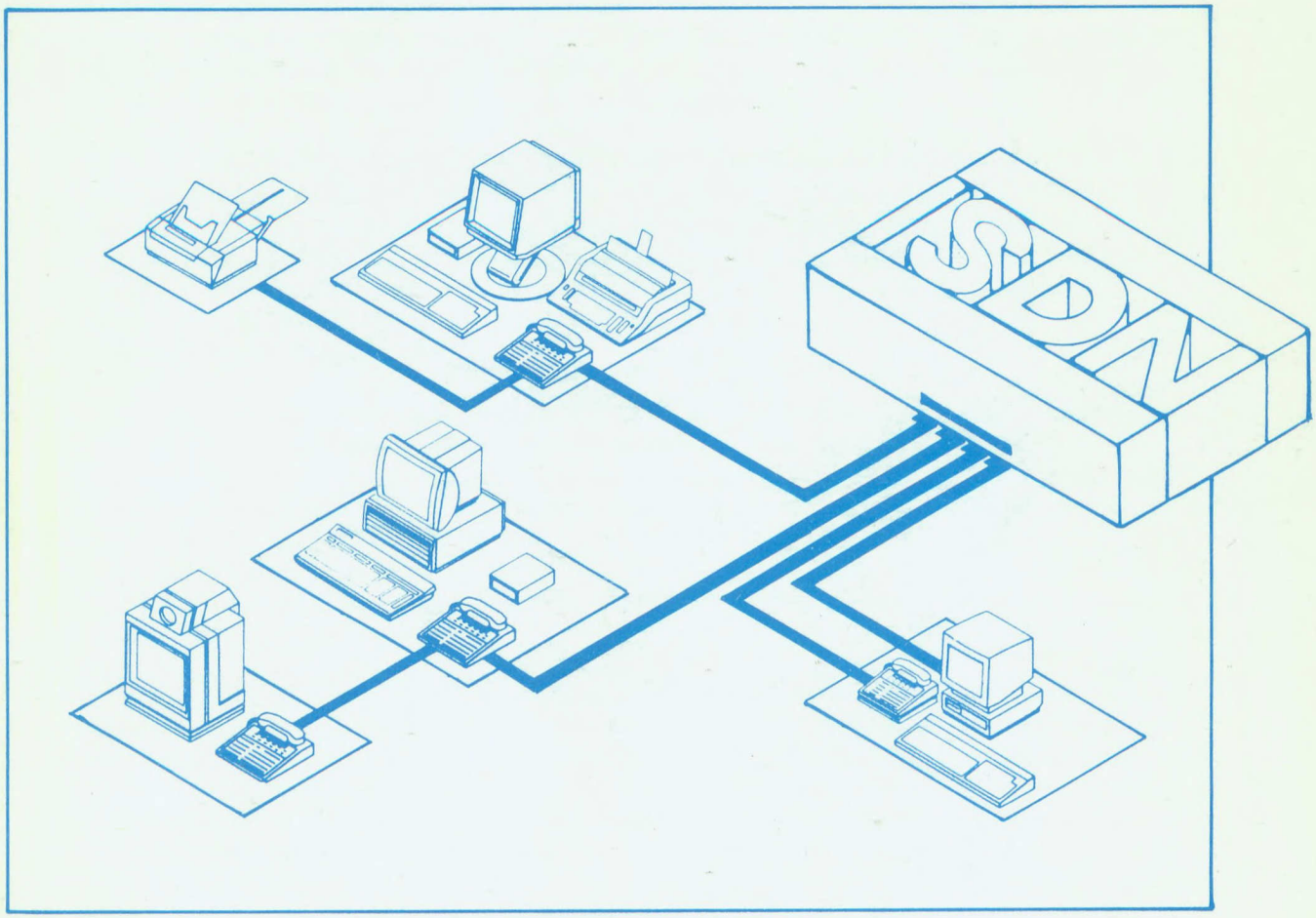
INTEGRATED SERVICES DIGITAL NETWORK



ISDN TERMINAL STANDARDS

REFERENCE MANUAL

Communications Canada

Canada

Foreword

Telecommunications networks in most of the industrialized world are moving steadily towards full digitization. The Integrated Services Digital Network (ISDN) provides the international standards to allow the offering of worldwide voice, data, text and image services. ISDN will provide integrated customer access to all these services using a standard multi-purpose user-network interface. ISDN promises to be the network architecture that will guide the future development of public networks well into the next century.

Several ISDN field trials on technology and services are taking place in North America. These give an opportunity for users to identify and develop their telecommunications needs using ISDN capabilities, for the telecommunications carriers to formalize new service offerings, and for manufacturers to develop network and terminal equipment that is competitive in the national and international market place.

Large business customers will be the first to take advantage of, and benefit from, ISDN service capabilities because of their greater demand for voice and data communications. The introduction of ISDN will create significant market opportunities for new products in the network and terminal areas. To remain competitive, terminal suppliers will not only have to fully understand their user's needs, but also be able to fully exploit ISDN service capabilities and network functions.

This ISDN Terminal Standards Reference Manual, developed under contract by Microtel Pacific Research, is designed to provide guidance to the Canadian terminal manufacturing industry on standards and related network functions that need to be considered in the development of products compatible with the ISDN network environment. These guidelines should be particularly useful to smaller terminal manufacturers catering for existing networks, who are not full participants in the standards development process and ISDN field trials.

This Reference Manual is also designed to stimulate a wider understanding of ISDN technology and to assist the Canadian terminal equipment industry to retain its competitive edge.

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ISDN TERMINAL STANDARDS REFERENCE MANUAL

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1. INTRODUCTION

1.1 Purpose of Document

The purpose of the Integrated Services Digital Network (ISDN) Terminal Standards Reference Manual is to provide technical guidance in the functional design of terminals that are compatible with, and competitive in, the future ISDN environment. The Manual also introduces ISDN concepts, and reviews national and international standards activities. In particular, terminal equipment functional requirements are addressed, including all mandatory requirements to interconnect to the ISDN and optional requirements to provide desired ISDN services. The Manual is required because the ISDN standards produced by the responsible organisations have not yet been extended to direct terminal device specifications.

It is expected that this document will be of particular value to organisations such as those identified in the Terminal Equipment List, put out by the Telecommunication Regulatory Service of the Department of Communications (in conjunction with the terminal attachment program). In addition, it may be useful to terminal equipment users such as the banking or insurance industries and other medium to heavy users of diverse communications facilities who wish to specify features for their future telecommunication terminals.

This Manual is not intended to be an indication of market support for a particular service or a set of services. Whilst the service capabilities of the ISDN presented herein are a consensus by the various standards organisations of the most likely future requirements, individual network operating companies may not support all of these capabilities. Therefore it is the responsibility of the manufacturer to determine which features are supported in their marketing area.

1.2 Scope

This document will consider only those terminal device requirements that are necessary in order to ensure compatibility with the internationally specified ISDN. National options are not specifically identified. The definition of functions required for additional features and user terminal interface capabilities that are not required to be compatible with the network, are the responsibility of the individual suppliers or users.

Because of the range of equipment which can be referred to as terminal devices, emphasis in this issue of the Manual will concentrate on those devices that are intended for the individual user. Some material will be provided to place other categories of terminal devices in context.

It is assumed that individual terminal designers are already familiar with the requirements of the user-terminal interfaces, therefore this area is not covered. The relationship between the internal functional requirements of the terminal and associated functions within the network is discussed, in particular for the ISDN basic rate access facilities. The ISDN primary rate terminal requirements will not be discussed in detail in this manual.

Since there will most likely be a wide range of terminal adaptors and multiple user terminals associated with ISDN, it will not be possible to treat these fully. However, some information will be included to put these into context.

Because there are significant differences between the techniques used in ISDN and those which are used in the current network, some background information is provided on ISDN concept and its implementation. In addition, descriptions of ISDN services will help to define the changing trends of the telecommunication business.

1.3 Methodology

The Reference Manual is based on the ISDN concepts and standards which have been developed by the Study Groups of CCITT. CCITT is one of the committees of the International Telecommunication Union (ITU), which in turn is an agency of the United Nations.

In order to put the terminal device requirements in context, the manual provides information on the nature and direction of ISDN and its impact on the terminal characteristics.

The CCITT has defined a number of standard ISDN services and the analysis of these services forms the basis for the identification of terminal functions.

The CCITT standards provide scope for national and regional options and the T1 Committee under the sponsorship of the American National Standards Institute, have developed some North American Standards as well as contributing input to the international fora.

1.4 Organisation of the Manual

The manual is divided into four major parts.

The first part (Chapter 1) introduces the purpose, scope and methodology of the manual.

The second part (Chapter 2 & 3) provides a brief introduction to the ISDN concepts, and more detailed description of those aspects of the ISDN which have a significant bearing on the characteristics of the terminal devices. It describes the sources and status of the relevant ISDN standards, the various network components and architecture, and the basis for terminal and network functional relationships. Chapter 3 concentrates on an identification and description of ISDN services.

The third part of the manual (Chapter 4,5,6,7) looks into the details of terminal functions. The analysis is divided into mandatory, optional and services dependent functional groupings primarily directed at the individual user terminal (TE1). Chapter 6 & 7 provide an introduction to terminal adaptors and multi-user terminals.

Chapter 8 provides a reference and bibliography section.

2. GENERAL BACKGROUND

In the current telecommunications networks, each network type provides a specific set of dedicated services. Thus there are specific networks for such services as:

- voice
- circuit switched data
- packet switched data
- video

As well, many of these networks are supported by analogue and digital equipment for access, switching and transmission. The capabilities of each network type in the areas of surveillance, control and maintenance can vary from manual to partial automation. In the present environment, a customer of a number of telecommunication services will have separate access lines, interface requirements and terminals for each service. Considering that most users will not fully occupy every service, the current approach to overall telecom services is inefficient and potentially costly for users of many service types.

There has been recently increased pressure for a new approach to the provision of all telecommunication services in a more integrated manner. The digitalization of the world's networks both in transmission and switching is allowing for end to end digital capabilities for services. The rapid increase in penetration of data services is acting as a catalyst to evolving the integration of voice and data. The advent of personal computers in the business and home offers a ready made more intelligent terminal for new service types. A general increase in network based processing and databases can support a whole new range of basic and supplementary services. This trend is evidenced by the recent influx of digital PABX and Centrex type services being offered today. However, there is yet no general way in which these services can be offered. Each manufacturer offers a switch with proprietary terminals and services. In order to provide a network-based approach, across the world, it was recognized that a set of standards was needed to head off the major problems of terminal and service interworking. This led to the ISDN concept.

2.1 ISDN Concept

In its present form, the Integrated Services Digital Network (ISDN) is a set of broadly applicable standards to accommodate a wide range of services. The object of ISDN is to be responsive, in an open way, to the evolving needs of the information society and to spur demand for information services. The ISDN is characterized as an end-to-end digital network which supports a wide range of services to which users will have access through a limited set of standard multipurpose interfaces. It provides to the carrier the economic advantages of facilities integration, services integration, operations integration, and demand integration. The evolution of telecommunications networks to an ISDN is a worldwide phenomena driven by the activity in the CCITT and other standards bodies. Evolution into ISDN is a complex and involved process. Due to the present investment and the existing infrastucture, changeover will inevitably be gradual.

The ISDN Concept can be found in CCITT Recommendation I.210, and is expanded in the other I Series Recommendations. A brief review of the ISDN concept is presented in this section.

The initial stages of ISDN are based on the support of existing 64 kbit/s based switched networks through integration on the access via the use of common channel signalling. The network include: existing public switched telephone networks (PSTN), circuit switched public data

networks (CSPDN) and access to packet switched public data networks (PSPDN's). Future stages include:

1. better integration of packet data networks,
2. the Narrowband ISDN with rates to 1.536 Mbit/s switching and;
3. the Broadband ISDN with rates up to 600 Mbit/s.

2.2 ISDN Standards

This section discusses the various sources of ISDN standards, the status of key standards and the nature of ISDN trials.

2.2.1 Sources of ISDN Standards

The main sources of ISDN standards are the seven Study Groups of the CCITT shown in Table 2.1. Study Group XVIII, whose major area is digital networks, was primarily concerned with ISDN during the 1981 to 1984 Study Period. Other groups covering related field such as Data Communication Networks, Switching and Signalling, and Transmission Performance are also involved in various aspects of ISDN.

TABLE 2.1. Main Source Of ISDN Standards

Study Group Number	Title
Study Group II	Telephone Operation and Quality of Service - Numbering plan - Routing - Service aspects of telephony
Study Group III	Tariff Principles
Study Group IV	Maintenance & Operations
Study Group VII	Data Communication Networks
Study Group XI	Switching and Signalling - CCS7 protocols - D Channel Protocol - Switch requirements
Study Group XII	Transmission Performance
Study Group XVIII	Digital Networks -Overall principles & co-ordination for ISDN

These Study Groups generate Recommendations based on a consensus process. Within each Study Group, there are various Joint Working Groups, Sub Groups for specific studies, and Expert Groups that may contribute to the process. The participants in the CCITT include National Administrations (e.g. D.O.C.), Recognized Private Operating Agencies (RPOA) (e.g. Telecom Canada, CNCP), and Scientific and Industrial Organizations (SIO). It is common practice for the National Administration to form a delegation of interested parties the purpose of

which is to present a single unified front. Thus in Canada there is a Canadian National Organization (CNO) that is chaired by the Department of Communications and has representatives from the operating agencies, manufacturing industry, regulatory bodies, R and D organizations and federal and provincial governments. The CNO is responsible for both CCITT and CCIR activities in Canada.

The International Standards Organisation is another source of standards. In particular, this organisation introduced the Open Systems Interconnect (OSI) concept much of which has been adopted by the CCITT and introduced into their ISDN Recommendations.

In the USA, the American National Standards Institute (ANSI) has sponsored a set of committees under the T1 designation to look at national issues. Because of the nature of the US market, the participants are not restricted to American companies. The more general results of their agreements are also submitted to the CCITT where appropriate.

Other standards organisations play a lesser role in the generation of ISDN standards and the common practise is to submit any considerations to one or other of the above major players.

2.2.2 Status of Key Standards

There are many sources of standards as indicated above. Some large international manufacturers such as IBM may establish "de-facto" standards independent of across the board consensus. International and national standards are usually derived from a discussion process taking into account the viewpoints of many interested parties. The status of these various standards in terms of availability, maturity, and conformance is discussed in general terms below.

In this manual, reference is occasionsally made to Recommendations which are expected to be approved by 1988 and are currently in draft form.

2.2.2.1 Availability

With respect to the international and national standards it is common practice to make standards generally available only when they are fully mature. In the case of CCITT Recommendations these are published typically every four years and are available directly from the ITU in Geneva, Switzerland.

2.2.2.2 Maturity

The maturity of the developing CCITT standards for establishing ISDN range from a brief outline of the proposed contents in draft versions to fully mature text that has reached consensus agreement over a period of time. The immature standards exist in interim documentation that, for obvious reasons, is not widely distributed. The published set of approved standards may still be subjected to change as experience with their application is acquired. The standards are closely inter-related and, while every effort is made to ensure consistency between them, inconsistencies can occasionally occur.

2.2.2.3 Conformance

Adherence to the ISDN standards does not necessarily ensure full compatibility between different manufacturers equipments. The standards are set in fairly general terms to allow some flexibility at the national and manufacturing level and different interpretations do occur. Even detailed written requirements do not nessarily ensure full compatibility. In addition, the term "ISDN" has been inappropriately and prematurely employed by some suppliers where the standards have not yet been finalised.

At the present time there is no approval body in Canada or the United States with the jurisdictional power to enforce complete uniformity. Furthermore, since CCITT standards are expressed as Recommendations and have no legal connotation, conformance is voluntary and the rate and degree of adoption is at the discretion of the individual administrations. Thus conformance testing of terminal equipment will need to be established to ensure compatibility at either regional, national or international levels.

2.2.3 Protocol Standards

The International Standards Organization (ISO) has developed an Open Systems Interconnection (OSI) reference model for the design of protocols which consists of seven layers that communicate with each other in a formal manner. This model has been adopted by the CCITT in Recommendation X.200. Generally the telecommunication network is concerned with the lower three layers and the remaining four layers are required for terminal to terminal compatibility and for specific network service offerings.

Within ISDN Recommendations, the use of the OSI Model is extensive. In the areas of:

- call control signalling
- network signalling
- operations, administration, and maintenance
- control of supplementary services
- data transmission
- higher layer services

A terminal for ISDN is specifically impacted in the areas of call control supplementary services, maintenance and higher layer services. These will be the basis of later sections in this report.

2.2.4 Nature of ISDN Trials

There are several trials underway that profess to illustrate the ISDN concept. Since many of the standards are not yet stable, these trials cannot be considered as true ISDN trials and the components used may therefore have a limited life. However, these trials are accomplishing many important objectives, for example:

- proving in of the techniques and technologies (both hardware and software aspects),
- possible evolution strategies from the present facilities eg. determining how much of the present equipment can be retained or upgraded,
- evaluation of user reaction to new services and features,
- evaluation of operating company reaction to increased user control,
- obtaining a better understanding of the increased network intelligence and how it should be distributed,
- developing a basis for initial market projections, and
- preliminary determination of the economic aspects of the future network eg. the required billing philosophy, method of depreciation, write-off or upgrading of the present network, etc.

2.3 Network Aspects

Network standards are required to provide a connection from one subscriber to another between two ISDN interfaces or between an ISDN interface and an existing network interface. These standards basically address:

- Connection types, which define the types of connections necessary to route calls across the network between ISDN interfaces.
- A numbering plan, which is necessary to accommodate voice and data terminals and to interwork with existing numbering plans.
- Interworking, to define interworking and compatibility requirements with existing networks and services, such as voice services and packet data services.
- Network signalling, including mapping between ISDN access and network signaling systems; and new network protocols and architecture models.

The subject of ISDN network aspects includes everything that is not access or services. Areas of particular interest to the terminal manufacturers include its architecture, protocol model, connection types, numbering, interworking and routing. Reference to specific I series should be found in each individual section.

2.3.1 ISDN Basic Architectural Model

Development of recommendations dealing with network aspects of the ISDN were based on Figure 5/I.310, basic architectural model of ISDN. A basic architectural model of an ISDN shows the seven main switching and signalling functional capabilities of ISDN:

- ISDN local functional capabilities (eg. user-network signalling).
- 64 kbit/s circuit switched functional capabilities.
- 64 kbit/s circuit non switched functional capabilities.
- common channel interexchange signalling functional capabilities.
- > 64 kbit/s switched functional capabilities.
- > 64 kbit/s non switched functional capabilities.

An objective of Study Group XVIII was to develop a functional model to describe essential network features without constraining network implementations or product designs. Such a model provides a common understanding to help study of network issues such as interworking, network protocols, and performance.

With the many diverse views presented, the objectives for the functional model could not be fully met in the 1981-'84 study period. They were, however, partially met by including the less controversial points in an overview document entitled "Network Functional Principles", Recommendation I.310. This recommendation provides a structure for the network series of recommendations.

The recommendation also include network functional requirements to support services and operational applications (see Figure 2 & 3/I.310):

- Low layer functions - eg. connection control.

- Additional low layer functions - eg. additional call control to support supplementary services.
- High layer functions - eg. OSI layers 4-7 to support tele-services.
- Operations and maintenance functions.

One of the most important agreements also included is the location of interface reference points for network interworking as shown in Figure 4/I.310. Identification of these points provides a firm basis on which to build essential interworking standards in 1985-1988.

2.3.2 ISDN Protocol Reference Model

It was recognized early in the study period that development of end-to-end network protocols would prove to be critical for development of the ISDN. Thus a reference model is described in Rec. I.320.

The objectives for an ISDN protocol reference model are to provide a base model to support development of protocol specifications and common understanding on control interactions across the network.

It was agreed that the OSI seven layer model should be used as the basis. Initial study, however, revealed that the OSI model at that time would not fully meet the needs of the ISDN. Typical areas on which the OSI model differed from the needs of ISDN include:-

* Outband signalling with correlation between B and D channels. An example of an early approach is shown in Figure 2.1.
* Interworking between circuit and packet switched networks. Also between inband and outband signalling systems.
* Need to describe network protocols.

The concept of perspectives was also developed.

* User perspective: in which signalling is encompassed in layers 1-3 of the D channel. The user applications are supported above layer 3 as appropriate.
* Control perspective: in which signalling control is in itself an application (ie. a control application). In this case D channel signalling encompasses all 7 layers.

Thus signalling for feature control. (e.g. to change call forward information) may appear as layer 3 signalling from the users perspective but will appear as layer 7 from the network perspective.

