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Networking
A Beginner's Guide

Bruce Hallberg

Mc Graw Hill Education

Networking

A Beginner's Guide
Sixth Edition

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Bruce Hallberg has 30 years' experience in information technology, including executive management, system implementations, and global network consulting for Fortune 1000 companies. He is the author of more than 30 books on a wide variety of computing topics, including operating systems, networking, and both server and desktop applications. He holds an MBA from Heriot Watt University, and resides in the Silicon Valley area of California with his two daughters.

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Mc Graw Hill Education

New York Chicago San Francisco Athens
London Madrid Mexico City Milan
New Delhi Singapore Sydney Toronto

ISBN: 978-0-07-181225-2

MHID: 0-07-181225-3

e-book conversion by Cenveo® Publisher Services

Version 1.0

The material in this e-book also appears in the print version of this title: ISBN: 978-0-07-181224-5, MHID: 0-07-181224-5

With all my love, for Bonnie Gordon,
and my two daughters, Vivian and Maxine.

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Acknowledgments

I'd like to thank Amy Jollymore for putting this project together. An acquisition editor's job is rarely an easy one (think "herding cats"), but Amy was unfailingly pleasant to work with.

Amanda Russell was the editorial coordinator for this book, which means she had the daunting job of ensuring that all of the myriad tasks were tracked and accomplished. Amanda brought to this job an amazing combination of poise and ability.

Sandhya Gola was our project manager, and once the manuscript was written, took charge of managing the overall copyedit process and the production of the book. I'd like to thank Sandhya for her competent work on the project; I enjoyed working with her!

I'd like to also thank Lisa McCoy, who copyedited the entire book. I really appreciate Lisa's deft improvements to the text of the book.

Finally, Steve Langford was the technical editor of the edition of this book. I've known Steve for many years, originally when we were colleagues and Steve was the network administrator for a fairly complex network. I'm grateful to Steve that he was willing to take on this job.

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Introduction

I've run into many people over the years who have gained good—even impressive—working knowledge of PCs, operating systems, applications, and common problems and solutions. Many of these people are wizards with desktop computers. Quite a few of them have been unable to make the transition into working with networks, however, and they have had trouble gaining the requisite knowledge to conceptualize, understand, install, administer, and troubleshoot networks. In many cases, this inability limits their career growth because most companies believe networking experience is fundamental to holding higher-level information technology (IT) positions. And, in fact, networking experience *is* very important.

Certainly, networks can be complicated beasts to learn about. To add to the difficulty, most companies aren't willing to let people unskilled with networks experiment and learn about them using the company's production network! This leaves the networking beginner in the difficult position of having to learn about networks by

- Reading an endless number of books and articles
- Attending classes
- Building small experimental networks at home, using cobbled-together and/or borrowed parts and software

This book is designed for people who understand computers and the rudiments of computer science, but who want to begin an education about networks and networking. I assume you understand and are comfortable with the following topics:

- How bits and bytes work
- The notion of binary, octal, decimal, and hexadecimal notation
- How basic PC hardware works, and how to install and replace PC peripheral components
- Two or three desktop operating systems in detail, such as Windows, Mac OS, Linux, or Unix
- Detailed knowledge of a wide variety of application software

The purpose of this book is both to educate and familiarize. The first part of the book discusses basic networking technology and hardware. Its purpose is to help you understand the basic components of networking so you can build a conceptual framework into which you can fit knowledge that is more detailed in your chosen area of expertise. The second part of the book is concerned with familiarizing you with two important network operating systems: Windows Server 2012 and Oracle Linux. In the second part, you learn the basics of setting up and administering these network operating systems, as well as about virtualization.

