Advances in ISDN and Broadband ISDN

William Stallings

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Advances in Integrated Services Digital Networks (ISDN) and Broadband ISDN

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Chapter 1: Integrated Services Digital Network (ISDN) Overview

The arrival of ISDN

Rapid advances in computer and communication technologies have resulted in the increasing merger of these two fields. The lines have blurred among computing, switching, and digital-transmission equipment, and the same digital techniques are being used for data, voice, and image transmissions. Merging and evolving technologies, coupled with increasing demands for the efficient and timely collection, processing, and dissemination of information, are leading to the development of integrated systems that transmit and process all types of data. The ultimate goal of this evolution is something its proponents — some of the most powerful forces in the computing and telecommunications industries — call the integrated services digital network (ISDN). ISDN will be a worldwide public telecommunications network that will replace existing public telecommunications networks. It will deliver a wide variety of services, both voice based and data based.

ISDN is defined by the standardization of user interfaces. Because it will be implemented as a set of digital switches and paths, ISDN will support a broad range of traffic types and provide value-added processing services. In practice, there will be multiple networks, implemented within national boundaries; however, from the user's point of view, there will be a single, uniformly accessible, worldwide network.

The impact of ISDN on both users and vendors will be profound. To control ISDN evolution and impact, a massive effort at standardization of user interfaces is under way. Although ISDN standards are still evolving, both the technology and the emerging implementation strategy are well understood.

Two key aspects of ISDN are universal access and user services, which are discussed below.

(1) Universal access. With standardization of the interfaces to ISDN, all ISDN-compatible equipment (for example, telephones, computer terminals, and personal computers) would be able to attach to the network anywhere in the world and connect to any other attached system. This ability would lead to extraordinary flexibility. For example, assigned telephone numbers — like US social security numbers — could be good for a lifetime. No matter where a user lived, or how often he moved, his telephone would ring when the number permanently assigned to him is dialed. In another example of the flexibility of universal access, a person, wherever he is, could reach — for instance — the nearest Holiday Inn by tapping the telephone buttons marked H-O-L-I-D-A-Y-I-N-N.

(2) User services. Two examples of user services that will be provided by implementation of ISDN are found in the medical field and the banking industry, respectively. The first example is in the medical field. A doctor maintains both a suburban office and an office at an in-town hospital. The medical records for all of his patients are kept in a database at the hospital. Suppose — with ISDN — that a patient places a call to the doctor at the hospital on a day that the doctor is at his suburban office. The call would be forwarded automatically from the hospital to the suburban office, where the incoming call would cause the telephone to ring. At the same time, the name and telephone number of the caller would be displayed on a small screen that would be part of the telephone. While the telephone is ringing, a message would be automatically sent back to the hospital to search for any records associated with this call. If a database search reveals that the caller is a patient of this doctor, the patient's medical record would be transmitted to the suburban office; the first page of that record would be displayed on a terminal screen next to the telephone by the time the receiver is picked up to answer the call. The second example is in the banking industry. Bank-by-phone services depend upon the automatic identification of the calling party; ISDN can provide such identification, while guaranteeing transaction privacy and security. In addition, ISDN will support increased — and increasingly easy-to-use — electronic funds transfer facilities, as well as rapid check clearing.

Many trends present today in the computer world are driving ISDN; these trends are part of the evolution to ISDN and will be accelerated as ISDN is implemented. Computers are being joined together, instead of being left standing alone. An estimated 30 percent of today's personal computers have communications capability, and this percentage is rising. While yesterday's corporate computer was a stand-alone device, today's business computers comprise a mix of small, medium, and large computers that can share resources (such as printers), share data, and exchange messages. Our analytical tools have sprouted wires; more and better wires are coming, and the wires will extend everywhere. Cellular radio is making communications mobile. Automobiles, taxis, and boats are becoming workstations. People can not only talk via cellular radio phones, but can also transmit data by linking up their portable computers. In the future, cellular phone/computer combinations will be developed; in time, automobiles will provide communication/computer systems as options: Any vehicle could be a unit capable of linking up to the global information network. Computers for personal use will be ubiquitous in the future; this will be especially true for students (starting with elementary school) and "knowledge workers," who deal primarily with paper documents, reports, and numbers. Soon, many office workers will have at least one workstation at the office and one at home. Furthermore, most people will own a powerful portable very personal computer (VPC) — possibly a wearable model. The hotel at which you stay may have personal computers in their rooms as amenities; some hotels already do. Computing power will be at every hand; most importantly, each computer will tap into the network.

