TROUBLESHOOTING WINDOWS 2000 TCP/IP

"This book is an important ally in keeping your Windows 2000 TCP/IP network running smoothly."

—Excerpt from Foreword by Ted Rohling, Chief Technical Officer Decision Networks, Inc.

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Warmest regards,

Duncan Anderson

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Foreword

When facing a new operating environment such as Windows 2000, resources such as this book are essential to your success. Here you will find all the information you need to understand the new TCP/IP administration tools available in the Windows 2000 environment. Rather than looking through countless CDs and volumes of documentation, you can look here. You will find the helpful hints you need to locate and troubleshoot the problems you will inevitably face. Experience and knowledge work together to help you do your job. This book is an important ally in keeping your Windows 2000 TCP/IP network running smoothly.

Our success as network analysts is often judged by our ability to find and fix problems. In the past, the process was often a hit-or-miss proposition made worse by difficult-to-use vendor documentation. I have spent countless hours with co-workers just trying to find clues to the nature of a problem because not enough good information was available. Hopefully this book will save you from the hit-or-miss approach, immediately increasing your value as a Windows 2000 network analyst. Read, highlight, dog-ear, tab, use sticky notes; in short, make the book yours!

—Ted Rohling, MCP, CCNA, CCDA

Mr. Rohling is the Chief Technical Officer of Decision Networks, Inc., a computer networks consulting and training company in San Antonio, Texas. Ted has over 33 years of experience in the computer and networking field.

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Preface and Acknowledgements

There are few people today who "don't do Windows." The Microsoft operating systems – Windows 3.x, Windows 95, Windows 98, Windows NT – have populated the desktops of millions. And over the last several years, Windows NT 4.0 has gained a large and increasing portion of the server market with almost 40 million installations throughout the world. At the same time, the popularity of networking in general and Internet connectivity in particular has increased exponentially. Now, with the release of Windows 2000, networking and internetworking have come into their own. And the default local area network (LAN) protocol for Windows 2000 is TCP/IP, which not coincidentally, is the protocol stack on which the global Internet is built.

Many books have been written about TCP/IP, and there will be many written about Windows 2000. We have worked with both for a long time and find them to be a very stable combination. TCP/IP was originally designed with reliability as a first priority, and the Windows 2000 operating system is, by far, the most reliable and robust Microsoft operating system ever released. Even so, the sheer complexity of both means problems will occur from time to time. This book was written for those times.

We have not attempted to make this book an all-encompassing guide to Windows 2000 or the TCP/IP protocol suite. What we *have* attempted to do is provide a foundation of useful information for network administrators and others responsible for setting up and maintaining a Windows 2000 TCP/IP network. That means this book is for you. Virtually all networks will run TCP/IP as their primary transport protocol due to the need to connect to the Internet. We have included some background on how TCP/IP communications work, as well as the specifics of Microsoft's implementation of the protocols in Windows 2000, but our focus is on what can go wrong, and how to fix it when it does.

This book is not a regurgitation of the Microsoft documentation and Internet Requests For Comments (RFCs), although we refer to those resources on occasion. Much of the information is based on our own experiences in working with TCP/IP in Windows 2000, both in the classroom/lab and in the field. We have also drawn on the experiences of fellow consultants and instructors who, like us, have been working with Windows 2000 since the early beta versions.

Microsoft has provided a tremendous amount of documentation: comprehensive articles in TechNet, Help Files that (unlike in earlier versions) actually help, and numerous white papers and Knowledge Base entries. Even so, there are a number of "little things," tips and tricks and required ways of doing things that aren't fully and/or clearly documented. We have included a liberal sprinkling of notes, tips and warnings throughout the text to advise you of those little stumbling blocks and to document the

"Eureka!" moments we experienced in learning to work with—and love—the new operating system.

Another thing this book is not is a study guide. Although we both teach Microsoft certification classes and have written other books aimed specifically at those seeking their MCP or MCSE, the primary audience for this book is the administrator running Windows 2000 who needs help with TCP/IP-related problems now, not in theory, but in fact. On the other hand, in order to make the material relevant to new administrators as well as those with many years of experience, we have provided a fair amount of explanatory information, analogies, and anecdotes that might be helpful in some aspects of studying for the Windows 2000 exams.

Troubleshooting Windows 2000 TCP/IP was not just another tech writing project for us. It started out as a challenge and an opportunity. The challenge was to adequately cover a very complex and technical topic that has been addressed by many before us, some of whom have been recognized experts in the field for decades. The opportunity was to take material that is complex and technical, and present it in a way that is understandable, useful, and maybe even at times enjoyable to read. That became our goal, the one that turned this project into a true labor of love.

