IEEE Standards for Local and Metropolitan Area Networks: Integrated Services (IS) LAN Interface at the Medium Access Control (MAC) and Physical (PHY) Layers

Sponsor

Technical Committee on Computer Communications of the IEEE Computer Society

Approved September 22, 1994

IEEE Standards Board

Abstract: A unified access method that offers integrated services (IS) to the desktop for a variety of publicly and privately administered backbone networks (e.g., ANSI FDDI, IEEE 802.x, and ISDN) is defined. In addition, the interface at the MAC sublayer and the PHY Layer is specified.

Keywords: access unit (AU), data link layer, hybrid multiplexer (HMUX), integrated services digital network (ISDN), integrated services terminal equipment (ISTE), layer management entity, local area network (LAN), logical link control, managed object, management information base (MIB), medium access control (MAC) sublayer, metropolitan area network (MAN), physical (PHY) layer, physical medium dependent, physical signalling, private switching network, protocol data unit (PDU), service access point, time division multiplexer (TDM)

The Institute of Electrical and Electronics Engineers, Inc.
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ISBN 1-55937-456-X

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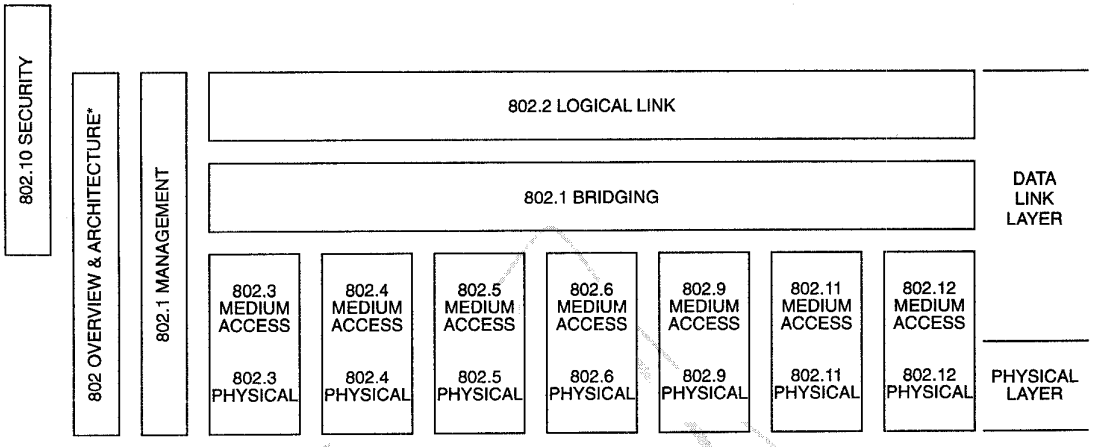
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Introduction

[This introduction is not a part of IEEE Std 802.9-1994, IEEE Standards for Local and Metropolitan Area Networks: Integrated Services (IS) LAN Interface at the Medium Access Control (MAC) and Physical (PHY) Layers.]

This standard is part of a family of standards for local and metropolitan area networks. The relationship of the members of the family to each other is shown below. (The numbers in the figure refer to IEEE standard numbers.)



This family of standards deals with the Physical and Data Link Layers as defined by the International Organization for Standardization (ISO) Open Systems Interconnection Basic Reference Model (ISO 7498 : 1984). The access standards define several types of medium access technologies and associated physical media, each appropriate for particular applications or system objectives. Other types are under investigation. The IEEE 802.9 ISLAN Interface Standard specifies both isochronous and packet mode services, and provides access to ISDN and other backbone networks for service provisioning.

The standards defining these technologies are as follows:

- IEEE Std 802[a]: Overview and Architecture. This standard provides an overview to the family of IEEE 802 Standards. This document forms part of the 802.1 scope of work.

- ISO/IEC DIS 15802-2 [IEEE Std 802.1B and 802.1k]: LAN/MAN Management. Defines an Open Systems Interconnection (OSI) management-compatible architecture, and services and protocol elements for use in a LAN/MAN environment for performing remote management.

- ISO/IEC 10038 [ANSI/IEEE Std 802.1D]: MAC Bridging. Specifies an architecture and protocol for the interconnection of IEEE 802 LANs below the MAC service boundary.

[a]The 802 Architecture and Overview Specification, originally known as IEEE Std 802.1A, has been renumbered as IEEE Std 802. This has been done to accommodate recognition of the base standard in a family of standards. References to IEEE Std 802.1A should be considered as references to IEEE Std 802.

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• ISO/IEC 15802-4 [ANSI/IEEE Std 802.1E]:	System Load Protocol. Specifies a set of services and protocol for those aspects of management concerned with the loading of systems on IEEE 802 LANs.
• ISO/IEC 8802-2 [ANSI/IEEE Std 802.2]:	Logical Link Control
• ISO/IEC 8802-3 [ANSI/IEEE Std 802.3]:	CSMA/CD Access Method and Physical Layer Specifications
• ISO/IEC 8802-4 [ANSI/IEEE Std 802.4]:	Token Bus Access Method and Physical Layer Specifications
• ISO/IEC 8802-5 [ANSI/IEEE Std 802.5]:	Token Ring Access Method and Physical Layer Specifications
• ISO/IEC 8802-6 [ANSI/IEEE Std 802.6]:	Distributed Queue Dual Bus Access Method and Physical Layer Specifications
• IEEE Std 802.9:	Integrated Services (IS) LAN Interface at the Medium Access Control (MAC) and Physical (PHY) Layers
• IEEE Std 802.10:	Interoperable LAN/MAN Security, *Currently approved:* Secure Data Exchange (SDE)

In addition to the family of standards, the following is a recommended practice for a common technology:

• IEEE Std 802.7:	IEEE Recommended Practice for Broadband Local Area Networks

The following additional working groups have authorized standards projects under development:

• IEEE 802.11:	Wireless LAN Medium Access Control (MAC) and Physical Layer Specifications
• IEEE 802.12:	Demand Priority Access Method/Physical Layer Specifications
• IEEE 802.14:	Standard Protocol for Cable-TV Based Broadband Communication Network

Conformance test methodology

An additional standards series, identified by the number 1802, has been established to identify the conformance test methodology documents for the 802 family of standards. Thus the conformance test documents for 802.3 are numbered 1802.3, the conformance test documents for 802.5 will be 1802.5, and so on. Similarly, ISO will use 18802 to number conformance test standards for 8802 standards.

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The ongoing work of the IEEE 802 committee has resulted in standards for data communications in a local area network (LAN) environment. As office workstations have proliferated, however, the demand for LANs has substantially increased. This has led to the inevitable diversification in market requirements.

Since the typical office worker requires access to both data and voice services, among others, at the desktop, there has been a growing trend toward integrated services (IS), namely voice, data, and video. Due to the increasing need for facsimile, image transfer, and video services, these services are included in the general category of the integration of voice and data services. Such integration offers potential economies to the business customer in terms of reduced components (one port per station instead of two or more), and in simpler management and maintenance (one network instead of two or more).

The provision of voice service is generally effected using unshielded twisted-pair wire. Not only is this medium widespread in typical office environments, but it is also inexpensive and easy to install and maintain. In the vast majority of installations, there is spare capacity, and in these cases, the use of such a medium is essentially free since the need for rewiring is significantly reduced. Moreover, with existing technology, it is possible to provide medium- to high-performance data service over the unshielded twisted-pair wire. This places special emphasis on the use of the unshielded twisted-pair wire to provide IS services. This standard extends the scope and capability of existing twisted-pair wiring and thus reduces the incentive for overlay wiring systems.

With respect to the provision of integrated services, there has been ongoing work in other standards bodies, notably, the International Telecommunication Union–Telecommunication Standardization Sector (ITU-T) on the provision of such services through integrated services digital networks (ISDNs). While the principal focus has been the provision of such services using public networks, efforts are under way [notably, in the European Computer Manufacturers Association (ECMA)] to extend such services to customer premises networks.

This standard defines a unified access method that offers global integrated services to the desktop for a variety of publicly and privately administered backbone networks (e.g., ANSI FDDI, IEEE 802.x[b], and ISDN). This standard will enable ISTEs to be attached to IEEE 802.9 LANs and will allow them to communicate with other IS stations as well as data-only stations, voice-only stations, and premises-based networks offering ISDN services. In addition, it specifies the use of unshielded telephone twisted pair as the primary medium of distribution.

The use of terminal adaptor (TA) devices will permit the direct coupling of native mode terminal devices such as data-only modules, voice modules, and ISDN basic rate terminals to the IEEE 802.9 interface. This standard has been designed to accommodate the adaptation of ISDN basic rate station devices and IEEE 802.x station devices to the IEEE 802.9 interface. In summary, this standard represents the integration of IEEE 802 services and ISDN services.

[b]IEEE 802.x refers to the entire family of IEEE 802 standards.

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IEEE Standards for Local and Metropolitan Area Networks: Integrated Services (IS) LAN Interface at the Medium Access Control (MAC) and Physical (PHY) Layers

1. Overview

1.1 Scope and purpose

The scope of this standard is to

- Develop an ISLAN interface at the medium access control (MAC) sublayer and the Physical (PHY) Layer compatible with IEEE 802.x[1] and ISDN standards and architectures
- Develop an ISLAN interface that operates independently from the backbone network
- Focus upon unshielded twisted-pair wiring as the primary distribution medium
- Enable implementation of IS terminal equipment (ISTE) that accesses IEEE 802 LAN and ISDN services through a common interface

The body of this standard

- Defines the service provided by the MAC sublayer to the IEEE 802 Logical Link Control (LLC) sublayer and management, and describes the services provided by the PHY Layer to the MAC sublayer and management in terms of service primitives and associated parameters
- Describes the services provided by the Physical Layer (PHY MUX) to support a basic rate interface (BRI) ISDN in terms of service primitives and associated parameters
- Describes the services provided by the PHY MUX to the isochronous channels
- Specifies the MAC functions that allow ISTEs access to one another and to LANs providing IEEE 802 services and/or ISDN services
- Specifies the frame format for the MAC frame
- Defines the MAC protocol
- Specifies the channel structure and frame format of the time division multiplexed (TDM) frame

[1]IEEE 802.x refers to the entire family of IEEE 802 standards.

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— Specifies the PHY Layer functions over unshielded telephone twisted-pair (UTTP) cable

— Specifies the characteristics of the UTTP attachment of the station to the access unit (AU) including the specification of the medium interface connector

— Specifies the definition of MAC and PHY managed objects (MOs)

— Describes recommended ISDN signalling and management methods to coordinate the multiple channels operated between ISTEs and the AU

The normative annexes provide

— The Protocol Implementation Conformance Statement (PICS) proforma

— The Managed Object Conformance Statement (MOCS)

— The Guidelines for the Definition of Managed Objects (GDMO) specifications

— Supplemental recommendations on the use of CCITT Q.93x signalling procedures

The informative annexes provide

— Reference models of common configurations as guidelines for implementation

— A sequence and description language (SDL) description of the information flow across protocol layers

— Description of an optional remote secure control (RSC) procedure to invoke secure communication device (SCD) operations

— Recommendations for a common, consistent synthesis of ISDN and IEEE 802 that conforms with the addressing of ISTE devices and services

— Description of a mechanism to support the transport of a broadband ISDN conformant "cell" bearer service

1.2 Notation

1.2.1 Service specification method and notation

This subclause describes the method of specification of the services required of the MAC sublayer by the LLC sublayer as well as of the PHY Layer by the MAC sublayer of the P channel, the Data Link Layer of the D channel, and the services provided on the B and C channels.

In general, the services of a layer (or sublayer) are the capabilities that it offers to a user in the next higher layer (or sublayer). In order to provide its services, a layer builds its functions on the services that it requires from the next lower layer. Figure 1-1 illustrates this notion of service hierarchy and shows the relationship of the two corresponding N Layer users.