The volume and richness of data are increasing dramatically. The first-generation personal computers have given way to the latest IBM PCs and MAC-IIs with color and high-quality graphics. New applications in the office environment are being developed that require much higher networking capacity than that of traditional office applications, and desktop image processors will soon increase network data flow by an unprecedented amount. Examples of these new applications include digital facsimile machines, document image processors, and graphics programs on personal computers. Resolutions as high as 400 dots per inch are typical for these applications. Even with compression techniques, these new applications will generate a tremendous data communications load. In addition, optical disks are beginning to reach technical maturity and are being developed toward realistic desktop capacities that exceed one gigabyte (Gbyte).

Two of the most difficult technologies to develop — voice recognition and natural-language processing — are gradually emerging from artificial-intelligence laboratories. Applications of these technologies will increase the intelligence of systems and networks. Voice recognition is the ability to recognize spoken words. Natural-language processing is the ability to extract the meaning of words and sentences. As these two technologies develop, access to information banks and databases will become increasingly easy, therefore creating a greater demand for access. A user will be able to perform a transaction or to access information with simple spoken or natural-language keyed commands. Interfacing with the worldwide network will be like talking with a very knowledgeable telephone operator, librarian, and universal expert, rolled into one. Government use of computer systems will become more efficient. (The government is the most prodigious producer and user of information in our society.) ISDN will improve and disperse access to — and help to remove incompatibilities among — different systems, so that more can be accomplished with less effort.

National and global business activities will benefit. The brokerage business has become almost a computer network unto itself, depending upon instant transmission of information and automated buy-sell orders. Banking today relies upon more than automatic tellers and computerized accounting. And banks are beginning to sell on-line information services as adjuncts to electronic banking.

Companies of all sizes are coming to depend upon telecommunications for their daily business activities. Remote data entry, electronic mail, facsimile transmission, and decision support systems are just some of the operations that rely upon communications. Multinational corporations and joint ventures between American and foreign firms depend upon quick interchange of information. Communication networks are absolutely essential for the continued globalization of trade and industry. Office buildings are being wired for intelligence. The so-called "smart building" is beginning to appear; such a building contains a network for voice, data, environmental control (of heat, humidity, and air conditioning), security (against burglary and fire), and closed-circuit TV. Many of these services generate out-of-building transmission requirements.

Electronic person-to-person interaction will increase. With electronic mail, voice mail, file transfer, document exchange, and video teleconferencing facilities, business is responding to the need for employees to interact and to avoid "telephone tag." All of these facilities generate large data communications requirements. In developed countries, fiber is rapidly replacing microwave and coaxial cable transmission paths. (Fiber, together with satellite, is appearing more gradually elsewhere.) The resulting quantum jump in capacity has permitted the planning and deployment of new applications on public and private networks.

Principles of ISDN

Standards for ISDN, called "recommendations," are being defined by the Comité Consultatif International Télégraphique et Téléphonique (CCITT) (International Consultative Committee for Telegraphy and Telephony). (This chapter explores these standards in greater detail later.) The top portion of Table 1-1, from one of the ISDN-related standards, gives the principles of ISDN from the point of view of the CCITT. Let us look at each of these principles in turn.

(1) Support of voice and nonvoice applications using a limited set of standardized facilities. This principle defines both the purpose of ISDN and the means of fulfilling this purpose. ISDN will support a variety of services related to voice communications (for example, telephone calls) and nonvoice communications (for example, digital data exchange). These services are to be provided in conformance with standards (CCITT recommendations) that specify a small number of interfaces and data transmission facilities. The benefit of standards are explored later in this chapter. For now, we simply state that — without such a limitation — a global, interconnected ISDN is virtually impossible.

(2) Support for switched and nonswitched applications. ISDN will support both circuit switching and packet switching. In addition, ISDN will support nonswitched services in the form of dedicated lines.

