



Telephony 101

ISDN • POTS • LEC • ATM • ISDN • LATA • POTS • DLC • LEC • ATM • ISDN • LATA •

*A Basic Introduction to How Telephone Services
Are Delivered in North America*



Introduction

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The much touted “convergence” of a range of key communications industries—cable TV, computers, local and long distance telephone service providers, among others—has added myriad new players to the market for telephony services. And, of course, in the thriving telecommunications market, new individuals are joining both established and new telephony companies every day.

While the stunning simplicity of the interface to the public switched network—the telephone—largely masks the complexity of the technology from the general public, the public network is, after all, the most massive and sophisticated networking system ever created. New entrants to the telephony business have an obvious need for a thumbnail introduction to a set of technologies and services that at first can seem daunting in their reach and complexity.

Telephony 101 is intended to begin filling this need by providing a basic understanding of how telephone services are currently delivered in North America.

First, it provides a concise overview of the impressive list of revenue-producing services that make the market so inviting to begin with. It then provides a basic look at the access, switching, and transmission infrastructures that are used to deliver these services. Finally, it profiles the key business and service organizations that today’s telephony subscribers expect to interface and use when they do business with a telephony provider.

Draw on Our Experience

This book provides your basic introduction to telephony. But no beginning course has ever provided all the answers. We’d be glad to help in the future.

If you have further questions about telephony services or technologies, please feel free to call us at 1-800-NORTHERN.

Much of North America’s telecommunications infrastructure was designed and built by Northern Telecom. We deployed the first fully digital switches almost two decades ago, and we have teamed with network providers worldwide to deliver over 110 million lines of digital switching in over 90 countries. Our SONET and microwave radio transmission product line is the benchmark against which “state-of-the-art” is measured, with over 10 million DS-1 lines of SONET and two million DS-1 lines of microwave capacity installed. We have helped build net-

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works for everyone from the largest Bell Operating Company, to the world's largest corporations, to the smallest independent telephone service provider. These experiences have given us an understanding of telephony issues from the perspectives of both the established provider and the new entrant to the market.

We hope *Telephony 101* translates this broad experience into a short and useful introduction to services and technologies that drive the telephony market.

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The Opportunity: Revenue-Producing Telephony Services

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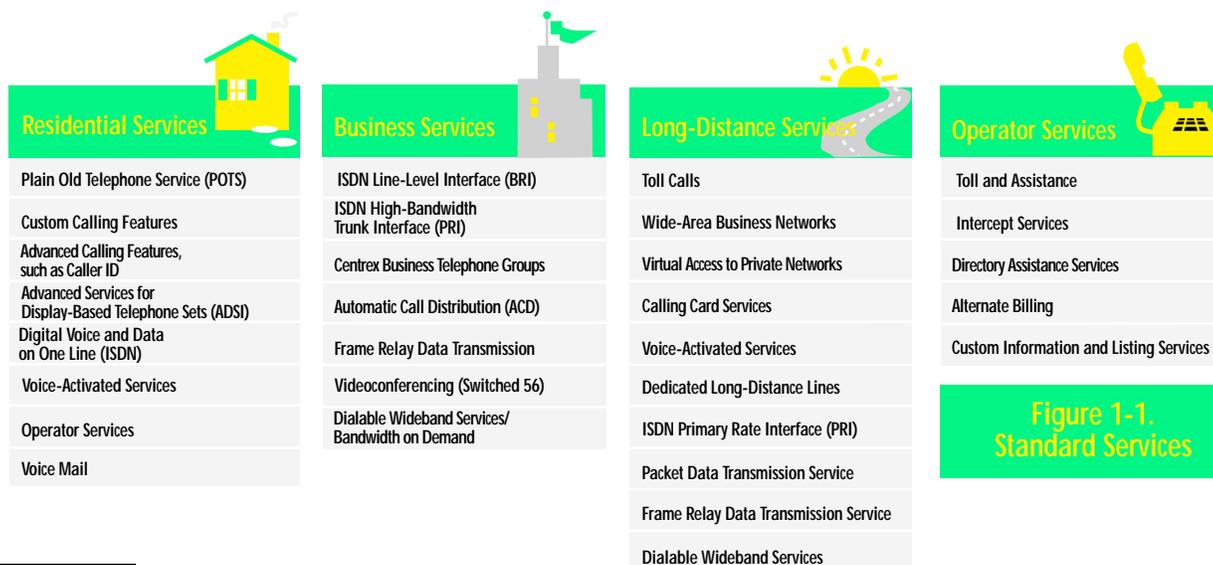
The success of a telephony provider is inevitably influenced by how it positions the suite of features that will be at the core of its service offering. On the one hand, few players are likely to be successful if their service portfolio isn't perceived as at least as good as the one customers currently have to choose from. On the other hand, few providers are likely to attract and keep subscribers if they can't deliver at least some key services that make their offering stand out from the competition.

This section details the wide range of revenue-producing features and services that today's providers are delivering from state-of-the-art digital switching systems.

STANDARD BUSINESS AND RESIDENTIAL SERVICES

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There are a set of standard services that can be offered by most modern digital switching systems. These standard services—the way they operate, the terminals and telephones they require, and their interworking with other switching systems—are defined in the United States and Canada by Bell Communications Research (Bellcore), Stentor, and a key group of standards bodies. Standardization means that subscribers can normally obtain these services no matter where they live, and choose from many different vendors with the confidence that any standard terminal will work with the service.



At comparable pricing rates, it will likely be difficult for a service provider to gain a competitive advantage in the delivery of standard services, because the feature set can be matched by other providers. Success in this increasingly contested arena will probably depend on two factors: 1) the new entrant will win subscribers by bundling these features with other service offerings such as cable TV or pricing the standard features in an attractive, innovative way; 2) the new entrant will up the ante by providing a value-added portfolio of powerful call management capabilities—capabilities that can be easily and intuitively accessed and that can be customized to strongly differentiate a provider's offering.

The provider can also differentiate itself in the business-services market by offering value-added services beyond the standard feature set. These various “branded” services available are described in the “Advanced Voice and Data Services” section of this book.

With the emerging Advanced Intelligent Network (AIN)—where service intelligence is moved out of the switch and into centralized databases connected by Signaling System No. 7 (SS7) trunking—these services will become even more powerful. Not only can the services be managed network-wide from a single location, but AIN allows the easy development of customized services as a way to differentiate a service offering (for an overview of AIN see the “Advanced Intelligent Networking” section).

Plain Old Telephone Service (POTS)

Standard service—referred to as plain old telephone service (POTS)—provides dial tone to rotary and push-button telephones and access to nationwide and international carriers. POTS service is compatible with the older 500-type telephones (rotary telephones) and 2500-type telephones (push-button phones), as well as other standard dialing devices such as modems.

POTS service today includes some services that have become nearly universal, such as Emergency Number Service (911) and Operator Services.

Increasingly, POTS service is being upgraded to include calling features that enhance the value of the line. These services include:

- **Custom Calling Features** and **Advanced Custom Calling Features**, which work with any telephone.
- **Custom Local Area Signaling Services (CLASS)**—Many of these services work with any telephone, while the display features like Calling Line Identification require a special CLASS telephone with a display area.

- **Messaging Services** like voice mail.
- **Analog Display Services Interface (ADSI)** features that employ a new generation of telephone equipment with large display areas and “soft keys” that change function according to the context of a call to make it easier to use advanced features.

Current Services	Residential	Business
Base Service	\$12.88	\$33.00
Tone Dialing	0.95	1.95
Additional Listing	0.95	1.15
Non-Published Number	1.70	1.70
Non-Listed Number	0.75	0.75
Custom Calling Services		
• Call Waiting	2.90	4.85
• Call Forwarding	1.95	2.90
• Three-Way Calling	2.90	3.85
• Speed Calling (8)	1.95	2.90
• Speed Calling (30)	3.40	5.35
Inside Wiring Maintenance Plan	2.50	2.50
IXC Access Charge	3.50	6.00

Figure 1-2. Sample Charges for Typical Telephone Services*

*Sample charges taken from 1994 Raleigh, NC, phone directory.

Custom Calling Features

The first advanced calling services made available to residential subscribers were Custom Calling features. Since their introduction, Custom Calling features have become increasingly popular—many subscriber lines have at least one Custom Calling feature assigned.

Custom Calling features are nodal—that is, they do not require that information be passed from one switch to another over SS7 trunking. Often bundled as packages of individual features, they offer convenience and control, as well as new revenue-generating opportunities for service providers.

- **Call Waiting**—One of the most successful Custom Calling services—signals a party already involved in a call that another call is incoming.

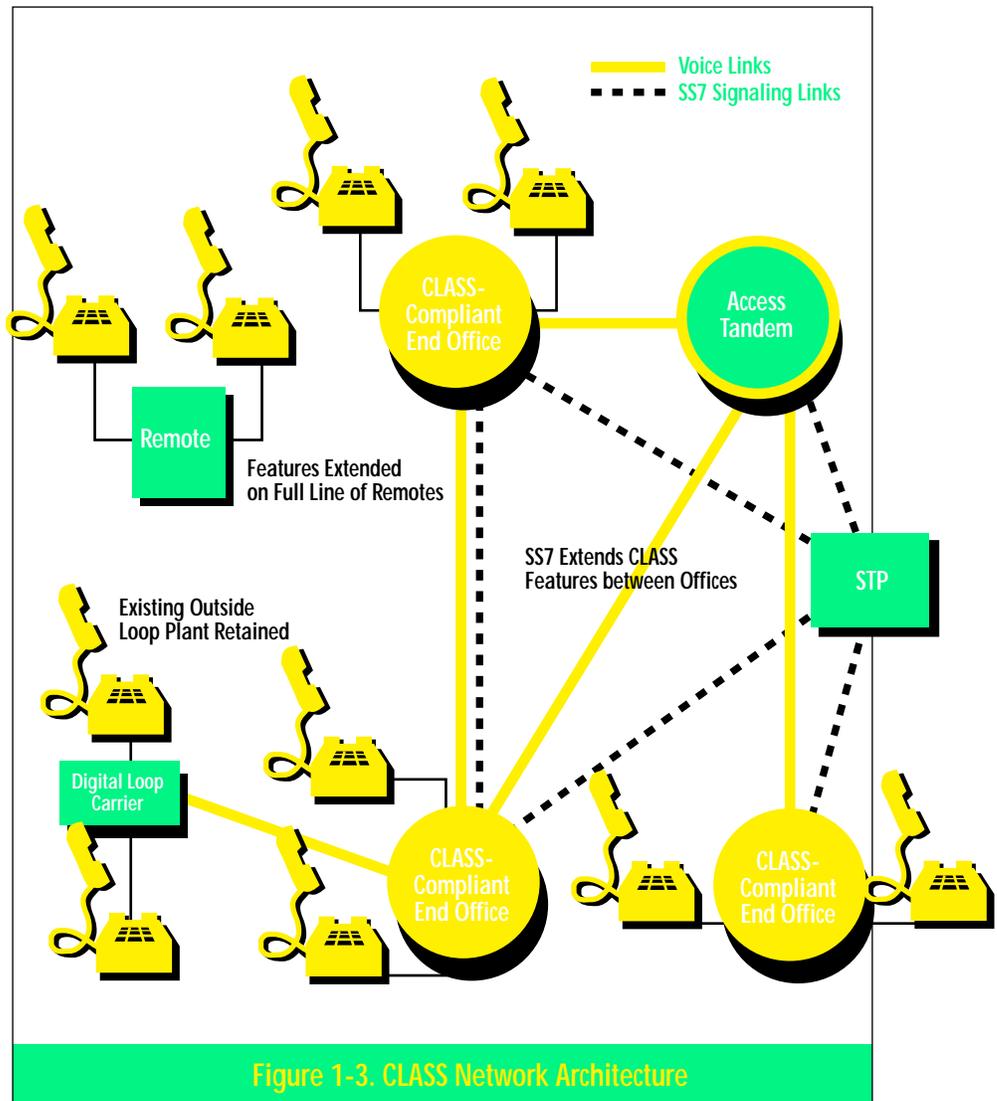
- **Call Forward** allows the subscriber to move from location to location while important calls follow. Various Call Forward options are available to allow great flexibility and control over the processing of subscriber calls.
- **Three-Way Calling** allows the subscriber to bring a third party into the conversation.
- **Speed Dialing** simplifies dialing for frequently called local or long distance calls.
- **Added Directory Number**—With an added directory number (often called Teen Service), a single telephone line can support more than one telephone number. Distinctive ringing patterns and distinctive call waiting tones tell the subscriber which telephone number has been dialed.
- **Multi-Line Custom Calling Features** give the network providers a cost-effective method of providing business-like services to the residential and small business market, such as abbreviated dialing and Group Intercom.
- **Extension Bridged Services** provides the capability to have extension phones in multiple locations. For instance, a subscriber who both works at home and from a business office can have one directory number for both locations.

CLASS Features

Custom Local Area Signaling Services (CLASS—also referred to as Call Management Services, CMS, in Canada) are Bellcore-standard features that build on the foundation of Custom Calling features by extending feature operation across multiple switches linked by SS7 trunks. SS7 allows information about a call to be passed from one switch to another, enabling new services that are gaining increased acceptance by both residential and business subscribers. As subscribers expect more from the telecommunications network, CLASS features will become the benchmark by which standard service is measured.

A range of market research has investigated which CLASS services are and will be the most successful and which market to target with any given service.

Benchmark Yankee Group research, in 1992 for instance, has indicated that the Customer-Originated Trace (COT) feature generates the most interest, with 68% of the survey group expressing interest in purchasing the service—but priced only on a usage basis, not a flat-rate subscription. The second and third most popular services are Automatic Callback (59% expressing interest) and Calling Number Delivery (55% expressing interest). Overall, CLASS feature penetration into the residential market is expected to reach 32% by 1998, according to a 1994 joint market survey conducted by NT Primary Research, Research First Consulting, Inc, and the Yankee Group.



Summary of CLASS Features

Powerful call processing services and features available with CLASS give subscribers call management convenience in placing calls, as well as unprecedented control over incoming calls.

- **CLASS Display Features** display the calling party's directory number and/or the calling party name and directory number. CLASS display features include **Calling Number Display** and **Calling Name Display**.
- **CLASS Security Features** help protect the subscriber against harassing telephone calls. Subscribers have the option of blocking the delivery of their own directory number, and can activate an immediate trace of the last incoming call. CLASS security features include:
 - **Customer-Originated Trace** allows those who receive a harassing call to dial a simple code and make the caller's telephone number available to a law-enforcement agency.
 - **Calling Number Deliver Blocking** allows callers to prevent their telephone number from appearing on the CLASS telephone of the called party. Blocking can be implemented on a per-call, per-line, or per-switch basis.
- **CLASS Call Screening Features** permit the subscriber to create a list of numbers that will be screened for acceptance, rejection, forwarding, or identification by a distinctive ringing or a distinctive call-waiting tone. CLASS Call Screening features include:
 - **Selective Call Acceptance** allows only calls from certain telephone numbers to ring the phone.
 - **Selective Call Rejection** allows the subscriber to keep certain telephone numbers from calling.
 - **Selective Call Forwarding** forwards only calls dialed from a certain list of numbers.
 - **Anonymous Caller Rejection** screens out calls from anyone who has blocked delivery of his or her telephone number.
 - **Distinctive Ringing/Call Waiting** allows the subscriber to assign a distinctive call-waiting tone to incoming calls from designated telephone numbers.

- **CLASS Convenience Features** allow the subscriber to activate an automatic redial of the last number dialed, or of the number of the last incoming call. CLASS Convenience Features include:
 - **Automatic Callback**, when the subscriber reaches a busy signal, lets the subscriber know when the called line is free and places the call.
 - **Automatic Recall** allows the subscriber to quickly return a missed call.

Voice Mail

Network-based voice mail provides distinct advantages for both residential and business users. Unlike answering machines, voice mail delivered by the network will let callers leave messages even if the phone is being used and is particularly inviting for users who don't want to buy and maintain their own equipment.

This ability to receive state-of-the-art voice mail without having to set up and run a system is particularly marketable to businesses, who may prefer to concentrate resources on core competencies rather than on running their telephone network. Revenue-generating features extend from basic call answering for small business subscribers to more sophisticated offerings for larger centrex customers:

- **Voice Messaging** allows subscribers to record and distribute messages to one or more mail systems.
- **Voice Menus** support “job information lines” and other centrex automated attendant applications.
- **Fax Messaging** services.
- **Voice Forms** that use verbal prompts to allow a caller to fill out a form over the telephone.

Non-Switched Transport Services

In addition to traditional switched voice and data traffic, a significant portion of the interoffice circuits of most local exchange carriers is dedicated point-to-point transport—that is, transport between fixed locations. These non-switched services are heavily oriented to the business portion of the market, and include a range of diverse applications—from low-speed data links for automated teller machine transactions and on-line lotteries, to private voice and data networks linking multiple business locations, to dedicated links for transferring high-resolution video images. They have also been a key element in building survivable corporate networks by providing businesses with alternate backup routes they can lease from telephony providers.

Traditionally, such services predominantly required DS-1 links; deployment of new bandwidth-intensive applications—videoconferencing, for instance, has increased the demand for higher speed private network connections at DS-3 rates and above.

Since the late 1980s, competitive access providers (CAPs) in particular have found a strong market niche providing these non-switched services to large corporations.

ADVANCED VOICE AND DATA SERVICES

The advanced competitive services offered by switching systems vendors can vary widely. The following sections describe in general terms the most common features available for these service sets:

- **Centrex Business Services**—Centrex is a switch-based business offering that can deliver services comparable to the most sophisticated PBX to businesses of any size.

In addition, Centrex usually includes:

- Multi-node networking
 - Advanced call-handling features
 - Data services, such as Dialable Wideband Services and other Bandwidth-on-Demand technologies
 - Customer network management capabilities
- **Call-Center Services—Automatic Call Distribution (ACD)** handles large volumes of incoming calls by distributing them equally among a group of answering positions on standard telephone lines. It also usually offers:
 - A management information system (MIS) that allows the subscriber to track traffic patterns and agent performance.
 - Networked ACD that allows answering positions to be located anywhere in the network, even on different central offices or at an agents' home or other remote location.
 - **Advanced Display-Based Features**—These features use display-based sets to help accelerate the deployment of existing and new network services into the subscriber market by making them even easier to use. In addition, the display capabilities make possible a range of innovative information services, home banking, and advertising possibilities.

- **Voice-Activated Services**—These services make telephony services easier to interface by using the spoken word—rather than feature buttons—to activate and control calling features.
- **ISDN**—Integrated Services Digital Network (ISDN) is a set of all-digital data and voice services that—like POTS service—use standard interfaces, protocols, and feature sets to ensure that the consumer has a choice of terminals and a standard set of features from which to choose, regardless of vendor.
- **Switched 56 Data Service**—Switched 56 kbps Service is currently used by many service providers as a low-cost digital dialed service for data rates at 56 kbps.
- **Multi-Rate ISDN/Dialable Wideband Service and Other Bandwidth-on-Demand Services**—These dialed services provide data connectivity in 64-kbps increments from 128 kbps through 1.536 Mbps for quality video transmission and videoconferencing, CAD/CAM applications, bulk data transfer, and private-network backup and augmentation.
- **Frame Relay Service**—Frame relay service is used to create cell-based high-speed virtual private data networks.

Centrex Business Services

Most businesses, regardless of size, would like the competitive advantages of a PBX voice and data network, such as calling features among the business group, call accounting, network management, and integrated voice and data. But the economics of a private network often lock out many small and start-up businesses, putting the very businesses that need every competitive edge to survive at a disadvantage. And many large businesses would prefer to spend their human and monetary capital on something other than private switching equipment.

Centrex can be the solution for these businesses. In fact, the public network offers advantages to business subscribers that cannot be matched by any private solution.

Centrex solutions such as Northern Telecom's Meridian Digital Centrex do not require on-premises switching equipment—such as a key system or PBX. Instead, the resources of the public-network switch deliver services over a telephone or data line from the central office. Switch software is partitioned to create a virtual

private business network with all the capabilities of a sophisticated on-premises system—call distribution and handling features, call accounting, high-speed digital data services, and networking with other sites.

Centrex usually offers a range of the following popular services:

- **Voice Features** that rival those of any PBX solution. In today's competitive environment, voice features are no longer just a matter of convenience. A missed call can mean missed revenue, and time spent playing "telephone tag" is time not spent on productive work. Centrex offers voice options for every business.

If the subscriber needs just the popular features like Call Waiting, Call Forwarding, and Call Transfer, Centrex offers easy-to-use single-key activation and reliable operation. If the subscriber's needs are more sophisticated, it can choose from literally hundreds of features from Meet-Me Conference to full Automatic Call Distribution (ACD) with a management information system:

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- **Call-Coverage**, such as hunt groups, many kinds of Call Forward, voice mail service, and attendant service.
 - **Call-Handling**, such as Call Transfer, Conference Calling, and Call Park.
 - **Convenience Features**, such as Speed Calling, Automatic Dial, Ring Again, and Busy Override.
 - **Centrex/CLASS** that allow features like Ring Again and Calling Line ID to work on calls with anyone—not just those in the corporate network.
 - **Voice-Mail Systems** that provide reliable service and the flexible use of recorded announcements.
- **ISDN Features**—See the "ISDN" section for a description of ISDN (although ISDN is a standard service, actual feature delivery varies widely according to the switching platform, and Centrex/ISDN synergies may add a competitive edge to the service with some key customers).
 - **Call-Center Services**—(See the following for further details).

This section examines some of the features commonly available with a Centrex offering. The feature set of various vendors' Centrex solutions may vary considerably.

Centrex Line Types

The Centrex customer can choose from among many types of lines and terminals. Any compatible line on a switch can be designated as a Centrex line by assigning that line to a Centrex customer group. Centrex lines can be located anywhere in the switch's serving area—allowing widely separated stations to operate seamlessly as a business network, without the need for tie or off-premises extension (OPX) lines. The following kinds of lines can be included in a Centrex group:

- **Standard Telephone Lines**—The same telephone lines used for residential service can be designated as Centrex lines to support non-proprietary and compatible devices, such as modems and fax machines.
- **Featured Phone Lines**—Centrex also supports featured telephones that offer features beyond those available to a standard telephone.
- **ISDN Lines**—ISDN is a fully standard, all-digital service that delivers two 64-kbps voice or data channels and a 9.6-kbps packet-data channel on a single telephone line.
- **Switched 56 Data Lines**—Switched 56 Data Service offers a 56/64-kbps digital channel for data connectivity among personal computer, host computers, and other devices.

Centrex Dialing Plans

Centrex dialing plans are customized for each customer group. If a business makes most of its calls internally, productivity can be increased by using an abbreviated dialing plan of private extensions. Depending on the size of a business, the number can be as short as two digits or as long as seven digits. A smaller business that makes mostly external calls can use public telephone numbers instead of private extensions.

Centrex End-User Management

All management of Centrex can be handled by the network operator, a distinct advantage for small businesses and other businesses that do not wish to dedicate employee time and company equipment to the task. For those businesses that do want a degree of control over their network, however, many vendors offer end-user management options.

Call Tracking, Fraud Prevention, and Network Security

All businesses today are concerned about unauthorized access to their networks, and preventing fraudulent toll calls from the business network. Centrex can include many options that can help keep data secure and minimize toll fraud.

- **Line Restrictions and Network Class of Service (NCOS)** determine what kinds of calls can be made from individual telephones, or groups of telephones.
- **Authorization Codes** can be assigned to employees to track who makes each call, particularly toll calls.
- **Data Lines** can use many of the security features used for voice lines—such as line restrictions and NCOS.
- **Virtual Access to Private Networks** control access to the corporate network on the basis of the calling line.
- **Station Message Detail Recording (SMDR)** records provide detailed call records from which users can extract unusual occurrences or look for trends.

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Centrex Networking

Without any special arrangements, the Centrex network can often reach anywhere in a serving area, including areas served by remote-access vehicles. All stations enjoy full feature networking and a common dialing plan—just as though they were at the same physical location. In contrast, extending the reach of a PBX system beyond a single site requires the use of tie lines or off-premises extension (OPX) lines.

ELECTRONIC TANDEM NETWORKS

Centrex sites served by multiple switching systems can be unified into a network with the use of private lines. Such an “Electronic Tandem Network” is supported by many PBX manufacturers, enabling the customer’s network to include a wide variety of switching systems. It supports complex alternate routing algorithms based on Class of Service, Time of Day, and available route segments (e.g., satellite).

MULTILOCATION BUSINESS GROUP (MBG)

Multilocation Business Group (MBG) services are designed to meet the needs of multilocation businesses served by more than one switch: those who currently network with private lines as well as those who do not network because they cannot justify the cost.

The major benefit of MBGs is that the customer is provided with private-network access and feature transparency over public SS7 facilities, rather than dedicated trunks. Businesses now using a private-line network can use MBG as an additional option for routing traffic and expanding their network to locations not served by private lines.

MBG allows Centrex and private-network traffic to be placed on public SS7 facilities while retaining customer-group identity. MBG makes this possible by preserving the customer-group identity of intra-network calls over public SS7 facilities. When an MBG call is routed over public SS7, the identity of the customer group is sent to the destination switch. This allows the switches to identify calls among members of the same customer group and handle them differently from other calls on the public network.

