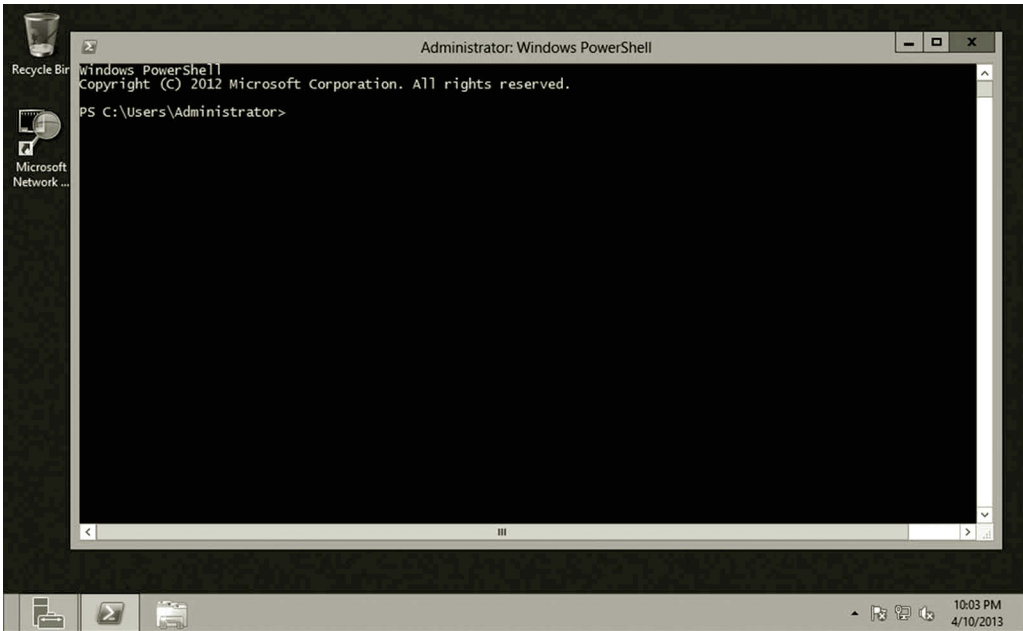


Figure 1.5 Server Manager.



**Figure 1.6** Windows PowerShell.

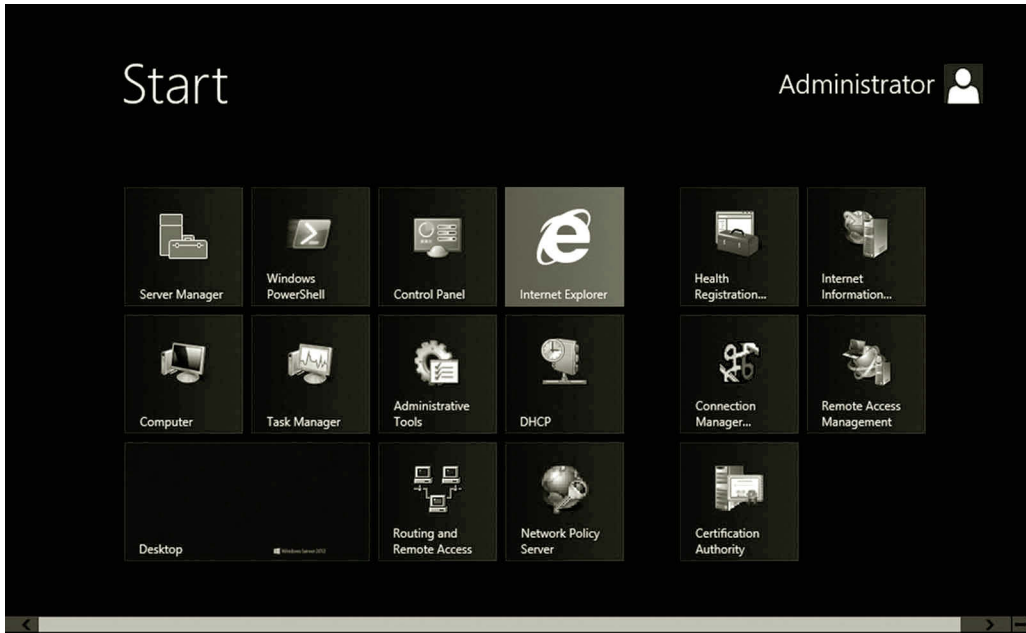
The management tasks can also be done through the command interface, Windows PowerShell (Figure 1.6). Windows PowerShell is a powerful management tool which includes 2430 cmdlets. A network administrator can write a script to automate a large task that needs to execute multiple cmdlets.

Windows Server 2012 uses a new Metro GUI design for touch-centric devices. In Metro GUI, the Start menu is a matrix of icons as shown in Figure 1.7.

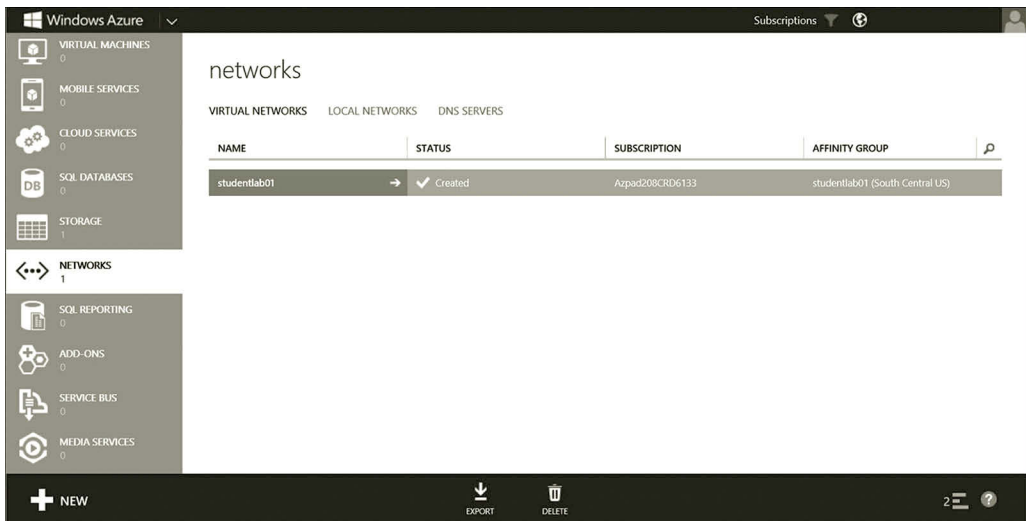
### 1.3.2 Microsoft Azure

Microsoft Azure is a cloud computing platform built on a global network of Microsoft-managed datacenters. Microsoft Azure uses a customized version of Hyper-V known as Windows Azure Hypervisor to handle virtualization tasks. The operating system running on Microsoft Azure is used to manage computing and storage resources. It also provides security protection and remote access mechanisms. The Microsoft Azure development environment is highly scalable. Additional computation capacities can be added as desired until the subscription limit is reached. Microsoft Azure provides a highly available computing environment. With Microsoft Azure, IT professionals can work on their projects from anywhere and at any time. With Microsoft Azure, there is no initial cost on IT infrastructure development and management. However, users need to pay monthly for the storage and computing usage. Figure 1.8 shows the Microsoft Azure Management Portal.

Microsoft Azure provides three types of cloud services, Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS). For data storage,

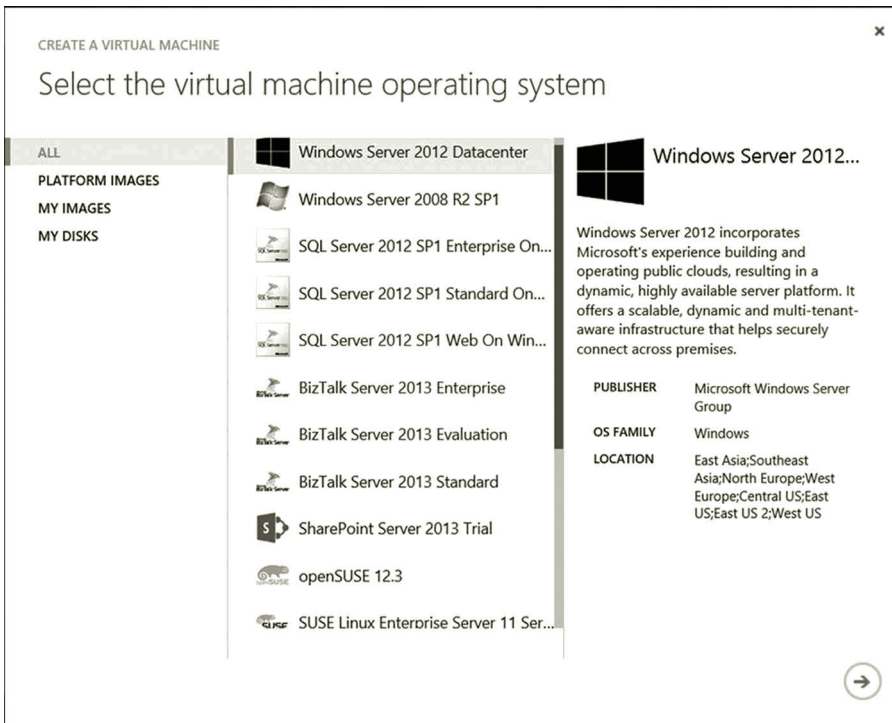


**Figure 1.7** Metro GUI.



**Figure 1.8** Windows Azure management portal.

Microsoft Azure offers Windows Azure SQL Database for storing and managing relational data and data storage services for storing and managing nonrelational data. Microsoft Azure provides software such as server operating systems like Windows Server 2012 and SUSE Linux Enterprise Server (SLES). It also provides database management system (DBMS) software such as Windows Azure SQL Database, which is the cloud version of Microsoft SQL Server. The Windows Azure emulation