(3) Reliance on 64-kilobit per second (Kbps) connections. ISDN will provide circuit-switched and packet-switched connections at 64 Kbps. This reliance on 64-Kbps connections is the fundamental building block of ISDN. The rate of 64 Kbps was chosen because, at the time that it was chosen, it was the standard rate for digitized voice; hence, it was being introduced into the evolving digital networks. Although this data rate is useful, relying solely upon it is unfortunately restrictive. Future developments in ISDN will permit greater flexibility.

(4) Intelligence in the network. ISDN will provide sophisticated services beyond the simple setup of a circuit-switched call.

(5) Layered protocol architecture. The protocols being developed for user access to ISDN exhibit a layered architecture and can be mapped into something referred to as the "OSI model," where OSI stands for "open systems interconnection." This layered protocol architecture has a number of advantages, as follows:

- Standards already developed for OSI-related applications may be used on ISDN. An example is X.25 level 3 for access to packet-switching services in ISDN.
- New ISDN-related standards can be based on existing standards, reducing the cost of new implementations. An example is link access protocol-D channel (LAPD), which is based on link access protocol-balanced (LAPB).
- Standards can be developed and implemented independently for various layers and for various functions within a layer. This advantage allows for the gradual implementation of ISDN services at a pace appropriate for a given provider or a given customer base.

(6) Variety of configurations. More than one physical configuration is possible for implementing ISDN. This allows for differences in national policy, in the state of technology, and in the needs and existing equipment of the customer base.

Evolution of ISDN

Although the evolution of digital technology in telecommunications networks has been driven by the need to provide economical voice communications, the resulting network is also well suited to meet the growing variety of digital data service needs. The lower portion of Table 1-1 gives the CCITT view of the ways in which ISDN will evolve. Let us look at each of these ways in turn.

(1) Evolution from telephone integrated digital networks (IDNs). The intent is that ISDN evolve from the existing telephone IDNs. From this intent, the following two conclusions can be drawn:

- The digital technology developed for, and evolving within, existing telephone networks forms the foundation for the services to be provided by ISDN.

Table 1-1. Integrated services digital networks (ISDN) — Recommendation I.120

1	**Principles of ISDN**
1.1	The main feature of the ISDN concept is the support of a wide range of voice and non-voice applications in the same network. A key element of service integration for an ISDN is the provision of a range of services using a limited set of connection types and multipurpose user-network interface arrangements.
1.2	ISDNs support a variety of applications including both switched and non-switched connections. Switched connections in an ISDN include both circuit-switched and packet-switched connections and their concatenations.
1.3	As far as practicable, new services introduced into an ISDN should be arranged to be compatible with 64 Kbit/s switched digital connections.
1.4	An ISDN will contain intelligence for the purpose of providing service features, maintenance and network management functions. This intelligence may not be sufficient for some new services and may have to be supplemented by either additional intelligence within the network, or possibly compatible intelligence in the user terminals.
1.5	A layered protocol structure should be used for the specification of the access to an ISDN. Access from a user to ISDN resources may vary depending upon the service required and upon the status of implementation of national ISDNs.
1.6	It is recognized that ISDNs may be implemented in a variety of configurations according to specific national situations.
2	**Evolution of ISDNs**
2.1	ISDNs will be based on the concepts developed for telephone IDNs and may evolve by progressively incorporating additional functions and network features including those of any other dedicated networks such as circuit-switching and packet-switching for data so as to provide for existing and new services.
2.2	The transition from an existing network to a comprehensive ISDN may require a period of time extending over one or more decades. During this period arrangements must be developed for the interworking of services on ISDNs and services on other networks.
2.3	In the evolution towards an ISDN, digital end-to-end connectivity will be obtained via plant and equipment used in existing networks, such as digital transmission, time-division multiplex switching and/or space-division multiplex switching. Existing relevant Recommendations for these constituent elements of an ISDN are contained in the appropriate series of Recommendations of CCITT and of CCIR.
2.4	In the early stages of the evolution of ISDNs, some interim user-network arrangements may need to be adopted in certain countries to facilitate early penetration of digital service capabilities. Arrangements corresponding to national variants may comply partly or wholly with I-Series Recommendations. However, the intention is that they not be specifically included in the I-Series.
2.5	An evolving ISDN may also include at later stages switched connections at bit rates higher and lower than 64 Kbit/s.