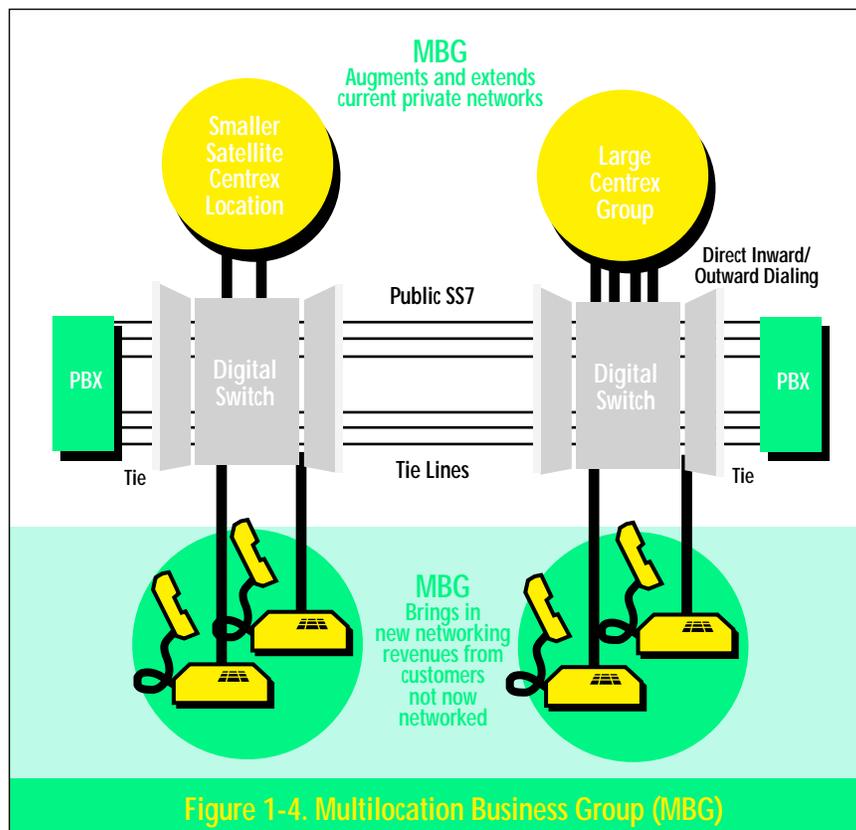


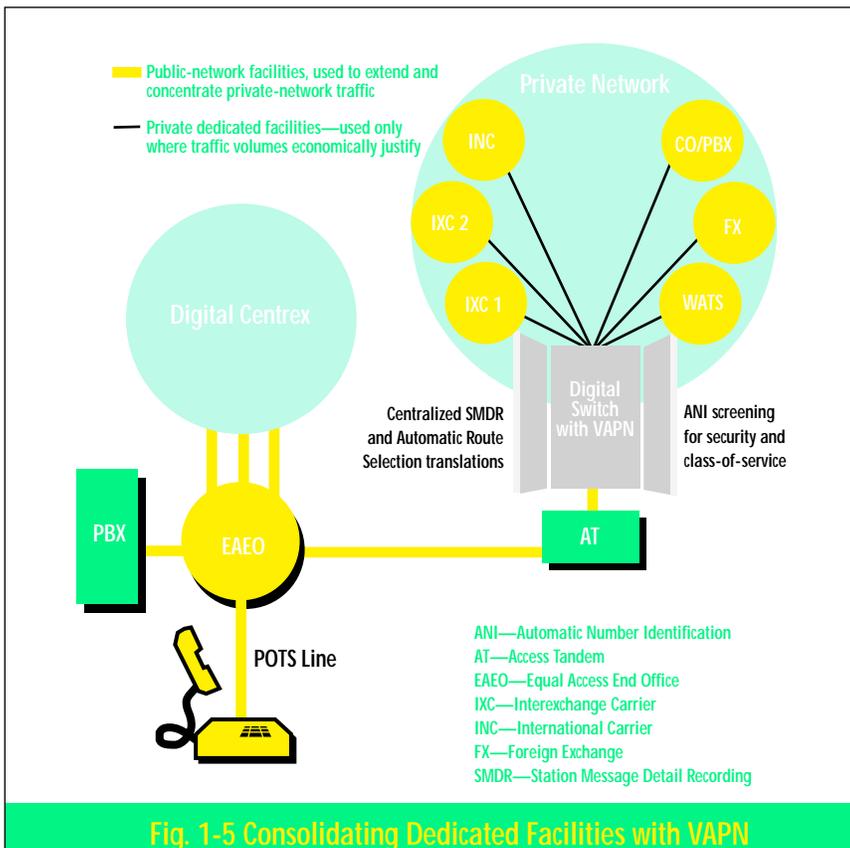
Figure 1-4. Multilocation Business Group (MBG)

With MBG, private-line customers can bring new locations into the network while improving the level of service across the entire network. It allows customer-group identification and other information—such as MSN class-of-service traveling (NCOS) or ETN traveling class mark (TCM)—to be inserted in the CCS7 ISUP message and sent to other switches. As a result, these switches can handle an MBG call differently from a public call.

VIRTUAL ACCESS TO PRIVATE NETWORKS

The basic networking problem facing multilocation businesses is how to link all of their stations with a uniform dialing plan and have their users at remote locations share common calling privileges—regardless of the line-size or location of the branch or type of switching equipment serving the site. But using dedicated facilities to extend the private network and its services becomes increasingly costly with each additional remote location and with each desired service.

Virtual Access to Private Networks addresses these customer concerns by using the reach of the public network to extend private network calling to all sites within the serving area of the access tandem. The dialing plan is uniform for end users across the network, and customers can consolidate their trunking.



Call-Center Services

Automatic Call Distribution (ACD) systems and Switch-to-Computer Applications Interface (SCAI) services are used by businesses to handle a large volume of incoming calls efficiently by distributing them equally among a designated group of answering positions. They typically serve agencies and companies such as mail order houses, government agencies, reservation centers, etc.:

- **Automatic Call Distribution (ACD)** efficiently handles large volumes of incoming calls by distributing them equally among a group of answering positions. ACD systems also offer a complete management information system (MIS) that allows the subscriber to track traffic patterns and agent performance.
- **Switch-to-Computer Applications Interface (SCAI)** allows the subscriber's computer system to interwork with the central-office switch. SCAI makes it possible for a company to coordinate information in its databases with incoming and outgoing phone calls. For example, a company representative can receive a customer telephone call and simultaneously receive the customer's file for viewing on a desktop workstation.

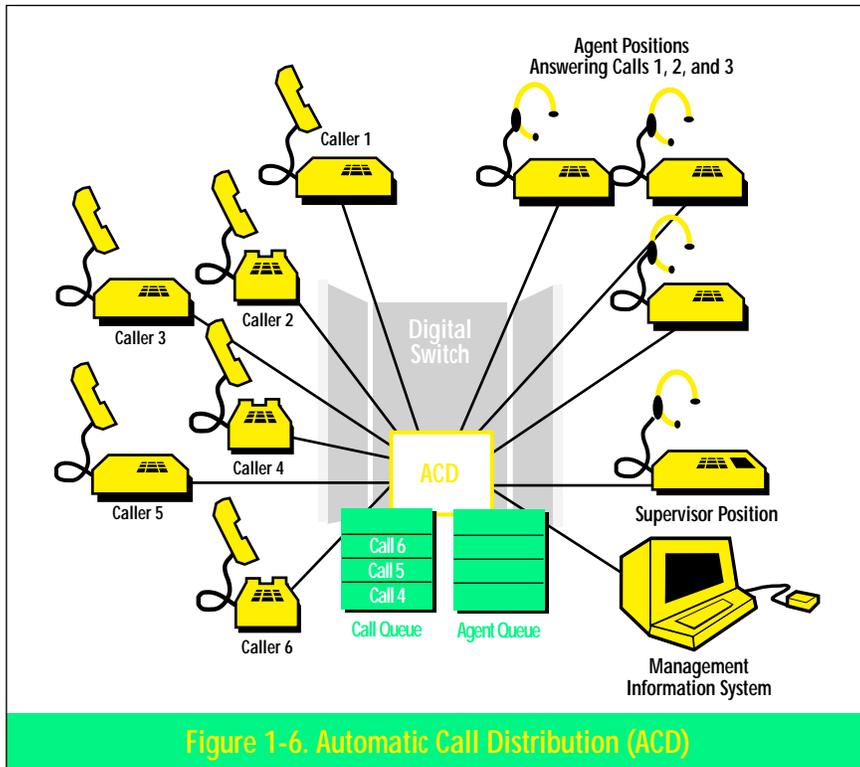
ACD systems are located either at the customer's premises, connected to the public network by trunks, or delivered by the network provider over public telephone lines.

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Automatic Call Distribution (ACD)

Many vendors offer automatic call distribution capabilities through the central office. Central-office ACD eliminates the need for costly hardware and software to reside on the customer's premises—instead, it offers a range of services supplied by the service provider. Just as businesses enjoy Centrex features like call forward and conference calling, they can now use ACD services without the disadvantages associated with standalone systems.

The ACD node queues agent positions and presents the first incoming call to the agent who has been idle longest. If all agents are busy, calls are queued and answered in the order of their arrival. By effectively eliminating the busy signal, ACD has become a highly effective business tool for mail order companies, service centers, telemarketing firms, and other enterprises that rely on the telephone for their revenues and services.



Switch-to-Computer Applications Interface

Switch-to-Computer Applications Interface (SCAI) enables a central office to communicate with a call center's business computer, so a call center can coordinate information in its data banks with incoming and outgoing telephone calls. SCAI services include:

- **Coordinated Voice and Data** provides an agent a screen of information about a caller concurrently with receipt of an incoming calls.
- **Third-Party Call Control** permits a customer's computer to interact with Coordinated Voice and Data to place outgoing calls and provide telephony control from a call center computer.
- **Voice-Processing Integration** allows a host application, interworking with an Interactive Voice Response (IVR) system or Voice Response Unit (VRU) to obtain additional information about callers and direct them to the appropriate agent.
- **Third-Party Agent Control** enables an external host computer to log-in and log-out ACD agents through SCAI signaling.

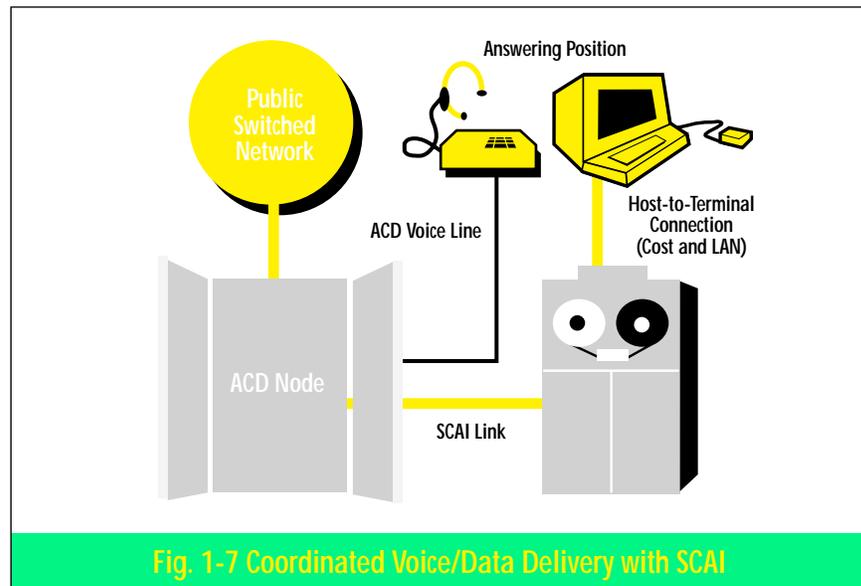


Fig. 1-7 Coordinated Voice/Data Delivery with SCAI

SCAI gives service providers the ability to offer their business customers an economical method to combine voice and data communications. This link makes it possible for a company to coordinate information in its data banks with incoming and outgoing telephone calls. For example, a company representative can receive a customer telephone call and simultaneously receive the customer's file for viewing on a desktop workstation. SCAI can increase productivity in a variety of telemarketing applications, including catalog sales, airline reservations, and customer service.

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Advanced Display-Based Features

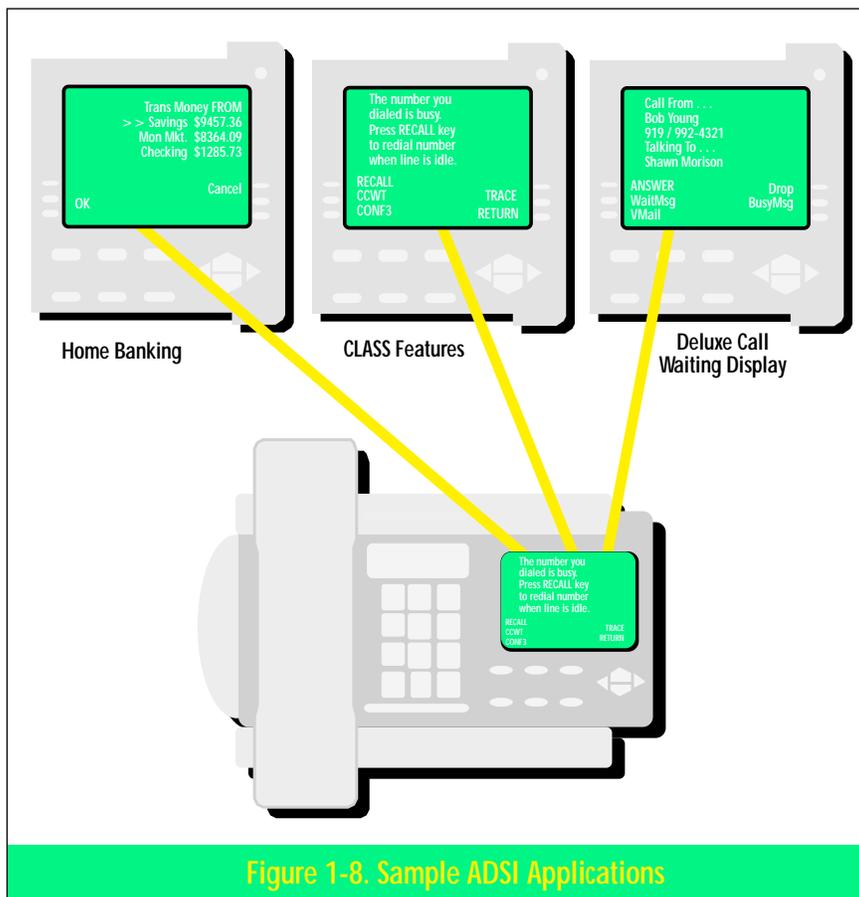
The emerging portfolio of analog display services is being developed by many vendors to comply with Bellcore-defined Analog Display Services Interface (ADSI) standards. ADSI services will employ new residential telephones that feature:

- **Large Display Areas** that can accommodate the display of feature instructions and other text information.
- **Soft Keys**—Feature buttons that change function according to the feature being activated on the telephone. The display area directly above the feature keys indicates their function at any time.

These services offer powerful, time-saving communications solutions to residential and small business subscribers. The flexibility and ease-of-use of these

features can stimulate additional interest in CLASS and help accelerate the deployment of existing and new network services into the subscriber market.

Linking user-friendly terminals with advanced network services provides new revenue opportunities. With central office software and customer premises equipment, service providers can offer end-to-end custom calling solutions—along with an improved interface to custom calling features, CLASS, and voice messaging services—to remain competitive in home and small business markets. In addition, the powerful display capabilities are opening a range of innovative information services, home banking, and advertising possibilities.



ADSI Features

Key near-term ADSI services include:

- **Visual Screening List Editing Features**—The large display area of an ADSI telephone allows the subscriber to easily edit the lists that CLASS features use to screen calls. Some of these screening features include:
 - Selective Call Acceptance
 - Selective Call Rejection
 - Selective Call Forwarding
 - Distinctive Ringing/Call Waiting
- **Call Logging** lists an end user’s unanswered, busy, and forwarded calls—even if the caller doesn’t leave a message. Each log entry provides the following information:
 - Calling party directory number and name (if available)
 - Time and date
 - Number of times that the calling party called
 - Status of the subscriber’s line when the call was logged
 - Current status (new or old entry)

By pressing the Dial soft key, the subscriber can call someone directly from the Call Log entry—even if the call was from a private, or unlisted, number.

- **Call Waiting Display with Disposition**—When a subscriber is already on the phone, Call Waiting Display with Disposition (DSCWID) not only identifies the incoming caller on the telephone’s display window, but provides options for handling the second call. The subscriber can send a “wait a minute” or “call me back” message, or route the call to a voice messaging service simply by pressing a soft key.
- **Call Waiting Deluxe**—This ADSI feature allows the subscriber to conference in the waiting party or drop either of the two callers first.

Voice-Activated Services

Voice Activated Services use the spoken word, rather than feature buttons—to activate and control calling features. Images of the “information superhighway” have unleashed new consumer expectations about how humans will interact with technology. No longer content to cope with remembering multiple access codes or keeping track of numerous telephone numbers, consumers seek time-saving human-machine interfaces. Effortless, instantaneous communications—occurring with the touch of a button or utterance of a word—is not a futuristic pipe dream, but a convenience that is already becoming available for both residential and business users.

Voice-Activated Services offer residential or business consumers the straightforward interfaces they have demanded for products such as computers and VCRs. Instead of difficult-to-recall numbers and access feature codes or cumbersome menus, callers use simple voice commands for services that have already proven their appeal to consumers.

- **Voice-Activated Dialing**—The subscriber simply speaks the name of the party to be called, and the number is dialed automatically.
- **Voice-Activated Network Control (VANC)** lets users access CLASS or Custom Calling features by saying the feature name. Users enter a single code, such as *44, and then speak the feature name. The service interprets the voice commands and provides access to a wide range of features.
- **Message Delivery Service (MDS)** lets callers placing 0+ calls avoid time-consuming redialing when they reach a busy signal or when a call is not answered. MDS automatically delivers messages on a pay-per-use basis—increasing call completion and providing new service provider revenue opportunities.
- **Premier Dialing** lets a caller dial a business simply by speaking the name of the business into the telephone handset. The service recognizes the speech command and automatically routes the call to the appropriate business site or franchise. The Premier Dialing service also can be easily updated to respond to time-sensitive business requirements
- **Auto Attendant** replaces confusing touchtone menus with an easy-to-use voice-activated interface. The service's speech recognition directories can be organized by location, department, product, or any other appropriate method—based on the specific needs of business subscribers.
- **Electronic White/Yellow Pages** support extensive information services and imaginative new audio capabilities that allow users to search information databases by name, telephone number, street, or category.

The ADSI interface, discussed above, provides a complementary service that simplifies access through telephones with displays and soft keys that walk the user through feature activation.

Integrated Services Digital Network (ISDN)

Integrated Services Digital Network (ISDN) is a set of all-digital data and voice services that—like POTS service—use standard interfaces, protocols, and feature sets to ensure that the consumer has a choice of terminals and a standard set of features from which to choose, regardless of vendor.

National ISDN is an agreement by switch vendors, Bell Operating Companies, computer and data-equipment manufacturers, and major ISDN users to develop, deploy, and market a standard ISDN offering. These major players are members of the Corporation for Open Systems (COS), a non-profit organization formed to encourage the widespread deployment of a standards-based telecommunications network—ISDN—through vendor cooperation.

ISDN services can be extended between switches by Common Channel Signaling No. 7 (SS7) and ISDN Primary Rate Interface (PRI) trunks, permitting more efficient use of network resources and allowing the delivery of such advanced network services as Calling Line ID (CLID), and Area-Wide Centrex (AWC).

Integrated Services Digital Network (ISDN) lines can be integrated into a Centrex group, with access to National ISDN features and many value-added Centrex features.

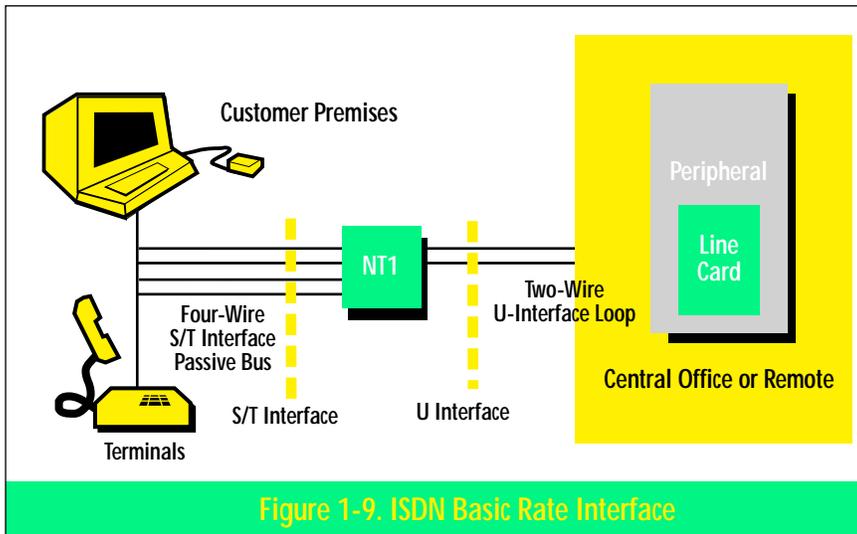
ISDN Basic Rate Interface (BRI)

The Basic Rate Interface (BRI) is the basic subscriber loop, delivering two 64-kbps channels (called B channels) and one 16-kbps channel (called the D channel) over a standard twisted-pair loop. Each of the circuit-switched B channels can transmit voice or data simultaneously, while the D channel transmits call control messages and user packet data at up to 9.6 kbps. BRI maximizes the value of today's copper-pair wiring by supporting higher data speeds and more accurate transmission compared with today's analog modems.

The interface between the subscriber's terminals and the NT1 (the small box that provides interface between the customer's equipment and the network) is known as the "S/T interface." The interface between the NT1 and the line card is known as the "U interface." Both these interfaces have been standardized so that any standard ISDN terminal can connect to any standard NT1, and any standard NT1 can connect to a standard ISDN line card.

ISDN Primary Rate Interface (PRI)

Increasingly, businesses are managing hybrid networks of public and private facilities. The problems of maintaining access to public-network services, connectivity with network elements, and a consistent grade of service at all customer locations are becoming more complex. Northern Telecom's Primary Rate Interface can help customers solve these problems, while increasing public-network traffic and opening up new revenue opportunities for the network provider.



ISDN Primary Rate Interface (PRI) is a digital four-wire service that divides the familiar 1.544-Mbps T1 trunk facility into twenty-three 64-kbps B channels and one 64-kbps D channel. The B channels carry voice and data at up to 64 kbps, while the D channel carries out-of-band signaling for one or more Primary Rate links.

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Primary Rate Interface (PRI) can serve customer-premises equipment, such as a private branch exchange (PBX), Local Area Network (LAN) gateway, or host computer, or can serve as a trunk interface between central offices. It is also the basis for Multi-Rate ISDN/Dialable Wideband Service, which allows wideband connections to be dialed through the public network as easily as a telephone call.

PRI—as a private trunking protocol—can be used by all-Centrex networks as interoffice trunks. PRI offers many of the advantages of SS7 to customers who wish to keep their interoffice traffic on private trunks.

Switched 56 Data Service

Switched 56 kbps Service is currently used by many service providers as a low-cost digital dial-up alternative to leased lines or analog services. Most importantly, the service is easy to use—the subscriber simply dials another user's directory number with compatible data capabilities to transmit data at 56 kilobits per second (kbps).

In addition to offering the flexibility of access on demand, Switched 56 kbps Service is useful for applications requiring high speed and a constant data

communications flow, such as videoconferencing, image transfer, accessing or bridging local area networks, Group IV fax, private line back-up for disaster recovery, 3270 remote access, high-grade audio, and the most popular data services, including telecommuting.

Common Switched 56 kbps applications include:

- Videoconferencing
- Access to frame relay networks
- Access to the Internet and other information services
- File transfer
- LAN interconnection

Switched 56 kbps Data Service commonly interworks with the more sophisticated ISDN Basic Rate service.

Multi-Rate ISDN/Dialable Wideband Service and Other Bandwidth-on-Demand Services

The emerging needs of today's customers for high-bandwidth applications—such as quality video transmission and videoconferencing, CAD/CAM applications, bulk data transfer, and private-network backup and augmentation—require bandwidth greater than the 64 kbps of today's narrowband public network. Dialable Wideband Service (DWS)—also known as Multi-Rate ISDN—addresses the need for dialed wideband connections without the need for private lines.

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Subscribers are provided the flexibility to dial a single directory number, select the desired bandwidth on a per call basis (from 128 kbps through 1.536 Mbps in 64-kbps increments), and dial any other DWS subscriber.

As a public-network capability, DWS allows several sophisticated applications to be easily integrated into public and hybrid data networks. Because of this, DWS provides the advantage of reaching beyond private-line networks to any wideband subscriber on the public network.

In some markets and situations—especially for rural startup markets—similar capabilities can be delivered through a combination of Switched 56 kbps Data Service and inverse multiplexers (customer premises equipment that aggregates individual 56-kbps channels to provide a bandwidth of up to 24 channels over a single DS-1 line) that allow the subscriber to deploy bandwidth-on-demand to meet the application.

DWS and Bandwidth-on-Demand Applications

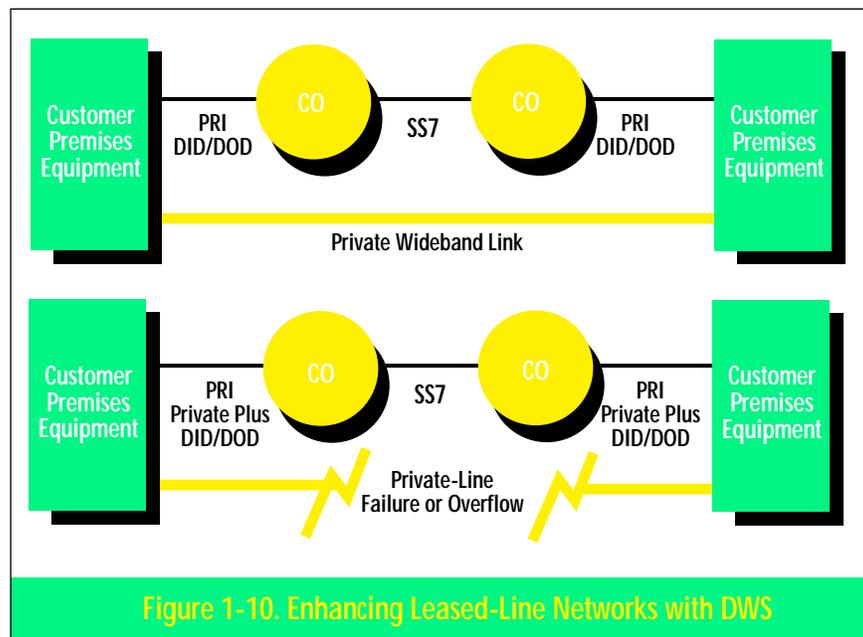
Prime examples of DWS and other bandwidth-on-demand applications include:

- **Videoconferencing**—In conjunction with the falling price of videoconference systems, the image quality at fractional T1 rates has also improved. The lower bandwidth has allowed users of videoconferencing systems to maintain quality while decreasing their costs. With DWS or other bandwidth-on-demand services, the end user chooses the desired bandwidth, and therefore the picture quality, at call set-up time. For example, for a small informal meeting, 128 kbps (two channels) would provide an adequate picture quality. A larger meeting might require 384 kbps (six channels), while a meeting with an external customer would probably require 768 kbps (twelve channels). DWS provides this level of flexibility for the user.
- **Criminal Justice**—Criminal justice applications such as remote bookings and hearings already use video technology today. Distance learning could also be available for prison inmates desiring to complete a course of study.
- **Distance Learning**—DWS and other bandwidth-on-demand services provide an economically attractive alternative to more expensive DS-3 bandwidths for many distance learning applications—an economy that is particularly persuasive to many budget-conscious school districts. The current (and constantly improving) video compression algorithms make it possible to achieve good quality at 768 kbps (half T1).
- **Medical Applications**—DWS and other bandwidth-on-demand services are also ideal for the high-speed data required for medical applications such as image transfer. For example, a hospital can use an X-ray scanner to record information on a patient's condition, and forward the information to another location for expert analysis. Doctors could dial into a university classroom to listen to a special speaker on recent medical treatments, while viewing her presentation materials and a video image.
- **On-Demand LAN/WAN Interconnectivity**—DWS and other bandwidth-on-demand services may also be used for interconnecting Local Area Networks (LANs) into Wide Area Networks (WANs). Because they are switched services that are deployed nationally (and later internationally), they can connect LANs anywhere in the network to create corporate or intercorporate WANs on-

demand instead of using dedicated services. This ability to make intercorporate connections can be of particular advantage to corporations that need to share information with key suppliers and customers.

