INFORMATION SYSTEMS SECURITY & ASSURANCE SERIES

ISSA

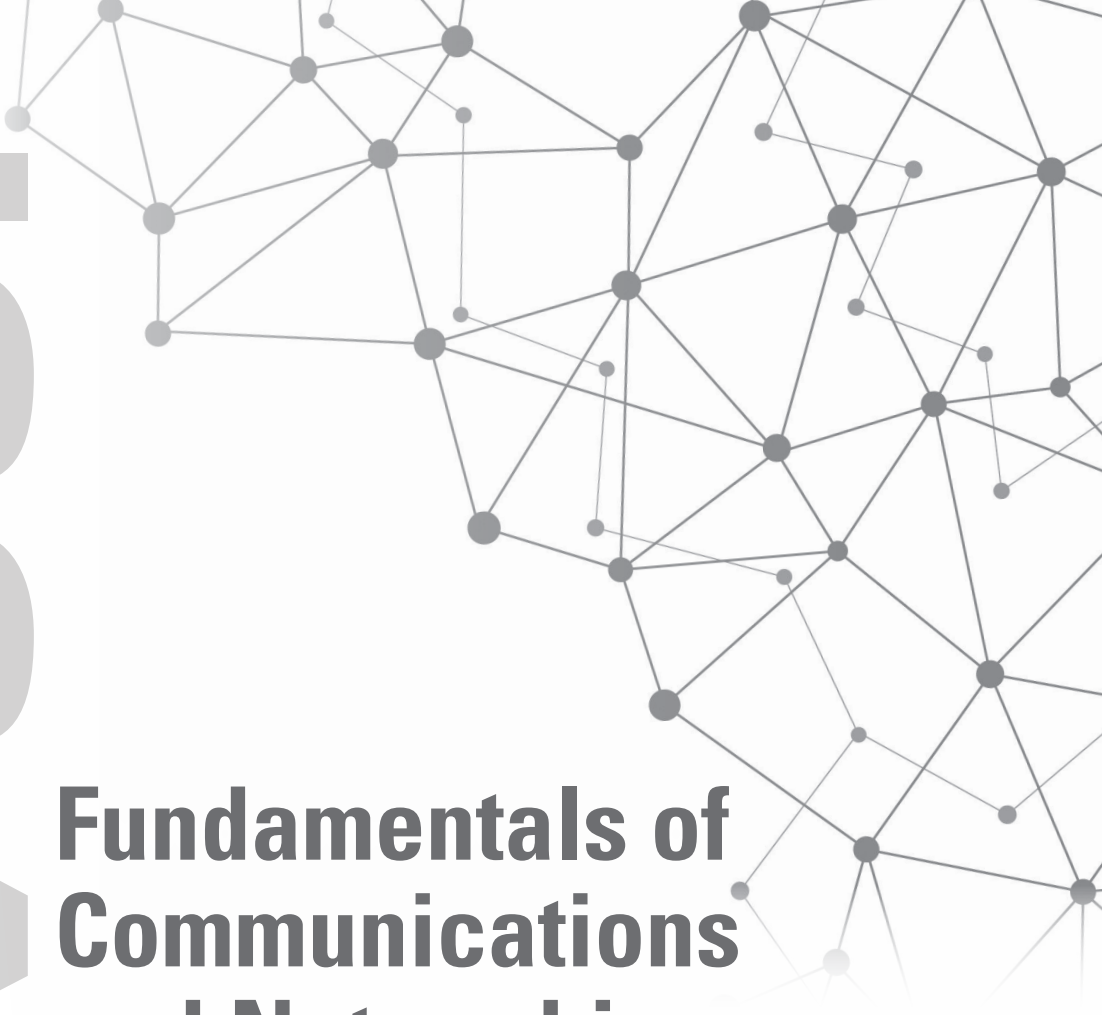
Fundamentals of Communications and Networking

THIRD EDITION

Michael G. Solomon | David Kim

INFORMATION SYSTEMS SECURITY & ASSURANCE SERIES

ISSA



Fundamentals of Communications and Networking

THIRD EDITION

Michael G. Solomon | David Kim

JONES & BARTLETT
LEARNING

World Headquarters
Jones & Bartlett Learning
5 Wall Street
Burlington, MA 01803
978-443-5000
info@jblearning.com
www.jblearning.com

Jones & Bartlett Learning books and products are available through most bookstores and online booksellers. To contact Jones & Bartlett Learning directly, call 800-832-0034, fax 978-443-8000, or visit our website, www.jblearning.com.

Substantial discounts on bulk quantities of Jones & Bartlett Learning publications are available to corporations, professional associations, and other qualified organizations. For details and specific discount information, contact the special sales department at Jones & Bartlett Learning via the above contact information or send an email to specialsales@jblearning.com.

20011-9

Production Credits
VP, Product Development: Christine Emerton
Director of Product Management: Laura Pagluica
Product Manager: Edward Hinman
Content Strategist: Melissa Duffy
Content Coordinator: Paula-Yuan Gregory
Project Manager: Kristen Rogers
Digital Project Specialist: Rachel DiMaggio
Director of Marketing: Andrea DeFronzo
Marketing Manager: Michael Sullivan
Content Services Manager: Colleen Lamy
Product Fulfillment Manager: Wendy Kilborn
Composition: Exela Technologies
Project Management: Exela Technologies
Cover Design: Briana Yates
Media Development Editor: Faith Brosnan
Rights & Permissions Manager: John Rusk
Rights Specialist: James Fortney
Cover Image (Title Page, Part Opener, Chapter Opener): © escyth/Shutterstock
Printing and Binding: McNaughton & Gunn

Library of Congress Cataloging-in-Publication Data

Library of Congress Cataloging-in-Publication Data unavailable at time of printing.

LCCN: 2020922274

6048

Printed in the United States of America

25 24 23 22 21 10 9 8 7 6 5 4 3 2

Brief Contents

Contents

I want to thank God for blessing me so richly with such a wonderful family, and for my family's support throughout the years. My best friend and wife of over three decades, Stacey, is my biggest cheerleader and supporter through many professional and academic endeavors. I would not be who I am without her.

And both our sons have always been sources of support and inspiration. To Noah, who still challenges me, keeps me sharp, and tries to keep me relevant; and Isaac, who left us far too early. We miss you, son.
—Michael G. Solomon

I dedicate this book to my twin-flame soulmate MiYoung Kim. No matter where our life journey takes us, I will always be waiting for you at the heaven train station (since you have my ticket)!
—David Kim

Preface

Purpose of This Book

This book is part of the Information Systems Security & Assurance Series from Jones & Bartlett Learning (www.jblearning.com). Designed for courses and curricula in IT Security, Cybersecurity, Information Assurance, and Information Systems Security, this series features a comprehensive, consistent treatment of the most current thinking and trends in this critical subject area. These titles deliver fundamental information security principles packed with real-world applications and examples. Authored by Certified Information Systems Security Professionals (CISSPs), they deliver comprehensive information on all aspects of information security. Reviewed word for word by leading technical experts in the field, these books are not only current but also forward-thinking—putting you in the position to solve the cybersecurity challenges not just of today but of tomorrow as well.

This book is a resource for understanding today's networks and the way they support the evolving requirements of different types of organizations. Networks have long been regarded as methods to connect resources. While this is still the case, today's networks are required to support an increasing array of real-time communication methods. Video chat, real-time messaging, and always-connected resources put demands on networks that were previously unimagined. Networks must respond to user requests in ways that require sub-second round-trip times. Such demands mean that network designers must rethink how they set up topologies or network layouts. Reliance on higher-layer flexibility is not sufficient. Performance often rises above flexibility in design priority.

Part 1 of the text covers the critical issues of designing a network that will meet an organization's performance needs. You will learn about how businesses use networks to solve business problems—not just technical problems. Today's networks must not only be technically proficient but they must also perform to a degree that they support an organization's ability to conduct operations as effectively as possible.

In Part 2, you will read about network basics and how to build functionality to support business demands. The focus of the topics is both on the technology and how the technology meets business goals. A functional network allows an organization to meet its goals—regardless of the technology it employs. You will learn how to choose what works for your organization. This text is organized to describe the basics of how networks work, how they support increasing demands of advanced communications, and how to map the right technology to the organization's needs.

Building a network is a great challenge. Once everything is up and running, keeping that network running smoothly is a new challenge. In Part 3 of this book, you will read about managing networks, keeping them secure, and responding when incidents occur.

Learning Features

The writing style of this book is practical and conversational. Step-by-step examples of information security concepts and procedures are presented throughout the text. Each chapter begins with a statement of learning objectives. Illustrations are used both to clarify the material and to vary the presentation. The text is sprinkled with Notes, Tips, FYIs, Warnings, and sidebars to alert the reader to additional helpful information related to the subject under discussion. Chapter Assessments appear at the end of each chapter, with solutions provided in the back of the book. Chapter summaries are included in the text to provide a rapid review or preview of the material and to help students understand the relative importance of the concepts presented.

Audience

The material is suitable for undergraduate or graduate computer science majors or information science majors, students at a two-year technical college or community college who have a basic technical background, or readers who have a basic understanding of IT security and want to expand their knowledge.

New to This Edition

This new edition has been updated to reflect the networking environments you will encounter in today's organizations. The content is organized logically to lead readers to a solid understanding of how networks work. Part 1, Evolution of Communications, covers how networks developed followed by Part 2, Fundamentals of Wired and Wireless Networks, which is a comprehensive dive into networking protocols and their uses. And finally, Part 3, Network Management and Security, introduces the concepts and tools needed to keep today's networks operating effectively and securely. This edition has been reorganized to align more closely with the OSI model to provide readers with a layered approach to understanding how networks really work. The latest techniques and protocols have been added to the material to provide coverage for readers who are new to networking concepts as well as those preparing for industry standard networking certifications. Concrete examples have been added to help present concepts that readers will encounter.