This book would not have been possible without the help and support of a large number of people, and we would like to recognize them here. First, we both want to thank everyone at Syngress, especially Matt Pedersen, who believed in our ability and gave us this chance, and Julie Smalley, who suffered with us each step of the way.

Deb particularly wants to thank Neal Wilson at Eastfield College, who encouraged her to expand her horizons and leave the nest when the time came; her children, Kris and Kristen, who always made it easier to accomplish great things in other areas of life because she could count on her great kids to be there; her mom, Sue Harris; and, posthumously, her dad, Tommie Harris, who she misses every day. Tom especially wants to thank his own mom, Eleanora Shinder, and his brothers Rich and Dee, along with fellow Microsoft professionals Jim Truscott and Doyal Alexander, whose experiences contributed to this book. Both of us want to extend a special thank you to Thomas Lee, our tech writing role model, and to Brian Miller, who made our first time fun instead of painful.

Most of all, we want to thank each other. The writing and tech editing of this book was a partnership effort, like our marriage. We argued some of the fine points, nit-picked one another's wording, questioned each other's facts and conclusions, and in so doing, made this a better book. We worked together, struggled together to meet the deadlines, shared the frustrations and the profound gratification, and now celebrate together the birth of this "baby." We look forward to doing it again.

Debra Littlejohn Shinder
Dr. Thomas W. Shinder

Chapter 1

TCP/IP Overview

Solutions in this chapter:

- **History of TCP/IP (ARPAnet); The Future of TCP/IP (IPv6)**
- **The TCP/IP Protocol Suite**
- **The OSI, DoD, and Windows Networking Models**
- **Basic Network Design Issues**

Introduction

The Transmission Control Protocol/Internet Protocol (also referred to as the TCP/IP protocol stack, or just plain TCP/IP) is a familiar—if poorly understood—networking component to most modern network administrators and Information Technology (IT) professionals.

If you work in any but the smallest networked environment, chances are you've encountered TCP/IP. However, it wasn't always that way. Just a few short years ago, TCP/IP was regarded as a somewhat sluggish, difficult-to-configure protocol used primarily by university or government networks participating in an exotic wide area networking project called ARPAnet. It was considered too slow and complex to be an appropriate choice for most private organizations' local area networks (LANs).

Microsoft and IBM workgroups ran fine on NetBEUI, a fast and simple transport protocol that could be set up easily and quickly by someone without a great deal of expertise. Novell NetWare LANs used the IPX/SPX stack, which was routable and thus could be used with larger server-based networks. Few business networks had any need for a powerful but high-overhead set of protocols like TCP/IP.

Then something happened: the Internet.

NOTE

Administrators and users may also be familiar with the higher-level protocols used on the Internet, such as File Transfer Protocol (FTP), Hypertext Transfer Protocol (HTTP), and Telnet. These, along with other protocols, are often packaged with TCP/IP as part of the "suite."

TCP/IP's "Net" Worth

The obscure worldwide network of networks had formerly been used by only a handful of elite groups until it was discovered by the corporate world—and then by individual computer users. An online population explosion erupted. Everyone rushed to get connected to the global Net, and TCP/IP, on which it was based, catapulted to the top of the protocol popularity polls.

There have been occasional attempts to usurp its position at the top. The Open Systems Interconnection protocol suite, based on the famous (or infamous) seven-layer OSI networking model, was conceived with the idea of unseating the incumbent and replacing TCP/IP as a universal standard for internetworking communications. In fact, in the late 1980s

the U.S. government, which had played an important part in creating and developing TCP/IP, made plans to phase it out in favor of the OSI suite. It didn't quite work out that way. TCP/IP turned out to be the protocol stack that refused to go quietly into that good night.

NOTE

Request for Comments (RFC) 1180, available on the Web, provides an authoritative tutorial on the TCP/IP protocol suite.

In fact, TCP/IP has flourished. It is available as a standard protocol included with all Windows operating systems and is installed by default in Windows 2000.

NOTE

Although TCP/IP is a "universal" protocol stack, which allows communication between machines running different operating systems or even running on different platforms, be aware that different vendors' implementations of the protocols may differ slightly. This book focuses on Microsoft's implementation of TCP/IP in Windows 2000, although we also discuss interoperability with NetWare and UNIX networks.