- **Electronic Data Interchange (EDI)**—Another model application for DWS and other bandwidth-on-demand services is the transmission of large amounts of data or bulk data transfer, known as electronic data interchange (EDI). Whether for corporate database reconciliation or the transmission of regional reports, bulk data transfers are characterized by the need for economical intermittent or regular high-bandwidth connections for extended periods of time.

The high cost of leasing and maintaining a private-line network is prompting businesses to consider hybrid solutions that can lower private-line expenses and improve network performance. DWS in particular is useful for allowing a subscriber to make a wideband connection over the public network to handle traffic overflow and private-line disaster recovery, and cost-effectively extend wideband services such as video transmission and conferencing, data storage/retrieval, and LAN interconnectivity to locations outside the private network.



The community of interest is changing for wideband services. It is moving away from being only an intra-company technology—used site-to-site within one company or business—to being also an inter-company, public technology. DWS affords new opportunities to offer value-added services to current private-line customers and address the wideband needs of customers who cannot now afford private lines. DWS is the solution for those who need wideband services, but not necessarily a private network.

Frame Relay Service

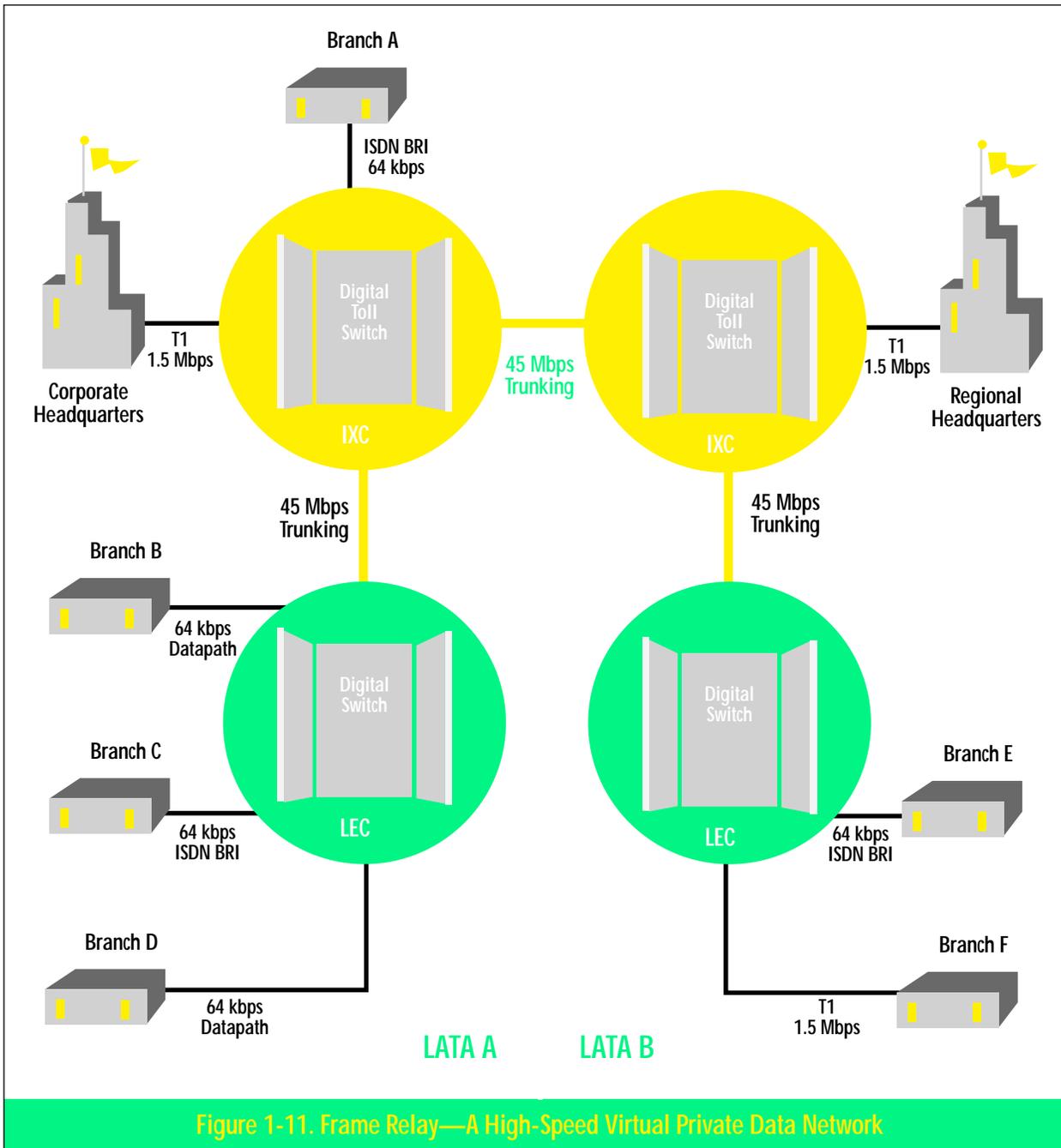
Frame relay provides non-switched bandwidth-on-demand and reduces the customer's network equipment and administrative costs by providing multiple virtual circuits for each physical access port. With frame relay, the customer can have a logical end-to-end link—a virtual private network—between all points connected to the service. While it appears to the customer as a dedicated private network, the virtual circuits and DS-3 internode trunking make frame relay a more cost-effective, higher-performance service than the alternative of dedicated private lines.

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With frame relay, a data site can interconnect with all other sites through a single access line to the network, creating a high-speed virtual private data network.

Moreover, with frame relay, logical links (new sites) are added or reconfigured with minimal interference to the existing network. The addition of another user site involves merely the physical connection of that site to the network and the establishment of an address to allow communications between other authorized sites. The result is a solution with higher throughput, greater connectivity, simplified network management, and lower cost.

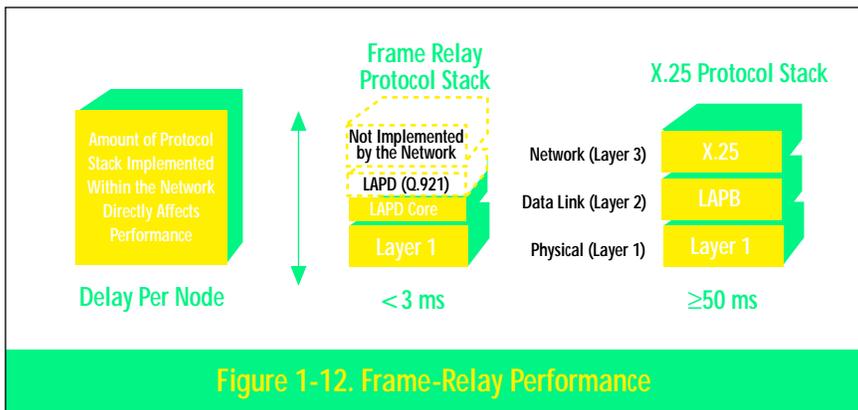
Frame relay is a modernization of X.25. Developed during the late 1970s, X.25 was designed to provide reliable data communications over error-prone analog networks. As a result, X.25—an open system interconnection (OSI) Layer-3 service—performs store, error-detection, and forward operations for every packet at every node in the network to ensure delivery. With the advent of digital transmission, network reliability has improved to the point that X.25's additional store and forward error checking represents unnecessary overhead in many cases, increasing delay and limiting access speeds.



Frame relay increases data networking performance by reducing the number of OSI layers that must be traversed at each node of the network (see Figure 1-11). With a frame relay network, two layers of protocol are implemented, while three layers are implemented for an X.25 network.

Frame relay can therefore provide faster access and transport speeds with less transmission delay. Frame relay switching and transmission delay is less than 3 milliseconds per node whereas X.25 switching and transmission delay can be up to 50 milliseconds per node. Frame relay's rapid and efficient method of data transport assures reliable delivery plus substantial performance improvement over current LAN interconnect solutions.

Switches that are not equipped with frame relay service can be provisioned with additional equipment that allows them to provide access to the frame relay network.



LONG DISTANCE SERVICES

In the competitive long distance market, the service provider needs a platform that offers a service-rich system that makes extensive use of advanced signaling systems such as SS7 and ISDN PRI, as well as Intelligent Network (IN) capabilities. In addition to toll revenues, the long-distance provider can offer additional revenue services, such as information databases, enterprise networking, data and video services, and multiple dialing plans such as International Direct Distance Dialing (IDDD).

Information Database Services

Information databases allow network providers to hold subscriber calling and called party information in a few locations rather than every central office to assist interexchange call processing and IN applications.

- **700 Number Services**—Number translations that allow the carrier to offer customer service numbers to its customers for information and assistance with network-offered features.
- **800 Number Services**—Number translations that allow businesses to receive, and pay a bulk rate for, high levels of incoming calling traffic across LATA boundaries.
- **900 Number Services**—Special translations that allow a business to conduct public opinion polls across a wide calling area or provide information when a subscriber dials an assigned 900 number exchange; the caller pays for 900 services.
- **Account Codes** provides collection and optional validation of Account Codes (2 to 12 digits in length) for customized billing identification methods while increasing protection against fraud on the network.
- **Authorization Codes**—5- to 7-digit numbers used for validation and feature activation over non-equal access trunks, and which play a key part in establishing virtual private network (VPN) services as well as protecting against fraudulent use of the network.
- **Calling Card and Personal Identification Number (PIN) Calls** recognizes dialed codes as a request by the customer for access to a special long distance service, carrier, or billing account.

Enterprise Network Services

Long-distance providers can offer various services that maximize the private use of public facilities by businesses that need cost-effective and efficient telecommunications outside LATA boundaries.

- **Dedicated Access Lines (DALs)** allow a business to lease public network trunks and use them for private wide area network (WAN) data communications.
- **Networked Centrex** allows Centrex business customers to use switching systems in a private network and communicate with other locations using an exclusive number exchange for intra-business calling.
- **Virtual Access to Private Networks (VAPN)** allows multilocation business customers to route private network traffic through public facilities and cross LATA boundaries to other company branches without the expense of leasing private lines.

Data and Video Services

Interexchange data and video switching is growing at an increasing pace as businesses expand operations and require sophisticated communications technologies to keep them competitive.

- **ISDN Primary Rate Interface (PRI)** provides highly reliable and flexible trunking facilities for traffic aggregation to WATS, DWS, and other services; enterprise-based hybrid network switching, and compatible interfaces with interexchange SS7-based networks.
- **Ethernet and X.25 File Transfers** provides high-speed data transfer for specific business network applications.
- **Bearer Capability Routing** routes an incoming call based on the contents of the user service information within the PRI or CCS7 messages.
- **Integrated Echo Cancellation**, on a per-call basis, employs the intelligence of digital switching to enhance the quality of transmission and allow the integration of voice and data within the network without the expense of external echo cancellers.
- **Dialable Wideband Service** offers on-demand, easily tracked connections of variable bandwidth—such as that required in videoconferencing—over public facilities, potentially reaching any subscriber in the international numbering plan.

Multiple Dialing Plans

The long-distance switch can recognize, process, and route different signaling protocols and multiple dialing plans.

- **Full 10-Digit Routing** provides 10-digit routing to the station level.
- **7-Digit On-Network Routing** facilitates VPN services by allowing private-to-private, private-to-public, and public-to-private network 7-digit dialing.
- **User Partitioning** allows multiple private users to share trunk facilities.
- **Private and Public Speed Dialing** allows abbreviated dialing for long distance calls.
- **Hotline Number Dialing** is an emergency number service that allows the user to connect to a dedicated number without dialing it.
- **Automatic Number Identification via DTMF Trunks** facilitates calling line identification to call centers not yet using ISDN PRI trunks.
- **International Direct Distance Dialing (IDDD)** allows direct dialing by the subscriber to international numbers.

OPERATOR SERVICES

In the early days of the telephone, customers called into the operator and simply spoke the name of the person they wanted to reach. Operators looked up the name from a list of subscribers and made the connection. Telephone numbers were not used—they were considered too impersonal—so operators had to memorize the names of all subscribers in their local exchange.

In time, the operator assumed a different role. Day-to-day calling was handled by central-office switching equipment, while operators were brought in to help with calls that required special handling, such as collect calls and directory assistance. Today, operator services are moving into a new era as a profit center, offering a new class of high-value services that accommodate multilingual communities and use sophisticated new technologies such as voice recognition.

Traditional Services

Operator services are usually described in terms of “traditional” and “nontraditional” services, where “traditional” refers to the following types of services.

- **Basic Toll and Assistance**—Although the great majority of calls are processed by the switch without operator intervention, many require some form of assistance for completion. For example, calls placed from public pay phones may require that the caller deposit a quarter, have that coin accounted for, and be notified if the call requires additional coins. Or, callers from any phone may wish to charge the call to the called party, a calling card, or a third number. Calls from hotel guests are controlled so the hotel can bill the guests for all calls before checkout. Some callers may simply wish the operator to provide rate information, general information, or to dial the number for them.

In fact, dialing “0” to reach an operator is such a universal habit that callers often dial “0” instead of 9-1-1 in emergencies. In those cases, the operator must rapidly and accurately transfer the call, with as much pertinent information as possible, to the appropriate emergency assistance center.

The growth of automation has made toll and assistance services more effective than ever, in some cases completely eliminating the need for operator involvement in the call. However, there will always be a need for skilled, thoughtful operators to provide these basic services that only a person can provide.

- **Alternate Billing**—Many of the 0+ calls handled by toll and assist operators are collect calls, calls billed to other numbers (third-party billing), and calls billed to calling cards or commercial credit cards, such as VISA, Master Card, American Express, and Discover. Formerly, these calls always required operator involvement. Today, automated systems perform much of this work.

For example, automated calling card service allows callers to dial “0” plus the number, wait for the bong tone, then enter a calling card number or commercial credit card number to pay for the call. The system uses SS7 signaling to query a local information database to validate the card number.

Automated alternate billing services also use speech recognition and recording technology to accept billing requests and confirm billing acceptance by the party being charged for the call. A voice-processing peripheral prompts the caller to speak his or her name. “Joe.” The system records this response and plays it back to the party to be billed. “You have a collect call from ‘Joe.’ Will you pay for the call?” The system recognizes the “yes” or “no” response and processes the call accordingly. For about 75 percent of such calls, no operator intervention is necessary.

- **Coin Call Service**—At one time, all calls placed from coin phones required operator assistance. The caller picked up the receiver and was automatically connected with an operator—or was connected after depositing a nickel or dime (later, a quarter). The caller dialed the number, and the operator informed the caller how many coins to deposit. The coin phone generated distinct tones after deposit of a nickel, dime, or quarter. The operator listened to these tones, calculated the total deposit, and either connected the call or prompted the caller to enter additional coins. The operator had to monitor the call and, after a designated period, interrupt the call to inform the caller to deposit additional coins. As a result, these calls traditionally required significant operator resources. This service can now be automated, so that 1+ calls can be dialed from a coin telephone station without operator intervention.
- **Directory Assistance**—Directory Assistance (DA) service allows the caller to request assistance from an operator in looking up a directory number. Rather than dialing “O,” the caller dials one of the following: 411, 1-555-1212, or 1-NPA-555-1212. The call is presented to the operator in a screen that immediately identifies the call as a DA call. The operator gets the necessary information from the subscriber and initiates a DA database search. The DA database returns all listings that match the search criteria. The operator selects the appropriate listing and releases the call to an audio response unit (ARU) that quotes the requested number to the subscriber.

New relational database systems support searches by name, business type, custom-defined category, street, or telephone number. Recent advances in computing speed and capacity have improved DA search performance, improving customer satisfaction. For example, keying in the name “Bear” would display listings for Baer, Baier, Bair, Bayer, Behr, and Beyer. Keying the numeral “4” in the name field would display entries for Fourth Estate Publishers, Four Corners Grocery, For Kid’s Sake, and Four Winds Trading Post.

- **Call Intercept**—Intercept is a database-driven service that provides status information on out-of-service telephone line numbers. “The number you dialed, 555-1234, has been changed. The new number is 555-5678.”

The most significant trend in operator services in recent years has been in the automation of traditional services. For example, service providers can automate the greeting and inquiry portion of the directory assistance (DA) call. With this capability, DA callers are greeted by an automated system and asked to state the name of the city and listing they are seeking. The system records the caller’s responses, removes initial and closing pauses, and replays the edited recording to the operator. The operator hears only the information needed to complete the call: “Clayton, Susan Jenkins.” The result is significant savings in operator work time, because the caller has been prompted to produce a concise response, and the operator is brought into the interaction at a later point.

Automated services relieve the operator from handling many rote, repetitive tasks—and increase the level of service the operator can provide to callers who need it the most. Automated services also reduce operator work time and free operators to provide value-added services.

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Value-Added Service Opportunities in the Operator Services Market

Value-added service opportunities fall into two categories: enhancements to traditional service offerings and innovative new services that have not traditionally been provided by telephone operators. In the first group are such enhancements as the following:

- **Custom Intercept Announcements**—Customized and personal message services can be sold to subscribers on a monthly or per-use basis. Customized announcements can be created to include valuable information about the called number or party—even for “split referrals,” where one number has been changed to two or more new numbers. “Ajax Dry Cleaners has moved from Maple Street to 1200 Mahogany Road. The new number for Ajax Dry Cleaners is 555-2200.”

The subscriber can record the announcements in his or her own voice, if desired. “This is Dr. Alice Winters. I have relocated to Suite 1600 in the Medical Office Building at 400 West Avenue. My new number is 555-4200. If you’ll stay on the line, you’ll be automatically connected to my new office.”

Announcements and call handling can be different according to the time of day or the day of the week.

- **Automated Intercept Call Completion**—An enhancement to basic intercept service provides value to business subscribers who expand their businesses or change locations but want to protect their incoming calls (and the revenues from those calls). The change is transparent to their customers—when customers call, they are connected to the business itself rather than to an announcement of a number change that leaves them with the responsibility for initiating a second call. No action is required by the caller, who simply stays on the line to have the call completed. An announcement of the number change can be made or not, at the discretion of the subscriber. Charges for the service are paid for by the called party, not the caller—usually as a flat monthly fee. If desired, automated intercept can be offered with personalized messages as a premium service.
- **Directory Assistance Call Completion**—This familiar service offers callers automatic connection to the number requested during a DA call, without redialing. For callers, this service offers a fast and simple way of reaching the person whose number they had requested—especially helpful if the caller is making a one-time call, has difficulty dialing, doesn't have a pencil, or needs a fast connection. DA call completion is particularly convenient for callers using cellular phones in their cars.

By charging a modest fee for this service—or by increasing the air time of cellular calls—the service provider gains a new revenue source. Alternate billing options for the call-completion service can increase these revenues even more.

Non-Traditional Operator Services

The traditional services described earlier have been offered by U.S. and Canadian telephone operating companies for many years, and many automated enhancements to these services are already a familiar part of the telephony landscape. The greatest opportunity for service providers to differentiate their offerings lies in new, non-traditional listing and information services.

The industry trend toward open architectures and open communication protocols lets service providers act on their own ingenuity—creating innovative new revenue-generating services to fit their very specific needs. With increasing interoperability among services and equipment from different vendors, service providers can do any of the following:

- Create custom information and listing applications that use powerful relational databases to send information to operator workstations or end users.
- Program intelligent operator workstations to support these new services.

- Define hundreds of call queues and agent profiles to closely manage the flow of calls to operators for these new services.
- Use audio development tools to create custom announcements, speech recognition vocabularies, and interactive “audiotext” applications.

Sophisticated call-queuing capabilities make it simple to route and manage calls for those services or systems separately from calls requiring traditional operator services. By tapping into databases, operators can offer callers such information as zip codes, sports updates, stock quotes, operator-assisted yellow pages, local directions, hotel and restaurant listings, order-taking for retail and service organizations, wake-up service, and weather conditions around the globe. The possibilities are limited only by imagination and regulatory constraints.

OVERVIEW OF THE PUBLIC NETWORK

The primary expectation of North American telephone subscribers is that they should be able to pick up their handset at any time and speak to virtually any other person in the world. This section provides a general overview of the organizing principles behind the vast and intricate fabric of lines, trunks, and exchanges that have evolved over the last century into the most sophisticated network in existence.

The Network Building Blocks

The most fundamental principle of that network is quite simple—because it would be impossible to install a line from each caller to every other caller, the telephone system is a switched network. A switched network brings each subscriber line into a centralized switching system, where connections are made for each call.

In addition to the switching systems such as Northern Telecom's DMS-500 or DMS-10 that route incoming voice and data calls to their destinations, the two other key components of a public switched telephony network are:

- **Access Lines** that carry traffic to and from subscribers. Access lines can be either physical connections such as “copper, fiber, or coax, or they can be built on wireless technologies. This part of the network is often referred to as the “local loop.”
- **Transmission Systems** that interconnect switching systems by copper wire, optical fiber cable, or microwave radio transmission. This interoffice facility is often called the “transport network.”

This section overviews basic design of the public telephony network and the basics of the underlying technology behind these network components.

The Organization of the Network

- Local Loops and End Offices
- Tandem, Operator Services, and Toll Switches
- International Gateways

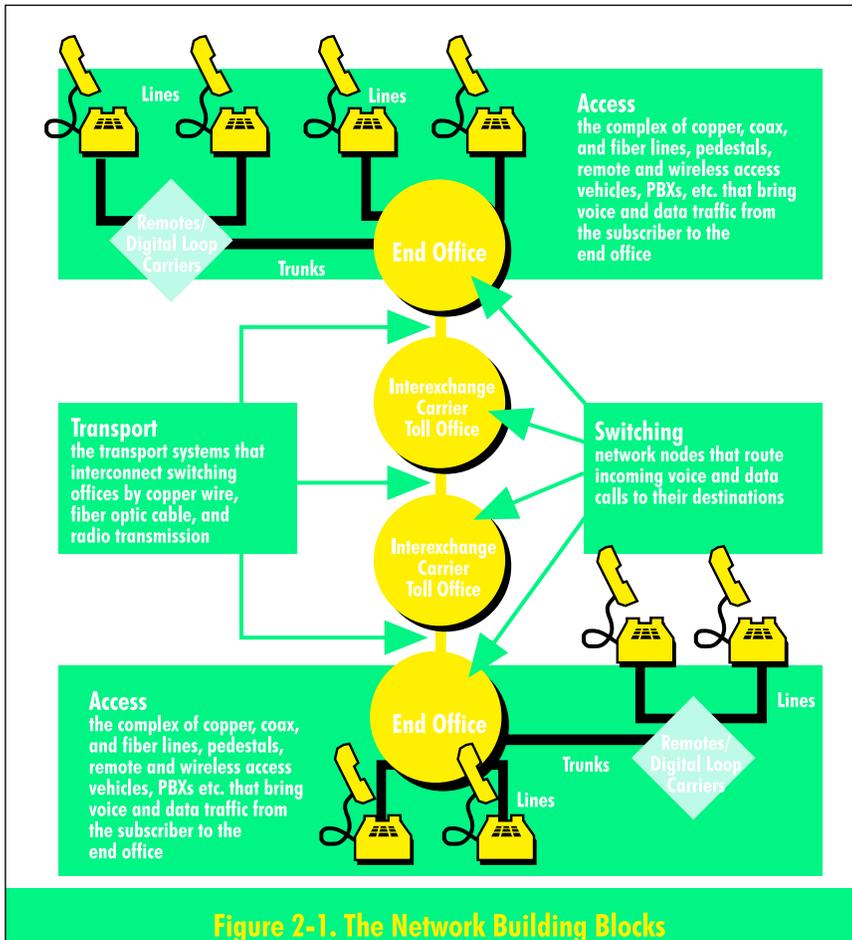
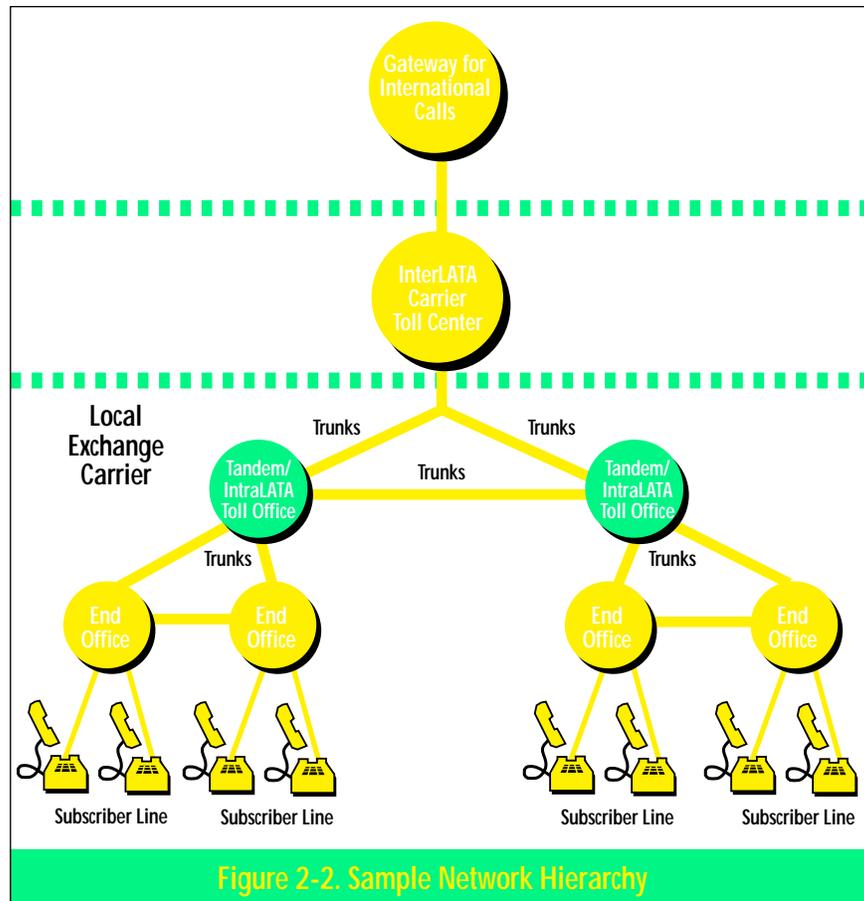


Figure 2-1. The Network Building Blocks

The switches that form the core of the public telecommunications network fall into three main categories (see Figure 2-1).

