CHAPTER 1

THE DATA COMMUNICATIONS INDUSTRY

Concepts Introduced

- Interacting Components of the Data Communications Industry
- Regulatory Process
- Deregulation and Divestiture
- Standards-Making Process
- Top-Down Model
- Data Communications as a Profession
- Data Communications and Information Systems
- OSI Model
- Internet Suite of Protocols Model
- I-P-O Model
- Protocols and Compatibility
- Job Skills
- Career Opportunities

OBJECTIVES

Upon successful completion of this chapter, you should:

1. Understand today's data communications industry as a system of interacting components.
2. Understand the current state of the data communications industry as well as the major issues facing each of the industry's constituent components.
3. Understand the challenges and solutions to business oriented data communications analysis.
4. Understand the importance of structured models such as the top-down model, the OSI model, and the I-P-O model to successful business oriented data communications analysis.
5. Understand the relationship of network analysis and design to information systems analysis and design.
6. Understand career opportunities in data communications and the job skills required to succeed in this field.

INTRODUCTION

Data communications is a field of study and an industry in a most rapid state of change. This chapter familiarizes the reader with the current state of the data communications industry and introduces the reader to a series of models or thinking frameworks. These frameworks provide a mechanism to organize thoughts, facts, requirements, solutions, and technology to overcome the challenges faced by today's data communications professionals. By mastering these thinking models, the reader will be developing a business-oriented, technology-independent process for the analysis and design of data communications systems. These models are used extensively throughout the remainder of the text to further familiarize the reader with them.

To better appreciate the wonderful professional opportunities available in data communications, it is important to understand how network analysis relates to information systems analysis in general, as well as the types of skills required for success in this most exciting field.

THE BEST WAY TO APPROACH DATA COMMUNICATIONS

Since the field of data communications is in a state of constant change—some would even refer to it as chaos—how can you study data communications and keep your sanity? The primary points to remember are:

- You will never know all there is to know about data communications.
- Be honest with yourself concerning what you don't know.

If you can accept these laws as facts, you will be well on your way to survival in this most exciting and rewarding field.

What, then, can you expect to master in a one-semester course in data communications based on this textbook? After successful mastery of the material contained in this text, you should be able to:

- Hold an intelligent conversation on a variety of data communications topics.
- Analyze networking requirements, evaluate networking options, ask appropriate networking questions, and know where to seek answers to those questions.

Understand, however, that you will not necessarily possess all of the answers. Nor will you necessarily be qualified to design networks. However, you will possess enough information to ask the essential questions and to keep yourself from getting in over your head.

What Is Data Communications?

Data communications can be viewed as a foreign language. Just as the mastery of any foreign language requires practice in speaking and writing that language, so it is with data communications. As when learning a foreign language practice is a key factor for success. Try to speak the language as often as possible. Don't be afraid of making mistakes. Form informal study groups if possible and review key concepts by forcing yourself to speak data communications. You will be pleasantly surprised at the speed at which you become comfortable with this new language.

A classic definition of **data communications** might be “the encoded transmission of data via electrical, optical, or wireless means between computers or network processors.” Traditionally, data communications is viewed as a subset of **telecommunications,** which encompasses the transmission of voice, data, and video. Throughout the text we’ll see that the fields of telecommunications and data communications are becoming so intertwined that it’s difficult, if not impossible, to differentiate between them. Voice, video, image, and fax transmission all currently fall within the domain of the data communications analyst.

In truth, any functional definition is really just a goal or outcome of a much larger process of interacting system components collectively known as the data communications industry. By breaking down a system-oriented representation of the data communications industry into constituent components, interaction among components and the resultant state of the data communications industry can be more easily understood.

THE DATA COMMUNICATIONS INDUSTRY

To be an effective participant in the data communications industry, it is important to understand the industry forces at work behind the scenes. In this manner, enlightened professionals can be proactive in their decision making rather than being at the mercy of an industry that at times seems to be beyond reason and out of control.

Figure 1-1 shows one way of breaking the complex world of data communications into a group of interacting components. As can be seen from the diagram, data communications is the sum total of the interacting components outlined. There is no distinct beginning or end. No single component is more important than another.

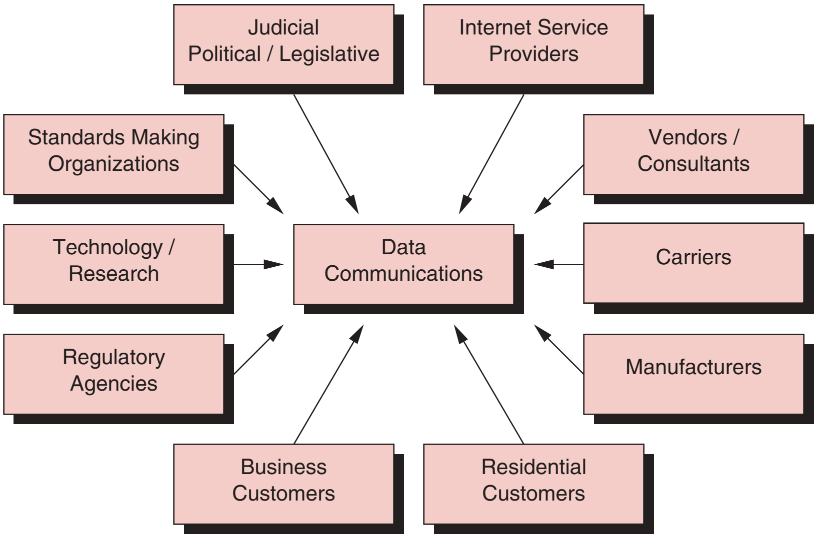


Figure 1-1 The Data Communications Industry: A Series of Interacting Components

The Regulatory Process

Two tightly dependent components in a constant and ongoing state of change are the **regulatory** and **carrier** components. The regulatory component represents local, state, and federal agencies charged with regulating telecommunications, while the carrier component represents companies such as telephone and cable TV companies that sell transmission services.

To fully understand these two important components of today's data communications environment, we must focus on their interaction, those forces that join them and influence their present status. This interaction is a rather formal process of a series of proposals, also known as tariffs. Tariffs are submitted to state and federal regulatory agencies by carriers, and rulings and approvals are issued in return. This relationship is illustrated in Figure 1-2.

Basic Telecommunications Infrastructure To understand the changing regulatory relationship between different phone companies and their associated regulatory agencies, it is important to understand the physical layout of a basic telecommunications infrastructure and the names of the interacting components and service boundaries contained therein. Figure 1-3 illustrates the major components of the **public switched telephone network (PSTN)** required to support long distance dial-up service for data communications.

Local access transport areas (LATA) were established as a result of the breakup of AT&T to segment long-distance traffic. Originally all phone traffic within a LATA (intra LATA traffic) was reserved for the local phone company, also known as a **local exchange carrier (LEC).** Although recent rulings and legislation have made the distinction between intra-LATA and inter-LATA calls less significant, the LATA structure is still important to the overall telecommunications architecture.

A LATA is sometimes, but not always, equivalent to the geographic region covered by a given area code. However, there can be several LATAs per area code. Another key difference between LATAs and area codes is that a LATA can cross state boundaries, but an area code cannot. Figure 1-4 illustrates both the area codes and LATAs for the state of Indiana.

Residences or businesses are connected to the PSTN via circuits known as **local loops.** Local loops run between the residence or business location and the local **central office (CO),** a facility belonging to the local phone company in which calls are switched to their proper destination. Any phone traffic destined for locations outside of the local LATA must be handed off to the long-distance or **inter-exchange carrier (IXC)** of the customer's choice. Competing long-distance carriers wishing to do business in a given LATA maintain a switching office in that LATA known as a **point of presence** or **POP.** This POP handles billing information and routes the call over the long-distance carrier's switched network to its POP in the destination's LATA. The

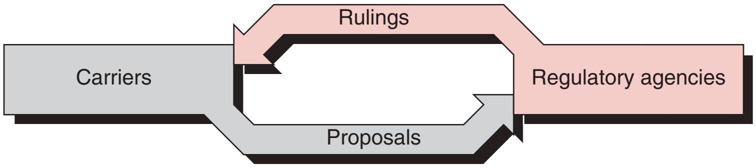


Figure 1-2 Systems Relationship of Regulatory Agencies and Carriers

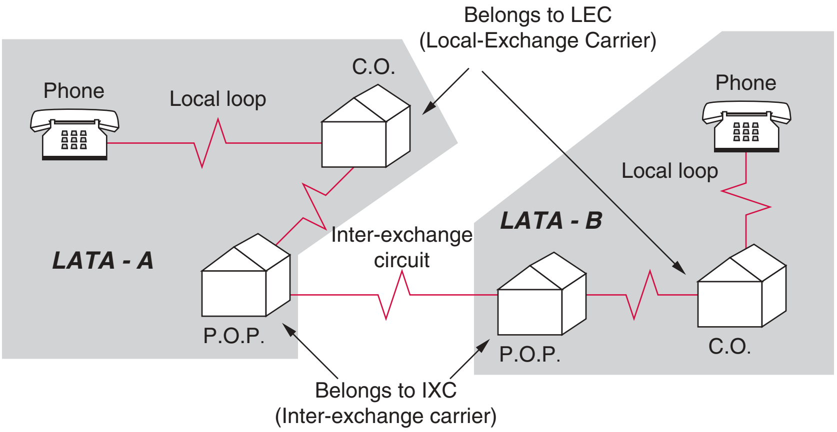


Figure 1-3 Basic Telecommunications Infrastructure

circuit between the POPs may be via satellite, microwave, fiber optic cable, traditional wiring, or some combination of these media. Depending on traffic levels on the long-distance carrier's network, calls may be routed through any combination of switches before reaching their final destination.