UNIX machines, the original cornerstones of Internet communication, have been running on TCP/IP since the early days of its development, and TCP/IP support is a part of every popular Linux distribution. Apple Macintosh computers and IBM's AS/400 machines use TCP/IP. Even NetWare, long a holdout for its Internet Packet Exchange/Sequenced Packet Exchange (IPX/SPX) stack, has finally come over to the TCP/IP camp; NetWare 5 is the first version designed to run on "pure" IP.

On the other hand, as you scroll through the list of protocols that can be installed from the Windows 2000, NT, or 9*x* CD-ROM, you won't see "OSI protocol suite" among them. The OSI model is an accepted standard for networking implementation, and the OSI suite mapped to the model more elegantly than other protocol sets already in use, However, TCP/IP was too firmly engrained to be easily dethroned as king of the internetworking world.

It was as if someone announced that he had discovered a replacement for dirt and suggested that we uproot all the trees and plants and then "reinstall" them in the new, superior substance. Restructuring the huge,

sprawling global Internet to plant it in a different protocol environment—regardless of any advantages that new environment might offer—is just too overwhelming an undertaking.

TCP/IP may have to adapt as computer communications continue to evolve (the expected transition to IPv6 is one example), but it is likely to be around for some time to come.

More Power, More Flexibility—and More Potential for Problems

TCP/IP had to be good to survive the challenges and attain the position it occupies today in computer networking, but that doesn't mean its implementation is always free of problems. On the contrary, the complexity that makes it so flexible and capable of connecting large, diverse networks also makes it prone to configuration errors and difficult to troubleshoot.

Luckily for network administrators, necessity being the mother of invention resulted in the development of many tools and utilities for troubleshooting TCP/IP connectivity problems. Many of these are free, and several are included as part of Windows 2000's implementation of the TCP/IP protocol suite.

Administrators of TCP/IP networks will also find the documentation of the TCP/IP protocol far more extensive than that for any other network/transport protocol. Because it is used on such a widespread basis, books, articles, courses, and Web resources for troubleshooting IP connectivity problems are plentiful.

What's Ahead in This Chapter

In this chapter, we will look at both the history and the future of the TCP/IP suite, to better help us understand what it is and how it works today. We'll examine in some depth the more generic OSI networking model and TCP/IP's own model, often referred to as the Department of Defense (DoD) model.

We will break down the components of the so-called "suite" of protocols that have taken up residence with the original TCP and IP stack. We'll also examine how common connectivity devices, such as repeaters, bridges, routers, and switches, are used to expand or segment TCP/IP networks.

Finally, we'll discuss some general guidelines for planning, testing, and implementing a big change such as the setup or migration of a Windows 2000 TCP/IP network. Just as a physician is better able to treat a sick patient if he knows the person's background, characteristics, and how the patient normally behaves when not ill, network administrators confronted with "sick" dysfunctioning networks will be at a big advantage if they know the network's "anatomy" or components well. The protocol on

which the network depends for communication is one of its most important "body parts." The objective of this chapter is to give you a detailed patient history and a quick review of TCP/IP physiology that will allow you to recognize symptoms, diagnose its illnesses, and select the most effective treatment. We know that a healthy network makes for a happy network administrator.

TCP/IP: Where It Came From, and Where It's Going

Acronyms abound in the computer industry, and network administrators may think of TCP/IP as just another collection of mysterious letters used to refer to some obscure concept whose name they've long forgotten.

If pressed, most could tell you that it's a protocol—and some even know that a protocol is a set of standardized rules for communicating. Maybe one or two could even tell you that the word comes from the Greek word *protocollon*, which referred to a leaf of paper glued to a manuscript volume that described the volume's contents.

But any basic networking text lists dozens or even hundreds of protocols: hardware protocols, routing protocols, remote access protocols, printing protocols, LAN and WAN protocols, encapsulation protocols. Why should we get all excited about TCP/IP? What makes it so special?

For the answer to that question, let's consider the origins of the TCP/IP protocol suite, and what it's used for today.

History of the TCP/IP Protocols

"The subject of history is the gradual realization of all that is practically necessary." (Friedrich Schlegel, 1772–1829, German philosopher).

Practical necessity is the driving force behind most important inventions and developments, and the need for a reliable set of communications protocols suitable for connecting large networks led to the creation of the TCP/IP stack.

In the 1960s, computer networking was in its infancy. The benefits of connecting computers together so they could share resources were only beginning to become apparent. The equipment was expensive, and products from different manufacturers were, for the most part, incompatible. Few business entities had the money or inclination to bother with creating local networks, much less attempt to get their computers to "talk" to distant systems.