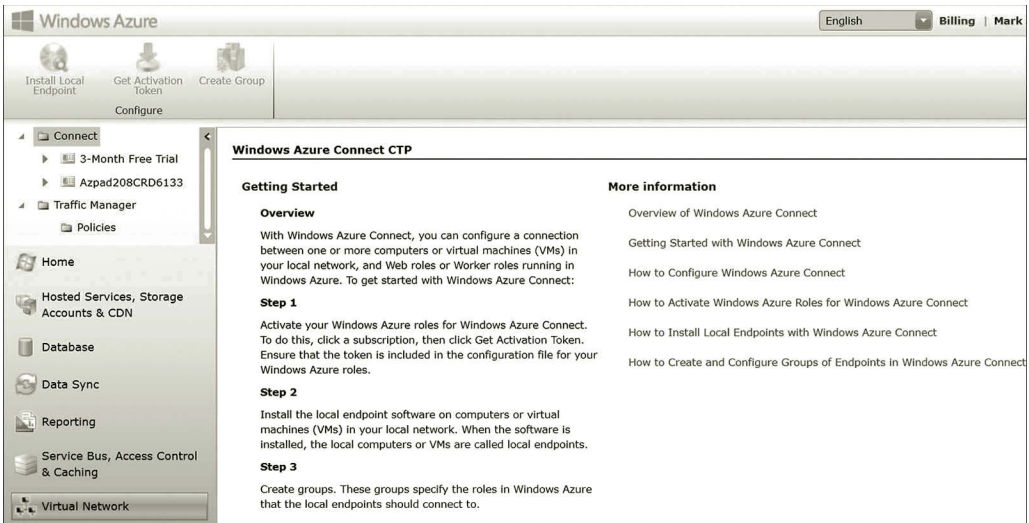
**Figure 1.9** Operating systems provided by Windows Azure.

software and Windows Azure Software Development Kit (SDK) can be downloaded to students' home computers to emulate the Microsoft Azure cloud environment on a local computer. Figure 1.9 shows the operating system software provided by Microsoft Azure.

To help cloud subscribers to extend their existing networks into the public cloud, Microsoft Azure offers a range of networking capabilities such as Virtual Network, Windows Azure Connect, and Traffic Manager. Figure 1.10 shows the Virtual Network tools.

Windows Azure Virtual Network provisions and manages the VPN connection between the on-premises IT infrastructure and Microsoft Azure. Virtual Network is used to set up a hybrid cloud, which consists of the private cloud run on the on-premises network and the public Microsoft Azure cloud. With Virtual Network, an administrator can accomplish tasks such as setting up IP security service to provide a secure connection between the corporate VPN gateway and Microsoft Azure. Virtual Network can also be used to configure DNS service and IP address for virtual machines.

Windows Azure Connect is a tool used to connect the services provided by two machines; one is located on the on-premises network and the other one is on Microsoft Azure. This tool can be used to help application developers to build cloud applications hosted in a hybrid environment. It allows services such as Web service on



**Figure 1.10** Virtual network tools.

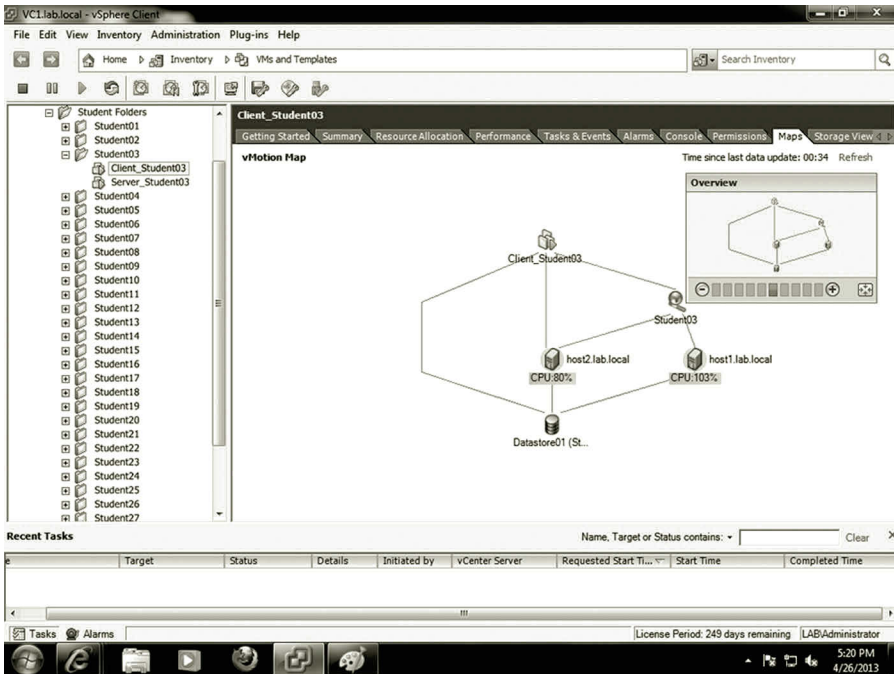
Microsoft Azure to securely access an on-premise SQL Server database server. It can also authenticate users on Microsoft Azure against an on-premise Active Directory service. With this tool, application developers can use the debugging tools provided by the on-premises applications to do troubleshooting for the applications hosted on the Microsoft Azure cloud.

Traffic Manager is a tool used to balance the network traffic across multiple Microsoft Azure hosted services. This tool can help improve an application's performance, availability, and elasticity. To improve availability, Traffic Manager provides automatic failover capabilities when a service goes down. It also monitors Microsoft Azure hosted services. To improve performance, it allows the services to run at the datacenter closest to the end-user to reduce latency.

### 1.3.3 VMware vCloud Suite

The VMware vCloud Suite® is an integrated package used to provide a full cloud solution at the enterprise level. It includes the operating system, management software, and front-end user interface. The following are the main products included in the suite.

*VMware vSphere:* vSphere is a cloud computing virtualization operating system provided by VMware. vSphere provides a virtualization platform for enterprises to make use of both the public and private cloud services. One of VMware's goals is to be able to connect a private cloud to any public cloud provider. When there is a burst of workload, vSphere can seamlessly migrate some of the workload to a public cloud. To achieve this goal, VMware has developed the open-source standard, Open Virtualization Format (OVF), used for packaging and distributing virtual machines. Through OVF, VMware enables the sharing of virtual machines between



**Figure 1.11** vMotion map.

two different virtual machine platforms and the sharing of virtual machines over the Internet. vSphere is able to migrate running virtual machines and attach storage devices to host servers. Figure 1.11 illustrates a map of host servers, virtual machines, and the centralized data store.

To enhance network security and manageability, VMware has been working on the new operating system NSX as the network and security virtualization platform. With NSX, to help with virtualization security, VMware provides tools to help users to store virtualized applications and data in a separated zone where no unauthorized user can access. NSX allows users to create virtual networks to accomplish tasks such as switching, routing, firewall setting, load-balancing, and so on. NSX also allows its partners to securely integrate their physical and virtual networks into the NSX platform. For security, NSX does not require disruptive hardware to be upgraded. To support virtual machines made by other server hypervisors, VMware is designed to support server hypervisors such as KVM and Xen. It can also work with any cloud management systems, for example, VMware vCloud, OpenStack, and CloudStack.

As a network operating system, vSphere can be used for datacenter-wide network integration by centralizing the network provision and network management. It provides management tools such as vSphere Distributed Resource Scheduler (DRS) for dynamically balancing computing resources and power consumption, vSphere High Availability for fault tolerance, data protection and replication, vShield Zones for securing vSphere with application-aware firewall and antivirus functions, and vSphere Auto Deploy for rapid deployment.

Applications developed by application developers such as those from Microsoft and Google all have their architectures, not to mention that many companies have their own applications. The architecture of an application may not match the architecture of a cloud provider. The difference in application architecture makes it hard to migrate these applications to the public cloud. Assisting the migration of applications to the cloud environment is another goal of VMware. VMware includes the plugins from application developers so that their applications can run on vSphere. VMware is also working on the technology that can help a company run their apps in a self-service provisioning enabled cloud. Self-service provisioning allows the end user to deploy and manage applications in the cloud computing environment.

For networking, vSphere provides four types of services for network system development:

- The first type of service is used to connect virtual network devices and virtual machines hosted by a vSphere server.
- The second type of service connects virtual network devices and virtual machines to the underlying physical network.
- The third type of service connects the services on the virtual network to the underlying physical network.
- The fourth type of service is used for managing the host server where the vSphere is installed.

VMware vSphere can virtualize network devices such as NICs and switches for connecting virtual machines. Figure 1.12 shows the virtual machines hosted by a vSphere server.

With VMware vSphere, various virtual IT infrastructures can be delivered as services. That is, the IT infrastructures designed for different types of businesses can be delivered without resetting the underlying physical network. VMware vSphere provides network performance analysis tools for network monitoring and management. Figure 1.13 shows a virtual machine performance chart and Figure 1.14 illustrates vSphere computing resources.

*vCloud Director:* This product is used to provide virtual datacenter services. It creates a secure multitenant environment to fully utilize the hardware capability and other computing resources. It allows the rapid cloning of the previously built virtualized IT infrastructure called vApps. It can also be used to deploy a virtualized multi-tier client-server IT infrastructure.

*vCloud Networking and Security:* This product offers a broad range of services including virtual firewalls, VPN, load balancing, and VXLAN extended networks. VXLAN is designed to allow an application to be scaled across clusters without any reconfiguration of a physical network. To protect data security, vCloud Networking and Security scans sensitive data and reports violations. The report can be used to assess the state of compliance with regulations.



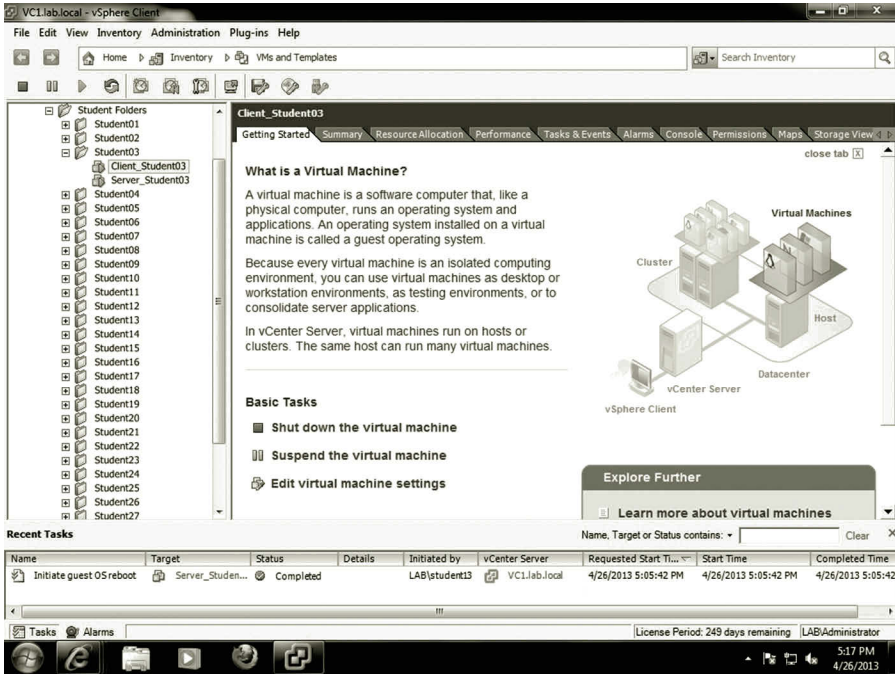


Figure 1.12 Virtual machines hosted by vSphere server.