In this case the control perspective is nested in layer 3 of the user perspective.

Three functional groupings were also identified:

* U functional grouping (user)
* C functional grouping (control)
* M functional grouping (management)

To represent these functional groupings a 3 dimensional model was developed. The user and control planes are divided into the conventional OSI seven layers. The management plane is unlayered as a backing to support user and control planes as necessary. The need for layering of the M plane is for further study.

An example of the use of the three dimensional model for a connection to a packet switch via a B channel is shown in Figure 2.2.

While the protocol model provides a good basis for describing user, control and management interactions in an ISDN, considerable further work remains to be done. For example:-

* Information flows and control for multi-media calls.
* Application to other than end systems e.g. signal transfer points.
* Layering for testing and maintenance functions.
* Timing or sequencing of control and application functions, for example, adding a data call to an existing voice call.

It is essential that this further work is the result of co-operative studies involving experts on the OSI model and ISDN protocols. The key difference identified between the ISO model and the ISDN model have been considered and joint work between ISO, CCITT Study Groups VII, XI and XVIII have been initiated to begin the difficult task of consolidation between the two models. The most important step, however, that of recognising and understanding the new and different protocol needs for ISDN, has been taken.

2.3.3 Network Connection Types

The ISDN is comprised of a limited set of interfaces through which a wide range of service applications may be achieved. A critical element in the development of the ISDN requires early identification of the types of connection necessary between ISDN interfaces across the network.

Network connections are the realization in the network of a bearer service request from a user. There is not necessarily a one to one relation between the connection available and the bearer services, since the network may choose to provide a higher level connection type than required for a specific service.

The currently developed set of ISDN connection types is shown in Figure 2.3 (I.340). For each connection type a set of attributes are defined ranging from information transfer capability to performance specification.

This range of connection types will eventually extend to wideband and sub rate capacities and new relationships with services, performance and interface standards will be developed.

2.3.4 Numbering and Addressing

The work in the 1981-1984 CCITT Study Period provided overall principles for ISDN numbering and addressing (Recommendation I.330) and a preliminary numbering plan (Recommendation I.331/E.164). The basic principle of the numbering plan (E.164) is the addressing of the user/network interface not the terminals on an individual basis.

The key numbering and addressing issues requiring resolution in the current Study Period include:

- terminal identification for compatibility purposes.
- interworking between different numbering plans,
- network identity and trunk routing for calls passing through more than one network or having multiple routing choices,

2.3.4.1 Terminal Identification

There are three alternative for identifying individual terminals connected to an ISDN interface:-

1. Terminal compatibility -- which uses information messages such as bearer services identity to ensure compatibility between originating and destination terminals. Selection in this case is only absolute if voice, data, etc. terminal capabilities are uniquely identifiable by such information messages.
2. DDI (Direct Dialing-In) through the use of separate E.164 numbers. Selection requires that terminal equipment (e.g. PBX or terminal bus) examines the incoming address and selects accordingly.
3. Subaddress -- in concert with existing data practices (X.121) terminals may be identified by a subaddress. The ISDN subaddress (up to 40 digits) is contained in a separate subaddress field in Q.931 and ISUP.

The compatibility approach is the most general one for the ISDN basic access bus.

2.3.4.2 Numbering Plan Interworking

The ability to interwork between users addressed by existing numbering plans such as telephony (E.163), data (X.121), telex (F.69) and the new ISDN numbering plan (I.331/E.164) is essential to the implementation of the ISDN. The basic problem is illustrated in Figure 2.4.

For example, a user connected to a public switched packet data network (PSPDN) must be able to route to user connected to an ISDN port, addressed by E.164. Similarly, an ISDN user must be able to call other ISDN users (using E.164) and to users connected to PSPDNs (addressed by X.121).

For network selection of the most appropriate routing, for example the selection of appropriate gateway (Figure 2.5), it is likely that both ISDN and PSPDN will eventually have to examine and route on both numbering plans.

An essential feature for success of the ISDN is the ability to address any user connected to existing public switched networks as well as those connected to ISDN.

2.3.4.2.1 Interworking with Telephony Numbering Plan (E.163)

The ISDN numbering plan (E.164) is based on an evolution of the telephony numbering plan (E.163). Thus E.163 is a subset of the ISDN numbering plan and telephony addresses are, by definition, integral to the ISDN numbering plan.

The ISDN numbering plan, however, allows for up to 15 digits for the main address, while the telephony numbering plan allows for only 12 digits. To resolve this potential incompatibility, an initial restriction to ISDN numbers of 12 digits has been agreed. This restriction will be lifted to a time T, when all telephone networks will be able to handle 15 digits. The date for time T is currently set to 1995.

2.3.4.2.2 Interworking with Data Numbering Plan (X.121)

The data network numbering plan (X.121) is quite different from the telephony numbering plan, and simple integration with the ISDN numbering plan is not possible. For example, data network routing is based on a 4 digit DNIC which includes country code (3 digits) and 1 digit for network identity. The ISDN numbering plan can have 1-3 digits for country code and 5-3 digits

additionally (6 total) for destination network identity.

2.3.4.3 Network Identification and Trunk Routing

The ISDN numbering plan (E.164) provides for up to 6 digits for network identification and routing.

Internationally, it is agreed that allocation of the 6 digits is a matter for national consideration and will not be subject to international agreement.

In North America, it is proposed to capitalize on the 10 digit standard telephone number, incorporating a 3 digit NPA (Numbering Plan Area) plus the trunk prefix. This may advance the need for interchangeability between NPA (area codes) and office codes-i.e. NPA=NXX with full expansion to 800 potential codes (up from the current maximum of 160).

2.3.5 Network Interworking

The use of different numbering plans is not the only interworking concern. Of equal importance for the implementation and evolution of ISDN is the physical and protocol interworking between networks.

Typical reference configurations have been developed in Recommendation X.300 and I.510 and also Recommendation I.500 provides coordination of interworking recommendations as shown in Figure 2.6.

The objective of specifying internetworking reference configurations is to define the bounds within which specific services will work, to identify where conversion/adaption may be required between networks and to provide a basis on which interworking functions between the networks can be determined.

Specifically for interworking between ISDN and PSTN, it is essential, for example, to ensure call announcement and tone compatibility. Accordingly, the ISDN will provide both inband tones for interworking with the PSTN, also outband signals for ISDN terminals and switches to control local generation of such tones.

Table 2.2/I.530 identifies the key characteristics of an ISDN and a PSTN, indicating possible interworking functions to accommodate dissimilar characteristics.

TABLE 2.2. Key ISDN & PSTN Characteristics

	ISDN	PSTN	INTERWORKING FUNCTIONS
Subscriber interface	Digital	Analogue	a
User-network signalling	Out-of-band (I.441/I.451)	Mainly inband(e.g. DTMF)	b,e b,e
User terminal equipment supported	Digital TE (ISDN NT, TE1 or TE2+TA)	Analogue TE (eg. dial pulse tele-phones, PABXs,modem-equipped DTEs)	c
Interexchange signalling	SSNo.7 ISDN User Part (ISUP)	Inband(eg.R1, R2,No.4,No.5) or Out-of-band e.g.No.6,No.7 TUP)	d,e
Transmission facilities	Digital	Analogue/digital	a
Exchange Types	Digital	Analogue/digital	f
Information transfer mode	Circuit/ Packet	Circuit	f
Information transfer capability	Speech digital un-restricted 3.1 kHz audio, video, etc.	3.1 kHz audio (voice/voiceband data)	f

The following are required:

a. Analogue-to-digital and digital-to-analogue conversion on transmission facilities.

b. Mapping between PSTN signals in the subscriber access and I.451 messages for intra-exchange calls.

c. Support of communication between modem-equipped PSTN DTEs and ISDN terminals.

d. Conversion between the PSTN signalling system and SS No.7 ISDN User Part.

e. Mapping between signals in the ISDN subscriber (I.441, I.451) access and PSTN inband interexchange signalling (e.g. R1).

f. Still to be defined.

Given that the transition period from a PSTN to an ISDN may occur over a long period of time, it is likely that there will be an ongoing requirement for ISDN-PSTN interworking. In addition, it is likely that interworking functions will be required at numerous locations for interworking

within one telephone companies network as well as for interworking with other national networks. As the transition to ISDN continues, interworking points will be brought into existence and later may not be required.

Therefore, points where interworking may exist are:

- within the local exchange
- at transit exchanges
- at international gateway offices.

Note: The optimum location of each interworking function may be different for each interworking function and dependent on the usage of the service, network topology, etc.

2.3.6 Routing

Work is progressing in CCITT to prepare two Recommendation covering, ISDN Routing Principles and ISDN Routing Plan. Study is focusing on:

- Ability to select from a range of appropriate connection types, as a network response to specific bearer service request from a user;
- Identificaton of information necessary during route selection such as destination, attributes required (e.g., call processing or services features), network control (e.g. echo cancellers), history (e.g. number of satellite hops);
- Requirements to ensure end-to-end connection type compatibility.

The Routing Plan when developed will specify all necessary information to determine permissible routings and to identify conditions under which connections must be changed in response to changes in service requirements during the progress of a call.

2.3.7 Operational Network Concerns

One of the major change that ISDN will bring to the telecommunications network will be a greatly enhanced support system for operations, administration and maintenance. The additional capabilities will eventually offer the user the ability to have a greater degree of control over the network resources than in the past. Some of these capabilities are described below:-

2.3.7.1 Choice of Connection Types

The network will eventually provide the user with a choice of alternative connection types which can be selected as part of the specific service requested by the terminal. These connections may differ in bit rate, performance or mode (e.g. a clear channel provides for 64 kbit/s of message information while a restricted channel provides only 56 kbit/s of clear capacity.)

2.3.7.2 Choice of Subscribed Service

It is expected that in future the subscriber may be able to modify the level of service by accessing and modifying a user profile in the network. This technique of interacting with the network in a dynamic fashion is made possible by the enhanced signalling capability of the ISDN access.

2.3.7.3 Access to Network Surveillance and Test Facilities

The network will also permit the subscriber to access surveillance and test facilities within the network to provide a direct check of a faulty connection. If the terminal also contains self

checking capabilities the impact of faults could be significantly reduced. Further information can be found in Recommendation I.6xx.

2.4 User to Network Aspects

The objective of user-to-network standards is to provide a limited set of ubiquitous interface service specifications. Currently, two interface types are defined - basic access and primary rate access.

Both interfaces use B- and D-channels. The B-channel is a 64 kbit/s digital access channel used for voice or data. The D-channel is a message-based 16 kbit/s or 64 kbit/s channel used for B-channel out of band signalling and packet-switched data. The primary rate interface structure may also include H0 and H1 channels (384 kbit/s and 1536 kbit/s respectively).

2.4.1 Access Configurations

To define the requirements for ISDN user access, an understanding of the anticipated configuration of user premises equipment and of the necessary standard interfaces is critical. The first step is to group access functions that may exist on the user's premises. Figure 2.7 shows the CCITT approach to this task, using:

* Reference points: conceptual points used to separate group of functions.
* Functional groupings: certain finite arrangements of physical equipment or combinations of equipment.

2.4.2 Functional Groupings

The following standards and definitions are being considered by the CCITT, and ANSI T1:

2.4.2.1 Network Termination 1 (NT1)

The NT1 includes functions broadly equivalent to layer 1 (Physical) of the OSI Reference Model (X.200). These functions are associated with the proper physical and electromagnetic termination of the network. NT1 functions are:

- transmission line termination
- Layer 1 maintenance functions and performance monitoring
- timing
- power transfer
- Layer 1 mutliplexing
- interface termination, including multidrop termination employing Layer 1 contention resolution.

2.4.2.2 Network Termination 2 (NT2)

NT2 includes functions broadly equivalent to Layers 1, 2, and 3 (Physical, Data-Link and Network) of the OSI Reference Model (X.200). PABXs, local area networks, and terminal controllers are examples of equipment that provides NT2 type functions. NT2 functions include:

- Layers 1, 2, and 3 protocol handling

- Layers 2 and 3 multiplexing
- switching
- concentration
- maintenance functions
- interface termination and other Layer 1 functions.

2.4.2.3 Terminal Equipment Type 1 (TE1)

TE1 refers to devices normally used by a single individual that support the standard ISDN interface. It has an interface that complies with the ISDN user/network interface specifications. Examples are a digital telephone, integrated voice/data terminal, and digital facsimile equipment.

2.4.2.4 Terminal Equipment Type 2 (TE2)

TE2 encompasses existing non-ISDN equipment that requires the user of a terminal adapter (TA) to convert to an ISDN interface point, because it is not compatible with the ISDN user/network interface. Examples are devices with RS-232-C and X.21 interfaces.

2.4.2.5 Terminal Adapter (TA)

TA provides the conversion functions that enable an existing terminal (TE2) to be served by an ISDN user/network interface.

2.4.3 Reference Points

Reference points are used to indicate the separation between functional groupings. They are not necessarily physically accessible and may be located within a physical entity.

To denote reference points at which the limited set of standard interfaces may be defined, standard reference configurations, depicted in Figure 2.8 and 2.9, have been developed.

The Interfaces which normally exist at these reference points are described as follows:

R existing terminal interface (e.g. RS232, X.25, analogue telephone)

S interface between NT2 and TE1

T interface between NT1 and either of NT2 or TE1 directly

U transmission interface at each end of the customer's loop.

Interfaces at points T and S has been defined to be identical in terms of the ISDN user/network interface procedural, electrical and mechanical characteristics. Point R is any user/network interface type supported by a TA and specified in other standards that are not part of the ISDN Recommendations. The U interface is currently being specified by the ANSI T1D1.3 Committee in the U.S.A. because of internal U.S. Regulatory needs. It allows for direct customer ownership of the NT1 device. For the remaining countries of the world, the S/T reference point has been adopted for the time being as that physical point where the terminal equipment connects to the network. Thus most of the CCITT ISDN Recommendations of interest to the access are directed at the S/T reference point.

2.4.4 Structures of S/T Interface

The S and T interfaces are essentially a 4 wire arrangement (although additional 4 wires are provided for carrying power). For a Basic access, each direction of transmission provides two B channels and one D channel multiplexed together with additional overhead bits to provide a robust transmission facility within the users premises. The B channels of 64 kbit/s each provide transparent digital paths to the network. These are the standard access channel for voice or data traffic. The signalling for the B channels is carried on the associated D channel.

The D channel for the Basic access operates at 16 kbit/s. The D channel protocol permits other digital information to be carried in addition to the signalling. This could include slower speed packet data or telemetry information.

The information transfer portion of the digital access is a maximum of 144 kbit/s (2B+D) full duplex. The overhead needed for operation between the users terminals and the NT1/NT2 is an additional 48 kbit/s, for a total digital stream of 192 kbit/s. While it is possible, for special applications to support only B+D or a D channel alone on the loop from the exchange to the NT1, the interface still operates at 192 kbit/s, in order to provide a standard interface for terminal devices.

Typically, an ISDN access line will support one or more digital telephones, one or more data terminals, and perhaps some telemetry devices (such as alarm or meter reading devices).

2.4.4.1 Physical Layer (Basic Access Interface)

The Physical Layer is the electrical and mechanical interface between the terminal and the S/T reference point. It includes such function as:

- frame code and frame structure (2B+D+overhead)
- powering from NT1
- emergency powering
- D channel contention
- activation/deactivation

2.4.4.2 Data Link Layer (D Channel)

The Data Link Layer allows a number of terminals connected to the S/T reference point to establish error free signalling and data links to the network. Each terminal has a unique identifier and may support more than one call at a time.

2.4.4.3 Network Layer (D Channel)

The Network Layer has two independent functions. For those calls using B channels for transmission, the Network Layer provides for the establishment, maintenance and disconnection of circuit and packet switched calls. For calls using the D channel, the Network Layer is the Layer 3 of X.25 (1984) with additional multipoint procedures for use on the ISDN bus.

2.4.5 Customer Wiring Consideration (Basic Access)

The wiring from the NT1 (normally located in the customers premises) going via the S or T interface to the terminal devices, can require from 4 to 8 wires, depending upon the need to use 4 of the wires for special terminal powering arrangements. The 4 wires carrying the access

channels are assigned two for transmit and two for receive.

The wiring to the terminals may take different configurations depending upon the application and to meet the specific needs of the user. The simplest arrangement is known as the short passive bus (see Figure 2.10) which can handle up to 8 bridged terminals over a bus length of 200 metres. Thus bus can be extended by a wires from the interface to the bus but limitations are placed on the extension and the number of terminals which can reliably be used. If only one terminal is required, this is referred to as a point to point arrangement and a distance of 1 km can be achieved. These distances make certain assumptions about the quality and characteristics of the wiring and the compatibility of terminals supplied by different manufacturers.

2.4.6 User Facility Maintenance

A draft recommendation I.6xx has identified a number of methods for ISDN subscriber access and installation maintenance. A general architecture in ISDN for maintenance also proposed in this draft. Studies include the maintenance of:

1. the part of the ISDN subscriber basic access, controlled by the network.
2. the network portion of the ISDN subscriber primary rate access controlled by the network.
3. the network portion of the ISDN subscriber higher rate access.
4. the subscriber installation.
5. the multiplexed basic rate access as controlled by the network.

The objectives of these activities are to detect fault conditions, identify the failed maintenance entity, take system protection actions, inform the maintenance staff of the administration, to incorporate facilities to allow clear differentiation of failures between subscriber installation and the network.

2.5 Service Aspects

As part of the standards activity, CCITT has found it necessary to define the services that the ISDN will provide in certain formal ways. Telecommunciation services are divided into several broad categories and then each service is described by a set of attributes as seen by the user.

2.5.1 Service Categories

Telecommunication services are divided into three categories. These are identified in Rec. I.211 as:

1. Bearer Services, whereby the carrier only provides transport between two user provided terminal equipments, i.e. between two user-network interfaces.
2. Teleservices, in which the carrier provide the terminal equipments as well as the transport capability.
3. Supplementary Services, which normally modifies or supplements a telecommunications transport service. This approximates to the concept of user facilities provided for current data services.

2.5.2 Service Attributes

The concept of attributes is used to permit the differentiation of services in a uniform manner. An attribute can have more than one value, e.g. the attribute 'Information Transfer Mode' can

have the values 'circuit or packet'. A list of these attributes can be found in Appendix 1 to Rec. I.130.

2.5.3 Functional Analysis of Services

Each service is provided by a number of network and terminal functions, e.g. establish connection, temporary storage, error control. It is therefore possible to define each service in terms of the functions required for its provision.

2.5.4 Service Description

A service may therefore have more than one description, a prose description which will be used by many customers, an attribute based description for use by the more sophisticated user and a functional description which is required by the engineer or designer.

2.5.5 Service, Equipment and Network Functions

The service functions introduced above will be provided by equipment in User Premises or by the Carrier on the other side of the user-network interface. The function may be provided by one entity or will require an interaction between two or more entities. In some cases, it will be clear on which side of the interface the function must be provided, in some cases the location will be optional. In the event that the function or set of functions can optionally be provided on the users side of the interface, the terminal equipment provider will be free to exercise ingenuity in the features selected for a particular terminal product. The following paragraphs discuss some of the relationships involved in providing the necessary service functions.

2.6 Relations Between Terminals, Services and The ISDN

2.6.1 Terminal Characteristics

A terminal can be described by the set of its functional and physical characteristics. Some of these characteristics are necessary in order to be compatible with the network. Depending upon the services it is intended to support, the terminal device must provide certain additional functions to provide access to specific network services capability. It may also require functions to provide compatibility with the far terminal, in general higher layer functions. Finally it will have features over which the designer has complete control e.g. physical or self contained features.

2.6.2 Terminal Relationships

The characteristics identified above imply certain relationships which are further demonstrated in Figure 2.11. It should be noted that user, terminals and network are all conditioned for the services required. This diagram shows that interfaces are required both towards user and to the network. In addition it will contain energizing functions 'power' and other functions for analyzing and processing the various message and control inputs. The physical characteristics are assumed.

2.6.3 Selecting The ISDN Related Functions

One of the purposes of this manual is to identify a list of functions, from which the designer or user can select those functions which are necessary because of the need to interwork with the ISDN. The following chapters separate this list into 'Mandatory' and 'Service' related functions. The Mandatory functions are those necessary to enable the terminal devices to interwork with the network but not to provide a service. Service related functions must be provided, in addition, in

order to user a particular service.

A small set of lower layer functions exist which may be provided on a mandatory basis, may be provided on a service basis or may not be provided by the network. These have been included in the Service set but identified separately as "optional" services.