- The telephone or data user is connected through the local loop to an end office.
- End offices are linked to tandem offices that switch traffic between central offices (and are generally where operator services are provisioned)—and to toll offices that carry long distance calls.
- International Gateways provide connectivity to networks around the world.

The public telecommunications network in the United States is organized such that each telephone user is connected by a subscriber line—or loop—to a local central office, also called an end office. (For a full discussion of the end office and the local loop, see the section that follows.) Groups of subscribers are divided into areas served by their own local exchanges. Traffic is carried from one office to another on trunks, which can carry traffic for many calls.



Calls that are bound for a destination served by another switch usually go over trunks to a tandem switch that switches trunk traffic from one office to another. Tandems that are toll centers (toll/tandem centers) have telephone operators and long-distance billing equipment. Some central offices switches—such as the DMS-100/200—serve as a combination end office and tandem/toll centers.

The Historical Network Hierarchy

In the past, the North American public switched network was really a hierarchy of smaller networks, each with its own switching center. Telephone calls were classified and designated according to a hierarchy, or rank, of the switching function performed. In the North American classification system, the switching function was organized into classes numbered 1 through 5, with Class 5 assigned to the **End Office**. Classes 1 through 4 were designated as **Toll Centers**. The national public network connects to international telephone networks through a switch called an **International Gateway**.

Long distance calls entering the network through the caller's end office would climb the switching hierarchy in search of an idle circuit. If the most direct route was busy, the call moved up the hierarchy to the next switching center, and the next, until a path was found to complete the call. The Class 1 office is the highest level to which the search can be carried out. International Gateways are equipped with software that can translate telecommunications protocols used in one portion of the world into protocols recognizable by switches at the destination.

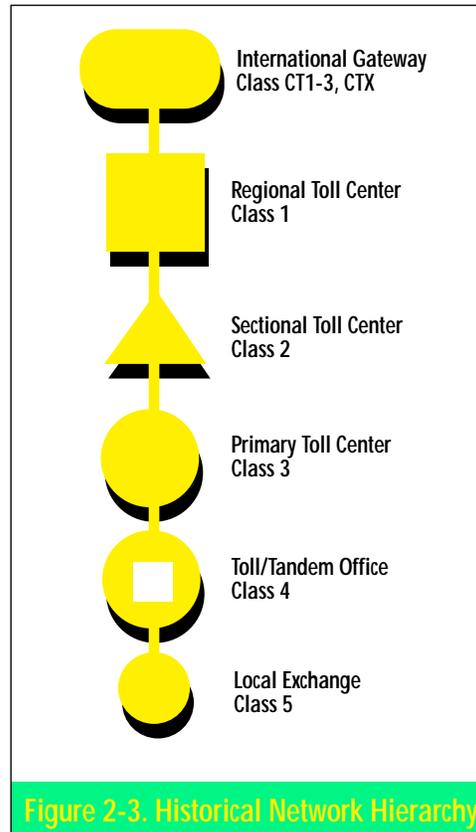


Figure 2-3. Historical Network Hierarchy

Although the structure of the public network has changed and flattened, reducing the need for as many distinctions between toll offices, the Class 5 end office and other traditional switching center nomenclature is still in use.

Types of Carriers

Until the early 1980s, most of the public switched network in the United States was in many respects an AT&T monopoly, set up to ensure universal service and to keep the price of local calls to a minimum. AT&T usually carried traffic the full trip from the originator's phone through an extensive long distance network, to its final destination.

A series of antitrust suits prompted the 1982 Modified Final Judgment (MFJ) from the federal judiciary, which broke off the seven Regional Bell Operating Companies (RBOCs—Ameritech, Bell Atlantic, BellSouth, NYNEX, Pacific Telesis, Southwestern Bell, and US West—often called the “Baby Bells”) from AT&T and prohibited the company from offering local telephone services.

Local Exchange and Interexchange Carriers

This divestiture created two essential types of wireline carriers in the U.S.:

- **Local Exchange Carriers (LECs)** which make connections for calls originating and terminating in the same local area.
- **Interexchange Carriers (IXCs, sometimes abbreviated as IECs)**—Long distance providers which take calls originating from one LEC and transport it for connection to a caller outside the local area.

Competition for the long distance market that opened up in the early and mid 1980s immediately started generating the over 500 IXCs that currently compete for long distance traffic in the U.S. Growing competition in the local exchange market has also brought a range of new groups into this market segment.

Competitive Access Providers (CAPS)

Capitalizing on the initial hesitation of many embedded local carriers to lay fiber to markets they already served with copper, CAPs moved into many of the larger cities in the U.S. in the late 1980s to try to capture large business users. By laying state-of-the-art fiber rings around major metropolitan areas, these providers were able to win some of the LEC's most attractive customers, offering competitive prices, increased survivability of the network, and especially responsive service, as well as meeting the growing demand for emerging wideband services. Large end-user's desire to diversify their networks and to provide duplicate communications paths in the event of network outages solidified the presence of CAPs in the local market.

Wireless Access Providers—Cellular and PCS

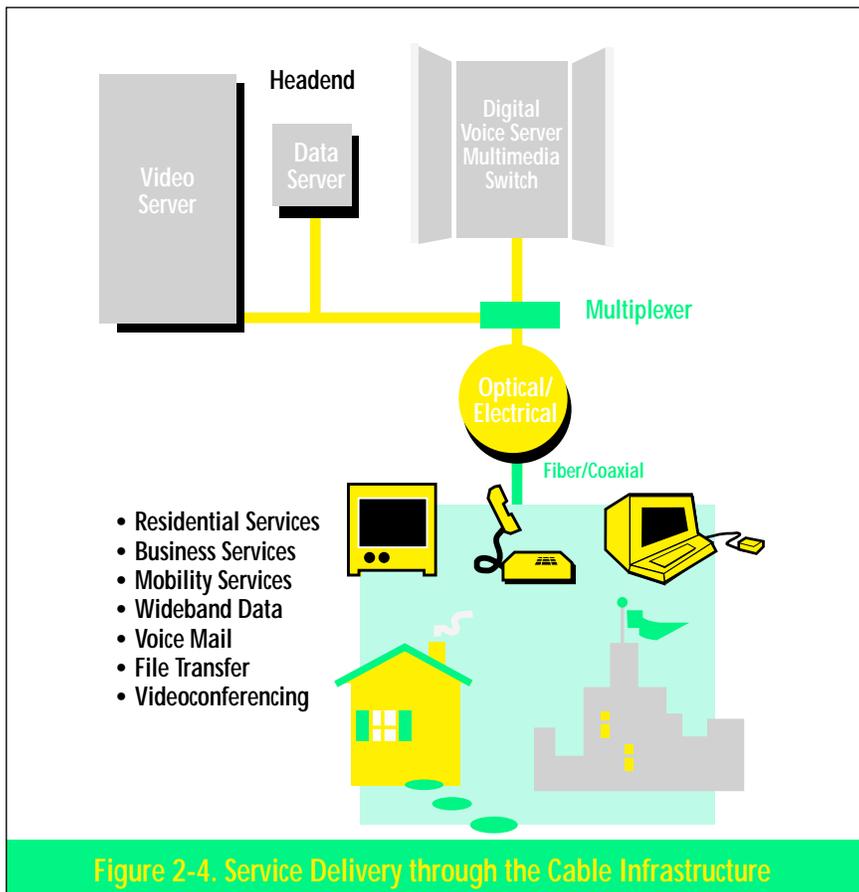
Traditional cellular and special mobile radio service is a firmly entrenched access method in North America, with 1993 revenues of over \$10 billion dollars. In the past, this service has largely been seen as complementary to wired local-exchange access, providing mobile service to customers who were also connected to the network at another fixed location such as their home and business.

The newly emerging range of Personal Communications Services (PCS) may soon change this equation. Low power PCS systems able to follow subscribers as they roam around a building or neighborhood—coupled with wireless data capabilities and the full feature set of traditional wired services—can provide a powerful alternative to wired copper lines into a business or home. Such strategies will likely be especially attractive to providers such as cable companies, which can use wireless access to move subscribers onto their already existing backbone networks. Wireless technologies also provide entry to profitable second-line services.

Cable Television Providers

Cable companies' embedded infrastructure of coaxial cable going in or by residences positions them to be a major player in the local exchange market. New coax phones and/or wireless sets and distributed antennas mounted onto the cable strand are delivering the technologies to make access cost-effective. And the cable company's ability to bundle video, voice telephony, and data services gives them powerful market leverage when approaching the residential marketplace. This advantage is emphasized by the ubiquity of the cable plant already in place in many localities. Cable providers in the U.S., for instance, already pass about 90% of residences, and have placed their services into approximately 60-65% of the homes where they offer service.

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The Importance of LATAs

To define exactly what was a local call or service—and thus the province of the local exchange carrier (LEC)—and what was an interexchange call, the MFJ established a series of Local Access and Transport Areas (LATAs) that divided the geography of the United States into a series of local service areas. Calls that originate and terminate in the same LATA can be carried by an LEC such as BellSouth, NYNEX, or Ameritech. Under current MFJ rulings, calls across a LATA boundary cannot be transported by the Regional Bell Operating Companies (Independent Operating Companies [IOCs])—that is, the local carriers who operate mainly in rural areas of the U.S., with the exception of the seven regional Bell companies and GTE—are not constrained in this way).

Interexchange carriers (IXCs) such as AT&T, MCI, Sprint, or WilTel typically carry calls across LATA boundaries.

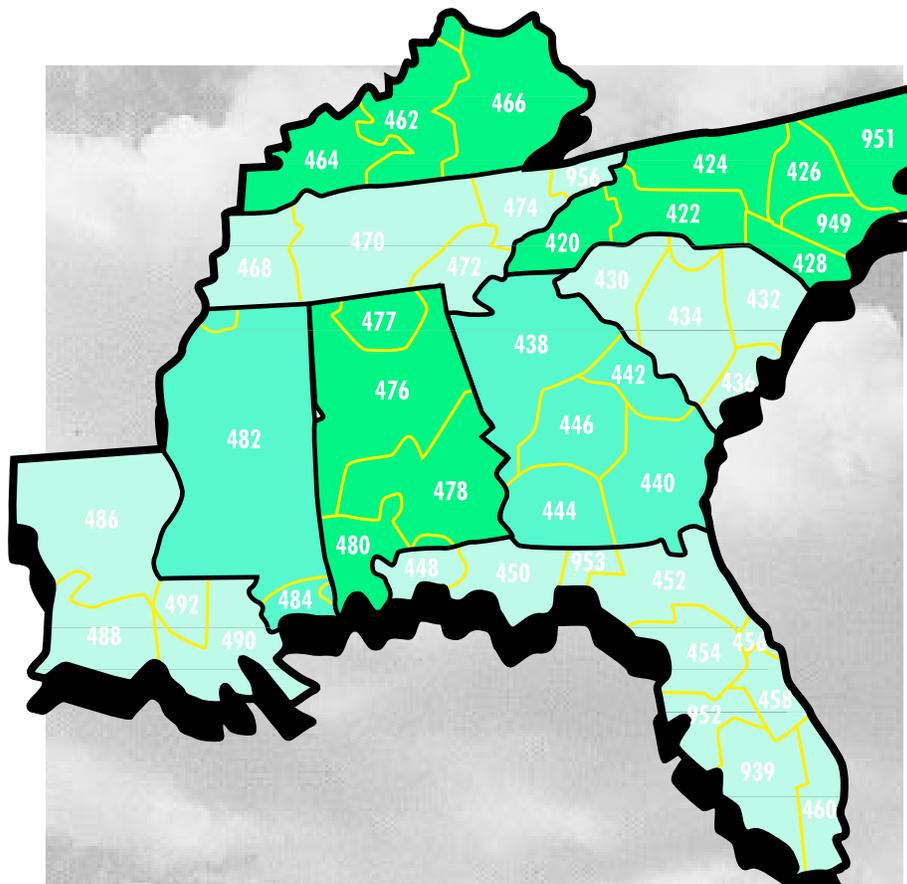
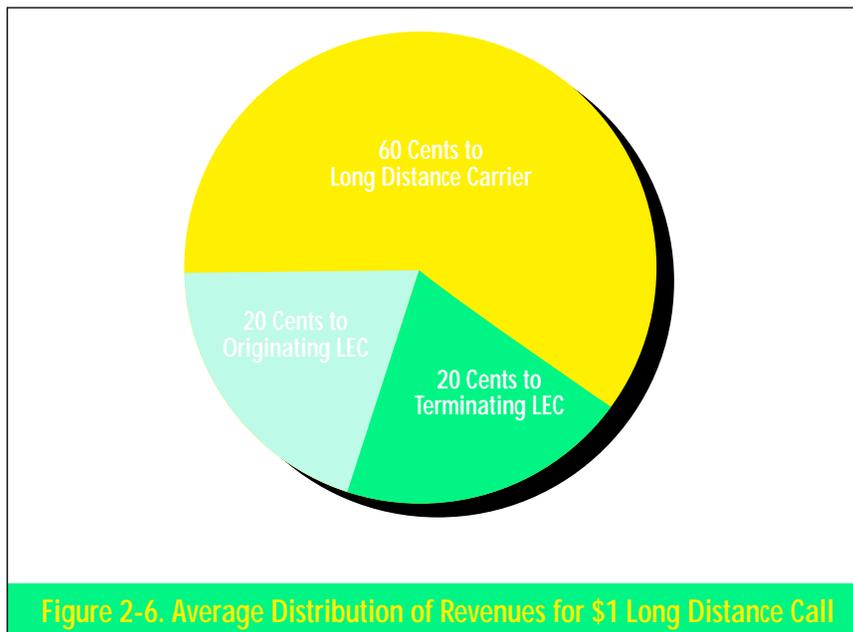


Figure 2-5. Sample LATA Map (South East Region)

POPs and Access Charges/Interconnection Fees

IXCs are entitled by the MFJ to establish points of presence (POPs) in each LATA so that calls originating in the LATA can be routed into the IXC network for transport across LATA boundaries. The per-call access charges paid by the IXCs for connection to the local network have become a major source of income for the local telephone companies, representing almost 40 percent of their revenues (and even larger percentage of their profits) in 1993. This large pot of money—approximately \$25 billion in 1993—has spawned intense competition and encouraged new market entrants, as well as generating unprecedented legal and lobbying activity to either protect or reduce the level of these charges.



To complete calls within a local calling area, service providers must connect to the facilities of the local telephone company. This ability to interconnect is regulated on a state-by-state basis. In some areas the established carrier can block any competitors from connecting to their networks, and in others established tariffs set by the state utility commissions or other regulatory agencies may disadvantage the new entrant.

Often the type of interconnection tariff applied to the new entrant is based on whether the carrier is classified as co-carrier or a reseller. Co-carriers (that is, companies considered as full peers to the telephone company) usually pay lower interconnection charges, but the new carrier is also likely to be subject to similar

stringent regulations as those that govern the established provider. Resellers, on the other hand, are less regulated but may have to operate under less favorable tariffs.

Equal Access

The equal access agreements of the Modification of Final Judgment (MFJ) are designed to ensure that subscribers served by the BOCs and GTE can easily access the long-distance carriers of their choice. Specifically, the BOCs and GTE must provide IXCs with “equal access”—access equal in type, quality, and price—to any of their respective local switches that serve over 10,000 lines.

Although the MFJ is not applicable to other service providers, in March 1985 the Federal Communications Commission (FCC) ordered that, if an IXC other than AT&T requests it, an independent service provider has three years to provide exchange access services that are equal in all respects to that offered to AT&T. If the independent can demonstrate unfeasibility, it may apply to the FCC for a waiver with a three-year time limit.

Equal access was mandated in Canada on July 1, 1994.

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Equal access routing is provided through a software program in the switching system. Depending on the economics of deployment, network providers generally provide equal access connectivity to long distance carriers at either an equal access end office (EAEO—an end office with the necessary equal access software) or at an access tandem equipped with equal access capabilities. Non-conforming end offices (offices without the equal access software) route toll traffic to a tandem with specialized software to satisfy the equal access requirement.

To accomplish equal access, each long-distance carrier is assigned a carrier identification code (CIC) of five to seven digits. Subscribers can dial these digits with each long distance call (this method is called “casual access”), or can pre-subscribe to a particular carrier and the switch software can add the CIC to dialed digits for each call.

Numbering Plans

In order for calls to reach their proper destinations, subscribers must have telephone numbers that are both unique and recognizable by all the switches in the public network. This is accomplished globally under guidelines of the CCITT, the pre-eminent international telecommunications standards organization. In the U.S. and Canada, the numbering process—the North American Numbering Plan

(NANP)—is implemented under the auspices of the North American Numbering Plan Administration (NANPA), a private group overseen by the FCC.

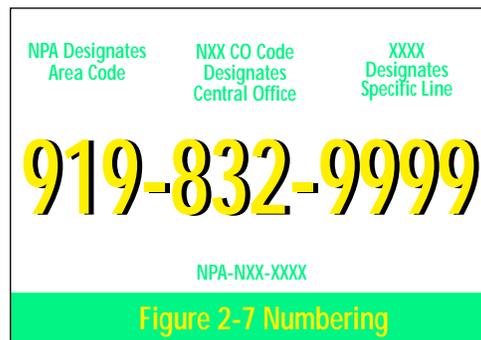
The assigned number consists of four parts:

- **A country code**—to designate the international destination.
- **A three-digit area code**—to identify the area of the country. In industry lingo this is the *NPA (numbering plan area) code*.
- **A three-digit central office code**—to designate to which switch the subscriber is connected. In industry lingo this is the *NXX code*.
- **Four digits**—to designate the individual subscriber line.

Numbering plans are currently expanding to 15 digits to enable direct dialing to international numbers.

In addition to the full public plan, business users who get their telephone features through the digital switch can establish abbreviated dialing plans to simplify internal calling.

In practice, the actual assignment of numbers falls to the dominant carrier in an area—i.e., the local BOC, GTE, or a large independent operating company. Before the existence of alternative carriers, numbers were assigned exclusively to the dominant carrier in an area. Central office



codes are now issued to providers other than LECs according to the procedure spelled out in *Central Office Code Assignment Guidelines* document (ICCF 93-0729-010), available through the Industry Carriers Compatibility Forum (ICCF).

The local telephone company that is asked to assign new CO codes (i.e., the first three numbers in a local number—**784**-1234) is required to respond within ten days; however, actual implementation time may take 15 weeks or longer. In reality, this procedure was designed primarily to provide numbers for cellular carriers. The applicability of the procedure for CAPs, cable companies, and other new entrants is still somewhat unclear, and these new providers probably need to build adequate time and resources to deal with the issue into their entry strategies.

Once the CO code is assigned, the providers themselves then assign numbers to individual subscribers.

The industry is now studying ways to ensure that subscribers can keep their telephone numbers (“number portability” in telephony lingo) if they should move from one carrier to another.

KEY CONCEPTS IN TELEPHONY SWITCHING

The history of telephony switching has exactly mapped the introduction and development of electronics technologies into North American life over the last century—from the early perfection of mechanically-based systems—to the revolution heralded by computers—to the dramatic changes made possible by the abundance of computing power captured in today’s silicon.

Electromechanical and Analog Switches

The earliest telephone switches were manual—that is, they required a human operator to make connections by plugging circuits into a switchboard. When a customer “rang” the central office, the operator scanned the switchboard and connected the caller by plugging into the requested line.

In 1889, Almon B. Strowger—an undertaker in Kansas City—discovered that a less-than-honest local operator on the take was diverting calls meant for his business to a rival undertaker. Strowger vowed he would build a “cuss-less” telephone system. In 1891, the Strowger system was patented. The Strowger system used moving mechanical devices, rather than human operators, to make physical connections. Strowger’s invention soon replaced the operator and switchboard, and the “step-by-step” (so named because each digit dialed moved one set of mechanical switches and took the call one step closer to completion) served as the standard switching system in the world for about 50 years.

The major drawbacks of Strowger switching were the large amount of space it occupied and the high electrical power consumption needed during busy-hour operation. And because the mechanical parts were subject to wear and electrical contacts were sensitive to damage and dirt, maintenance for a Strowger switch was extremely labor-intensive, requiring an army of maintenance staff with oil cans and cleaning utensils.

The Strowger “step-by-step” switch, like all early systems, was based on the analog technology that was state-of-the-art electronics at the time.

Analog switching systems converted sound waves (speech) into electrical signals with varying frequency and amplitude. The analog signals were connected

through one of a large number of individual switches in the central office. Each telephone call required a chain of separate connecting switches, which remained dedicated for the duration of the call—thus the massive telephone offices that once dominated the centers of cities throughout North America.

Following the step-by-step switching mechanism, several types of analog switching devices evolved over time, including the cross-bar switch, the electronic switching system (ESS), and the stored program control (SPC) system. All of these analog systems use “space switching” techniques that connect and disconnect physical contacts through a matrix of switchpoints. Analog systems tend to be slower, larger, and more difficult to maintain than systems that employ digital technology.

The cross-bar switch took a significant step forward by employing small, moveable metal contacts in an electromagnetic cross-bar matrix to make connections, making it faster, quieter, and smaller than the Strowger switch. The cross-bar switch became more common than Strowger switches in the 1940s. The cross-bar switch was more flexible than earlier systems because it would re-try a connection if line blocking occurred. It continued to consume a lot of power, though, and still used physical contacts which would eventually deteriorate.

Electronic switching systems (ESSs) capitalized on semiconductor developments and marked the first use of computer technology to streamline operations and reduce switching costs. The ESS or Stored Program Control (SPC) exchanges manage switching activity by using a dedicated computer to analyze the dialed number and activate the required switching action in the system’s switching matrix.

The Move to Digital Switching

In the mid 1970s Northern Telecom—followed shortly by a host of other vendors—began introducing digital technologies into the core of the public switched network. Digital switches fully capitalize on the strength of the computer revolution by routing both voice and data through the switch in the form of 0/1 binary coded information, which can be moved through the switch in a very short period of time. Because the digital switch was faster, smaller, more able to efficiently handle data, and provided infinitely more bang for the buck—especially when power, real estate, and maintenance costs were factored in—the digital switch soon became the standard switching system in North America. A single digital switch typically serves anywhere from under 1000 to over 100,000 subscribers.

How Digital Technology Works

The familiar telephone set creates an analog wave representation of the human voice by using the air pressure from speech to vibrate the diaphragm in the handset, which in turn activates carbon granules to produce an electrical signal of varying strengths.

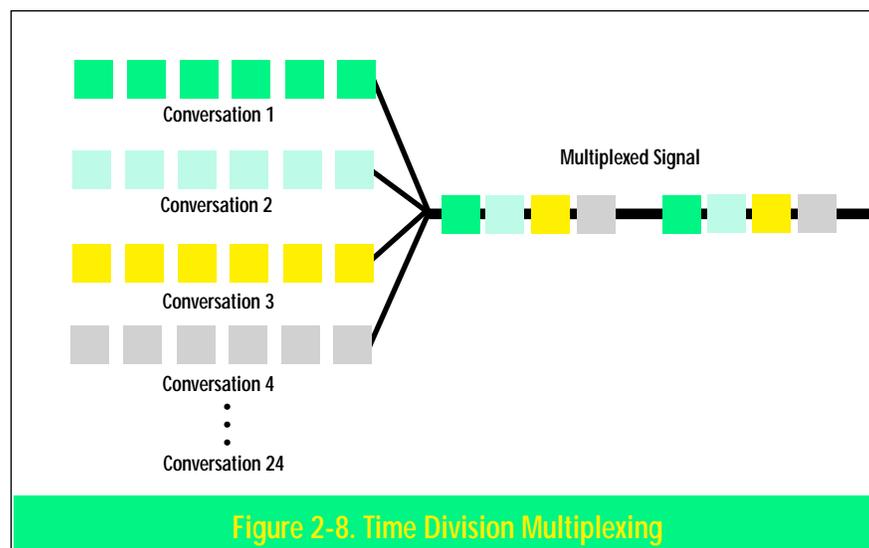
Pulse Code Modulation—Converting Analog to Digital Signals

In a process called pulse code modulation (PCM), this analog wave signal is then sampled every 125 microseconds (8000 times a second) and converted to pulses. The amplitude of each pulse is represented by the amplitude of the analog signal. This PCM signal is then put into 8-bit packets and “quantized” by measuring and rounding it off to one of 255 levels of sound. Each sample is then converted into a digital representation of the PCM packet—that is, it is converted into a code represented totally by discrete 0s and 1s.