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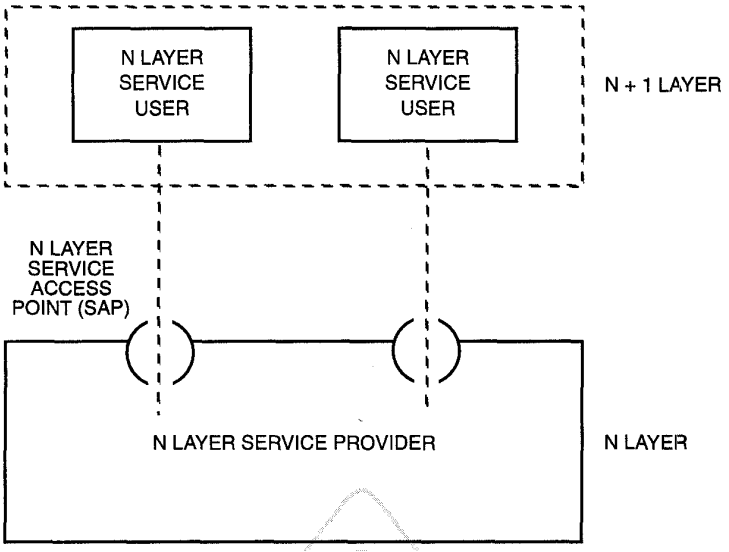


Figure 1-1—Layer service model

This information flow is modeled by discrete, instantaneous events that characterize the provision of a service. Each event consists of passing a service primitive from one layer to the other through an N Layer service access point (SAP) associated with an N+1 Layer service user. These SAPs are shown in figure 1-1. Service primitives convey the information required to provide a particular service. These service primitives are an abstraction in that they specify only the service provided rather than the means by which the service is provided. This definition of layer service is independent of any particular interface implementation, and is not subject to conformance testing requirements.

In order to comply with the service message flow signals described in the CCITT Recommendations on ISDN, it is necessary to consider all four primitive flow types.

a) *Request primitive.* This primitive is passed from the N+1 Layer service user to the N Layer (or sublayer) to request that a service be initiated.

b) *Indication primitive.* This primitive is passed from the N Layer (or sublayer) to the N+1 Layer service user to indicate an internal N Layer event that is significant to the N+1 Layer service user. This may be logically related to a remote service request, or may be caused by an event internal to the N Layer.

c) *Response primitive.* This primitive is passed from the N+1 Layer service user to the N Layer (or sublayer) to complete a procedure previously invoked by an indication primitive.

d) *Confirm primitive.* This primitive is passed from the N Layer (or sublayer) to the N+1 Layer service user to convey the results of one or more associated previous service requests.

Figure 1-2 shows the service primitives and N+1 Layer peer protocol entities associated with the two corresponding N+1 Layer service users. Services are specified by describing the service primitives and parameters that characterize each service. A service may have one or more related primitives that constitute the activity that is related to the particular service. Each service primitive may have zero or more parameters that convey the information required to provide the service.

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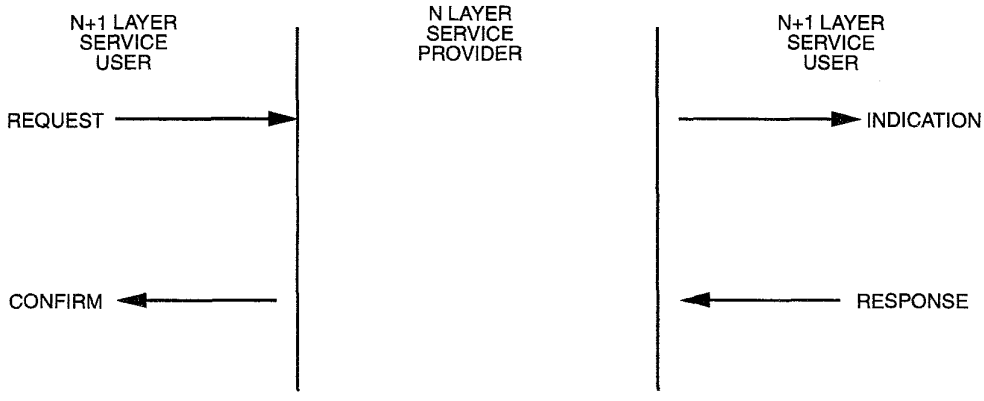


Figure 1-2—Service primitives

Figure 1-3 illustrates the end-to-end relationship of the service primitives and the N Layer peer protocol entities across a communication network.

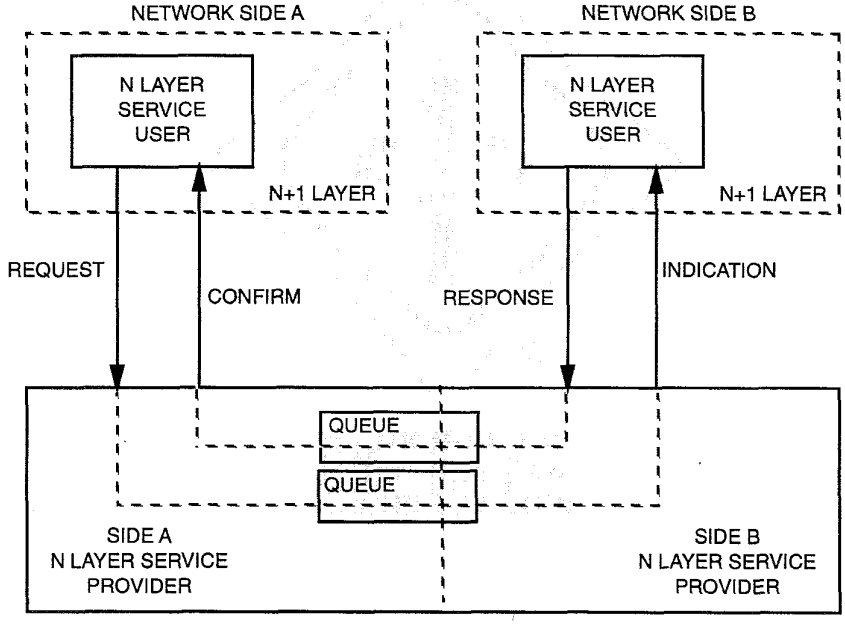


Figure 1-3—End-to-end relationship of service primitives

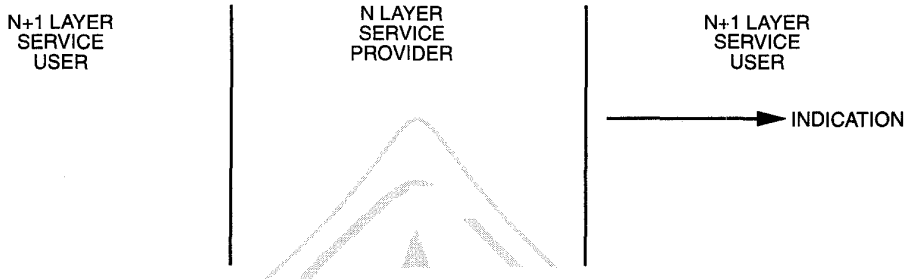
1.2.2 Timing relationship between service primitives

Figure 1-4 a) illustrates the flow from the service user to the service provider for a request. Figure 1-4 b) illustrates the notification to the service user of an event that has occurred in the service provider. Figure 1-4 c) illustrates the event wherein two separate service users are simultaneously making a service request at each end of the peer communication. Figure 1-4 d) illustrates the event wherein both ends of a communication link have the service provider sending up an indication of an event occurrence. Figure 1-4 e) illustrates the common situation wherein a "request" from a service user at one side of a network is sent in the form of a message action across the network to the peer side. The service provider at the other end of the network will report the incoming protocol packet as an "indication." Figure 1-4 f) depicts a communication flow in which all four types of primitives are used as part of a communication between two ends of the network.

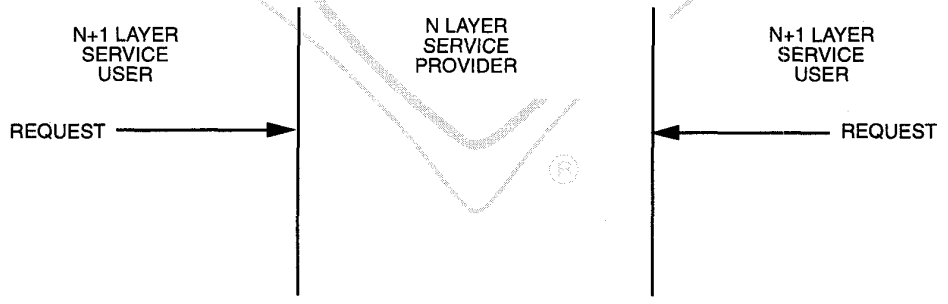
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a) Request from user to provider



b) Indication from provider to user



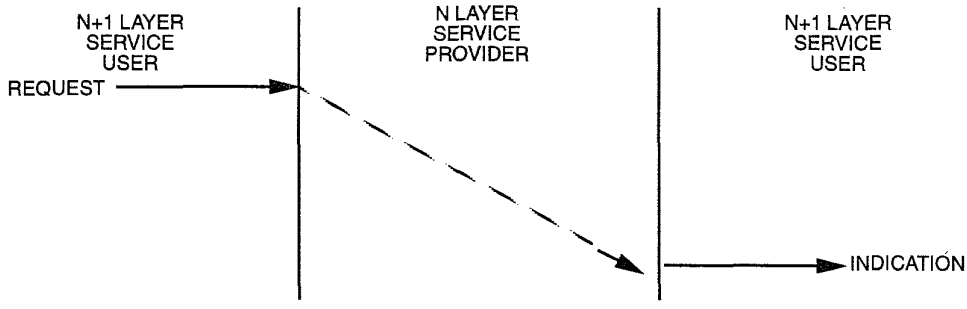
c) Independent simultaneous request at the two ends



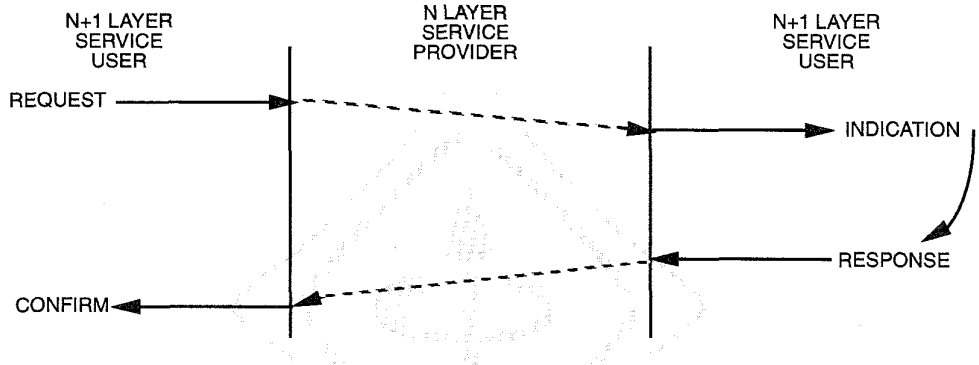
d) Independent simultaneous indications at the two ends

Figure 1-4—Timing relationship between service primitives

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e) Request leading to an indication at the peer entity



f) Cycle of interactions between peer entities

Figure 1-4—Timing relationship between service primitives

1.3 Service model

In the general N Layer service model, the N+1 Layer service user communicates with the N Layer service provider via individual request and indication primitives. In theory, this model requires that the transmit and receive processes in the N+1 Layer be synchronized to the N Layer in a serial fashion.

In the OSI model there is a presumption of sending and receiving application layer independence. This is inclusive of asynchronous service operation and hence there shall be at least one queue between communicating peer operations. However, it does not make any particular layer or layer boundary responsible for effecting the required queue.

Furthermore, the OSI model provides no means of describing the conveyance of timing information that is necessarily associated with the data request and indication primitives of an isochronous service.

It is now widely recognized that the description of ISDN "out-of-band" signalling services is best modeled by a coordination function that associates lower level control plane and user plane stacks.

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1.3.1 Isochronous services

The IEEE 802.9 ISLAN employs a TDM bearer mechanism within the PHY Layer. This permits the support and delivery of a plurality of transparent separate isochronous service channels, the provision of an octet alignment signal for these channels, and a facility to provide (optionally) and accept precise timing signals.

It is the provision of the timing signal that principally distinguishes the isochronous services from the asynchronous packet services that IEEE 802.9 provides. In 9.2, the PHY interface service specification includes in addition to received and transmitted data signals, a clock indication (and optionally clock request) as well as framing (TDM) indication and request signals. It is these additional signals that permit the IEEE 802.9 PHY Layer to support the conveyance of isochronous information.

In delivering an ISDN service, it is essential that the information rate at an ISTE exactly match that of the ISDN network to which the host IEEE 802.9 AU is attached. Thus, in the case of the AU it is a requirement that the TDM bearer clock rate recovered from the ISDN network can be input to the IEEE PHY for conveyance to a supported ISTE/TA. For this reason an IEEE 802.9 AU PHY transmit clock is an input signal while at the IEEE 802.9 ISTE/TA the signal is an output indicating the time at which sequential PHY data request signals will be serviced.

The details of the abstract PHY service specification can be found in 7.1.1.5.