Deregulation and Divestiture: 1980s After one understands the overall interaction of carriers and regulatory agencies as well as the basic infrastructure of today's telecommunications industry, the historical aspects of this regulatory relationship must be explored to better understand how today's regulatory environment evolved. Today's competitive telecommunications industry in the United States is largely the

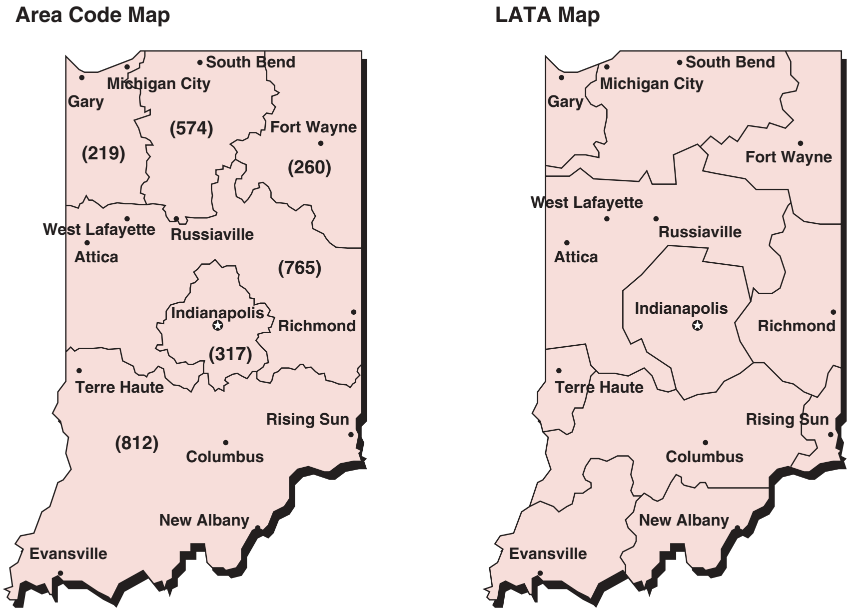


Figure 1-4 Area Codes vs. LATAs

result of rulings by the Justice Department in the early 1980s. These rulings are generally referred to as **deregulation** and **divestiture.** These two terms are related but not synonymous.

Before deregulation and divestiture, America's telecommunications needs (data and voice), (hardware and services) were supplied, with few exceptions, by a single vendor: AT&T (American Telephone and Telegraph). At that time, homeowners were not allowed to purchase and install their own phones. AT&T owned all equipment connected to the PSTN. Customers rented their phones from AT&T.

Local Bell operating companies provided local service but were still part of AT&T. All telephone service, both local and long distance, was coordinated through one telecommunications organization. Most indoor wiring was also the responsibility of AT&T, not the owner of the building in which the wiring existed. This top-to-bottom integration allowed for excellent coordination and interoperability. It was easy to know who to call for new service or a repair problem because installation and maintenance of hardware, as well as long-distance and local service for voice or data were all coordinated through one company. On the other hand, the total control of the telecommunications industry by one company severely limited customer choice. If you wanted a telephone, you became an AT&T customer. If you were not happy with AT&T's service or pricing, the only option was to terminate your service. This top-to-bottom control of the telecommunications industry was seen as a monopoly, especially by other vendors wishing to compete in the telecommunications industry.

The single company telecommunications industry model came to an end through deregulation and divestiture in the late 1970s and early 1980s. It is important to note that the initial divestiture and deregulation of the telecommunications industry was not the result of a purely regulatory process. This enormously important event was primarily a judicial process, fought out in the courtrooms and largely fostered by one man, Bill McGowan, former president of MCI.

Although the Federal Communications Committee (FCC), a federal regulatory agency, initially ruled in 1971 that MCI could compete with AT&T for long-distance service, it was McGowan's 1974 lawsuit that got the Justice Department involved and led to the actual breakup of the telecommunications monopoly in the United States. AT&T was declared a monopoly and broken into several smaller companies in a process known as divestiture as set forth by Federal Judge Harold Greene in the 1982 **Modified Final Judgment (MFJ).** By interpreting the MFJ, Judge Greene effectively controlled the U.S. telecommunications industry from the original ruling in 1982 until the Telecommunications Act of 1996 expressly ended his control.

Divestiture broke up the telephone network services of AT&T into separate long-distance and local service companies. AT&T would retain the right to offer long-distance services, while the former local Bell operating companies were grouped into new regional Bell operating companies **(RBOCs)** to offer local telecommunications service. Figure 1-5 illustrates the RBOCs and their constituent former Bell operating companies (BOCs) after divestiture through 1996.

Deregulation introduced an entirely different aspect of the telecommunications industry in the United States: the ability of "phone companies" in America to compete in an unrestricted manner in other industries such as the computer and information systems fields. Before deregulation, phone companies were either banned from doing business in other industries or were subject to having their profits and / or rates monitored or "regulated" in a fashion similar to the way in which their rates for phone service were regulated.

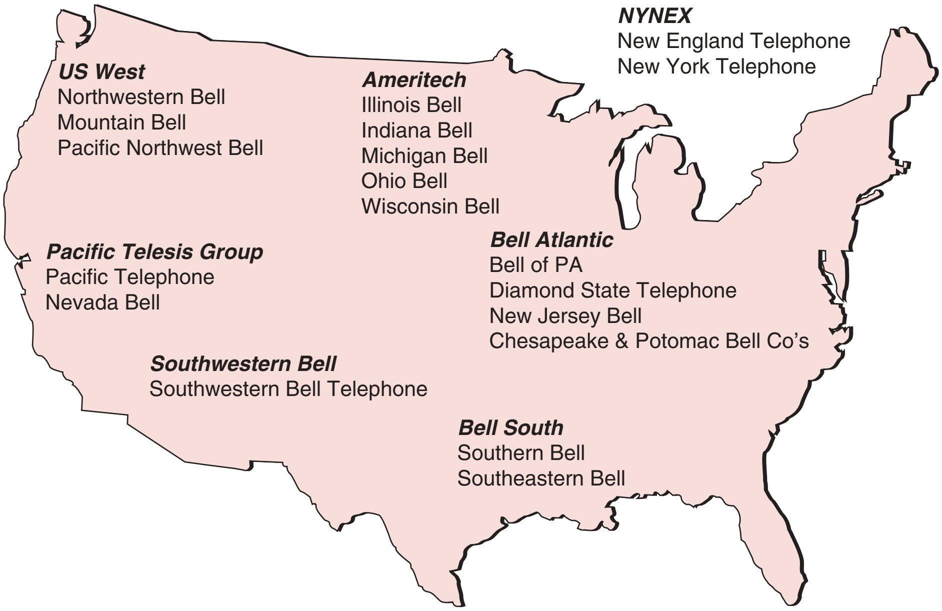


Figure 1-5 Post Divestiture / Pre-Telecommunications Act of 1996 RBOC and BOC Alignment

As a result of deregulation, both AT&T and the RBOCs were allowed to enter into other industries by forming additional subsidiaries. For the first time, phone companies were competing in a market-driven, customer-dictated economy. A common misconception about deregulation is that phone companies became totally deregulated and could charge whatever the market would bear for phone services. This is not the case. Phone companies today have both regulated and deregulated portions of their business, which are often segregated into separate companies.

Network services offered by phone companies are still regulated. New rate proposals from phone companies are filed as tariffs with state or federal regulatory authorities. Local service rate changes are filed on the state level with a particular state's Public Utilities Commission and on a federal level with the FCC for interstate service proposals and rate change requests. These commissions must balance objectives that are sometimes contradictory:

- Basic phone service must remain affordable enough that all residents of a state can afford it. This guarantee is sometimes known as **universal service** or **universal access.**
- Phone companies must remain profitable to be able to afford to constantly reinvest in upgrading their physical resources (hardware, cables, buildings) as well as in educating and training their human resources.

The divestiture and deregulation activities of the 1980s allowed competing long-distance carriers such as MCI and US Sprint to sell long-distance services on a level playing field with AT&T thanks to a ruling known as **equal access.** This means that all long-distance carriers must be treated equally by the local BOCs in terms of access to the local carrier switching equipment, and ultimately to their customers.

From the end-user's perspective, the divestiture and deregulation activities of the 1980s enabled freedom of choice for long-distance carriers. The competition for business and residential customers' long-distance business has forced down prices for long-distance service. On the other hand, the simplicity of ordering, installing, and maintaining services from one company was replaced by a series of services from multiple companies.

This loss of coordinated installation and troubleshooting is perhaps the biggest loss to telecommunications users as a result of deregulation and divestiture. Service problems can often result in finger-pointing between hardware vendors, local service carriers, and long distance carriers while the telecommunications users are left rather helplessly in the middle.

Deregulation, Divestiture, and Realignment: 1990s In September 1992, the FCC enacted additional rulings that enabled limited competition in the local loop. The competition was limited to leased or private lines that bypass the phone company's switching equipment. Before these rulings, only the RBOCs were allowed to transport calls from a residence or business to the local central office and ultimately to the point of presence of any of the long-distance carriers.

After this ruling, a company could use a leased line to transport voice and/or data between corporate locations on a 24 hr/day, 7 day/week basis. Leased lines have no dial tone. They are private, point-to-point, "pipes" into which customers can transport voice and data to only the predetermined ends of those pipes. The differences among all of the various switched and leased voice and data services are explored further in Chapters 3 and 7.

Through a mandated process known as **co-location,** RBOCs had to allow alternate local loop carriers to install their equipment in the RBOC's CO. In return, RBOCs were allowed to charge **access charges** for co-location of the alternate carrier's equipment in their COs. End-users could also co-locate networking equipment in the RBOC's CO. Businesses could now build their own virtual private networks by co-locating their own networking equipment in local phone company COs.

Remembering that this ruling only affected leased line traffic, only those businesses that had a need for point-to-point or multipoint leased lines, usually for data transmission, were likely to benefit from this ruling. However, this local loop leased line deregulation was but a shadow of things to come.

In 1995, AT&T reacted to a changing marketplace in an unusual manner. To free its various divisions to seek business opportunities without regard for the interests of other AT&T divisions, AT&T split into three separate companies. Whereas the divestiture of AT&T in the 1980s was vigorously fought by AT&T and eventually government-imposed, the trivestiture of AT&T in 1995 was self-imposed. The three companies are as follows:

- AT&T—The carrier services, wireless services, and half of Bell Labs retain the AT&T name.
- Lucent Technologies—Data, voice, and networking equipment and the other half of Bell Labs.
- NCR—Known as AT&T Global Information Solutions after the 1991 takeover, NCR is once again an independent computer manufacturer.