• Although other facilities — such as third-party (not the telephone provider) packet-switched networks and satellite links — will play a role in ISDN, the telephone networks will play the dominant role.

Although packet-switching and satellite providers may be less than happy with these conclusions, the overwhelming prevalence of telephone networks dictates that these networks form the basis for ISDN.

(2) Transition of one or more decades. The evolution to ISDN will be a slow process. This is true of any migration of a complex application or set of applications from one technical base to a newer one. The introduction of ISDN services will be done in the context of existing digital facilities and existing services. There will be a period of coexistence, in which connections and perhaps protocol conversion will be needed between alternative facilities and/or services.

(3) Use of existing networks. [This item elaborates on item (2).] ISDN will provide a packet-switched service. For the time being, the interface to that service will be X.25. With the introduction of fast packet switching and more sophisticated virtual call control, a new interface may be needed in the future.

(4) Interim user-network arrangements. Primarily, the concern with interim user-network arrangements is that the lack of digital subscriber loops might delay introduction of digital services, particularly in developing countries. With the use of modems and other equipment, existing analog facilities can support at least some ISDN services.

(5) Connections at other than 64 Kbps. The 64-Kbps data rate was chosen as the basic channel for circuit switching. With improvements in voice-digitizing technology, this rate is unnecessarily high. On the other hand, this rate is too low for many digital data applications. Thus, other data rates will be needed in the future.

The details of the evolution of ISDN facilities and services will vary from one country to another — and indeed will vary from one provider to another in the same country. The above ways in which ISDN will evolve simply provide a general description, from the CCITT's point of view, of the evolution.

The user interface

Figure 1-1 is a conceptual view of ISDN features from a customer's (or user's) point of view. The user has access to ISDN by means of a local interface to a digital "pipe" of a certain bit rate. Pipes of various sizes will be available to satisfy differing needs. For example, a residential customer may require only sufficient capacity to handle a videotex terminal and a telephone. On the other hand, an office will typically wish to connect to ISDN via an on-premise digital private branch exchange (PBX); such a connection will require a much higher capacity pipe.

At any given point in time, the pipe to the user's premises has a fixed capacity, but the traffic on the pipe may be a variable mix, up to the capacity limit. Thus, a user may access packet-switched and circuit-switched services, as well as other services, in a dynamic mix of signal types and bit rates. ISDN will require rather complex control signals to instruct it how to sort out the time-multiplexed data and provide the required services. These control signals will also be multiplexed onto the same digital pipe as that for user data.

An important aspect of the interface is that the user may, at any time, employ less than the maximum capacity of the pipe; the user will be charged according to the capacity used, rather than the "connect time." This aspect will tend to lessen the value of current user design efforts that are geared to optimize circuit utilization by use of concentrators, multiplexers, packet switches, and other line-sharing arrangements.

Objectives

Activities currently under way are leading to the development of a worldwide ISDN. This effort involves national governments, data-processing and communication companies, standards organizations, and others. Certain common objectives are, by and large, shared by this disparate group. Key objectives are

- Standardization,
- Transparency,
- Separation of competitive functions,
- Leased and switched services,