1.3.2 Service queues between layers and layer management

The service channel provided by the IEEE 802.9 PHY Layer for support of the OSI Data Link Layer functions of the IEEE 802.9 is not distinct from any other PHY service channel; it too is isochronous. However, it is neither possible nor required that the MAC sublayer should provide an isochronous service to the IEEE 802 LLC sublayer. It is in the IEEE 802.9 MAC sublayer that the timing information conveyed by the PHY is discarded. In practice, it is conventional to implement within the MAC sublayer a first-in first-out (FIFO) queue both for the send and receive paths. This advantageously allows decoupling of the PHY, MAC, and LLC processes. It is not, however, a requirement.

However, the interface between station management processes and both the IEEE 802.9 PHY and MAC Layers must be asynchronous since the station management process is an Application Layer entity. It follows, therefore, that there must be a queue between the PHY Layer and its layer management and between the MAC Layer and its layer management.

To allow for the adjoining layers to operate more asynchronously, the N+1 Layer's transmit request may be stored in a transmit work queue wherein the N Layer may choose to serve this request at a later instant in time. Likewise, the N Layer may store its receive messages (in correct time order) in a receive queue. This enables the N+1 Layer to respond to the incoming message at a later instant in time.

Figure 1-5 illustrates this asynchronous linkage between layers. The queues are shown with dashed lines to depict the dynamic length of the given queue. It should be noted that at a given instant in time, the length of the queue may be zero and there may be no measurable delay in the passing of request/indication signals. The general model allows for queues between any two adjoining layers. Since the N Layer management entity may wish to send information to its peer layer management entity via the N Layer, figure 1-5 also shows queues between the N Layer and its associated layer management entity. The management of these queues is the responsibility of layer management. This management/control of the queues is shown with the dotted "control" signals.

The transmit and receive queues that are illustrated between the LME entity and the N Layer are for peer-to-peer LME exchange.

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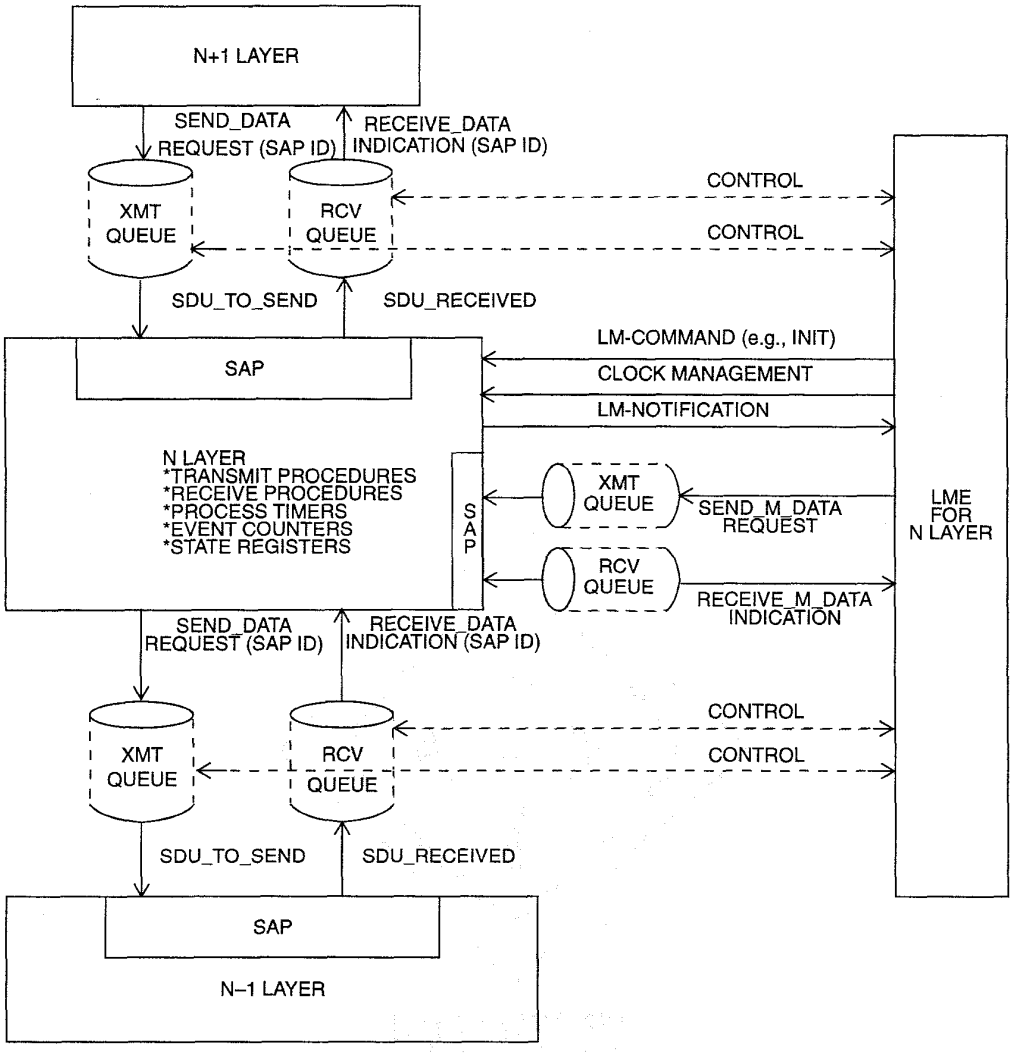


Figure 1-5—Service queues between adjacent layers

This definition of queues is independent of any particular interface implementation, and is not subject to conformance testing requirements.

1.3.3 Coordination function

The ISDN out-of-band signalling operations may be seen as being implemented by a "control" plane OSI stack that is associated with a user plane in which end-to-end user information may be conveyed. In the case of on-demand services (e.g., a dialed telephone service) a sequential process of call establishment, followed by an information interchange phase (in the user plane), and finally a call release phase, is required. To ensure that provision of the end-to-end user service is fully established and functional, a coordination function is required. In providing the dynamic bandwidth allocation functions provided in the IEEE 802.9 PHY Layer's HMUX sublayer, there is a need for additional higher (OSI) level coordination functions. The details of these functional requirements can be found in Chapter 8.

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1.3.4 State machine notation

The operation of a protocol can be described by subdividing the protocol into a number of interrelated functions. The operation of a function can be described by state machines. Each machine represents the domain of a function and consists of a group of connected, mutually exclusive states. The specification of the state machine determines the order of the transition. Only one state of a function is active at any given time.

Signals and flags refer to the form by which one functional block communicates with another. Both terms arise from the use of the state machines as a descriptive method in this standard. Signals are transient communications (in theory, they are of infinitesimal width) that occur during a change of state. Flags are steady, nontransient indications that remain constant until explicitly changed.

Each state that the function can assume is represented by a box or a circle. All permissible transitions between states of a function are represented by arrows from one state to the next state. The condition that causes a change from one state to another is shown next to the transition arrow.

1.3.5 General introduction of finite state machine (FSM) diagrams and tables

The procedures employed in the receive and transmit functions that operate to convey the request/grant protocol are specified in terms of a finite state machine (FSM). The principles of FSM are as follows:

a) A process is evaluated as one finite step during an instant in time.

b) Each "state" represents an information level consisting of:

   1) *Output operand directives (commands).* These output commands specify the work output from the FSM.

   2) *Input operand directives (test events/signals).* These input events are utilized by the FSM process to determine what state transition should be performed. These input events may be subdivided into external events (signals) and internal events (signals).

c) A description of a process may be expressed via a combination of states, control flags/state variables, input events (test conditions), and output actions.

d) This FSM definition technique is very implementation styled since it defines things in such fine detail.

e) The FSM documentation consists of two forms of graphic documentation:

   1) FSM state diagrams

   2) FSM state tables

1.3.5.1 FSM diagrams

The FSM diagrams are intended to illustrate a "minimum" set of processing states that comprise the functional operation of the process. Figure 1-6 illustrates the manner in which the FSM diagrams are used in this standard.

In figure 1-6, the FSM has two states: A and B. The occurrence of External Signal 1 equals "true" will cause a transition from State A to State B. Once the FSM is operational in State B, the occurrence of Internal Signal 2 equals "false" will cause the FSM to transition back to State A. Note that for the purpose of documentation, the value "0" will be equivalent to the condition "false" and the value "1" will be equivalent to the condition "true."

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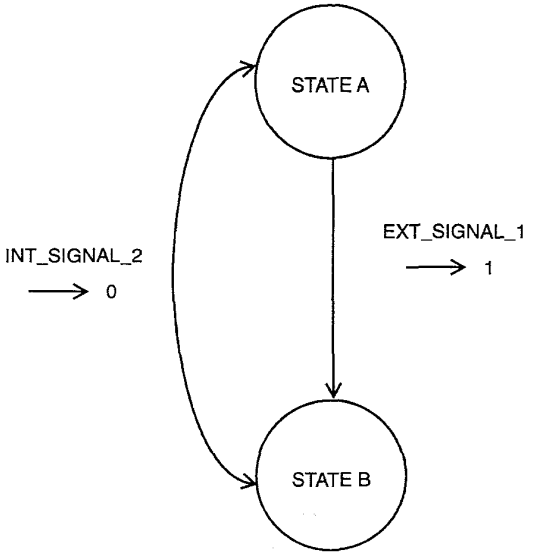


Figure 1-6—Example FSM diagram

As can be seen from this example, the FSM diagram technique overviews the essential operational states and identifies the key signal events that cause a transition from one state to another. In order to illustrate the precise details of input signal processing, output signal generation, and the treatment of error counters/timers/control variables, there is a companion description called state transition tables.

1.3.5.2 FSM state transition tables

FSM state transition tables are a companion description to the FSM state diagrams. These tables illustrate a finite set of actions that occur while the FSM is operational within a given state. Table 1-1 illustrates an example of a portion of a state transition table that would accompany the state diagram in figure 1-6.

Table 1-1—Example state transition table

Current state	Event	Action(s)	Next state
STATE_A	EXT_SIGNAL_1→1	SEND_MESSAGE_2 SET_FLAG_3:=1 START_TIMER_1	STATE_B
STATE_B	INT_SIGNAL_2→0	SEND_MESSAGE_4 SET_FLAG_3:=0 STOP_TIMER_1	STATE_A

In this example, a horizontal row represents a finite FSM processing step. While the FSM is in State A, it will regularly test or sample for the presence of external signal EXT_SIGNAL_1. When this EXT_SIGNAL_1 transitions to a "1," this will cause the FSM to vector to State B. In addition, the output actions will be to

— Send MESSAGE_2
— Set internal flag FLAG_3 to value "1"
— Start timer TIMER_1

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While the FSM is in State B, it will regularly test for the presence of internal signal INT_SIGNAL_2. When this signal transitions to a "0," this will cause the FSM to vector back to State A. In addition, the output actions will be to

— Send MESSAGE_4
— Clear internal flag FLAG_3 to value "0"
— Stop timer TIMER_1

1.4 Document organization

This standard is organized as follows:

Chapters 1 through 4 contain the overview, references, definitions, and abbreviations, respectively.

Chapter 5 presents the overall architecture of the IEEE 802.9 ISLAN. The protocol sublayers and the layer service boundaries are introduced.

Chapter 6 presents the specification of the structure for the TDM and MAC frames. The individual fields are defined.

Chapter 7 presents the service specifications for the LLC/MAC and the MAC/PHY for the P channel. The isochronous service specifications from PHY to Layer 2 are presented. The management service specifications for all sublayers are presented.

Chapter 8 presents a detailed description of the procedures for the various functional modules that operate within the MAC. The descriptions contain detailed FSM models to describe the functional operations.

Chapter 9 provides a detailed description of the three sublayers of the PHY Layer: the HMUX sublayer, the PS sublayer, and the physical medium dependent (PMD) sublayer. The IEEE 802.9 interface supports two PMD sublayers: a 4.096 Mb/s line rate interface and a 20.480 Mb/s line rate interface. Complete descriptions for both are contained in this chapter.

Chapter 10 presents the ISLAN layer management. A complete description of the managed objects (MOs) contained in the management information base (MIB) for the IEEE 802.9 interface is presented.

Chapter 11 presents ISDN signalling and management, followed by a complete description of the information flow of ISDN management information. A set of enhancements to the ISDN standard repertoire is presented to complete the signalling message set.

Annex A contains the Protocol Implementation Conformance Statement (PICS) proforma. The detailed specification of the PICS is a matter for further study.

Annex B contains the Managed Object Conformance Statement (MOCS). The detailed specification of the MOCS is a matter for further study.

Annex C contains GDMO specifications of information elements required for the full definition of ISLAN systems and layer management.

