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Wireless Access Method and Physical Layer

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TITLE: Similarities Between 802.9 IVD LAN and 802.11

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ABSTRACT

This contribution attempts to point out some of the work done by IEEE 802.9 Integrated Voice and Data LAN that is similar to proposals and ideas currently being explored by 802.11. The intent is to point out places where we can leverage existing work, places where we need to be compatible with existing work, and places where differences are essential.

A copy of an article from the October 1990 issue of *Lan Magazine* entitled "ISDNs and LANs Unite", by Gary C. Kessler, has been reproduced with permission of the publisher. This article serves as an excellent tutorial on the current direction of the 802.9 IVD LAN work and provides a basis for comparison between 802.9 and 802.11 philosophies and techniques.

1. INTRODUCTION

The attached article from the October 1990 issue of *Lan Magazine* entitled "ISDNs and LANs Unite", by Gary C. Kessler, has been reproduced with permission of the publisher. This article serves as an excellent tutorial on the current direction of the 802.9 IVD LAN work and should be read first in order to gain full appreciation of the following comments.

2. SYSTEM ARCHITECTURE

The 802.9 system architectural aspects are summarized in the section entitled "IVD LAN Overview". It is interesting to note that the overall system concept presented in Figure 1 is very similar to Extended System Architectures (ESAs) presented in previous contributions [1,2,3]. The access point proposed by those contributions that serves as an interface to existing networks and facilitates the exchange of information between devices in different coverage areas is similar to the 802.9 Access Unit (AU). The current 802.11 PAR calls for the specification of an air interface between devices and the specification of a backbone interconnection network. The air interface is analogous to the 802.9 IVD LAN Interface and the backbone is similar to the 802.9 Premise-Based Backbone.

The 802.9 standards work differs in that there is no treatment of a Basic Service Area (BSA) since communication directly between devices is not allowed, i.e., everything in an 802.9 network is relayed through at least one AU.

The 802.9 committee limited the scope of the standard to the IVD LAN Interface because specification of the AU and its backbone interfaces was viewed as not necessary due to the belief that an AU could be designed in many different ways, and the probable backbones are or will be standardized. Different realizations of the AU is viewed as a means for allowing competition, especially in terms of capacity, throughput, and performance, between AU manufacturers.

The 802.11 committee should adopt a similar philosophy in regards to access points to a premise backbone. We should strive to standardize an air interface and attempt compatibility with existing backbone standards efforts. A specially-designed backbone for a radio network is not necessarily a bad idea since it may help to achieve better performance, but it will require additional time to create.

3. CHANNELS and PROTOCOLS

The 802.11 committee should strive to provide support the channel types mentioned in the section entitled "Channels". These channels were explicitly chosen to satisfy the requirements of data, voice, and limited video (eg., 384 Kbps slow-scan) in a manner compatible with existing data, future voice, and future video networks.

The protocol architecture that results from these channel requirements is presented in Figure 2 and discussed in the section entitled "802.9 Protocols". A straw-man protocol stack for 802.11 was proposed at the last meeting in [4] and a copy of the model is attached. The major differences between the 802.9 and proposed 802.11 model are related to the support of isochronous services at the MAC sublayer and the multiplexing of asynchronous and isochronous information streams. Further discussion of these differences can be found in [4] and a companion contribution entitled *Providing Isochronous Services*.

4. TDM FRAME STRUCTURE

The TDM frame structure of 802.9 (shown in Figure 3) is not appropriate for 802.11 at the bits or bytes level; however, the overall format has some appeal if we replace bytes with packets. For example, the D-channel byte can be turned into a D-channel packet either by changing the framing rate from 125 μsec to several milliseconds or by having the D-channel packets share the P channel. In either case, the result is a bundling of the bits from an isochronous channel that arrive every 125 μsecs into packets that can be transmitted less frequently.

The 802.9 frame rate of 8000 frames per second is motivated by the need to transmit bits from the B and D channels every 125 μsecs. If 802.11 chooses to packetize these channels, then the frame rate will be determined not by the 125 μsec interarrival time, but by the need for synchronization in a radio LAN and by the delivery requirements of isochronous information.

In the overall structure of the frame, the Hybrid Template (HTEMP) and Access Control (AC) fields are particularly interesting. The HTEMP is used to allocate bandwidth to a particular service (channel type). For example, the current 802.9 use of the HTEMP field would be to allocate one or more C channels out of the P/C payload. A complete protocol is needed to coordinate the allocation, deallocation, and management of the C channels between IVD terminals (TEs) and the AU. This protocol could be extended to include the allocation of all isochronous channels, i.e., B, C, and D. The 802.9 committee has chosen to permanently allocate the B and D channels since they don't consume much bandwidth. The 802.11 committee should strive for more efficient utilization of capacity through dynamic channel allocation.