This book is meant to be a springboard from which you can start pursuing more detailed knowledge in the areas that interest you. Following are some areas that you may wish to continue exploring, depending on your career goals:

- **Small-to-medium network administrator** If you plan on building and administering networks with 200 or fewer users, you should extend your knowledge by studying the network operating systems you intend to use, server hardware, client PC administration, and network management. You may find more detailed knowledge of network hardware, like routers, bridges, gateways, switches, and the like, to be useful, but these may not be an important focus for you.
- **Large network administrator** If you plan on working with networks with more than 200 users, then you need to pursue detailed knowledge about TCP/IP addressing and routing and network hardware, including routers, bridges, gateways, switches, and firewalls. Also, in large networks, administrators tend to specialize in certain areas, so you should consider several areas of particular specialization, such as e-mail servers like Microsoft Exchange, or database servers like Oracle or SQL Server.
- **Internet administrator** Many people these days are pursuing specialization in Internet-based technologies. Depending on what area you want to work in, you should learn more about web and FTP servers, HTTP and other application-level Internet protocols, CGI and other web scripting technologies, HTML design, and SMTP mail connections. You may also want to become an expert in TCP/IP and all its related protocols, addressing rules, and routing techniques.

- **End-user support** If your primary job is supporting end users, perhaps with application or client computer support, you may still benefit from a deeper understanding of networking. Client computer applications usually interact with the network, and understanding networks will undoubtedly help you be more effective.

TIP If you're working toward getting a job in the field of networking, find job postings on the Internet and carefully study the job requirements. This can be a useful technique to direct your studies appropriately. When you do this, you will notice that for their most important jobs, most employers ask for people who are certified by Microsoft, Cisco, or other companies. You should seriously consider pursuing an appropriate certification. While certifications can never replace experience, they are one way that a person can demonstrate a needed level of knowledge and expertise in a particular area. This difference may be key in getting the best possible job offers and in being able to gain more experience. Often, an appropriate certification can be worth several years' experience in terms of compensation and job responsibilities, so it's an investment in yourself that will usually pay for itself over a fairly short period of time.

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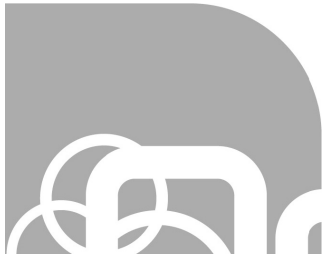
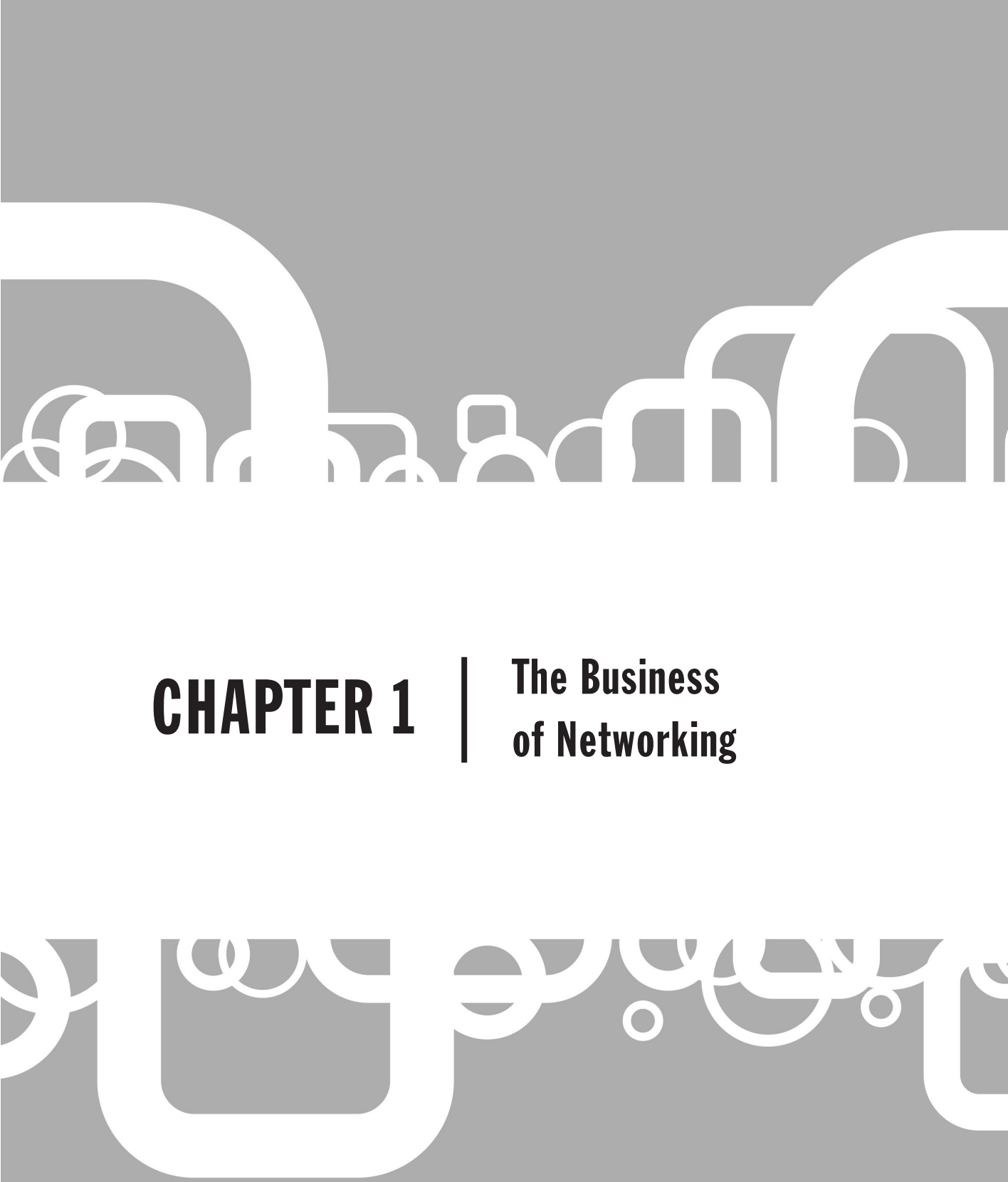
PART I | Networking Ins and Outs