FIGURE 2.1. Circuit Switch Call Control

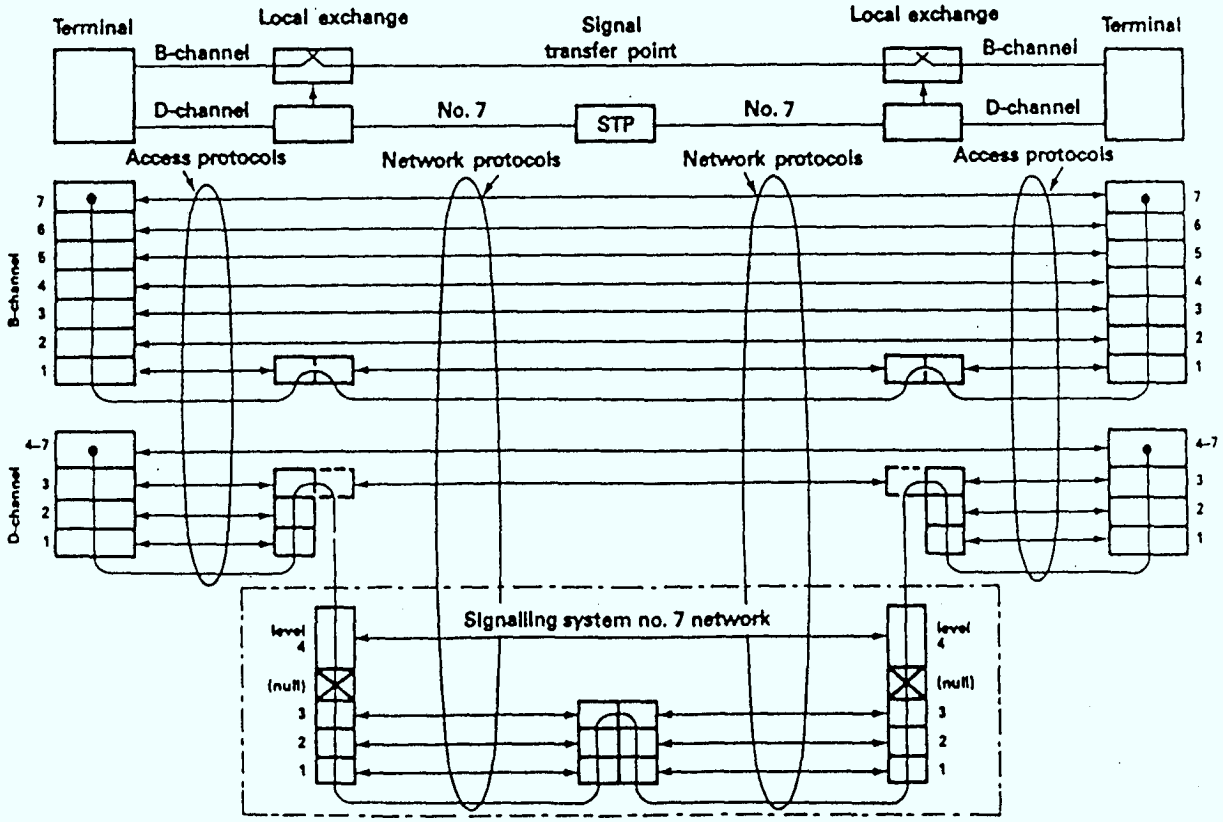


FIGURE 2.2. Protocol Reference Model For Packet Access

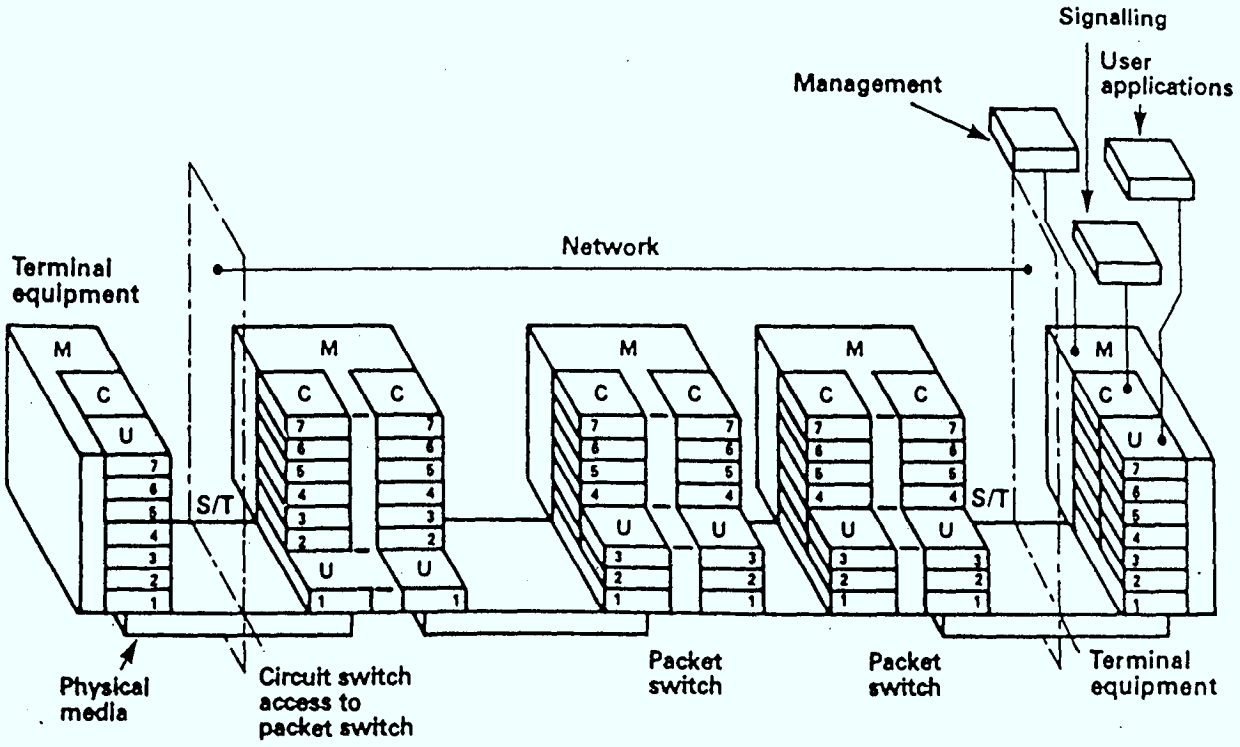


FIGURE 2.3. Examples of Connection Types

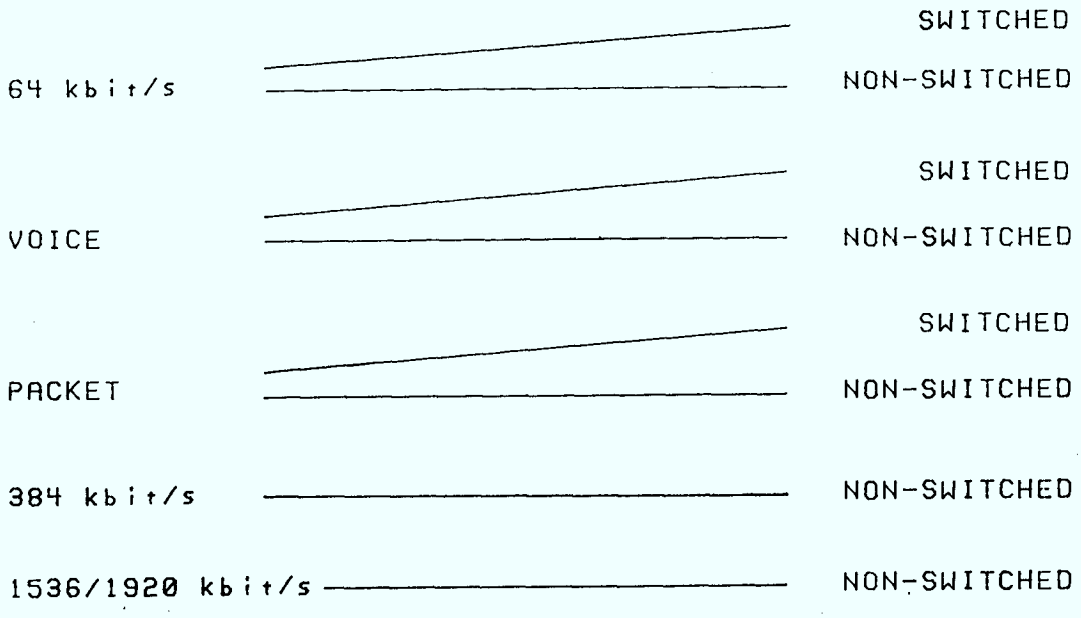


FIGURE 2.4. Numbering Plan Interworking

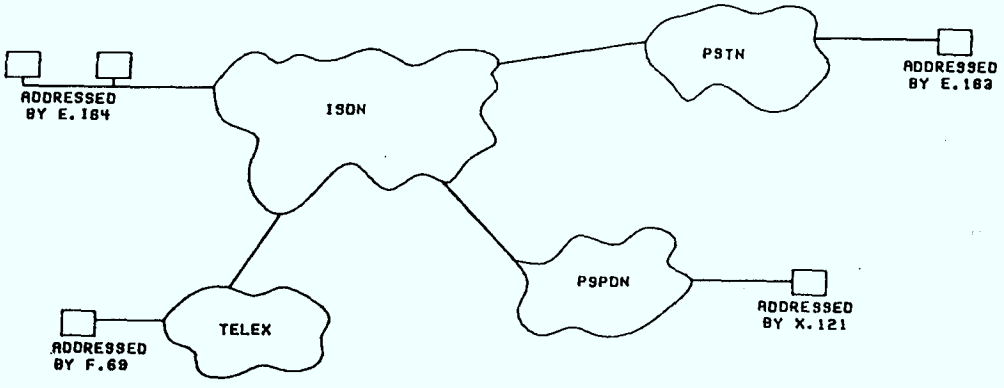


FIGURE 2.5. Numbering Plan Interworking Routing Alternatives

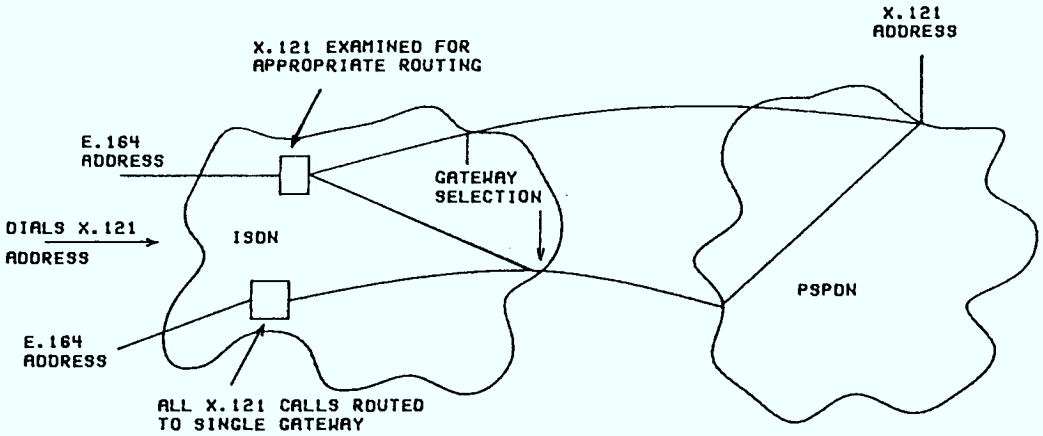


FIGURE 2.6. ISDN Interworking Recommendations

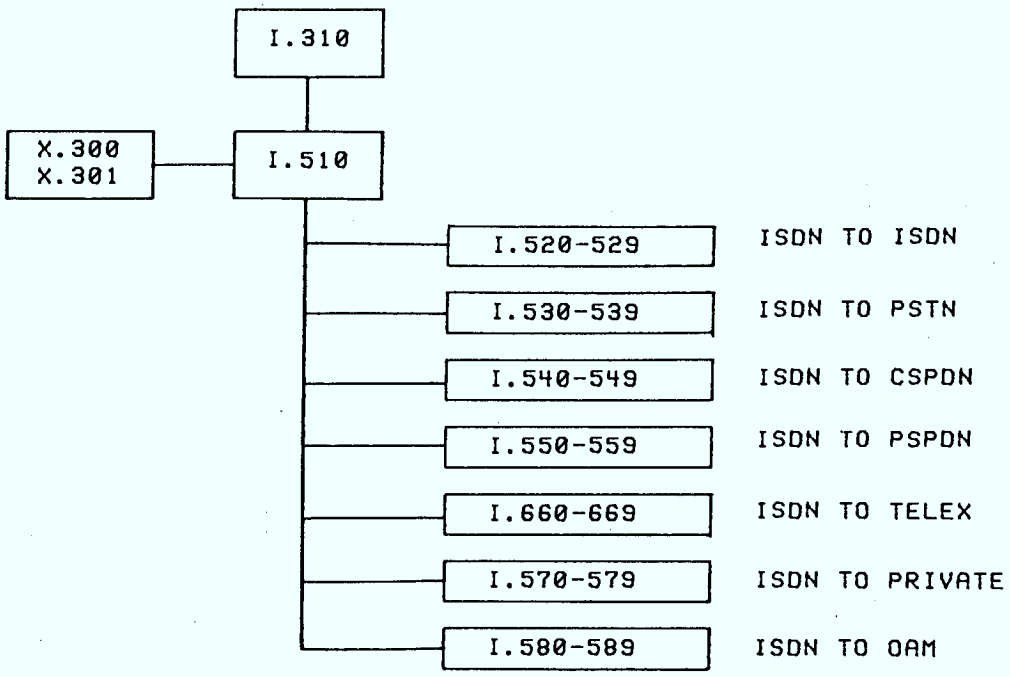
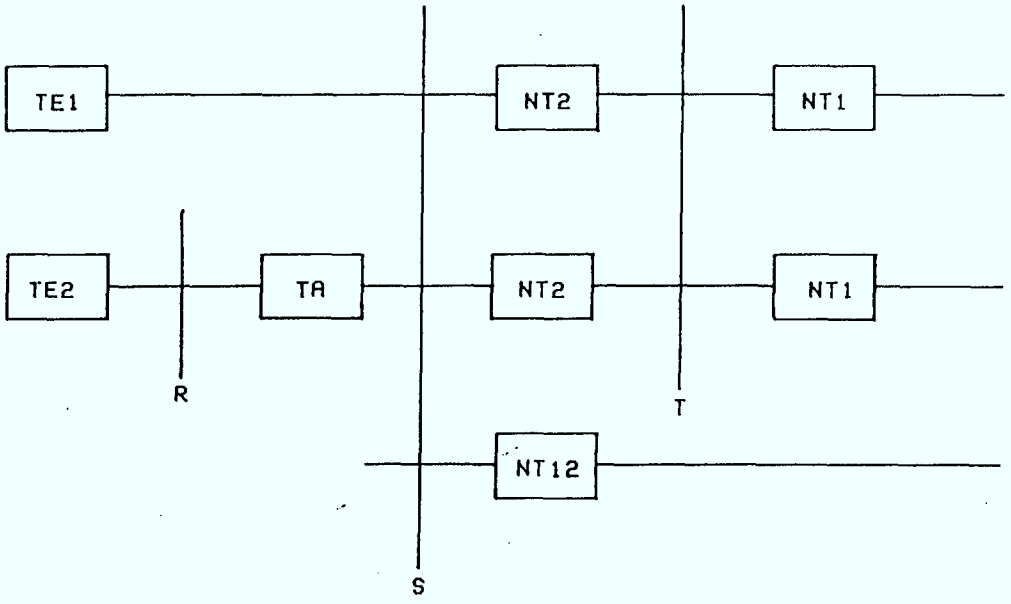


FIGURE 2.7. ISDN Reference Points and Functional Groupings



R, S, T	- REFERENCE INTERFACE POINTS
TE1	- SUBSCRIBER TERMINAL TYPE 1
TE2	- SUBSCRIBER TERMINAL TYPE 2
TA	- TERMINAL ADAPTER
NT1	- NETWORK TERMINATION 1
NT2	- NETWORK TERMINATION 2
NT12	- COMBINED NETWORK TERMINATION 1 AND 2