Readers will learn about networks from the physical layer up to the application layer and how each layer impacts the network's usability and its security. This edition also focuses on the topics of implementing and managing complex networks. Topics such as auditing, monitoring, interruption planning, troubleshooting, and incident response have been added or expanded to provide readers with a better understanding of general network operations requirements. Throughout the book, this edition is built on previous content to better punctuate the most important topics and added content to align with today's

business requirements for its networks. This edition is loaded with real-world examples, technical tips, and notes throughout to help prepare readers to solve technical challenges that network engineers commonly face.

Cloud Labs

This text is accompanied by Cybersecurity Cloud Labs. These hands-on virtual labs provide immersive mock IT infrastructures where students can learn and practice foundational cybersecurity skills as an extension of the lessons in this textbook. For more information or to purchase the labs, visit go.jblearning.com/netcomm3e.

Acknowledgments

I would like to thank David Kim for providing great content for this book and several iterations of updates, as well as the book's incredibly talented team (Ned, Melissa, Paula, Belinda, Kim, Chris, and Jeff). All of your input has really made this a better book. And thanks to my dad, who retired from AT&T with a ton of knowledge of how communications work, and passed a fair amount on to me. He helped put things in perspective with stories and some great analogies.

Michael G. Solomon

First, I would like to thank Michael Solomon for convincing me to participate in this 3rd edition update to "Fundamentals of Communications & Networking". Co-authoring a book requires a certain amount of patience and understanding for what the other author is writing. Working with Michael has not only brought our professional lives together but also our personal lives. I consider Michael my friend now thanks to multiple book projects we have co-authored together over the past few years.

Second, I am grateful for the professional support team put together by Jones & Bartlett Learning and the Ascend Learning team. Working with Ned, Belinda, Kim, Paula, Melissa, and our technical editing duo of Jeff and Chris made this fun and engaging from start to finish. Thank you so much for your fluid workflows and constant push to get things done on time. I am convinced now that authoring a book can be fun and engaging.

Third, to the reader or student of this book, congratulations! You are on the right career path. Any information technology (IT) career path that you take must include a foundational understanding of how data networking works. Understanding TCP/IP protocol behavior and how data networking works will help any IT professional with their career given that IP communications is fundamental to how today's applications and the Internet operate.

Finally, behind every book, chapter, page, word, and line drawing that I have ever created is a woman who has always stood by my side, day and night, for better or worse, in health or in sickness, and until death do us part. When I am in book-writing mode, she brings me my morning coffee, feeds me from dawn to dusk, sings love songs for me when I have a lull, and ensures that I have quiet time when I am writing a book chapter. She is and always will be the one who gives me purpose in life to work hard, to be the best I can be, and to make me always want to love her and our children more.

David Kim

Jones & Bartlett Learning would personally like to thank all of the people who reviewed the 2nd edition of this book, whose feedback helped to shape this revision:

Ata Elahi
Southern Connecticut State University

Shengli Fu
University of North Texas

Glyn Gowing
LeTourneau University

John M. Hunt
Covenant College

Jingfeng Li
Southwestern Oklahoma State University

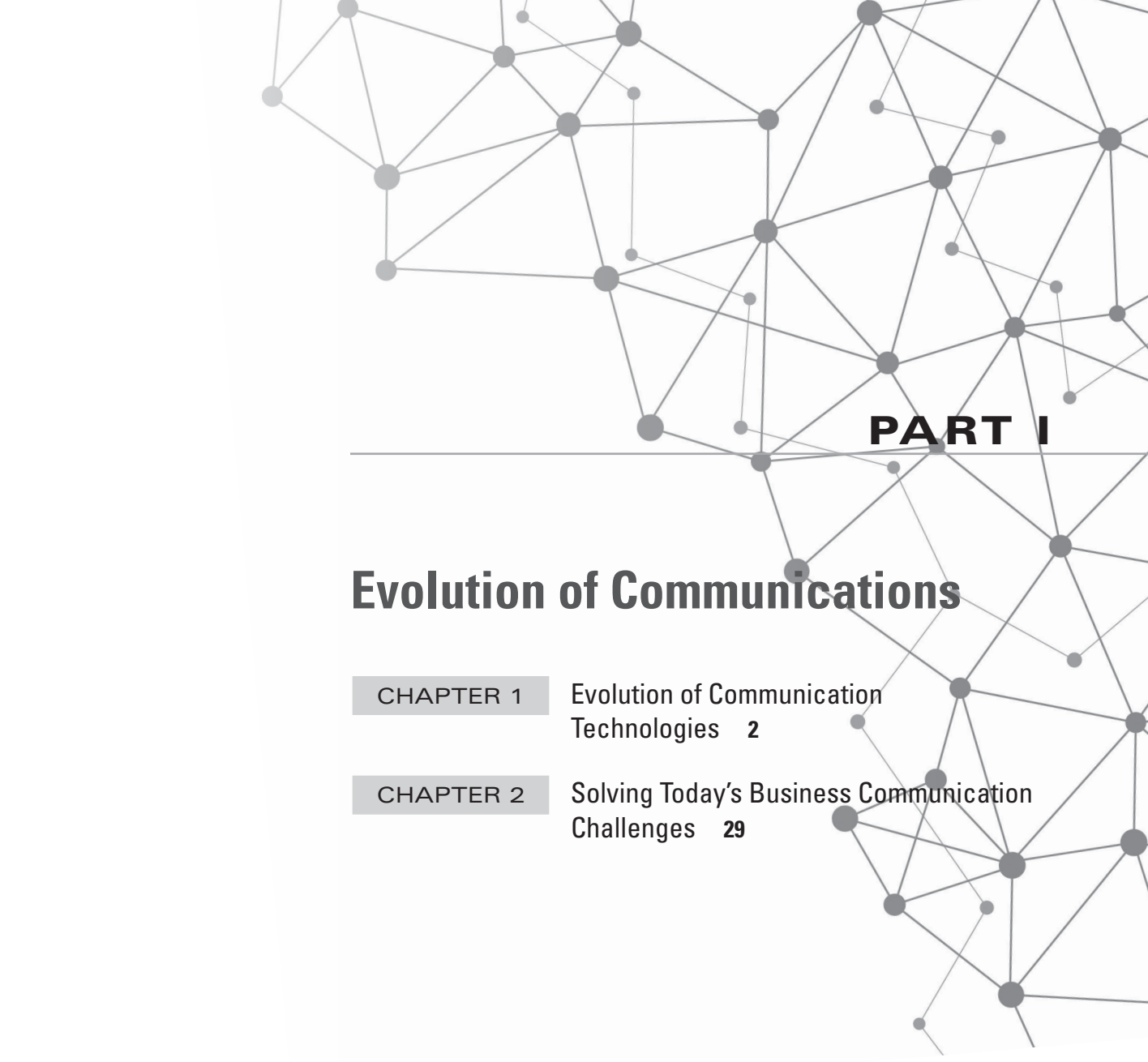
Andrew Morrow
Penn State University

Richard W. Vanderbilt
University Heights

About the Authors

Michael G. Solomon, PhD, CISSP, PMP, CISM, PenTest+, CySA+, is an author, educator, and consultant focusing on privacy, security, blockchain, and identity management. As an IT professional and consultant since 1987, Dr. Solomon has led project teams for many Fortune 500 companies and has authored and contributed to more than 25 books and numerous training courses. Dr. Solomon is a Professor of Cybersecurity and Global Business with Blockchain Technology at the University of the Cumberlands and holds a PhD in Computer Science and Informatics from Emory University.

David Kim, BSEE, CCNA, CISSP, CSCI, is president of Security Evolutions, Inc. (SEI), located outside of the metropolitan Washington, D.C., area. SEI provides governance, risk, compliance, and IT security consulting services for public- and private-sector clients worldwide. Mr. Kim's IT and IT security experience encompasses more than 30 years of technical engineering, technical management, and solutions selling and sales management. This experience includes LAN/WAN, internetworking, enterprise network management, and IT security for voice, video, and data networking infrastructures. He is an accomplished author and part-time adjunct professor who enjoys teaching cybersecurity to students across the United States.



PART I

Evolution of Communications

CHAPTER

1

Evolution of Communication Technologies

COMMUNICATION HAS CHANGED TREMENDOUSLY in just the past century. In fact, it has changed more than in the previous several thousand years. People communicate in ways few could imagine even a generation ago. The new options and methods to carry on conversations have changed the ways we interact with one another and how we conduct business. Good communication is essential to business. The most innovative organizations include new and emerging communication methods in their ongoing business plans. Consumers often find that the organizations that communicate most effectively deserve their repeat business. In this chapter, you will learn how personal and business communication requirements have changed and how these changes affect our daily lives.

Chapter 1 Topics

This chapter covers the following topics and concepts:

- What being hyperconnected means
- How communication evolved from analog to digital to Internet Protocol (IP)
- How IP communications has evolved
- The pervasiveness of the Internet and IP communications
- How unified communications (UC) connect people and businesses
- How snail mail, store-and-forward messaging, social media, and real-time messaging compare
- How the World Wide Web, the Internet of Things, and cloud computing have transformed business

Chapter 1 Goals

When you complete this chapter, you will be able to:

- Describe what it means to be hyperconnected
- Explain the benefits of Internet connectivity
- Define and describe some benefits of unified communications (UC)
- Contrast snail mail, store-and-forward messaging, social media, and real-time messaging
- Explain how the World Wide Web, Internet of Things, and cloud computing have changed the way businesses operate

Today's Hyperconnected World

Being online in today's world is nearly a universal assumption. The inability to connect to the Internet is no longer seen as acceptable, but instead is viewed as an obstacle and a hardship. Today we routinely see computers, smartphones, tablets, printers, soft drink dispensing machines, automobiles, refrigerators, doorbells, security systems, entertainment systems, voice-activated assistants, and a growing number of other devices already able to connect to digital networks. There is almost no limit to what you can do remotely now. All you need is a smartphone app and a connection to the Internet. Anyone can interact with many devices in their home or place of business without actually being there. It also means that people are connected to their homes and offices more than ever before. We live in the era of **hyperconnectivity**. The increasing reliance on digital documents and always being connected means that few transactions absolutely require a physical presence. You can do most of what you need remotely. This remote ability applies to both personal and business activities.