The Telecommunications Act of 1996 sought to encourage competition in all aspects and markets of telecommunications services including switched and dedicated local and inter-LATA traffic, cable TV, and wireless services such as paging, cellular, and satellite services. The legislation directs the FCC to produce the rules that will allow LECs and IXCs to compete in each other's markets. Companies that wish to offer local access service in competition with RBOCs are known as **competitive local exchange carriers (CLEC).**

Perhaps most importantly the law completely changed the regulatory environment of the telecommunications marketplace by expressly preempting the authority of Judge Greene to dictate the operation of the telecommunications industry in the United States. As a result of the act, the FCC has been given the task of establishing a fair and equitable market environment in which a variety of companies can compete in a deregulated manner. The goal of the Telecommunications Act of 1996 can be summarized in three words: *free market economy*. Figure 1-6 summarizes the major implications of the Telecommunications Act of 1996 from a variety of perspectives.

Managerial Perspective

TELECOMMUNICATIONS ACT OF 1996 IMPACT

In addition to its primary goal of creating competition in all aspects of the U.S. telecommunication market, the Telecommunications Act of 1996 has had several other effects on the various players in the marketplace. One of the most visible impacts is the merger and acquisition of telecommunications vendors in an attempt to gain competitive advantage. Because traditional long-distance carriers (IXCs) can potentially enter their marketplace, RBOCs have merged to increase territory size, capitalize major new ventures, and create a more formidable competitor for IXCs. The major RBOC realignments are as follows:

- NYNEX and Bell Atlantic combined as Bell Atlantic to control the northeast corridor region from Washington D.C. to Boston.
- Bell Atlantic and GTE combined operations to expand their service offerings under the Verizon brand name.
- PacTel (Pacific Telesis) and Southwestern Bell combined as SBC Communications to control telecommunications in the Texas to California high-tech region.
- SBC then merged with Ameritech to add a large section of the Midwest to their portfolio.

Similarly traditional long-distance companies are merging to consolidate market position and capitalize on research and development dollars. In addition to mergers within the long-distance company ranks, IXCs have merged with companies that cover other sectors of the telecommunications industry.

- European based WorldCom communications purchased UUNET, a leading Internet carrier.
- MCI merged with WorldCom to form MCI-WorldCom.
- America Online is currently trying to acquire Sprint.
- MCI-WorldCom acquired SkyTel, a leading two-way pager service provider.
- AT&T has acquired TCI cable systems to expand its presence in the cable television and high-speed Internet via cable marketplaces.
- Various IXCs are merging with or acquiring wireless carriers.

Perspective	**Implication/Importance**
Strategic Intent	• Provides for a procompetitive deregulatory national policy framework by opening all telecommunications markets to competition • Directs the FCC to create rulemakings to produce this deregulated environment
FCC	• Imposes a significant burden on the FCC to produce new rules so that the deregulated market operates fairly for all competitors • Examines all regulations imposed on carriers and eliminates any that no longer serve a productive purpose
IXCs	• Eliminates the need for long distance carriers to file tariffs. Rates are determined by competitive pricing and the free market • Can enter into local access markets, thereby gaining access to local loops on a national basis • Will likely resell access to RBOC's local networks rather than building their own
CLECs	• Gain access to RBOCs local loop markets • Will likely resell access to RBOC's local networks rather than building their own • Looking at wireless solutions as an alternative to using the RBOC's local loops
LECs	• Can compete for IXC business within their own region as long as they can prove there is at least potential for competition in the local loop • Can enter into equipment manufacturing businesses
Cable TV Companies	• Can enter telephone business but must wait until cable rates are deregulated
Users	• Will be offered more opportunities for bundled services from a single vendor • May regain single source for voice and data services lost in original divestiture / deregulation • Increased competition in a variety of markets may produce lower costs

Figure 1-6 Telecommunications Act of 1996

Although the resulting companies do not have the market position of the prebreakup AT&T, the market seems to be moving toward a scenario in which a few companies can offer all types of communications services from traditional telephony to wireless telephony, cable television, and Internet service. These companies, also known as **universal carriers,** hope that by bundling various services together, they can become a one-stop solution for all of their customers' communications needs.

One of the key aspects of the Telecommunications Act of 1996 was that it opened the door for competition in the local phone service market. However, progress in this area has proven to be slow. Some state regulatory agencies delayed the ability for CLECs to enter the market. In those states that have successfully allowed CLECs to compete, the mid-2003 market share of CLECs ranges from around 30% in Michigan to under 3% in New Mexico.

The main reason that CLECs are having trouble entering the local service marketplace is local loop access. A CLEC can deliver local telephone access in two ways: lease the existing loop from the incumbent local service provider or provide an alternate means of customer connection.

If the CLEC chooses to lease local loop access from the incumbent LEC, it is limited to a retailer's profit, as the Act ensures the incumbent LEC of a reasonable profit for maintaining the local loops by setting the cost of local loop access to wholesale levels. The economics of this model simply have not spawned much interest in local access competition. However, new wireless technologies are making the second option, providing an alternate connection to the customer, far more viable. By implementing fixed-point wireless solutions, a CLEC can offer customers not only multiple lines of local telephone service, but also high-speed Internet access. By combining these new technologies with traditional local loop service, CLECs are aggressively beginning to enter the local service marketplace.

Interestingly, this competition in the local service marketplace is welcomed by the incumbent LECs. According to the Act, LECs cannot enter the highly lucrative long-distance marketplace until they can show meaningful competition in the local service marketplace. In this case, the potential profit lost on local service (which is usually fixed) will be more than made up for in increased revenue from long-distance services.

Another key player in the industry that has been affected by the Act is the cable television (CATV) industry. The CATV industry has an inherent advantage over traditional local service providers: Its connection to the user natively provides significantly greater bandwidth than the traditional telephone local loop. This increased bandwidth allows multiple phone lines and high-speed Internet access to be bundled with traditional cable service.

Although they are well positioned from a cable plant basis to deliver service in the local market, most cable companies are poorly positioned economically to do so. Bearing large debt loads as a result of rapid expansion, CATV providers are too undercapitalized to make the required investment to upgrade their traditional one-way analog networks to support the two-way digital transmission required to deliver local telephone service. Besides the economic issue, CATV providers also lack expertise in switching environments to implement telephony over the cable infrastructure. These issues are currently driving multiple mergers and partnerships between CATV companies and traditional long-distance carriers. The combined companies can offer bundled local and long-distance service along with television and Internet access.

The importance of the Internet and the ability to offer high-speed Internet access to telephone service providers cannot be overstated. New technologies such as Voice Over IP (VOIP) have the potential to replace traditional circuit-switched telephone technologies with packet-switched voice. The impact of such a shift will likely be more dramatic on the telecommunications industry than all legislative and regulatory rulings combined.

Due to the distance insensitivity of packet-switched Internet telephone technologies, the concept of pay per minute long distance could become obsolete. Instead it might soon be possible to pay a monthly fee for access to long-distance network and make an unlimited number of calls to anywhere in the world for no additional charge. Several IXCs including MCI and AT&T are experimenting with using Internet technologies in the core of their network between POPs to leverage the distance insensitivity of packet-switched voice.

The ability of Internet telephony to compete with traditional telephone networks may ultimately depend as much on the regulatory environment as it does on the quality and reliability of the technology. It remains to be seen what influence, if any, the FCC will have on packet-switched Internet telephony. Recent rulings are inconclusive because the FCC has expressed concern about the impact of such technologies on universal access, but has yet to place any new barriers to their implementation.

The Standards Process

While the regulatory process is most important to carriers and their customers, the standards process is important to all constituencies of the data communications industry. Without standards, data communications would be nearly impossible, as single-vendor, customized transmission solutions would probably be the only way to achieve end-to-end transmissions. **Standards** allow multiple vendors to manufacture competing products that work together effectively. End-users can be confident that devices will operate as specified and will interoperate successfully. Standards can have a tremendous potential economic impact on vendors of data communications equipment, and the standards-making process is affected by both political and financial influences.

Although the charter of each standards-making organization dictates the exact procedure for standards development, the process can be generalized as follows:

1. Recognition of the need for a standard
2. Formation of some type of committee or task force
3. Information / recommendation gathering phase
4. Tentative / alternative standards issued
5. Feedback on tentative / alternative standards
6. Final standards issued
7. Compliance with final standards

Standards-Making Organizations Standards-making organizations for the data communications industry fall into two major categories:

- Officially sanctioned
- Ad hoc

Some of the most significant officially sanctioned standards-making organizations, whose standards are referred to throughout the book, are listed in Figure 1-7.

Because of the lag time often required to produce standards in an officially sanctioned standards-making organization, or perhaps in response to the ever-broadening scope of data communications-related technology, many ad hoc standards-making organizations continue to be formed. Known by a variety of terms including *task forces, user groups, interest groups, consortium, forum, alliances,* or

Organization Name	Abbreviation	Authority/Charter	Mission/Contribution
International Organization for Standardization	ISO	International; voluntary	OSI 7 layer model
Comite Consultif International Telegraphique et Telephonique	CCITT	International; U.N. chartered	Telecommunications standards
International Telecommunications Union	ITU-T	International; U.N. chartered	Parent organization and successor to CCITT
American National Standards Institute	ANSI	U.S. government representative to ISO	Information systems standards
Institute of Electrical and Electronics Engineers	IEEE	Industrial professional society	Local area network standards
Internet Engineering Task Force	IETF	International, open	Design protocol and other standards for the Internet
Internet Architecture Board	IAB	International, open	Oversees the standards process for Internet standards as developed by the IETF
Internet Society	ISOC	International, open	Parent organization of the IETF and IAB
Electronics Industries Association	EIA	Trade organization	Electrical signaling standards, wiring standards

Figure 1-7 Officially Sanctioned Standards-Making Organizations

institutes, these groups have developed standards for specific areas of the data communications industry.

Although these ad hoc organizations are able to produce standards faster, in most cases, than official standards-making organizations, their existence and operation pose a few potential problems. Vendor-initiated ad hoc standards-making organizations are occasionally organized into opposing camps, with users left as victims caught between multiple standards for a single item. These vendor-driven consortia do not necessarily have the best interests of end-users as their highest priority. Some ad hoc standards groups do not produce final standards, but rather seek to expedite the standards-making process by hammering out technical debates and issuing unified recommendations to official standards-making organizations for official sanction and ratification.