Time Division Multiplexing

In a key process known as time division multiplexing (TDM), these 8-bit digital signals—each a “channel” of information—are then combined into a 24 channel, 125 microsecond frame. This multiplexing allows many channels of information to be simultaneously transmitted over the same pathway, as pieces of the signal are woven together one after the other and assigned time slots on the pathway. In most North American digital systems, 24 channels (i.e., 24 voice or data “conversations”) are simultaneously carried on a single pathway. An often cited analogy of TDM is to imagine a train carrying 24 conversations, with a piece of each conversation in each of its boxcars. As the train rolls up to the loading dock,

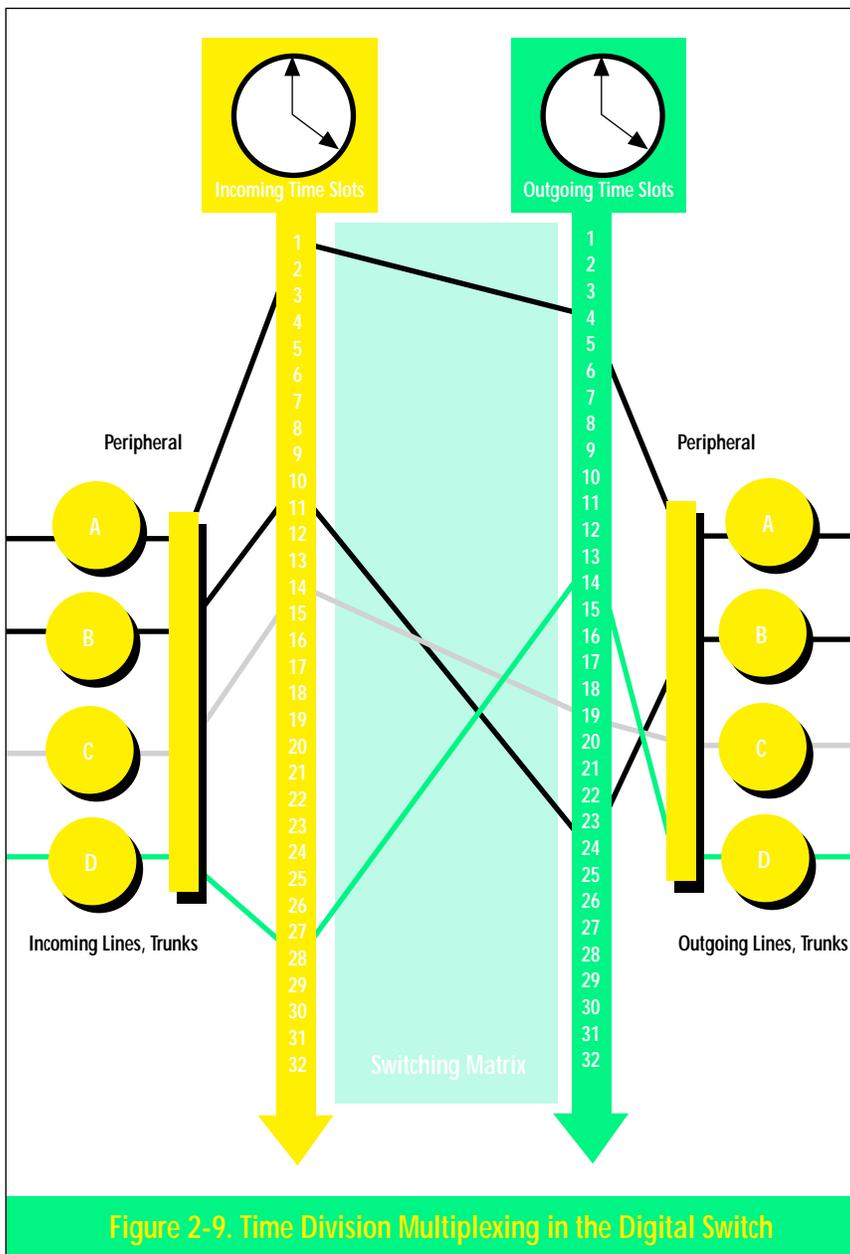
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conversation 1 is put into boxcars 1, 25, 49, etc. Conversation 2 is put into boxcars 2, 26, 50, etc.—and so forth. At the destination, the process is reversed and the conversation is reassembled. In a similar fashion digital signals travel through the network in groups of 24 multiplexed channels.

TIME DIVISION SWITCHING IN THE DIGITAL SWITCH

Digital switches use TDM to process a huge number of calls in the smallest amount of time. In the DMS SuperNode and DMS-10 400 Series systems, for instance, digital signals are multiplexed onto 32-channel links—called time slots—to the switching



matrix of the switch. The switching matrix uses time division switching to place this incoming traffic onto the proper outgoing time slots to lines and trunks. For example, in the figure on the previous page, time slot 1 is mapped to time slot 4 to make the proper connection. After switching, the digital signals are multiplexed back together and sent to the called party.

KEY COMPONENTS OF THE DIGITAL SWITCH

The typical digital switch has four essential components: the central processor, the switch matrix, a range of peripherals, and input/output controllers.

- **Central Processor**—The central processor controls call processing activities—for example, assigning time slots and administering features such as call forwarding—as well as directing system-control functions, system maintenance, and the loading and downloading of software. To ensure reliability, the central processor is generally duplicated on digital switches. Each call is processed simultaneously on both processors; if the “hot” processor should develop a problem, the system automatically shifts to the standby processor—without the caller noticing any interruption of service.

State-of-the-art larger digital switches are increasing processing power through additional specialized processors for functions such as frame-relay data, ISDN packet handling, service control point functionality, etc. Digital switches for smaller, rural communities often adopt alternate service access strategies that can be more easily justified for these markets.

- **Switch Matrix**, also referred to as the network, handles the actual connection of calls to their destinations. The latest switching modules, such as the DMS SuperNode Enhanced Network (ENET), can process up to 64,000 channels in a single cabinet and switch wideband data as effortlessly as a voice conversation.
- **Peripherals**—The typical digital switch has a range of peripheral modules to interface the range of lines and trunks coming in from the network. The peripherals convert incoming voice and data signals into the digital format used by the switch and perform some low-level call processing tasks. Typical peripherals include those that terminate lines, trunks, digital loop carriers, and maintenance trunks.
- **Input/Output Controller** system provides access to the switch for maintenance, billing, routine operations and administration, and loading of software.

Call Processing

The telephone is ubiquitous... our familiar connection to the world. The simple act of lifting the receiver and dialing is second nature to the caller. The instant appearance of a dial tone is an unquestioned expectation of most telephone users in North America. What the caller does not see is the stream of instructions executed by the switch before dial tone occurs. Dial tone, in fact, is delivered, not

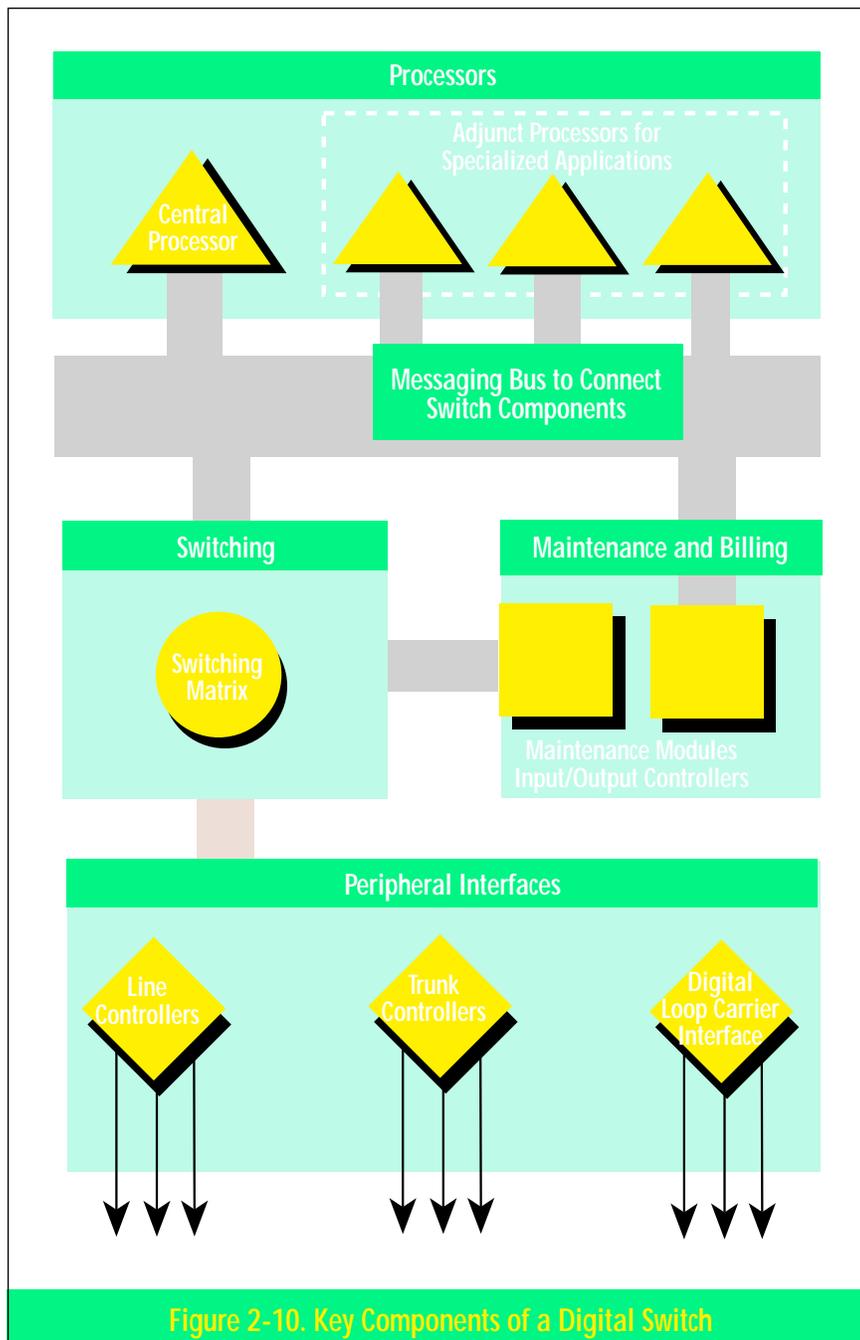


Figure 2-10. Key Components of a Digital Switch

from the telephone itself, but from a central office switch located perhaps miles away. By the time the dialing sequence is complete, the switch has performed thousands of “transparent” call processing activities. This section follows a simple telephone call step-by-step through the digital system.

The primary function of the switch is to establish connections between telephones and data equipment for the transmission of voice or data. When a local call is placed, the fundamental switch call processing components come into play. These are:

- **Call Detection**—Detecting that the telephone receiver has been lifted.
- **Dial Tone Provided**—Providing a dial tone to the caller.
- **Digit Collection**—Collecting the dialed digits.
- **Digit Translation**—Translating the digits dialed to a called number.
- **Call Routing**—Routing the call to its destination.
- **Call Connection**—Establishing a connection between the parties.
- **Audible Ringing/Ringback**—Signaling the called party by audible ringing, and the calling party by ringback.
- **Speech Path Established**—Detecting when the called line is answered.
- **Call Termination**—Detecting disconnect and terminating the call when a party hangs up.

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A description of a call from John Smith to Henry Jones illustrates the network components that come into play for processing the simplest call. The process begins when John lifts his telephone receiver, “going off-hook” and closing an electrical circuit between his telephone set and the central office switch (the following description is somewhat simplified by assuming that John and Henry are connected to the same switch).

Call Detection

In a digital switch, the off-hook condition appears as a change of state on the line card serving John Smith’s line at the central office. The change of state is detected by the line peripheral, which reports the message to the network circuitry in the switch. When the network receives the report, it sends an interrupt message to the central processor.

The central processor invokes instructions in the switch's memory to check the validity of the message. A program examines the memory for confirmation and the status of the originating line. In this case John's line would appear as "idle." The central processor determines that John is a valid subscriber and determines the state change as an off-hook condition, or a demand for service, and marks the line as "busy."

The switch then examines the characteristics of John Smith's line in the switch's memory; for instance, will this line send rotary-dialed digits or push-button digits (DTMF—dual tone multifrequency in industry lingo). A call register is created to receive and store the data, and a device register is established to handle additional messages to and from the line.

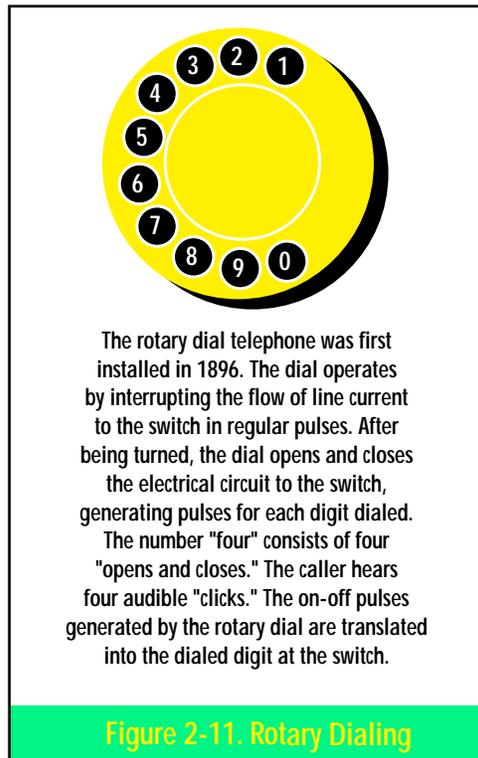
Dial Tone Provided

A dial tone is then issued to John's line from a tone generator.

Digit Collection

When John hears the dial tone, he begins to enter Henry's number on the 12-key push-button dialing pad. The digital switch differentiates between rotary-dialed and tone-dialed digits. Rotary-dialed digits consist of a series of state changes (on-off pulses) in the subscriber loop, while tone digits consist of two simultaneous pure tones of predetermined frequencies.

- **Rotary-Dialed Digits** are passed directly to the switch for interpretation. The peripheral equipment at the switch recognizes the regularity of the dialed pulses and stores the information temporarily in a device register configured for the calling line. The incoming pulses are then translated into individual digits and stored in the call register.



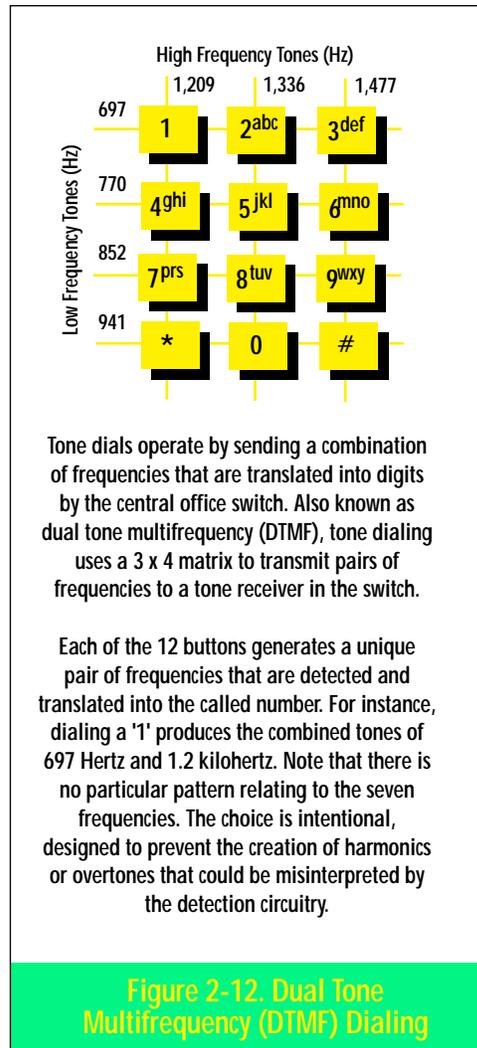
- Dual Tone Multifrequency Digits**—If the call originates from a touch-tone telephone—such as John Smith’s—dual tone multifrequency (DTMF) signal pairs are received and interpreted by a tone receiver in the switch’s peripheral equipment. Digit information (the telephone number John dials) is received and transmitted from the peripheral equipment to the central processor through dedicated signal time slots. As soon as the first incoming digit of Henry Jones’ number is received, the switch removes dial tone from John’s line.

Digit Translation

The incoming digits of Henry’s telephone number are translated by the switch as they are received. The translating process continues until enough digits have been collected to identify where the call is to be routed (the call termination). If the switch detects invalid information in the incoming digits, call processing control directs the call to a special tone or recorded announcement. For example, in most parts of North America, if John attempts to dial a long-distance number without first dialing “1,” he will receive a recording explaining that his call could not be placed.

Call Routing

After the dialed digits are translated and determined to be a local calling destination, the call termination is identified as Henry Jones’ telephone number, and the switch consults switch memory for information about Henry’s line. The information is extracted and memory registers are configured to receive the data.



The switch's memory is consulted again to determine if two time slots are available in the switch's switching matrix: one time slot is required for each circuit serving John Smith and Henry Jones. If time slots are available, they are reserved for future use; otherwise, the switch issues a tone or recorded announcement to John advising him that no circuit is available. This is often heard as a "fast-busy tone" by the caller.

Call Connection

If the switch determines that the call can be completed, the terminating circuit (Henry Jones' line) is marked "busy" in switch memory so that no other calls can attempt to terminate on Henry's line.

Audible Ringing/Ringback

After the switch has established all the required connection resources (call, data, and device registers) in the memory, the connection is routed through the switch matrix, and the switch signals Henry by "ringing" generated at the switch and applied to the terminating line. At the same time, an audible "ringback" tone is generated and routed from the switch to the originating line. The ringback indicates to John that Henry's line is idle and ringing. If Henry's line is busy, the switch sends a busy tone to John Smith's line from a tone generator.

Speech Path Established

The speech path connection between John and Henry is established by linking the connection facilities previously reserved for the call. When Henry answers, the status of his line changes to "off-hook." The system detects this change of state, recognizes it as a "ring trip," and removes the ringing and audible ringback from the two lines.

The central processor then instructs the peripheral equipment to link John Smith's line and Henry Jones' line to the reserved path established in the switching network. When the speech path is established, conversation can begin, and the switch's memory is updated to reflect the active status of the call.

Call Termination

John and Henry complete their conversation, and hang up. The receiver returns to the telephone cradle, breaking the circuit to the central office. The disconnected circuit is detected as a change of state by the line peripheral equipment.

When the disconnect is confirmed, the switch frees network resources reserved for the call. Connection memories are released and circuits, timeslots, stations, and so on are marked “idle” in memory so they can be used for other calls. Call registers are also released and all resources are available for further call processing.

Planning and Engineering the Digital Switch

Switch planners largely are in the business of juggling two contradictory mandates:

1. Ideally, they need to build a network with enough resources so that every call will always and immediately connect to its destination.
2. Since traffic surges on certain days of the year and varies widely by the hour of the day, meeting this ideal would mean provisioning significantly more equipment than needed most of the time—and would substantially drive up the cost of providing service.

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A short overview of some key concepts of network planning will help to lay out the basic elements of how planners stack up these two competing needs to determine how much switch and trunk resources to allocate in any given network.

The bread-and-butter concept of network engineering is the busy hour, the hour in an average day—usually late morning—when the system is stressed with the most traffic (a related term—high day busy hour [HDBH]—is the busiest hour on the busiest day of the year, traditionally Mother’s Day. If the network were engineered to carry all the traffic during HDBH, then it would, of course, be capable of always carrying the traffic at any other time. However, it would be a very needlessly expensive network, with a large part of its equipment standing idle most of the time.

Telephony traffic engineers earn their livings by weighing and balancing the busy hour needs of the network against their customers’ tolerance for allowing calls to be blocked occasionally during the busiest calling times of the year. This basic

determination of grade of service—or probability that a call will get blocked—assigns a percentage, from 0 percent up to 10 percent, of calls that are allowed to be blocked during times when the network is congested. The decision to block, say, 3 percent of calls during peak hours means a dramatic reduction in the amount of incremental equipment that needs to be bought, engineered, deployed, and maintained—and thus a dramatic reduction in the cost of running the network.

Another key concern for planners is the average amount of time that any given line or trunk is being used. Obviously, a residential line is going to be in use, on average, substantially less than a business line, and lines that can handle several simultaneous voice and data calls, such as ISDN lines, will have an even heavier percentage of use. Planners calculate this percentage in units called ccs (centum call seconds)—or the number of 100 seconds in any given hour that a line is in use. A 3 ccs line means the line is, on average, in use 300 seconds out of every hour. (A related term often used in trunk planning—erlang—is equal to 36 ccs. One erlang is the maximum physical capacity of a line or trunk and is expressed in percentages, i.e., 0.7 erlangs, etc.)

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Planners combine average ccs figures for incoming lines and trunks (3 ccs is commonly used for a residential line, 6 ccs for a Centrex business line, 12 ccs for an ISDN line, for instance) with Poisson tables or other similar mathematical tools that predict future usage by past trends to determine the level of traffic they are likely to encounter for any given neighborhood or area—and provision equipment for the switching and distribution networks accordingly.

Digital Switch Maintenance

A key advantage of today's digital switches is the degree to which maintenance is automated and centralized. Switches like the DMS-10 or DMS-100 routinely monitor their own performance and perform diagnostic programs that allow proactive preventative action if a difficulty is developing. The system also generates logs of all significant activity within the switch to simplify troubleshooting, and both visual and audible alarms are generated in the event of any subsystem failure. Activities that require human intervention are largely centralized at a maintenance and administration position, a terminal that allows craftspersons to interface the switch for internal maintenance and to troubleshoot individual lines.

In addition, large network operators reduce expenses by using an operations support system (OSS) to monitor and administer a large number of switches from a centralized location.

Environmental and Powering Concerns

While the digital switch does not require the “clean room” atmosphere of many more sensitive computing systems, it does need to operate within specific parameters for temperature, humidity, air quality, system grounding, and electromagnetic interference. The “footprint”—the amount of space taken up by the switch—is dramatically smaller for digital switches than for older analog systems, but still can be substantial for larger line sizes and must be carefully planned for by the network provider.

Because telephone and data users expect to continue service even if the power to the community has failed, switching systems are generally indirectly powered by large bays of batteries in the central office. Commercial AC power normally keeps these batteries charged in a non-emergency situation. Remote access vehicles normally also have on-board batteries to ensure the survivability of service if power is lost to the area.

ATM in the Switched Network

While bandwidth-hungry applications such as distance learning and desktop videoconferencing are currently being supported by today’s narrowband/wideband switches such as the DMS SuperNode and DMS-10 systems, network providers are also beginning to provision Asynchronous Transfer Mode (ATM) switches where these and other services produce enough aggregated traffic to justify a broadband switching system that can support integrated audio, data, video, and image over high-speed fiber-optic lines.

ATM is based on a cell-switching technology that places variable-length packets into uniform 53-byte cells. The fixed length of the cells allows support of delay-sensitive traffic such as audio and video as well as bursts of data traffic at rates above 45 Mbps. The simplicity of the cell format also allows ATM switches to cost-effectively deliver rates of many gigabits per second.

As data applications continue to grow on the public network—and as videoconferencing, telemedicine, distance learning, and work-at-home applications come on line—most network planners see an evolving network that will feed the traffic from narrowband voice and wideband digital switches onto a backbone network of ATM switches connected by SONET transport. Existing digital switches will continue to anchor the voice and narrowband data segment of the telephony market for the foreseeable future.

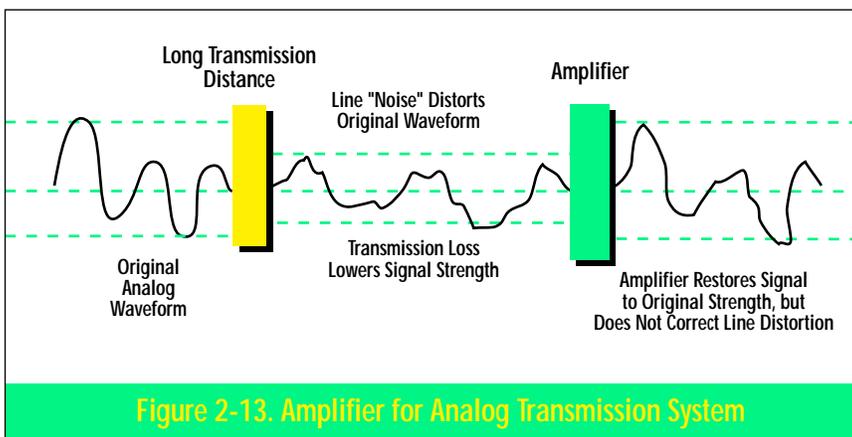
KEY CONCEPTS IN TELEPHONY TRANSMISSION

- **Analog Transmission**
- **Digital Transmission**
- **Transmission Media**—Copper Wire, Coaxial Cable, Access Radio, Microwave Radio, Satellite, and Fiber-Optic
- **Transmission Rates**
- **Interoffice Signaling Protocols and Trunks**

The transmission segment of telephony networks is concerned with moving information from one location to another. Transmission can use either analog or digital signals, and those signals can be carried over various transmission media, such as copper wire, radio waves, and fiber-optic cable. For companies seeking to establish differentiators from their competitors, the transmission technologies have taken on increasing importance in recent years as digital and fiber-optic technologies have provided network providers with the means to deliver exciting new high bandwidth services, such as ISDN, dialable video, or other wideband services.

Analog Transmission

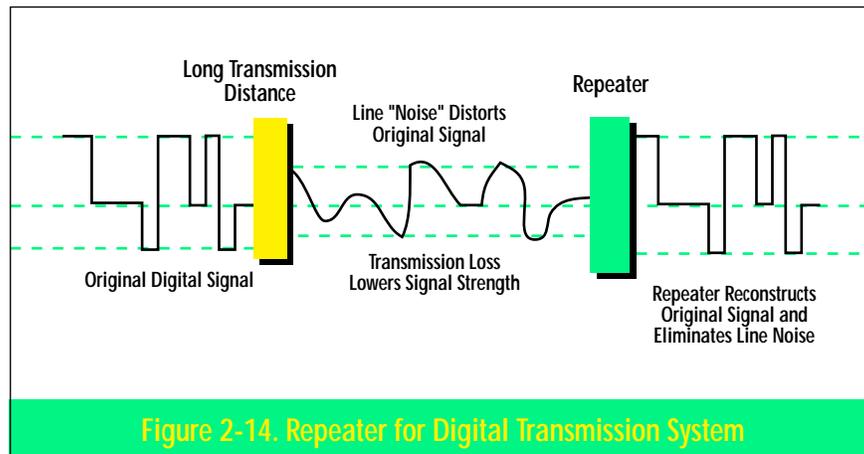
While some analog transmission systems are still active in the public network, most providers are moving as quickly as possible to digital technology. All transmission carried over long distances must be amplified periodically because the signal is always losing strength and unwanted “noise” is always being introduced into the signal. Analog transmission systems have severe limitations in this amplification process. Analog amplifiers not only amplify the voice and data signals, but also the noise. And because analog waveforms can vary continuously over the bandwidth, much of the original signal can be lost because it is very difficult for the receiving end to exactly reproduce the original waveform from the distorted, noisy transmission.