CHAPTER 1 | The Business of Networking

This book is a soup-to-nuts beginner's guide to networking. Before delving into the bits and bytes of networking, which are covered in the rest of the book, you should start by understanding the whys and wherefores of networking.

This chapter discusses networking from a business perspective. You'll learn about the benefits that networking brings a company and the different types of networking jobs available. You'll also discover how networks are supported from the business perspective, and how you can begin a career in networking. Finally, you'll learn about the Sarbanes-Oxley Act of 2002 and how its requirements affect networking professionals.

Understanding Networking: The Corporate Perspective

To be truly effective in the field of networking, you need to start by understanding networking from the corporate perspective. Why are networks important to companies? What do they accomplish for the company? How can networking professionals more clearly meet the needs of the company with the networks that they build and maintain? It's important to realize that there are no single correct answers to these questions. Every company will have different needs and expectations with regard to their network. What is important is that you learn the relevant questions to ask about networking for your company and arrive at the best possible answers to those questions for your particular company. Doing so will ensure that the company's network best meets its needs.

What Does the Company Need?

There are many possible reasons that a company might need or benefit from a network. In order to understand your particular company, you should start by exploring the following questions. You may need to ask a variety of different people in the company their perspective on these questions. Some of the managers that you may need to interview include the chief executive officer or owner, the chief financial officer, and the heads of the various key departments within the company, such as manufacturing, sales and marketing, accounting, purchasing and materials, retail operations, and so forth. The range of managers that you interview will depend on the type of business in which the company is engaged.

It's important that you first start by understanding the business itself and the business-oriented perspectives of these different individuals and the people in their departments. Consider the following questions for each of these key areas of the organization:

- What is their function for the company?
- How do their objectives tie into the company objectives?
- What are the key goals for their function in the coming year? How about in the coming five years?
- What do they see as the chief challenges to overcome in achieving their objectives?

- How might information technology (IT) play a role in supporting their objectives?
- What sorts of automation do they think might help them accomplish their objectives?
- How is the work in their area accomplished? For instance, do most of the employees do mechanical work, like on a production line, or are most of them so-called "knowledge workers" who generate documents, analyze information, and so forth?
- What are the key inputs for the functional area in terms of information or materials, and what are the key outputs for the functional area? What processes convert the inputs into the outputs?
- Does the current performance of the network meet their needs? If not, how does it affect them? What level of improved performance is needed, and what benefits will accrue to the company as a whole by addressing them?
- Do the capabilities of the existing network meet their needs? If not, what capabilities are needed, and how will adding those capabilities benefit their functional area and the company?

Your objective in asking these questions, and others that may occur to you, is to get a good understanding of each functional area: what it does and how it does it, as well as what it wants to be able to do in the future. With this knowledge, you can then start to analyze the impact that the network—or improvements to the existing network—might have in those various areas.