Hyperconnectivity does have its drawbacks. Always being connected tends to breed its own expectations. Most people who rely on their smartphones tend to frequently "check in" to fetch the latest email or social network messages. The fear is that you might miss something important in today's fast-flowing information society. Hyperconnectivity means the expectation is that everyone is online, connected, and available all the time. Many find it uncomfortable, or even next to impossible, to put the phone down and focus on a single face-to-face conversation. Hyperconnectivity easily provides access to more information than any human can digest and interpret. The primary challenge for today's networks and data providers is not to provide more ways to connect, but to use available network infrastructure and networked resources to present useful information to users and limit the growing volume of useless data.

Businesses are finding hyperconnectivity to be a growing challenge to their operations as well. With so much information deluging anyone with a connected device, businesses are

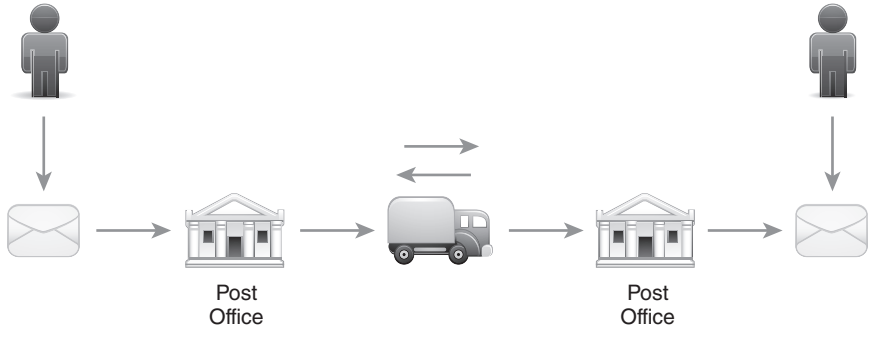
finding it increasingly difficult to stand out from the crowd. Advertisements and other customer touch points are continuously maturing to avoid getting lost in the sea of data. Hyperconnectivity is driving many business decisions when it comes to attracting customers and investing in postconversion customer care. The days when a telephone number provided a primary point of contact for prospects or customers is long gone. Successful businesses today routinely provide multiple access paths for their hyperconnected customers and prospects. The communication expectations for today's businesses are higher than ever before, and today's networks provide the ability to meet those expectations.

From Analog to Digital to IP

The common experience of always being connected to the rest of the world is fairly recent. Until about 1990, almost all electronic communication used **analog** media. Analog devices transmit data using continuously variable signals. The analog devices had limitations that made it difficult to do much more than engage in voice conversations and slowly transmit other types of data. Of course, before telephones, most communication occurred through either face-to-face interaction or written documents. Letters were the primary method for communicating when face-to-face meetings were not practical. At that time, the transmission speed depended entirely on how fast the sender could deliver a letter to the recipient. This practice that has lasted for thousands of years is still the main communication method for formal and legal correspondence (see **FIGURE 1-1**). Businesses have just recently improved the shipping and delivery process that enables any sender to transport a physical document to virtually any recipient overnight.

The introduction of the telegraph, and then the telephone, in the 19th century started a steady communication revolution. The electrical telegraph, commonly just known as the telegraph, was the first successful electronic communication device. The telegraph can send electrical signals over long distances using simple cables. Samuel Morse developed a code made up of long and short signals that could represent letters of the alphabet, and even numbers. Humans who knew this Morse code could send and receive the equivalent of today's text messages (without emojis, though). Alexander Graham Bell developed the telephone late in the 19th century. The telephone allowed people to talk to one another across long distances using simple cables.

FIGURE 1-1
Transporting written communication.



Once the basic infrastructure was in place to support telephones, people and businesses quickly adopted the new invention. They began to replace many face-to-face meetings with telephone conversations. As long as both parties had access to telephones, this type of communication filled the need for many informal conversations. Businesses embraced this new way to communicate. Telephones allowed workers to carry on conversations with associates and customers without having to leave their workplaces. Businesses increased worker efficiency and extended the area they could serve. The new invention gave them the ability to talk with more people in any given day. Distance between people became less of an obstacle to communication, and the world began to seem a little smaller.

Answering machines became popular in the early 1970s and started another wave in the communication revolution. Prior to the common use of answering machines, it was possible to communicate using a telephone only if both parties were at their respective telephones. During this time, nearly all telephones were hard-wired and could not move more than a few feet. The first approach to handling missed calls was to route all calls through a central person. The switchboard operator would intercept all calls and take messages when a recipient wasn't able to answer the call. This approach worked well, but it required at least one person who was dedicated to the task of handling telephone calls and messages. Answering machines made it possible to leave a recorded message for someone who was not available to answer a telephone call. Although this did not substitute for a complete conversation, it did allow parties to send messages that the recipient could retrieve later. This practice was one of the first electronic versions of sending complete messages.

In the last 40 years, the range of communication options has exploded. Facsimile devices, better known as fax machines, became popular in the 1980s. These devices allowed anyone with a phone line to send and receive printed documents in addition to voice communication. Fax machines could scan multiple-page documents and transmit the document image over regular analog telephone cables. Users didn't need any special hardware other than the fax machine. Anyone could receive a faxed document as long as they had a fax machine connected to their telephone line. The quality wasn't great, and large documents took minutes to transmit, but the process was much faster than mailing a document.

Beepers, also called pagers, and mobile phones emerged soon after fax machines. These allowed people to maintain communication without the restriction of wires. The first pagers only received messages. Anyone could call a specific telephone number associated with the pager to cause the pager to sound an alarm. Second-generation pagers supported two-way conversations. The messages could only be a few characters long, but two-way pagers gave users the first taste of freedom from telephone wires. They made it possible to reach people regardless of where they were. These devices made it possible to carry on simple conversations while engaging in unrelated activities. Users could participate in personal activities and still provide input for business matters. Mobile phones enabled the next step toward full communication freedom. Mobile phone users could carry telephones with them wherever they went without any wires. As long as they were in an area covered by the growing cellular service networks, they could make and receive calls with other mobile phones or any regular telephones. These technologies gave the average person the ability to stay connected with anyone else in many locations throughout the world. Most pagers and early-generation mobile phones still relied on analog communication and had to contend with its limited speed and quality.

The latest group of technology advances focused on the transition from analog to **digital** communication. Advances included digital wireless access and readily available **broadband**, or faster-access Internet connections. Easy access to digital networks means devices with any electronic components are candidates to connect to one another. This type of connection supports easy access for remote users.

Internet and IP Connectivity Are Pervasive

The global network we know as the **Internet** grew from a network created in the 1960s by the U.S. Department of Defense. In the early days, only military facilities and some academic research labs could access the network. Users began to rely on the network resources and often suggested adding more organizations to the growing network. Each time new groups of computers and users joined the network, the nature of the network changed to meet their needs. By the mid-1990s, the Internet had grown to include many businesses and private users. The **World Wide Web**, commonly referred to as the "web," was brand new, and it was clear this new phenomenon had staggering potential to change the way we understand and use networks. More and more small networks and computers connected to the Internet around the world and accelerated its growth.

In the early years of the Internet, many segments of the network used analog media. That meant network devices translated messages from analog to digital and back again many times as the messages traveled to their destinations. The ability for such a large network to operate on both analog and digital media made it easy to use existing telecommunication equipment. The ease of connecting to the Internet generated more demand for services—and more speed. Engineering techniques allowed service providers to use the maximum **bandwidth** of existing cabling and transmission technologies. But it was not enough. Network users demanded a faster solution.

The next step in solving the Internet's performance problems was to replace the analog segments with digital segments. In many cases, that meant upgrading network access hardware and laying new cable. The result was a global network supported by newer hardware with far greater bandwidth than before. Expanding the digital components of the Internet and its supporting networks made it possible to support far more users than was ever possible using analog components. These new changes made an even greater impact in highly populated areas. Today's Internet can provide network access to large groups of users in population centers and still allow access using analog components to service more remote areas, as shown in **FIGURE 1-2**.

The digital network revolution made it possible for billions of devices and computers to attach to the Internet. The only requirement is to get an **Internet Protocol (IP)** address from a recognized **Internet service provider (ISP)**. ISPs provide a unique **IP address**, or range of IP addresses, for their customers. The customer connects to the ISP's network and uses the assigned IP address to exchange messages with other computers and devices on the Internet. Any computers or devices connected to the customer's network can potentially access the Internet's resources using the single ISP connection. The original IP address format, called IPv4, provides unique addresses for approximately 4.3 billion devices; however, the existing 4.3 billion IP addresses are not

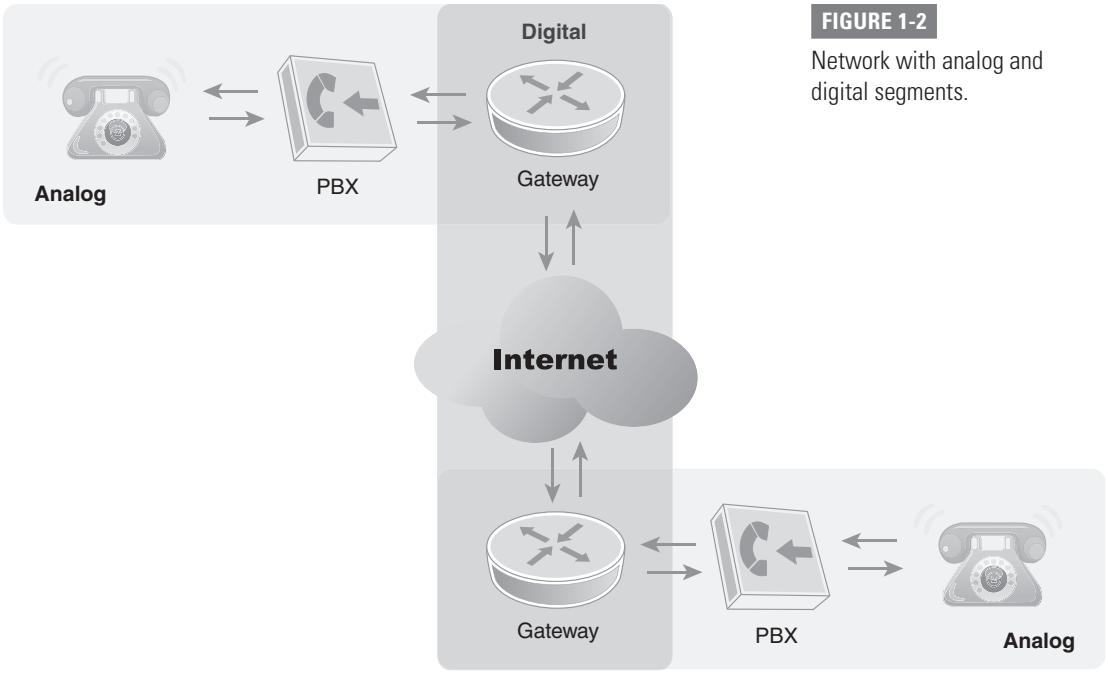


FIGURE 1-2
Network with analog and digital segments.

enough to keep up with the Internet's rapid growth. Internet users are in the process of transitioning to a new IP address format, IPv6, to solve the address exhaustion problem.