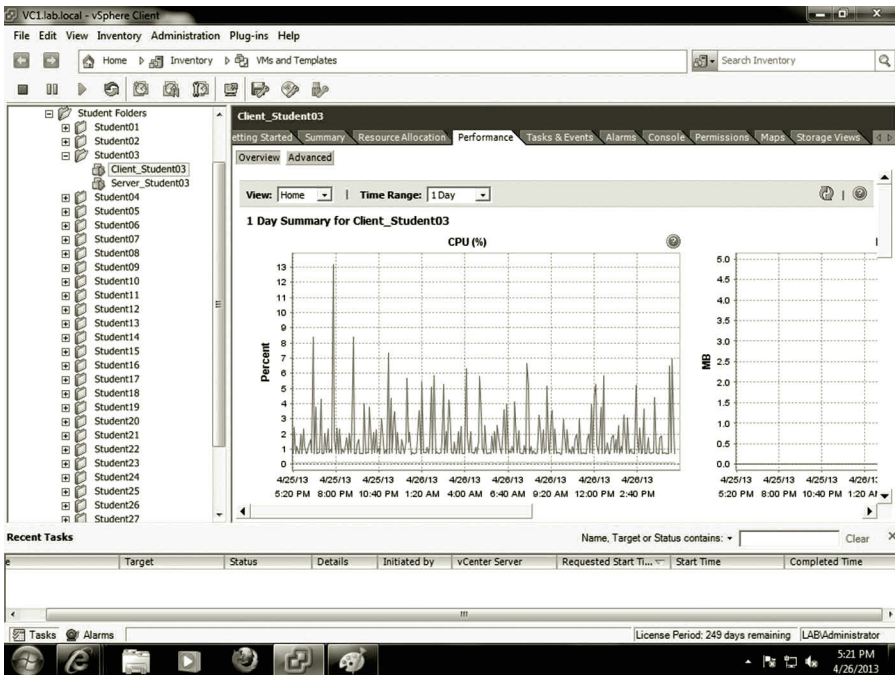


Figure 1.13 Performance monitoring.

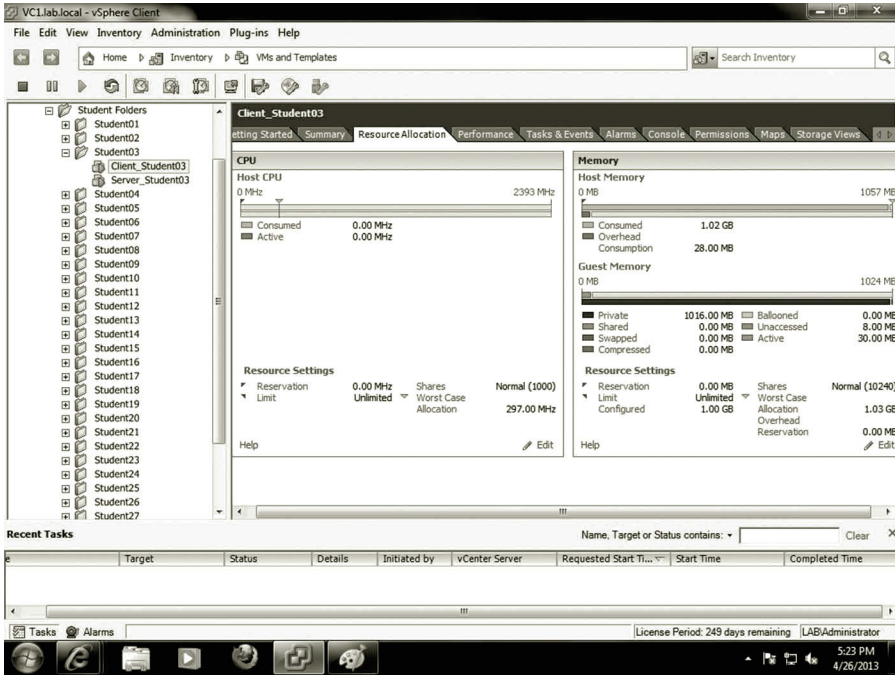


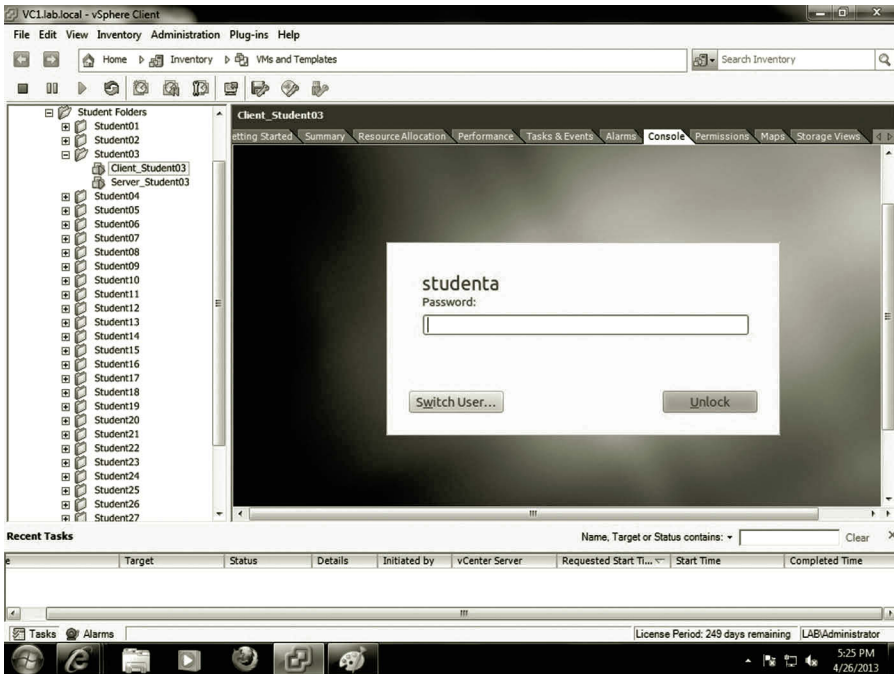
Figure 1.14 Computing resources.

*vCenter Operations Management Suite:* As a management tool, the product provides automated operations management through an integrated approach to performance, capacity, and configuration management. The vCenter Operations Management Suite enables IT organizations to get better visibility and actionable intelligence to proactively ensure service levels, optimum resource usage, and configuration compliance in dynamic virtual and cloud environments.

*vFabric Application Director for Provisioning:* It is a cloud-enabled application provisioning and maintenance solution. This tool simplifies the process of creating and standardizing application deployment across cloud services. With the tool, multitier applications can be deployed to any cloud.

*vCloud Automation Center:* With this tool, users can rapidly deploy and provide cloud services across private and public clouds, physical infrastructures, hypervisors, and public cloud providers. It provides user authentication service and helps to enforce business policies throughout the service lifecycle.

*vSphere Client:* vSphere Client is a GUI tool for managing vSphere. vSphere has two versions of vSphere Client, the regular vSphere Desktop Client, and the vSphere Web Client. Some of the new features of vSphere can only be managed with the vSphere Web Client. With the vSphere Desktop Client, a network administrator can accomplish tasks such as connecting to a vSphere host, VXLAN Networking, changing the guest OS on an existing virtual machine, editing virtual network attributes, viewing vCenter Server maps, and so on. Figure 1.15 demonstrates the guest operating system running on a vSphere host server.



**Figure 1.15** Guest operating system on host server.

By using the vSphere Web Client, the network administrator can perform tasks such as user authentication management, inventory management, vSphere replication, workflow management, virtual machine migration management, logging, virtual distributed switch management, and vSphere data protection.

#### 1.3.4 Linux

Linux is an open source operating system, which is licensed under the GNU General Public License. The operating system source code can be freely modified, used, and redistributed by anyone. Since the World Wide Web and Internet-related protocols such as IP are open source technologies, it is convenient to include these protocols in the operating system. With these open source protocols, Linux is widely used as a network server to accomplish various networking tasks. Linux can be made to serve as an enterprise-level server operating system. It is built to multitask and allow multiple users to work on the same server computer at the same time. Therefore, a Linux operating system is often used in a grid system for distributed computing. As Linux is able to communicate with other network technologies such as Windows and Novell, Linux can also host the directory service. As an open source product, the total cost of using Linux is low. However, it requires technicians to have adequate knowledge to handle daily operations. The main cost of using Linux is the support and services offered by Linux distributions. In general, Linux requires less computing resources and is able to

work with older network devices. The Linux operating system is able to run on a broad range of computing architectures such as x86, POWER, SAPRC, and Itanium 2. This feature is especially suitable for organizations that have a limited budget and are not able to upgrade their equipment frequently.

Next, we will look at some of the Linux operating systems that are capable of supporting cloud computing. Among these Linux operating systems, you can find virtual machines preinstalled with SUSE Linux Enterprise or Ubuntu Linux on Microsoft Azure. Also, you can download a readymade virtual machine with Red Hat Linux installed for VMware.

*Red Hat Linux:* Red Hat, Inc. was founded in 1993. Red Hat has two editions of operating systems, Fedora and Red Hat Enterprise Linux. Fedora is the open source version of the Linux operating system, which is managed by the Linux user community and Red Hat employees. Even though Fedora is free, it is a fully functioning operating system. Red Hat uses Fedora as a testing platform for many new services and innovation tools. During the testing period, programmers from the user community and Red Hat work together to fix problems found in the new products. As Linux is updated frequently, Fedora is updated every 4–6 months. Since Fedora is a free operating system, Red Hat does not provide training and support for Fedora.