Beginning from a business perspective is absolutely essential. Networks are not built and improved "just because." Instead, any particular network or network upgrade needs to be driven by the needs of the business. Justifications for networks or improvements to existing networks should clearly show how they are necessary to the proper functioning of the business or how they will play an important role in the company achieving its objectives, consistent with the cost and effort involved.

How Will the Network Benefit the Company?

After getting a good understanding of the company, its objectives, and how it accomplishes its work, you can then analyze different ideas that you may have for the network and how those ideas will benefit some or all parts of the business. In doing so, you need to consider at least the following areas:

- Are there any areas in which the lack of a network, or some failing of the existing network, is inhibiting the company from realizing its goals or accomplishing its work? For example, if an existing network is undersized and this causes people to waste too much time on routine tasks (such as saving or sending files, transacting in the system, or getting information from the system), what improvements might address those shortcomings? Or maybe the network and its servers are unreliable, and so people are frequently losing their work or are unproductive while problems are addressed.

- Are there capabilities that you could add to the network that would provide benefits to the business? For example, if many people in the company are constantly sending faxes (for instance, salespeople sending price quotations to customers), would adding a network-based fax system produce significant productivity benefits? What about other network-based applications? (Chapter 2 lists some common network features that you may want to review to help in answering this question.)
- What other automation plans exist that will require the support of the network? For example, say you're the network administrator in a company. What new applications or features will be added to the network that you need to support? Is the company planning on installing some kind of videoconferencing system, for instance? If so, do you know what changes you will need to make to the network to support the system?
- What needs to be done to the network simply to maintain it? In most companies, file space requirements grow rapidly, even if the business itself isn't expanding. How much additional storage space does the network need to keep going forward? How many additional servers and other components will be needed to keep the network working smoothly?

Obviously, a list such as the preceding one can't be exhaustive. The important point is that you need to approach the job of networking first from the perspective of the company and its needs. Within that framework, use your creativity, knowledge, experience, and business and technical acumen to propose and execute a plan for the network. The remainder of this book discusses the information you need to start learning about this important part of any company's infrastructure.

Understanding Networking Jobs

If you're planning on entering the field of networking (and this book is designed as a good start for that), it's important to have some understanding of the various networking jobs that you're likely to encounter and what they typically require. Of course, actual job requirements will vary widely between companies and for different established networks. Also, companies may have different entry-level opportunities through which you can enter a networking career. That said, the following descriptions are broad overviews of some key jobs.

Network Administrator

Network administrators are responsible for the operations of a network or, in larger companies, for the operations of key parts of the network. In a smaller company that has only one network administrator, duties include the following:

- Creating, maintaining, and removing user accounts
- Ensuring that necessary backups are made on a regular basis

- Managing the "keys" to the network, such as the administrative accounts and their passwords
- Managing network security policies
- Adding new networking equipment, such as servers, routers, hubs, and switches, and managing that equipment
- Monitoring the network, its hardware, and its software for potential problems and for utilization levels for planning network upgrades
- Troubleshooting network problems

In larger firms, individual jobs may cover just one or two of the aforementioned bullets. In these cases, the level of expertise in that more narrow set of responsibilities would be expected to be much higher.

Network administrators may also be called system administrators, local area network (LAN) administrators, and other variations on that theme.

Typically, you should have several years' experience performing network-related duties with a similar network for this job. Certifications such as the Microsoft Certified Solutions Associate/Expert/Master (MCSA/MCSE/MCSM), one of the appropriate Cisco certifications, or one of the appropriate CompTIA certifications can reduce the amount of experience that an employer will require. Employers usually consider these certifications important because they clearly establish that a candidate meets minimum requirements for the networking system in question.

TIP The Computing Technology Industry Association (CompTIA) offers a number of different vendor-neutral certifications that can help you enter the field of networking. You can learn more about them at http://certification.comptia.org/.

Network Engineer

Network engineers are more deeply involved in the bits and bytes of a network. They are expected to be expert in the network operating systems with which they work, especially in the network's key hardware, such as its hubs, routers, switches, and so forth. Network engineers are also usually the troubleshooters of last resort, who are brought in to diagnose and fix the most vexing problems that surpass the ability of the network administrator to resolve.