The Role of the U.S. Department of Defense

The U.S. Department of Defense recognized the value of establishing electronic communications links between major military installations. (Grim as it may seem, a primary motivation was the desire to maintain communication capabilities in the event of the mass destruction that would come with nuclear war.) Major universities were also involved in networking projects. The DoD funded research sites throughout the United States, and in 1968, the Advanced Research Projects Agency (ARPA) contracted with a company called BNN to build a network based on *packet-switching* technology.

For IT Professionals

Tech Talk

Many people easily confuse the terms *packet switching* and *circuit switching*. Even experienced network administrators, if they haven't had much exposure to the conceptual and hardware sides of WAN technology, find them a little mysterious. They sound like the same thing, but they're not.

Circuit switching technology is something we use all the time, whether we're aware of it or not. The public telephone system (which is formally called PSTN, or Public Switched Telephone Network) is the more familiar example of switched-circuit communication. An end-to-end communication link is established when you place a telephone call, and that same physical path from one end (your telephone) to the other (Aunt Mary's telephone in Boise, Idaho, for example) is maintained for the duration of that call. The path is reserved until you break the connection by hanging up.

If you call Aunt Mary again next week, the pathway (also called the "circuit") used may be completely different. That's where the "switching" comes in, and that explains why sometimes when you talk to Aunt Mary, the connection is clear, while other times there's so much noise and static on the line that you have to ask her to repeat herself when she tells you whose quilt won first prize at this year's county fair.

Packet switching is different in that there is no dedicated pathway or circuit established. It is known as a "connectionless" technology for that reason. If you send data from your computer to your company's national headquarters in New York over a packet-switched

Continued

network, each individual packet, or chunk of data, can take a different physical route to get there. Most traffic sent across the Internet uses packet switching.

A type of digital packet switching network called X.25 can also support virtual circuits, in which a logical connection is established for two parties on a dedicated basis for a certain duration (a Permanent Virtual Circuit, or PVC, is an ongoing, dedicated logical connection, but the physical circuit can be shared by more than one logical connection).

In1969 the ARPAnet was born when its first *node*, or connection point, was installed at the University of California at Los Angeles. Within three years, the network had spread across the United States, and two years after that, to the European continent.

Remember that ARPAnet's original purpose was to provide a network capable of surviving a devastating war. This meant redundancy and reliability took precedence over other considerations (like data transmission speed). Consequently, the first links were slow by today's standards (56k leased lines).

NOTE

An excellent detailed history of the creation of ARPAnet and its evolution into today's Internet is available at the Web site of the international organization called the Internet Society (ISOC) at www.isoc.org/internet/history/brief.html.

It was important that the networking protocols be reliable and scalable to accommodate multiple redundant sites and anticipated growth (although no one at that time expected the rate of growth that was to come). Perhaps following the timeworn advice that "if you want it done right, you have to do it yourself," the developers of the ARPAnet designed a new group of protocols that fit the bill. Their first attempt was the Network Control Protocol, but it proved to be unsuitable as traffic increased. By the mid-1970s, necessity had mothered invention again, and the TCP/IP protocol suite was implemented.

From ARPAnet to the Internet

The "network" continued to grow in population and popularity. It eventually split into two parts, with the military calling its part of the

internetwork Milnet, with ARPAnet still being used to describe the network that connected research and university sites. In the 1980s, ARPAnet was replaced by the Defense Data Network (a separate military network) and NSFNet, a network of scientific and academic sites funded by the National Science Foundation.

In the 1990s, the global network (now called the Internet) went commercial in a big way. Corporations realized the advertising and marketing potential of a medium that spanned the whole world. Smaller businesses began to see the light—and the dollar signs—as well. Individuals wanted access to the vast amount of information (and entertainment) available on the World Wide Web. Internet Service Providers (ISPs) sprang up like weeds to satisfy the demand for connectivity.

NOTE

Estimates vary, but according to the Internet Software Consortium, by July 1999 there were over 50 million host computers connected to the Internet.

As the year 2000 begins, the impact of the Internet on the computer industry and on lifestyles in general is being felt across the planet. We have, to a large extent, networked the world. The Internet, still running on the TCP/IP protocol suite, has made it possible to do things that could not have been imagined by the average person just a decade ago.

School children have the equivalent of large libraries at their fingertips; business executives stay on top of what's going on at the office from thousands of miles away; telecommuters do a full day's work without ever leaving home. We can play the stock market via computer, do our banking online, or chat casually with close friends we've never met in places we might have never known existed except for the Net.

Few of those whose lives have been changed by the rapid development of computer networking technology realize that they owe it all (well, at least a lot of it) to TCP/IP.