Red Hat Enterprise Linux is known as the Linux operating system for supporting enterprise-level computation. It charges fees for support and services. The support and services are necessary for developing and managing an enterprise-level IT infrastructure. Red Hat Enterprise Linux provides 24 × 7 integrated service. Customers can often get response within 1 h. In addition to the support and services, Red Hat also provides various training and certification service on Red Hat Enterprise Linux. Red Hat Enterprise Linux is a more stable operating system. It only includes those new services and innovation tools that are proven to work. Red Hat Enterprise Linux will be upgraded to a new version after three new upgrades of Fedora. Red Hat Enterprise Linux is going to be fully supported by Red Hat for 7 years after it is upgraded. It is widely supported by computer hardware companies such as Dell, HP, and IBM. It is also supported by over a thousand application software companies such as Oracle, CA, IBM, and so forth. The software from these companies is tested on the Red Hat operating system. Although the Red Hat operating system often runs on the x86 platform, it is also able to run on other platforms.

For cloud computing, Red Hat provides an open hybrid cloud solution. Red Hat allows its customers to create a hybrid cloud in their own way and there is no vendor lock-in. That is, the customer has the freedom to access data in various structures, to build any application or service regardless of technology and platform. The open cloud allows customers to add a variety of features, cloud providers, and technologies from different vendors. With Red Hat, customers can fully utilize the existing IT infrastructure and build a cloud solution piece by piece. They are able to connect their private clouds to a wide range of public clouds such as Amazon and IBM.

Red Hat can make applications and data portable across different clouds. It also allows the management of applications across heterogeneous infrastructures.

Red Hat provides a number of products for developing cloud services. Among these products, CloudForms can be used to develop IaaS service and OpenShift can be used to develop PaaS service. With CloudForms, one can construct a virtualized system with a mixture of hypervisors and virtualization management software, and the technologies from various public clouds. CloudForms allows users to create a pool of virtual machine images consisting of an operating system, applications, and associated supporting software. It also allows users to manage, deploy, and monitor virtualized systems. OpenShift has two versions, OpenShift Online and OpenShift Enterprise. OpenShift Online is a public cloud providing PaaS service. OpenShift Enterprise is a comprehensive enterprise development platform. With OpenShift Enterprise, a team of developers can develop, deploy, and execute enterprise applications in either a private or public cloud environment.

*SUSE Linux*: SUSE Linux is another major Linux distribution owned by Novell. Like Red Hat Linux, there are two editions of SUSE Linux, openSUSE and SUSE Linux Enterprise. openSUSE is available in a free-download open source package. It is also available in a retail package, which contains a printed manual, a DVD, and bundled software. openSUSE also includes some proprietary components such as Adobe Flash. After Novell acquired SUSE Linux from a SUSE UNIX consulting company in Germany, Novell added the GUI-based system management software YaST2 to SUSE Linux. Novell also provides two proprietary editions of the Linux operating system, SUSE Linux Enterprise Server (SLES) and SUSE Linux Enterprise Desktop (SLED). These two editions of SUSE Linux are designed for developing and managing enterprise-level IT infrastructure. As a server operating system, SLES can run on servers with platforms such as x86, PowerPC, Itanium 2, and so on. SLES includes over 2000 proprietary application software packages from Microsoft, Oracle, SAP, and WebSphere. In addition, it includes over 1000 open source applications. SLES is a relatively stable operating system. It is usually upgraded to a new version every 2 years. The new version will be supported by SUSE for 7 years. Figure 1.16 displays the SUSE Linux Enterprise login interface.

As a desktop operating system, SLED is designed for enterprise use. Like SLES, it is relatively stable when compared with openSUSE. It also includes proprietary software such as the antivirus software McAfee. Both SLED and SLES include technical support from Novell and certification by hardware and software vendors. SUSE Linux Enterprise is often installed on servers sold by hardware vendors such as IBM, HP, Sun Microsystems, Dell, and SGI. These hardware vendors install, configure, and test SUSE Linux Enterprise before their computer systems are shipped to customers.

As for cloud computing, the SUSE Cloud package is an open source, enterprise cloud computing platform. The platform includes an administration server used for setting up the cloud. The administration server is also used for configuring and

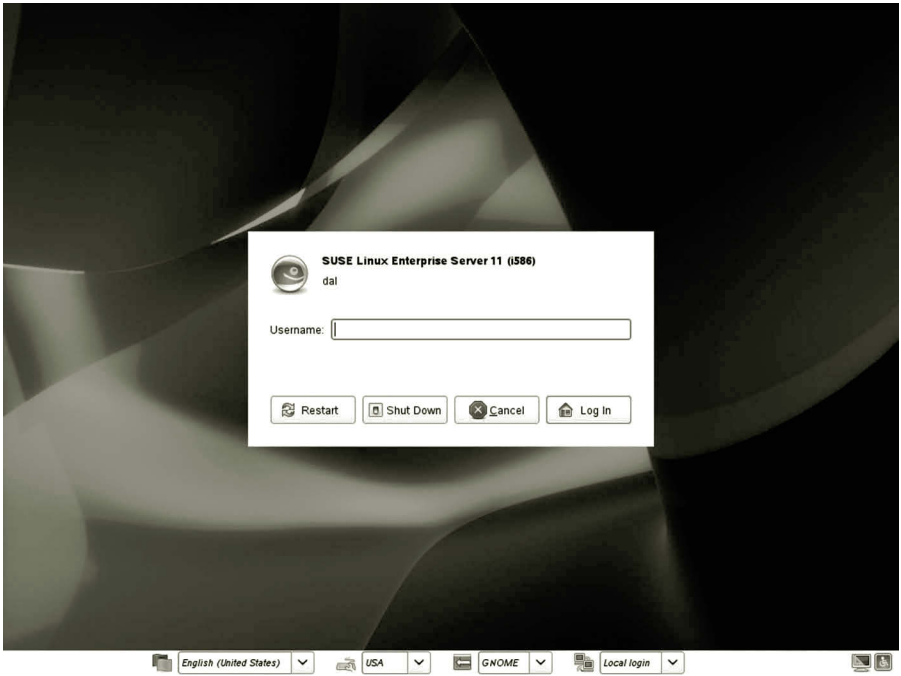


Figure 1.16 SUSE Linux enterprise server.

provisioning cloud control nodes and cloud compute or storage nodes. A control node automatically tracks the resource state of the cloud compute or storage nodes, identifies the available capacity within the cloud, and deploys workloads. The compute or storage nodes are physical servers that are either used to host virtual machines or to host storage devices.

SUSE Cloud is an OpenStack-based platform that supports multiple hypervisors such as Xen, KVM, QEMU, LXC, and Hyper-V. The support of Hyper-V enables enterprises to deploy their open source private clouds on the public cloud Microsoft Azure, or to be hosted by on-premises Windows Server machines. The collaboration with Hyper-V also facilitates the installation of compute nodes based on Hyper-V on the SUSE Cloud platform.

SUSE collaborates with the hardware vendor Dell to develop the enterprise-class private cloud infrastructure solution, which combines Dell’s hardware and services with SUSE software. The Dell SUSE Cloud Solution gets support from both Dell and SUSE worldwide support organizations. It simplifies the IT infrastructure development process, enables an enterprise to set up clouds on an existing data center quickly, and reduces tasks needed to add capacity as the need continues to grow.

*Ubuntu Linux:* Ubuntu is also a major Linux distribution sponsored by Canonical Ltd., a private company from South Africa. The Ubuntu Linux operating system is free and consists of all open source products. It is updated every 6 months. It also provides a long-term support version of the operating system, which upgrades every 3 years.

The Ubuntu Linux operating system has three editions, the server edition, the desktop edition, and the mobile edition. The server edition of Ubuntu Linux includes the LAMP (Linux, Apache, MySQL, and PHP) package. The installation of Ubuntu is quick and simple. The LAMP package is installed automatically. The Ubuntu desktop edition is specially designed to be easy-to-use. It includes many utilities for handling multimedia content such as photo editing and media editing tools. Like the Windows operating system, it includes a large number of GUI tools for searching, calendaring, Web form spell checking, phishing detection, and system administration. It also includes e-mail and the latest Web browsing technology, the office suite OpenOffice.org, the instant messenger Pidgin, and the image editor GIMP. The mobile edition is designed to run multimedia content on mobile devices. The mobile edition operating system can run with small memory and storage space. It also delivers fast boot and resume time. Figure 1.17 illustrates the GUI interface of Ubuntu Server.

Ubuntu Cloud is designed to allow companies to provide fast and efficient cloud services. With Ubuntu Cloud, a pool of scalable compute and storage IT resources can be made available for on-demand access. Ubuntu is the reference operating system for OpenStack. That is, Ubuntu is the base operating system used by the developers of OpenStack. OpenStack is a free and open-source software platform on which cloud services can be built, tested, and deployed. As the reference operating system

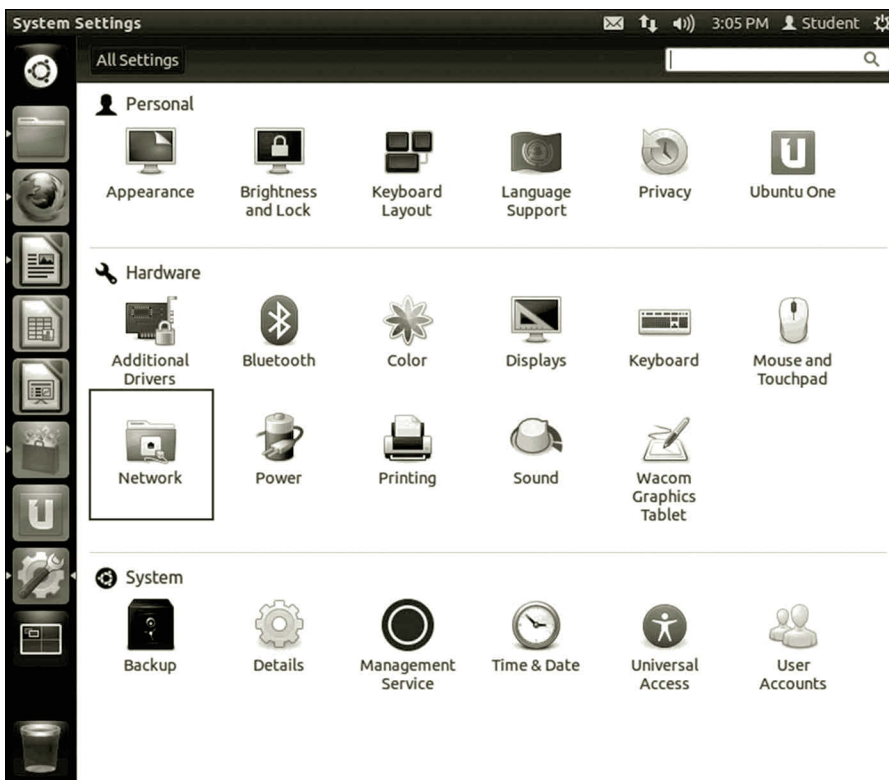


Figure 1.17 Ubuntu Server.

for OpenStack, Ubuntu cuts down the complexity in developing an OpenStack cloud, which stops the lock-in to a specific cloud vendor.