Business Impacts of Standards The standards-making process is important to manufacturers and they monitor it closely and participate in it actively. The development of new technology most often precedes its standardization. The development process is usually performed by either individual manufacturers or groups of manufacturers as part of their research and development work. Competing manufacturers may propose differing technological solutions for a given opportunity. It is often only after these competing technologies are about to come to market that the need for standardization prompts the formation of a standards committee.

It should be obvious that competing manufacturers have a strong desire to get their own technology declared as “the standard.” To capture early market share and thereby influence the standards-making process, manufacturers often produce and sell equipment before standards are issued. Make no mistake about it: standards making can be a very political process. Furthermore, by the time standards are actually adopted for a given technology, the next generation of that technology is sometimes ready to be introduced to the market. Figure 1-8 attempts to illustrate this time lag between technological development and standards creation.

Practical Advice and Information

PROPRIETARY STANDARDS

Purchasers of data communications equipment should be wary of buying equipment that complies with proprietary prestandards. Have accommodations been made to upgrade the equipment to comply with official standards once they are issued? Will there be a charge for this upgrade? Will the upgrade require a return to the factory, or is it a software upgrade that can be downloaded and installed in the field?

In general, standards work to the advantage of the data communications consumer, as they allow interoperability of equipment manufactured by a variety of vendors. However, users should be aware of at least two standards-related issues that can cause confusion and potentially lead to bad purchase decisions and operational nightmares.

Standards Extensions Recalling the potentially competitive nature of the standards-making process, it should come as no surprise that final standards are sometimes “least common denominator” implementations of competing proposals. To differentiate their own product offerings, vendors are likely to offer “extensions” to a given “standard.” Naturally, one vendor’s “extensions” do not necessarily match all the other vendors’ “extensions.” Users must be careful not only to make sure that a particular vendor’s equipment meets industry standards, but also to know *how* the equipment meets the standards and whether or not the vendor has implemented extensions to the standard.

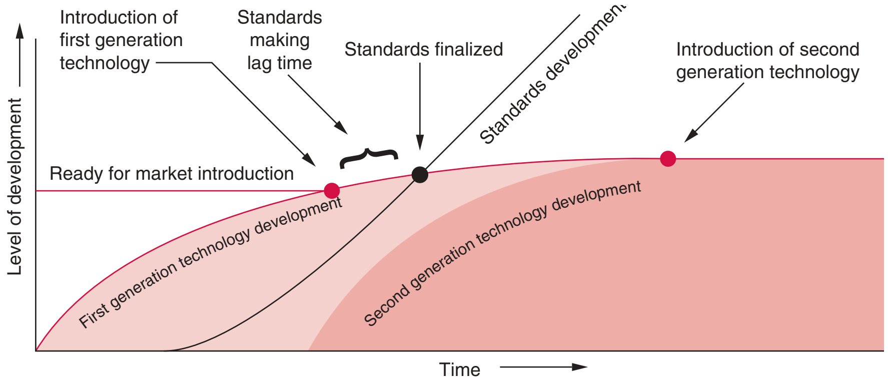


Figure 1-8 Technology Development and Standards Creation

The Jargon Jungle Unfortunately, standards do not apply to the vocabulary used by salespeople and marketing agencies to describe data communications hardware and software technology. There is no standards-making body to regulate data communications vocabulary and its use. As a result, the data communications user is trapped in a situation sometimes referred to as the "jargon jungle." Competing manufacturers often call similar features or operational characteristics by different names, leaving it to the data communications consumer to sort out the differences.

The best way to prevent being lost in the "jargon jungle" is to ask lots of questions. Be prepared to determine functionality of equipment based on operational characteristics rather than on package labels.

Manufacturing, Research, and Technology

Just as the regulatory and carriers components of the data communications environment were grouped together based on their respective interactions, many of the remaining component entities portrayed in Figure 1-1 can be legitimately grouped together based on their most important interactive force: business.

Supply and Demand Unlike the formal interactions of proposals and rulings that join regulatory and carrier components, the interacting forces that join the remaining components as well as carriers are supply and demand, basic economic concepts. That's right, *data communications is business.* Figure 1-9 attempts to graphically illustrate the complex relationship among these many data communications environment components. The present status and near-term trends of any particular component are directly related to the net effect of the supply and demand forces of all other components combined.

This same phenomenon is sometimes referred to as **technology push/demand pull.** In a technology push scenario, new technologies may be introduced to the market to spawn innovative uses for this technology and thereby generate demand. Conversely, business needs may create a demand for services or technological innovation that are not currently available. However, the demand pull causes research and development efforts to accelerate, thereby introducing the new technology sooner than it would have otherwise been brought to market.

As an example, business and users may demand faster transfer of data. However, if research has not supplied the technology to accomplish these faster transfers, then manufacturers cannot produce and supply (sell) these products to business and users. Nor can vendors and consultants distribute and recommend their use.

Available technology also plays a key role in the relationship between business and carriers. Understanding that the phone companies are in business to make a profit and therefore need to sell the network services that business is willing to buy at a price business is willing to pay, it should follow that these enabling technologies tie the business demand for network services to the carrier's supply of network services. Stated another way, a carrier cannot provide the network services that businesses demand unless the proper technology is in place. Carriers can afford to invest in new technology only through profitable operations. This dynamic relationship can be expressed in the following equation:

$$\text{Business Demand} + \text{Available Technology} = \text{Emerging Network Services}$$

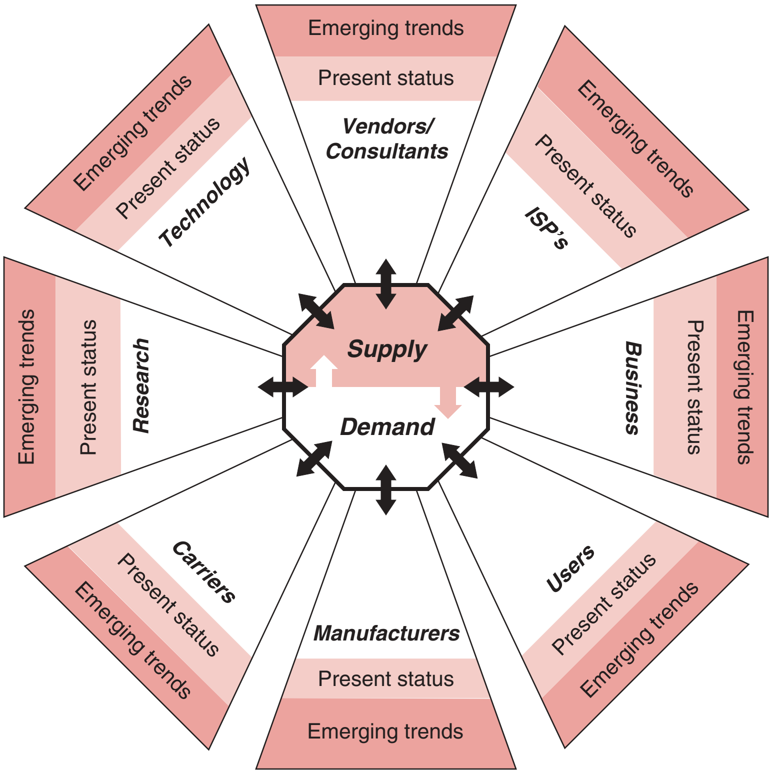


Figure 1-9 Supply and Demand as Driving Forces of the Data Communications Industry

CHALLENGES AND SOLUTIONS TO BUSINESS-ORIENTED DATA COMMUNICATIONS ANALYSIS

Having explored the interacting components of the data communications industry to gain an appreciation of its dynamic nature, the network analyst must next identify the key challenges to success in the data communications field and the potential solutions to those challenges. One of the most important things to realize is that corporations are not interested in investing in technology merely for technology's sake. Rather, implemented technology must produce measurable impact on business goals and requirements. Ensuring and accounting for this technological impact on business goals is a significant challenge.

Challenge: Information Technology Investment vs. Productivity Gains, Ensuring Implemented Technology Meets Business Needs

In the past decade, over $1 trillion dollars has been invested by business in information technology. Despite this massive investment, carefully conducted research indicates that there has been little if any increase in productivity as a direct result of this investment. This dilemma is known as the **productivity paradox.** How did so much money get invested in technology that failed to deliver increases in productivity? What was the nature of the analysis and design process that recommended the purchase of this technology? Clearly, something is wrong with an analysis and design process that recommends technology implementations that fail to meet the strategic business objective of increased productivity.

What are the characteristics required of an analysis and design process that has the potential to overcome the productivity paradox? How can a network analyst remain properly focused on business requirements while performing technology analysis? Bringing this general investment in technology issue down to a particular investment in data communications and networking, it may be safe to say that: If the network doesn't make good business sense, it probably makes no sense.

To overcome the productivity paradox, a structured methodology must be followed to ensure that the implemented network technology meets the communications and business needs of the intended business, organization, or individual. The top-down approach and benchmarking are two potential solutions to the productivity paradox.

Applied Problem Solving

SOLUTION: THE TOP-DOWN APPROACH

One such structured methodology is known as the top-down approach. Such an approach can be graphically illustrated in a **top-down model** shown in Figure 1-10. Use of the top-down approach as illustrated in the top-down model is relatively straightforward. Insisting that a top-down approach to network analysis and design is undertaken should ensure that the network design implemented meets the business needs and objectives that motivated the design in the first place.

This top-down approach requires network analysts to understand business constraints and objectives, as well as information systems applications and the data on which those applications run, before considering data communications and networking options.

Notice where the network layer occurs in the top-down model. It is no accident that data communications and networking form the foundation of today's sophisticated

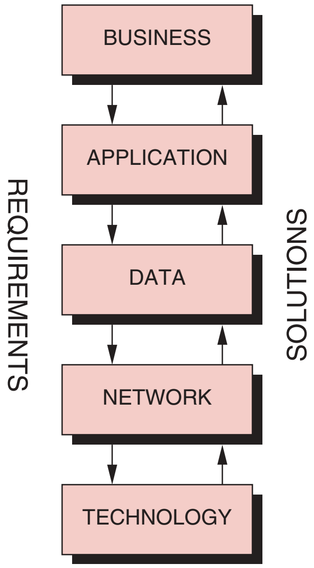


Figure 1-10 The Top-Down Model

information systems. A properly designed network supports flexible delivery of data to distributed application programs, allowing businesses to respond quickly to customer needs and rapidly changing market conditions.