FIGURE 2.8. Reference Circuit For Basic Access

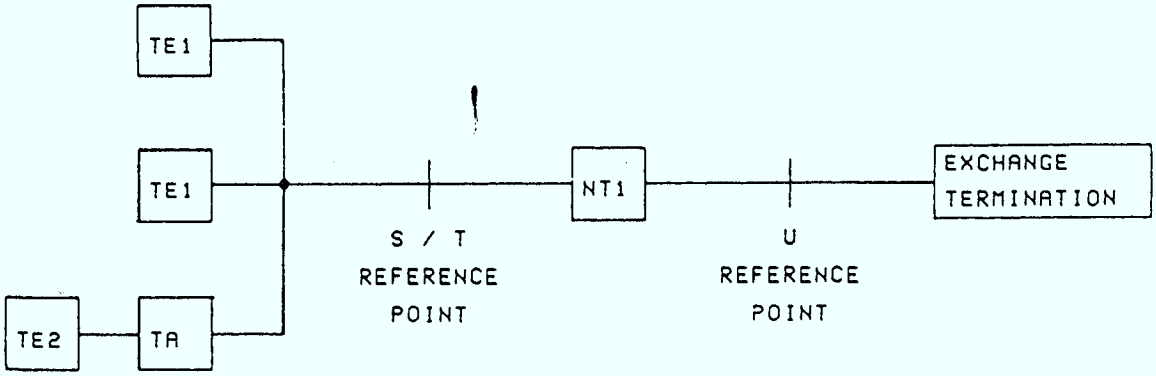


FIGURE 2.9. Reference Circuit For Basic and Primary Access

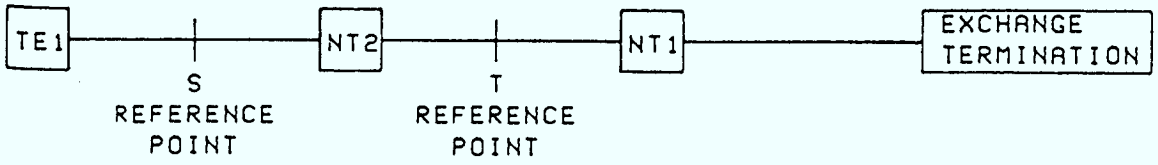


FIGURE 2.10. Wiring Configuration at the Basic Interface

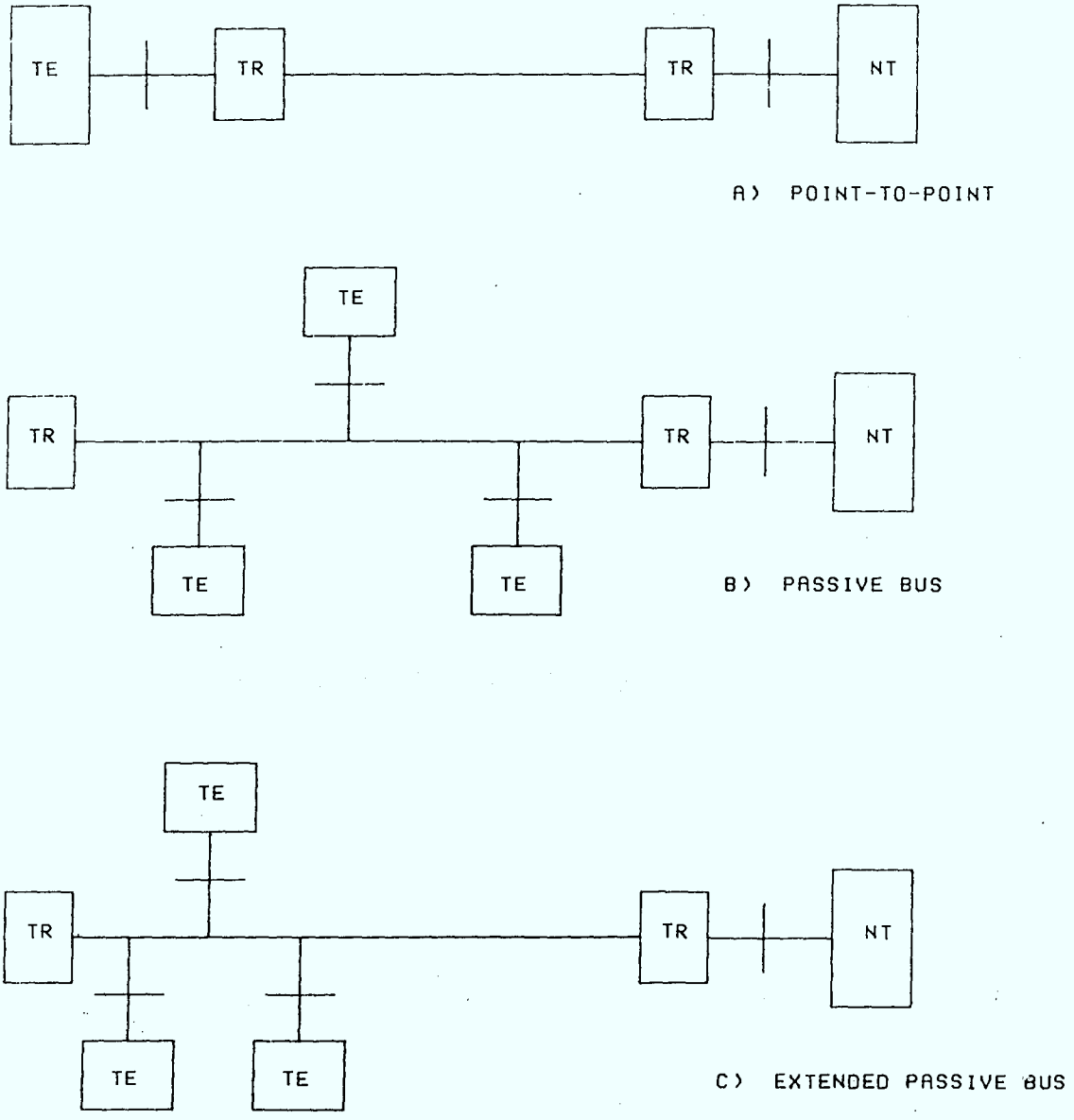


FIGURE 2.11. Terminal Relationships

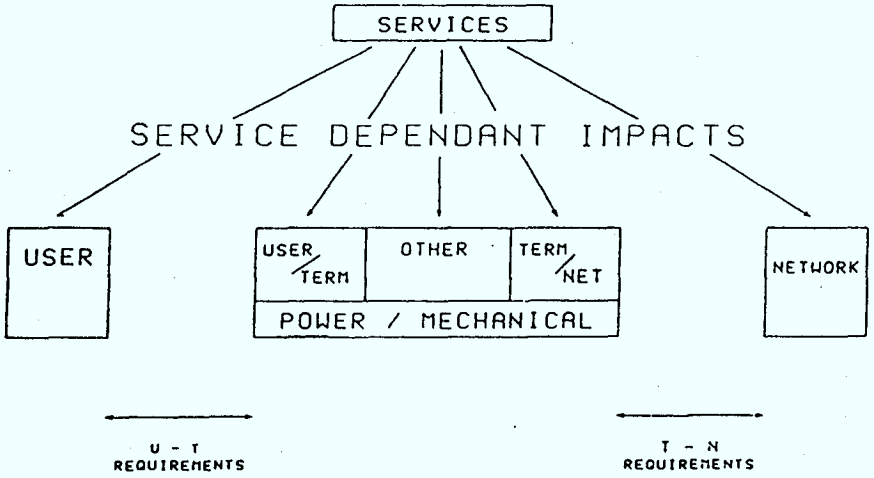
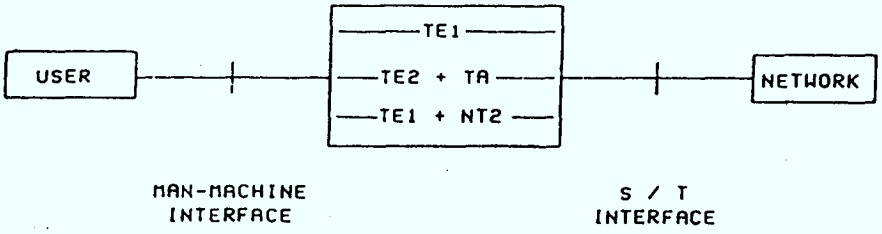


FIGURE 2.12. Terminal Versions



3. ISDN SERVICES

ISDN services are identified below as bearer, supplementary services and optional network features. It should be noted that Teleservices are not identified in this section, since they use the same set of network and terminal functions as are required for the other services.

If terminals do not conform to the ISDN interface standard,(i.e. terminals based on existing Recommendations such as X.21 or X.25), access to the network requires an R interface. In these cases a terminal adapter is required for adaptation of the existing standards to ISDN interface standards at the S/T reference points. (see Section 6 of this manual)

In CCITT Recommendation I.211 the definition and description of bearer services are given. This class of service comprises with the set of basic 64 kbit/s services.

A specific Bearer Services is clearly defined by a basic set of attributes. These can be extended by so-called supplementary services which as a rule enhance the performance of the Bearer Service compared with the basic service. For this reason the supplementary services cannot be regarded as independent services but are normally made available to customers in conjunction with the other functions and therefore in combination with the basic service. Twenty supplementary 64 kbit/s services have been given priority status for study in the current period. By mid 1989 the definition and description of these services should be available in the CCITT Recommendations (blue book).

This section is subdivided according to these categories of services.

3.1 Bearer Services

This section describes several bearer services accessed via the standard network access provided by an ISDN. These bearer services are typically characterized by the provision of user information over one type of channel and signaling over another type of channel. The list of bearer services follows:

a. Circuit Switched Speech

b. Circuit Switched Audio

c. Circuit Switched Unrestricted Digital Data

d. Circuit Switched Restricted Digital Data

e. Packet Switched Digital Data (Permanent and Switched Virtual Circuits)

f. Packet Switched Connectionless (D-Channel)

3.2 Supplementary Services

Supplementary services modify and supplement a basic service. The list of priority supplementary services for the 1985-88 Study Period is given below:

a. Call Forwarding Unconditional

b. Call Forwarding Busy

c. Call Deflection

d. User-to-User Signalling

e. Closed User Group

f. Direct Dialling In

g. Multiple Subscriber Number (Terminal Selection)

h. ISDN Networking Services (City Wide Centrex)

i. Call Waiting

j. Call Completion To Busy Subscriber

k. Calling Line Identification Presentation

l. Calling Line Identification Restriction

m. Called Line Identification

n. Line Hunting

o. Conference Call

p. Three Party Service

q. Call Transfer

r. Credit Card Calling

A description of the service are given in Section 5 of this manual.

3.3 Teleservices

Teleservices are described in I.212. It should be noted that the low layer functions correspond to those used by the characterization of the Bearer Services. The higher layer functions, in general, are not network-related, however they serve to describe the message-related characteristics of each service. They correspond to the functions and protocols of layers 4-7 in Recommendation X.200. These functions are described in Section 5.

4. MANDATORY TERMINAL FUNCTIONS

Within the ISDN Recommendations there are many references to "mandatory" and "optional" functions; however, these references are generally concerned with optional provision of specific services or features. Furthermore, there is a need to discriminate between functions which are not associated with any service but mandatory for any terminal to achieve access to the network and also those functions required, once access is achieved, to obtain on an optional basis of specific services from the network. It is in this respect that the terms "mandatory" and "optional" are used. Section 4 is devoted to the first or mandatory set of functions and Section 5 relates to the second or optional and service-related functions. Both Sections concern terminals designed for use on the Basic Access, although it can be seen that some will be common to Basic Rate Terminal Adaptors and Equipment designed for other access rates.

This section covers the mandatory functions from an OSI perspective starting with those functions associated with the physical interface. Following that are the data link layer and network layer interfaces functions. All of these functions (all 3 layers) are developed from the ISDN Recommendations for the Basic S/T interface.

4.1 Access Types

Basic access refers to a channel structure consisting of two 64 kbit/s bi-directional B channels for voices or data plus a 16 kbit/s bi-directional D channel. This is primarily intended for individual terminal access and is capable of supporting multiple terminals in a star or bus configuration. (see Figure 4.1(a), 4.1(b))

Primary Rate access, as implied by its name, is based upon the use of primary rate digital transmission channel structure (e.g., 1.544 Mbit/s in N. America and Japan, 2.048 Mbit/s in Europe and elsewhere). It consists of a single 64 kbit/s D channel plus 23 (in the case of 1.544 Mbit/s) or 30 (in the case of 2.048 Mbit/s) 64 kbit/s B channels for voice and/or data. This type of access is intended to meet the needs of medium to large PBX access, but could be used for ISDN access from other devices requiring multiple B channels.

This handbook covers only basic access type of ISDN terminal functional requirements.

4.2 Physical Layer (Layer 1)

4.2.1 Introduction

Layer 1 characteristics of the ISDN basic rate S or T user-network interface is described in CCITT Rec. I.430.

The basic access interface supports the bidirectional transmission of two independent 64 kbit/s B channels and a 16 kbit/s D channel. These channels are combined with framing bits and other information in TDM streams of 192 kbit/s. At least two individual metallic pairs are required to provide the interchange for each direction of transmission. However, an 8-contact connector is recommended to provide for two optional pairs to be used for power transfer across the interface. A fundamental physical layer capability is the simultaneous support of a number of TEs with a contention process to resolve access to the D channel.

4.2.2 Status

The current red book is replaced by the accelerated procedure for this section.

4.3 Mandatory Physical Layer Functions

The mandatory functions associated with the physical layer interface at the T reference point are described below. The status of each functions are also included as well as the section reference in Rec. I.430.

4.3.1 Wiring Configurations

4.3.1.1 Description

The basic access interface provides for the interconnection of one TE with one NT, a point-to-point wiring configuration, or the interconnection of multiple TEs with an NT, a passive bus or point-to-multipoint wiring configuration. The general wiring configuration of Recommendation I.430 is shown in Figure 4.2.

One important feature illustrated in the Figure is that physical interfaces may be located adjacent to both the NT and TEs. The Recommendation includes the specification of requirements at both TE and NT interfaces. The specifications are written to be compatible with specific minimum lengths of cabling in various configurations but the requirements on the interface cabling are not explicitly stated; rather they are implied by the specifications for TEs and for NTs. The specification is intended to provide for interface cable lengths of about 1000 meters (6 dB loss) in point-to-point configurations and up to about 200 meters in simple passive bus configurations. The specification also provides for extended bus configurations (TEs clustered closer together at the end of the cable) at a distance of about 500 meters from the NT. The NT requirements for this extended bus configuration are among the refinements developed since the publication of the Red Book.

A second important feature of the interface specification is that the interchange circuit pair terminations (TR) are part of (or associated with) the cabling (wiring). This is to accommodate the Passive Bus configuration where multiple TEs, bridged on the interface cabling, must present high impedances to provide for satisfactory signal transmission.

While not illustrated in Figure 4.2, the NT is not required to be at the end of the interface cabling in passive bus configurations. However, where the NT is at the end of the bus or is in a point-to-point configuration, the termination at the NT may be internal to the equipment and a variety of interconnection arrangements are possible.

4.3.1.2 Status

The NT requirements for extended bus configuration are among the refinements developed since the publication of the Red Book. Also provisions to clarify the variety of acceptable arrangements will be included in the revised Recommendation.

4.3.2 Line Code

4.3.2.1 Description

The line code is essentially the inverse of AMI. It uses a pulse for binary ZERO and no pulse for binary ONE. Pulses are inverted relative to the polarity of the preceding pulse to eliminate the dc component and permit the use of balanced ac coupled interchange circuits. Violations of the alternating polarity rule are used to delimit frames. A binary ONE is transmitted as the absence of a pulse to facilitate operation in the passive bus configuration with the HDLC-based Layer 2 (LAPD) protocol on the D channel. The idle state is continuous binary ONEs. With this convention, only TEs that are active transmit signals on the bus and idle TEs do not transmit

signals that would interfere. The coding allows for the nondestructive resolution of contention among multiple TEs trying to access the bus at the same time.

4.3.2.2 Status

No changes from the red book.

4.3.3 Frame Structure (Alignment:bit, octet and frame)

4.3.3.1 Description

The frame structures employed for the two directions of transmission are illustrated in Figure 3/I.430. The frame length is 48 bits. The frames are symmetrical except for the Fa bits and (an associated N/L bits) which are located in the 13th bit position in each frame. Each frame contains two octets for each of the two B channels, B1 and B2, and four bits for the D channel. The provision of an integral number of B channel octets assures the alignment essential for circuit switched voice applications which are based on octet switching. Identification of octets in the D channel is not required because traffic on this channel is packet based and the protocol used on the D channel (LAPD) is HDLC-based and octet alignment is unnecessarily. As indicated the frames are delimited by coding violations. The auxiliary framing bits (Fa) are included to assure that a repetitive pattern of contiguous ZEROs in a B or D channel cannot emulate the framing pattern. The balance bits, (L), assure DC balance over each frame in the NT to TE direction. In the TE-to-NT direction, the L bits are used to assure DC balance of the transmission from indiviual TEs and of the signal on the bus when several TEs are active simultaneously. The special function of the bit designated N in the NT to TE direction frame is discussed in connection with the provision of a multiframe to provided spare capacity in the TE to NT direction.

All TEs transmit framing pulses so that, as long as any TE on a bus is powered up, framing is received at the NT.

4.3.3.2 Status

No changes from the red book.

4.3.4 D Channel Contention Control

4.3.4.1 Description

When operating in a bus configuration, multiple terminals compete for a shared D channel to send signaling or data messages to the network. To control access to the D channel between competing terminals, a contention resolution mechanism, based on collision detection and back off, is provided by this function at this layer.

The E bits are used to provide for the resolution of contention of two or more TEs on a passive bus each trying to access to the D channel. Before explaining the function of E bits in the resolution of contention, it is important to note that TEs are required to present a high impedance when transmitting a binary ONE (no pulse) and therefore the transmission of a binary ZERO by a TE overrides the transmission by a second TE of a binary ONE. Now, at an NT, each D channel bit received is transmitted back in the next E-bit position as indicated in Figure 3/I.430. And each contending TE examines each D channel D(E) bit before it transmits another bit on the D channel. A TE is required to withdraw and stop contending for the D channel if it sent a ONE and receives a ZERO as the echoed D bit. Since each layer 2 frame transmitted from a TE has a unique identification, all TEs contending for access except one will be forced to withdraw. A

priority mechanism assures that a TE cannot seek access and transmit a second frame if another TE is seeking access.

4.3.4.2 Status

No change from the red book.

4.3.5 Channel Identification

4.3.5.1 Description

This function is necessary for identifying the B and D channels.

4.3.5.2 Status

No change from the red book.

4.3.6 Maintenance

4.3.6.1 Description

As indicated in Section 6 of the accelerated procedure, maintenance function signaling channels are provided in both the NT-to-TE and TE-to-NT directions. The functions to be signaled on these channels and the associated protocol are specified in Section 7 of the accelerated procedure.

4.3.6.2 Status

The subject of maintenance capabilities to be provided for in the Recommendation is still under review in the 1985 - 1988 Study Period. A major step forward has been agreement to a draft recommendation specifying loop backs and other maintenance functions. However, many maintenance capabilities remain for study. Differing environments in different countries have made it particularly difficult to reach agreement on maintenance capabilities.

4.3.7 Electrical Characteristics

4.3.7.1 Description

The electrical characteristics are defined to provide for proper interfacing in passive bus interconnections.

4.3.7.2 Status

They have been the subject of considerable clarification and refinement during the 1984-1988 study period. Changes to the Red Book version of I.430 which will be expected in the Grey (accelerated) Book are the following:

1. Clarification of the TE and NT output signal jitter limitations.
2. Clarification of the TE input to output signal phase delay limitation.
3. Modifications of the pulse masks to allow practical implementations.
4. Modification of the transmitter source impedance requirements such that finite impedance current limited voltage sources are permitted.
5. Correction of the receiver sensitivity requirements.

4.3.8 Physical Characteristics

4.3.8.1 Description

Physical characteristics refers to the physical connector that is located at reference points S or T, between TEs and NTs. It defines the eight pin connector and the associated wiring arrangement.

4.3.8.2 Status

The interface connector and contact assignments are to be specified in an ISO standard. The standard, which specifies the 8-contact modular plug and jack similar to those used in the USA for a variety of telephony applications, has reached the draft international standard status.

4.3.9 Mapping to Section Reference

The above mandatory functions for the physical layer with section reference in I.430 unless otherwise indicated are summarized and mapped in Table 4.1.

TABLE 4.1. Mandatory Physical Layer Functions

Functions	Description	Section Reference
Wiring Configuration	Interconnection of one TE with one NT	4.0
Line Code	Inverse of AMI	5.5
Frame Structure	Alignment of bit, octet and frame	6.3
D Channel Contention Control	To control access to D channel	6.1
Channel Identification	To identify B,D channels	Rec.I.412 (Definition)
Maintenance	Activities in support of maintaining network,subscriber access and installations	7.0
Electrical Characteristics	Interfacing in passive bus interconnections	8.0
Physical Characteristics	Interface connector and contact assignments	10.0

4.4 Data Link Layer (Layer 2)

4.4.1 Introduction

The link access procedure on the D channel, called LAPD (data link layer), is defined in Recommendations I.440 and I.441. LAPD is based on X.25 LAPB, but the procedure is enhanced in LAPD by including address and terminal identification capabilities, which permit sharing of an access line by more than one terminal device.

The fundamental role of the data link layer is to transfer the information exchanged between the network layers to/from different network equipment for their communication purpose, without it being affected by errors arising from the physical layers. To achieve the said information transfer, the LAPD has the similar functions of error detection, re-transmission and sequence control of those of the LAPB that functions as Level 2 of the CCITT recommendation X.25.

LAPD supports only multiframe procedures. This aligns with the operation of LAPB, in that it allows multiple frames to be sent before an acknowledgement or a retransmission request is received for the first. Multiframe procedures have the advantage of high throughput at the expense of additional complexity. In particular multiframe operation requires that send and receive frame sequence numbers and a retransmission buffer containing copies of all outstanding unacknowledged frames be maintained at each end of each logical link.

Unlike LAPB, it is essential for LAPD to accommodate a plural number of terminals on one hand and to provide on the other hand various signals, user packets and control information for a plural number of Level 3 entities. For this purpose the LAPD is equipped with the functions of setting up and managing a number of data link connections that are identified by the DLCI (data link connection identifier) composed of identifiers referred to as TEI and SAPI (below).

The capabilities of the two octet link layer address in LAPD extend beyond the identification of command and response frames, as in LAPB of X.25. They include the identification of different layer 3 entities, using a Service Access Point Identifier (SAPI), as well as the identification of separate terminal devices, using a Terminal End Point Identifier (TEI). These addressing capabilities enable independent logical links to be operated over the same physical D channel. Each logical link is assigned to a particular terminal device and a particular pair of layer 3 entities (one in the terminal and one in the network) and each has essentially independent error and flow control messages.

The LAPD further transfers to a number of terminals the same information from the network (broadcasting) as well as carrying the information required for the TEI assignment procedure. Another significant feature of LAPD includes the UI frame (unnumbered information frame) transfer function for data link control.

4.4.2 Status

The 1984 version of Recommendation Q.921 specified two forms of acknowledged information transfer: single frame operation (Section 5.5) and multiple frame operation (Section 5.6). The former operation has been deleted in current work. Similarly, in the 1984 version, both modulo 128 and modulo 8 operations were specified without any further qualification (Section 3.4 and 3.6.2). However, this has been changed to support only multiple frame operation with modulo 128 sequencing. In an interim period, support of existing equipment using modulo 8 sequencing may be necessary. In other words, for future terminals, modulo 128 should be considered to be the standard.

4.5 Mandatory Layer 2 Functions

The layer 2 mandatory functions (LAPD) associated with the D Channel Protocol are described below. The status of each individual functions are also presented as well as the reference section in Rec. I.441 of the red book.

4.5.1 Zero Insertion & Suppression (Transparency Transfer)

4.5.1.1 Description

This function on transmission is to insert a "0" whenever more than five contiguous ones are encountered and on reception is to discard any "0" bit which directly follows five contiguous "1" bits. (see Section 2.6/I.441 for framing and transparent transfer). This is to prevent false identification as a flag sequence or an abort signal.

4.5.1.2 Status

No changes from the red book.

4.5.2 Frame Identification

4.5.2.1 Description

Information to be carried between higher layer entities is encapsulated in a Layer 2 frame. All frames shall start and end with the flag sequence consisting of one "0" bit followed by six contiguous "1" bits and one "0" bit. The flag preceding the address field is defined as the opening flag. The flag following the FCS field is defined as the closing flag. This function must recognize and validate each fields of the frame as indicated in Figure 1/I.441. Invalid frames shall be discarded without notification to the sender. No action is taken as the result of that frame. Also receipt of seven or more contiguous "1" bits shall be interpreted as an abort and the data link layer entity shall ignore the frame being received.