Ubuntu is broadly supported by public clouds such as Amazon Web Services, Rackspace Cloud, HP Public Cloud, and Microsoft Azure, and so on. It can be used either as an underlying infrastructure or as a guest operating system on virtual machines hosted in a cloud. Ubuntu works with the leading public cloud infrastructures to enhance performance, handle updates, and achieve compliance and reliability on the public clouds. Ubuntu has been creating tools such as cloud-init to ease the process of bringing up new instances on a public cloud.

Ubuntu can also be used to create cloud services that are deployed on private IT infrastructures. With Ubuntu Cloud Infrastructure, a company can deliver all its compute, network, and storage resources as cloud service. Ubuntu provides necessary tools for developing a private Infrastructure as a Service (IaaS) cloud service on an existing private IT infrastructure. With these tools, one can quickly set up scalable storage and integrate the features into a cloud service. The private cloud created with Ubuntu is compliant with some of the public cloud standards including Amazon EC2 and Rackspace APIs. Therefore, it has the freedom to migrate the cloud services between the public cloud and the private cloud.

With Ubuntu Cloud Infrastructure, a private cloud can be extended into the public cloud to form a hybrid cloud. When Ubuntu is on both the private cloud and the public cloud, Ubuntu Cloud Infrastructure enables users to burst workloads from their private clouds to the major public clouds, or vice versa. Ubuntu provides a service orchestration tool called Juju to accomplish tasks such as automated arrangement, coordination, and management of virtual machines, middleware, and services. With Juju, one can define the Software as a Service (SaaS) and deploy it to a cloud, either a private cloud or a public cloud or both. Juju is so designed that it is cloud provider independent; therefore, it can deploy services to different cloud providers.

Earlier, we have discussed several operating systems that are capable of cloud computing and network virtualization. There are many other operating systems that may also be capable of cloud development and network virtualization. The selection of an operating system for networking depends on the tasks to be accomplished, the flexibility, the scalability, ease-of-use, and the cost. For most networking-related tasks, the operating system mentioned in this section should be able to do the job. Next, we will focus on network architecture which is the logic model used by the networking capable operating systems.

## 1.4 Network Architecture

This section will discuss network architecture and the tasks to be accomplished during a networking process. It will introduce the major components in a network system. We will take a look at how network functionalities are designed and



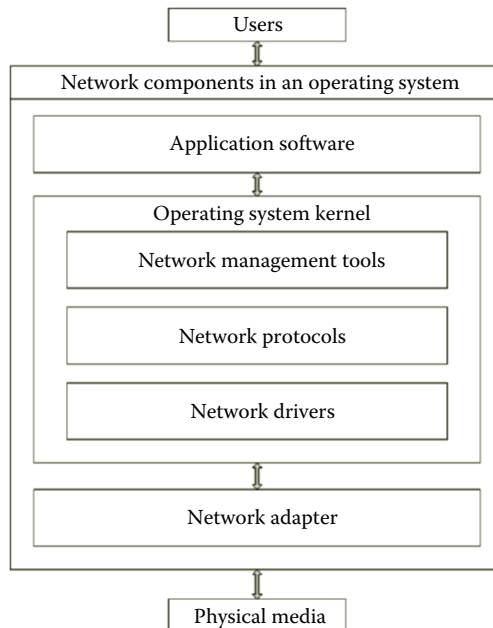
implemented in an operating system. Network management tools will also be introduced in this section.

A network can be as small as two computers connected by a copper wire or as large as the Internet that links millions of computers and network devices. For computers to be able to communicate with each other through physical media, as an example, the Linux operating system provides four major components: application, service, protocol, and adapter.

A network system can be represented by a network model, also called network architecture, which is often presented as a layer system. The network architecture provides an overview of a network system by including the major components for a network and the interfaces between components. To be able to handle data transmission tasks on various networks, the network components in an operating system are built according to the network architecture. An operating system controls data transmission from the application software to the physical wire, which connects the computers. Figure 1.18 illustrates the network components in an operating system.

As a service interface between users and the operating system kernel, the application software manages data communication between the users and the operating system. It takes the users' requests for file transfer, database query, and message exchange, and then submits the requests to the operating system. Once the requests are submitted to the operating system, the network management component will collect the data and identify the network protocols to be used for data communication.

A network protocol serves as a service interface between the application software and the network driver. There are hundreds of protocols supported by an operating system.



**Figure 1.18** Network components.

The network protocols perform tasks such as establishing the communication ports, detecting data transmission errors, data formatting, controlling the data transmission process, resolving network addresses, maintaining network traffic, locating the destination computer and setting up the route to the destination, defining how the data are sent and received, and so on. For security, some of the protocols are used for data encryption and authentication.

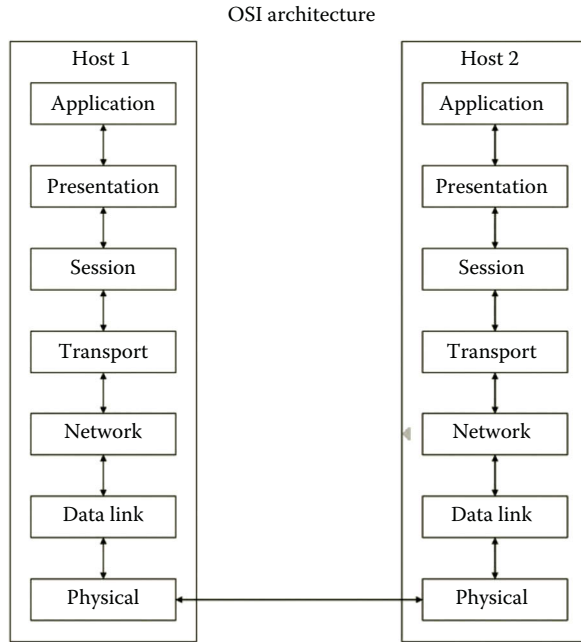
A network driver serves as an interface between the software and the hardware. The driver enables the operating system to communicate with the NIC, which connects the physical data transmission media. Drivers can be used to handle I/O interrupts during a data transmission process. In addition to interacting with the operating system, drivers also interact with buffers, network protocols, and network adapters.

A network adapter is a piece of hardware that connects the physical media to a computer on the network. During data transmission, a network adapter communicates with its peer network adapter installed on another computer. Network adapters may be a wired Ethernet NIC, or it can also be a wireless network device. A network adapter serves as an interface between the operating system kernel and the physical media. Electrical signals are framed in a network adapter. The frame specifies the transmission rate and the shape and strength of the binary signals. By using a network adapter, the binary electric signals are sent to or received from physical transmission media. The network adapter is able to locate its peer network adapter through the hardware address. Once the data arrive at the receiving network adapter, the receiving network adapter informs the operating system to get ready to process the incoming binary signals.

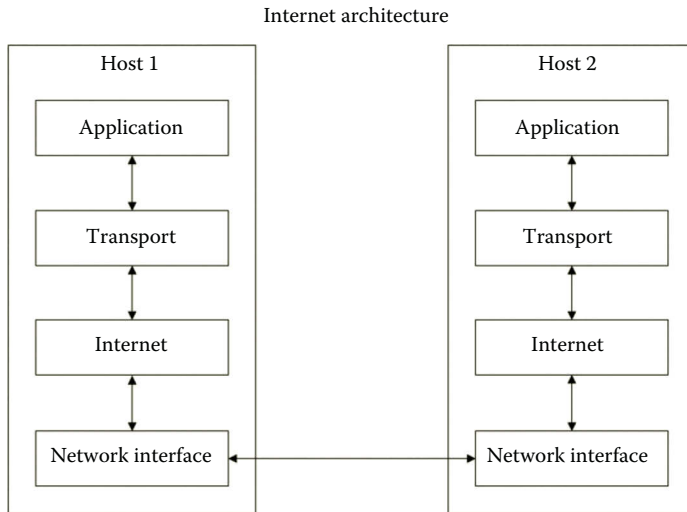
The physical medium links two network hosts such as computers or network devices. The electric signals representing the binary bits are transmitted through the physical media such as copper cables, fiber glass, radio waves, etc. The physical media may also include network devices used to pass the electric signals to a particular destination.

A network can be presented in two different network architectures. The first one is the Open Systems Interconnection (OSI) architecture developed by the International Organization for Standardization (ISO). OSI is a network architecture that defines the communication process between two computers. OSI categorizes the entire communication process into seven layers as shown in Figure 1.19. The second one is the Internet architecture. This architecture is built around the Transmission Control Protocol and Internet Protocol (TCP/IP). Therefore, the Internet architecture is also called the TCP/IP architecture, which includes four layers as shown in Figure 1.20.

In the OSI network architecture, the top layer is the application. The protocols in the application layer are provided by application software. The application layer protocols handle requests from users for file transfer, database query, message exchange, and so on. The protocols in the application layer communicate with the protocols in the presentation layer.



**Figure 1.19** OSI architecture diagram.



**Figure 1.20** Internet architecture diagram.

The protocols in the presentation layer format the data so that the data meet certain transmission requirements. The tasks to be handled by this layer can be data compression, data encryption, video streaming, data format conversion, and so forth.