IPv4 uses a 32-bit address and is commonly expressed as a group of four bytes, separated by a period; for example, an IPv4 address would appear as 192.168.1.254. IPv6 addresses are 128-bit numbers. The new format provides the ability to uniquely address 2^{128}, or 3.4×10^{38} (340 undecillion) devices. IPv6 addresses are expressed as a group of eight 2-byte numbers (using hexadecimal notation) separated by colons; for example, an IPv6 address would appear as 2001:db8:45a5:3:200:f8bf:fe21:67cf.

NOTE

IPv6 is more than just bigger numbers. Although IPv6 does dramatically expand the number of available IP addresses, it attempts to improve IP network efficiency as well. The new format makes it easier to aggregate subnets using routing prefixes. When this subnet routing occurs at routing nodes, it can reduce overall traffic. The new format should reduce the Internet's bandwidth use and make it more efficient.

The original designers of the Internet Protocol addressing standards wisely set aside a range of **private IP addresses**. These private addresses made it possible for devices to connect to the Internet without having to have a globally unique IP address. Private IP addresses are nonroutable, which means the addresses are valid only for private networks, not the Internet. These addresses provide organizations with the ability to create their own networks with standard IP addresses. All an organization needs is a single public IP address from its ISP. All of the other IP addresses can be private addresses. IPv6 calls the equivalent of private IP addresses **unique local addresses (ULAs)**. ULAs are not routable on the Internet but can be routed on private networks. Although the ULA

prefix starts at fc00::/7, Request for Comments (RFC) 4193, the standards document for IPv6 as defined by the Internet Engineering Task Force (IETF), reserves fc00::/8, so the actual usable space is from fd00::/8 through fdff::/8. The ranges of private IPv4 and IPv6 addresses are:

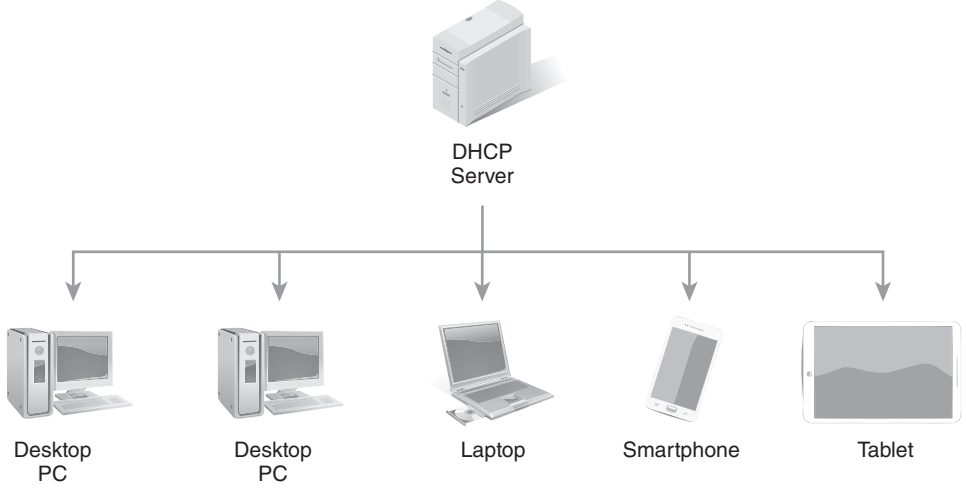
- *IPv4:* 10.0.0.0 to 10.255.255.255
- *IPv4:* 172.16.0.0 to 172.31.255.255
- *IPv4:* 192.168.0.0 to 192.168.255.255
- *IPv6:* fc00:0:0:0:0:0:0:0 to fdff:ffff:ffff:ffff:ffff:ffff:ffff:ffff

Organizations can assign IP addresses in the private address ranges or can set up a server or device to dynamically assign private IP addresses as needed (see **FIGURE 1-3**). Dynamic addressing uses the **Dynamic Host Configuration Protocol (DHCP)** to request and assign IP addresses.

In the Internet's earlier days, a network connection required a physical cable. The last 10 years, however, have seen tremendous growth in wireless network capabilities and numbers of wireless devices. It is common to find Internet connectivity using either Wi-Fi or cellular wireless networks. Most of today's home and business networks include both wired and wireless segments. Wireless networks make connecting computers and devices much easier than in the past. It has always been easy to plug a network cable into two computers; however, it has generally been difficult to ensure that there are appropriate cables in place to connect all computers. Wireless networks make it possible to connect computers and devices to home or business networks and the Internet where no network cables exist.

FIGURE 1-3

Network with DHCP server.



The ease of wired and wireless connections to the Internet made it possible to connect any device to a global network. But the Internet did not expand alone to just wait for new devices. The Internet expanded at the same time products began to appear that needed Internet access. Manufacturers of all types had been preparing their products for Internet connectivity. Many of today's products either rely on an Internet connection or provide features that depend on an Internet connection. For example, many home and business security systems allow remote users to arm, disarm, and check the status of the system. Remote users access the system by connecting to the security system through an Internet connection. This allows users to monitor and manage their security system from anywhere in the world.

Most standalone devices or those connected to an organization's internal network are now potential candidates to support remote Internet users. Printers, copiers, scanners, storage devices, and computers are common examples of network resources that can access the Internet (see **FIGURE 1-4**) or are accessible over the Internet. Of course, organizations must implement robust security controls to limit use to authorized users. This is especially important with technology such as cars and medical devices (such as insulin pumps and pacemakers) that use wireless connections to access the Internet.

Today it is easy to connect to the Internet with little regard for location. Although there are still some places with no easy Internet access, the list of such locations is rapidly shrinking. You don't have to go very far in any direction to find Wi-Fi or cellular access to a network that provides Internet access. Some existing coverage requires connection fees, but free access points are growing in numbers daily. The easily available Internet connections and large number of IP-enabled devices have made Internet access a common feature of many electronic devices.

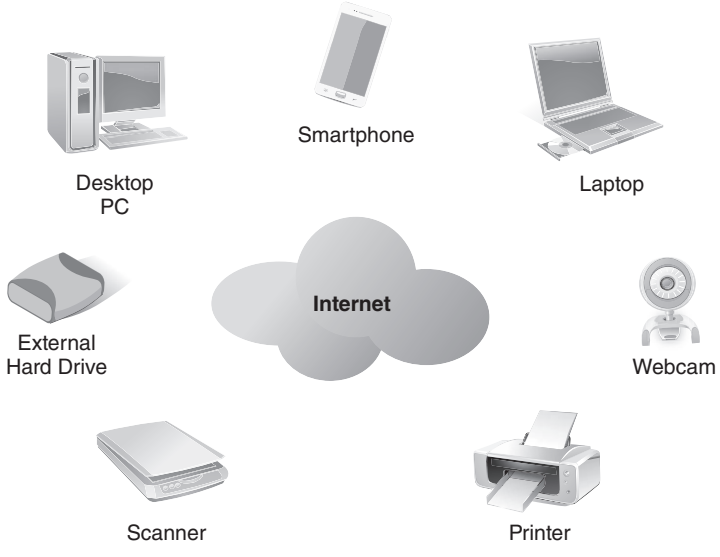


FIGURE 1-4
Devices that use wired and wireless connections to the Internet.

How Unified Communications Connect People and Businesses

There are a growing number of devices connected to the Internet—and easier access to the Internet than ever before. This means that users have access to an unprecedented amount of information. Although "more is better" sounds good, having lots of data often means that useful information gets lost in the noise. As users receive more and more information, it becomes difficult to manage all of the devices and streams of data. In the past, organizations suffered from the inability to make timely decisions due to a lack of accurate information. Now it seems that the large volume of information is just too much: Making timely decisions is still difficult due to the time it takes to identify and interpret the good information.

Information Overload

The McDonnell Douglas F-4 Phantom II jet entered service in the U.S. Navy in 1960. By the mid-1960s, the U.S. Air Force and U.S. Marine Corps were flying the versatile jet as well. This new aircraft carried many new electronic devices and dramatically increased the workload of its crew. During combat, the F-4 pilot would encounter a large volume of input, including the voices of the Radar Intercept Officer (RIO) in the back seat, the wingman, a Forward Air Controller (FAC), Combat Information Center (CIC, or Red Crown), and other aircraft on the same frequency. He also would hear various tones and sounds from incoming threats and his own infrared (IR) and radar-guided weapons. On top of all this, he had to read the primary instruments and a map while flying the aircraft. Keep in mind they didn't have global positioning system (GPS) during the Vietnam War. The real challenge was that all this information was important at some point during the flight. There were multiple documented cases of information overload—pilots missed crucial inputs because they just had too much information to process and prioritize. The U.S. military began to study the problem and developed guidelines to streamline the information pilots received. They learned that too much information is sometimes worse than too little.