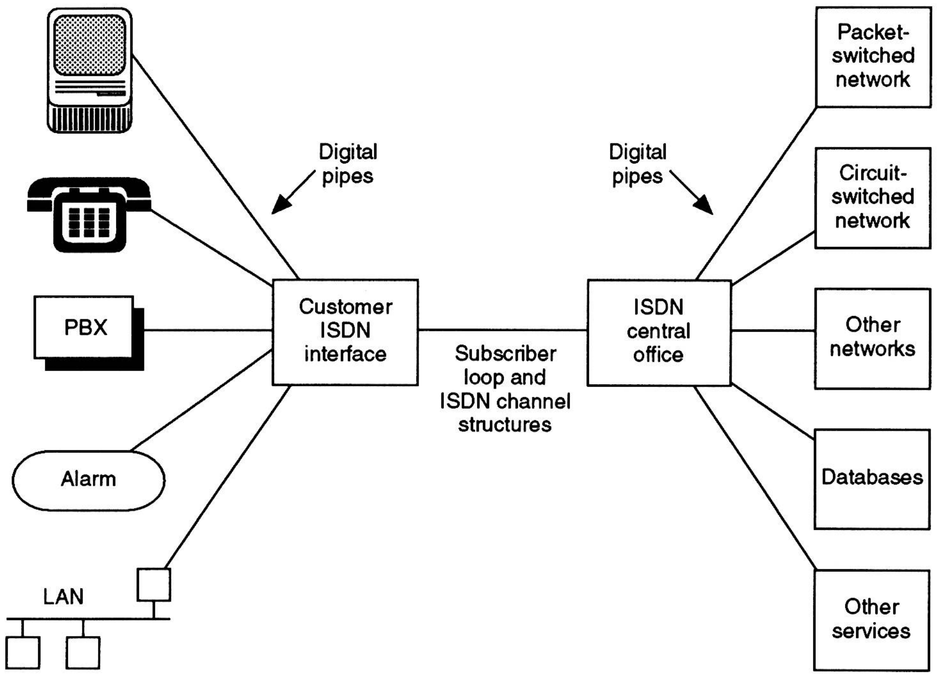

Figure 1-1. Conceptual view of ISDN features from a customer's (or user's) point of view.

- Cost-related tariffs,
- Smooth migration, and
- Multiplexed support.

Of course, additional objectives could be named; however, those listed are certainly among the most important and widely accepted, and they help to define the character of ISDN.

Standardization. Standardization is essential to the success of ISDN. Standards will provide for universal access to the network. ISDN-standard equipment can be moved from one location to another, indeed from one country to another, and be plugged into the network. The cost of such equipment will be minimized because of the competition among many vendors to provide the same type of functionality. In addition, the use of a layered protocol architecture and standardized interfaces allows users to select equipment from multiple suppliers and allows changes to be made to a configuration in a gradual, piece-by-piece fashion.

Transparency. It is also important that the digital-transmission service have the property of transparency. A service that has "transparency" is one that is independent of, and does not affect, the content of the user data to be transmitted. Transparency permits users to develop applications and protocols with the confidence that these applications and protocols will not be affected by the underlying ISDN. Once a circuit or virtual circuit has been set up, the user should be able to send information without the provider being aware of the type of information being carried. In addition, user-provided encryption techniques can be employed to provide security of user information.

Separation of competitive functions. ISDN must be defined in a way that does not preclude the separation of competitive functions from the basic digital-transmission services. Separating out functions that could be provided competitively — as opposed to those that are fundamentally part of ISDN — must be possible. In many countries, a single, government-owned entity will provide all services. Some countries desire (or require, as in the case of the United States) that certain enhanced services be offered competitively (for example, videotex and electronic mail). Competition promotes innovation and the ability to respond to and satisfy a wide range of user requirements.

Leased and switched services. ISDN should provide both leased and switched services. This will give the user the greatest range of options in configuring network services and will allow the user to optimize on the basis of cost and performance.

Cost-related tariffs. The price for ISDN services should be related to cost; it should be independent of the type of data being carried. Such a cost-related tariff will assure that one type of service is not in the position of subsidizing others. Price distinctions should be related to the cost of providing specific performance and to the functional characteristics of a service. In this way, distortions will be avoided and providers can be driven by customer need, rather than some artificial tariff structure.

Smooth migration. Because of the large installed base of telecommunications equipment in the networks, and because of customer equipment with interfaces designed for these networks, the conversion to ISDN will be gradual. Thus, for an extended period of time, the evolving ISDN must coexist with existing equipment and services. To provide for a smooth migration to ISDN, ISDN interfaces should evolve from existing interfaces, and interworking arrangements must be designed. Specific capabilities that will be needed include adapter equipment that allows pre-ISDN terminal equipment to interface to ISDN, internetwork protocols that allow data to be routed through a mixed ISDN/non-ISDN network complex, and protocol converters that allow interoperation of ISDN services and similar non-ISDN services.

Multiplexed support. To accommodate user-owned PBX and local area network (LAN) equipment, multiplexed support — in addition to low-capacity support — must be provided.