The protocols in the session layer establish the communication session between two applications such as a conference call or remote connection to a database server. These protocols can be used to start, manage, and terminate a communication session.

They also perform tasks such as requesting and responding during a data transmission process between applications.

The protocols in the transport layer establish and manage the connection between two hosts on the network. This layer handles tasks such as detecting transmission errors; controlling network flow; transporting data; and establishing, managing and terminating connections.

The protocols in the network layer can identify the destination network and establish the data transmission route to a destination host. This is the layer that works with routers and network logical address configuration tools. The routing protocols are able to calculate the shortest path to the destination host and update the routing table periodically.

The data link layer is often implemented in the network card driver. This layer defines the beginning and ending of a binary data transmission frame. It also defines data types. During the process of sending and receiving binary code, this layer also detects and corrects errors in the binary code.

The physical layer transmits electrical binary signals over the physical media that link two hosts. It also defines the shape of electronic signals. When an electrical binary signal arrives from the physical media, the physical layer passes the binary signal up to the data link layer.

Another commonly used network architecture, the Internet architecture, is designed for modeling data exchange through the Internet. The application layer in the Internet architecture includes the application layer, the presentation layer, and the session layer of the OSI architecture. The transport layer of the Internet architecture is equivalent to the transport layer of the OSI architecture. The Internet layer of the Internet architecture is similar to the network layer of the OSI architecture. The network interface layer of the Internet architecture includes data link layer and the physical layer of the OSI architecture. Figure 1.20 shows the diagram of the Internet (TCP/IP) architecture.

The OSI network architecture is the standard adopted by the U.S. government. Therefore, the hardware and software companies working for the U.S. government need to follow the OSI network architecture. On the other hand, many private companies have been traditionally using the TCP/IP architecture, which matches the network architecture used by the Berkeley UNIX operating system. The Microsoft Windows Server operating system uses the TCP/IP architecture to describe its network system.

Both Linux and Windows network systems can be implemented by closely following the TCP/IP network architecture. Comparing the network components in Figure 1.18 with the TCP/IP network architecture, one can see that the application layer in the TCP/IP network architecture matches the component of application software in Figure 1.18. Application software often carries out tasks such as data compression, data encryption, video streaming, and data format conversion. The application software component also includes network management tools. These tools are used

to handle tasks related to session establishment, maintenance, and termination. The operating system kernel manages protocols such as TCP and IP around which the TCP/IP architecture is constructed. The combination of network drivers, network adapters, and physical media in Figure 1.18 matches the network interface layer in the TCP/IP architecture.

Earlier, we briefly discussed the network architecture, which shows how data communication is carried out between applications over a network. The network architecture models the data communication process. In later chapters, more detailed discussion about each layer of the network architecture will be given.

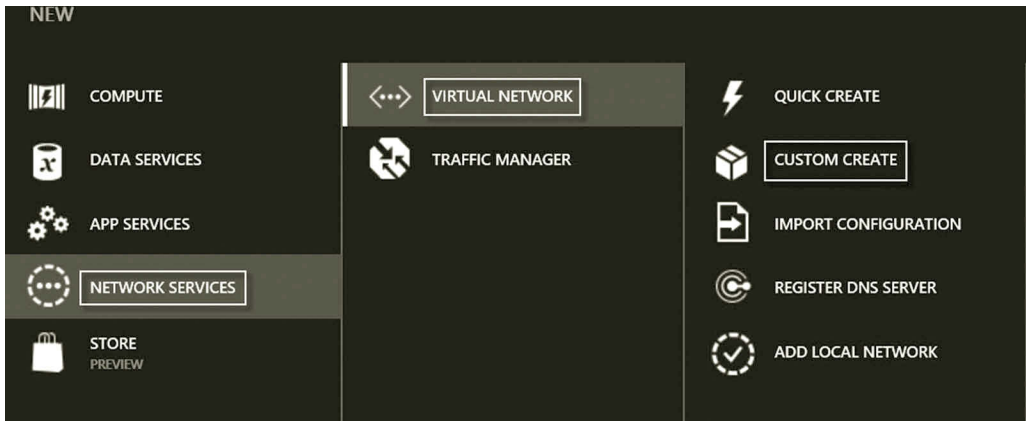
### Activity 1.1: Preparing for Hands-On Activities

To carry out the lab activities covered in this book, we need to install the operating system and virtualization software. We also need to prepare the cloud environment for the hands-on practice. As for the public cloud provider, we will choose Microsoft Windows Azure since it has a free trial period, academic support, and it supports both Linux and Windows operating systems. To develop virtual networks, we can use Microsoft Azure, or use Hyper-V if Windows Server 2012 or Windows 8, or use VMware Workstation, which can work with various desktop operating systems. The following tasks will be performed on Microsoft Azure.

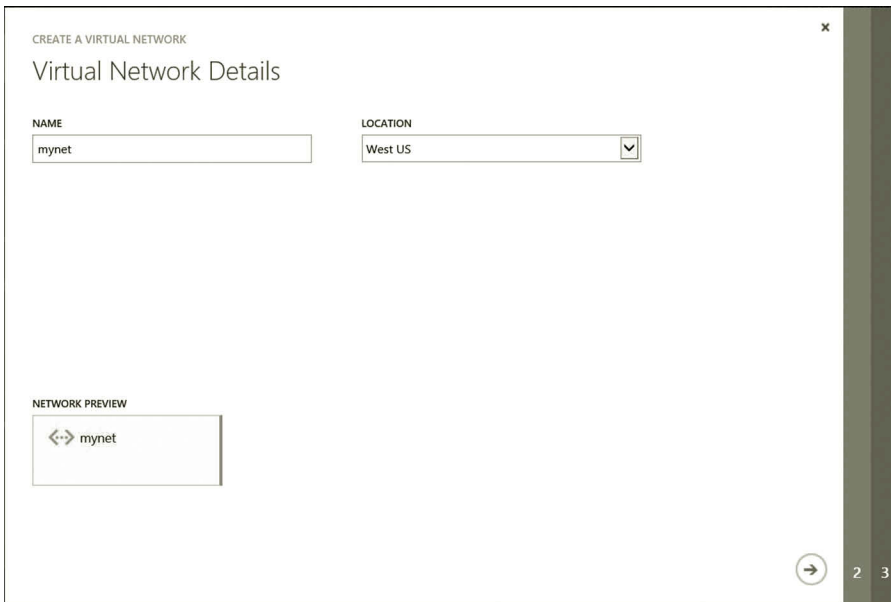
#### *Getting Started with Microsoft Azure*

To be able to use Microsoft Azure, you need to first create a free account. You also need to create a storage account and virtual network on Microsoft Azure. Then, you will create a virtual machine on Microsoft Azure as shown in the following steps:

1. Assume that you have established the free trial account or academic account. First, you need to go to the following Web site to log on to Microsoft Azure (Microsoft Azure, The cloud for modern business, May, 2015): <http://azure.microsoft.com/en-us/>.
2. Log on to your Microsoft Azure Management Portal with your user name and password.
3. In the lower left-hand corner of your screen, click **New**. Then, click **NETWORK SERVICES**, and then click **VIRTUAL NETWORK**. Click **CUSTOM CREATE** as shown in Figure 1.21.
4. On the Virtual Network Details page, enter the information about the name and location as shown in Figure 1.22, and then click the **Next** arrow at the lower right corner.
5. On the DNS Server and VPN Connectivity page, leave DNS server blank as shown in Figure 1.23. Then, click the **next arrow** on the lower right.



**Figure 1.21** Creating new virtual network.



**Figure 1.22** Virtual network configuration.

6. On the Virtual Network Address Spaces page, click **add subnet** button to create a subnet as shown in Figure 1.24. Then, click the **check mark** on the lower right.
7. In addition to the virtual network, you may create a storage account that provides the namespace for data storage. At the lower left-hand corner of the screen, click **New**.
8. In the navigation pane, click **DATA SERVICES, STORAGE**, and then **QUICK CREATE**. Specify the URL and Affinity group as shown in Figure 1.25. Then, click the **CREATE STORAGE ACCOUNT** check mark on the lower right.

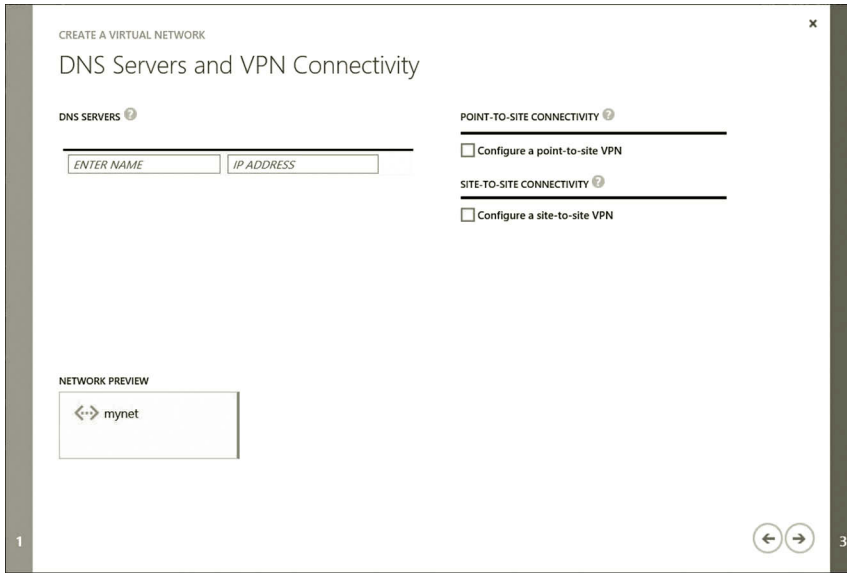


Figure 1.23 DNS server configuration.