Another Contender for the Title: The OSI Protocol Suite

The OSI protocol suite was intended to be TCP/IP's replacement. In fact, a few years ago, it was an accepted "fact" in many parts of the computer industry that the future of networking would be built on the OSI suite.

It seemed like a good idea at the time. The OSI suite consisted of a set of protocols that would map directly to the popular OSI networking model, and which would—at least in theory—make for less confusion and easier standardization of networking products among multiple vendors. The TCP/IP stack had been designed on the less finely tuned DoD networking model.

The OSI protocol suite was developed under the umbrella of a body called the ISO—making for an interesting conglomeration of initials. As if it weren't already confusing enough, the full official name of the ISO is the International Organization for Standardization, which would seem to call for an acronym of IOS (which would be further confused with Cisco's Internetworking Operating System, or IOS, used to command its fleet of routers). The organization is quick to point out that its short name—ISO—is not an acronym but a word, derived from the Greek *isos*, meaning "equal." The ISO is, according to its own accounts, a worldwide federation of national standards bodies from 130 countries whose stated mission is the promotion of the development of standardization and related activities throughout the world.

The ISO's role in establishing standards is not confined to the computer industry. For years, photographers have been familiar with the ISO film speed codes used by manufacturers of photographic film. The ISO, headquartered in Geneva, Switzerland, has been instrumental in developing standards for the format of telephone and banking cards, so that the cards can be used in different countries throughout the world. The international country and currency codes are another example of an ISO standard.

NOTE

For more information about the organizational structure and mission of the International Organization for Standardization (ISO), visit its Web site at www.iso.ch/.

The idea of a carefully planned and implemented new set of protocols for connecting to the global Internet that could be standardized throughout the world was an attractive proposition. A great deal of work went into development of the OSI protocol suite, hailed as the heir to the Internet protocol crown. But it turned out that the reports of TCP/IP's death had been greatly exaggerated.

Survival of the Fittest?

In the late 1980s, the Department of Defense decreed that by August 1990 all its computer communications would use OSI protocols, and the U.S. federal government formed a set of specifications called GOSIP (Government OSI Profile) that defined standards for these protocols. The federal government had, in effect, planned the death of the TCP/IP suite.

TCP/IP was now considered a temporary solution to the problem of providing reliable internetworking protocols. The new proposed Internet standards included X.400 (for e-mail) and X.500 (for directory services).

The computer industry was gearing up to make the transition, but not everyone welcomed the change. So in 1990, the ISO Development Environment (ISODE) was created. The ISODE software allowed OSI applications to run over TCP/IP. The TCP/IP suite was already in wide use and was not going away as planned, so it was decided that GOSIP would incorporate TCP and IP, loosening its original "only OSI protocols" requirements.

The current goals of OSI proponents seem to be less ambitious, now focused on a convergence of TCP and OSI Transport Protocol Class 4, which would support both OSI applications and applications from the Internet Protocol Suite. IPv6 (sometimes called IPng for IP "next generation") is expected to be the big protocol player at the IP layer.

The Future of TCP/IP

Although the TCP/IP suite has proven its endurance and is likely to be with us for a while, it will undoubtedly undergo some changes. For protocols, as for people, a long life usually requires the ability to adapt to changing conditions. As the Internet continues to grow, the most pressing need is a way to overcome the limitations of the current version of IP in terms of the number of IP addresses available.

At the time IP's 32-bit addressing scheme was designed, computers were still expensive devices used primarily by large companies. Many businesses were not yet computerized, and the idea of an individual owning a computer—much less setting up a home network—bordered on absurdity. It must have seemed that there would never be any danger of running out of addresses (and consequently, many usable addresses were "wasted" by the assignment method), but then at that time it was also inconceivable that computers would ever be as powerful and as inexpensive as they are today.

When it comes to making predictions about technological progress, the one constant has been a tendency to underestimate. After all, Thomas Watson, former chairman of IBM, is best remembered for the following statement, made in 1949: "I think there is a world market for maybe five computers."

Looking Ahead to IPv6

IPv6, or IPng (the "ng" stands for "next generation"), is the new version of the Internet Protocol (IP). The Internet Engineering Task Force (IETF) designed it as the next step up from IPv4. It builds on IPv4 and is a natural progression. It is compatible with IPv4, which is currently used on the Internet and other TCP/IP networks. The specific intent of IPv6 is to work efficiently in high-performance networks such as ATM (Asynchronous Transfer Mode), while still working efficiently over low-bandwidth networks (which would include many of the wireless technologies).