One of the best ways to avoid information overload is to streamline business processes and minimize the amount of information users receive. Make sure you don't send information to users unless they need it to do their jobs. Emphasize process flow, required information, and process automation. This focus can reduce the amount of human input required to complete many business functions. Reduced user input allows personnel to focus on absorbing and interpreting smaller amounts of better quality information. This reduced workload allows users to focus on making good decisions, rather than processing lots of data. Aligning business processes and mapping each one to software applications and IT solutions is called **business process management (BPM)**. FIGURE 1-5 shows the BPM life cycle. BPM empowers organizations to be more productive and effective. It relies on reducing redundancy and increasing automation throughout the enterprise. The goal of BPM is to streamline business processes and create an environment that promotes competitive advantage and customer responsiveness.

Developing effective communications methods is a central focus of many BPM implementation projects. The BPM process often attempts to bring all communication mediums

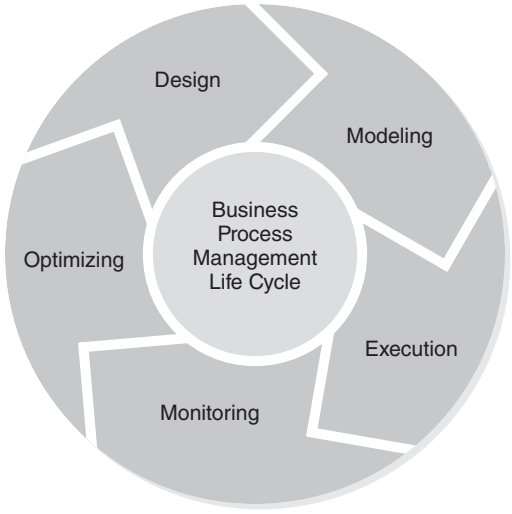


FIGURE 1-5

Businesses process management (BPM) life cycle.

Data from Liu, Dale and Luigi DeGrande., Introduction to Networking in Cisco CCNA/CCENT Exam 640-802, 640-822, 640-816 Preparation Kit, Syngress, 2009.

together into a unified structure. The final result of this effort is called **unified communications (UC)**. UC isn't just one technology. It refers to combining multiple technologies to provide the most effective real-time and non-real-time communication with the correct individual. Common **real-time communication** methods that UC solutions use include:

- Telephony
- Presence/availability
- Instant messaging
- Video conferencing
- Collaboration

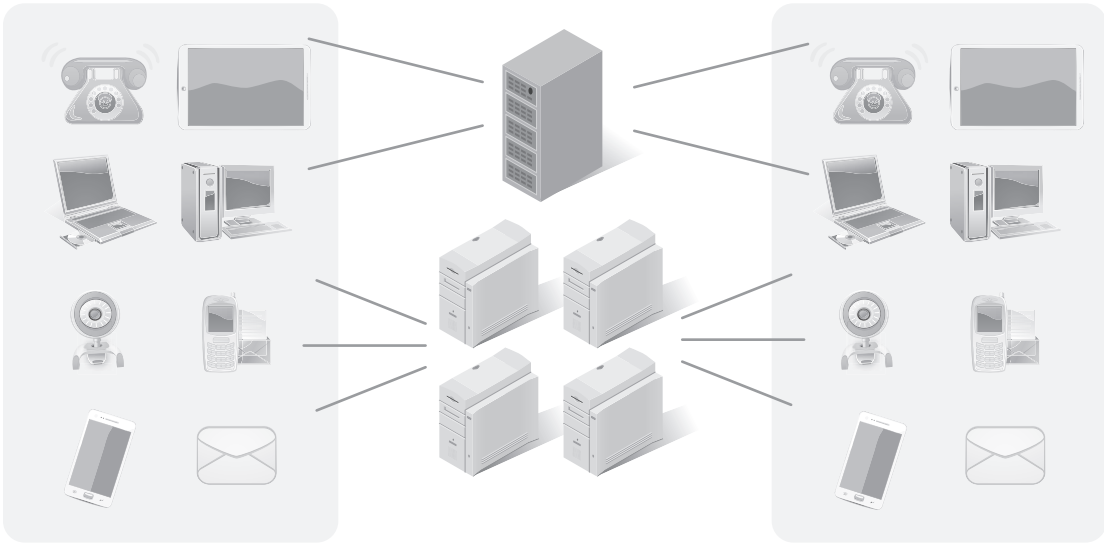
An effective UC solution integrates real-time communication methods with other methods, such as voice mail, email, and Short Message Service (SMS) or text messaging, to provide the best all-around solution, as shown in **FIGURE 1-6**. A solid UC implementation involves automation to identify the best target and medium to use when a person or application needs to communicate. UC can dramatically reduce the time spent searching for a person to answer a critical question. UC processes can automatically identify the correct resources and decide the best way or ways to contact them.

Organizations can implement UC throughout the enterprise. UC has many benefits, including the clarity gained just from examining existing processes. The UC analysis process often identifies outdated and inefficient processes. This process of planning for UC helps to ensure that the organization keeps only the communication processes it really needs. UC can improve communication efficiency in many areas, including:

- Reducing communication between modules and streamlining critical software applications
- Making communication less time-consuming and increasing customer service effectiveness
- Reducing wasted calls when managing customer relationships

FIGURE 1-6

Unified communications.



- Targeting critical decisions in the enterprise resource planning (ERP) process
- Automating tedious portions of supply chain management (SCM) and sales force automation (SFA)

UC can't solve all of an organization's problems, but it does provide a process to make communications more effective. Analyzing current communication and using technology to unify communication methods can make an organization far more effective. If nothing else, UC generally reduces the number of messages sent and received. UC helps to ensure that each message goes to the correct recipient and contains just the information necessary to continue the business process. Organizations that use UC generally see a drop in the number of duplicate or meaningless messages. That makes users happy. UC also means that the organization and its personnel require fewer devices and less network bandwidth to communicate. This means that equipment costs may go down.

There are many benefits to UC. Organizations may realize some, or many, cost and effort savings. The list of potential UC benefits includes:

- Better support of remote and mobile users, which reduces the number of workers that need a physical office; this can reduce the facilities an organization must maintain.
- Increased ability to conduct teleconferences and video conferences, which can reduce travel expenses for meetings and training.
- Higher worker productivity and retention because remote worker support provides more flexibility to conform to personal needs and schedules.
- Reduced sales cycle timeline due to more effective communication with all parties involved in the sales effort.

- Shortened project timelines due to a reduced lag time in communications.
- Better identification of communication paths to resolve questions and issues.
- Increased customer satisfaction due to more effective communication throughout the issue resolution process.

UC provides organizations with an approach to communication that leverages existing technology and makes business processes more effective. The key to a solid UC plan is to understand the organization's process and communication needs. Once the organization understands these needs, analysts can develop a UC plan that makes the overall organization more effective.

How Communications Have Evolved

One of the advantages of UC is the effective use of blended communication methods. UC combines real-time communication with other methods. In most organizations, the sender of a message chooses the delivery method before sending the message. It is the responsibility of the message sender to compose the message, select the best recipient, and then select the best delivery method. This approach requires that every message sender understand the communication process and make the best delivery decision. Although this approach may sound good, it has several flaws.

First, not all message senders fully understand the impact of their delivery method decisions. For instance, is there any real difference between an instant message, a text message, and an email message? In some cases there is not any major difference. Questions that don't require an immediate response aren't extremely time sensitive. In other cases, there are huge differences. Time-sensitive messages such as "Our primary database has crashed. What do we do?" require an immediate response. If the recipient is frequently monitoring their email inbox, the email message will arrive shortly after the instant message. The recipient won't immediately receive either message if he or she is not near the computer. In fact, instant message clients may not even deliver messages if the recipient is not logged in. Message senders in legacy environments must determine how sensitive a message is and whether the chosen method is the right one.

Second, most message senders have more to do than just monitor messages they send. It's more efficient to send a message and continue working until a response arrives. This efficient method of exchanging messages depends on a **reliable communication** process, shown in **FIGURE 1-7**. A reliable communication process is one in which senders have verification that recipients received all sent messages. Few communication methods provide such assurance without some type of monitoring. In most classic communication methods, senders must monitor sent messages for errors or potentially missing messages. Errors are generally easier to detect and handle. Many errors in the communication process

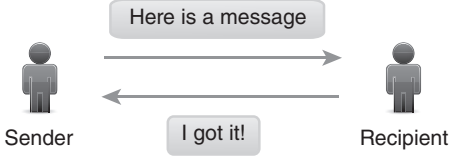


FIGURE 1-7
Reliable communication.

result in some type of sender notification. Dropped or missing messages are more difficult to handle. How do you know when a message doesn't reach its intended recipient? The simplest response is for the sender to wait for some period of time and try to contact the recipient again if there is no response. This method is inefficient and relies on an arbitrary amount of waiting time. Reliable communication provides sender feedback that verifies message receipt.

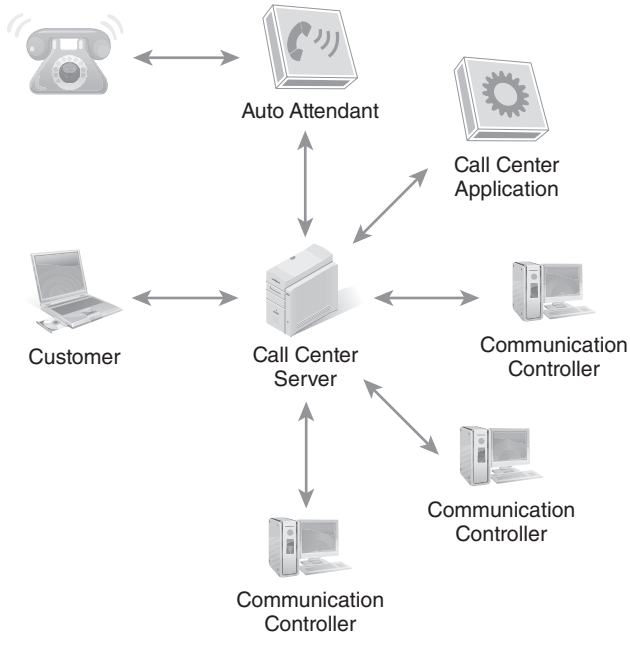
Third, most communication methods require that the sender know the recipient to send a message. In some situations the sender knows the message contents but not the recipient. The sender may not even know the role of the recipient. For example, suppose a website user wants to know if a specific food product contains allergens, such as gluten. Many websites provide generic request pages that send messages to a "catch-all" email address. Someone must read these messages and determine the best recipient. UC solutions may pass generic customer requests to a software program that analyzes the message content and determines the most likely recipient (see **FIGURE 1-8**). An automated UC process gets the message to the selected recipient faster than a process that requires human input. The UC process may determine that the best recipient for the allergen-related request may be the organization's automated response system. The system may be able to find an answer in a knowledge base and provide an immediate response to the original question. In many cases, UC can provide valuable, timely information without requiring human interaction.