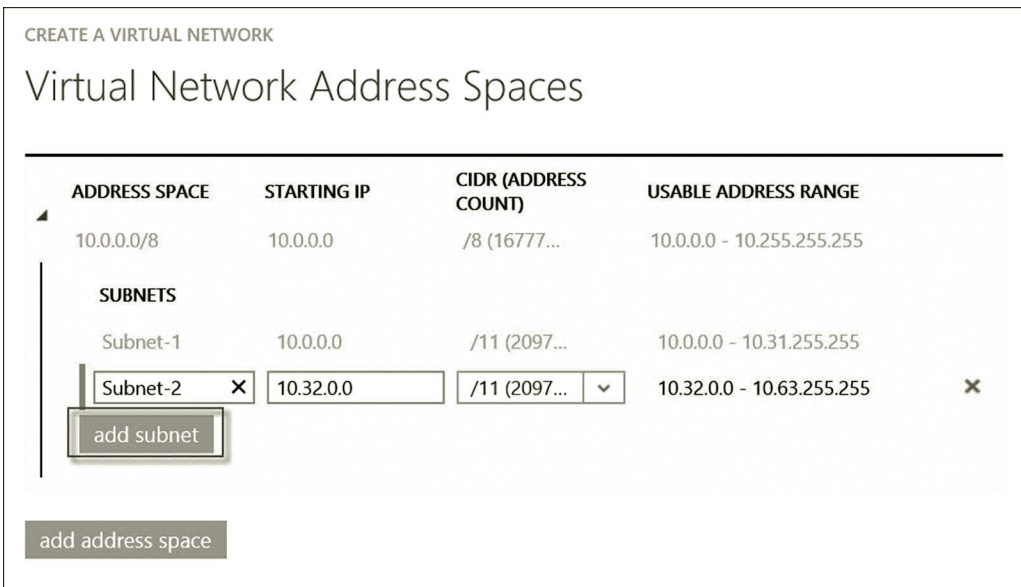


Figure 1.24 Adding virtual subnet.

9. Your next step is to create a virtual machine installed with Windows Server 2012. To do so, at the lower left-hand corner of your screen, click **New**. Then, click **COMPUTE, VIRTUAL MACHINE, FROM GALLERY** as shown in Figure 1.26.
10. On the Select virtual machine operating system page, click **Windows Server 2012 R2 Datacenter** (Figure 1.27) and then click the **Next** arrow on the lower right.

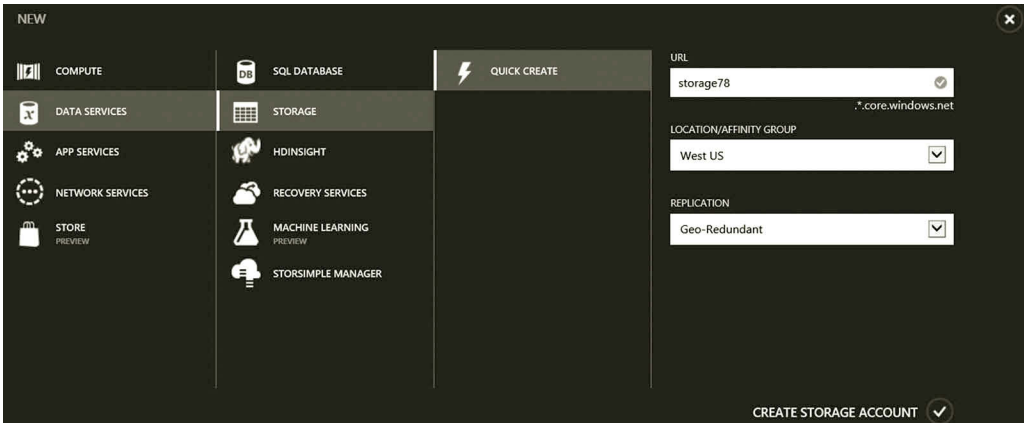


Figure 1.25 Creating storage account.

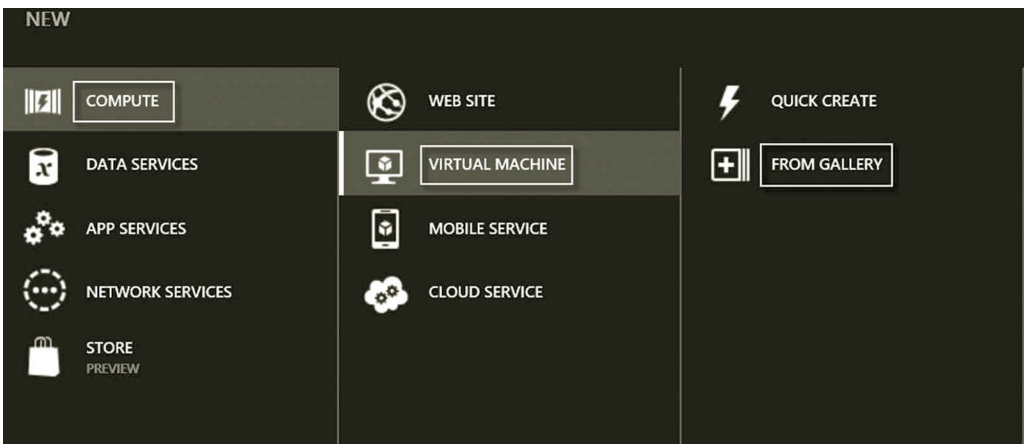


Figure 1.26 Selecting virtual machine.

11. On the Virtual machine configuration page, enter your virtual machine name **servera**, the user **student** and the password, confirm the password, and select the size of your virtual machine as shown in Figure 1.28. The A1 size is adequate for the hands-on activities in this book. Then, click the **Next** arrow.
12. On the Virtual machine configuration page, specify the virtual machine as shown in Figure 1.29.
13. Depending on the needs, you may add a few more communication protocols as shown in Figure 1.30. Then, click the **Next** arrow.
14. On the Virtual machine configuration page, click the **check mark** at the lower right corner to create the virtual machine.
15. After the virtual machine is created, click the **CONNECT** link at the bottom of your screen. Select the option **Use another account**. Enter the user name as **student** and the password for the user and then click **OK** to log on to the virtual machine (Figure 1.31).



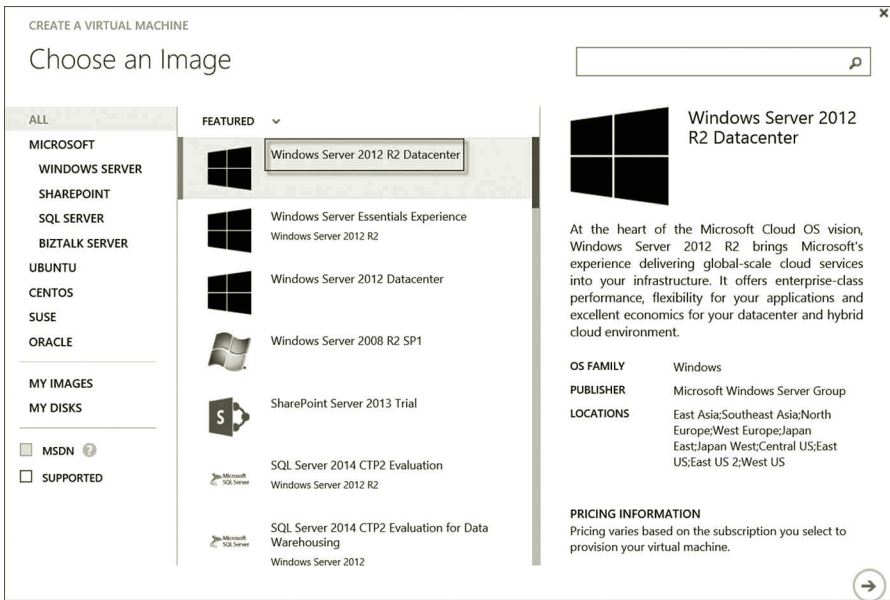


Figure 1.27 Selecting operating system.

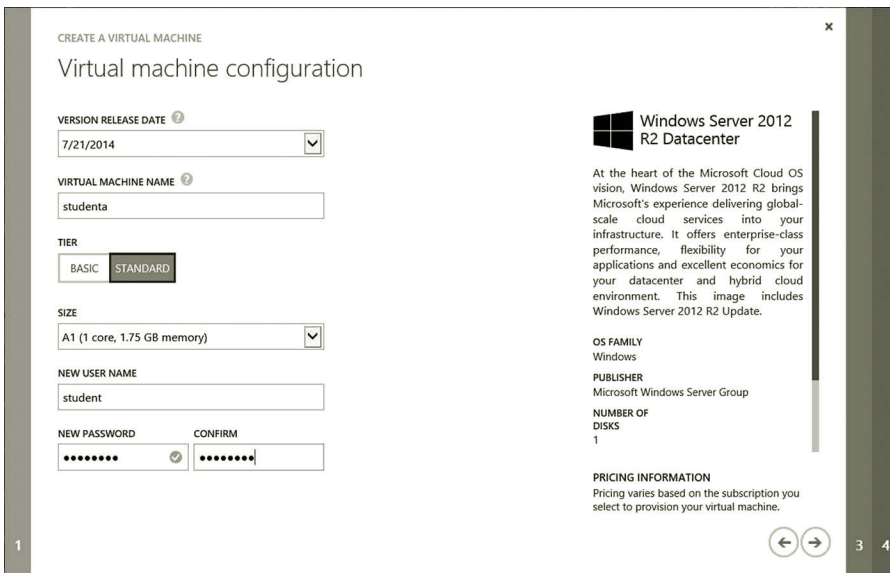


Figure 1.28 Configuring virtual machine.

CREATE A VIRTUAL MACHINE

### Virtual machine configuration

CLOUD SERVICE <sup>?</sup>

CLOUD SERVICE DNS NAME  
 .cloudapp.net

REGION/AFFINITY GROUP/VIRTUAL NETWORK <sup>?</sup>

VIRTUAL NETWORK SUBNETS

STORAGE ACCOUNT

AVAILABILITY SET <sup>?</sup>

ENDPOINTS <sup>?</sup>

NAME	PROTOCOL	PUBLIC PORT	PRIVATE PORT
Remote Desktop	TCP	AUTO	3389
PowerShell	TCP	5986	5986

**Windows Server 2012 R2 Datacenter**

At the heart of the Microsoft Cloud OS vision, Windows Server 2012 R2 brings Microsoft's experience delivering global-scale cloud services into your infrastructure. It offers enterprise-class performance, flexibility for your applications and excellent economics for your datacenter and hybrid cloud environment. This image includes Windows Server 2012 R2 Update.