Annex D describes the CCITT Q.93x message set used during local bandwidth management between the AU and the ISTE. The relationship of the HMC control field exchange between the AU and the ISTE and their respective layer management entities are defined.

Annex E provides reference models for the AU and guidelines for implementation.

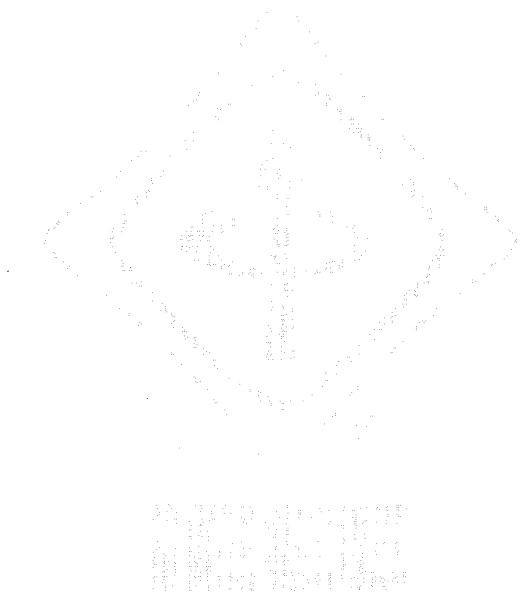
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Annex F contains the SDL description of the information flow across layers.

Annex G describes the optional procedures for secure control involved with the RSC procedures used to gate on/off an SCD that resides at the network side of the AU.

Annex H describes how address structures may be applied for a topology involving addressing techniques to access a wide area network (WAN) destination.

Annex I describes the optional procedures involved with the support of a cell bearer service across an IEEE 802.9 subnetwork. This service results in a restructure of the MAC frame so that the cell-based payload units may be transported.



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2. References

The IEEE 802.9 ISLAN standard's architecture is required to interwork with the standard data-only and integrated services local area network (LAN) and metropolitan area network (MAN) backbone networks, as well as with ISDN networks. As such, the following specifications are important references:

ANSI/EIA/TIA-568-91, Commercial Building Telecommunications Wiring Standard.[2]

ANSI X3.139-1987 (Reaff 1992), Information Systems—Fiber Distributed Data Interface (FDDI)—Token Ring Media Access Control (MAC).[3]

ANSI X3.186-1992, Fiber Distributed Data Interface (FDDI) Hybrid Ring Control (HRC).

CCITT Recommendation E.164 (1991), Numbering plan for the ISDN era, Rev. 1 (I.331).[4]

CCITT Recommendation F.69 (1993), Plan for telex destination codes, Rev. 1.

CCITT Recommendation I.112 (1993), Vocabulary of terms for ISDNs, Rev. 1.

CCITT Recommendation I.210 (1993), Principles of telecommunication services supported by ISDN and the means to describe them, Rev. 1.

CCITT Recommendation I.320 (1988), ISDN protocol reference model. In vol. III.8 of the *CCITT Blue Books*—Integrated Services Digital Network (ISDN)—Overall network aspects and function, user-network interface.

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CCITT Recommendation I.430 (1993), Basic user-network interface—Layer 1 specification, Rev. 1.

CCITT Recommendation I.431 (1993), Primary rate user-network interface—Layer 1 specification, Rev. 1.

CCITT Recommendation I.440 (Q.920 protocol) (1993), ISDN user-network interface data link layer—General aspects, Rev. 1.

CCITT Recommendation I.441 (Q.921 protocol) (1993), ISDN user-network interface—Data link layer specification, Rev. 1.

CCITT Recommendation I.450 (Q.930 protocol) (1993), ISDN user-network interface layer 3—General aspects, Rev. 1.

CCITT Recommendation I.451 (Q.931 protocol) (1993), ISDN user-network interface layer 3 specification for basic call control, Rev. 1.

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[2]EIA publications are available from Global Engineering, 1990 M Street NW, Suite 400, Washington, DC, 20036, USA.

[3]ANSI publications are available from the Sales Department, American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036, USA.

[4]All CCITT publications are now being labeled as International Telecommunications Union (ITU-T) publications. They are available from the International Telecommunications Union, Sales Section, Place des Nations, CH-1211, Genève 20, Switzerland/Suisse. They are also available in the United States from the U.S. Department of Commerce, Technology Administration, National Technical Information Service (NTIS), Springfield, VA 22161, USA.

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CCITT Recommendation I.452 (Q.932 protocol) (1993), Generic procedures for the control of ISDN supplementary services, Rev. 1.

CCITT Recommendation Q.933 (1993), Layer 3 signalling specification for frame mode bearer service.

CCITT Recommendation Q.940 (1988), ISDN user-network interface protocol for management—General aspects. In vol. VI.11 of the *CCITT Blue Books*—Digital access signalling system, network layer, user—network management.

CCITT Recommendation X.3 (1993), Packet assembly disassembly facility (PAD) in a public data network, Rev. 1.

CCITT Recommendation X.25 (1993), Interface between data terminal equipment (DTE) and data circuit-terminating equipment (DCE) for terminals operating in the packet mode and connected to public data networks by dedicated circuit, Rev. 1.

CCITT Recommendation X.28 (1993), DTE/DCE interface for a start-stop mode data terminal equipment accessing the packet assembly/disassembly facility (PAD) in a public data network situated in the same country, Rev. 1.

CCITT Recommendation X.29 (1993), Procedures for the exchange of control information and user data between a packet assembly/disassembly (PAD) facility and a packet mode DTE or another PAD, Rev. 1.

CCITT Recommendation X.121 (1992), International numbering plan for public data networks, Rev. 1.

CCITT Recommendation X.200 (1988), Reference Model of Open Systems Interconnection for CCITT Applications. In vol. VIII.4 of the *CCITT Blue Books*—Open Systems Interconnection (OSI)—model and notation, service definition.

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ECMA TR 51: 1990, Requirements for Access to Integrated Voice and Data Local and Metropolitan Area Networks.

EIA SP-2840A, Commercial Building Telecommunications Cabling Standard, April 19, 1994 (Draft).[6]

IEC 60-1 (1989), High-voltage test techniques—Part 1: General definitions and test requirements.[7]

IEC 60-3 (1976), High-voltage test techniques—Part 3: Measuring devices.

IEC 60-4 (1977), High-voltage test techniques—Part 4: Application guide for measuring devices.

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[5]ECMA publications are available from Global Engineering, 1990 M Street NW, Suite 400, Washington, DC, 20036, USA.

[6]EIA publications are available from Global Engineering, 1990 M Street NW, Suite 400, Washington, DC, 20036, USA. This standard is expected to be published in February 1995.

[7]IEC publications are available from IEC Sales Department, Case Postale 131, 3 rue de Varembé, CH-1211, Genève 20, Switzerland/Suisse. IEC publications are also available in the United States from the Sales Department, American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036, USA.

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IEEE Std 802.1B-1992, IEEE Standards for Local and Metropolitan Area Networks: LAN/MAN Management (ANSI).

IEEE Std 802.1F-1993, IEEE Standards for Local and Metropolitan Area Networks: Common Definitions and Procedures for IEEE 802 Management Information (ANSI).

ISO 3166: 1993, Codes for the representation of names of countries.[9]

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ISO 7498-4: 1989, Information processing systems—Open Systems Interconnection—Basic Reference Model— Part 4: Management framework.

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ISO/IEC 8802-4: 1990 [ANSI/IEEE Std 802.4-1990], Information processing systems—Local area networks—Part 4: Token-passing bus access method and physical layer specifications.

ISO/IEC 8802-5: 1992 [ANSI/IEEE Std 802.5-1992], Information technology—Local and metropolitan area networks—Part 5: Token ring access method and physical layer specifications.

ISO/IEC 8802-6: 1994 [ANSI/IEEE Std 802.6, 1994 Edition], Information technology—Telecommunications and information exchange between systems—Local and metropolitan area networks—Specific requirements—Part 6: Distributed Queue Dual Bus (DQDB) access method and physical layer specifications.

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[8]IEEE publications are available from the Institute of Electrical and Electronics Engineers, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331, USA.

[9]ISO publications are available from the ISO Central Secretariat, Case Postale 56, 1 rue de Varembé, CH-1211, Genève 20, Switzerland/Suisse. ISO publications are also available in the United States from the Sales Department, American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036, USA.

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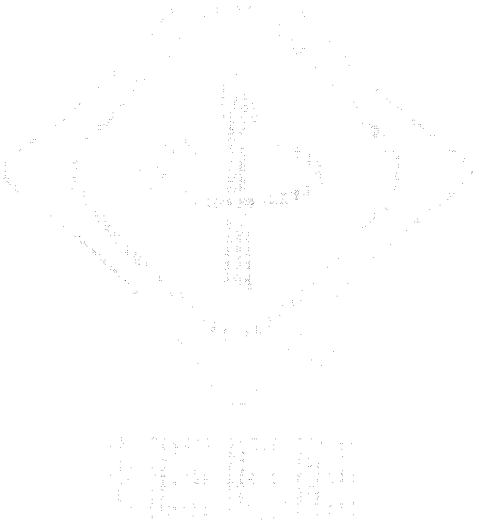
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ISO/IEC TR 9577: 1993, Information technology—Telecommunications and information exchange between systems—Protocol identification in the network layer.

ISO/IEC TR 10178: 1992, Information technology—Telecommunications and information exchange between systems—The structure and coding of Logical Link Control addresses in Local Area Networks.

[10]Presently at state of Draft International Standard.
[11]See footnote 10.

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3. Definitions

The following are definitions of terms used in this standard that are widely used in IEEE 802 as well as CCITT I series and other standards documents. For the CCITT Recommendation I series, the basic vocabulary and terms can be found in CCITT Recommendation I.112 (1993).[12]

3.1 access unit (AU): The abstraction of the device that provides the IEEE 802.9 functionality, i.e., the integrated set of services, to stations connected across the IEEE 802.9 interface.

3.2 bearer service: A telecommunication service that provides the capability for the transmission of signals between user-network interfaces [see CCITT Recommendation I.210 (1993)].

3.3 bearer channel protocol intervention level: The highest protocol level at which a private switching network (PSN) provides protocol termination on a given bearer channel.

3.4 B channel: A channel that provides 64 kb/s, full duplex, isochronous access. B channels support all ISDN bearer services. The information on a B channel may be non-switched or either circuit or packet switched depending on user request and network capabilities. In the IEEE 802.9 TDM frame, two B channel slots have been defined. There may be more than two B channels configured across a given IEEE 802.9 interface (in this event the B channels would be configured as $C sub 1$ channels).

3.5 C channel: A channel that provides an integer multiple of 64 kb/s, full duplex, isochronous clear channels. The "C" is used to indicate that this is a circuit-switched channel. $C sub m$ stands for a channel (m) times 64 kb/s in size. In general, a C channel has the same characteristics as an ISDN B or H channel, except that it can be any multiple of 64 kb/s in size, rather than only the CCITT approved rates. There may be multiple C channels of varying sizes (n × C).

Note the following equivalencies:

C_1	= B	= 64 kb/s
C_6	= H_0	= 384 kb/s
C_{24}	= H_{11}	= 1.536 Mb/s
C_{30}	= H_{12}	= 1.920 Mb/s

The maximum composite bandwidth allocated for the C channel(s) shall be limited by the application requirements for the P channel. That is, the available bandwidth that may be assigned for C channels shall be limited to the difference between the TDM payload field minus the bandwidth required for the P channel. In practice, the C channel size(s) will be effected by the interconnection facility(ies) between the AU and the ISDN wide area network (WAN).

3.6 convergence protocol: A protocol that provides the convergence service for the provision of enhancements to an underlying service in order to provide for the specific requirements of the convergence service user.

3.7 coordinating entity: That part of the Network Layer within an end system or interworking unit responsible for the coordination and synchronization of functions belonging to the Data and Signalling subentities of the layer entity implementing a PSN access protocol.

3.8 D channel: A channel that provides 16 kb/s or 64 kb/s, full duplex packet access. The D channel provides ISDN call control services via the CCITT Q.93x family of protocols. The use of the D channel may be restricted to conveying signalling information in some applications. The D channel is capable of supporting packet mode bearer information. All information on the D channel is packetized.

[12]Information on references can be found in Chapter 2.

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3.9 data circuit terminating equipment (DCE): A device that provides the signal conversion and coding between the data terminal equipment and the network carrier facility. Note that in the context of a CCITT X.25 network, for example, the DCE performs functions at the network end of an access line to the network.

3.10 data terminal equipment (DTE): A device that serves as a data source and/or a data sink.