Analog transmission is sufficient for most voice transmissions, because a small inaccuracy in the received signal will not be detected by a listener. But accurate transmission is absolutely essential to data transmission, where a single changed bit could completely destroy the meaning of the original signal.

Digital Transmission

Digital signals can be transmitted over great distances and coded, regenerated, and decoded with no degradation of quality. Digital transmission employs repeaters rather than amplifiers. Repeaters read the incoming signal (which has been distorted and weakened during transmission) and determines the original sequence of discrete signal levels. The repeater then reproduces the original signal and sends it to the next network destination. Coupled with fiber-optic transmission gear—which transmits the 0s and 1s through bursts of light—only a digital network can handle high-speed data and graphics/video transmission, as well as voice calls.



Transmission Media

Copper Wire

In the past, copper wire was the most popular transmission medium for access and transport applications. The only place in the network where copper wire is virtually ubiquitous today is in the individual subscriber lines that serve homes and businesses. Copper wire has become quite expensive and fiber optics has enabled higher bandwidths, so other technologies look more attractive when creating new transmission routes or expanding the capacity of existing routes.

Coaxial Cable

The onset of broadband multimedia services is leading many service providers to deploy coaxial cable—long used by cable TV operators—to deliver video, voice, and data signals to homes and businesses over the same transmission infrastructure. Unlike copper facilities, coax has the potential for virtually unlimited bandwidth.

Access Radio

Radio is used in wireless and cellular systems to provide subscriber access to a switching system, and as a transport between switching systems. Cellular mobile service uses a series of radio transmitters and receivers, each of which serves a relatively small area called a “cell.” Calls are automatically “handed off” from one transmitter/receiver to another when a mobile subscriber moves from one cell to another.

Wireless systems can also serve telephones and data terminals over a smaller, fixed area, such as an office building.

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Microwave Radio

Microwave radio systems are available for long-haul transport, short-haul transport, and cellular backbone applications. For transport over long distances and for linking multiple cell sites to a mobile telephone switching office, microwave radio is still a common transmission technology in North America.

A microwave system consists of a network of transmitters and receivers that are in “line of sight” of each other (microwave radio signals do not follow the curvature of the earth). When necessary, repeaters boost the signal strength at appropriate distance intervals when the transmitter and receiver are not in line of sight of each other. Common frequencies include 4, 6, and 11 GHz.

Satellite

Satellite transmission is very similar to microwave transmission on earth. The satellite acts as a repeater to boost and re-transmit the signal to the destination. Satellite systems can operate at higher frequencies than terrestrial systems because they are not subject to as much interference. Because of this, satellite systems are well-suited for broadband services such as video broadcasts.

Fiber-Optic

Fiber-optic transmission systems (FOTS) use pulses of laser light carried on fiber-optic cable, providing far greater capacity, higher transmission rates, greater bandwidth and operating more economically than traditional copper wire cable.

Introduced into North America in the late 1970s, FOTS have grown dramatically in capacity and have become increasingly important in both interoffice and access applications. A single cable of 96 fibers is less than an inch in diameter, yet it can support millions of voice channels. Traditional copper transmission requires a repeater station to regenerate and amplify the signal every mile or so. However, with fiber-optic cable, repeater stations are required only every 25 to 50 miles.

The main components of fiber-optic transmission systems are optoelectronic terminals and fiber-optic cable. Optoelectronic terminals have two components: receivers and transmitters. Receivers convert incoming voice, data, and video signals into a laser signal and send them over fiber-optic cable. Receivers detect these laser signals at the other end and convert them back into electrical signals that can be recognized by the voice, data, or video terminal.

Transmission Rates

To ensure easy interoperability among equipment from multiple vendors, transmission is standardized in the public network for different protocols and transmission rates. Following are some of the most common transmission protocols and rates for copper and fiber-optic transmission.

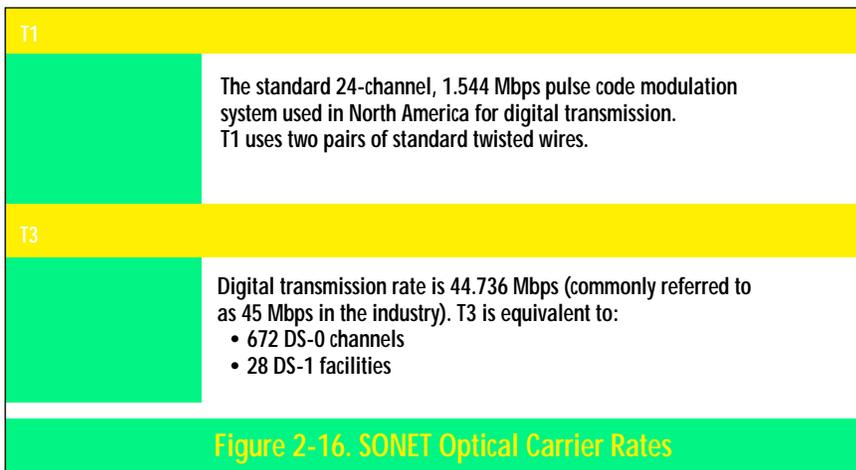
DS-0		Transmits voice, data, and signaling at 64 kbps. DS-0 is the standard data rate for transmitting voice and data, and is the building block for all data rates up through DS-3 and T3—all these rates are multiples of 64 kbps.
DS-1		Transmits voice, data, and signaling at 1.544 Mbps. With the same data rate as T1, DS-1 is equivalent to 24 DS-0 channels.
DS-3		Transmits voice, data, and signaling at 45 Mbps. One DS-3 facility is equivalent to: <ul style="list-style-type: none"> • 672 DS-0 channels • 28 DS-1 facilities
Figure 2-15. Digital Signal Levels		

Digital Signal Levels

The Digital Signal (DS) levels form a time division multiplexing hierarchy developed for North America.

Transmission Carrier Signaling

Transmission (T) rates are used for transmission outside the switching system. The data rates are the same as Digital Signal levels (such as DS-1) but use a stronger electrical signal.



SONET Optical Carrier Rates

Optical Carrier (OC) signals are the line transmission rates as defined by the Synchronous Optical Network (SONET) standard for fiber optic transmission.

SONET transmission equipment has spread rapidly through the public network in the past few years because of its high transmission rates, its multivendor orientation, its enhanced performance and ability to support hub and ring architectures, and the simplifications it enables for operations, administration, maintenance, and provisioning (OAM&P).

SONET's ability to support fiber-optic rings has become especially important in network survivability plans. In the event of a failure any place in the network, SONET bidirectional rings can re-route affected traffic away from the fault in milliseconds—thus preventing a service outage.

Multivendor interworking	
	Because SONET provides an industry-wide standard high-speed transport, it ensures that providers can mix and match vendor equipment and interface with other SONET networks.
Reduced hardware costs with multipoint configurations and enhanced bandwidth management	
	SONET allows providers to build hub, rather than just point-to-point, networks so traffic can be delivered to multiple spurs with the most efficient use of facilities. More efficient bandwidth management also reduces the need for cabling, multiplexers, and cross-connects.
Enhanced OAM&P	
	Overhead information built into the SONET protocol allows providers to provide centralized operations, administration, maintenance, and provisioning.
New Services	
	The bandwidth flexibility of the SONET standard enables it to transport new high-speed packet data services, high definition TV, and services built on the asynchronous transfer mode (ATM) standard.
Figure 2-17. Key SONET Benefits	

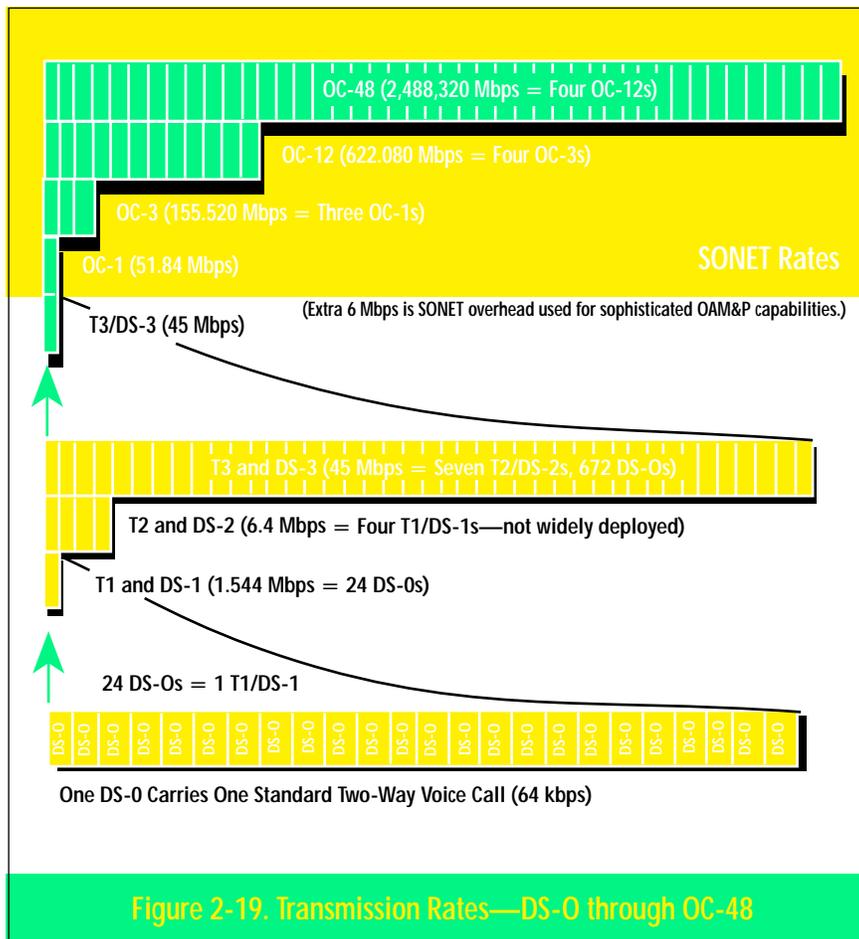
OC-1	
	The fiber-optic carrier signal transmitting at 51.84 Mbps.
OC-3	
	The fiber-optic carrier signal transmitting at 155.520 Mbps. It is equivalent to three OC-1 facilities.
OC-12	
	Transmits at 622.080 Mbps. It is equivalent to: <ul style="list-style-type: none"> • 12 OC-1 facilities • four OC-3 facilities
OC-48	
	Transmits at 2,488.320 Mbps. It is equivalent to: <ul style="list-style-type: none"> • 48 OC-1 facilities • 16 OC-3 facilities • four OC-12 facilities
Figure 2-18. OC Transmission Rates	

SONET uses a 51.84 Mbps signal as the basic building block for higher OC transmission rates.

Transmission products currently in the marketplace support up to the OC-48 SONET rate. Even faster SONET rates are now under study, including:

- OC-96 at 4,976.64 Mbps (5 gigabits), twice the OC-48 rate, and
- OC-192 at 9,953.28 Mbps (10 gigabits), four times the OC-48 rate.

A similar hierarchy —SDH (Synchronous Digital Hierarchy)—is outside North America.



Interoffice Signaling Protocols and Trunks

The exchange of telephone or data calls requires that the network know whether an individual set is currently on hook or being used, whether any given trunk is available between two destinations, what the best route to send the message is—

in short, the complete range of information needed to complete interactive communication through a complex world-wide network.

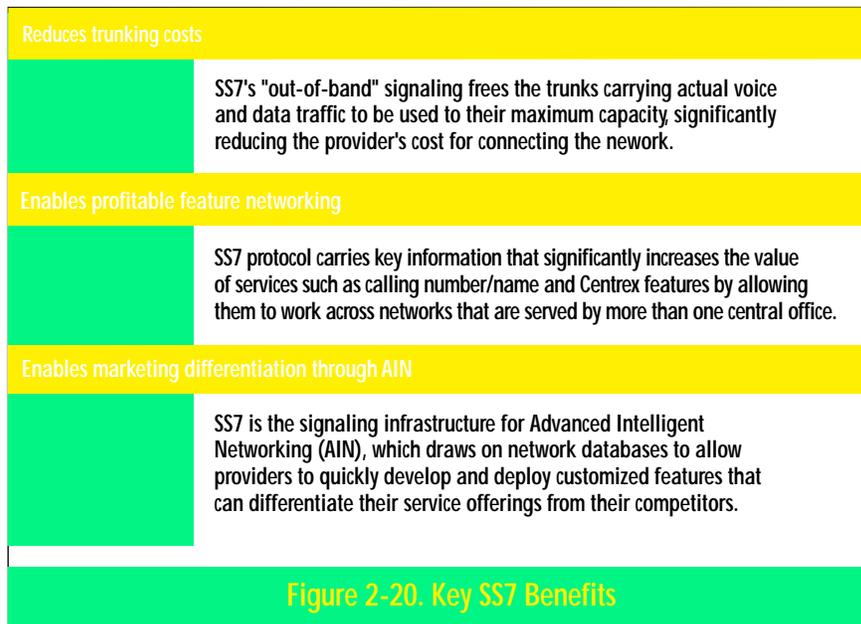
Multi-Frequency (MF) Signaling

In today’s network, two primary types of interoffice signaling are used to set up and take down calls and determine routing between destinations. Multi-frequency (MF) signaling—the older system—uses combinations of pulses as specified frequencies to signal across the network. These signals are carried on the same circuits that voice traffic uses—and thus is often called “in-band” signaling.

Because many calls are not initially completed (when the far end is busy, for instance), MF in-band signaling is relatively inefficient, using expensive trunking facilities that could be used instead to transmit telephone calls. And because the frequencies can be duplicated by hackers and the like, MF trunking is also vulnerable to toll fraud.

Signaling System No. 7 (SS7)

SS7—also known as Common Channel System No. 7 (SS7)—is rapidly replacing MF signaling in the public network. By using an overlay network of separate high-speed “out-of-band” links operating at 56 or 64 kbps, SS7 signaling significantly reduces network provider expenses for call setup procedures and frees up voice and data trunks to carry their optimal amount of traffic.



In addition, because the SS7 protocol carries the calling number and other critical information with it through the network, it allows sophisticated services such as calling number/calling name, automatic callback, and ISDN networking to work across an entire network rather than just between subscribers served by the same central office. SS7 is also the signaling technology that enables Advanced Intelligent Networking (AIN), which allows providers to quickly develop and deploy powerful customized features such as the ability for a business to advertise one number nationwide but automatically receive calls at the branch nearest the caller (see earlier section “Advanced Intelligent Networking”).

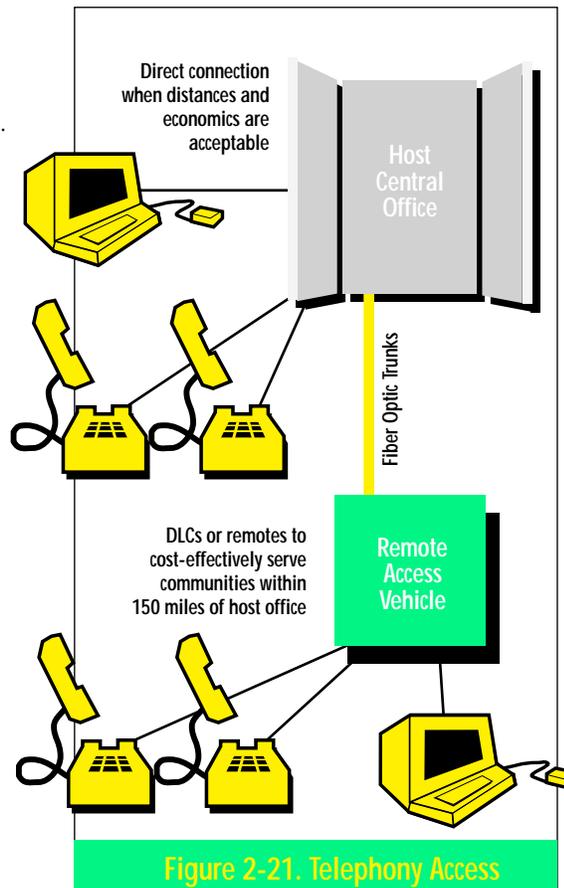
KEY CONCEPTS IN TELEPHONY ACCESS

The access portion of the public network is the equipment that connects the individual telephone or data subscriber to the provider’s central office. It is the path that the user takes to “access” the resources of the public network. Subscribers gain access to the switched network over lines, trunks, and wireless systems to their homes or offices.

The network of lines and trunks that serve subscribers is called the outside plant or the local loop. Today, the outside plant is primarily made up of copper wire carrying both lines and trunk traffic, and high-capacity fiber-optic cable, usually carrying multiplexed traffic from many lines or trunks.

Line Access

Individual subscriber lines usually connect to the central office in one of two ways: either directly or through remote access vehicles. The physical attributes of the copper lines limit direct connection to approximately 18,000 feet, but, more importantly, network providers tend to limit the number of direct connections because of the prohibitive cost of stringing and maintaining expensive copper wire.

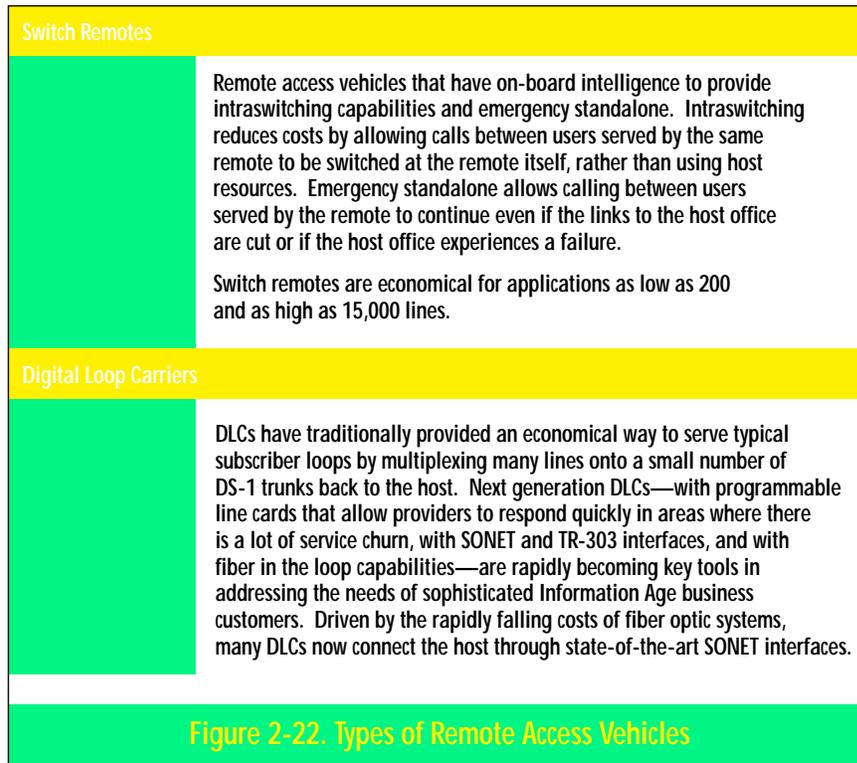


Remote Access Vehicles

Digital remote access vehicles provide a cost-effective solution to this limitation. By consolidating traffic from hundreds—even thousands—of subscribers onto a small number of DS-1 or fiber-optic facilities, they significantly enhance the reach of the central office and reduce the cost of serving remote subscribers. The Northern Telecom Remote Switching Center-S can, for instance, consolidate the traffic of over 10,000 lines onto just 16 DS-1 trunks.

Crucial to the strategies necessary for entering new markets, remote access vehicles can deliver most, if not all, of the features available at the central office—to sites up to 100 or 150 miles from the host office. Some remotes can, in fact, now deliver the full portfolio of services up to 500 miles from the serving office. This enables new market entrants to deploy a relatively small number of central offices targeted to penetrate a wide range of service areas.

Traditionally, network providers have deployed two types of remote access vehicles:



THE IMPORTANCE OF TR-008 AND TR-303

The protocols and signaling for connecting remote access vehicles to the public network has been standardized by Bellcore (Bell Communications Research Inc.,

the research and development arm of the seven regional BOCs—these standards are published in Bellcore TRs [Technical References]). In particular, two of these standards—TR-008 and TR-303—are important to new providers of telephony services because they allow the traffic coming from the new provider to seamlessly interface the switching facilities of the local telephone company. Access products currently being developed to upgrade existing cable systems to provide voice telephone services are being built to either the TR-008 or TR-303 standards. Many providers are using these standards to build networks of increasingly “lineless” switches, with the line cards that support switching being placed in remote access vehicles rather than in switch peripherals.

- **TR-008**, the older standard, defines a generic means for connecting digital switches from one supplier with access systems from a different supplier. TR-008 uses DS-1 based transmission facilities to support a set of basic analog switched services and small line-sized remote terminals, 96 lines or less.
- **TR-303** enhances the TR-008 standard and reduces the costs of providing services by capitalizing on the intelligent microprocessor capabilities that are built into the next generation of DLCs now coming onto the market. TR-303’s support of both DS-1 and SONET-based transmission facilities positions the access network for future broadband service delivery by enabling cost-effective fiber deployment in the access network. Key benefits of the TR-303 standard include:
 - **Reduced Switch-Port/Facility Costs**—TR-303’s support of large DLCs, up to 2,048 lines, and larger concentration groups enables significant reductions in the number of transmission facilities and switch ports needed to support any given line size, while maintaining the same grade of service as in the past.
 - **New Service Revenues**—TR-303 enables new services such as ISDN to be offered to remote locations in a more cost-effective, fully integrated manner.
 - **Enhanced OAM**—TR-303 reduces operating expenses by:
 - Remote provisioning of line cards within a DLC, substantially reducing the need for remote site visits and improving response time to customer-requested service changes.
 - Enhanced remote surveillance capabilities, allowing more accurate identification of network problems and reducing the number of erroneous dispatches.
 - **Simplified Network Planning**—TR-303 ensures that the network provider may mix and match DLCs from a range of vendors, regardless of the switch that serves any area.

Trunk Access

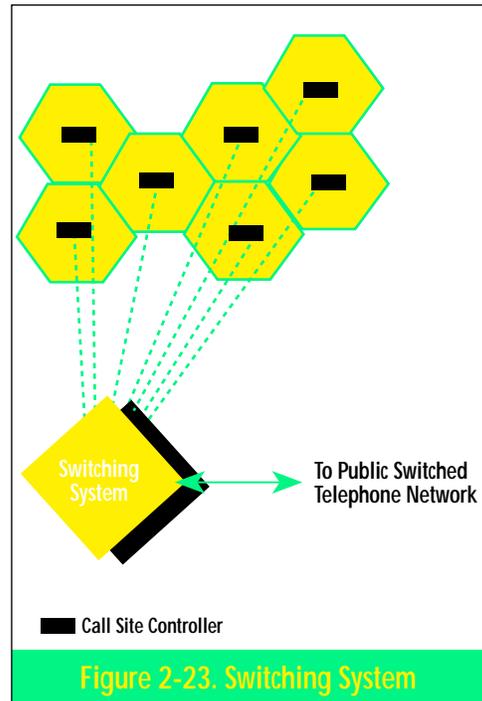
One of the key revenue generators for current network providers is providing trunk access to business users. A company’s private branch exchange (PBXs)—a private switching system on the customer’s premises—generally accesses the network through a DS-1 trunk (larger users may require higher transmission rates, and ISDN Primary Rate Interface [PRI] is becoming a preferred method of PBX trunking). Data users also usually access the public network through trunking facilities.

Wireless and Cellular Access

Cellular mobile radio systems differ from conventional mobile systems in that the service area is divided into relatively small cells—each approximately two to 20 miles in diameter. Each cell contains a computerized cell site controller and radio transmitting and receiving equipment.

Fiber-Optic Access

Some traditional network providers are increasingly deploying fiber optics in the outside plant (often called “Fiber In The Loop”) both because the technology has become a cost-effective trunking vehicle and in anticipation of an emerging host of high bandwidth interactive services such as video-on-demand. When fiber-optic cable is run to the pedestal (where the copper subscriber line connects), it is known as fiber to the curb. Increasingly, cable providers, traditional telephone companies, and others are deploying hybrid fiber/coax systems that use coaxial cable to carry the signal the last segment to the subscriber’s house or business.

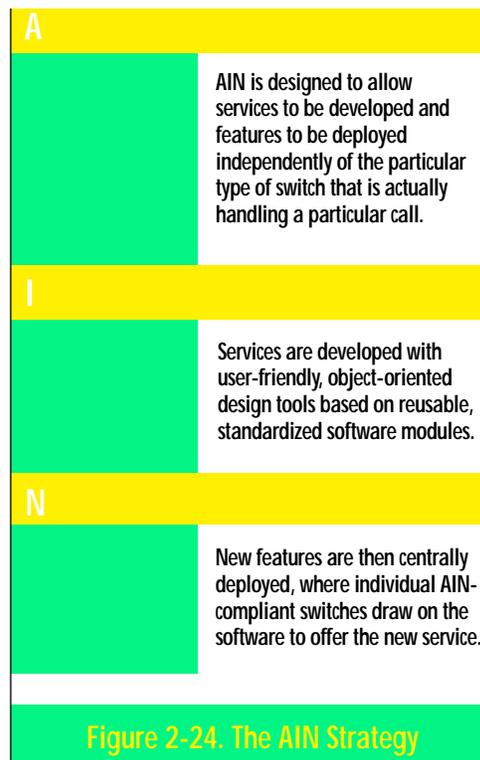


ADVANCED INTELLIGENT NETWORKING

Today, most services are resident in the software in each central office switch. While this has allowed providers to deliver a vast array of revenue-generating features, it also means that providers must depend on vendors to develop new features and then must often coordinate the development of these features among the several switch vendors that they buy equipment from. When the features are available, they must then be loaded into each individual switch in the network, a complex task for networks that may contain hundreds of central offices.

As competition intensifies between providers of telephony services, providers are looking for three key competitive advantages:

- They want to be able to rapidly develop customized features to differentiate their offering in the marketplace.
- They want to be able to quickly deploy new features ubiquitously throughout their serving areas as cost-effectively as possible.
- They want to put certain processing-intensive or network-based (as opposed to switch-based) services such as local number portability and PCS into centralized databases that all network switches can access.



Advanced Intelligent Networking (AIN—also known, especially outside of North America, as Intelligent Networking [IN]) is currently being deployed across the U.S. and Canada to provide these key advantages.