4.5.2.2 Status

No changes from the red book.

4.5.3 Establish Transfer Mode (fixed TEI)

4.5.3.1 Description

Before any service is established, each terminal must have a unique TEI (or fixed TEI) assigned. Also a TEI will be assigned to a terminal normally at the time of first call origination from the terminal or first incoming call, and not at the time when it is plugged into the interface and power switched on. This is to prevent congestion at a local exchange for assigning TEI's to terminals simultaneously requesting TEI assignment after a no power condition is cleared in an area which the local exchange is serving.

4.5.3.2 Status

In order to speed up the TEI assignment to a terminal in a TEI-unassigned state at the time of call origination or responding to an incoming call, it was decided to delete the TEI check procedure (Section 5.3.3/Q.921) from the overall TEI assignment procedure.

TEI check procedure is now defined as an independent procedure, e.g. for auditing. TEI check procedure was originally included to satisfy the objective that no information on assigned TEIs should be stored in a local exchange. However, it was agreed that the performance should have the priority and that storing of assigned TEIs in a local exchange would not be a problem, if auditing is performed to remove unwanted TEIs at a certain period by the exchange using an independent TEI check procedure. Measures against double TEI assignment were also added, such as its detection by the receipt of an unsolicited UA (Unnumbered Acknowledgement) response and TEI verify request and removal procedures.

4.5.4 Sequence Control

4.5.4.1 Description

This function is to control sequence integrity of frame transfer/reception on one connection. Each information (I) frame is sequentially numbered and may have the value 0 through "n" minus 1 (where "n" is the modulus of the sequence numbers). Each point-to-point data link connection endpoint shall have an associated send state variable (V(S)) when using I frame commands. The send state variable denotes the sequence number of the next in-sequence I frame to be transmitted. The send state variable can take on the value 0 through "n" minus 1. The value of the send state variable shall be incremented by 1 with each successive I frame transmission, and shall not exceed acknowledge state variable V(A) by more than the maximum number of k outstanding I frames. The value of k is in the range of $1 < k < 127$ for modulo 128 operation.

4.5.4.2 Status

No changes from the red book.

4.5.5 Error Detection

4.5.5.1 Description

This function is to detect errors in transfer format and operation. The frame includes a 16 bit CRC 16 cyclic redundancy check code, which provides for error detection. The identification process is used to initiate error correction.

4.5.5.2 Status

No changes from the red book.

4.5.6 Error Recovery

4.5.6.1 Description

This function permits recovery of detected errors and information outputs to the management entity for unrecoverable errors. Error correction is performed by retransmission of erroneous frames. Both error free and retransmitted frames are delivered in correct sequence.

4.5.6.2 Status

No changes from the red book.

4.5.7 Flow Control

4.5.7.1 Description

Flow control is basically performed by modulo 128 acknowledgements and by use of supervisory functions such as receive ready (RR), receive not ready (RNR) and reject (REJ). These are implemented as command and response control fields as shown in Table 4/I.441.

4.5.7.2 Status

Commands and responses for unacknowledged, single frame acknowledged and multiple frame acknowledged (modulo 8) operation has been discarded for the 1988 version. Therefore Table 3/I.441 will be deleted from next publication.

4.5.8 Broadcast Capability

4.5.8.1 Description

LAPD addressing also includes a broadcast capability. This allows information sent by a particular layer 3 entity in the network to be received by all terminals on a particular ISDN access system, which support that layer 3 entity. This facility allows, for example, an incoming call to be simultaneously offered to all terminals on a basic access system.

The TEI subfield bit pattern "111 1111" (=127) is defined as the group TEI. The group TEI is assigned to the broadcast data link connection associated with the addressed service access point.

4.5.8.2 Status

No changes from the red book.

4.5.9 Mapping to Section Reference

Those mandatory LAPD functions identified in Rec.I.441 and mentioned in Section above are summarized in Table 4.2.

TABLE 4.2. Mandatory LAPD Functions

Functions	Description	Section Reference
Zero Suppression	Transparency transfer	2.6
Frame Identification	To recognize and validate all frames	2.0,3.0
Establish Transfer mode	terminal transmits message to network for initiation	5.3
Sequential control	Sequence integrity of frame transfer/reception on one connection	3.5.2
Error detection	Detection of errors in transfer format errors and operation errors	5.9
Recovery	Recovery from detected errors and information outputs to management entity for unrecoverable errors	5.9
Flow Control	Flow control by modulo and acknowledgement	3.6
Broadcast Capability	Provision of broadcast data links that are identifiable by Global TEI	3.3.4.1

4.6 Network Layer (Layer 3)

4.6.1 Introduction

Layer 3 is defined in Recommendation I.450 (general aspects) and I.451 (detailed specification). These Recommendations describe the procedures for the establishing and clearing of network connections.

The layer 3 signaling protocol is required to two variants of the messages and procedures for circuit-switched call control. These variants are termed "functional" and "stimulus" signaling protocols respectively, and in general the particular variant to be used is negotiated at the start of the call set-up procedure.

Functional signaling is the layer 3 variant best suited to intelligent devices such as intelligent terminals. Functional signaling messages have an unambiguously defined meaning known to both the sender and receiver of the messages.

Stimulus signaling was designed to accommodate inexpensive 'dumb' terminals. It essentially allowed communication between the human user of the 'dumb' terminal and the ISDN exchange, with the 'dumb' terminal acting as a more or less transparent intermediary. In particular, functional signaling requires that both ends (i.e. the terminal and ISDN exchange) keep track of call state information, whereas, in the case of stimulus signaling, only the ISDN exchange keeps track.

4.6.2 Status

In 1984 version of the recommendation, both the stimulus and functional signaling protocols were aligned to the extent that the message sequences for set-up and clear-down of a simple circuit switched call were essentially the same.

However, the recent Study Group XI meeting at Phoenix in March has dropped the use of the stimulus-mode signaling protocol for basic call control.

4.7 Mandatory Network Layer Functions

The service independent functions associated with the network layer of the D Channel Protocol are described below with a brief description on the current status. Also a section reference also given to serve as a guide to the red book.

4.7.1 Identify and Process Messages

4.7.1.1 Description

The Layer 3 signaling protocol used on the D channel is based on a set of signaling messages needed to set up and clear down a simple 64 kbit/s circuit-switched voice or data connection. This function must be able to identify and process these messages. The process involves unpacking the contents of the messages. Every layer 3 signalling message should contain, as shown in Figure 4/I.451,protocol discriminator, call reference, and message type. In addition, a message may contain mandatory information elements, as required, and additional information elements, when required, both of which are specific to each message type.

4.7.1.2 Status

No changes from the red book.

4.7.2 Call reference handling

4.7.2.1 Description

Call references are mandatory in every layer 3 signalling message. The purpose of the call reference is to identify the call or facility registration/cancellation request at the local user-network interface to which a particular message applies. However the call reference has only local significance and does not have end-to-end significance across ISDN.

4.7.2.2 Status

No changes from the red book.

4.7.3 List of Support Messages

The set of messages which are mandatory for call control procedures for both circuit-switched (I.441) and packet-switched calls (I.462) are defined in Table 4.3. See Figure 4.3 for call control procedure for simple circuit-switched call.

Incoming call procedure in a multipoint terminal configuration is shown in Figure 4.4. In order to handle a multipoint terminal configuration, the SETUP message must be sent using a broadcast data link at the layer 2.

When the first CONNect message is received in response to a previously sent SETUP message, the network sends the CONNect ACKnowledge message to the terminal selected for the call. In addition, the network sends a RELease message to all other terminals at the interface which had sent an ALERTing (optional to functional terminals) or CONNect message to notify these terminals that the call is no longer offered to them.

TABLE 4.3. Support of Messages

Message	Description	Section Reference
SETUP	Call establishment indication	3.2.24
CALL PROCeeding	Indication of requested call has been initiated	3.2.2
SETUP ACKnowledge	Optional for B-channel negotiation	3.2.25
INFormation	Optional for B-channel negotiation	3.2.15
CONNect	Indication of call acceptance by the called user	3.2.7
CONNect ACKnowledge	An acknowledgement to the called user	3.2.8
DISConnect	An invitation to release the channel and call reference	3.2.11
RELease	Indication of equipment disconnected	3.2.19
RELease COMplete	Indication for channel available for reuse	3.2.20

For packet switched calls via B-channel, an ISDN provides a physical 64 kbit/s semi-permanent or switched B-channel between the user terminal and the packet handling function within an ISDN. Two cases for packet switched calls are covered.

In the case of switched access, the user terminal shall first set up, via the normal ISDN signalling procedure, a B channel switched 64 kbit/s connection either circuit or packet mode to the packet

handling function or to the entry point to the packet data network, which can then be used to complete the packet communication according to X.25 layer 2 and layer 3 protocols.

For packet switched calls via D-channel, the D-channel enables ISDN user terminals to access a packet handling function within an ISDN by establishing a data link connection to that function which can then be used to support packet communication according to X.25 layer 3 protocol.

4.7.4 List of Support Information Elements

The coding rules for the information elements are defined in Section 4.5.1/I.451. For the supported Information elements listed in Table 4.4, the coding of the Information elements identifier bits is summarized in Table 34/I.451.

The purpose of the bearer capability information element is to indicate provision, by the network, of one of the bearer capabilities as defined in Recommendation I.211. It is coded as shown in Figure 11/I.451 and Tables 36a/I.451 to 36d/I.451. The bearer capability information element may be repeated in a message to identify multiple services, e.g. in individual transit networks.

TABLE 4.4. Support of Information Elements

Message Element	Description	Section Reference
Bearer Capability	Indication of provision of one of the bearer capabilities	4.5.5
Channel Identification	Identification of a channel or subchannel within the interfaces controlled by these signalling procedures.	4.5.10
Cause	Description for reason in generating certain messages	4.5.8
Destination Address	Identification of one destination of a call.	4.5.13

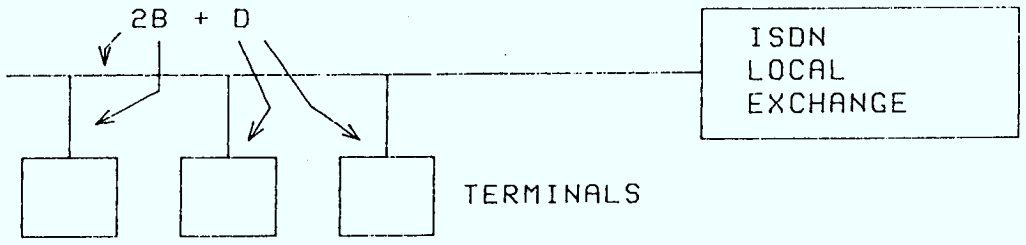
4.8 Mapping to Section Reference

Those mandatory Network Layer functions as discussed in Section 4.7 are summarized in Table 4.5. These functions are mapped to specific sections of the Recommendation.

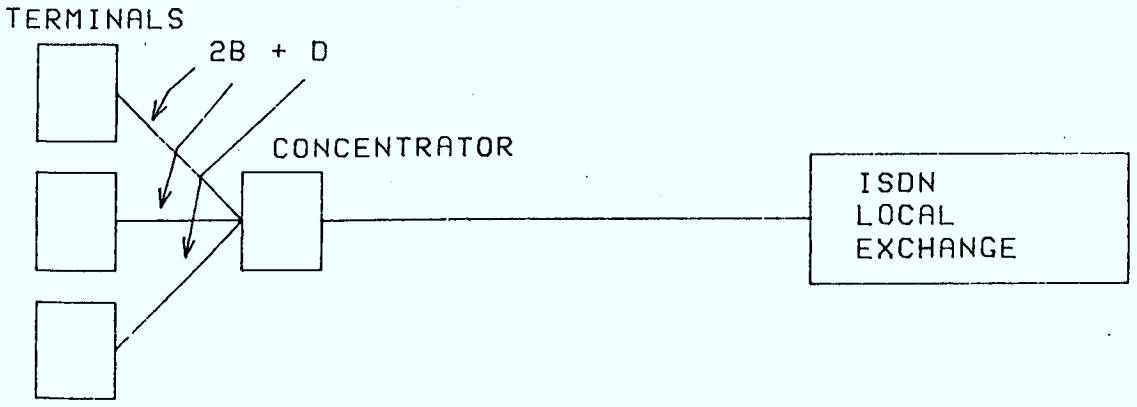
TABLE 4.5. Mandatory Network Layer Functions

Functions	Description	Section Reference
Identify Message and Process Message	To recognize and validate the message formats	4.0
Call Reference	To identify the call request at the local user-network interface	4.3
Support Messages	A set of mandatory messages for basic call control procedures	3.0
Support Information Elements	Specification of the message types	4.5

FIGURE 4.1. ISDN Basic Access Examples (Simplified)

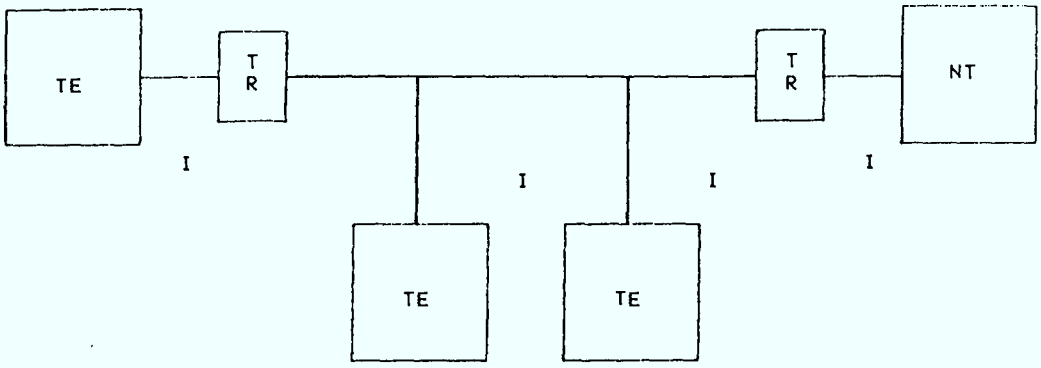


A) BASIC ACCESS - BUS CONFIGURATION EXAMPLE



B) BASIC ACCESS - STAR CONFIGURATION EXAMPLE

FIGURE 4.2. General Wiring Configuration



TR = TERMINATING RESISTOR
I = ELECTRICAL INTERFACE

FIGURE 4.3. Call Control Procedure (simple circuit-switched call)

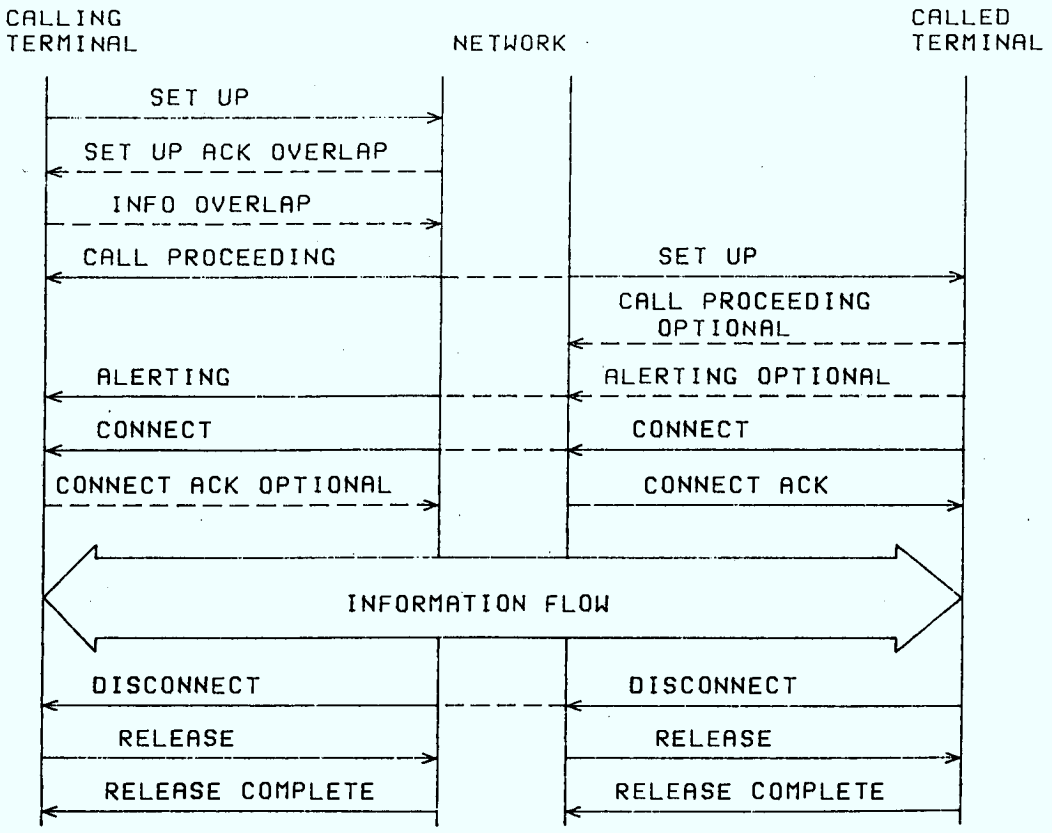
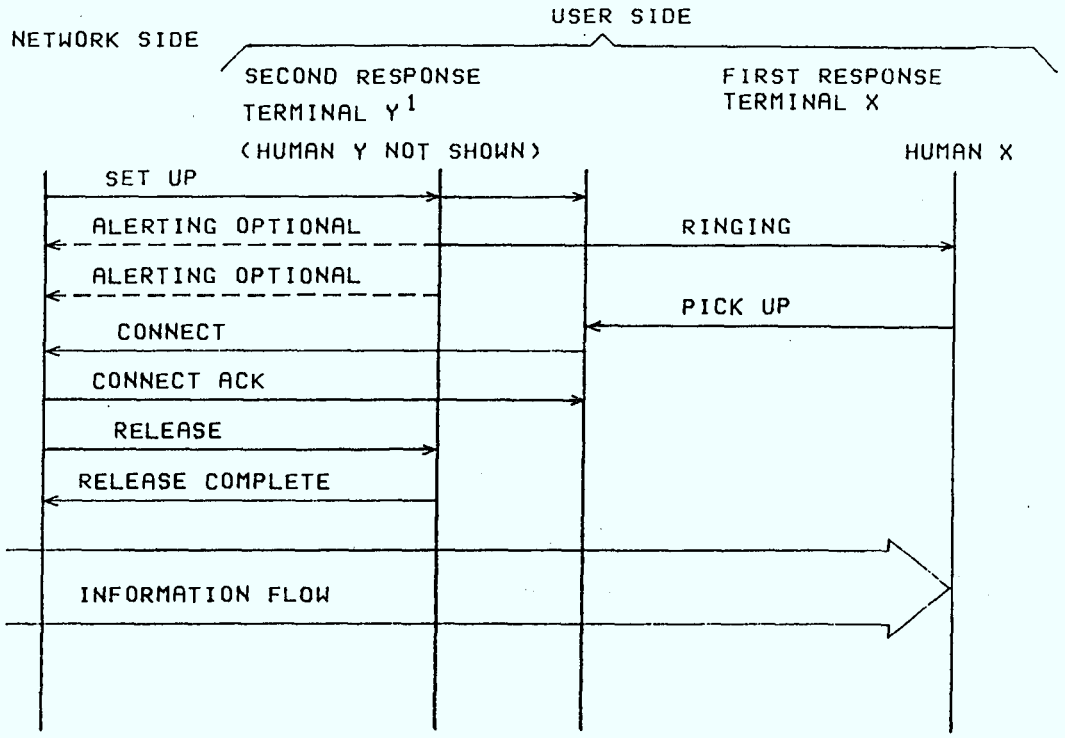


FIGURE 4.4. Incoming Call Procedure (multipoint terminal configuration)



5. ISDN TERMINAL SERVICE FUNCTIONAL REQUIREMENTS (TE1)

5.1 Introduction

The ISDN terminal (TE1) is intended as an individual station. It exists at both basic and primary rate although different sets of functions may be required for the different rates. The ISDN terminal includes functions broadly belonging to layer 1 and higher layers of the Recommendation X.200 reference model. Digital telephones, data terminal equipment, and integrated work stations are examples of equipment or combinations of equipment that provide the functions. The ISDN terminal functions include:

- protocol handling;
- maintenance functions;
- interface functions;
- connection functions to other equipments.

The interface of TE1 (ISDN terminal) must comply with the ISDN user-network interface Recommendations. The Mandatory portion of the requirements was covered in Section 4.