3.11 H channel: A wideband channel (i.e., a channel that contains multiples of 64 kb/s). See CCITT Recommendation I.412 (1988).

3.12 in-band signalling: Signalling applications in which the signalling information is transmitted in the same information flow as the data. *See also:* **out-of-band signalling**.

3.13 integrated services terminal equipment (ISTE): A device that serves as an information source and/or an information sink for the provision of voice, facsimile, video, data, and other information.

3.14 interworking unit (IWU): A unit that provides the functions needed to allow interworking between a PSN and another network, e.g., interworking between a PSN and a CCITT X.25 packet-switched public data network (PSPDN).

3.15 isochronous: A communication stream transport that is uniform in time. The delivery of the physical stream of information is recurring at regular intervals.

3.16 layer service: The service that a layer provides to the next higher layer. See ISO 7498-4: 1989 and CCITT Recommendation X.200 (1988).

3.17 out-of-band signalling: Signalling applications in which the signalling information is outside of the user information channel, whether or not transmitted in a different physical or logical channel from the associated user data, e.g., over different physical paths, in different time-slots in a time division multiplex (TDM) stream.

3.18 P channel: A full duplex packet channel that provides IEEE 802 MAC Layer services. The P channel may optionally carry CCITT Q.93x (where x refers to the family of CCITT Q.930 protocols) call control in a logically out-of-band fashion, which may be highlighted by referring to it as P_D. Presently there is only one P channel defined per ISLAN interface. The minimum size of the P channel shall be limited by the application requirements of the topology that represents the connection of the AU to the backbone LAN application. The support of station management communication will be an important factor in the characterization of P channel bandwidth size.

3.19 packet assembler/disassembler (PAD): A device that assembles and disassembles packets. Examples are found in CCITT Recommendations X.3 (1993), X.28 (1993), and X.29 (1993).

3.20 packet handler (PH): A device for processing packets or frames in a manner so as to be able to route individual frames or packets out of one data stream into multiple different data streams.

3.21 packet mode protocol: The access protocol based on the use of out-of-band control and Link Layer multiplexing. *Syn:* PSN packet mode protocol.

3.22 packet switched public data network (PSPDN): A public subnetwork that is accessed via the CCITT X.25 protocol and that provides virtual circuit service.

3.23 packetized data transfer: Transfer of data through a network where data is conveyed in packets and/or frames in a statistical manner. Packets or frames are propagated through the network and delivered to destinations based on addressing information contained therein.

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3.24 private packet/frame and circuit switching network (PPCSN): A private switching network that provides both circuit and packet/frame switching functions (i.e., all the functions of both PCSNs and PPSNs).

3.25 private circuit switching network (PCSN): A private network that only provides circuit switching functions, except that it may be able to transport packetized "user-to-user" information passed over the signalling channel.

3.26 private packet/frame switching network (PPSN): A private network that only provides packet/frame switching functions.

3.27 private switching network (PSN): A private network that provides switching functions (circuit and/or packet/frame switching). It is operated by the user and located on user premises to cover the communications needs in the user's domain. The term private-switching network includes both the private circuit-switching network and the private packet-switching network.

3.28 packet-switched data network (PSDN): A packet-switched subnetwork that can be a PPSN (private) or a PSPDN (public) packet-switched network.

3.29 R interface: The interface provided at the R reference point to allow the connection of non-ISDN terminals using, for example, CCITT V- or X-series interfaces.

3.30 relaying: A function performed at intermediate nodes on an interconnection between communicating end-systems. The relaying function is performed by connecting two independent layer entities. For example, a relaying function at the Data Link Layer connects two Data Link Layer entities to make an interconnection.

3.31 S interface: The interface provided at the S reference point for ISDN user-to-network interface.

3.32 signalling: The exchange of information specifically concerned with the establishment and control of connections, and the transfer of user-to-user and management information in a telecommunication network, e.g., in a PPSN.

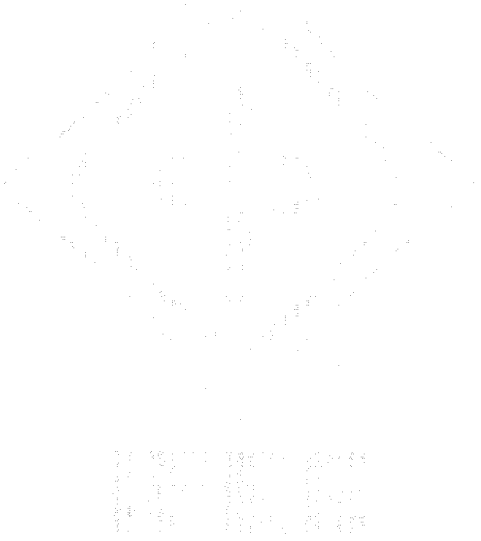
3.33 subnetwork: A set of one or more intermediate open systems that provide relaying and through which end open systems may communicate. It is a representation within the OSI model of a real network such as a carrier network, a provider network, or a LAN. It can also be defined as a collection of equipment and physical media that forms an autonomous whole and that can be used to interconnect real systems for the purpose of communication (see ISO 8648: 1988).

3.34 subnetwork service: The service supported by the subnetwork access protocol.

3.35 terminal adapter (TA): An adapter required to map one specified interface to another. An example is the adapting of the R interface in the CCITT ISDN interface (e.g., according to the CCITT V- or X-series) to the S interface. The TA may be an integral functional entity as part of the terminal or may be a separate physical unit connected between an R interface and the S interface.

3.36 virtual circuit: The generic concept of a logical connection. A virtual circuit may be implemented by means of a frame-switched service or a packet-switched service.

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4. Abbreviations

The following abbreviations are used in this standard as well as in IEEE 802 CCITT I series and other standards documents. For the CCITT Recommendation I series, the basic vocabulary and terms can be found in CCITT Recommendation I.112 (1993).

AC	access control field
ACSE	association control service element
ADPCM	adaptive differential pulse code modulation
AFI	authority and format identifier
AM/PM	amplitude modulation/phase modulation
APDU	application protocol data unit
APM	additional packet mode services
ANSI	American National Standards Institute
ASN.1	Abstract Syntax Notation One
ATM	asynchronous transfer mode
AU	access unit
B	B channel
BB	broadband
BCD	binary coded decimal
BER	bit error rate
BISDN	broadband integrated services digital network
BRI	basic rate interface
C	circuit-switched channel
CAP	combined amplitude and phase
CC	country code
CCITT	Consultative Committee of International Telephone and Telegraph
CEI	connection endpoint identifier
CLNP	connectionless network protocol
CMIP	common management information protocol
CMIPDU	common management information protocol data unit
CMIS	common management information service
CMISE	common management information service element
CO	central office
CRC	cyclic redundancy check
D	D channel
DA	destination address
DCC	data country code

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DCE	data communication equipment
DCR	D channel rate select bit
DIW	D-type inside wire
DL	data link layer
DLC	data link control
DSAP	destination service access point
DSP	domain-specific part
DSS	digital signalling system 1
DTE	data terminal equipment
ECMA	European Computer Manufacturers Association
EMI	electromagnetic interference
FAW	frame alignment word
FC	frame control
FCC	Federal Communications Commission
FCS	frame check sequence
FDDI	fiber distributed data interface
FIFO	first-in first-out
FSM	finite state machine
G	grant
GDMO	guidelines for the definition of managed objects
GOSIP	Government OSI profile
H	H channel
HDLC	high-level data link control
HMC	hybrid multiplexer control field
HMF	hybrid multiplexer multiframing bit
HMUX	hybrid multiplexer
ICD	international code designator
IDI	initial domain identifier
IDP	initial domain part
IE	information element
IEC	International Electronic Commission
IP	internet protocol
IPX	internet protocol X
IS	integrated services
ISDN	integrated services digital network
ISLAN	integrated services LAN

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ISO	International Standards Organization
ISPBX	integrated services private branch exchange
ISTA	integrated services terminal adaptor
ISTE	integrated services terminal equipment
ITU-T	International Telecommunication Union–Telecommunication Standardization Sector
IWU	interworking unit
LAN	local area network
LAPB	link access procedure, balanced
LAPD	link access procedures for the D channel
LAPD+	extended procedures for LAPD
LEN	length field
LLA	logical link address
LLB	local loopback status bit
LLC	logical link control
LLS	logical link services
LM	layer management
LME	layer management entity
LMI	layer management interface
LMMS	layer management MAC services
LMMP	layer management MAC protocol
LPDU	logical link protocol data unit
LSAP	link layer service access point
LSb	least significant bit
LSB	least significant byte
LSDU	link layer service data unit
LTB	local template buffer
MA	management
MAC	medium access control
MAN	metropolitan area network
MAPDU	management application protocol data unit
MDI	medium dependent interface
MIB	management information base
MIS	management information services
MLME	managed layer management entity
MO	managed object
MOCS	managed object conformance statement

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MPDU	medium access control protocol data unit
MSAP	medium access control service access point
MSb	most significant bit
MSB	most significant byte
MSDU	MAC service data unit
MT	management
MUX	multiplexing
NDC	national destination code
NOT	notification
NSAP	network service access point
NSN	national significant number
NTW	network
OP	operation
OSI	Open Systems Interconnection
P	packet channel
PABX	private automated branch exchange
PAD	packet assembler disassembler
PAR	project authorization request
PBX	private branch exchange
PCM	pulse code modulation
PDN	packet data network
PDU	protocol data unit
PERR	parity error status bit
PEVN	even parity cumulative bit
PhSAP	Physical Layer service access point
PH	packet handler
PHY	Physical Layer
PLME	Physical Layer management entity
PLS	Physical Layer signalling
PMA	physical medium attachment
PMD	physical medium dependent
PODD	odd parity cumulative bit
PCSN	private circuit switching network
PPCSN	private packet/frame and circuit switching network
PPE	provider protocol entity
PRI	primary rate interface

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PS	physical signalling
PSPDN	packet-switched public data network
PSN	private switching network
PTT	Post, Telegraph, and Telecommunications (administration)
Q.93x	CCITT Q series protocol ("x" refers to the members of the CCITT Q.930 family of protocols)
QOS	quality of service
R	request
RLBREQ	remote loopback request bit
RLBRESP	remote loopback response bit
RSC	remote secure control
ROSE	remote operation service element
SA	source address
SAP	service access point
SAPI	service access point identifier
SB	service boundary
SCD	secure communications device
SDL	sequence and description language
SDLC	synchronous data link control
SDU	service data unit
SID	service identifier field
SMAE	system management application entity
SMAP	system management application process
SMASE	system management application service element
SMI	structure of management information
SN	subscriber number
SNMP	simple network management protocol
SNPA	subnetwork point of attachment
SOF	start-of-frame bit
SSAP	source service access point
SYN	synchronization field
TA	terminal adaptor
TCP/IP	transport control protocol/Internet protocol
TDM	time division multiplexer
TDMMTN	time division multiplexer maintenance field
TE	terminal equipment

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TEI	terminal endpoint identifier
TTP	telephone twisted pair
TXC	template exchange notification bit
UTTP	unshielded telephone twisted pair
UPE	user provider entity
VCCI	virtual cell circuit identifier
WAN	wide area network
WG	working group



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5. Architecture

5.1 Overview and basic concepts

The ISLAN interface is an integrated voice, data, and video interface that provides packet service and isochronous digital channels on a full duplex interface to the desktop over unshielded telephone twisted-pair (UTTP) wiring. The principal target of the initial Physical (PHY) Layer specification is the office environment on premises-based networks. It is intended to be used on UTTP wiring in a physical point-to-point configuration.

The integrated services are provided to the IS terminal equipment (ISTE) across an interface serviced by a functional entity called the access unit (AU). The ISTEs are connected by UTTP wiring to the AU. Thus, from the perspective of the ISTEs, their PHY interface is to the AU and the services are functionally provided via the AU. From the perspective of the ISTE, there is one interface into which it sends/receives a multiplexed communication stream, independent of the network topology. The AU accommodates two fundamentally different application topologies. First, the interface may be to a stand-alone LAN in which the AU actually provides the complete pathway for the required services of the attached ISTEs. The second application is the environment wherein the IEEE 802.9 ISLAN serves an access interface that feeds into a backbone consisting of an IEEE 802.x LAN, a fiber distributed data interface (FDDI), or an integrated services digital network (ISDN) provided via a private network using a PABX or via the public network. In this case, the AU becomes an interworking unit to the system providing the services. Combinations of the two scenarios are also possible. Unlike the IEEE 802.3/4/5/6 LANs, the medium between the ISTE and the AU is not shared; rather, it is a point-to-point configuration.