The Top-Down Model How does the proper use of the top-down model ensure effective, business-oriented network analysis and design? Figure 1-11 lists the analysis processes associated with each layer of the top-down model. One must start with the *business* level objectives. What is the company (organization, individual) trying to accomplish by installing this network? Without a clear understanding of business level objectives it is nearly impossible to configure and implement a successful network. In many cases, businesses take this opportunity to critically reexamine their business processes in an analysis methodology known as **business process reengineering (BPR).**

Once business level objectives are understood, one must understand the *applications* that will be running on the computer systems attached to these networks. After all, it is the applications that will be generating the traffic that will travel over the implemented network.

Once applications are understood and have been documented, the *data* that the applications generate must be examined. In this case, the term *data* is used in a general

Top-Down Model Layer	Associated Analysis Processes
Business Layer	• Strategic business planning • Business process reengineering • Identify major business functions • Identify business processes • Identify business opportunities
Applications Layer	• Applications development • Systems analysis and design • Identify information needs • Relate information needs to business processes and opportunities
Data Layer	• Database analysis and design • Data modeling • Data distribution analysis • Client / server architecture design • Distributed database design • Relate data collection and distribution to information and business needs
Network Layer	• Network analysis and design • Logical network design (what) • Network implementation planning • Network management and performance monitoring • Relate logical network design to data collection and distribution design
Technology Layer	• Technology analysis grids • Hardware software-media technology analysis • Physical network design (how) • Physical network implementation • Relate physical network design to logical network design

Figure 1-11 Analysis Processes of the Top-Down Model

sense, as today's networks are likely to transport a variety of payloads including voice, video, image, and fax in addition to true data. Data traffic analysis must determine not only the amount of data to be transported, but also important characteristics about the nature of that data.

Once data traffic analysis has been completed, the following should be known:

- Physical locations of data (Where?)
- Data characteristics and compatibility issues (What?)
- Amount of data generated and transported (How much?)

Given these requirements as determined by the upper layers of the top-down model, the next job is to determine the requirements of the *network* that will possess the capability to deliver this data in a timely, cost-effective manner. These network performance criteria could be referred to as *what* the implemented network must do to meet the business objectives outlined at the outset of this top-down analysis. These requirements are also referred to as the **logical network design.**

The *technology* layer analysis, in contrast, determines *how* various hardware and software components are combined to build a functional network that meets the predetermined business objectives. The delineation of required technology is referred to as the **physical network design.**

Overall, the relationship between the layers of the top-down model can be described as follows: analysis at upper layers produces requirements that are passed down to lower layers, while solutions meeting these requirements are passed back to upper layers. If this relationship among layers holds true throughout the business oriented network analysis, then the implemented technology (bottom layer) should meet the initially outlined business objectives (top layer). Hence, the name, top-down approach.

Applied Problem Solving

SOLUTION: BENCHMARKING

If using the top-down approach ensures that implemented technology meets business objectives, how can the impact of implemented technology on business objectives be measured? Without measurement, the top-down approach can't be proven to be any more effective at overcoming the productivity paradox than any other analysis and design methodology. In the age of limited professional staffs and operating budgets, network managers must be able to prove the strategic importance of networking resources to achieve overall business objectives. Without such proof, network managers may soon find themselves and their staffs replaced by outside contractors.

One way to demonstrate the impact of implemented technology is to tie networking costs to business value through a process known as **benchmarking.** Benchmarking can be summarized into the following three major steps:

1. Examine and document quantifiable improvements to business processes.
2. Perform surveys to measure customer satisfaction with deployed network services.
3. Compare actual implementation costs with the cost to purchase similar services from outside vendors (outsourcing) or examine other companies in the same vertical market to compare costs.

Benchmarking the impact of networking technology is not an exact science. Although costs are relatively easy to quantify, the same cannot be said for benefits. Controlling all variables affecting business improvement is difficult at best. For example, how can improved business performance be directly attributed to network improvements while eliminating such variables as an improved economy or a reduction in competition?

Challenge: Analysis of Complex Data Communications Connectivity and Compatibility Issues

Assuming that the proper use of the top-down model will ensure that implemented technical solutions will meet stated business requirements, the more technical challenges of network analysis and design must be addressed.

Introduction to Protocols and Compatibility Solving incompatibility problems is at the heart of successful network implementation. Compatibility can be thought of as successfully bridging the gap or communicating between two or more technology components, whether hardware or software. This logical gap between components is commonly referred to as an **interface.**

Interfaces may be physical (hardware to hardware) in nature:

- Cables physically connecting to serial ports on a computer.
- A network interface card physically plugging into the expansion bus inside a computer.

Interfaces may also be logical or software-oriented (software to software):

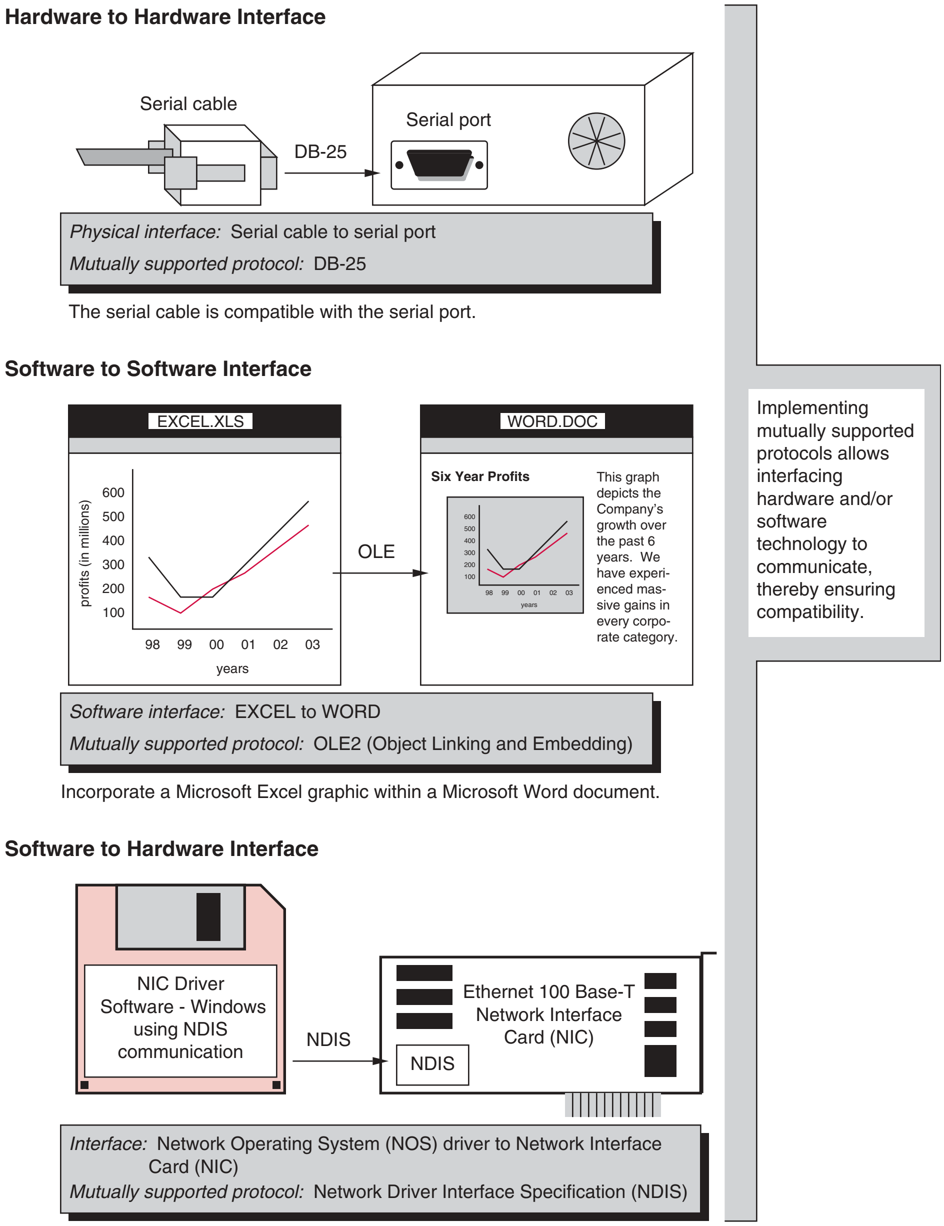
- A network operating system client software (Novell Netware) communicating with the client PC's operating system (Windows).
- A client-based data query tool (Microsoft Access) gathering data from a large database management system (Oracle).

Finally, interfaces may cross the hardware to software boundary:

- A network operating system specific piece of software known as a driver that interfaces to an installed network interface card (NIC).
- A piece of operating system software known as a kernel that interfaces to a computer's CPU chip.

These various interfaces can be successfully bridged to support compatibility between components because of **protocols.** Protocols are nothing more than rules for how communicating hardware and software components bridge interfaces or talk to one another. Protocols may be proprietary (used exclusively by one or more vendors) or open (used freely by all interested parties). Protocols may be officially sanctioned by international standards-making bodies such as the International Organization for Standardization (ISO), or they may be purely market driven (de facto protocols). Figure 1-12 illustrates the relationship between interfaces, protocols, and compatibility.

For every potential hardware-to-hardware, software-to-software, and hardware-to-software interface, there is likely to be one or more protocols supported. The sum of all of the protocols employed in a particular computer is sometimes referred to as



Physical interface: Serial cable to serial port

Mutually supported protocol: DB-25

The serial cable is compatible with the serial port.

Software interface: EXCEL to WORD

Mutually supported protocol: OLE2 (Object Linking and Embedding)

Incorporate a Microsoft Excel graphic within a Microsoft Word document.

Interface: Network Operating System (NOS) driver to Network Interface Card (NIC)

Mutually supported protocol: Network Driver Interface Specification (NDIS)

Implementing mutually supported protocols allows interfacing hardware and/or software technology to communicate, thereby ensuring compatibility.

Figure 1-12 Interfaces, Protocols, and Compatibility

that computer's **protocol stack.** Successfully determining which protocols must be supported in which instances for the multitude of possible interfaces in a complicated network design is likely to mean the difference between the success or failure of a network implementation.