AIN places the intelligence to deliver key features in a centralized network database—called a service control point (SCP) instead of in each individual switch. “Triggers” in the software of individual service switching points (SSPs—central office switches with AIN software) momentarily interrupt call processing and generate queries to the SCP for instructions on how to process features for individual calls.

AIN also provides a standardized service creation environment (SCE) that lets any vendor, including the service provider, develop software for the SCP. Providers can then quickly create (or have other specialized companies create) custom features and load them into the SCP, where they can be immediately accessed and used by any SSP in the network.

New market entrants can either install their own AIN infrastructure, or purchase AIN capabilities from established providers.

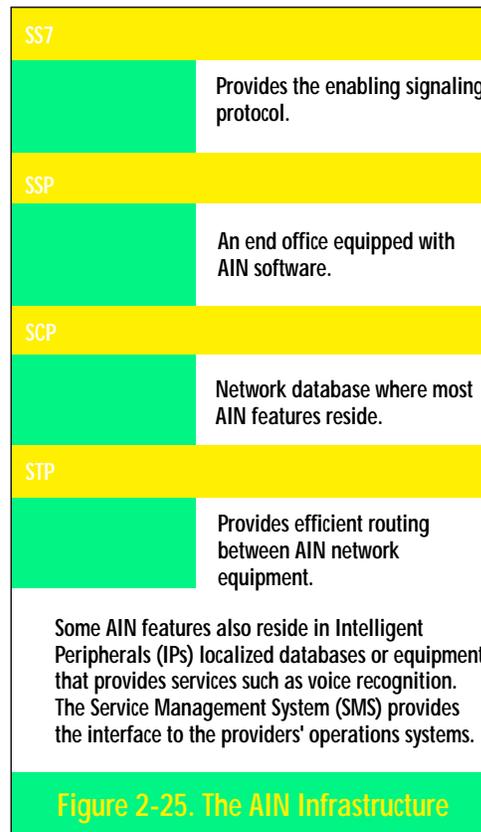
Initial AIN features include:

- **For the Residential Subscriber**

- **Sophisticated Call Screening and Management Features** that allow users to determine who can reach them and when—a caller could, for instance, decide to take only long distance calls, or calls from immediate family, during dinner time, or that 900 calls could only be made during the times of the day when the parents are typically at home.
- **Enhanced Voice Mail and Messaging Services** over the public network.
- **Personal Communications Services** that allow users to receive fully-featured calls anywhere in the network, wherever they happen to be.

- **For the Business Subscriber**

- **Private Virtual Networks** that give users cost-effective customized networks using any combination of public and private facilities.
- **Virtual Offices** that allow users to port business features to a home or cellular phone as they move about the network.
- **Area Number Calling** that allows a business to advertise one number throughout an area, but automatically receive calls at the branch nearest to the caller.
- **Network and Nodal Automatic Call Distribution** available from any central office.
- **Fax Servers**



Sample AIN Call

AIN would, for example, be ideal for developing and delivering a custom service to allow areawide or nationwide chains to advertise one number that would automatically connect callers to the closest outlet. In the example below, the callers anywhere in the U.S. dial 1-800-EAT-PIZZa to order from the PiZZaParlor. The SSP collects the incoming digits and recognizes this as a call requiring a database translation by the SCP. The SSP routes the dialed digits as a message requesting translation from the SCP (message routing is facilitated by the STP). The SCP receives the message, consults a database of locations and number translations, and translates the digits to a “real” number. The SCP routes the translated number, with billing information, back to the SSP, which sets up the call and bills it to PiZZaParlor.

The SCP receives the message, consults a database of locations and number translations, and translates the digits to a “real” number. The SCP routes the translated number, with billing information, back to the SSP, which sets up the call and bills it to PiZZaParlor.

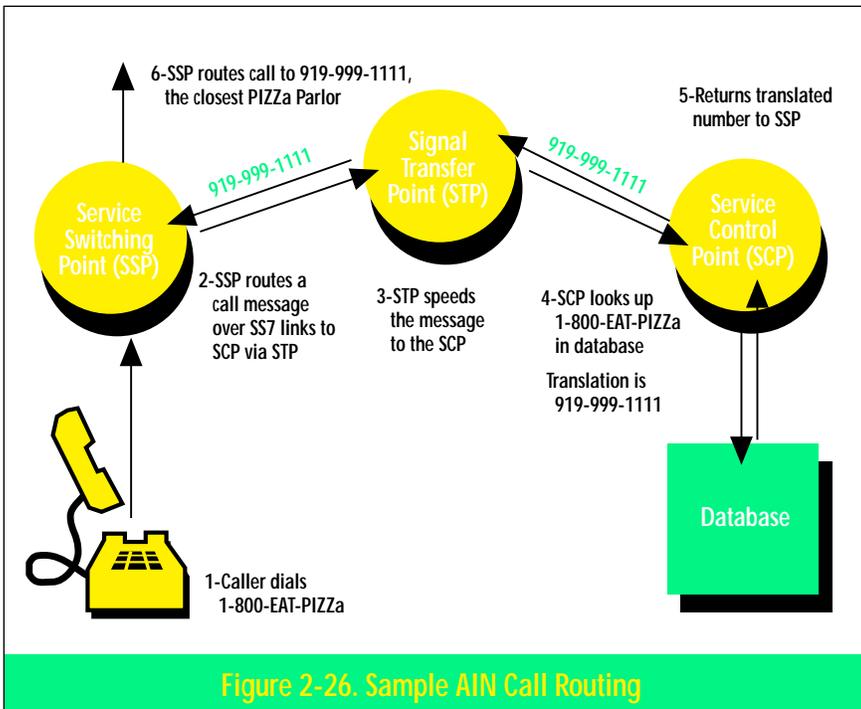


Figure 2-26. Sample AIN Call Routing

Key AIN Network Elements

- **Service Switching Point (SSP)** is a central office switch enhanced with SS7 messaging links to permit communication with application databases. Triggers in SSP software initiate queries to network SCPs for information to complete call processing.
- **Signaling Transfer Point (STP)** transports messages between SS7 nodes.
- **Service Control Point (SCP)** is the intelligence center in an SS7 network, processing queries for information and sending the response out to the originator.
- **Service Management System (SMS)**, the operations support system for AIN, provides the mechanism for downloading new features and monitoring the networking.
- **Intelligent Peripherals (IPs)**, like SCP, provide the intelligence to drive AIN features, but they are more specialized network elements that, for instance, only control a specialized set of features (voice recognition services, for instance) or provide a specialized set of functions to support features (IPs, for instance, may supply the voice prompts for some operator services features).
- **Service Creation Environment (SCE)** is the set of tools and related activities that are used to quickly create new AIN services.

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RELIABILITY AND SURVIVABILITY IN THE PUBLIC SWITCHED NETWORK

Residential and business customers expect that their telephone services will be consistently up and running, under any conditions short of the occasional catastrophic natural disaster that destroys the actual facilities that deliver their service. The phone is now perceived as more than a convenience. For residential subscribers, it is the lifeline to emergency 911 services. To business users, it is a lifeline to their customer base. When data transmission is thrown into the service mix, the business line often becomes even more mission-critical to the core of the business.

Reliability in the Switching Components

The digital switch is designed to have essentially no unplanned downtime (many digital switches, for instance, have traditionally been built to specifications that ensure they are out-of-service for unplanned purposes no more than a few minutes in a forty year period).

This level of reliability is accomplished in the digital switch by having all essential components duplicated. Any given call is simultaneously processed by a primary (or hot) and a standby processor. If the primary component fails, the standby unit takes over the call with no perceivable loss of service. Routine automated diagnostic and maintenance programs in the switch software identify and correct problems before they are service-affecting, and a sophisticated automated system of alarms and logs keep central office staff informed of any troubles with the switching system.

In addition, most large providers provision network-wide operations systems (OSs) that give them a real-time view of all their switching systems. The OS provides a centralized place to anticipate and preempt problems that might span multiple network nodes.

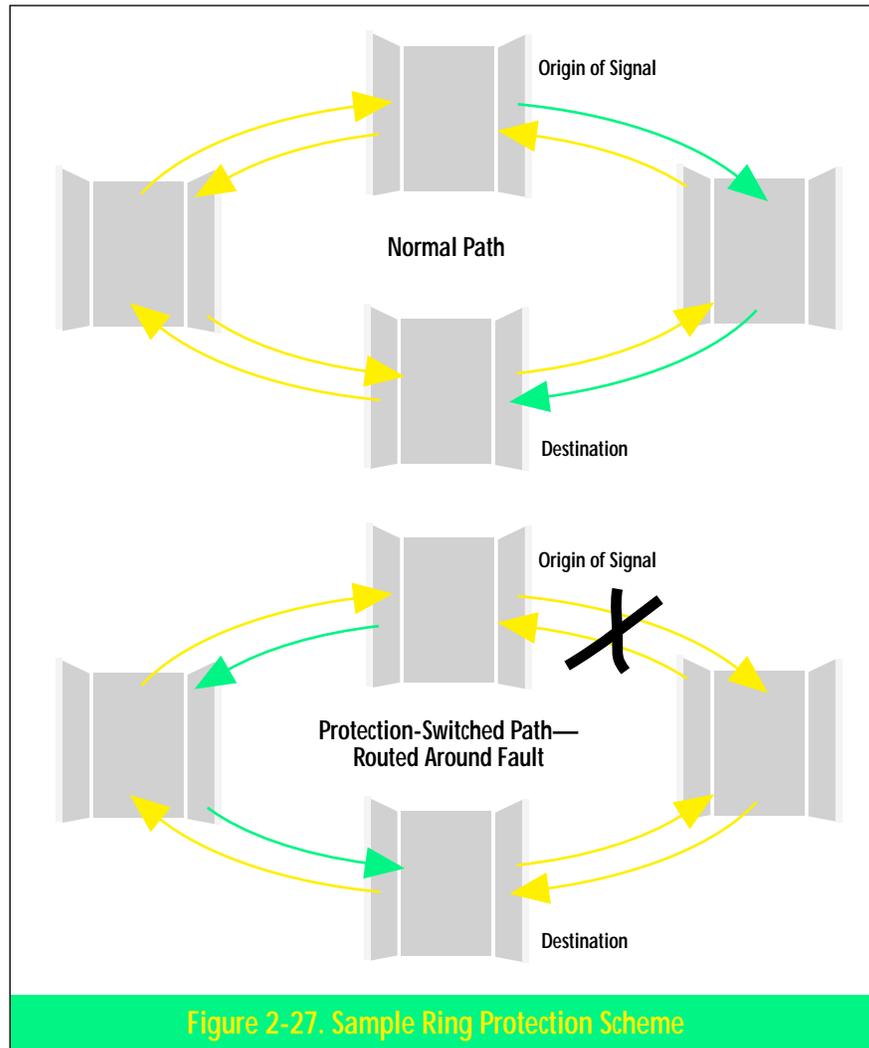
Reliability in the Transmission Network

The common enemy of transmission networks is the back hoe—the inadvertent cutting of the transmission route. Network providers have traditionally ensured the reliability of their transmission networks by configuring and engineering alternate routes for their traffic. One route—the working path—between City A and City B, for instance, might be placed along a major highway while the alternate route—the protection path—might be placed along a utility right-of-way.

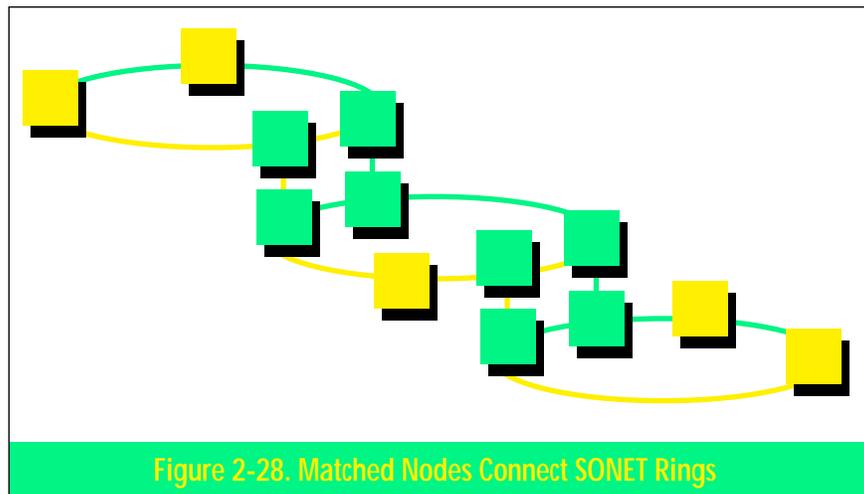
Microwave transmission is another widely used way to provide alternate routing.

The advent of high-speed fiber optics—especially when coupled with the SONET standard—has recently made possible dramatic increases in the reliability of transmission networks through self-healing fiber ring technologies.

With a bidirectional line-switched SONET ring, for instance, multiple offices are linked by pairs of fiber rings, each of which is provisioned to normally carry half the traffic on the system. The remaining bandwidth is held in reserve for protection. In the event of a cable cut or degradation of optical signal, the transmission equipment automatically places the affected traffic on the other route and sends it around the ring in the opposite direction, routing around the point of failure. Since the reroute is accomplished in milliseconds, service outages are prevented.



By provisioning matched SONET node, providers can ensure end-to-end survivability for routes that cross two or more SONET rings—offering continuous service for traffic that originates in a node on one ring and terminates in a node on another ring. (See the Figure 2-28.)



Subscribers of basic telephone services have had over 100 years to build a set of expectations about how reliable their service will be, how much it will cost, how complaints and maintenance will be dealt with, how billing will look and feel—in short, how they will be treated and will interact with their service provider.

On the one hand, service providers need to have a working understanding of these table stakes expectations to succeed in the new competitive telephony environment. On the other hand, new Information Age services, the ability of many new entrants to bundle other services such as cable TV with standard telephony offerings, and a dramatic range of other market discontinuities now present an historic opportunity for innovative service providers to substantially change the rules.

MARKETING TELEPHONE SERVICES

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Traditional marketing activities for telephony services have varied significantly according to the market segment being addressed:

POTS Services

Plain Old Telephone Service (POTS) has traditionally generated little marketing activity since the local telephone company has faced little or no competition as the sole provider of dial tone. When a traditional provider has marketed these services, the emphasis has usually been on broad campaigns that attempt to increase the use of the telephone by the general public.

The flood of new entrants moving into the local market is likely to change the equation substantially, however—the intense marketing activity and market shift from AT&T to MCI, Sprint, and others that followed with deployment of Equal Access is probably the model for the new environment.

Pricing will almost certainly be a key strategy. Providers may also, for example, move to bundle and market POTS services with advanced features, long distance service, or with non-telephony services such as home shopping or traditional video services—creating value-added portfolios of services that attempt to lure customers away from established providers. Since many new entrants will not necessarily be regulated under traditional tariffs, pricing is almost certainly to be used as a competitive tool. In short, marketing efforts are likely to increase substantially for this key market segment.

IntraLATA Toll

Toll traffic within a local provider's area has in the past not generated much marketing activity—again because the provider generally had a virtual monopoly on the service (though some providers have mounted campaigns designed to increase toll calls). As with the POTS market, the opening of this arena to competition (a market change that has already been mandated by regulators in a number of states in the U.S.) means marketing skills are needed to enjoy a large market share.

InterLATA Toll

The interLATA toll market is already characterized by the competition, fierce advertising, and targeted marketing techniques that most of us are familiar with through the battles between AT&T, MCI, and Sprint. The vast revenues available from this segment intensify the necessity to employ a broad range of marketing strategies, from traditional advertising to strategic pricing.

The access charges available for connections to long distance companies particularly encourage niche marketing by local access providers. For instance, a significant number of companies throughout the 1980s built successful enterprises solely by collecting access charges they earned by connecting large businesses directly to long distance carriers to “bypass” the local telephone company. Approximately one-seventh of residential subscribers (15 million lines) and two-thirds of business lines (20 million lines) are “high toll” users who spend \$100 dollars or more per month on long distance calls—and are thus another inviting market niche for new entrants.

Advanced Services

Modern digital switches make available a broad range of revenue-generating advanced services. These range from traditional custom calling features such as Call Forwarding and Call Waiting to sophisticated CLASS screening features to AIN-based personal mobility services.

Traditionally, these advanced features have been the services most aggressively marketed by the local telephone company because they provided incremental revenues from the LEC's most powerful marketing asset—their large established base of customers. New features are comparatively inexpensive to add to the digital switch (they generally require only an incremental software addition rather than hardware changeouts), and each feature, on average, adds \$3 to \$6 in revenue per line.

Because of the high potential of additional revenues through advanced services, telephone companies typically use the entire gamut of mass marketing techniques to reach potential customers—from newspaper inserts to television ads. Since the monthly bill provides a direct entry into the customer's home or business, bill stuffers have been a particularly effective marketing vehicle.

Free trial uses of new features and per-use charges that allow users not to have to pre-subscribe for features like Three-Way Calling have proven especially powerful in stimulating demand for advanced features. New display-based telephones, as well as voice activated technologies, now make these features even more attractive by making them easier to use.

New entrants and established providers who are branching out into new areas are again likely to add to this marketing mix by bundling non-telephony services with advanced features to create attractive new competitive offerings.

Cooperative Marketing

Since vendors of telecommunications equipment and features have a vested interest in stimulating demand for the products they sell, they are often available as partners in the marketing process—sharing both costs, risks, and strategies. These partnerships ranges from:

- Providing admaker kits to quickly customize and deliver newspaper, bill stuffers, and television campaigns.
- Providing soft copy of other collateral and technical marketing materials for customization under the provider's logo.
- Sharing customer databases.
- Sharing technical and marketing expertise for the provider's tariffing and pricing activities.
- Providing cooperative marketing funds in the form of a percentage rebate on sale of equipment/software for redeployment into marketing efforts.

TELEPHONE OPERATIONS

A working understanding of telephony extends beyond building the physical network and the marketing of the services.

The operations side of the telephony business, in particular, is essential for two key reasons. First, efficient operations, administration, maintenance, and provisioning (usually abbreviated in telephony lingo to OAM&P) is central to containing costs in what is an increasingly competitive environment. Perhaps even more importantly, the business office, trouble desk, the operator, and the telephone directory are the pieces of the business with which customers most often have direct contact—and customers expect, at the very least, to receive a level of service as reliable and responsive as they are used to. Below are thumbnail sketches of key elements of the operations side of the telephony business.

Network Planning and Engineering

The provider's network planning and engineering organization is usually staffed and equipped to accomplish two main goals:

- In a competitive environment, the network must be planned lean, without unneeded excessive capacity and equipment. (See the "Technology" section for an overview of typical planning concepts used to correctly size network resources.)
- Customers expect to receive service quickly after requesting it. While all customers are demanding faster service delivery small businesses, in particular, need to move quickly in rapidly changing markets—and expect their telephony service provider to support this need for agility. This customer desire for quick service drives the traditional planning task of ensuring that the network has the necessary equipment in place to anticipate growth and service churn and move quickly to capture new market opportunities.

Telephony providers usually support organizations of both long-term and short-term planners. These planners:

- Plan and deploy the local loop and outside plant facilities.
- Engineer the central office switch and switch remotes.
- Size transport facilities for interoffice trunking.

Business Office and Trouble Desk

The business office and trouble desk are the first line of contact in a business where service is increasingly becoming a differentiator. The established customer expectations are simple ones: they expect features and services to be turned up

quickly and they expect these services to be maintained in all but the most catastrophic of natural emergencies.

Normally, the business office accepts orders for new service. In most cases, the work order is then submitted to an automated process that handles the actual activation of services and sets up the billing mechanisms for the subscriber's line. The operations and administration interfaces of today's digital switches contain costs by minimizing the human interaction needed to actually provision the new service. Some of the more innovative switches allow telephone companies to further automate their operations by providing customer-originated service provisioning that lets end users change some services on their lines without manual involvement from the service provider. For example, a subscriber can press a soft key or enter a code on the telephone key pad to assign a feature such as Call Forwarding or Call Hold on a per-call basis. This switch capability not only minimizes operations overhead, but also can help increase service penetration by encouraging feature use. In the future, Advanced Intelligent Networking (AIN) will likely enable this capability to be expanded to allow the whole feature set on a line to be forwarded to another line.

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The customer expectation in most areas for POTS is that service should be turned up within 24 hours. Customers currently accept longer turnaround times for special services (a commonly used term for non-switched services such as data feeds or foreign exchange lines that are provisioned outside the normal automated processes) and advanced voice and data features such as ISDN. As competitive pressures increase, however, responsiveness to these requests is likely to emerge as a key differentiator among service providers. Next generation digital loop carriers with downloadable line cards are providing the technological means to reduce response times to meet complex customer needs.

The trouble desk operates under similar expectations. Once a subscriber initiates a trouble ticket to the provider, the assumption is that help is on the way.

The maintenance task is somewhat reduced by the fact that the provider's responsibility stops at the outside wall of the subscriber's house, leaving maintenance for the often-troublesome inside wiring to the home or business owner. This situation has been a revenue opportunity for many service providers, who offer monthly maintenance plans for inside wiring or position themselves as repair centers of choice if the customer chooses not to subscribe to the plan.

Billing

The real-time, transaction-based billing of many telephone services is likely to appear a formidable challenge to new market entrants used to less complex, often flat-rate, methods adopted in industries such as cable TV. In reality, software available for digital switches significantly simplifies the task by automatically providing the raw data from which bills are constructed. This data—usually provided from the switch in the Bellcore-compliant Automated Message Accounting (AMA) format for local exchange carriers, for instance—is then transported—either on tape or electronically over dial-up or dedicated data links—to a regional Revenue Accounting Office (RAO). The local carrier may also be the invoicing agent for the IXC, in which case IXC charges are also provided to the RAO.

This billing center then computes and creates the actual bill to the customer. Information generated in the course of billing often becomes invaluable source material for strategic market analysis.

Third-party firms are also available for providers who wish to outsource the billing function. Alternately, the provider can establish its own billing center and resell the capability to other telephony providers outside its service area.

Other Tablestakes Public Network Services

Other key services that subscribers will consider absolutely necessary from their service provider include:

- **White Pages**—When subscribers sign up for voice services through a telephony provider, they expect their telephone numbers to be listed in a publicly available directory. In turn, they expect to be able to access white and yellow pages.

New entrants need to be prepared to satisfy these expectations—either by turning out their own comprehensive directories, negotiating listing of their subscriber's numbers in the existing local telephone directory, or formulating some other innovative way to satisfy the listing requirement. Emerging voice-activated technologies and display-based telephones—"electronic white pages"—offer alternatives to traditional paper telephone books.

For many new providers, listing new numbers in the established telephone book will probably be the initial solution of choice. However, local telephone companies typically charge between 50 cents and \$5 per directory number for

entering subscribers into the traditional white pages. Some may even deny the listing of competitors' numbers altogether. Access to white pages may, therefore, turn out to be an entry barrier.

- **Emergency Services**—A key subscriber expectation is that their primary telephone service will be a reliable and direct link to a local 911 center. The telephony provider is also expected to be able to automatically download specific information about the calling party—the exact location the call originated from, for example—to the local emergency bureau. Software available for most digital switches allows providers to meet this requirement with relative ease and cost-effectiveness.
- **Operator Services**—Since the implementation of telephone services in the late 1800s, subscribers have expected to be able to call on an operator for directory assistance and toll assistance as they need it. These services are now largely delivered through equipment based on digital switching technologies (vendors, for instance, can package a combined end office/operator services switch), advanced operator workstations, and external databases to hold directory information, etc.

Because of the complexity and cost associated with such operation, many new providers may not initially want to establish their own operator service centers. Outsourcing arrangements with other providers are readily available for companies that make this choice.

Larger providers who provision their own operator force, however, can find it an important source of revenue. In addition to offering traditional operator services and wholesaling operator services to other providers, many state-of-the-art operator bureaus are now beginning to use operators to deploy information services such as “talking” yellow pages and innovative listing services that let the operator act as a community navigator to restaurants, retail establishments, etc.



A Glossary of Key Telephony Terms

DTM • LATA • POTS • ISDN • ATM • ISDN • LATA • POTS • DLC • LEC • ATM • ISDN • LATA •

One of the most daunting barriers to entry for new players in the telecommunications market is the entrenched jargon that pervades many discussions in the industry. To make the initiation into the world of telephony a little easier, this section provides brief translations of the acronyms and key terms that new market entrants are likely to encounter.*

*Thanks to the editors of *America's Network* for permission to reprint a number of these definitions from *Telco-Talk*, a publication jointly sponsored by *America's Network* and Northern Telecom.

A

ACD (Automatic Call Distribution)—A specialized telephone answering method that handles large volumes of incoming calls by distributing them equally among a group of answering positions on standard telephone lines. Calls to airline reservation departments, for instance, are served by ACDs.

ADPCM (Adaptive Differential Pulse Code Modulation)—A coding scheme standardized by CCITT (see CCITT) that allows an analog voice to be carried on a 32-kbps digital channel instead of the standard 64-kbps PCM channel.

ADSI (Analog Display Services Interface)—A protocol that simplifies use of advanced features by displaying text messages generated by a remote computer or central office switch on a display on a user's telephone or television set.

ADSL (Asymmetric Digital Subscriber Line)—A standard allowing digital broadband (over 6 Mbps) signals and plain old telephone service to be transmitted up to 12,000 feet over a twisted copper pair.

AIN (Advanced Intelligent Network)—Bellcore's switching concept that centralizes a significant amount of intelligence rather than constantly placing more and more information in the central office switch.

ALI (Automatic Location Identification)—Works hand-in-hand with automatic number identification (see ANI), and uses a computer database to associate a physical location with a telephone number.

AMA (Automated Message Accounting)—Format in which a digital switch usually creates the usage data used for billing.

AMPS (Advanced Mobile Phone Service)—The name applied to the original analog cellular system. Still the predominant cellular transmission scheme.

ANI (Automatic Number Identification)—A feature that sends a calling party's telephone number over the network to the called party. Particularly useful in enhanced 911 systems.

ANSI (American National Standards Institute)—A U.S. standards-setting organization, not an arm of the government. Accredits various other standards setting committees.

AOS (Alternative Operator Services)—Name applied to those non-telephone company businesses that provide operator services (e.g., to private pay phone operators).

APS (Automatic Protection Switching)—A method of allowing transmission equipment to automatically recover from failures such as a cable cut.