5.2 Optional Network Functions Determined by the Network

In section 4, Mandatory functions for TE1's on the Basic Access were discussed. This section will continue with those network functions which are "optional" in nature. The network provider can have a choice of either providing them, or marketing them as options to services. These functions include power feeding, activation/deactivation, dynamic TEI assignments and timer values.

5.2.1 Power Feeding (Basic Access)

5.2.1.1 Description

The Recommendation provides for powering of TEs from an NT by using the phantom mode NT over the transmit and receive pairs. It also provides for powering of TEs over a third pair, e.g., from a remote wiring closet. Finally, it also provides for power transfer in TE-to-TE applications and for powering NTs by having a fourth wire pair. All powering capabilities are optional and this last capability is not specified in the current I.430 Recommendation.

The specification of a phantom mode powering capability is compatible with power being provided over the loop from the local central office or from some other power source during outages of commercial power. To this end, provision is made for TEs to go into a low power drain state between calls and to limit power that can be drawn by the one TE that is permitted to be active during this "restricted power" condition. These functions are essential where power is provided from the central office to avoid excessive office battery requirements. The designated terminal to be powered during an outage may draw up to about 380 mw.

5.2.1.2 Requirement

The terminal must support the procedures of Section 9 in I.430 describing the power feeding function of the ISDN Interface.

5.2.1.3 Status

The details of the powering capabilities, are the subject of substantial draft amendments developed during the 1985-1988 study period. When provided, the power to be available to TEs in the phantom mode under normal and restricted conditions are now specified as 1 w and 380 mw, respectively. These values are also specified as the maximum power to be drawn, under the specified conditions, by a TE. The minimum power to be available to TEs on the third pair is specified as 7 w. Provisions for the power sources separate from, and independent of, an NT are clarified.

5.2.2 Activation/Deactivation (Basic Access)

5.2.2.1 Description

Procedures for activating and deactivating TEs are included to provide for minimizing the power drawn when all terminals on a basic access are inactive.

In a deactivated state, TEs stop transmission and reduce power drawn from a phantom mode source to a low level. When a call is to be originated, a deactivated TE1 sends a special sequence to request activation. Similarly the network may send an activation request to a TE when there is an incoming call. TEs are also forced into a deactivated state when requested by the network in order to permit networks to deactivate TEs.

5.2.2.2 Requirement

TE1's supporting the activation/deactivation function must follow the procedures in Sections 6.2.3 and 6.3.4 of I.430.

5.2.2.3 Status

The activation/deactivation procedures are relatively complex. Clarification and refinement to the procedures have received the most attention during the "1985-1988" study period. Draft amendments to the limits for TEs, refinements of the procedures and clarifications to the specification have been proposed.

5.2.3 Dynamic TEI Assignment

5.2.3.1 Description

Another name for this function is Automatic TEI Allocation. This procedures are defined to allocate a TEI value automatically to a newly connected user terminal equipment at a specific user-network interface point, so that no manual setting of a TEI value is necessary every time a terminal is connected to a user-network interface point.

5.2.3.2 Requirement

See Section 5.3.2 of Rec. I.441 for details of this function.

5.2.3.3 Status

No change from the Red book.

5.2.4 Timer Values for Layers 1 and 2

5.2.4.1 Description

Timers usually have default values which assigned to them to support those timers in both the network and the terminal.

5.2.4.2 Requirement

In the physical layer, timer values for terminal for activation/deactivation are detailed in Section 6.2.5/I.430.

Similary in the data link layer, a list of network timers includes T200, T201, T202, and T203 which are interrelated to each other. The default values for these timers are in Section 3.10 and Appendix 1 of Q.921.

5.2.4.3 Status

No change from the Red Book.

5.3 Bearer Service Functions

Bearer Services are - from a technical viewpoint - internationally standardized only in the lower three layers according to the OSI Reference Model (OSI - Open System Interconnection, a model developed by the International Standards Organization - ISO - describing communication processes). Therefore the ISDN acts purely as a communication media allowing the information transfer from one user-network interface to another user-network interface. They are offered by the network provider via international standardized ISDN-interfaces at S/T reference point.

The technical characteristics at these access points together with operational and commercial characteristics form the Bearer Services offered to the users. Bearer Services do not include specifications of end-to-end protocols, i.e. the characteristics of the terminals are not included in the service definition.

Bearer Services are typically characterized by the provision of user information over one type of channel and signalling over another type of channel. The list of Bearer Services Functions for both circuit-switched and packet-switched services are discussed below:

5.3.1 General Requirements (Layer 3)

5.3.1.1 General Aspects

Recommendation Q.930 (I.450) describes in general terms the requirements at layer 3 for an ISDN Terminal (TE1). All ISDN terminals must align with the principles in the Recommendation.

5.3.2 Circuit Switched Services

All ISDN Circuit Switched Services have a number of common characteristics noted in the following:

i. Each shares a set of common signalling procedures.

ii. All signalling is performed on the D Channel.

iii. All information transfer is on the B Channel.

iv. All Circuit Switched services are presently based on a 64 kbit/s rate.

v. All signalling is performed on the SAPI 's' type logical link at layer 2 of the D channel.

The following subsections cover the functions required for those services operating in a circuit switched mode in ISDN. They are in two categories; the first covers the general functions of circuit switching and the second covers the service specific items.

5.3.2.1 General Functions for Circuit Switched Services

5.3.2.1.1 Service Access Point Identifier (SAPI)

5.3.2.1.1.1 Description

In order to communicate with the network, a layer two link must be established. For call control signalling, this takes place via a specific SAPI in the Link Layer D Channel Protocol.

5.3.2.1.1.2 Requirement

All communication between the network and the terminal takes place over the D channel using SAPI = all zeroes. This is referred to as the 's' type link. This is covered in section 3.3.3 of Recommendation Q.921(I.441).

5.3.2.1.1.3 Status

No change for 1988.

5.3.2.1.2 Call States

5.3.2.1.2.1 Description

All ISDN terminals must support functional signalling for circuit switched call control. This imposes a state machine approach for the terminal operation.

5.3.2.1.2.2 Requirement

The terminal must support all the call states of section 2.1.1 of Recommendation Q.931(I.451) except for U13 and U14.

5.3.2.1.2.3 Status

Additional States have been proposed for the 1988 Blue Book. Detach procedures have been removed for 1988.

5.3.2.1.3 SDL's

5.3.2.1.3.1 Description

The SDL's are a visual description of the state driven operation of an ISDN terminal.

5.3.2.1.3.2 Requirement

All ISDN Circuit Switched terminals must support the user side SDL's of Section 2.1.3 and Figure 38/Q.931 (5 pages) of Q.931.

5.3.2.1.3.3 Status

No significant change for 1988. The SDL's are viewed as an aid to the procedures of Section 5 of Q.931.

5.3.2.1.4 STATUS Message

5.3.2.1.4.1 Description

It is necessary for each side of the call ie. the terminal and the network, to maintain corresponding states. Should something happen to disrupt this, a recovery mechanism must be in place. The STATUS message is used to tell either side the state of the other.

5.3.2.1.4.2 Requirement

The terminal must support the STATUS message and all its elements within the context of the procedures in section 5.0 of Q.931. The message format is covered in section 3.2.26 and the message elements are covered in section 4. For the STATUS message, all message elements are mandatory. The CALL STATE element should take on the value of the current state of the terminal.

5.3.2.1.4.3 Status

Changes have been proposed for 1988. This includes a new STATUS ENQuiry message and procedural changes.

5.3.2.1.5 Signalling Procedures

5.3.2.1.5.1 Description

The procedures for circuit switched call control are required for all circuit switched terminals. The procedures cover the call setup and takedown at both the origination and destination ends of the call. Note that the procedures for call setup at the destination are designed to handle the multipoint passive bus to select the proper terminal.

5.3.2.1.5.2 Requirement

For ISDN terminals the signalling procedures of section 5.1 of Q.931 must be supported. All references to stimulus mode of operation, stimulus signalling, etc. can be ignored given that the 1988 version will not support stimulus mode for basic all procedures. Since a number of subsections of 5.1 deal with the primary rate interface which is not covered in this document, the required subsections are noted below:

Section 5.1	all
Section 5.1.1	all
Section 5.1.2	all except 5.1.2.2 (ii) and 5.1.2.3 (b) both dealing with the primary rate interface.
Section 5.1.3	all except 5.1.3.1 (c), 5.1.3.2 (b) and (c) dealing with the DETACH procedures which are changed for 1988.
Section 5.1.4	all
Section 5.1.5	all

5.3.2.1.5.3 Status

All references to stimulus mode of operation, stimulus signalling, etc. can be ignored given that the current 1988 draft test does not have a section on stimulus basic call procedures. Some changes have been proposed for the 1988 Recommendation. Additional procedures for

Interworking, additional uses for the INFOrmation Message and a new 'PROGRESS' message are also proposed for 1988.

5.3.2.1.6 Signalling Messages

5.3.2.1.6.1 Description

The required messages for circuit switched call control over and above those already identified as mandatory in section 4 of this report are listed below. Any special restriction on their use is noted with the message otherwise, no restrictions for ISDN terminals on a basic access arrangements are assumed.

5.3.2.1.6.2 Requirement

The following messages are required:

INFOrmation — used to enter call information missing from the SETUP message. The best example is completion of the destination address.

STATUS — already covered earlier in this report.

SUSPEND

SUSPEND ACKnowlege

SUSPEND REJect

Descriptions of each message format can be found in Section 3 of Q.931. The procedures for their use are covered in Section 5.1 of Q.931.

5.3.2.1.6.3 Status

No significant change in 1988 with the exception of new PROGRESS message proposal.

5.3.2.1.7 Message Elements

5.3.2.1.7.1 Description

This covers the entries of the required message elements for the set of messages required for circuit switched calls in an ISDN. From the set of messages needed up to this point, the message elements required are listed below. For each element, the value or values to cover general circuit switching are noted. Those values specific to one service type are covered in the section dealing with that service.

5.3.2.1.7.2 Requirement

The following message elements and encoded values are required:

Bearer Capability -- This defines the service characteristics requested of the network and is described in Section 4.5.5 of Q.931. The values required for general circuit switching are listed in Table 5.1.

TABLE 5.1. Encoded Values/Message Elements-General Circuit Switching

OCTET #	NAME	VALUE
1	Info element Identifier	see text
2	length of Bearer Service Id.	as required
3	coding standard	CCITT
3	info transfer capability	as per service
4	transfer mode	circuit-mode
4	info transfer rate	64 kbit/s
4a,4b	all	can be omitted
5	bearer capability multiplier/ protocol identifier	as per service
5	multiplier/layer identifier	as per service

These values allow for a terminal to operate in circuit switched, demand, point to point, bidirectional symmetric, 8kHz. integrity 64 kbit/s mode. This is consistent with the initial capabilities of any ISDN based on the existing networks currently planning to evolve into ISDN.

Channel Identification -- This specification supports terminals that are connected to an ISDN Basic Access which supports up to 2 B Channels for circuit switching purposes. Thus the Channel ID element for this terminal is relatively simple. The element is described in Section 4.5.10 of Q.931. Only the first three octets are required. Octet three is encoded as follows:

extension bit	1
interface identifier	0
interface type	0
preferred/exclusive	as required
D Channel indicator	0
information channel	as required

Setting the preferrer/exclusive bit depends on the nature of the service request by the user. Normally, the bit should be set to indicate preference not exclusively.

Destination Address -- This element is described in Section 4.5.13 of Q.931. The possible entries are described in Section 4.5.12. The entries in this element are dependent on the network connected to and the network to which the destination is connected. The most general cases for the Public carriers are:

Type of address:	national or international number
Numbering/Addressing:	ISDN or Data Network

Cause -- This element is described in Section 4.5.8 of Q.931. The terminal must be able to interpret and received cause value and to originate certain values depending upon the situation occurring. In the latter case, the location code would be "user". In all cases, coding standard should be "CCITT"; octet 3a should be omitted or if present indicate "Q.931".

Transit Network Selection -- This element is outlined in Section 4.5.26. It may be required in terminals operating within the United States of America due to their exchange/interexchange network regulations. This element is better defined for 1988.

Display -- This element is described in Section 4.5.14. If received in a message and if the terminal has a display capability, it should be presented to the user. Call Identity -- This element is described in Section 4.5.6. It is used to identify a separated call.

Call Identity -- This element is described in Section 4.5.6 of Q.931. It is used to identify a suspended call.

5.3.2.1.7.3 Status

No changes to these elements are proposed, however some new elements have been proposed in the 1988 version.

5.3.2.2 Specific Functions

Having now covered the common functions of circuit switching services, the next step is to look at the additional functions necessary for each circuit switched service type in ISDN. The principal functions here are built around the coding of the Bearer Capability element and the possible need for an ALERTing message.

5.3.2.2.1 Speech

5.3.2.2.1.1 Description

Speech is defined as a service designed for voice services exclusively. The network may impose speech processing devices, such as low bit rate transcoders or digital speech interpolation, for this type of call. Thus, voiceband data in the form of continuous signal transfer from modems may not be supported by this service type.

5.3.2.2.1.2 Requirement

The following messages and message elements are required for the speech service:

Bearer Capability - In this element, it is necessary to indicate the service type and the layer one speech encoding supported by the terminal. Additional requirements for terminals supporting this service are listed in Table 5.2.

TABLE 5.2. Added Requirements for Terminals Supporting Speech Service

OCTET #	NAME	VALUE
3	info transfer capability	speech
5	extension	1
5	bits 7,6	layer 1
5	bits 5..1	mu-law
5	bits 5..1	A-law

Mu law encoding is used in networks in North America and Japan. A-law encoding is used in most other areas of the world. Digital ISDN audio terminals connecting to a specific network must be encoded in the intrinsic coding of that network for correct operation.

ALERTing Message -- For an ISDN speech terminal, the ALERTing message described in section 3.2.1 of Q.931 and the procedures outlined in sections 5.1.1.3 and 5.1.2.3 must be supported. Note that the ALERTing message is not required for every type of circuit switched service.

5.3.2.2.1.3 Status

No major changes in 1988.

5.3.2.2.2 3.1 kHz. Audio

5.3.2.2.2.1 Description

3.1 kHz. Audio allow for continuous two way transmission with the bandwidth equivalent to that offered by the current telephony network. As such, this service is appropriate for voiceband data and music programming needs.

5.3.2.2.2.2 Requirement

The following messages and message elements are required for the 3.1 kHz. audio service:

Bearer Capability -- In this element, it is necessary to indicate the service type and the layer one speech encoding supported by the terminal. Additional requirements for terminals supporting this service are listed in Table 5.3.

TABLE 5.3. Added Requirements for Terminals Supporting 3.1 kHz Audio Service

OCTET #	NAME	VALUE
3	info transfer capability	audio
5	extension	1
5	bits 7,6	layer 1
5	bits 5..1	mu-law
5	bits 5..1	A-law

Mu law encoding is used in networks in North America and Japan. A-law encoding is used in most other areas of the world. Digital ISDN audio terminals connecting to a specific network

must be encoded in the intrinsic coding of that network for correct operation.

5.3.2.2.2.3 Status

No major changes in 1988.

5.3.2.2.3 Unrestricted Digital Information

5.3.2.2.3.1 Description

UDI supports end to end digital data at the 64 kbit/s rate. It allows for existing rates lower than 64 kbit/s to be adapted to the 64 kbit/s rate. All rates supported are in synchronous mode. Asynchronous operation will be covered no earlier than in the 1988 Recommendations. A further point is the need for end to end compatibility versus the need for the network to know the bearer service requested.

Rate Adaption -- The transmission rate of UDI is at present, 64 kbit/s. The majority of terminals operate at different rates lower than 64 kbit/s. To accomodate this situation, a number of rate adaption Recommendations can be employed. I.460 covers the cases of 8, 16, and 32 kbit/s to 64 kbit/s. I.461 (X.30) covers the rates and encoding for X.21 terminals includng .6, 1.2, 2.4, 4.8, 9.6 and 48 kbit/s. I.463 covers the rates and encoding for V series terminals including 3.6, 7.2, 14.4, 19.2 and 56 kbit/s. Note that there is a two stage adaption process in all cases. First, the adaption is to the next higher 1.460 rate; then the I.460 rate is adapted to the 64 kbit/s rate. For example, 9.6 kbit/s is rate adapted to 16 kbit/s first; then the 16 kbit/s rate is adapted to the 64 kbit/s rate.

Compatibility Checking -- The current procedues for the initiation and reception of the SETUP message indicate that the Bearer Capability element carries the compatibility information for the destination terminal. This is true if the terminal operates at 64 kbit/s. However, if the terminal operates at a lower rate, additional information is requires to satisfy the multipoint terminal selection of 5.1.2.1. This can be carried in either the Bearer Capability (BC) element as an additional octet or within a second element, Low Layer Compatibility (LLC).

The rationale for this is one of domain between network and user. For some networks, the rate adaption is considered part of the network service and may not be transparent to the network. In other networks, the role of the network is strictly to carry the clear channel 64 kbit/s information. Whatever the terminal uses it for and the necessary extra signalling is not relevant to the network and can be passed transparently end to end. In the first case, an extension to the BC is required. In the second case, the LLC element carries the terminal to terminal information transparently.

The first case is predominately European where little competition is allowed by the state owned Administrations. The second case is likely to occur in the U.S.A. under its regulatory situation.

5.3.2.2.3.2 Requirement

The following messages and message elements are required for the UDI service:

In all cases, octet 3 (Information Transfer Capability) is set to "unrestricted digital information".

For the first case above, octet 5 of the BC is set to:

Bit 8	1
Bits 7,6	0,1 (layer one protocol)

Bits 5..1 rate adaption employed (as per Section 4.5.5 Q.931)

For the second case, octet 5 of the BC is omitted and a LLC is generated ie copied from the BC and octet 5 as required for the first case is included but in the LLC.

The terminal must be able to originate calls using either method based on the network connected. It must also be able to terminate an incoming call in both modes.

ALERTing Message -- This message is considered optional in the UDI service. It is in theory required only for manual terminals however, the network signalling systems may choose to generate an artificial alerting type message as part of the network signalling procedures. The UDI terminal must therefore be able to at least properly handle a received ALERTing message.

5.3.2.2.3.3 Status

No basic change in 1988 has been proposed, however, the procedures using the LLC and BC are a candidate for change in 1988.

5.3.2.2.4 Restricted Digital Information (RDI)

5.3.2.2.4.1 Description

Because of a number of technical considerations, the current digital transmission systems of North America cannot guarantee more than 7 bits of information out of each 8 bit DS0 channel. This effectively limits the capability of these systems to 56 kbit/s rather than the clear channel capability of 64 kbit/s with all 8 bits. This has given rise to the RDI for ISDN. It is intended as an interim step until clear 64 kbit/s is prevalent.

5.3.2.2.4.2 Requirement

Except for the limit on maximum rate transported, there is very little difference between RDI and UDI both in procedures and messages. The differences are noted below:

1. Bearer Capability - Set octet 3 bits 5..1 to " restricted digital information".
2. BC/LLC Octet 5 -- Set to appropriate value. RDI cannot support the 48 kbit/s adaption rate used in X.21.

5.3.2.2.4.3 Status

No change for 1988.

5.3.3 Packet Switched Services

5.3.3.1 General Description

The underlying principles adopted for packet switched services in 1984 are based on interworking between an X.25 DTE terminal using a terminal adaptor to control the ISDN portion of the calls and a DTE terminal on the packet switched public data network (PSPDN). This does not necessarily constitute a true ISDN packet service however this service is viewed as the first step towards an ISDN packet mode bearer service. The approach used in the following section outlines the differences between the packet and circuit use of the ISDN interface. Recommendation X.31 (I.462) is the principle vehicle for packet switched services. Although Section 5.3 of Q.931 also has packet operations, X.31 should prevail in any design decision. This allows for a terminal manufacturer to build a single TE1 capable of providing packet bearer services in an ISDN.

In all cases noted below, a two stage process is involved in the packet call. The first stage involves satisfying the ISDN signalling requirement to establish the call path. The second is the application of X.25 virtual call procedures to complete the connection and transmit call information.

Two specific services are available to packet-mode terminals connected to the ISDN:

a. B-channel packet services using circuit mode operation; and

b. B/D-channel packet services using packet mode operation.

In service (a) an ISDN transparent circuit mode connection, either permanent (i.e non-switched) or demand (i.e., switched), is used to gain access to the PSPDN.

In service (b) an ISDN virtual circuit bearer service is used, as described in Recommendation I.211, section 3.2.1. The services available is described in I-series Recommendations.