How can a network analyst possibly keep track of all potential interfaces and their associated protocols? What is needed is a framework in which to organize the various interfaces and protocols in complicated network designs. More than one such framework, otherwise known as communications architectures, exists. Two of the most popular communications architectures are the seven-layer OSI model and the four-layer internet suite of protocols model.

Applied Problem Solving

SOLUTION: THE OSI NETWORK REFERENCE MODEL

Choosing the technology and protocols that can meet the requirements as determined in the logical network design from the network layer of the top down model requires a structured methodology of its own. Fortunately, the ISO has developed a framework for organizing networking technology and protocol solutions known as the open systems interconnection (OSI) network reference model or OSI model for short. The following section offers the reader only a brief introduction to the overall functionality of the OSI model as a network analysis tool; more detailed information on the model is provided throughout the remainder of the text. The OSI model should be looked on as a powerful, but somewhat complex, tool.

The **OSI Model** consists of a hierarchy of 7 layers that loosely group the functional requirements for communication between two computing devices regardless of the software, hardware, or geographical differences between the devices. The power of the OSI Model, officially known as ISO Standard 7489, lies in its openness and flexibility. It can be used to organize and define protocols involved in communicating between two computing devices located in the same room as effectively as two devices located on opposite sides of the world.

Each layer in the OSI Model relies on lower layers to perform more elementary functions and to offer total transparency as to the intricacies of those functions. At the same time, each layer provides incrementally more sophisticated transparent services to upper layers. In theory, if the transparency of this model is supported, changes in the protocols of one layer should not require changes in protocols of other layers. A **protocol** is a set of rules that govern communication between hardware and / or software components.

Physical Layer The **physical layer,** also known as layer 1, is responsible for the establishment, maintenance and termination of physical connections between communicating devices. The physical layer transmits and receives a stream of bits. There is no data recognition at the physical layer.

Specifically, the physical layer operation is controlled by protocols that define the electrical, mechanical, and procedural specifications for data transmission. The RS232-C specification for serial transmission is an example of a physical layer protocol. Strictly speaking, the physical layer does not define the specifications for connectors and cables that are sometimes referred to as belonging to Layer 0. The physical layer will be covered in detail in chapter 3.

DataLink Layer The **data-link layer** is responsible for providing protocols that deliver reliable point-to-point connections. The data-link layer is of particular interest to the study of local area networks as this is the layer in which network architecture standards are defined. These standards are debated and established by the **IEEE** (**Institute of Electrical and Electronic Engineers**) **802** committee and will be introduced and explained later in this chapter. The number 802 is derived from the date of the committee's formation in 1980 (80) in the month of February (2).

The data-link layer provides reliability to the physical layer transmission by organizing the bit stream into structured **frames** which add addressing and error checking information. Additional information added to the front of data is called a **header,** while information added to the back of data is called a **trailer.** Data link layer protocols provide error detection, notification, and recovery.

The data-link layer frames are built within the **network interface card** installed in a computer according to the pre-determined frame layout particular to the network architecture of the installed network interface card. Network interface cards are given a unique address in a format determined by their network architecture. These addresses are usually assigned and pre-programmed by the NIC manufacturer. The network interface card provides the connection to the LAN, transferring any data frames that are addressed to it from the connected network media to the computer's memory for processing.

The first two layers of the OSI model, physical and data link, are typically manifested as hardware (media and NICs, respectively) whereas the remaining layers of the OSI model are all installed as software protocols. The Data Link layer will be covered in detail in chapter 4.

In order to allow the OSI Model to more closely adhere to the protocol structure and operation of a local area network, the IEEE 802 committee split the data-link layer into two sub-layers.

Media Access Control The **media access control** or **MAC sub-layer** interfaces with the physical layer and is represented by protocols which define how the shared local area network media is to be accessed by the many connected computers. As will be explained more fully later is this chapter, Token ring (IEEE 802.5) and Ethernet (IEEE 802.3) networks use different media access methodologies and are therefore assigned different IEEE 802 protocol numbers. Unique addresses assigned to NICs at the time of manufacturer are commonly referred to as MAC addresses or MAC layer addresses.

Logical Link Control The upper sub-layer of the data-link layer which interfaces to the network layer is known as the **logical link control** or **LLC sub-layer** and is represented by a single IEEE 802 protocol (IEEE 802.2). The LLC sub-layer also interfaces transparently to the MAC sublayer protocol beneath it. The advantage to splitting the data-link layer into two sub-layers and to having a single, common LLC protocol is that it offers transparency to the upper layers (network and above) while allowing the MAC sub-layer protocol to vary independently. In terms of technology, the splitting of the sub-layers and the single LLC protocol allows a given network operating system to run equally well over a variety of different network architectures as embodied in network interface cards.

Network Layer The **network layer** protocols are responsible for the establishment, maintenance, and termination of **end-to-end network links.** Network layer protocols are required when computers that are not physically connected to the same LAN must communicate. Network layer protocols are responsible for providing network layer (end-to-end) addressing schemes and for enabling inter-network routing of network layer data **packets.** The term packets is usually associated with network layer protocols while the term frames is usually associated with data link layer protocols. Unfortunately, not all networking professionals or texts adhere to this generally accepted convention. Addressing schemes and routing will be thoroughly reviewed in the remainder of the text.

Network layer protocols are part of a particular network operating system's protocol stack. Different networking operating systems may use different network layer protocols. Many network operating systems have the ability to use more than one network layer protocol. This capability is especially important to heterogeneous, multi-platform, multi-vendor client/server computing environments. The network layer will be covered in detail in chapter 5.

Transport Layer Just as the data-link layer was responsible for providing reliability for the physical layer, the **transport layer** protocols are responsible for providing reliability for the end-to-end network layer connections. Transport layer protocols provide end-to-end error recovery and flow control. Transport layer protocols also provide mechanisms for sequentially organizing multiple network layer packets into a coherent **message.**

Transport layer protocols are supplied by a given network operating system and are most often closely linked with a particular network layer protocol. For example, NetWare uses IPX / SPX in which IPX (Internet Packet Exchange) is the network layer protocol and SPX (Sequenced Packet Exchange) is the transport layer protocol. Another popular transport / network protocol duo is TCP / IP in which TCP (Transmission Control Protocol) is the transport layer protocol that provides reliability services for IP (Internet Protocol), the network layer protocol. The transport layer will be covered in detail in chapter 5.

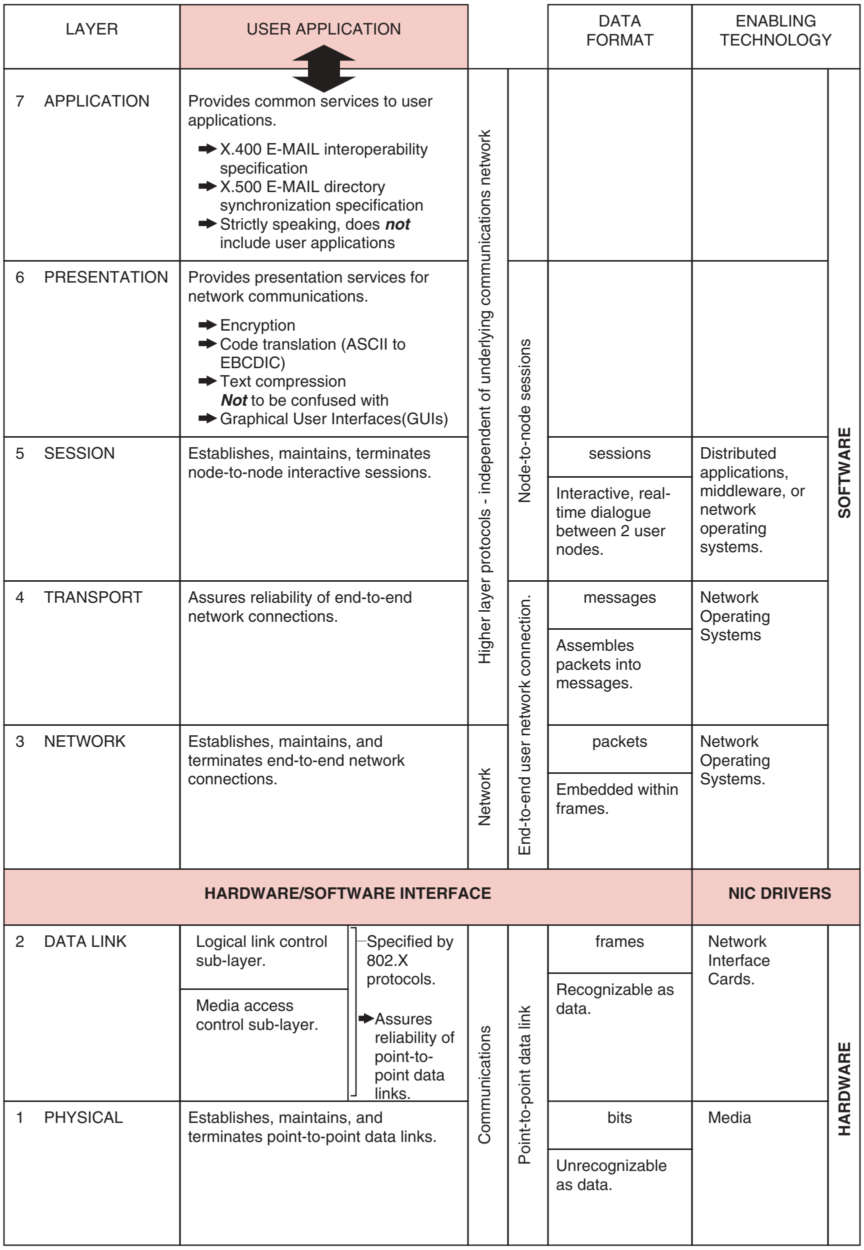
Session Layer **Session layer** protocols are responsible for establishing, maintaining, and terminating sessions between user application programs. Sessions are interactive dialogues between networked computers and are of particular importance to distributed computing applications in a client / server environment. As the area of distributed computing is in an evolutionary state, the session layer protocols may be supplied by the distributed application, the network operating system, or a specialized piece of additional software designed to render differences between computing platforms transparent, known as middleware. RPC, or remote procedure call protocol, is one example of a session layer protocol. The session layer will be covered in detail in chapter 5.