OS FAMILY  
Windows

PUBLISHER  
Microsoft Windows Server Group

NUMBER OF DISKS  
1

**PRICING INFORMATION**  
Pricing varies based on the subscription you select to provision your virtual machine.

1 2 4

Figure 1.29 Virtual machine configuration.

CREATE A VIRTUAL MACHINE

### Virtual machine configuration

STORAGE ACCOUNT

AVAILABILITY SET <sup>?</sup>

ENDPOINTS <sup>?</sup>

NAME	PROTOCOL	PUBLIC PORT	PRIVATE PORT
Remote Desktop	TCP	AUTO	3389
PowerShell	TCP	5986	5986
DNS	TCP	53	53
SSH	TCP	22	22
HTTPS	TCP	443	443
HTTP	TCP	80	80
MSSQL	TCP	1433	1433

**Windows Server 2012 R2 Datacenter**

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OS FAMILY  
Windows

PUBLISHER  
Microsoft Windows Server Group

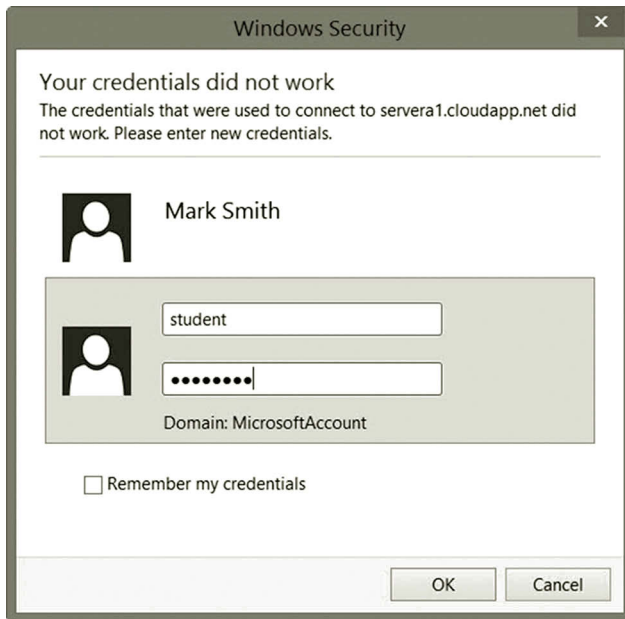
NUMBER OF DISKS  
1

**PRICING INFORMATION**  
Pricing varies based on the subscription you select to provision your virtual machine.

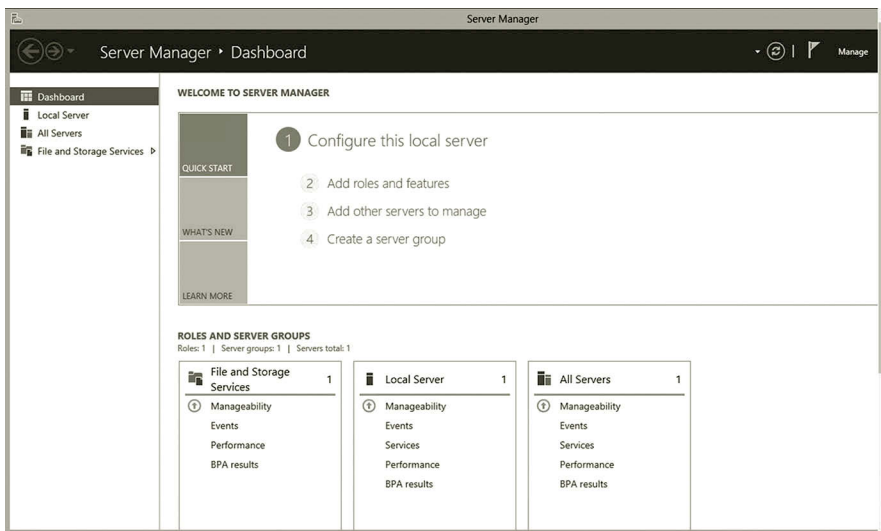
1 2 4

Figure 1.30 Adding network protocols.

16. After logging on to the virtual machine, you should be able to see Server Manager as shown in Figure 1.32.
17. For networking, you need to create another virtual machine. Assume that you are still logged on to the Microsoft Azure Management Portal. Click **NEW** at the bottom of the screen. Click **FROM GALLERY** and select **Windows Server 2012 R2 Datacenter**. Enter the virtual machine **serverb** and user



**Figure 1.31** Remotely logging on to virtual machine.



**Figure 1.32** Server Manager.

name **student**. Enter your password as shown in Figure 1.33 and click the **Next arrow**.

18. On the Virtual Machine Configuration page, specify the virtual machine as shown in Figure 1.34. Similarly, add some network protocols as shown in Figures 1.30. Then, click the **Next arrow**.
19. On the Virtual machine option page, click the **check mark** at the lower right corner to create the virtual machine.

CREATE A VIRTUAL MACHINE

### Virtual machine configuration

VERSION RELEASE DATE ?  
7/21/2014

VIRTUAL MACHINE NAME ?  
serverb

TIER  
BASIC STANDARD

SIZE  
A1 (1 core, 1.75 GB memory)

NEW USER NAME  
student

NEW PASSWORD ? CONFIRM  
•••••• ••••••

**Windows Server 2012 R2 Datacenter**

At the heart of the Microsoft Cloud OS vision, Windows Server 2012 R2 brings Microsoft's experience delivering global-scale cloud services into your infrastructure. It offers enterprise-class performance, flexibility for your applications and excellent economics for your datacenter and hybrid cloud environment. This image includes Windows Server 2012 R2 Update.

OS FAMILY  
Windows

PUBLISHER  
Microsoft Windows Server Group

NUMBER OF DISKS  
1

**PRICING INFORMATION**  
Pricing varies based on the subscription you select to provision your virtual machine.

1 3 4

**Figure 1.33** Configuring virtual machine server.

CREATE A VIRTUAL MACHINE

### Virtual machine configuration

CLOUD SERVICE ?  
Create a new cloud service

CLOUD SERVICE DNS NAME  
serverb78 .cloudapp.net

REGION/AFFINITY GROUP/VIRTUAL NETWORK ?  
mynet

VIRTUAL NETWORK SUBNETS  
Subnet-1(10.0.0.0/11)

STORAGE ACCOUNT  
storage78

AVAILABILITY SET ?  
(None)

NAME	PROTOCOL	PUBLIC PORT	PRIVATE PORT
Remote Desktop	TCP	AUTO	3389
PowerShell	TCP	5986	5986

**Windows Server 2012 R2 Datacenter**

At the heart of the Microsoft Cloud OS vision, Windows Server 2012 R2 brings Microsoft's experience delivering global-scale cloud services into your infrastructure. It offers enterprise-class performance, flexibility for your applications and excellent economics for your datacenter and hybrid cloud environment. This image includes Windows Server 2012 R2 Update.

OS FAMILY  
Windows

PUBLISHER  
Microsoft Windows Server Group

NUMBER OF DISKS  
1

**PRICING INFORMATION**  
Pricing varies based on the subscription you select to provision your virtual machine.

1 2 4

**Figure 1.34** Configuring virtual machine.

20. Due to the spending limit on Azure, make sure to shutdown the virtual machines whenever you are not using them. In the Microsoft Azure Management Portal, you should shutdown both servera and serverb before exiting the Microsoft Azure Management Portal.

So far, you have created two virtual machines on Microsoft Azure. Later, you will perform networking on these two virtual machines.

## 1.5 Summary

This chapter introduces networking. It first provides an overview of networks. Then, it discusses network operating systems. It also provides information on how the operating systems handle virtualization and support cloud computing. This chapter reviews network architectures. Two abstract network architectures, the OSI network architecture and Internet network architecture, are introduced. The chapter then describes the role of operating systems in developing network systems.

To prepare the computing environment for the hands-on practice in later chapters, the activity of this chapter walked the reader through a process of creating virtual machines and installing a guest operating system on the virtual machines. Once the virtual machines are created, we are ready to discover how these virtual machines are used to accomplish various networking tasks.

## Review Questions

1. What are hosts?
2. What is LAN?
3. What is WAN?
4. Describe the Internet.
5. What is POP?
6. What is NAP?
7. Which operating system mentioned in this chapter is designed for the cloud platform?
8. Which operating system mentioned in this chapter provides the virtualization tool, Hyper-V?
9. What do you do with Hyper-V?
10. What are cloud services provided by Microsoft Azure?
11. What is vSphere?
12. Name five hypervisors supported by OpenStack.
13. Describe the application layer in the OSI network architecture.
14. What tasks can be handled by the transport layer in the OSI network architecture?
15. What tasks can be handled by the network layer in the OSI network architecture?
16. Which layers in the OSI network architecture are included in the application layer of the TCP/IP network architecture?
17. Which layers in the OSI network architecture are included in the network interface layer of the TCP/IP network architecture?
18. What tasks can be accomplished by the TCP in the transport layer?
19. IP is in which layer of the TCP/IP network architecture?
20. Network drivers are in which layer of the TCP/IP network architecture?



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Cloud computing is the most significant technology transformation since the introduction of the Internet in the early 1990s. As more and more companies and educational institutions plan to adopt a cloud-based IT infrastructure, today's job market requires IT professionals who understand cloud computing and have hands-on experience developing cloud-based networks. **Cloud Computing Networking: Theory, Practice, and Development** covers the key networking and system administration concepts as well as the vital hands-on skills you need to master cloud technology.

This book is designed to help you quickly get started in deploying cloud services for a real-world business. It provides detailed step-by-step instructions for creating a fully functioning cloud-based IT infrastructure using the Microsoft® Azure™ cloud platform. In this environment, you can develop cloud services collaboratively or individually. The book enhances your hands-on skills through numerous lab activities. In these lab activities, you will learn to

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- Configure Windows® Server so it can route IP traffic
- Implement IP Security Policy and Windows Firewall with Advanced Security tools
- Create a point-to-site connection between Microsoft Azure and a local computer
- Create a site-to-site connection between Microsoft Azure and an on-premises network
- Develop a hybrid cloud that integrates Microsoft Azure with a private cloud created on a local network

**Cloud Computing Networking: Theory, Practice, and Development** includes numerous examples, figures, and screen shots to help you understand the information. Each chapter concludes with a summary of the major topics and a set of review questions. With this book, you will soon have the critical knowledge and skills to develop and manage cloud-based networks.

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