You learned in the previous section that UC involves multiple technologies. UC isn't only about real-time communication. Each of the three classic communication methods has a place in UC. A robust UC strategy should include snail mail, **store-and-forward communication**, social media, and real-time communication. Each communication method has advantages and disadvantages in an enterprise communication model.

FIGURE 1-8

Automated knowledge base response system.

Data from Proxim.



Snail Mail

The oldest and arguably slowest form of communication is written documents. The sender creates the document and sends the physical paper to the recipient. The sender can write the message using long-hand or print the message using a computer printer. The sender either delivers the document directly or gives the document to a delivery person in the first step of the delivery process. This type of physical document delivery has been around for thousands of years and is still the most common method for legal and official documents.

In the simplest case, the sender delivers the document to the recipient directly. A more common approach involves some type of delivery service. The simplest delivery service is a courier service. Couriers generally work in metropolitan areas to deliver documents and packages directly from senders to recipients. Deliveries involving more distance between the sender and the recipient generally involve more complex delivery organizations. The specialized organizations include government postal services, United Parcel Service (UPS), and Federal Express (FedEx). There are many more delivery organizations of all sizes. Some are regional; others have a global reach. Regardless of the size or scope of the delivery organization, they normally deliver letters and small packages in a matter of hours or days. This type of delivery is the slowest of the modern methods available, so it is often referred to as snail mail.

Store-and-Forward Messages

Once computers joined even the earliest networks, users came up with new and unique ways to use them to communicate. Early network users appreciated the ability to use computer communication to support human communication. They simply created an electronic model of snail mail. The problem was that computers and humans communicate in different ways. Computer programs generally communicate in pairs. A common strategy was to create a communication channel similar to a telephone conversation. The initiator sets up a connection and waits for the target to complete the connection. Once both sides of the conversation were ready, the sender started sending messages. This model worked well between two computers but didn't work as well with two people who might not be near each other. In fact, some people who needed to communicate using computer networks worked on opposite sides of the earth. Different time zones meant that there were few times where both parties of the conversation would be at their computers at the same time.

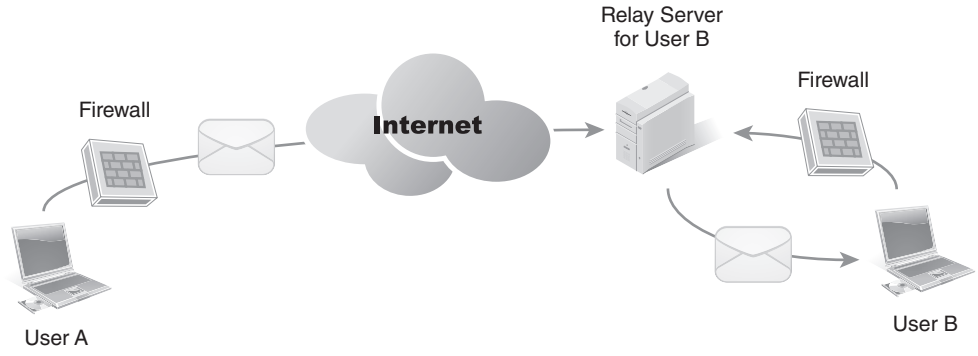
Software developers created a store-and-forward method of message delivery to allow a message sender to send a message to a recipient at any time. The message delivery didn't depend on the recipient being available to receive the message. Actually, the sender only had to send a message to the recipient's address. The delivery agent program would deliver the message to the recipient's address, but the recipient wouldn't immediately receive the message. The recipient would have to access the contents of the agent's mailbox to extract any delivered messages.

This model was built on the snail mail model of message delivery. Think of how you receive a letter. The letter carrier picks up mail from the main post office and delivers it to your mailbox. You don't actually receive your letter until you visit your mailbox after the letter carrier delivers the letter. The letter carrier doesn't wait for you. She just drops the letter into your mailbox and then leaves to deliver other mail. The store-and-forward method of

FIGURE 1-9

Store-and-forward communication.

Data from Slideshare.net.



electronic mail, often just called email, follows this same approach, as shown in **FIGURE 1-9**. When you send an email message, you actually send it to an email server. The email server decides where to send the message to get it to the recipient. The recipient is actually a mailbox on another email server. The target email server doesn't actually deliver the message to the final recipient until that recipient connects to the server to collect any delivered messages. The email server stores messages until the recipient connects, then forwards any messages to the recipient.

Real-Time Communication

Another common type of communication is similar to face-to-face or telephone communication. This type of communication depends on immediate feedback and response. In nearly all cases, real-time communication is less formal than snail mail or store-and-forward communication. Telephone conversations are a common type of real-time communication. The advantage over other forms of message exchanges is immediate feedback and the opportunity to exchange multiple messages in a short period of time. This type of message exchange lends itself well to conversations that are less developed than formal documents. It encourages a back-and-forth style of exchange that allows conversations to develop. This format also works well when conversations depend on answers to questions raised earlier in the conversation.

Real-time conversation has changed somewhat in the electronic age. Although it is easier to connect and carry on an electronic real-time conversation, these formats often lack some of the important cues to detect message tone and intended impact. **TABLE 1-1** lists common real-time communication options along with their advantages and disadvantages.

Although real-time communication is the latest form of informal electronic communication, it may not always be the best method. This is particularly true when dealing with transmission of real-time communication such as **Voice over IP (VoIP)** and **Session Initiation Protocol (SIP)**, which are used by unified communications applications throughout an

TABLE 1-1 Real-time Communication

TYPE	ADVANTAGES	DISADVANTAGES
Face-to-face meeting	• Full spectrum of communication, including voice inflection, nonverbal cues, and expressions	• Requires all parties be present • Generally more expensive when travel is necessary
Video conference	• Most of the advantages of a face-to-face meeting	• Not as intuitive as face-to-face meetings—participants can easily miss nonverbal cues • Visual cues are limited by camera quality and field of view • Requires hardware, software, and network support for each participant's location
Telephone conversation	• Usually convenient for all participants • Low cost to set up	• Absence of nonverbal cues • Less personal than previous options
Instant messaging	• Easy to participate in an informal conversation—especially when the messages are generally simple and time-sensitive • Enables multitasking during conversations	• Low attention requirement often means conversations may be fragmented when participants are multitasking • Very difficult to convey tone
SMS text messaging	• Easy to carry on conversations anywhere • Good when communicating simple messages quickly	• Difficult to convey tone or complex concepts • Most supplemental cues are missing

IP networking infrastructure. Real-time communication is subject to the following time-sensitive requirements:

- **Bandwidth**—The amount or capacity of the number of bits transmitted per second. VoIP and SIP usually require from 24 kbps to 90 kbps. (Bandwidth is often expressed as how many bits you can transmit per second; for example, 1 kbps is 1000 bits per second, 1 Mbps is 1 million bits per second, and 1 Gbps is 1 billion bits per second.)
- **Time delay or latency**—The total amount of time elapsed (queuing, contention, serialization, etc.) from source to destination through the IP network infrastructure, normally measured in milliseconds (ms). VoIP and SIP usually require from 100 ms to a maximum of 150 ms **latency** end-to-end for acceptable speech quality.
- **Packet loss**—The **packet loss** is measured as a percentage of total **packets** sent. VoIP and SIP can endure packet losses of 1 percent or less; above that, speech quality degrades.

- **Packet jitter**—The measure of the average of the deviation from the mean latency of a network. Consistent network performance means low **packet jitter** values. Quality of service (QoS) controls or traffic prioritization can help mitigate packet jitter through an IP network to achieve less than 400 ms end-to-end latency.

The use and deployment of VoIP and SIP as time-sensitive protocols will dictate the need for real-time communication and support for these protocols through an IP network. This commingling of real-time communication with store-and-forward communication requires unique solutions for end-to-end networking and communications connectivity. This is particularly true given that VoIP and SIP are both inherently insecure protocols.

Social Media

The last common type of communication is **social media**. As recently as a few decades ago, the primary way to meet and exchange ideas with others who share common interests was to physically meet. For example, if you were a private pilot and wanted to meet other pilots, you'd probably hang around the airport. Most small airports have pilot lounges and bulletin boards with information of interest to other pilots. The physical location and ability to exchange messages allowed pilots to establish a community with others who share a passion for flying.

The Internet made it possible to connect to remote people using email, and then through online bulletin board systems. The web gave rise to networked apps and the ability to connect to others even more easily. Many social media apps have become popular over the last 20 years, including LinkedIn, Facebook, Instagram, Twitter, and Snapchat. These apps allow users to find others with similar interests, connect with those users, and exchange media and messages, sometimes with extremely wide distribution.

A central concept of social media is that each user joins a social network. Joining a network simply means that you voluntarily connect with one member or with a defined network. Once you connect, you can send and receive messages, or posts, with other members in the same virtual network. Most social media users belong to more than just one network, so many social media interactions come from users who are connected to your friends, also sometimes called *connections*. This "friend-of-a-friend" connection provides a vast reach for indirect communication.

Businesses leverage indirect connections in social media to reach new prospects and customers. Social media provides a rich marketing pool of opportunities and makes it easy for customers to communicate with product and service providers. The social media model is based on publishing and subscribing. Publishers can publish messages at any time, and only those users who have subscribed to a specific publisher, often called *following* a publisher, will receive those messages. The publish–subscribe model makes it easy to communicate to a limited network of targeted users. Social media makes it possible to interact with pertinent, targeted, high-impact messages. The ability to avoid wasted communication effort makes social media an attractive method for businesses and individuals to communicate.