Presentation Layer The **presentation layer** protocols provide an interface between user applications and various presentation-related services required by those applications. For example, data encryption / decryption protocols are considered presentation layer protocols as are protocols that translate between encoding schemes such as ASCII to EBCDIC. A common misconception is that graphical user interfaces such as Microsoft Windows and X-Windows are presentation layer protocols. This is not true. Presentation-layer protocols are dealing with network communications whereas Microsoft Windows and / or X-Windows are installed on end-user computers.

Application Layer The **application layer,** layer 7 of the OSI Model is also open to misinterpretation. Application layer protocols do not include end-user application programs. Rather, they include utilities and network-0Based services that support end-user application programs. Some people include network operating systems in this category. Strictly speaking, the best examples of application layer protocols are the OSI protocols X.400 and X.500. X.400 is an open systems protocol that offers interoperability between different e-mail programs and X.500 offers e-mail directory synchronization among different e-mail systems. DNS, Domain Name Service, which is an Internet protocol that resolves a computer's common or domain name to a specific IP address, is also considered an application layer protocol.

Figure 1-13 offers a conceptual view of the OSI Model and summarizes many of the previous comments.

Network analysts literally talk in terms of the OSI model. When troubleshooting network problems, inevitably the savvy network analyst starts with the physical layer (layer 1) and ensures that protocols and interfaces are operational at each layer before moving up the OSI model. Another benefit of the OSI model is that it allows



LAYER	USER APPLICATION			DATA FORMAT	ENABLING TECHNOLOGY	
7 APPLICATION	Provides common services to user applications. ➡ X.400 E-MAIL interoperability specification ➡ X.500 E-MAIL directory synchronization specification ➡ Strictly speaking, does ***not*** include user applications	Higher layer protocols - independent of underlying communications network				SOFTWARE
6 PRESENTATION	Provides presentation services for network communications. ➡ Encryption ➡ Code translation (ASCII to EBCDIC) ➡ Text compression ***Not*** to be confused with ➡ Graphical User Interfaces(GUIs)		Node-to-node sessions			
5 SESSION	Establishes, maintains, terminates node-to-node interactive sessions.			sessions Interactive, real-time dialogue between 2 user nodes.	Distributed applications, middleware, or network operating systems.	
4 TRANSPORT	Assures reliability of end-to-end network connections.		End-to-end user network connection.	messages Assembles packets into messages.	Network Operating Systems	
3 NETWORK	Establishes, maintains, and terminates end-to-end network connections.	Network		packets Embedded within frames.	Network Operating Systems.	
HARDWARE/SOFTWARE INTERFACE					**NIC DRIVERS**	
2 DATA LINK	Logical link control sub-layer. Media access control sub-layer. Specified by 802.X protocols. ➡ Assures reliability of point-to-point data links.	Communications	Point-to-point data link	frames Recognizable as data.	Network Interface Cards.	HARDWARE
1 PHYSICAL	Establishes, maintains, and terminates point-to-point data links.			bits Unrecognizable as data.	Media	

Figure 1-13 OSI Model—A Conceptual View

data communications technology developers and standards developers to talk about the interconnection of two networks or computers in common terms without dealing in proprietary vendor jargon.

These "common terms" are the result of the layered architecture of the seven layer OSI model. The architecture breaks the task of two computers communicating with each other into separate but interrelated tasks, each represented by its own layer. As can be seen in Figure 1-13, the top layer (layer 7) represents services offered to the application programs running on each computer and is therefore aptly named the application layer. The bottom layer (layer 1) is concerned with the actual physical connection of the two computers or networks and is therefore named the physical layer. The remaining layers (2–6) may not be as obvious but, nonetheless, represent a sufficiently distinct logical group of functions required to connect two computers, as to justify a separate layer. As will be seen later in the text, some of the layers are divided into sublayers.

To use the OSI model, a network analyst lists the known protocols for each computing device or network node in the proper layer of its own seven-layer OSI model. The collection of these categorized protocols is known as the protocol stack of the network node. For example, the physical media employed, such as unshielded twisted pair, coaxial cable, or fiber optic cable, would be entered as a layer 1 protocol, while Ethernet or token ring network architectures might be entered as a layer 2 protocol. As will be seen later in Chapter 4, a given computer may employ more than one protocol on one or more layers of the OSI model. In these cases, such computers are described as supporting multiple protocol stacks or simply as multiprotocol.

The OSI model allows network analysts to produce an accurate inventory of protocols present on any given network node. This protocol profile represents a unique personality of each network node and gives the network analyst some insight into what **protocol conversion,** if any, may be necessary to allow any two network nodes to communicate successfully. Ultimately, the OSI model provides a structured methodology for determining the hardware and software technology required in the physical network design to meet the requirements of the logical network design.

Perhaps the best analogy for the OSI model is an assembly line producing an automobile. Although each process or step is independently managed and performed, each step also depends on previous steps to be performed according to standardized specifications or protocols for the overall process to be successful. Similarly, each layer of the OSI model operates independently while depending on neighboring layers to perform tasks according to specification while cooperating in the attainment of the overall task of communication between two computers or networks.

The OSI model is not a protocol or group of protocols. It is a standardized, empty framework into which protocols can be listed to perform an effective network analysis and design. As will be seen later in the text, however, the ISO has also produced a set of OSI protocols that correspond to some of the layers of the OSI model. It is important to differentiate between the OSI model and OSI protocols.

The OSI model is used throughout the remainder of the text as the protocol stacks of various network operating systems are analyzed and in the analysis and design of advanced network connectivity alternatives.

Applied Problem Solving

SOLUTION: THE INTERNET SUITE OF PROTOCOLS MODEL

Although the OSI model is perhaps more famous than any OSI protocol, just the opposite is true for the **internet suite of protocols model** and its associated protocols. Also known as the **TCP/IP** protocol suite, or **TCP/IP** architecture, this communications architecture takes its name from **transmission control protocol/internet protocol,** the de facto standard protocols for open systems internetworking. As can be seen in Figure 1-14, TCP and IP are just two of the protocols associated with this model.

Like the OSI model, the TCP / IP model is a layered communications architecture in which upper layers use the functionality offered by lower layer protocols. Each

Layer	OSI	INTERNET	Data Format	Protocols
7	Application	Application	Messages or Streams	TELNET FTP TFTP SMTP SNMP HTTP
6	Presentation			
5	Session			
4	Transport	Transport or Host-Host	Transport Protocol Packets	TCP UDP
3	Network	Internet	IP Diagrams	IP
2	Data Link	Network Access	Frames	
1	Physical			

Figure 1-14 Internet Suite of Protocols vs. OSI

layer's protocols are able to operate independently from the protocols of other layers. For example, protocols on a given layer can be updated or modified without having to change the protocols in any other layers. A recent example of this independence is the new version of IP known as IPng (IP next generation) developed in response to a pending shortage of IP addresses. This proposed change is possible without the need to change all other protocols in the TCP / IP communication architecture. The exact mechanics of how TCP / IP and related protocols work are explored in greater depth in Chapter 7.

Figure 1-14 compares the four layer Internet suite of protocols model with the seven-layer OSI model. Either communications architecture can be used to analyze and design communication networks. In the case of the internet suite of protocols model, the full functionality of internetwork communications is divided into four layers rather than seven. Because of the fewer layers and the dominant market position of TCP / IP, some network analysts consider the internet suite of protocols model to be more simple and practical than the OSI model.

Applied Problem Solving

SOLUTION: THE I-P-O MODEL

Once the protocols are determined for two or more computers that wish to communicate, the next step is to determine the technology required to deliver the identified internetworking functionality and protocols.

To understand the basic function of any piece of networking equipment, one really need only understand the differences between the characteristics of the data that came in and the data that went out. Those differences identified were processed by the data communications equipment.

This input-processing-output or **I-P-O model** is another key model used throughout the textbook to analyze a wide variety of networking equipment and opportunities. The I-P-O model provides a framework in which to focus on the difference between the data that came into a particular networked device (I) and the data that came out of that same device (O). By defining this difference, the processing (P) performed by the device is documented.

As a simple example of the use of the I-P-O model, let's assume that we wish to hook a particular PC to a particular printer. After some investigation, we discover that the PC can provide input (I) to the printer (O) only through the PC's serial port. However, the printer (O) only has a parallel interface. As a result, we have a serial interface (perhaps DB-25, RS-232) as an input and have a parallel interface (centronics connector) as an output. What is required is a device to provide the necessary (P) recessing to convert our serial input to the required parallel output. Such devices are readily available. However, before purchasing such a device, it is essential to have organized and documented the required electrical and mechanical protocols that must be interfaced and converted between. By organizing such interfaces in a simple I-P-O model, the exact conversions that must take place are immediately evident.

Although at first glance the I-P-O model may seem overly simplistic, it is another valuable model that can assist network analysts in organizing thoughts, documenting requirements, and articulating needs.

THE DATA COMMUNICATIONS PROFESSION

Where Does Data Communications Fit in an Overall Information Systems Architecture?

How is a top-down approach to data communications analysis and design actually implemented in today's corporations? What is the overall information systems structure into which this top-down approach fits? Figure 1-15 illustrates one way in which a top-down approach could be implemented within the overall framework of an information systems architecture.

Several key points illustrated in the diagram are worth noting. Predictably, the entire information systems development process begins with the business analysis process. What is important to note, however, is that all major sections of the top-down approach model—business, applications, data, and network—take part in the business analysis process.

In some cases, a separate technology assessment group exists within a corporation and partakes in the business analysis phase of the information systems development process. In so doing, each layer of the top-down model is represented by trained individuals and complementary processes in the top-down approach to information systems development. This initial participation of all segments of the information systems development team in the business analysis portion of the process ensures that the implemented system will adequately support the business functions for which it was intended.

After this initial participation of all segments of the team in the business analysis phase, each segment develops its portion of the information system. However, merely knowing the business needs that an information system is trying to meet is an insufficient guarantee of successful implementation. It is essential that during the development process, the applications, database, network, and technology development teams continually communicate to ensure that their finished subsystems will interoperate effectively enough to support the identified business needs. This critical communication between subsystems as well as between the individuals who developed these subsystems is illustrated in Figure 1-15.

Professional Development

The accomplishment of this communication between business, application, database, network, and technology analysts should not be taken for granted. These analysts must be able to speak each other's languages and jargon to communicate effectively. The need to understand all aspects of the information systems architecture has major implications for the proper training of data communications and networking professionals.