The configurations given in Figures 1,2,3/I.462(X.31) are the basis on which the support of X.25 DTEs and TE1s by the ISDN are standardized.

Figure 1/I.462, refers to service (a), and describes a transparent handling of packet calls through an ISDN. Only access via the B-channel is possible. In this context, the only support that an ISDN gives to packet calls is a physical 64 kbit/s circuit-mode permanent or demand transparent network connection type between the appropriate PSPDN port and the X.25 TE1 at the customer premises.

Figure 2/I.462 refers to service (b), the case where a packet handling (PH) function is provided within the ISDN. This relates to the case of X.25 link and packet layer procedures conveyed through the B-channel. In this case, the packet call is routed, within an ISDN, a PH function where the complete processing of the X.25 call can be carried out.

Figure 3/I.462 refers to service (b) the case of X.25 packet layer procedures conveyed through the D-channel. In this case, a number of DTEs can operate simultaneously through a D-channel by using connection identifier discrimination at layer 2. The accessed port PH is still able to support X.25 packet layer procedures.

It is important to note that the procedures for accessing a PSDTS (packet switched data transmission service) through an ISDN user-network interface over a B or D-channel are independent of where the service provider chooses to locate packet handling functions. However, the procedures for packet access through the B-channel or the D-channel are different.

5.3.3.2 General Status

During the 1984-1988 study period, major changes have been made to Section message sequence for call establishment. Where possible, references to the Red Book are included however, because of the changes proposed for 1988 this is not possible in all cases.

5.3.3.3 Channel Packet Service (Circuit Mode Operation)

5.3.3.3.1 Description

The basic principles of this service type is twofold. ISDN circuit switched procedures are used to set up the B channel call between the packet handler PH and the ISDN terminal. Once the ISDN portion of the call is established, the terminal applies X.25 virtual call procedures to complete the call. There are some differences between this packet service and other circuit switched services.

Call organization is the same as the other circuit switched calls. However, it should be noted that once the circuit path has been established, X.25 procedures can set up more than one virtual call on the circuit.

Call control at the destination end must now account for terminals that are:

- free of calls
- active with existing virtual calls yet not busy
- busy (all virtual calls used up)

Call clearing is also changed in that the ISDN portion of the call can only be cleared when the last active virtual call is cleared.

5.3.3.3.2 Requirement

The pertinent sections of X.31 (I.462) that must be supported by an ISDN Terminal operating a B channel packet switch service are listed in Table 5.4.

TABLE 5.4. ISDN Terminal Support Requirements/Circuit Mode

X.31/I.462 SECTION	TITLE	APPLICABLE SUBSECTIONS
1	Reference configuration	1.1
2	ISDN packet switched data transmission service characteristics	2.1.1 2.1.2 2.2.1 2.2.3
3	Packet communication addressing3.1 and routing aspects3.2.1	
4	Interworking with dedicated networks	4.1
5	Message consequences	5.1.1 5.1.2 5.1.3

Applicable figures in CCITT Recommendation X.31/I.462 are:

Figure 1
Figure 4a
Figure 4d
Figure 5a
Figure 5b
Figures 7a(i) and (ii)

5.3.3.3.3 Status

A number of substantial changes have been proposed for 1988. Although the basic principles still survive, some of the terminology is likely to change. This section should be updated to reflect the new 1988 Blue Book Recommendation. The Red Book Recommendation X.31/I.462 must be viewed as preliminary in nature and should be employed carefully in any terminal design given

the extensive change to it for 1988.

5.3.3.4 B/D Channel Packet Service (Packet Mode Operation)

5.3.3.4.1 Description

The basic principles for this service are described in Recommendation X.31/I.462 under the term "maximum integration scenario". Essentially it is a two step process at both ends of the call. For call organization, the terminal sets up an ISDN packet mode call either via D channel signalling procedures for B channels or D channel packet procedures for the D channel. Once established, X.25 procedures are used to complete the connection. Unlike the B Channel Circuit Mode Operation, the ISDN part of the call origination is transparent to the user in that the nature of the packet mode service causes the network to automatically route the nearest packet handler (PH).

Call control at the destination end is a complex procedure depending on the options taken. A call offering procedure has been developed for the Packet Mode operation which allows for the following options:

Channel Options	B exclusively D exclusively B or D possible
Signalling procedures at Layer Two	's' or 'p' SAPI

The call offering procedure uses the mandatory messages and elements of section 4 of this handbook to indicate to all packet mode terminals on the ISDN access arrangement the presence of a packet call. Each terminal responds as to its capabilities with respect to the services request. The network then selects the most appropriate terminal to award the call.

Call clearing procedures for the ISDN portion of the connection cannot provide until the last X.25 virtual call on a particular B or D channel is itself clear.

It should be noted here that there is a significant difference between the procedures for B channel packet mode calls which use the D channel strictly for signalling and those procedures for the D channel packet mode which must indicate signalling via D channel layer 2 'p' procedures and transmission via X.25 at layer 3.

5.3.3.4.2 Requirement

In order to provide a terminal for ISDN packet services in packet mode operation the sections of X.31/I.462 which apply are listed in Table 5.5.

TABLE 5.5. ISDN Terminal Support Requirements/Packet Mode

X.31/I.462 SECTION	TITLE	APPLICABLE SUBSECTIONS
1.	Reference configuration	1.2
2	ISDN Packet Switched Data Transmission Service Characteristics	2.1.2 2.1.3 2.2.2 2.2.3
3	Packet Communication Addressing and Routing Aspects	3.1 3.2.2
4	Interworking with dedicated networks	4.2
5	Message Consequences	5.1.1 5.1.2 5.2 5.3

Applicable figures in CCITT Recommendation X.31/I.462 are:

Figure 2
Figure 3
Figures 4a, 4b, 4c, 4d, 4e
Figures 5a, 5b
Figures 6a, 6b
Figures 7a, 7b (all)

Particular attention should be taken with Figures 6 and 7 which demonstrate the incoming call procedures on the multipoint terminal bus for terminal selection in packet mode.

5.3.3.4.3 Status

As with the circuit mode operation, a number of changes have been proposed for 1988 although the basic principles of operation are unchanged. One significant change is the proposed deletion of the 'p' type call offering procedure. As with the circuit mode operation. The Red Book Recommendation X.31/I.462 must be viewed as preliminary in nature and should be employed carefully in any terminal design given the extensive change to it for 1988.

5.4 Teleservices

5.4.1 Description

The Recommendation I.212 on Teleservices defines a set of attributes to be used for the description of the individual service and for defining the network capabilities required. According to the definition of teleservices the attributes are grouped into three categories:

I. Lower Layer attributes

- information transfer attributes;

- access attributes.

II. High Layer attributes.

III. General attributes.

The low layer attributes are similar to those given for Bearer Services.

The high layer atributes define primarily the protocols of layers 4-7 of the OSI reference model, to be used for the individual type of service.

The general attributes, cover - as in the case of Bearer Services - the supplementary services available, the quality of service parameters, service interworking possibilities and operational and commercial aspects.

5.4.2 Requirement

Teleservices in contrary to Bearer Services are internationally standardized in all seven layers of the OSI Reference Model, i.e. the terminal characteristics and the end-to-end protocols (which are usually not processed by the network) are fully defined. Teleservices guarentee full compatibility for the user and hence provide for open communication.

As the higher layers usually only exist within the terminals, Teleservices can only be offered with the terminals which conform to these specifications.

The inclusion of the terminal characteristics in the Teleservice definition does not imply, that the terminals will be provided by the network providers. Depending on the network provider's policy or national regulations, terminals may or may not be provided, this will be part of the commercial characteristics of the individual Teleservice and may differ from Teleservice to Teleservice and from country to country.

5.4.3 Status

In the existing recommendation no individual teleservice has been identified so far. However, in "1985-1988" study period, preliminary draft specifications of the following teleservices to be provided by the ISDN are prepared:

- Teletex
- Facsimile
- Telex

5.4.4 High Layer Compatibility Element (HLC)

5.4.4.1 Description

For all TE1's that need to indicate to the network provision of a teleservice, a specific message element: High Layer Compatibility, has been included in Q.931. This message element is included in any originating SETUP message to indicate the particular set of layer 4 to 7 protocols to be employed in the call. At the destination end of the call, the HLC is used in conjuction with the Bearer Capability and/or Low Layer Compatibility to select only those terminal(s) that are compatible to the specific teleservice.

5.4.4.2 Requirement

The HLC is described in Section 4.5.15 in Q.931 and must be used to indicate and to accept a teleservice call.

5.4.4.3 Status

No change from 1984; additional teleservices are proposed for 1988 - including:

Telephony
Videotex
Message Handling Systems (X.400)
OSI (X.200) Services

5.5 Supplementary Services

5.5.1 General Description

Supplementary Services shall upgrade the performance of basic Bearer Services and Teleservices. For the user's benefit they need to be standardized in order to make them usable in international communications. Especially the implications on signalling procedures at the user-to-network interface have to be considered. Considering the great importance of supplementary services and their provision in ISDN, CCITT has identified those supplementary services whose implementation should be given priority. Firstly, a description for supplementary services from the users point of view are provided. Secondly, a technical description mechanism which allows to develop the necessary signalling procedures at the user-network interface and within the network without predetermining a specific implementation in the network, are also provided.

The concept of so called "supplementary functional components" has been developed, which can be seen as building blocks for the realization of supplementary services. They may be implemented in the network nodes (switching centers), in special "service centers" or in the terminals for the support of supplementary services.

5.5.2 Status

The existing Red Book does not have any information on supplementary services. These will be expected in the 1988 Blue Book. The information mentioned in this section is obtained from the current draft specifications and must be viewed as speculative.

5.5.3 General Requirement

5.5.3.1 Signalling Procedures

Two approaches have been outlined for supplementary services.

5.5.3.2 Functional Approach

Inherent in the functional approach to signalling for supplementary services is the knowledge, on the part of both the terminal and the network, of which feature is being requested. To date, very little in the way of functional procedures has been defined for supplementary services. Many features may use service-specific messages; however, most features will likely be invoked by means of the FACILITY message. In particular, codepoints have been defined to indicate several commonly-known features, e.g. reverse charging.

5.5.3.3 Stimulus Approach

The CCITT's "stimulus" approach to signalling for supplementary services defines service-specific information elements for many services. Two generalized information elements, Feature Activation and Feature Indication, are proposed. All of these elements would be conveyed to the network in INFOrmation messages. For the establishment of services such stimulus operations at the man-machine interface will normally be conveyed in the keypad or Feature Activation information element within, for example, the information message. The meaning of the keypad or Feature Activation information may be customer specific. Similarly, signalling messages sent by the network to terminals using stimulus procedures may contain explicit instructions regarding the operations to be performed by the terminal (e.g. Feature Indication, start alerting, etc.).

Terminals using stimulus supplementary procedures are not expected to maintain a record of the states of that service since they have a master-slave relationship with the network.

5.5.3.4 Status

Both functional and stimulus approaches are currently under investigation at this time. Functional signalling for supplementary services is viewed as a long term requirement once each service has been well defined and unlikely to change. The stimulus approaches are viewed more short term when services are undergoing changes and need experimentation. The use of stimulus procedures for the longer term is not precluded.

What follows in this section is a general description of each CCITT supplementary service, the general requirements and the status with respect to the 1988 Blue Book Recommendations. This section will require updating based on the 1988 results.

5.5.4 Service Description & Requirement

5.5.4.1 User-to-User Signalling

5.5.4.1.1 Description

User-to-User Signalling (UUS) allows the user to send/receive a limited amount of user generated information to/from another user-network interface. This information is passed transparently (i.e. without modification of contents) through the network. Normally, the network will not interpret or act upon this information. A user can transfer up to 128 octets of user generated information per signalling message.

The user can transfer User to User Information (UUI) in different phases of the call depending on the service(s) to which the user subscribes. These are:

Service 1: The transfer of UUI during the setup and clearing phases of a call, with UUI embedded within call control messages.

Service 2: The transfer of UUI during the setup phase of a call, transferred independently of call control messages.

Service 3: During the active phase of a call, transferred independently of call control messages.

5.5.4.1.2 Requirement

Activation/Deactivation -- Services 1, 2, 3 may be subscribed to by the calling, called user at the network's option. Whether these three services are offered to the user as separate supplementary

services or in any particular combination is an option of the network. User-to-User signalling may be requested by the calling user at the beginning of the call for services 1, 2, or 3.

Invocation method -- A user wishing to send UUI will be informed by the network as part of call establishment if there is not sufficient signalling connectivity to allow the transfer of UUI. Confirmation of delivery is not provided by the network.

5.5.4.1.3 Status

It is important to note that these procedures are applicable to User-to-User Information (UUI) transfer in association with a circuit-switched telecommunication service only. Procedures to permit UUI transfer in association with other types of calls (e.g. Packet bearer services) are under investigation.

5.5.4.2 Call Forwarding Unconditional

5.5.4.2.1 Description

This service permits an ISDN user to request that all calls be forwarded unconditionally. The ISDN user's originating service is unaffected. If this service is activated, calls are forwarded no matter what the condition of the termination. Other Call Forwarding services provide for call forwarding based on condition (e.g. Call Forwarding No Reply (CFNR), Call Forwarding Busy (CFB)).

This service (including options) may be subscribed to for each basic service to which of the ISDN user's subscription number, or collectively for all the basic service to which the user subscribes. Since subscription is on an ISDN number basis, the same Call Forwarding subscription will apply to all terminals using this number.

5.5.4.2.2 Requirement

Activation/Deactivation -- To activate CFU, the ISDN user must supply:

1. the Forwarded-to Number
2. information as to whether all calls or all calls of a specified basic service should be forwarded.
3. the ISDN number for which CFU should apply.

For multiple access installations it could be possible for the user to specify, on activation, if the service is applicable to specific access or all access associated with that installation.

Invocation method -- The forward-to user will receive an indication that the call has been forwarded with the appropriate forwarding condition. The forward-to user may receive identification of the invocating user's number.

5.5.4.2.3 Status

Under investigation at this time.

5.5.4.3 Call Forwarding No Reply (CFNR)

5.5.4.3.1 Description

This service permits an ISDN user to request that all calls to his number be forwarded upon condition of No Reply.

5.5.4.3.2 Requirement

Invocation method -- If the forwarded call cannot be completed to the forwarded-to destination, then the network will clear the call. Specifically, if CFNR has been invoked and in-band ring back tone is applied at the forwarding exchange, then only the second call would be cleared and the calling party would continue to receive inband ringing tone.

Inband Tones & Announcements -- If Tones and Announcements are subscribed to along with CFNR, these will provide confirmation tones upon successful activation and deactivation of CFNR and reorder tone upon failure of an activation/deactivation request.

5.5.4.3.3 Status

The Activation and Deactivation procedures are still under investigation.

5.5.4.4 Call Forwarding Busy

5.5.4.4.1 Description

This service permits an ISDN user to request that all calls to his number be forwarded upon condition of Busy.

5.5.4.4.2 Requirement

Invocation method -- The forwarded-to user will receive an indication that the call has been forwarded with the cause indicating be the appropriate forwarding condition. The forward-to user may, from the last forwarding user, receive identification of the ISDN user's number. When multiple forwarding occurs, the reason for forwarding given to the forwarded -to user should relate to the last forwarding user in the chain.

5.5.4.4.3 Status

Activation and Deactivation procedures are still under investigation.

5.5.4.5 Call Deflection

5.5.4.5.1 Description

Call Deflection (CDF) permits an ISDN user to request that all calls to his number be redirected to another number. The ISDN user's originating services is unaffected.

5.5.4.5.2 Requirement

Activation/Deactivation -- The activation/deactivation procedure is slightly different from Call Forwarding service. Call Deflection is active upon completion of subscription via the service order process. Deactivation of CDF is also achieved via service order.

Invocation method -- The deflected-to user will receive an indication that the call has been deflected. If multiple deflections are allowed, the deflected-to user may receive the calling user's number, the original called user's number, and the last diverting user's number.

5.5.4.5.3 Status

Activation and Deactivation procedures are still under investigation.

5.5.4.6 Call Transfer

5.5.4.6.1 Description

The Call Transfer supplementary service enables a user to transfer an established incoming or outgoing calling or called party call to a third party. This service is different from the Call Forward supplementary service since, in this case the call to be transferred must have an established end-to-end connection prior to the transfer.

5.5.4.6.2 Requirement

Activation/Deactivation -- The user A can transfer an established call with user B to another call between user B and user C. Before activating the call transfer service, the user A or the network puts the already established call (to user B) on hold and user A proceeds with setup procedure for the second call to user C.

Invocation method -- The network would notify user B the address of user C and user C the address of user B, provided all users are ISDN users, and no call (or calls) require interworking with non-ISDN network(s).

5.5.4.6.3 Status

The service description at this stage is developed, now it is entering into the second or information flow, stage.

5.5.4.7 Conference Calling

5.5.4.7.1 Description

Conference Calling allows a user to communicate simultaneously with multiple parties, which may also communicate among themselves. It is assumed that, initially, calls established with this service request the speech bearer capability. It is expected that the procedures for this service would apply to other bearer capabilities.

5.5.4.7.2 Requirement

Activation/deactivation -- This function has not been identified at this stage.

Invocation method -- The service request must include the following information when a user requesting for this service:

- Conference size
- Call IDs/Party IDs/Disposition of related B Channel connections
- Controller B Channel Allocation
- Conference Type
- Conference Bridge Location

5.5.4.7.3 Status

Under investigation.

5.5.4.8 Three Party Service

5.5.4.8.1 Description

The Three Party Service enables a user who is active on a call to hold that call, make an additional call to a third party, switch from one call to the other as required (privacy being provided between the two calls), and/or release one call and return to the other. Optionally, the ISDN user could subscribe to an ability to join the two calls together into a three-way conversation.

5.5.4.8.2 Requirement

User A, who has an existing active call with User B, asks the service provider to begin the Three-Party Service. The service provider puts the existing call on hold. User A then proceeds to establish the second call (to User C). Similar action take place when the User A asks the service provider to the start the "normal" Call Transfer Service.

5.5.4.8.3 Status

Under investigation.

5.5.4.9 Credit Card Calling

5.5.4.9.1 Description

This service allows the automatic charging of communication. The use of a telecommunication card number, combined in some cases with a confidential code, permits a user to charge calls to an account which may either be associated with a particular ISDN number or be independent of any number.

5.5.4.9.2 Requirement

Three possibilities can be envisaged concerning the transfer of the telecommunication card number and confidential code to the network:

- Verbally -- via an operator;
- Manually -- the user enters the numbers into the terminal;
- Automatically -- using the card reader.

Each method provides a different activation/deactivation and invocation procedures.

5.5.4.9.3 Status

Under investigation.

5.5.4.10 Call Hold

5.5.4.10.1 Description

The Hold Service allows a user to interrupt communication on an existing call connection and then subsequently, if desired, re-establish communication. For instance, a B channel may or may not be reserved after the communication is interrupted to allow the origination or possible termination of other calls.

5.5.4.10.2 Requirement

Activation/Deactivation -- This must be specified at subscription time.

Invocation method -- The user indicates to the service provider that communication on the interface is to be interrupted. This call may be either in the active or call establishment phase. The communication on the connection is then interrupted. The services provider acknowledges this action, and the associated channel is now available to originate or accept a waiting call.

5.5.4.10.3 Status

Under investigation.

5.5.4.11 Closed User Group (CUG)

5.5.4.11.1 Description

The possibility for a group of user to intercommunicate only amongst themselves or, as required, one or more users may be provided with incoming/outgoing access to users outside the group.

A CUG is a list of subscribers which may belong to one or several public networks; each ISDN number of a CUG is identified by an ISDN number.

5.5.4.11.2 Requirement

Normal call set up procedures will apply to all CUG calls, in addition the network shall carry out internal checks to make sure that the particular call is allowed between the two parties concerned.

Origination -- At the time of call set up the user specifies a CUG Index to indicate that service to a particular CUG is required. This is achieved by the user including a CUG facility request and the relevant CUG Index is his call set up message sequence.

Termination -- An incoming call from another CUG member will be indicated to the called CUG user with a CUG facility indication and the appropriate CUG Index. An incoming call to a non-CUG user, assuming that the called CUG user has Incoming Access allowed, will contain no CUG related information in the call offering message.

5.5.4.11.3 Status

Under investigation.

5.5.4.12 Line Hunting

5.5.4.12.1 Description

Line hunting is the facility which enables incoming calls to a specific ISDN number (or numbers) to be distributed over a group of interfaces or terminals. Outgoing calls from a line hunting group member are unaffected by this service. If no compatible terminal on a selected line responds, no further line hunting action is provided; i.e. it is the responsibility of the user to provision terminals to lines for effective operation of the service.