AT (Access Tandem)—A switching system that provides traffic concentration and distribution functions for interLATA traffic.

ATM (Asynchronous Transfer Mode)—A transmission/switching scheme that is used for very high speed transmission. ATM will be the technology of choice for multimedia transmission.

B

BER (Bit Error Rate)—A measure of transmission accuracy. It is the ratio of bits received in error to bits sent. A BER of 10^{-9} (or one error in a billion bits) is common in voice and data transmission systems.

BETRS (Basic Exchange Telecommunications Radio Service)—In its simplest form, it is “fixed cellular,” a form of wireless local exchange service. In such an application, handoff is not required.

BHCC (Busy Hour Call Completion)—A term used in traffic measurement. Normally there is one hour of one day that is considered the “busy hour.” Equipment is provisioned based on this measurement.

BISDN (Broadband Integrated Services Digital Network)—A very high speed ISDN service intended to support full motion video and image applications, as well as data. Has a base rate of approximately 150 Mbps.

BOC (Bell Operating Company)—Any of the 22 regulated telephone companies that are organized into seven Regional Bell holding companies. See RBOC and RHC.

BRI—Basic Rate Interface—This ISDN scheme is identified as 2B1D, and permits two “bearer” channels, each operating at 64 kbps, and one “data” channel, operating at 16 kbps, to be carried over a single twisted pair.

C

CAC (Carrier Access Code)—Five- to seven-digit number that identifies which interexchange carrier a call will use. Subscribers can dial these digits with each long distance call, or can pre-subscribe to a particular carrier and let the digital switch software add the CAC.

CAP (Competitive Access Provider)—Alternative carrier (e.g., Teleport and Metropolitan Fiber Systems) that competes with telephone companies in carrying traffic. Usually these companies construct a fiber ring in an urban area to attract businesses to use their services in addition to or in place of the services of the local telephone company.

CCF (Custom Calling Features)—The basic custom calling features now available to subscribers include Call Waiting, Call Forwarding, Abbreviated Dialing, Three-Way Calling, etc. These revenue-generating features are available from the central office, and do not require any special customer premises equipment.

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CCITT (Comité Consultatif Internationale de Telegraphique et Telephonique)—An international group operating under the auspices of the International Telecommunications Union (ITU) and charged with establishing telecommunications standards. Name recently changed to ITU-TSS (International Telecommunications Union-Telecommunications Standards Sector).

ccs (Hundred Call Seconds)—A measure of traffic used to determine the capacity of telephone systems.

CDMA (Code Division Multiple Access)—A digital transmission scheme claimed to be more efficient than other systems and to offer up to 20 times more call handling capacity than analog cellular systems.

CEV (Controlled Environmental Vault)—A below-ground enclosure used by the telephone companies for which virtually anything an above-ground hut would be used. These units generally house batteries, electronic equipment, terminating and cross-connect frames, etc.

CLASS (Custom Local Area Signaling Services)—A set of more powerful custom calling services now provided by telephone companies; sometimes referred to as advanced custom calling features. Examples are Automatic Callback, Automatic Recall, Calling Number Delivery, Customer Originated Trace, Distinctive Ringing, Selective Call Forwarding, and Selective Call Rejection.

CLID (Calling Line Identification)—A relatively new offering that permits subscribers to see the telephone number and/or name of the calling party. Frequently, “calling number blocking” is offered as well. In this case, calling parties can block the display of their telephone numbers.

CO (Central Office)—The building in which telephone companies, etc., locate their switching equipment and terminate their circuits. Sometimes used interchangeably with “exchange.”

COCOT (Customer Owned Coin Operated Telephones)—In as much as pay phones are no longer the sole province of the telephone company, any entrepreneur can buy, place, and collect from a set of privately-owned pay phones.

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CODEC (Coder/Decoder)—The electronic circuit converts analog voice signals into digital signals for transmission and switching, and digital signals to analog voice signals so that they can be used by the telephone.

COT (Customer Originated Trace)—An advanced subscriber feature that allows a telephone user to initiate a trace of the last incoming call. The number is then automatically reported to the service provider, a law enforcement agency, or other designated agency.

CPE (Customer Premises Equipment)—The telecommunications equipment located on a customer’s premises. Usually refers to key systems, private branch exchanges (PBXs), telephones, etc.

CRC (Cyclic Redundancy Check)—A form of error detection. Accomplished by reading a block of incoming data, operating on the binary number equivalent of this block (e.g., dividing by another binary number) and noting the remainder. If this remainder is the same as a character transmitted in the message, it is assumed that the transmission was error free.

CSA (Canadian Standards Association)—One of several bodies—this one based in Canada—that develops telecommunications standards.

CSU (Channel Service Unit)—A device that is located on the customer's premises. It terminates and tests digital data and voice circuits.

CT1, CT2, CT3 (first, second, and third generation of cordless telephones)—The first generation is the cordless phone found today in 60 percent of American homes. CT2 is typically used in low-power applications such as "cordless pay phone" or wireless PBX. CT3 is a vague term often applied to new PCS telephones.

D

dB (Decibel)—A logarithmic unit describing the ratio of two powers.

dBm (Decibel Referenced to a Milliwatt)—The ratio of two power levels, in which the second is one milliwatt.

DCS (Digital Cross-Connect)—A cross-connect system, totally electronic, that routes DS-1, DS-3, and DS-0 lines among multiple paths. The DCS makes demultiplexing unnecessary. Although it operates very rapidly, it in no way replaces a central office switch. It can, however, re-route traffic should a major system fault occur.

DDS (Digital Data Service)—A 56- or 64-kbps digital private line channel.

DECT (Digital European Cordless Telephone)—The European standard for wireless transmission. Generally associated with office communications.

DID (Direct Inward Dialing)—The feature of Centrex systems and large PBXs that allows a caller outside a company to call an internal extension without going through the switchboard.

DLC (Digital Loop Carrier)—A digital transmission system designed for subscriber loop plant. Multiplexes many circuits onto very few wires or onto a single fiber pair.

DMS (Digital Multiplex Systems)—A system that combines, on a digital basis, a number of circuits. Also the prefix for the Northern Telecom family of digital central office switches (DMS-10, DMS-100/200, DMS-250, DMS-300, and DMS-500).

DMT (Discrete Multitone)—A frequency-agile modulation scheme in which available bandwidth is divided into many sub-channels. Each sub-channel is then analyzed for its ability to carry digital data. Noisy sub-channels carry few or zero bits, while clear channels carry a maximum number of bits. Advanced DSP techniques allow these bits-to-sub-channel assignments to occur in real time.

DPN (Data Packet Network)—A packet network is one in which “bundles” of information are transmitted, one after another. This differs from a circuit network, in which an entire circuit is dedicated to a particular user. Also the prefix for Northern Telecom’s DPN data networking switches.

DRAM (Digital Recorded Announcement Machine)—Device associated with a switching system that provides recorded announcements, such as “Please deposit 50 cents for the first three minutes.”

DSCWID (Call Waiting Display with Disposition)—An advanced subscriber feature that not only identifies the incoming caller on a telephone’s display window, but also provides options for handling the waiting call.

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DSU (Data Service Unit)—A device located on the customer’s premises that converts a digital data signal to a digital transmission signal.

DTC (Decoder Time Clock)—Used in decoding a compressed video signal. A clock distinct from the distant-end encoding clock, but kept in time and phase with the incoming signal by bits inserted in this incoming bit stream.

DTE (Data Terminal Equipment)—The name applied to a piece of terminal equipment.

DTMF (Dual Tone Multifrequency)—The tones sent out by a touch tone dialing unit.

DWS (Dialable Wideband Service)—An alternative name for Multi-Rate ISDN. Provides dialed data connectivity at desired bandwidth on a per call basis (from 128 kbps through 1.536 Mbps in 64 kbps increments).

E

E-TDMA (Enhanced Time Division Multiple Access)—One of many digital transmission schemes proposed as “standard” for cellular radio. Primary proponent is Hughes Network Systems. Fundamentally it is a time division multiple access system.

EAS (Extended Area Service)—A service provided by many telephone companies in which towns with a common community of interest are considered “local.” Hence subscribers calling these towns do not incur a long distance charge.

ECSA (Exchange Carrier Standard Association)—A standards body sponsored by the exchange carriers, and accredited by American National Standards Institute (ANSI). Recently the name of this organization has been changed to Alliance for Telecommunications Industry Solutions (ATIS).

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EMI (Electro-Magnetic Interference)—Electromagnetic waves emitted by some electrical devices. Distorts or overwhelms communications signals being transmitted over the air.

EPROM (Erasable Programmable Read Only Memory)—An integrated circuit read-only memory device that can be electrically programmed and erased either electrically or with ultraviolet light.

ESA (Emergency Stand Alone)—The ability of a switch remote to continue handling local calls when links to the host switch are lost. Especially critical for Centrex applications such as hospitals.

ESP (Enhanced Service Provider)—The FCC defines enhanced services as “services offered over common carriers’ transmission facilities...which employ computer processing applications that act on the format, content, code, protocol...” Therefore an enhanced service provider operates, in one way or another, on the information being transmitted.

ETSI (European Telecommunications Standards Institute)—One of several Europe-based standards bodies.

F

FCOT (Fiber Central Office Terminal)—Electronic equipment designed to terminate multiple fiber feeders from next generation digital loop carrier systems.

FDDI (Fiber Distributed Data Interface)—A standard designed to allow traffic of up to 100 Mbps to be transmitted in a local area network.

FDMA (Frequency Division Multiple Access)—The original U.S. transmission scheme for cellular radio. Analog in nature, it is used in every Metropolitan Service Area and Remote Service Area in the country.

FEC (Forward Error Correction)—Frequently used in data transmission systems. Redundant bits are transmitted along with the payload, and the location and value of these bits in the message allows the receiving station to not only detect errors but also to correct them.

FITL (Fiber In The Loop)—Used generally to refer to the deployment of fiber between the central office and the subscriber.

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FM (Frequency Modulation)—One of many modulation schemes. The message signal modulates a carrier signal in such a way that the frequency (as opposed to the amplitude or phase) of the carrier is varied.

FOTS (Fiber Optic Transmission System)—A generic term applied to any fiber optic transmission system.

FSK (Frequency Shift Keying)—A means used to transmit binary data. A “1” is represented by one frequency, and a “0” by a second.

FTTC (Fiber-To-The-Curb)—Fiber has been placed first in the long distance network, then in the feeder plant, then the distribution plant. In this case the fiber then proceeds to the curb, with copper going from the curb to the home itself.

FTTH (Fiber-To-The-Home)—Extending fiber past the curb, all the way to the wall of the subscriber’s home.

FX (Foreign Exchange)—Provided local exchange telephone service from a central office that serves a different exchange area. Thus a subscriber in one city will receive dial tone from, and have a telephone number of, a distant city.

G

Gbps (Gigabits per second)—Giga is the prefix representing 10^9 , or one billion. For example, 8 Gbps means 8 billion data bits per second.

GPS (Global Positioning System)—Atomic clocks control radio signals from orbiting satellites with almost perfect accuracy. A signal sent by three (four in actual practice) synchronous satellites can be received by a vehicle-mounted global positioning system, and through triangulation techniques the vehicle can determine its position to within a few meters.

GSM (Global System for Mobile Communications)—A comprehensive network specification that includes transmission scheme, network architecture, network services etc.—proposed as “standard” for cellular radio. This system is the standard in Europe and many countries in Asia, and a proposed standard for personal communications services in North America. It is a time division-type system.

H

HDBH (High Day Busy Hour)—The busiest hour of the busiest day of the year for a piece of telecommunications system. A central concept for network planning.

HDSL (High bit rate Digital Subscriber Line)—By using sophisticated coding techniques, a large amount of information may be transmitted over copper. The HDSL scheme uses such coding over four copper wires and is primarily intended for high capacity bidirectional business services.

HDTV (High Definition TV)—Television with very high resolution and a wide aspect ratio. Requires significantly greater bandwidth than conventional television.

I

ICN (Integrated Community Network)—A shared public network for services such as distance learning, remote arraignment, and medical imaging.

IDDD (International Direct Distance Dialing)—Feature that allows subscriber to directly dial international numbers.

IDLC (Integrated Digital Loop Carrier)—A digital loop carrier system that connects directly to a digital central office switch.

IEC (Interexchange Carrier)—See IXC.

IMTS (Improved Mobile Telephone Service)—The precursor to cellular. Utilized a single transmitting station that was able to cover a great piece of geography. Was very channel-limited, and its shortcomings led to the invention of cellular.

IN (Intelligent Network)—The generic term for the Advanced Intelligent Network.

IP (Intelligent Peripheral)—An Advanced Intelligent Networking network element that, for instance, only controls a specialized set of features (voice recognition services, for instance) or provides a specialized set of functions to support features (IPs, for instance, may supply the voice prompts for some operator services features).

ISDN (Integrated Services Digital Network)—In its simplest form, called Basic Rate ISDN, it provides a means of transmitting two voice channels (each operating at 64 kbps) and one data channel (operating at 16 kbps) over a single pair of twisted copper conductors. The two voice channels are called bearer, or “b” channels; the single data channel is the “d” channel. A more complex form of ISDN is called Primary Rate ISDN; in this system there are 23 “B” channels operating at 64 kbps and one “D” channel operating at 64 kbps. Thus the transmission capability of Basic Rate ISDN is 144 kbps, and that of Primary Rate ISDN nearly 1.5 Mbps.

IXC (Interexchange Carrier)—Quite literally, these carriers transmit information between exchanges; frequently simply called long distance carriers. Major examples are AT&T, MCI, and Sprint.

K

kbps (kilobits per second)—Kilo is the prefix representing 103, or one thousand. For example, 64 kbps means 64,000 data bits per second.

L

LAN (Local Area Network)—A local network connecting a defined set of terminals. Could connect work stations in an office, offices in a building, buildings on a campus, etc.

LATA (Local Access and Transport Area)—The geographic area that is the domain of the local exchange carrier. Bell Operating Companies are generally precluded from carrying traffic across LATA boundaries; this traffic must be handed off to an interexchange carrier.

LEC (Local Exchange Carrier)—The local telephone company. Generally subdivided into Bell Operating Companies and Independents.

LEO (Low Earth Orbit)—Low earth orbit satellites are being proposed for worldwide wireless communications systems. These satellites (every proposal is different, but constellations of many dozen are usually specified) operate at an altitude of 300 to 600 miles, rather than the 22,300 miles of a synchronous orbit satellite. Therefore, they travel across the sky rather than remaining stationary over a single point. Communications with earth stations, or with earth-bound subscribers, requires some kind of hand off.

LMDS (Local Multipoint Distribution Service)—A proposed radio-based distribution system. It is anticipated that initial deployment would be for video distribution. Ultimate use would involve two-way voice, video, and data.

LSSGR (LATA Switching System Generic Requirements)—Multi-volume set of Bellcore technical references dealing with basic switching requirements used by switch manufacturers, procurement staffs, planners, and switch technicians.

M

MAN (Metropolitan Area Network)—A network linking multiple, geographically separate LANs together usually confined to a metropolitan area.

MBG (Multilocation Business Group)—Networking scheme that allows private business to tie sites together through the use of public SS7 trunks.

Mbps (Megabits per second or millions of bits per second)—A measure of digital transmission speed used in computer and telephone networks.

MDC (Meridian Digital Centrex)—Northern Telecom's name for a package of business communication services provided by a DMS-10, DMS-100, or DMS-500 central office switch.

MDF (Main Distribution Frame)—The point of termination inside the central office for outside plant cable and central office equipment lines. A crossconnect between vertical and horizontal components associates the two.

MF (Multi-Frequency)—An older signaling protocol used in network trunking. Uses combinations of pulses as specified frequencies to signal across the network.

MFJ (Modification of Final Judgement)—Official name for the 1982 Federal court ruling resulting in divestiture of the Bell Operating Companies from AT&T.

MSA (Metropolitan Service Area)—FCC designated market areas which are the basis for cellular service boundaries. In addition, there are Rural Service Area (RSA) markets.

MSA (Metropolitan Statistical Area, formerly Standard Metropolitan Statistical Area)—A federal government defined geographic area consisting of a large population nucleus and surrounding communities with economic and social association with the nucleus.

MTBF (Mean Time Between Failures)—Average period of time a piece of equipment or component remains working before failure.

MTSO (Mobile Telephone Switching Office)—Location of the switch controlling operation of a cellular system.

N

NAMPS (Narrowband AMPS)—An enhanced AMPS analog cellular radio standard for increased capacity.

NANP (North American Numbering Plan)—The system or method by which calls are routed in the public network of North America. The plan divides phone numbers into three parts—an area code, central office code, and subscriber code.

NE (Network Element)—An individual piece of telecommunications equipment providing a component function in the overall network. Channel banks, multiplexers, and SONET transmission gear are all network elements.

NII (National Information Infrastructure)—In the words of Vice President Al Gore, “a seamless web of communications networks, computers, databases and consumer electronics that will put vast amounts of information at users’ fingertips.”

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NIU (Network Interface Unit)—The demarcation point between service providers-owned and customer-owned wiring and equipment. Also called Network Interface Device.

NNI (Network-Network Interface)—The interface connecting one network node to another.

NPA (Numbering Plan Area)—Another name for area code. The three digit NPA makes up the first part of every phone number in the North American Numbering Plan.

NVOD (Near Video-On-Demand)—Unlike video-on-demand, the customer does not control a virtual channel. Popular movies are placed on multiple channels with staggered start times. Customer tunes to appropriate channel for nearest start time. VCR-like controls (e.g., pause, stop) are not available.

O

OC-N (Optical Carrier - Level N)—The hierarchy of optical SONET signals at multiples of 51.840 Mbps. A direct counterpart to the electrical STS-N. The value of N ranges from 1 to 48.

OCC (Other Common Carrier)—Carriers other than AT&T providing long distance service. These companies, plus AT&T, are now referred to as IXC's or interexchange carriers.

ONA (Open Network Architecture)—A network architecture arrangement where outside providers can interconnect to the Regional Bell Operating Companies' networks and offer enhanced services on an equal footing.

OSI (Open Systems Interconnection)—A seven-layer framework of standards for network communication. OSI creates an open systems networking environment where different systems can share data regardless of vendor or platform.

OSS (Operations Support System)—A system that furnishes tools to provide network control, monitoring, and business functions from a centralized location. Nearly all pieces of network equipment or major network functions have an OSS.

OTDR (Optical Time Domain Reflectometer)—A device used to measure parameters of optical fiber. A light pulse is sent down the fiber and ratio and timing of incident and reflected light power is measured. The device can be used to determine if and where a fiber might be broken.

P

PAD (Packet Assembler and Disassembler)—A device performing the interface between an X.25 data network and an asynchronous device such as a personal computer. The PAD assembles user data into packets with identifying information used to control routing.

PBX (Private Branch Exchange)—Customer premises version of a central office switch.

PCM (Pulse Code Modulation)—A coding scheme for converting analog voice signals into a digital bit stream. A digitizing technique, PCM is the basis for digital communications in North America.

PCN (Personal Communications Network)—A wireless telephone network concept similar to cellular, operating in the 1800-2000 MHz range. Smaller, low-power cells reduce range in comparison to cellular, but keep handset cost low.

PCS (Personal Communications Services)—Any service offered on the personal communications network. These include basic telephone, voice mail, paging, and others.

PM (Phase Modulation)—A form of modulation where the phase of the transmitted signal is changed as the value (content) of the information changes.

POP (Point of Presence)—The physical location where a long distance carrier terminates lines before connecting to the local exchange company, another carrier, or directly to a customer.

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POTS (Plain Old Telephone Service)—Basic telephone service—dial tone without special features.

PRI (Primary Rate Interface)—An ISDN interface providing 23 “B” channels, each operating at 64 kbps, and a single “D” channel also operating at 64 kbps to a customer’s premises.

PSC (Public Service Commission)—Also known as Public Utilities Commission. The State agency regulating telephone operations.

PTSN (Public Switched Telephone Network)—The worldwide switched voice network.

PTT (Post Telephone & Telegraph)—Government controlled agencies providing telephone and telecommunications services in many foreign countries.

PUC (Public Utilities Commission)—See PSC.

Q

QAM (Quadrature Amplitude Modulation)—Modulation technique combining phase and amplitude modulation to increase the number of bits per second.

R

RAD/RASP (Remote Antenna Device/Remote Antenna Signal Processing)—A technique to separate radio antennas for personal communications services from their associated electronic equipment.

RAM (Random Access Memory)—A computer's direct access memory. It can be accessed very quickly, can be overwritten with new information, and loses its content when power is turned off.

RAO (Revenue Accounting Office)—Generic name for the billing center that computes and creates subscriber bills for telephone companies.

RBOC (Regional Bell Operating Company)—A term for the seven Regional Holding Companies created when AT&T divested the Bell Operating Companies.

RCC (Radio Common Carrier)—A company furnishing services to the public using radio frequencies. The original non-wireline cellular franchise in each market was reserved for an RCC.

REA (Rural Electrification Administration)—A government agency and program that makes loans to companies providing telephone service in rural areas.

RF (Radio Frequency)—An electromagnetic signal between the audio and infrared frequency range of 500 kHz to 300 GHz.

RFI (Radio Frequency Interference)—Disruption of signal reception by radio waves at the same frequency as the desired signal.

RHC (Regional Holding Company)—See RBOC. Another name for one of the seven companies formed when AT&T divested the Bell Operating Companies.

RISC (Reduced Instruction Set Computing)—A high speed computer processing technology using a simple set of operating commands that allow it to process each command faster.

RSA (Rural Service Area)—An FCC designated rural market area for cellular service. These areas were designated in addition to the Metropolitan Service Areas. See MSA.

S

SCAI (Switch-to-Computer Applications Interface)—Protocol that allows a subscriber's computer to interact with a digital switch. Makes it possible to coordinate information in a database with incoming and outgoing phone calls to allow a company representative, for instance, to receive a customer call and simultaneously receive the customer's file for viewing on a desktop work station.

SCE (Service Creation Environment)—The set of tools and activities required to create new services for subscribers in the AIN arena.

SCP (Service Control Point)—The centralized network element in the Advanced Intelligent Network architecture that individual switches call on to obtain information and commands necessary for completing an AIN call.

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SDH (Synchronous Digital Hierarchy)—Similar to SONET, it is a standard for synchronous digital transmission rates used outside North America.

SMDR (Station Message Detail Recording)—A feature of telephone systems that permits information on outgoing telephone calls to be collected and recorded.

SMDS (Switched Multimegabit Data Service)—A public, wide-area packet-switched data service developed by Bellcore that provides DS-1 to DS-3 switched access.

SMS (Service Management System)—The operations support system for Advanced Intelligent Networking. Provides the mechanism for downloading new features and monitoring the AIN network.

SNA (Systems Network Architecture)—IBM's standard network architecture describing logical structure, formats, protocols and operational sequences for transmitting information between software and hardware devices.

SNMP (Simple Network Management Protocol)—Network management architecture initially designed for the Internet, but easily applied or extended to any network type.

SONET (Synchronous Optical Network)—Family of optical transmission rates and interface standards allowing interworking of products from different vendors. Base optical line rate is 51.840 Mbps. Higher rates are direct multiples.

SS7 (Signaling System No. 7)—An out-of-band signaling system used to provide basic routing information, call set-up, and other call termination functions. Signaling is removed from the voice channel itself and put on a separate data network. Also known as Common Channel Signaling No. 7 (CCS7).

SSP (Service Switching Point)—That node of the Intelligent Network normally associated with an end office. The entrance to the Intelligent Network.

STP (Signal Transfer Point)—A packet switch in the SS7 network that enables cost-effective routing of SS7 signals between other network elements.

STS (Synchronous Transport Signal)—The electrical equivalent of the SONET-defined optical signal with a base rate of 51.840 Mbps.

T

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TA (Technical Advisory)—A document describing Bellcore's preliminary view of proposed requirements for products, interfaces, technologies, or services.

TCP/IP (Transmission Control Protocol/Internet Protocol)—A communications protocol linking different computer platforms across networks. TCP/IP functions at the 3rd and 4th layers of the open system integration model.

TDD (Telecommunications Device for the Deaf)—The teletypewriter device normally associated with telephones—including payphones—that permits hearing-impaired people to communicate over the public switched network.

TDM (Time Division Multiplexing)—A digital multiplexing technique for combining a number of signals into a single transmission facility by interleaving pieces from each source into separate time slots.

TDMA (Time Division Multiple Access)—A digital cellular transmission standard that increases cellular capacity by dividing frequencies into time slots.

TOPS (Traffic Operator Position System)—A Northern Telecom operator services system.

TR (Technical Reference)—Bellcore-created technical document with proposed generic requirements for products, interfaces, technologies, or services.

TSI (Time Slot Interchange)—A high-speed technique for switching time division multiplexed signals so they can be sent out in a different order or on a different signal than they were received.

U

UNI (User-Network Interface)—Interface connecting users to the network.

UPS (Uninterruptible Power Supply)—An auxiliary power unit providing continuous power to a telephone system in case commercial power is lost.

V

VANC (Voice Activated Network Control)—Feature that allows subscriber to access advanced services such as call forwarding through voice commands.

VAPN (Virtual Access to Private Networks)—A networking scheme that uses public network facilities to extend private network calling to remote sites.

VBR (Variable Bit Rate)—A service where the transmission rate varies over time incorporating the concept of bandwidth-on-demand.

VDT (Video Dial Tone)—An FCC concept where telephone companies act as a common carrier serving video programmers to deliver video-based services to customers.

VLSI (Very Large Scale Integration)—The technique of putting hundreds of thousands of transistors onto a single integrated circuit.

VOD (Video-On-Demand)—Customers request video programming from their home and receive it immediately. They control the video stream transmitted from within the network and have full VCR functionality over it (e.g., pause, fast forward, rewind).

VSAT (Very Small Aperture Terminal)—A small antenna used for transmitting and receiving data communications.

VT (Virtual Tributary)—A SONET structure designed for transporting sub-base rate payloads.

W

WAN (Wide Area Network)—An integrated data network linking metropolitan or local networks over common carrier facilities.

WATS (Wide Area Telephone Service)—Discounted toll service offered on an inward or outward basis. Inward WATS is better known as 800 Service.

WDM (Wavelength Division Multiplexing)—A method for transmitting two or more separate signals on the same fiber path by carrying each signal at a different wavelength.