Unless one understands "the big picture" of the top-down model, one cannot effectively design and implement the data communications and networking foundation to support this same big picture. Put another way, data communications cannot be studied in a vacuum. The study of data communications and networking must be approached from "the big picture" perspective, ever-mindful of the tremendous potential effect that data communications and networking decisions have on this same big picture.

Critical Skills for Data Communications Professionals To understand the critical skills required of data communications professionals, one must first thoroughly understand the business environment in which these professionals operate. Today's economic environment has been alternatively described as the information age or a knowledge-based economy. Characteristics of such an economy are the recognition of information as a corporate asset to be leveraged for competitive advantage and the need for highly reliable networks to support the mission-critical applications that deliver valuable information to key decision makers.

Such an economic environment requires data communications professionals who can move beyond their technical expertise and specialization by demonstrating the ability to solve business problems. In this role, data communications professionals will be seen increasingly as change agents and partners and less as technology experts and consultants.

So what do the current trends in data communications indicate in terms of employment opportunities? Given the recognition by business of the importance of

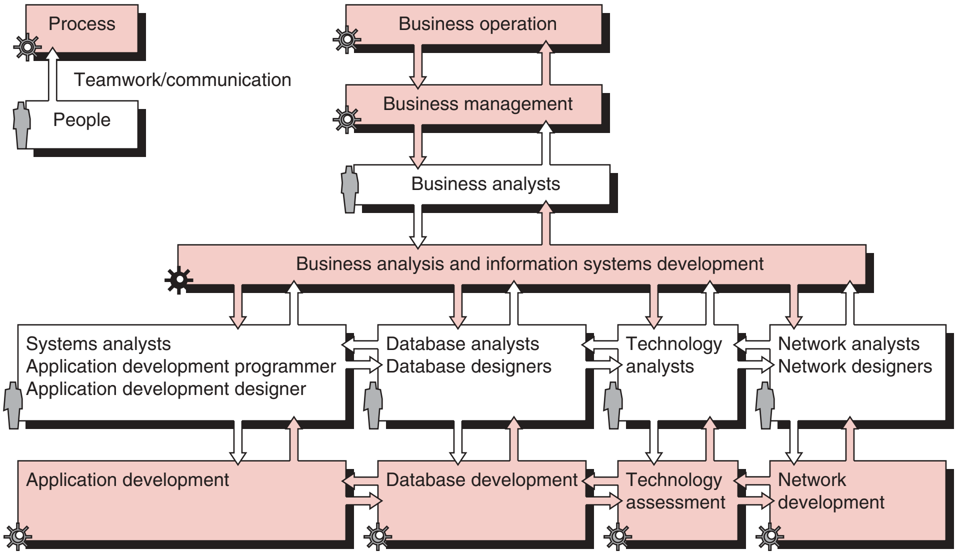


Figure 1-15 The Top-Down Approach to Information Systems Development

networks and given the complicated nature of both the data communications technology and the integration of that technology to carrier-provided network services, job opportunities should be excellent for data communications professionals who:

- Understand and can speak "business."
- Demonstrate an ability to own and solve business problems in a partnership rather than consultative role.
- Demonstrate an ability to look outside their own expertise for solutions.
- Exhibit an understanding of the need for lifelong learning.
- Demonstrate an ability to evaluate technology with a critical eye as to cost / benefit and potential for significant business impact of that technology.
- Understand comparative value and proper application of available network services and can work effectively with carriers to see that implementations are completed properly and cost effectively.
- Communicate effectively, both verbally and orally, with both technically oriented people and business management personnel.

The multitalented nature of these data communications professionals is illustrated in Figure 1-16.

The Certification Question Certification as an indication of mastery of a particular technology may be important in some employment situations. Figure 1-17 lists some of the certifications available to data communications professionals.

Some concerns with certification programs are

- The amount of practical, hands-on experience required to earn a given certification.
- The amount of continuing education and experience required to retain a certification.
- Vendor-specific certifications do not provide the broad background required for today's multivendor internetworks.

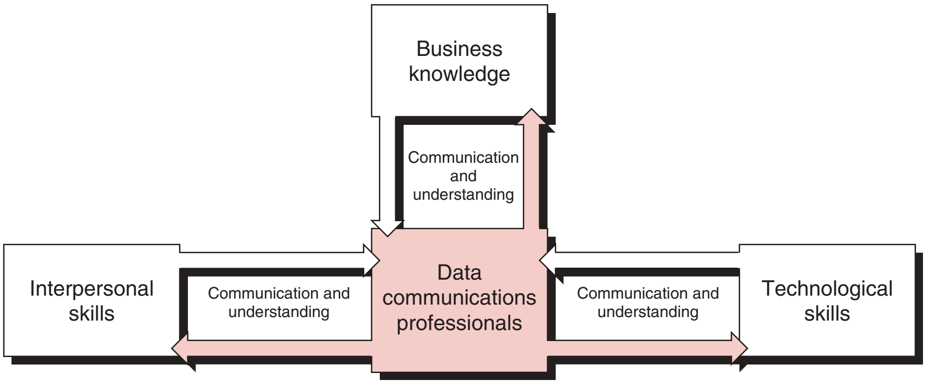


Figure 1-16 Critical Skills for Data Communications Professionals

Vendor/Sponsor	Certification
COMPTIA	A+ (hardware), Network+ (network)
Microsoft	Certified systems engineer (MCSE)
Novell	Certified Novell engineer (CNE)
Cisco Systems	Cisco Certified Network Associate (CCNA) Cisco certified internetwork expert (CCIE)

Figure 1-17 Vendor-Specific Certifications

The Opportunity To say that these are exciting times in the field of data communications is an understatement of untold proportions. The opportunities are indeed significant for those individuals properly prepared. We invite you to enter the exciting world of data communications with us. We are confident that it is a journey you will not soon forget.

SUMMARY

Today's data communications industry is characterized by an environment consisting of a group of interacting components such a business, technology and research, standards-making organizations, regulatory agencies, and common carriers. The state of the overall industry at any time is the product of the interaction of these components. To be an effective participant in the data communications field, one must be aware of the forces at work that are shaping the industry.

The data communications industry was traditionally tightly regulated. Although changes such as the breakup of AT&T in the early 1980s and the Telecommunications Act of 1996 have moved the marketplace toward a competitive model, local telephone and cable rates are still tightly regulated.

Data communications and networking are integral parts of an overall information systems architecture. The ultimate success of an implemented information system depends largely on the design of the network that forms the foundation of that system. This high degree of integration between networking and other information system architecture components is graphically illustrated in the top-down model.

The top-down model implies that any information system design must begin with a thorough understanding of business requirements before subsequent issues such as applications, data, networking, and technology are addressed.

The integrated nature of the network layer of an information systems architecture is mirrored in the skills required of today's data communications professionals. The demand is high for individuals well versed in business analysis, information systems, and networking design combined with outstanding written and verbal communications skills.

Remember—if the network does not make good business sense, it probably makes no sense at all.

KEY TERMS

access charges
benchmarking
business process reengineering
carriers
central office
CLEC
CO
co-location
competitive local exchange carriers
data communications
demand pull
deregulation
divestiture
equal access
I-P-O model

interexchange carriers
interface
Internet suite of protocols model
IXC
LATA
LEC
local access transport area
local exchange carrier
local loops
logical network design
MFJ
modified final judgment
OSI seven layer model
outsourcing
physical network design
point of presence
POP
productivity paradox
protocol conversion
protocol stack
protocols
PSTN
public switched telephone network
RBOC
regional Bell operating companies
regulatory [agencies]
standards
TCP / IP
technology push
telecommunications
Telecommunications Act of 1996
top-down model
transmission control protocol / internet protocol
universal access
universal carriers
universal service

REVIEW QUESTIONS

1. What are the major interacting components that make up today's data communications industry?
2. What are the specific interaction scenarios between the following components: Manufacturers and standards-making organizations, Business and manufacturers, Carriers and regulatory agencies, Carriers and political / judicial / legislative?
3. Where does data communications and networking fit in an overall information systems architecture?
4. What is the role of business requirements analysis in network analysis and design?
5. What is the top-down model and how is it employed in network analysis and design?
6. Define the relationship between the following terms: inter-LATA and intra-LATA, CO and POP, local loop and RBOC.
7. What is the overall intent of the Telecommunications Act of 1996?
8. What has been the impact of the Telecommunications Act of 1996 on the traditional telecommunications players?
9. What skills are required of today's data communications professional?
10. What is divestiture and how does it differ from deregulation?
11. What is an RBOC?
12. Why is the data communications industry in such a state of change?
13. What is the Modified Final Judgment and why is it important?
14. What are the key events that led up to divestiture and deregulation?
15. Who were the big winners and losers as a result of divestiture?
16. From a data communications user's perspective, what have been the most important impacts of divestiture and deregulation?
17. Explain how carriers can engage in both regulated and unregulated business ventures.
18. Which agencies are responsible for regulation of carriers on both a state and federal level?
19. What is the OSI model and why is it important?
20. Why is the standards-making process so politically charged at times?
21. Why do standards often lag behind technological development?
22. What are the possible business impacts of standards on a manufacturer of data communications equipment?
23. How do the laws of supply and demand apply to the data communications industry? Give examples.
24. What is benchmarking and how is it related to the top-down model?
25. What is the I-P-O model and of what value is it?
26. What are the major processes performed by most data communications equipment?
27. Distinguish between and give an example of each of the three types of interfaces discussed in the chapter.
28. What is the relationship between interfaces, protocols, and standards?
29. What is meant by the statement, "Data communications solutions are business solutions"?
30. What is the internet suite of protocols model?
31. Describe the similarities and differences between the OSI model and the internet suite of protocols model.
32. What are the benefits and shortcomings of certification?
33. What are the major differences between logical network design and physical network design?
34. Explain how the processes associated with each layer of the top-down model contribute to effective information systems development.

35. How can one avoid wasting money on technology that does not improve productivity?
36. What kinds of opportunities are available in the data communications industry for properly trained graduates?
37. How can equations such as “Business Demands + Available Technology = Emerging Network Services” remain useful to you in the future?
38. What is the productivity paradox and why should a network analyst be concerned with it?