Benefits

The principal benefits of ISDN to the customer can be expressed in terms of cost savings, flexibility, and the advantages of competition among equipment vendors.

Cost savings. The integration of voice and a variety of data on a single transport system means that the user does not have to buy multiple services to meet multiple needs. The efficiencies and economies of scale of an integrated network allow these services to be offered at lower cost than if they were provided separately. Further, the user needs to bear the expense of just a single access line to these multiple services.

Flexibility. Requirements of various users can differ greatly in a number of ways: in information volume, traffic pattern, response time, and interface types. ISDN will allow the user to tailor the service purchased to actual needs to a degree not possible at present.

Competition. Advantages from competition among equipment vendors include product diversity, low price, and wide availability of services. Interface standards permit selection of terminal equipment and transport and other services from a range of competitors, without changes in equipment or use of special adapters.

Specific benefits. Specific benefits to network providers, manufacturers, and enhanced service providers are detailed below.

Network providers. Compared to customers, network providers will profit on a larger scale — but in a similar way — from the advantages of competition, including that in the areas of digital switches and digital-transmission equipment. Also, standards support universality and a larger potential market for services. Interface standards permit flexibility in selection of suppliers, consistent control-signaling procedures, and technical innovation and evolution within the network without customer involvement.

Manufacturers. Manufacturers can focus research and development on technical applications and be assured that a broad potential demand exists. In particular, the cost of developing chip implementations is justified by the size of the potential market. Specialized niches in the market create opportunities for competitive, smaller manufacturers. Significant economies of scale can be realized by manufacturers of all sizes. Interface standards assure that the manufacturer's equipment will be compatible with the equipment across the interface.

Enhanced service providers. Enhanced service providers, such as for information-retrieval or transaction-based services, will benefit from simplified user access. End users will not be required to buy special-access arrangements or terminal devices in order to gain access to particular services.

Disadvantages

Of course, any technical innovation comes with disadvantages as well as benefits. The main disadvantage in ISDN is the cost of migration. However, this cost must be seen in the context of evolving customer needs. With or without ISDN, the telecommunications offerings available to customers will change. It is hoped that the ISDN framework will at least control the cost and reduce the confusion of migration. Another potential disadvantage of ISDN is that it will retard technical innovation. The process of adopting standards is a long and complex one, with the result that by the time a standard is adopted and products are available, more advanced technical solutions have appeared. This time lag is always a problem with standards. By and large, the benefits of standards outweigh the fact that they are always at least a little way behind the state of the art.

The role of ISDN

The previous subsection presented the many potential benefits of ISDN. It is important to balance this presentation with the recognition that a number of alternatives to ISDN exist and that the reality may be that ISDN will play much less of a role than originally intended by its designers.

A paper by Carr, entitled "The Message-Makers," in the March 10, 1990, issue of *The Economist*, made a startling comparison between telex and ISDN. Ten years ago, telex dominated the text-transmission market; however, it was provided primarily as a monopoly service belonging to carriers. The telecommunications industry did little to respond to improvements in technology or to the growing sophistication of customer demands. As a result, telex failed and has been virtually replaced by the fax machine.

Similarly, ISDN was dreamed up when telephone companies still thought like utilities that provide a blanket public service. Market forces have driven telecommunications technology, products, and services beyond the slow pace of ISDN standardization, with the result that ISDN is fated to be a special service, one among a variety of alternatives for the business user. As *The Economist* put it: "ISDN is not a universal service, the next step to the future and all that jazz. If it is sold as such, it will be nothing but a disappointment to those that subscribe to it." This sober publication is not normally given to exaggeration. Indeed, it is not alone in rethinking the potential role of ISDN in the telecommunications market. ISDN was intended to be the master plan for an advanced, all-digital network and was to completely replace today's telecommunications networks. A much more modest role appears certain.