The scope of this standard includes the access link between the IEEE 802.9 ISTE and the AU. Figure 5-1 provides an architectural overview of the IEEE 802.9 ISLAN interface to better explain how the MAC arises, and what its point of departure is from the other IEEE 802 MACs. Figure 5-1 is a logical view only and does not imply any particular implementation. The connection between the AU and the ISTEs is a star arrangement. Carried over these point-to-point links between the AU and the ISTEs is a multiplexed bit stream of packet data, voice, wideband data, and other services such as facsimile, image, or video delivered over isochronous channels. The ISTEs may contend for access to integrated services from the AU. These services may be provided directly from the AU or from beyond the AU by networks which provide IEEE 802 LAN service, integrated services, or ISDN bearer services. Thus, beyond the AU there may exist a connection to another IEEE 802 LAN or FDDI network, an ISDN switch, or an integrated services network such as IEEE 802.6. This is illustrated in figure 5-2.

In the IEEE 802.9 architecture, the medium is not a shared resource. However, the AU is a shared resource which manages and supports multiple ISTEs, each connected in a point-to-point arrangement with the AU. In fact, the AU architecture participates as the integral manager of the shared service and directly influences how the shared resources become available. The particular AU architecture will provide the arbitration scheme for access to the medium. Note that the definition of the AU architecture is outside of the scope of this standard.

The IEEE 802.9 ISLAN architecture employs a more sophisticated PHY Layer than other LANs, and is able to support the multiplexing of several channels of information by means of a time division multiplexed (TDM) bearer. Architecturally this bearer is specified to be capable of supporting information transfer rates that are multiples of 4.096 Mb/s in isochronous frames delivered at 8 kHz. These frame are synchronous with any "host" ISDN to which the backbone side of the IS-AU may be attached. In this standard, specifications are provided for the use of 4.096 Mb/s and 20.48 Mb/s TDM bearers, having 64 and 320 slots, each comprising one octet.

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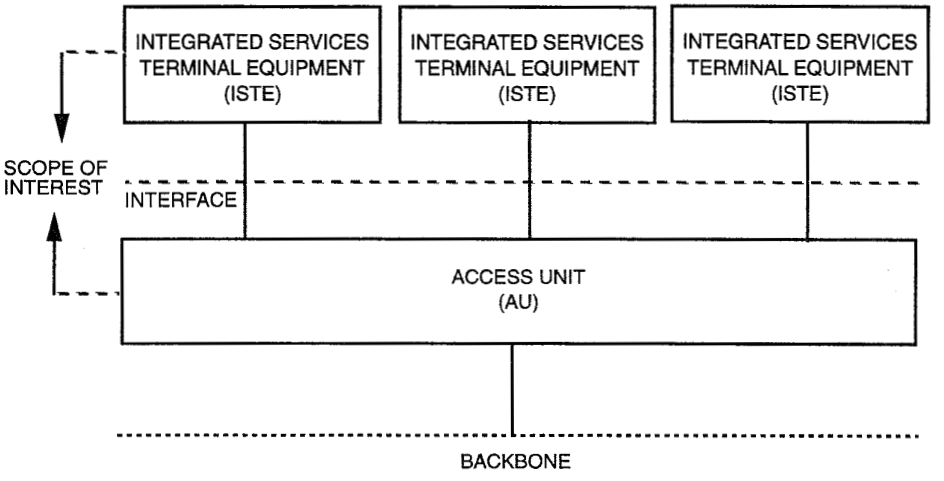


Figure 5-1—Overview of IEEE 802.9 ISLAN interface

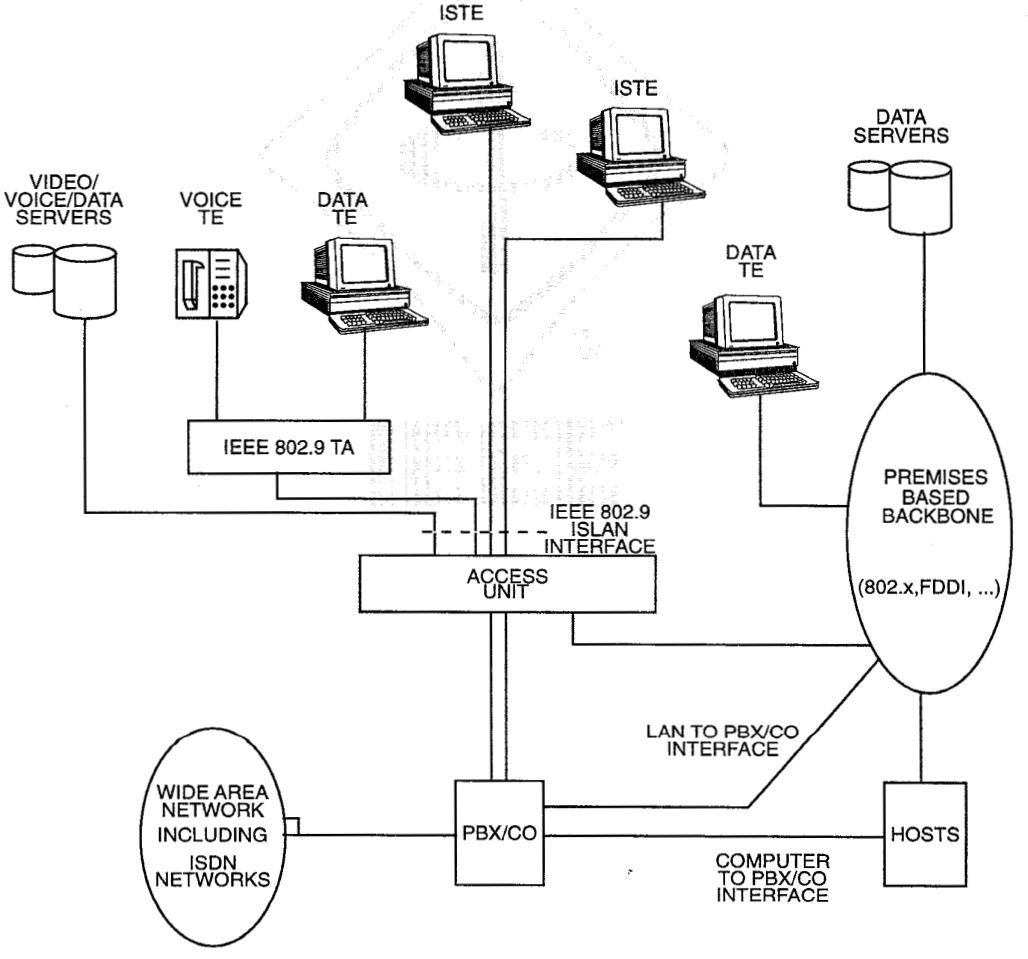


Figure 5-2—IEEE 802.9 ISLAN interface configuration

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The multiplexing of the several services carried by octets or multiples thereof within the common TDM bearer is a function of the Hybrid Multiplexing (HMUX) sublayer of the IEEE 802.9 PHY Layer, but it does effect the complete management and control of the channels. HMUX sublayer management procedures combined with extension to ISDN signalling (recommended in annex D) complete the provision of a mechanism that can transparently and dynamically establish and release multiple independent user service channels. The IEEE 802.9 PHY Layer is able to offer each of these to higher level Layer 2 processes as variable bandwidth isochronous bearers.

These channel types are:

— *D channel:* A 16 kb/s or 64 kb/s, full duplex packet channel for the provision of call control service via the CCITT Q.93x family of protocols. The use of the D channel may be restricted to conveying signalling information in some applications. The D channel is capable of supporting packet mode bearer information. All information on the D channel is packetized.

— *B channel:* A full duplex, 64 kb/s isochronous channel. From the perspective of this standard, the B channel requires no specific upper layer protocol suite above the PHY's HMUX sublayer. The information on a B channel may be non-switched or either circuit or packet switched depending on user request and network capabilities. In the IEEE 802.9 TDM frame, two B channel slots have been defined. There may be more than two B channels configured across a given IEEE 802.9 interface (in this event, the B channels would be configured as C_1 channels).

— *C channel:* A full duplex isochronous channel whose bandwidth is a multiple of 64 kb/s. The expression "C" is used to indicate that this is a circuit-switched channel. C_m stands for a channel (m) times 64 kb/s in size. In general, a C channel has the same characteristics as an ISDN B or H channel, except that it can be any multiple of 64 kb/s in size, rather than only the CCITT approved rates. There may be multiple C channels of varying sizes ($n \times C$).

  Note the following equivalencies:

  $C_1 = B =$ 64 kb/s
  $C_6 = H_0 =$ 384 kb/s
  $C_{24} = H_{11} = 1.536$ Mb/s
  $C_{30} = H_{12} = 1.920$ Mb/s

  The maximum composite bandwidth allocated for the C channel(s) shall be limited by the application requirements for the P channel. That is, the available bandwidth that may be assigned for C channels shall be bounded by the difference between the TDM payload field minus the bandwidth required for the P channel. In practice, the C channel size will be affected by the interconnection facility(ies) between the AU and the ISDN wide area network (WAN). As for the B channel, from the perspective of this standard, no MAC sublayer protocol is defined.

— *AC channel:* A full duplex, isochronous 64 kb/s channel for transporting information relating to the MAC for the request/grant arbitration procedure used in governing access to the P channel for MPDU transport.

— *P channel:* A full duplex packet channel that provides IEEE 802 MAC services for data. The IEEE 802.9 interface requires that CCITT Q.93x call control be used between the AU and the ISTE for the purpose of local bandwidth management. Conventionally, there is a D channel dedicated to this transport. In some network topologies, it may be possible to configure this as a "logically" separate D channel, which is referred to as P_D. The use of the P channel to carry CCITT Q.93x call control in a logically out-of-band fashion, which may be highlighted by referring to it as P_D, is a matter for further study.

Presently there is only one P channel defined per ISLAN interface. The minimum size of the P channel shall be limited by the application requirements of the topology that represents the connection of the AU to the backbone LAN application. The support of station management communication will be an important factor in the characterization of the P channel bandwidth size.

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The IEEE 802.9 MAC is defined over the P channel. The services supported on the P channel may include both the IEEE 802 MAC data service and ISDN packet mode bearer services. The issue of supporting signalling based on the CCITT Q.93x family of standards on the P channel (P_D) is a matter for further study.

Since the function of the MAC is to provide underlying service for Logical Link PDUs (LPDUs), the characteristics of the IEEE 802.9 MAC will depend on the services required by the LPDUs. The ISDN bearer services for packet data utilize LAPB for CCITT X.25 service and LAPD for the additional packet mode service (APM), in addition to call control. Thus, in its full generality, the IEEE 802.9 MAC could support the IEEE 802 LLC, the LAPD, and the LAPB.

The LAPD service is uniquely identified by the service identification (SID) field of the MAC frame. The convergence details of the MAC frame support are a matter for further study.

The AU is provided as an architectural model to represent both the interworking interfaces to allow the extension of the IEEE 802.9 ISLAN interface service into the far side IS backbone such as LAN and ISDN networks, as well as the necessary support functions to allow concentration of multiple ISTE interfaces. The ISLAN interface part of the architecture of the AU is implementation independent while the backbone part is implementation dependent. This is discussed further in annex E.

To permit a wide range of capabilities of vendor implementation of IEEE 802.9-conformant products, the IEEE 802.9 ISLAN provides in the PHY Layer signalling the ability to support several modes of ISTE and AU interworking. Rudimentary IEEE 802.9 packet service only or ISDN basic rate interface (BRI) only devices can be supported. In addition, equipment that is capable of supporting multiple dynamic wideband channels is designated a specific mode of operation. Further details on this can be found in 9.2.3.

The IEEE 802.9 architecture also provides for the conveyance of broadband ISDN-conformant asynchronous transfer mode (ATM) cells. There are no normative specifications for such a service within this standard; however, there is a description in annex I of a set of methods by which such a service could be realized.

5.2 Application areas

A variety of applications have been identified for the various channels. The P channel may be used for the provision of LAN service to ISTEs using transport service which may traverse an ISDN or IS network to get to the LAN service. It may provide the IEEE 802 LAN service or the ISDN bearer service and also support call control using the CCITT Q.93x family of protocols. Among the end-user data applications are: file transfer between ISTE, remote terminal interactive sessions, remote database access by transaction-oriented programs, computer-aided design, and object-oriented and pixel-oriented graphic terminal interactive sessions.

The P channel is primarily intended for the provision of IEEE 802 LAN data. The potential for the channel to provide call control service via the CCITT Q.93x family of protocols and other ISDN services is a matter for further study.