Aside from often holding a degree in electrical engineering or computer science, network engineers typically have at least five years' experience running and troubleshooting complex networks. Also, network engineers typically carry certifications from networking equipment companies, such as Cisco's well-regarded certification program.

TIP Learn more about Cisco's certification programs at http://www.cisco.com.

Network Architect/Designer

Network architects (sometimes also called network designers) usually work for companies that sell and support networks or for organizations with large networks that are constantly changing and expanding. Essentially, network architects design networks. They need to combine important qualities to be successful. They must know the business requirements that the network needs to meet and have a thorough *current* understanding of all of the networking products available, as well as how those products interact. Network architects are also important when growing a sophisticated network and helping to ensure that new additions to the network don't cause problems elsewhere in the network.

Other Network-Related Jobs

There are a wide variety of other network-related jobs, including some that do not involve working directly with the network, such as the job of database administrator. Organizations employ e-mail administrators, webmasters, web designers, network support technicians, and so on. In fact, a dizzying number of different jobs are available in the networking field.

If you've chosen to enter the field of networking, it would make sense to spend time browsing job ads for the various networking jobs and to get a sense of what these different types of jobs require. Once you find one that reflects your interests, you can then analyze what additional skills, classes, or certifications you may need to enter one of those jobs. Many opportunities are available. The important thing is to get started and pursue your objectives.

Sarbanes-Oxley Act of 2002

You may be wondering what a law that was passed by the U.S. Congress has to do with the field of networking and why it's discussed in this book. The reason is that this law has an important impact on the networks of all public companies, and so it's important for you to understand what all the fuss is about.

The Sarbanes-Oxley Act of 2002 (usually referred to as SOX, pronounced "socks") was an act sponsored by Senator Sarbanes and Representative Oxley in response to the many cases of corporate wrongdoing that preceded it, such as Enron, Global Crossing, Arthur Andersen, Tyco, and others. The act makes sweeping changes to a number of areas of corporate governance and accounting. One change in particular is likely to impact most networking professionals, especially those involved in day-to-day network operations, such as network administrators.

Section 404 of the act places new requirements on public companies to annually assess their system of internal controls, and on their outside auditors to examine the company's internal controls and to attest to the effectiveness of the company's internal controls over the company's use and reporting of financial information. This may sound like a requirement that pertains only to accounting departments, and in fact, it mostly does. However, accounting internal controls rely heavily on network system

controls—in particular, those system controls that impact important systems the company uses for managing and reporting financial information.

Generally, outside auditors classify company systems as being either within the scope of their audit ("in scope") or outside the scope of their audit. Systems that are in scope include the company's accounting system, payroll system, stock administration system, materials management system, shipping system, billing system, banking system, and so forth. The computers and all related hardware and software that perform those functions or host or run the software that performs those functions are also in scope. In addition, other network operations that support those systems may be in scope, such as the network-wide password settings, backup and restore procedures, new and terminated user account management, and so forth.

Accordingly, network administrators for publicly traded companies will need to work closely with their accounting departments to comply with the SOX 404 requirements on an ongoing basis. Doing so will include activities such as the following:

- Documentation of all user account creation, maintenance, and deactivation activities, including appropriate sign-offs for new, changed, and terminated users of in-scope systems
- Creation of a change-control system for any systems that the company modifies from time to time, such as an accounting system for which the company uses custom-developed reports or processing programs
- Documentation of the security settings of the network
- Documentation of the security settings and user account and password management of the in-scope systems
- Documentation of routine maintenance activities for in-scope systems
- Collaboration with the accounting staff and the auditors to prove that all of the controls that are in place are being followed, without exceptions
- Creation and maintenance of systems (even manual procedural systems) to detect unauthorized changes to any in-scope systems

Obviously, a book about networking cannot fully address all of the factors involved in Sarbanes-Oxley compliance. You should, however, have a general idea of what it is and what is involved. The accounting professionals charged with this important requirement will have more detailed information about the exact steps required for your company.

Chapter Summary

Many people I've met who work in some area of information technology, such as networking, don't consider the business reasons for the network when they go about their day-to-day jobs or when they propose improvements to the network. This certainly isn't limited to the field of networking; many people who work in any area of a company