The Web's Impact on Business

Easy and reliable access to the Internet and the web changed more than just how people communicate. It also revolutionized how organizations conduct business. Physical places of commerce, often called brick-and-mortar stores, now have global reach by extending business to include customers that are not geographically nearby the physical store. The practice of doing business with remote customers over the Internet is commonly called **e-commerce**. E-commerce changed how organizations carry out business transactions, and the web changed how organizations market their goods.

E-commerce Business Models

Today's customers can use e-commerce to buy goods and services from a vendor online. In current business environments, the vendor's presence on the Internet is almost always a website. A website makes it easy for customers to interact with organizations using generic, standard software and the Internet. Customers can exchange information and conduct business activities that used to require a physical presence. They can exchange information of all types, including private data such as checking account or credit card information. The potential for private data exchange means that organizations that conduct e-commerce must take measures to protect their customers' data.

E-commerce provides organizations with more than just the ability to interact with their customers. In fact, e-commerce supports three primary business models. The first model, **business to consumer (B2C)**, focuses on conducting business with customers. The second model, **business to business (B2B)**, focuses on conducting business with other organizations. The third model, **business to government (B2G)**, focuses on doing business with government agencies. TABLE 1-2 describes the three common e-commerce models.

Solving E-commerce Business Challenges

The web expanded the Internet from a large network to a global online market in just a few short years. Very few people predicted the long-range impact and how it would affect the methods of conducting business. Organizations of all types must now consider the online aspects of advertising, sales, marketing, and customer/partner management. These activities extend the traditional methods of reaching and interacting with customers and partners. Television, radio, print media, and telephones are no longer sufficient to find customers and meet their changing needs. Today's business demands an online presence, and organizations must respond to these demands to remain competitive. The new challenges that face organizations in today's connected business environment include:

- How to expand business offerings using the web
- Converting an existing organization to enable e-commerce
- Ensuring data security and privacy for online customers and business partners
- Incorporating online technology into the organization's core business activities

TABLE 1-2 E-commerce Business Models

MODEL	DESCRIPTION	FEATURES
Business to consumer (B2C)	Also called business to customer, this model describes business activities that involve providing products or services directly to end consumers. The most common B2C activities involve retail sales.	• Typically low volume • Fixed or limited pricing • Little integration with customers' systems
Business to business (B2B)	Describes activities that involve doing business with other businesses. B2B interactions often occur in the supply chain prior to B2C. Common B2B interactions take place between manufacturers and wholesalers.	• Much higher volume • Price negotiation is common • Integration generally is desired or mandatory between participants' systems
Business to government (B2G)	Describes activities that support business activities between commercial organizations and government agencies, also called public sector organizations (PSO).	• Requests for proposal (RFPs) provide the relationship basis • Usually have a prenegotiated price • Strict constraints on allowed products, services, and activities

Data from ExamGuides.com.

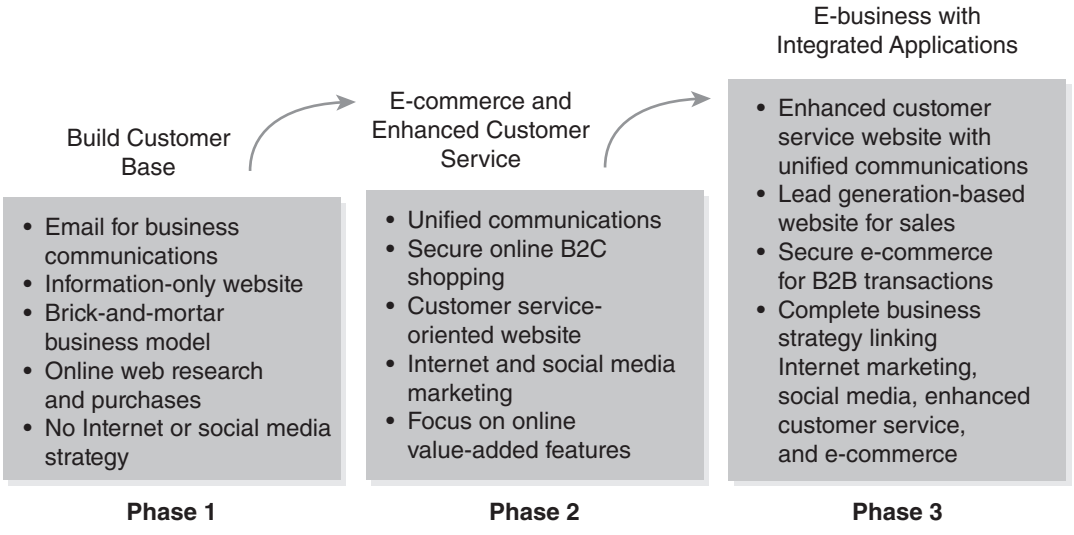
- Keeping up with new technologies
- Using online resources and capabilities to reach new customers and develop ongoing relationships with them

It takes more than just a website to solve the many challenges of transforming a traditional business model into an e-commerce model. There are many things to consider and pitfalls along the way. The first important decision is which model will be the primary model. Will your organization become primarily an online entity, or will e-commerce support the traditional activities? How will you continue to interact with existing customers? How will you find new customers? These are just some of the questions to get the process started. Organizations transitioning to an online model have to understand how to use online resources to find new customers and business partners. Once they find new prospects, they must provide the right services to convert the prospects into repeat customers or long-term business partners.

Today's population is generally Internet savvy. They are comfortable using the Internet and the web to find products and services. They routinely make online purchases and communicate online. Not everyone is an Internet guru, but most people can tell the difference

FIGURE 1-10

Transforming a traditional business model into an online model.



between a website that is easy to use and one that is difficult to use. Creating a good website to conduct e-commerce can be difficult. An organization understands its customers and partners and needs to ensure that its website meets those customers' and partners' current needs. A well-designed website also should anticipate future user needs and provide the flexibility to change based on demand. The overall goal of an online presence is to "attract as many people as possible, interest them enough to keep them there, and meet their needs to encourage them to return in the near future." **FIGURE 1-10** shows the process of transforming a traditional business model into an online model.

Customers and partners who find what they want at an organization's online presence will likely continue to do business with that organization. If they can't find what they're looking for, or if they find the e-commerce solution difficult to use, they will leave the website and search for a better one. Keep in mind that an online presence is often more than a website. Social media, review and opinion apps, and company-specific apps designed to engage or assist customers all contribute to building and retaining a customer base.

The Internet of Things' Impact on Business

Advancing technology has allowed an ever-growing number of smart devices to appear on the market. Just within the last 10 years, the number of these devices that have the ability to connect to the Internet has exploded. As of today, it is estimated there are more Internet-connected devices than there are people on the Earth. Where previously, most Internet-connected devices were smartphones, tablets, computers, and traditional peripherals, it

seems that now everything can connect. Cars, refrigerators, toasters, cameras, sound systems, farm equipment, and even automated temperature sensors can connect to the Internet and operate autonomously.

So many Internet-connected devices exist today that there is a specific term, the **Internet of Things (IoT)**, to describe the new ecosystem. At its most basic level, each IoT device is just a network node with some computing power. However, these IoT devices, or nodes, are designed to operate autonomously, unlike more traditional smart devices, such as smartphones, that exist to provide humans access to Internet resources. IoT nodes carry out their assigned tasks, including communicating and exchanging data with other nodes, without the need for human interaction.

IoT autonomy is expected to have noticeable and material impacts on consumer interaction and business operations. IoT can automate many repetitive tasks and do so with more isolation than earlier robotics solutions. For example, autonomous vehicles can carry out their entire lifecycle activities without the need for human interaction. An autonomous truck can drive itself to a pickup location, deliver its load to a destination, monitor its own operational well-being, and travel to fuel or maintenance centers for fuel and repairs as needed. IoT devices need management and deployment infrastructure to achieve such goals, but the technology already exists to support it.

IoT is expected to impact businesses in the following ways:

- **You can track everything.** One of the common characteristics of IoT devices is their ability to operate in a specific context. Context may mean physical location or logical step in a larger process. Whether an IoT device determines location via GPS, radio frequency identification (RFID), scanner ID, or some other relative metric, the device knows its location and generally reports or records it periodically. As a result, IoT devices are easy to track in real time.
- **Data will grow even faster.** The ability to understand and report location and progress in a process means that each IoT device is capable of generating lots of data. To track the history of any device, you have to store its historical trajectory in a repository somewhere. That means your data transmission, processing, and storage requirements are going to keep growing.
- **Administrative delays will shrink.** Business processes depend on defined steps, many of which require some type of human interaction. An example would be authorizing a shipment for release to a carrier. Any administrative action that involves a human response leads to delays in the process. IoT autonomy can move some administrative decisions into programs that don't need human interaction, reducing delays and increasing the throughput of end-to-end processes.
- **Waste will be easier to identify.** Another advantage of IoT autonomy is its ability to detect and report very granular activities. IoT devices keep track of their place in processes and can determine resource use at each step. This granular information makes it possible to determine process steps that may result in waste and be targets for optimization. IoT won't make everything more efficient, but it can provide the data to help organizations make their processes better.
- **Identity and authorization management will become more complex.** One of the drawbacks to IoT is in managing the devices as separate entities. To take advantage

of the rich data each IoT device generates, it is necessary to distinguish one device from another. If your warehouse contains 48 picking robots, you'll only get actionable data if you can distinguish one robot from another. Distinguishing devices means you have to manage each one with a separate identity, very much like managing human identities. Likewise, each device will have its own authorizations list to permit or deny its ability to carry out specific actions. Defining and managing device identities and authorizations makes identity management far more complex than just managing humans.

- **Some jobs or roles may change or go away.** IoT may change some process steps and could completely replace others. In the case of a warehouse, the traditional role of stock picker (the person who fetches an ordered product from its bin) could be completely replaced by a robot. On the other hand, the truck unloading function may still need a human to initially transfer cartons from a truck to the conveyor belt. IoT will have varying impacts on personnel, depending on the level of automation.

The full impact of IoT on business hasn't yet been realized. As more and more businesses incorporate IoT or even consume services that are supported by IoT, you'll see the new ecosystem's impact at all levels of commerce.