The D channel provides for a 16 kb/s or 64 kb/s channel for call connection and control using the CCITT Q.93x family of protocols. This implies the transport of signalling information for the call connection/control of the B and C channels and also the transport of ISDN management information. The D channel could also be used to support other ISDN bearer services such as frame relay, frame switching, CCITT X.31, etc.

The B channel's bearer characteristics in the IEEE 802.9 environment are identical to that of the ISDN B channel. The B channels are primarily intended for the provision of PCM voice but could be used to provide any 64 kb/s (or rate-adapted to 64 kb/s) isochronous voice or data services. Among such services

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would be circuit-mode data supporting: unrestricted 64 kb/s information transfer, restricted 56 kb/s information transfer capability, asynchronous data using rate adaption, asynchronous data via CCITT X.3 packet assembler disassembler (PAD) and CCITT X.25, synchronous (SDLC, HDLC, etc.) via rate adaption, and facsimile support; and packet mode data intended for the ISDN network.

A C channel is a wideband isochronous channel that can support both circuit-mode and packet-mode services to which the interface provides access. A C channel whose bandwidth is configured to be 64 kb/s in size is identical to a B channel. Typical examples of C channel applications would include access to image and video services as well as access to ISDN wideband services.

To support existing terminals and stations on the ISLAN interface, use is made of terminal adaptors (TAs). Since the TA will depend on the native mode subnetwork being adapted to the IEEE 802.9 interface, a family of TAs is expected to result. This will facilitate interworking with the installed base while making it possible for such stations to make use of new IS applications.

5.3 Layers and layer service boundaries

The IEEE 802.9 ISLAN model and its relationship to the open system interconnection (OSI) reference model of the International Organization for Standardization (ISO) is illustrated in figure 5-3.

The scope of this standard covers the Data Link and PHY Layers for information transfer. It should be noted that CCITT Q.931, which is a Layer 3 protocol, is used for call control. The Data Link Layer protocols are defined over the packet channels, i.e., the D and P channels. The PHY Layer considerations apply to all of the channels—both packet and isochronous.

With respect to the Data Link Layer protocols, there are three types of information channels: the IEEE 802.9 P channel, isochronous channels, and the ISDN D channel. The Link Layer for the P channel consists of the IEEE 802.9 MAC sublayer together with the IEEE 802.2 LLC sublayer. The ISDN D channel services require use of the LAPD protocol at the Link Layer. The isochronous channels, the B and C channels, may use a Layer 2 and higher layer protocol, as appropriate, for the type of service that is being provided over the channel for the given data, voice, or video communication application. Note that isochronous service may not conform to the OSI stack of protocols (e.g., voice encoding streams).

The packet and isochronous channels are multiplexed at the HMUX sublayer. Thus, the physical frame contains the P, C, B, D, and access control (AC) channels, but the MAC described in this standard is the protocol defined for the P channel.

The Data Link and PHY Layers have an interface to management (MT). From a modeling perspective, each layer (or sublayer) has its individual layer management entity (LME). The combination of the individual LMEs interacting with the system management application process is described as the management entity.

The layers interact by way of well-defined interfaces to provide specific services.

5.3.1 Data Link Layer

The role of the Data Link Layer (DL) is to provide for the transparent and reliable transfer of data link protocol data units (PDUs) between peer data link entities. The functions provided are as follows.

a) *Frame delimiting*. The capability to indicate where the data link PDU begins and ends. This involves the recognition of a sequence of octets transmitted/received in the P channel of the IEEE 802.9 PHY Layer as a MAC frame.

b) *Transparency*. The capability to transfer a PDU regardless of content, format, or coding.

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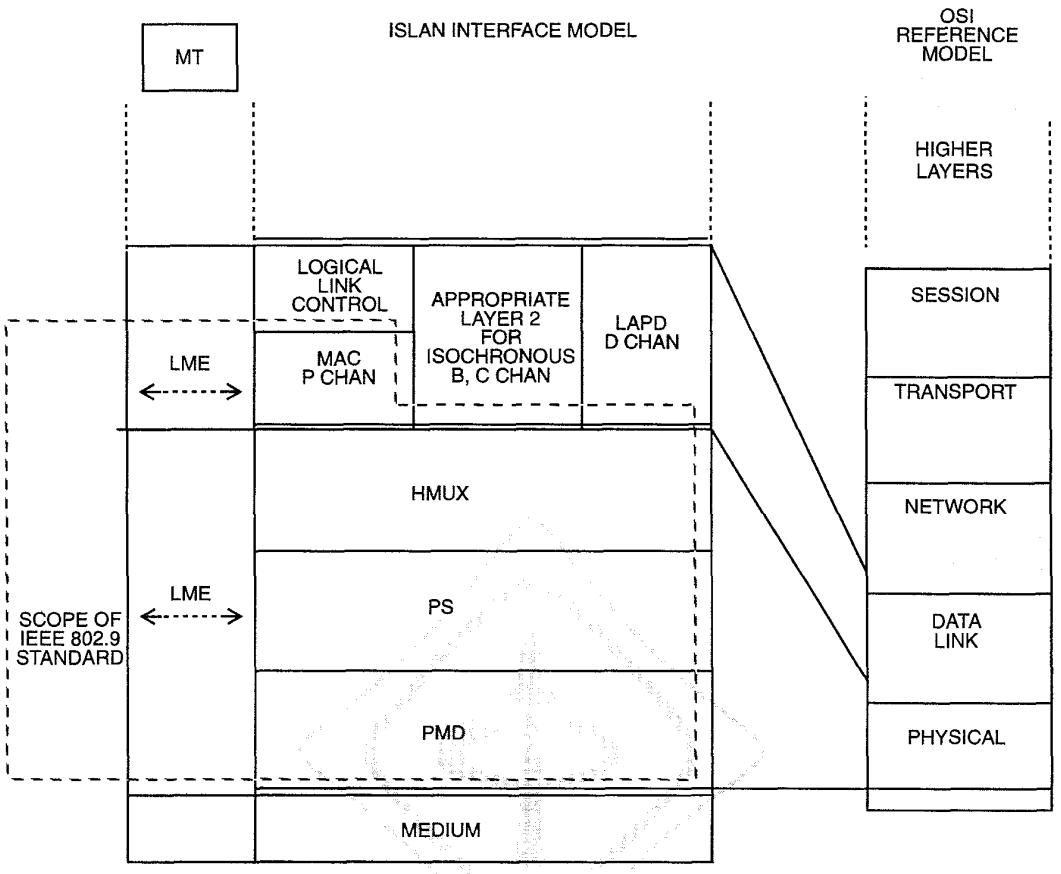


Figure 5-3—Relationship of ISLAN interface model to OSI reference model

c) *Addressing.* The capability to identify the data link service access point (SAP) to which a data link connection is established and, where multipoint links are involved, the capability to differentiate among the various connections.

d) *Error control.* The capability to detect errors and, possibly, recover from errors resulting from the physical medium. These errors include loss, corruption, insertion, and misordering.

e) *Flow control.* The capability of the receiving DL entity to regulate the rate at which the sending DL entity may send data link PDUs.

f) *Medium management.* The capability to use the physical medium for the exchange of PDUs among multiple stations. This consists of medium allocation, adaptation, and medium recovery. Medium allocation provides access to the medium for multiple stations, provides for the efficient utilization of the medium, provides for the release of the medium, and takes care of logical additions and removals of stations. Adaptation involves any scheme, such as the use of a PAD to ensure minimum frame length, to enable the proper functioning within the medium. Medium recovery restores the use of the medium following malfunction of the allocation scheme. With the star-wired topology of connecting a workstation to the AU, this recovery function becomes very simplified.

g) Procedures for the exchange of data link PDUs.

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In the IEEE 802.9 model, three different types of DL services are supported:

— For the isochronous channels (B and C), the DL services are dependent on the application, and therefore this standard does not address the DL.

— For the D channel, the DL services comprise the services provided by LAPD.

— For the P channel, the DL services consist of the services defined by IEEE 802 for packet communication. The service identification (SID) field carries information that serves as a selector function to activate the appropriate MAC convergence functionality at the receiver (see 6.6.3).

In the IEEE 802 model, the DL services are provided by the MAC and the Logical Link Control (LLC) sublayers.

The relationship of the DL to the other layers and the variety of services provided are shown in figure 5-3.

5.3.1.1 LLC sublayer

The LLC sublayer constitutes the top sublayer in the DL and is common to the various medium access methods that are defined and supported by IEEE 802. It is responsible for the initiation of data link control interchange, organization of data flow, the interpretation of received command PDUs and generation of appropriate response PDUs, and actions regarding error control and error recovery functions, as needed in that sublayer. The LLC sublayer is responsible for the management of LSAP addressing. Figure 5-4 depicts the relationship between the LLC sublayer and the other layers.

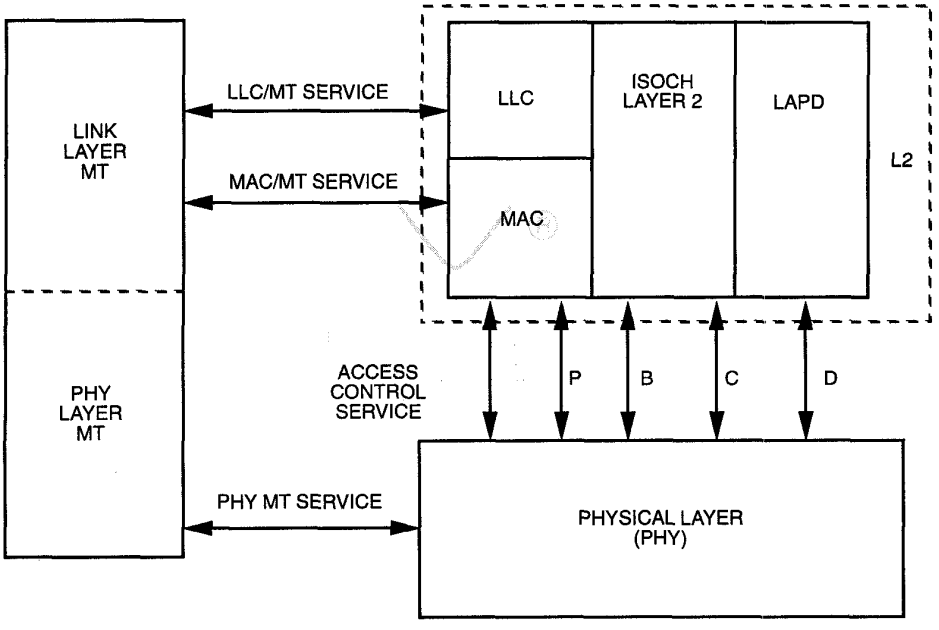


Figure 5-4—General overview of the Data Link Layer model for the IEEE 802.9 interface

5.3.1.1.1 LLC/MAC service boundary

The interface between the MAC sublayer and the LLC sublayer includes facilities for transmitting and receiving frames, and provides peer-operation status information for use by higher-level error recovery procedures.

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5.3.1.2 MAC sublayer

The MAC sublayer provides for the transparent transfer of LPDUs of a specified maximum size to and from the LLC sublayer. It does not restrict the content, format, or coding of the LPDU. It has interfaces to the LLC and the HMUX sublayers, as well as to management. Figure 5-4 describes the relationship between the MAC sublayer and the other layers.

The IEEE 802.9 MAC sublayer provides MAC frame delimiting, transparency, MAC addressing, error detection, and access control between the ISTEs and the AU.

5.3.1.2.1 MAC/MT service boundary

The interface between the MAC sublayer and layer management includes facilities for MT to monitor and control operations of the MAC sublayer, in the service of a system management application process (SMAP).

5.3.1.2.2 MAC/physical service boundary

The interface between the MAC sublayer and the PHY Layer includes MAC framing signals and access control information for exchanging a pair of serial bit (symbol) streams between the two layers.

5.3.1.2.3 MAC/HMUX service boundary

As shown in figure 5-5, the HMUX sublayer, in the transmit direction, receives an IEEE 802.9 MAC frame from the MAC sublayer to be carried in the P channel payload. The access is governed by the P channel access control method described in Chapter 8. The P channel access control information also passes across this boundary. In the receive direction, the P channel payload as well as the P channel access control information is passed from the HMUX sublayer to the MAC sublayer.

Both the P channel itself and the access control channel at the MAC/HMUX service boundary are isochronous bearer channels. In this respect, they are distinct from the isochronous services provided by the IEEE 802.9 PHY only in so far as they are separate channels with distinct SAPs.