The AC field is used to control access to the P channel. Largely, it functions as a flow control mechanism for the AU. A sophisticated AU may be able to handle communications from all connected TEs at any time due to ample buffering and processing time; however, a less sophisticated AU may need to throttle traffic from the attached TEs. The request/grant protocol proposed to control traffic is described in the section entitled "P-Channel Access Control".

The HTEMP and AC protocols could form the basis of the protocols needed to manage isochronous and asynchronous channel management in 802.11. These protocols were still under debate in 802.9 as of the November 1990 Plenary with the AC protocol having gone through more discussion that the HTEMP protocol. More information on these protocols can be found in [5].

5. REFERENCES

[1] IEEE 802.11/90-10, Minutes of the IEEE 802.11 and 4L Working Groups, Intermediate Meeting, Oshawa, Ontario, Canada, September 10-14, 1990, pp. 20-32

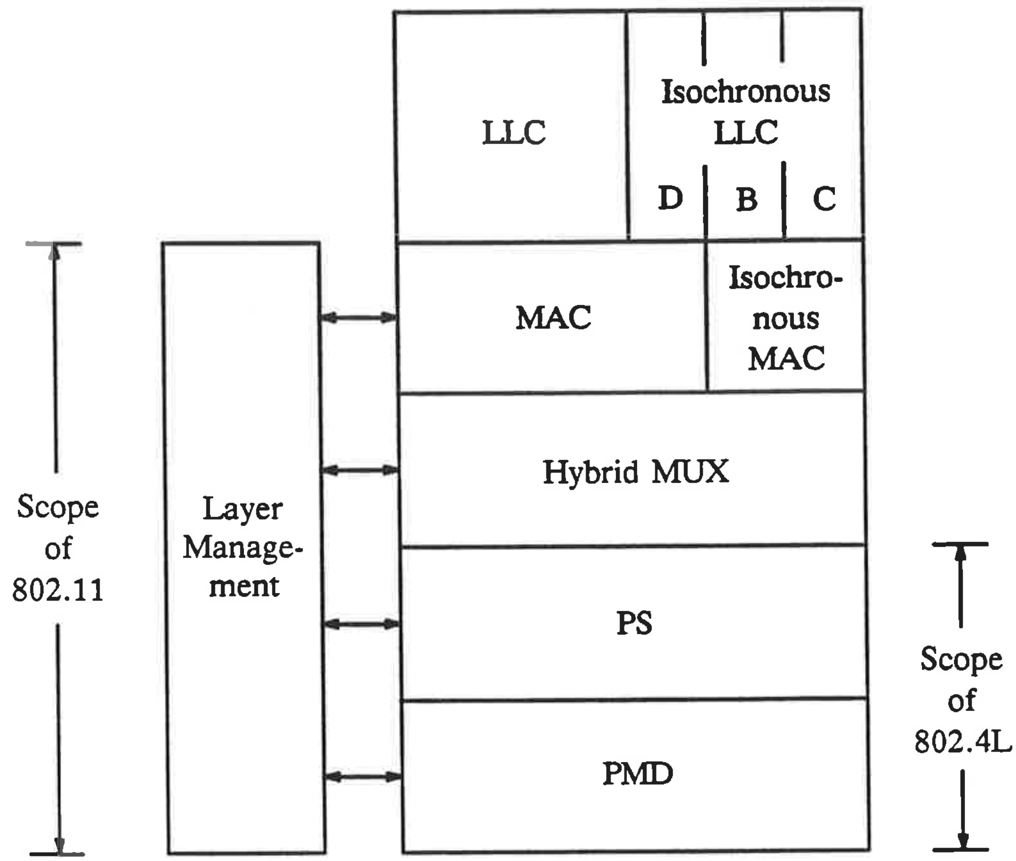
[2] IEEE 802.11/91-01, Wireless Signal Distribution Architectural Considerations

[3] IEEE 802.11/91-G11, A Proposed IEEE 802.11 Radio Lan Architecture

[4] IEEE 802.11/91-G9, "Straw-Man" Protocol Model

[5] IEEE 802.9/91-D11, IEEE 802.9 Draft Standard

[6] ISDNs & LANs Unite - The IEEE 802.9 Integrated Voice and Data Standard. Gary C. Kessler LAN Magazine October 1990



LLC = Logical Link Control
MAC= Medium Access Control
PS = Physical Signalling
PMD = Physical Medium Dependent

Figure 1. Integrated Data and Voice Architecture

STANDARDS

ISDNs & LANs Unite

THE IEEE 802.9 INTEGRATED VOICE AND DATA LAN STANDARD

by Gary C. Kessler

The IEEE 802.9 may be the offspring of a marriage between LANs and Integrated Services Digital Network. Combining voice with data such as words, numbers, and images allow people to communicate more naturally with computers. The virtual network may become a reality. The IEEE 802.9 standard to support integrated voice and data applications is evolving, although it is near completion.