5.5.4.12.2 Requirement

An incoming call to an ISDN number on which line hunting is in operation will be allocated to a specific available interface (terminal) in a predefined manner. If no interface is available, the line hunting service is unsuccessful and a busy indication is returned to the calling subscriber.

5.5.4.12.3 Status

Under investigation.

5.5.4.13 ISDN Networking Service (City Wide Centrex)

5.5.4.13.1 Description

This service allows a subscriber (e.g. a business having multiple offices) to manage the communications capabilities of his user access interfaces. Application of this service will allow a subscriber to define how calls are to be established between his various user access interfaces while using the resources of the public network.

Each subscriber can have a private numbering plan to establish his calls through the public network, (e.g. leading digits of the directory number could be common even though group members are connected to different exchanges). A call could be placed by inputting only the last few digits of the called party's number.

5.5.4.13.2 Requirement

Activation/Deactivation -- The nature of this service implies co-ordination between the subscriber and the network provider. Activation/Deactivation must be through subscription.

Invocation method -- The calling party places a call using the private numbering plan. The private numbering plan may allow calls to the public network using, for example, an escape prefix.

5.5.4.13.3 Status

Under investigation.

5.5.4.14 Direct Dialling In

5.5.4.14.1 Description

This service enables a user to call directly to another user on a PABX/Centrex, without attendant intervention, or to call a terminal on a passive bus selectively. This supplementary service is based on the use of the ISDN number and does not include subaddressing. This service is subscribed to by the receiving user.

5.5.4.14.2 Requirement

Call initiation and completion procedures are the same as the basic service, without attendant intervention.

5.5.4.14.3 Status

Under investigation.

5.5.4.15 Multiple Subscriber Number (Terminal Selection)

5.5.4.15.1 Description

Calls can be dialled from a line connected to a public network directly to terminals connected to the basic access. The essential difference between this supplementary service and Direct Dial Inward (DDI) concerns the length of the number sent to, and processed by, the user's installation. In the DDI situation the user (PABX) will be taken on a per installation basis to receive the particular number of digits necessary to identify the terminals of the user (PABX).

5.5.4.15.2 Requirement

The addressing of terminals on a basic access may be achieved by applying a set of directory numbers to the single basic access. In general, any set of numbers may be sent from the exchange to the subscribers equipment. However it is recognized that Administrative practices and certain equipment designs may lead to the adoption of restricted numbering sequences e.g. by relating the last digit(s) of a fixed length directory number to a particular terminal is a matter of national implementation but may, for example, be done by central intelligence or by distributed intelligence within the terminals.

"Sub-addressing" and/or "Service Indication" may be used as an alternative or in conjunction with the above in a pure ISDN communication, to identify a specific terminal in a multi-functional installation.

A call to a number in the terminal selection numbering set shall be routed to the appropriate terminal(s) at the basic access. A part or the complete ISDN number will be transferred without modification across the called user-network interface at the option of the service provider. All called terminals of a service which identify this transferred number equal to their own terminal identification will respond to the incoming call. If a call is made by sending incomplete address information the connection will be released by time supervision within the public exchange. The digit(s) significant for terminal selection is/are an integral part of the ISDN numbering scheme.

With the multiple subscriber number of this supplementary services however, the service provider will fix the length of the number to be transmitted to the user's installation. It may comprise 1 or 2 or 3 digits up to the full ISDN number. This number will be sent to the user network interface.

5.5.4.15.3 Status

Under investigation.

5.5.4.16 Call Waiting

5.5.4.16.1 Description

Call Waiting is a service which permits a subscriber to accept an incoming call on a specified information channel which is already in use. For instance, it enables a terminal equipment, which is already active in a communication, to notify its user of an incoming call. The user then has the choice of accepting, rejecting of ignoring the waiting call.

5.5.4.16.2 Requirement

Activation/Deactivation -- User B may activate and deactivate Call Waiting with an appropriate request. This function is optional to the network provider.

5.5.4.16.3 Status

Under investigation.

5.5.4.17 Call Completion to Busy Subscriber (CCBS)

5.5.4.17.1 Description

CCBS allows a calling user A encountering a busy destination B to be notified when the busy destination B becomes not busy and to have the service provider reintiate the call to the specified destination B if User A desires.

5.5.4.17.2 Requirement

Invocation method -- When a User A encounters a busy destination, User A can request the supplementary service. If User A is allowed to use this service and has encountered a busy indication, the network will get the identification of the Destination to be scanned/monitored from the information in the initial call request. This information is retained by the network for a defined period (Retention Timer) during which the User A may request CCBS on Party B. During this period, the service provider should acknowledge User's A request.

5.5.4.17.3 Status

The service description stage has been developed, it is entering into the information flow stage -- stage two.

5.5.4.18 Calling Line Identification Presentation

5.5.4.18.1 Description

Calling line identification (CLI) is a supplementary service offered to the called party which provides the calling party ISDN-number, possibly with additional address information to the called party.

5.5.4.18.2 Requirement

Activation/Deactivation -- This value is specified on subscription.

Invocation -- This service is invoked on each incoming call.

5.5.4.18.3 Status

Under investigation.

5.5.4.19 Calling Line Identification Restriction

5.5.4.19.1 Description

Calling Line Identification Restriction is a supplementary service offered to the calling party to restrict presentation of the calling party's ISDN-number, possible with additional address information to the called party.

5.5.4.19.2 Requirement

Similar requirement applying to calling line identification presentation.

5.5.4.19.3 Status

Under investigation.

5.5.4.20 Called Line Identification Presentation

5.5.4.20.1 Description

Called Line Identification Presentation (CDLIP) is a service offered to the calling party which provides the called party's ISDN-number to the calling party.

5.5.4.20.2 Requirement

Premature at this stage.

5.5.4.20.3 Status

Under investigation.

5.5.4.21 Summary

Most of the service descriptions are in a sufficiently complete and stable state. The main outstanding item on these services is the completion of the attribute values. All of the above supplementary services will be part of the 1988 Recommendation (Blue Book).

5.6 Service and Functional Mapping

Figure 5.1 illustrates the general functional relationship in ISDN TE1's operating on a basic access arrangement. The information presented can be used to direct the terminal manufuacturer to the functions required for a particular service.

Some important aspects of the Figure are:

— All Mandatory Functions are required

— Optional Functions are Network Dependent

— There is a choice of general service type: Circuit or Packet

— Within each general service type are a number of specific services

— Teleservices are only required if a specific teleservice is required. An ISDN terminal does not yet need to always define a teleservice.

— Supplementary Services are on an as required basis and are not necessarily specific to a single service type.

An example should assist in understanding the relations:
Suppose a manufacturer wishes to build an ISDN terminal with the following specifications:

- 56 kbit/s
- circuit switched data
- teletex service
- to work with a network supporting dynamic TEI assignment
- call waiting supplementary service.

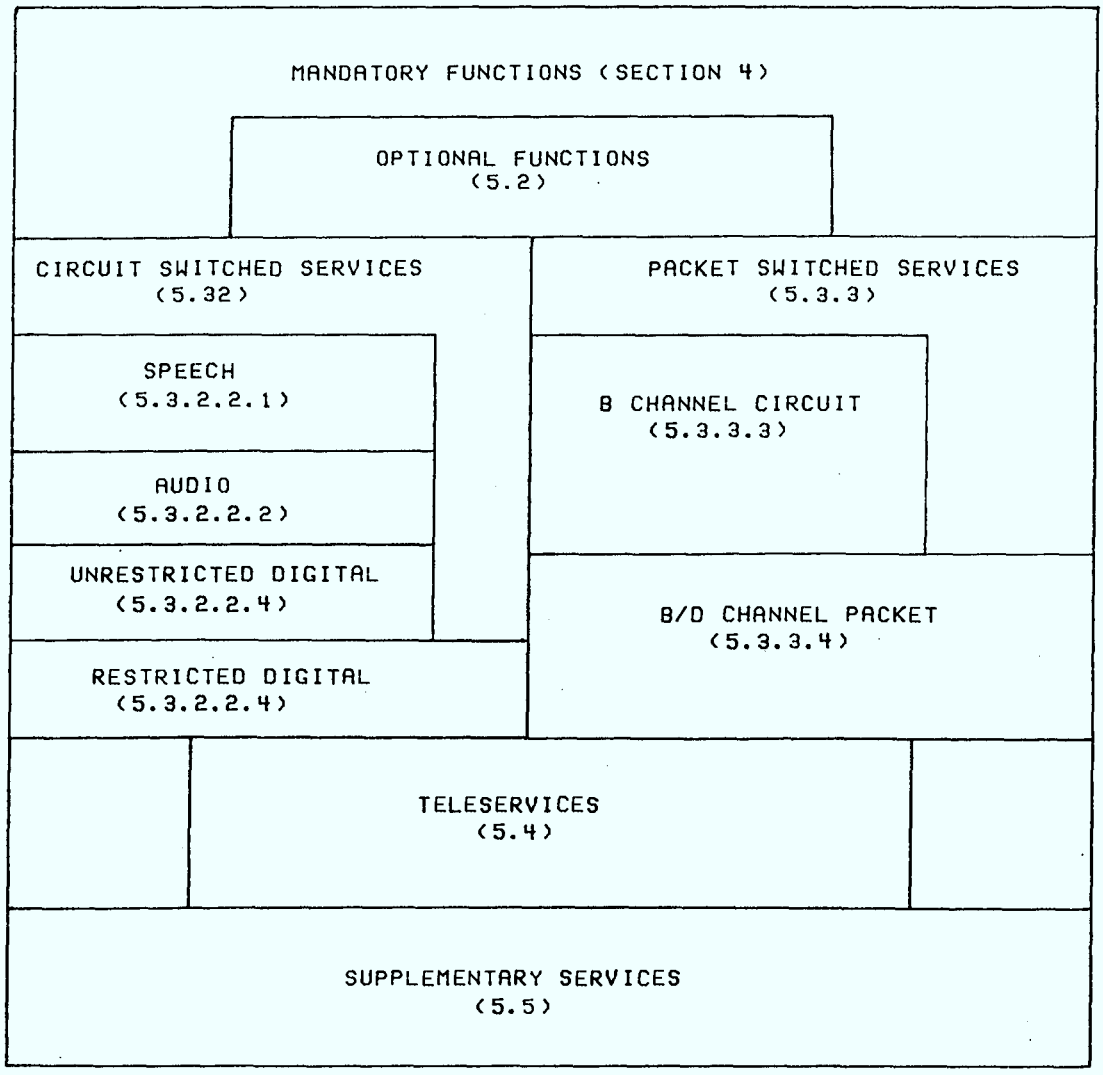
The required functional groupings are:

1) All Mandatory Functions
2) From the Optional Functions:

    - dynamic TEI
    - others (if required)

3) All Circuit Switched Services
4) Unrestricted or Restricted Digital
5) The Teletex Teleservice
6) The Call Waiting Supplementary Service

FIGURE 5.1. General Functional Relationship



6. ADAPTORS FOR USE WITH NON-ISDN TERMINALS (TA)

[Because of the extensive list of potential Terminal Adaptors, this chapter will only contain a limited introduction to the functional requirements.]

This section covers the requirements for the ISDN configuration consisting of an existing terminal (TE2), having an R reference interface, connected to an ISDN Terminal Adaptor (TA) which provides the necessary functionality to interface to the ISDN S/T reference point. The functional blocks are shown in Figure 6.1.

The TE2 is designated as existing or pre-ISDN terminal equipment with a variety of interfaces and services supported. The TE2 can be any of the following types:

1. Voice Terminals
    - analogue voice terminals employing:
        - analogue signalling: dial pulse or DTMF
        - analogue transmission/reception
        - analogue ringing for call alerting
        - switchhook on/off indication
    - feature voice terminal (same as analogue voice terminal plus)
        - feature indications (lights)
        - feature control (buttons)
        - character displays
2. Data Terminals
    - asynchronous data terminals employing:
        - EIA levels
        - RS232 interfaces and procedures
        - keyboard
        - bit rates to 19.2 kbit/s
    - synchronous data terminals
        - X.25 packet data types
        - X.21 circuit data types
        - other circuit data types (CSDC-AT&T, Datalink-NTL)
3. Future Types
    - telemetry types
        - alarms/meter reading/control systems
    - video

The TA provides the necessary functions to interface the existing terminal type (R interface) to the ISDN S/T reference point. Since there are a myriad of different R interfaces each with different interface and services characteristics, each TA will be customized to the supported R interface rather than developing a universal TA for all existing terminal types (TE2's).

A further consideration is the comparison with the ISDN terminal (TE1). The functions implemented within a particular TA will be governed by the capabilities available from the R interface supported. Thus, it may not be possible to support all the features of an equivalent TE1 terminal by the TE2+TA combination because of the distributed nature and the possible restrictions on the R interface for intercommunication. This situation will affect the requirements placed on the S/T interface to the network.

(Sections to be added in future editions)

7. NETWORK TERMINATION FOR MULTIPLE USERS (NT2)

[Because of the extensive list of potential Mult-User Terminals, this chapter will only contain a limited introduction to the functional requirements.]

This section outlines the requirements for the ISDN customer configuration whereby one or more TE1's are connected to the ISDN through S Interfaces to an NT2 capability and then via a T interface to the ISDN.

The main difference between this configuration and those of other sections of this handbook is that the T interface is usually at the Primary Rate rather than the Basic Rate. This simplifies somewhat the range of functions required for the T interface itself, however, within the NT2, significant intelligence for the support for PABX-like functions such as switching and supplementary features is prerequisite.

(Section to be added in future editions)

8. REFERENCES/BIBLIOGRAPHY

8.1 References

8.1.1 CCITT Recommendations

1. I series, ISDN, Red Book Vol.III -Fascicle III.5 (Note: the revised version of I.430 has received provisional approval and will be available in Grey Book format in 1988).
2. E.100-E.323, International Telephone Service - Operation, Red Book Vol.II - Fascicle II.2.
3. Q.920-Q.931, Digital Access Signalling System, Red Book Vol.VI - Fascicle VI.9 (Note: the revised versions of Q.920 and Q.921 have received provisional approval and will be available in Grey Book format in 1988).
4. X.20-X.32, Data Communication Networks: Interfaces, Red Book Vol.VIII - Fascicle VIII.3.
5. X.200-X.250, Data Communication Networks: Message Handling Systems, Red Book Vol.VIII - Fascicle VIII.5.
6. X.400-X.430, Data Communication Networks: Message Handling Systems, Red Book Vol.VIII - Fascicle VIII.7.

(NOTE: All Red Books will be revised and reissued as Blue Books which should be available in the spring of 1989.)

8.1.2 Sources for CCITT Documents

International Telecommunication Union,
General Secretariat Sales Service
Place Du Nations CH-1211
Geneva 20, Switzerland
Tel 41-22-99-51-11
Telex 421000 UIT CH

8.1.3 International Standards Organization

In North America copies of ISO standards can be obtained from:-

American National Standards Institute,
1430 Broadway,
New York, New York, 10018
Tel. (212) 354 3471

The address of the Central Sectretariat of the ISO is:-

1, rue de Varembe,
CH-1211,
Geneva 20, Switzerland.
tel. (41) 22 34 12 40

8.1.4 References in Open Literature

1. "Future Trends, Aaron, IEEE Communications Magazine, March 1986.
2. "Computer Networks", A.S.Tanenbaum, Prentice-Hall Inc., ISBN 0-13-165183-8.
3. "Integrated Services Digital Networks", A.M.Rutkowski, Artech House, Washington, ISBN 0-89006-146-7.
4. "ISDN Tutorial", IEEE, '86.
5. "Support of Packet Mode Terminal Equipment By an ISDN", Recommendation X.31 [Revision October, 1986], T1D1.2/86-358.
6. "Physical Layer Specification, Basic User-Network Interface", September 18, 1986, T1D1.3/86-166.
7. "Integrated Services Digital Network (ISDN) Implementation in the Canadian Telecommunications System", Microtel Pacific Research Limited, B.A. Howley, Aug.'84.
8. "ISDN-Services A Review of CCITT Standardization to Date", Fernmeldetechnisches Zentralamt of the Deutsche Bundespost, Peter Kahl, Aug.
9. "ISDN-Services -Status and Preview on Services Standardization", Fernmeldetechnisches Zentralamt, Darmstadt, Dipl.-Ing. Joachim Claus, Mar
10. "Extending 1984 CCITT Recommendations to Support Advanced ISDN Services", AT&T Bell Laboratories, H.Aldermeshian, R.C.Chang, J.L.Neigh. G.S.Soloway, May '87.
11. "ISDN -- A Basis For Enhanced And New Services For The Next Decades", Siemans AG, Peter Lyhne and Dieter Gneiting, May '87.
12. "CCITT Recommendations -- Network Aspects of the ISDN", BNR-Canada, J.C.Luetchford, Aug.'85.
13. "Advances in Network Standards For ISDN", BNR-Ottawa-Canada, John C. Luetchford, Mar.'86.
14. "Layer 1 ISDN Recommendations", Societa Italiana per l'Isercizio Telefonico, Rome-Italy, Umberto de Julio and Giorgio Pellegrini, Aug.'85.
15. "Layers 2 and 3 ISDN Recommendations", Musashino Electrical Communication Laboratory, NTT, Japan, Sadahiko Kano, Aug.'85.
16. "ISDN User-Network Interfaces", Bell Communications Research, Warren S. Gifford, Aug.'85.
17. "User/Network Interfaces In ISDN", CNET/LAA/RSM, F.Lucas, Mar.'86.
18. "VLSI Design Considerations Regarding LAPD Handler", NEC Corporation, Y.Yoshida, K.Tuzuke,S.Iwasaki,H.Kurokawa,T.Ishizuka,H.Hisamatsu, Mar.'86.
19. "ISDN Access Protocols - Status & Applications", Bell-Northern Research, R.K.Williams, R.J.Gillman, 1985.

8.2 Bibliography

8.2.1 Conferences and Journal Publications

1. "ISDN Opportunities and Issues", IRD 6 Prowitt St., Norwalk, CT 06855, Tel 203-866-7800.
2. "The ISDN Rollercoaster", Communications Engineering International, June'86.
3. "ISDN - Nowhere to Hide", J.Lane, Communications, Jan'87.
4. "Communication Terminals", Fudemoto et al, Fujistu Science and Technology Journal, Autumn'86.
5. "ISDN - The Opportunity Begins", Herr and Pleyvak, IEEE Communications Magazine, Nov'86.
6. "Beyond the 49'th Parallel", TeleCon'86 Conference Proceedings, Canadian Business Telecommunications Alliance, Sept.'86.
7. "Integrated Services Digital Network Primary Rate Interface", Preliminary Technical Reference, AT&T, June'86.
8. "A Fuzzy Concept Takes Some Shape", J.Chatterley et al (BNR), Communication Aug.21'86.
9. "Request for Proposal for ISDN Terminals -- Technical Document", Bell Canada, Oct.'86.
10. "Integrated Data/Voice Terminal", Bellsouth Services, Revision 1.3, W.A.Avery-Corporate Communications, 1985.
11. "AT&T ISDN Terminals", Telephony, Feb.23'87.
12. "ICS for Telephony", Communications International, Feb.2'87.
13. IEEE Communications, Special Issue on Subscriber Loop Systems and Services. Vol.25,No.3, March'87:-
    "Network Evolution Strategies: Network and Equipment Providers Perspective", I.G. Ebert.
    "Services and Customers Equipment", J.M.Griffiths and S.Kano.
    "Terminals for the ISDN Era: from Speech to Image", F.Du Castel, G.Pays, G.Brillet.

8.2.2 Government Publications

1. "The telecommunications equipment demand of the Canadian telecommunications carriers 1981-1984", Department of Communications Industry and Economic Development Branch publication, Oct.'83.
2. "The World Telecommunications Market, Characteristics, Structures and Trends", G.Ara et al, University of Ottawa, Faculty of Administration, contract study for the Department of Communications, 1983.
3. "Telecommunications Products for World Markets", External Affairs Canada.
4. "Standard for Terminal Equipment, Systems, Network Protection Devices and Connection Arrangements", Department of Communications Engineering Programs Branch, Jan.'86.

5. Draft Supplement C to above "Requirements for Terminal Equipment Interfaces for Attachment to (Basic Rate) ISDN Facilities", Oct.'86.

6. Terminal Attachment Program - Terminal Equipment List, Certified Equipment. DOC, April'86.

ISDN TERMINAL STANDARDS REFERENCE MANUAL