5.3.1.2.4 Isochronous Layer 2/HMUX service boundary

As shown in figure 5-5, the HMUX sublayer transmits and receives C channels and B channels to and from the isochronous Layer 2.

An interface specification is provided in 9.2.4 that describes the logical signals that provide the isochronous service. These signals include information for distinguishing the transmit and receive information into separate channels, information to assist in framing (octet alignment), and timing information. To ensure a high degree of product interworking and vendor independence at the IEEE 802.9 isochronous service interface to the PHY layer, a description of the signals that implement this service is provided.

5.3.1.2.5 LAPD/HMUX service boundary

As shown in figure 5-5, the HMUX sublayer transmits and receives D channel information to and from the LAPD Layer. The D channel supports the signalling required to establish, maintain, and release CCITT ISDN call connections for bearer service.

The architectural support in IEEE 802.9 for scalable multiple independent services calls for flexible nondisruptive channel and bandwidth changes. In addition, the D channel supports extensions required to the CCITT Q.93x signalling protocols for the support of dynamic bandwidth allocation.

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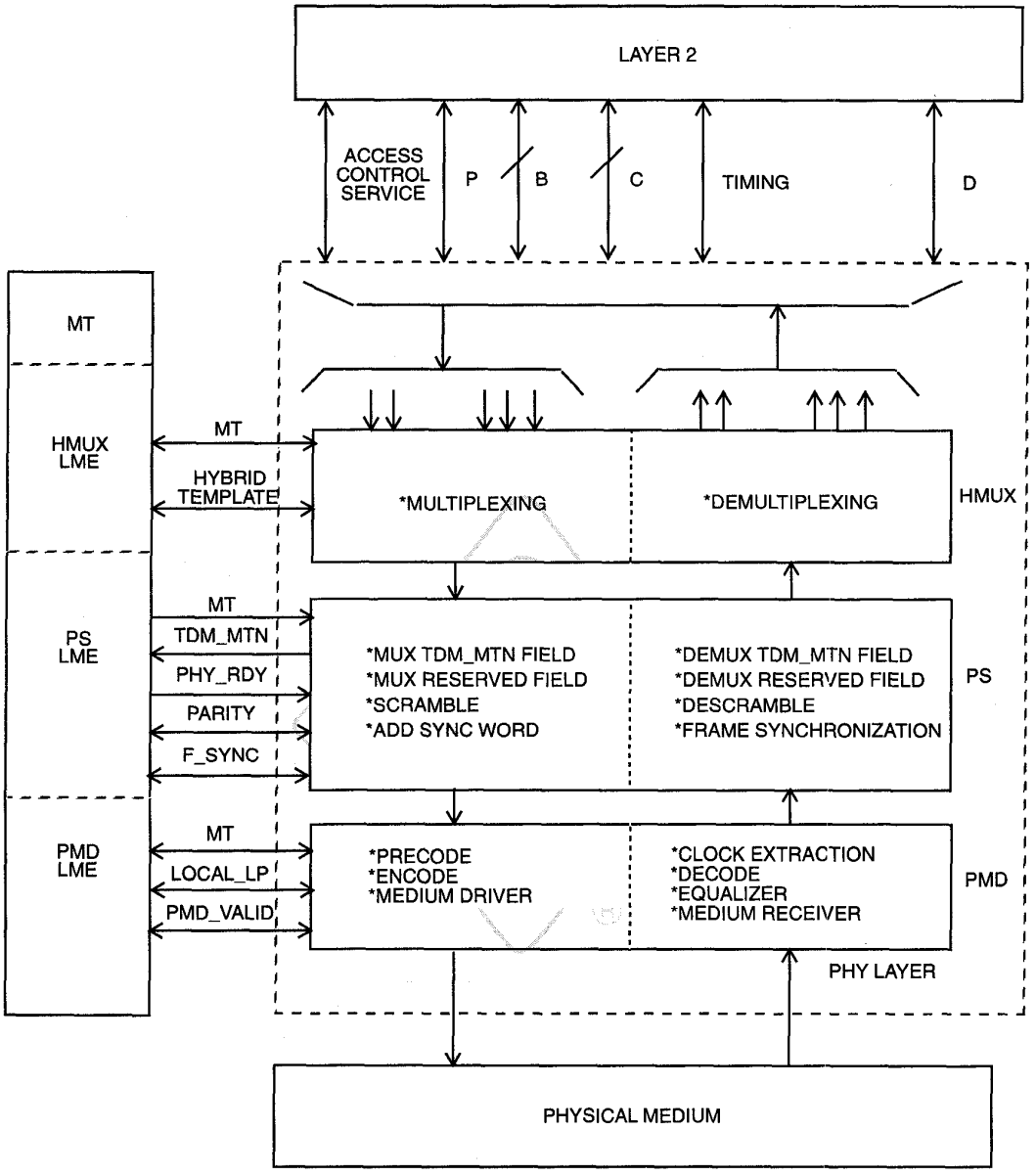


Figure 5-5—IEEE 802.9 ISLAN interface configuration

Chapter 11 and annex D describe the procedures and messages related to the dynamic bandwidth allocation of the 802.9 TDM payload.

5.3.2 PHY Layer

The PHY Layer performs functions such as multiplexing the multiple bit streams, adding and removing TDM framing and synchronization information, and providing access to the transmission medium. As shown in figure 5-3, the PHY Layer is subdivided into the HMUX, physical signalling (PS), and physical medium dependent (PMD) sublayers.

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A more detailed model of the PHY Layer is shown in figure 5-5. The functions of each sublayer and the interfaces between the sublayers are described in the following subclauses.

5.3.2.1 HMUX sublayer

The highest sublayer within the PHY Layer is the HMUX sublayer. This sublayer processes the contents of the hybrid multiplexer control (HMC) field in the IEEE 802.9 physical TDM frame. This sublayer provides an interface to the IEEE 802.9 MAC sublayer for the P channel and provides an interface to the user interface of the IEEE 802.9 isochronous services. One of the transmit functions of the HMUX sublayer is to multiplex streams of information from the higher layers and from the HMUX layer management into a single stream of octets for acceptance by the PS sublayer. The HMUX sublayer additionally demultiplexes the stream of octets received by the PS sublayer into a set of channels, each directed to an appropriate higher layer SAP. Finally, the HMUX sublayer provides the functionality needed to dynamically modify the allocation of the PS sublayer's TDM slots to connect and disconnect individual "N × 64 kb/s" channels without disrupting the activity of other channels.

5.3.2.1.1 HMUX/MT service boundary

The interface between the HMUX sublayer and MT includes template synchronization information for a dynamic bandwidth allocation of the P and C channels, generated through the bandwidth management service procedure. The information is mapped and multiplexed onto the HMC field of the TDM frame and transferred to the other peer. The interface also provides for the exchange of HMUX mode parameters.

5.3.2.1.2 HMUX/PS service boundary

The interface between the HMUX sublayer and the PS sublayer conveys the multiplexed information stream composed of P channel, P channel access control information, HMC, D channel, B channels, C channel(s), maintenance information, reserved field information, and timing information.

5.3.2.2 PS sublayer

The PS sublayer is responsible for interfacing between the HMUX sublayer and the PMD sublayer. As such, the PS sublayer is responsible for applying required processing to the multiplexed bit stream and the received bit stream before transmitting them to the PMD sublayer and the HMUX sublayer, respectively. The PS sublayer has an interface to layer management.

As shown in figure 5-5, the PS sublayer is responsible for a variety of functions. In the transmit direction, it completes the formation of an entire TDM frame by appending maintenance information, calculating parity, adding the resulting parity bit, scrambling the bit stream, and appending framing information. In the receive direction, the PS sublayer is responsible for establishing frame synchronization and removing the framing information field. The PS sublayer is responsible for the descrambling function and the parity check function on the received information stream, and for passing maintenance information on to layer management.

5.3.2.2.1 PS/MT service boundary

The interface between the PS sublayer and MT includes the maintenance information, such as activation/deactivation, remote loopback, the bit check result, and the framing status. The framing establishment and other conditions related to receiver function may be used to define PHY READY/NOT READY.

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5.3.2.2.2 PS/PMD service boundary

The interface between the PS sublayer and the PMD sublayer is defined in terms of the bit stream forming a complete IEEE 802.9 TDM frame. The service characteristics include quality of service (QOS) parameters. These QOS parameters include but are not limited to:

a) Single bit error (BER) and clock slips (Note that clock slips will be designated in terms of "data invalid." The data invalid signal may be presented 1 or 2 clock times later than the actual occurrence.)

b) Bit error clustering

c) Sublayer delay characteristics

Figure 5-6 illustrates the signal communication between the PS sublayer and the PMD sublayer.

5.3.2.3 PMD sublayer

The PMD sublayer provides the electrical interface to the physical medium. Included under the PMD sublayer are the functions necessary to connect the interface to the medium (UTTP in this case). Specifically, the PMD sublayer defines the medium dependent encoding method, the transmitter and receiver, physical cable and connectors, and other related issues. The PMD sublayer has an interface to layer management.

The IEEE 802.9 PS/PMD service boundary specification supports multiple media dependent sublayers. Therefore, multiple PMD definitions are possible. In this standard, two separate PMD specifications are described supporting two distinct premise distribution loop length configurations. The operational properties of the PMDs describe the properties and functionality for the transmitter and the receiver. This functionality includes a description of the pulse mask, transmitter output power spectrum and impedance characteristics, receiver input impedance characteristics, and the crosstalk and impulse noise requirements. This standard specifies the PMDs for:

— 4.096 Mb/s aggregate rate at 450 m
— 20.480 Mb/s aggregate at 135 m

5.3.2.3.1 PMD/MT service boundary

The interface between the PMD sublayer and MT includes the maintenance information, such as local loopback at the PMD/media interface.

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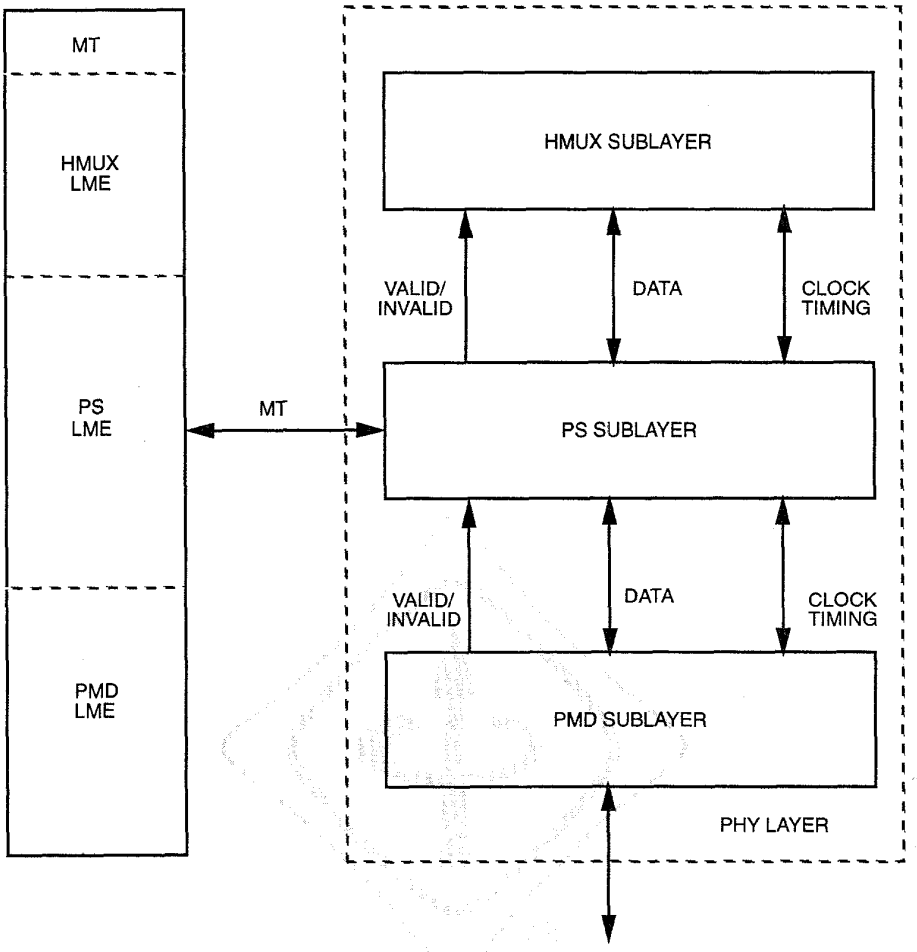


Figure 5-6—PS to PMD service boundary

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