The Cloud's Impact on Business

As if the web and IoT weren't enough to disrupt business, **cloud computing** has become a staple of doing business with any online footprint. Historically, incorporating information systems in a business environment meant investing in infrastructure and personnel to manage IT assets. It didn't take long for businesses to need enterprise data centers that require substantial budget support. To make matters worse, as businesses rely more and more on information systems to conduct critical business functions, those information systems become core assets. The loss of IT resources can pose obstacles that interrupt business operations. The most common response is to invest in even more IT infrastructure to replace primary assets that may fail or become unavailable.

Cloud computing provides an alternative for businesses wanting to rely on IT assets but not wanting to build state-of-the-art data centers. At its simplest level, cloud computing consists of renting someone else's computers and network to run software to support your business. When a business relies on cloud computing, it doesn't have to invest as much into IT infrastructure and personnel as would be required for an on-premises data center. Cloud computing isn't free, though. Businesses that offer cloud computing services, called **cloud service providers (CSPs)**, take on the expense and responsibility to build their own IT infrastructure, and then charge customers to use it to run software. That's the cloud computing delivery model in a nutshell.

Virtualization

At first glance it may seem that CSPs are just taking on the cost, risk, and responsibility of on-premises data centers. It is true that CSPs relocate IT infrastructure to their own data centers, but they don't just physically move computers to a new location. Moving existing

computers to a bigger building would be more of a simple technology transfer than a technology innovation.

Cloud computing offers far more than simple infrastructure transfer. **Virtualization** technology made cloud computing possible. Virtualization allows one physical computer to run multiple images of operating systems (OSs) in virtual environments. Each running image is called a **virtual machine (VM)**. A VM looks, feels, and operates just like a physical computer. When you log into a VM it is difficult, or even impossible, to determine if you're connected to a physical or virtual computer. Virtualization allows a single computer to run multiple VMs, each with its own operating system. Users of VMs each think they are running on dedicated computers, but they actually are sharing resources among potentially thousands of other users. The cloud computing model depends on virtualization to allow a data center to support many more VMs than physical computers present in the infrastructure.

CSP customers can launch, use, and even resize VMs based on need. If a business has a busy month starting, they can use **dynamic provisioning** to request (and pay for) more memory, CPU power, or external storage. When business demands decrease, the business can provision resources back down to use less and pay less. The ability to provision up and down through virtualization provides CSP customers cost control and provides CSPs the ability to efficiently use their physical IT assets.

Because VMs operate within a virtualization environment, also called a **hypervisor**, a running instance of a complete operating system can be represented as a collection of files. Memory, processes, and data all look like files. You can store a copy of these files at a specific point in time, creating a VM **snapshot**, which proves extremely useful for backups and fault tolerance. Instead of relying on duplicate hardware with replicated data, businesses can recover from crashes simply by spinning up another VM and restoring the most recent snapshot. (Of course, the real recovery process is a little more involved than a few simple steps, but cloud computing makes it far easier than ever before.)

Types of Cloud Services and Delivery Models

Up to now we've presented cloud computing as only providing complete VMs as if you added a new computer to your network. Providing newly installed operating systems as VMs is only one type of cloud service. Some businesses want to take advantage of all that CSPs can offer, but don't want to manage their own virtual computers in someone else's data center. Here are the main types of cloud services and what each provides:

- **Infrastructure as a Service (IaaS)**—This is the original service type. CSP customers can provision and launch any number of VMs that originally appear to be newly installed operating systems. It is the responsibility of the CSP customer to configure the VM and install any software they need to make use of the VM.
- **Platform as a Service (PaaS)**—Some businesses need more than just a new OS when they create a new VM. They may want to support application development and need development libraries, compilers, databases, and web or application services. The PaaS service type provides VMs with pre-installed and configured software that gives users a stable platform from which to start.

- **Software as a Service (SaaS)**—Often considered to be the highest level of cloud service type, SaaS offerings rent access to specific software applications, such as SalesForce.com. SaaS customers do not want to install or manage software—they just want to use it. All of the installation, configuration, and maintenance responsibilities fall on the CSP. This service type is generally the most expensive, but the one that requires the lowest level of customer involvement.
- **Anything else as a Service (AaaS, also commonly called XaaS)**—Extending the SaaS service type, many businesses offer their SaaS solutions as professional services, not just software their customers can use. The list of service offerings is always growing and currently includes services such as Security as a Service, Database as a Service, Blockchain as a Service, and Privacy as a Service.

Cloud computing's focus is flexibility. Virtualization makes it possible to provision just the right infrastructure and software to meet specific needs. Accessible networking provides unparalleled connectivity; however, there is a tradeoff between ultimate flexibility and security.

The **public cloud** model is the most common view of cloud computing. A public cloud, also called the *public delivery model*, consists of CSP services offered to any subscribers using the Internet to connect. The CSP hosts infrastructure and software for many different types of businesses. Some of the largest public CSPs are Windows Azure, Amazon Cloud Services, and Rackspace. A public cloud provides lots of flexibility, but security and control are issues.

To restrict who can access your data and infrastructure, some businesses use a **private cloud**. With a private cloud, also called a *private delivery model*, the virtualization layer is managed by the owning organization as opposed to a CSP. The physical infrastructure could be in the organization's data center or could be hosted by a CSP, but it is accessible only by users the owning organization authorizes. A private cloud allows the owning organization to provide more security for its data and processes than a public cloud.

The third main delivery model, the hybrid delivery model, combines the best of the public and private delivery models. A **hybrid cloud** includes one or more public cloud services and one or more private cloud services. Private clouds tend to be more expensive than public clouds and require more effort to manage. A hybrid cloud allows an organization to use private clouds where they need to, and use more cost-effective public cloud services for less sensitive applications and data.

Cloud computing has revolutionized the way businesses consume IT resources. CSPs can relieve many IT headaches (for a fee) but can't solve every problem. Anytime a business moves IT assets outside its own trust boundary to another environment, identity and access become issues. You'll encounter some of the issues and obstacles of cloud computing as you learn more about network communications, but don't let that minimize cloud computing's value. With a little planning and a good security policy, cloud computing can help businesses leverage IT assets and manage costs.

CHAPTER SUMMARY

Communication technology has changed in dramatic ways in just the last century. These changes have had far more impact than just giving us more options. The new technology of communication has transformed the ways in which we interact with one another. Online capabilities have made it possible to stay in touch with people all over the world. This allows relationships to exist with little or no face-to-face interaction. The new communication methods reach far beyond personal relationships as well. Hyperconnectivity has revolutionized the way we conduct business, and virtualization has allowed businesses to extend their reach around the world. Businesses are more connected with each other and their customers. They can be more responsive and more in tune with what their customers want and need. In short, the technological advances in communications have essentially rewritten the rules on how to conduct business. Understanding the technology of communication, such as social media, cloud technologies, and IoT, is mandatory to running a successful business in today's economy.

KEY CONCEPTS AND TERMS

Analog
Bandwidth
Broadband
Business process management (BPM)
Business to business (B2B)
Business to consumer (B2C)
Business to government (B2G)
Cloud computing
Cloud service provider (CSP)
Digital
Dynamic Host Configuration Protocol (DHCP)
Dynamic provisioning
E-commerce
Hybrid cloud
Hyperconnectivity
Hypervisor
Internet
Internet of Things (IoT)
Internet Protocol (IP)
Internet service provider (ISP)
IP address
Latency
Packet
Packet jitter
Packet loss
Private cloud
Private IP address
Public cloud
Real-time communication
Reliable communication
Session Initiation Protocol (SIP)
Snapshot
Social media
Store-and-forward communication
Unified communications (UC)
Unique local address (ULA)
Virtual machine (VM)
Virtualization
Voice over IP (VoIP)
World Wide Web

CHAPTER 1 ASSESSMENT

1. Which type of communication is based on the publish–subscribe model?

A. Email
B. Social media
C. Video conferencing
D. Instant messaging

2. Cloud computing is made possible by what technology that supports running multiple images of operating systems on a single server?

A. IoT
B. Machine-commerce
C. Virtualization
D. Automation

3. Which device that became popular in the 1980s enabled users to send and receive printed documents using analog telephone lines?

A. Telephone
B. Fax machine
C. Answering machine
D. Pager

4. What was the originator behind what we know of as the Internet today?

A. IBM
B. U.S. Department of Defense
C. U.S. Federal Communications Commission
D. AT&T

5. Which of the following IP address ranges is *not* a private IPv4 address range?

A. 10.0.0.0 to 10.255.255.255
B. 152.0.0.0 to 152.255.255.255
C. 172.16.0.0 to 172.31.255.255
D. 192.168.0.0 to 192.168.255.255

6. A network's _____ server provides IP addresses to devices dynamically.

A. Authentication
B. DHCP
C. Office automation
D. Email

7. The formal process of aligning business processes and mapping each one to software applications and IT solutions is called configuration management (CM).

A. True
B. False

8. Unified communications (UC) is the process of bringing all communication mediums together into a unified structure.

A. True
B. False

9. _____ communication is faster than snail mail but slower than immediate or _____ communication.

10. Which of the following is *not* a unified communications application and service?

A. SMS text messaging
B. Video conferencing
C. Collaboration
D. IM chat
E. Audio conferencing

11. Which of the following is defined as the amount or capacity of the number of bits transmitted per second?

A. Bandwidth
B. Time delay or latency
C. Packet loss
D. Packet jitter

12. Which cloud service type provides VMs with pre-installed and configured software?

A. IaaS
B. PaaS
C. SaaS
D. AaaS

13. How is the term *hyperconnectivity* best described?

A. Everyone is online and available all the time.
B. Migration from analog to digital makes communication part of today's networks.
C. Cloud computing makes apps and data universally available.
D. Social media networks make personal connections easy.

14. Which of the following business drivers can be addressed with unified communications?

A. Driving incremental services revenue
B. Implementing managed services revenue
C. Enhancing customer service delivery
D. Lowering operational costs

15. Businesses that transform to the web with an Internet presence and an e-commerce solution require an e-customer service and self-serve customer service delivery strategy.

A. True
B. False