The following two key transmission characteristics of ISDN need to be kept in mind in assessing its potential role:

(1) The basic unit of switching is a 64-Kbps channel. Although it is possible to use a technique known as "subrate multiplexing" to carry multiple subchannels over a single 64-Kbps channel, all of the subchannels are carried on a single circuit between the same two endpoints. This capability has its uses, but the ability to set up circuits of less than 64 Kbps is a potentially cost-effective service not provided by ISDN. It is also possible to switch at higher data rates using a variety of higher speed channels on ISDN; however, as a practical matter, these are not being widely implemented in current ISDN offerings and in those in the pipeline. Again, the ability to set up circuits of greater than 64 Kbps is a potentially attractive service. The difficulty with the 64-Kbps channel is that its data rate is a poor compromise between the

needs of voice and data. For voice transmission, a capacity of 64 Kbps is now extravagant: High-quality voice transmission can be achieved at 32 Kbps, at 16 Kbps, and perhaps at lower values. For data transmission, 64 Kbps produces excellent response-time/throughput characteristics for many interactive applications. However, the increasing use of high-power workstations and graphics/image-processing applications makes 64 Kbps increasingly inadequate for many subscribers.

(2) The standardized primary service offered to customers operates at 1.544 megabits per second (Mbps) or 2.048 Mbps. Customers are expected to make do with these data rates until the leap — later this decade or early next century — into broadband ISDN, with data rates in the hundreds of Mbps. The ISDN data rates may be fine for public and private voice networks, but they are woefully inadequate for many users who are bringing on line high-demand image applications and ultra-high-speed LANs.

With the limitations imposed by the above transmission characteristics, ISDN must compete with a wide array of technical and packaged-network alternatives. Among the most important of these alternatives are

(1) Fractional T1. This facility is offered by carriers who provide the basic T1 (1.544-Mbps) service. Fractional T1 allows the customer to order capacity in increments of 64, 128, 256, 512, and 768 Kbps to meet the needs of specific applications.

(2) Frame-relaying bridges and routers. These products are bridges and routers that link LANs using frame relay technology. Frame relay was initially developed as an ISDN service (see Chapter 3), but many vendors are exploiting this technology independent of ISDN.

(3) Software-defined virtual networks. This facility is based on a public circuit-switched network that gives the user the appearance of a private network. The network is "software defined" in the sense that the user provides the service supplier with entries to a database used by the supplier to configure, manage, monitor, and report on the operation of the network.

(4) IEEE 802.6 metropolitan area networks (MANs). This standard uses a dual-bus architecture that appears similar to an open ring. It provides very high data rates and is intended for MAN applications.

(5) Switched Multimegabit Data Service (SMDS). This facility extends data transmission services for LANs and high-speed devices far beyond the customer's premises, but provides high-speed access without the costs associated with conventional private lines. SMDS makes use of the access protocols defined in IEEE 802.6.

Fundamentally, ISDN provides a circuit-switching service coupled with an anemic (64-Kbps access line) packet-switching service. On the one hand, this set of services must compete with the alternatives just listed to meet many customers needs. On the other hand, it is inadequate to meet a number of high-capacity requirements generated by the fast-moving pace of performance improvement in data-processing and telecommunications equipment. Put another way, ISDN is not essential, since many users are happy with existing non-ISDN solutions, and it is not responsive, given the absurdly slow pace that was evident in the development of its technical specifications. Ominously, the fate of broadband ISDN (B-ISDN) is at least partially tied to that of ISDN because of the commonality of interfaces, control-signaling schemes, and protocols.

What then is the role of ISDN? ISDN must be marketed in the context of a variety of packet-switched, circuit-switched, and dedicated services already in place. Because of the diversity of network services, ISDN cannot be imposed as was possible in the days of monopoly telecommunications. It must be marketed as a set of useful, standardized capabilities that has a — but not the — role to play in long-distance voice and data communications. ISDN can be many useful things to many people, but it won't be the universal service of which its creators dreamed. The window of opportunity was lost, if indeed it ever existed. Users listened for 10 years to the gospel of ISDN and concluded that it was oversold. Hopefully, a similar fate will not befall B-ISDN, given a once-bit, twice-shy attitude from potential customers.

Paper summary

The first paper included in this chapter, "ISDN: A Snapshot," by Wu and Livne, is a brief status report on ISDN. This paper discusses the various standards groups that are involved in the ISDN effort, looks at the current state of field trials, and summarizes existing network services and equipment offerings.