People are multimedia oriented. We communicate better through a combination of words, images, video, and numbers than through a single one of these media. The physical integration of voice and data on a single network will result in new applications that will logically integrate voice, data and other media types.

Integrating voice and data on a single network offers long-term economic advantages. A customer needs only one Integrated Services Digital Network (ISDN) port per office, rather than separate voice and data ports. Service providers only have to maintain and manage a single network, rather than two.

ISDNs provide a viable wide area network (WAN) alternative for interconnecting LANs for several reasons. ISDNs will incorporate packet data services, including support for X.25 packet-switched hosts. This will protect a company's current investment in X.25 equipment. Voice/data terminals will become much more commonplace as ISDN service expands and integrated voice/data applications become more common.

Six Goals of 802.9

The IEEE is working on a standard to support voice and data over a single network. Several areas are still under discussion, although the standard is very near completion. In February 1986, the IEEE 802 Executive Committee formed an ad hoc study group on integrated voice/data (IVD) LAN solutions. In November, the ad hoc committee recommended that an 802 Working Group be formed to create an IVD LAN standard. Accordingly, the IEEE 802.9 Working Group was chartered to provide an interface for the "marriage of LANs and ISDN." The working group began to define a standard IVD LAN interface compatible with the already defined IEEE 802 LAN and CCITT ISDN standards, architectures, and services. (CCITT, which is part of the United Nation's International Telecommunication Union, is the primary agency creating international ISDN standards.)

According to the November 1986 recommendation to the IEEE 802 Executive Committee, an IVD LAN interface has the following functional requirements:

- It should be attractive to manufacturers and users from the perspectives of economy, installation, and network operation;
- It should provide IEEE 802 Media Access Control (MAC) services and ISDN-compatible voice and data services;
- It should target the current office environment by using existing twisted-pair wiring as well as providing sufficient bandwidth for voice, data, and IVD applications;
- It should support voice services of the quality now available and also support expected future improvements;
- It should allow for the implementation of a range of both centralized applications (such as connection to the public telephone network via a PBX) and distributed applications (such as access to shared databases via a LAN file servers and hosts);
- The IVD LAN physical layer and MAC sublayer must not depend upon any specific LAN with respect to arbitration, bandwidth, encoding scheme, and topology; and
- It should provide good fault isolation characteristics and maintenance procedures.

IVD LAN Overview

The IVD LAN standard is intended to provide an interface between integrated voice/data terminal equipment (IVDTE) and a backbone IVD network. The standard provides a high-bandwidth interface to the desktop in support of packet data service and isochronous (or time-sensitive) services. It is intended for operation over unshielded twisted-pair (UTP) wire.

The 802.9 standard describes the interface between the IVDTEs and the access unit (AU) as shown in Figure 1. An AU is a "black box" that sits between the network and the user station. IVDTEs are connected to an IEEE 802.9 AU in a physical star topology. A digital bit stream is sent over each point-to-point link between the AU and an IVDTE. This bit stream carries packet data, and isochronous data, such as voice, data, image, video, and facsimile. These bits are carried in separate channels on the line using time division multiplexing (TDM).

From the perspective of the IVDTE, 802.9 only defines the interface to the AU, and the AU provides all the services. This means that the 802.9 standard applies to two scenarios. First, the interface can be between an IVDTE and a standalone LAN, in which case the AU actually provides the IVD services. Second, the interface could provide the IVDTE with access to another network that provides the required services, in which case the AU is just a gateway to that other network.

If the AU is a gateway, it is attached to a backbone network that provides the IVD services. This backbone network may be existing IEEE 802 LANs, ISDN, an FDDI Metropolitan Area Network (MAN), or an IVD LAN (such as 802.6 MAN or FDDI-II). Figure 1 shows some of the possible interface configurations. The AU-to-backbone connection is beyond the scope of the

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IEEE 802.9 standard and, in any case, is transparent to the IVDTEs.

Channels

One difficult concept in ISDN or 802.9 is how multiple channels simultaneously share the wire. Each channel has a specific purpose or application. The easiest way to understand multiple channels is to compare them to a multiline telephone; each line on the telephone may serve a different user at any point in time.

Multiple channels share the same physical medium using TDM. Under TDM, every channel is assigned a block of time at specified intervals. Since the physical channel operates at a much higher bit rate than any individual channel, information loss doesn't occur.

The time-division multiplexed bit stream between the AU and IVDTE comprises several different full-duplex digital channels, each defined for a different purpose. These channels are:

P-channel: The packet channel provides an IEEE 802 MAC service for

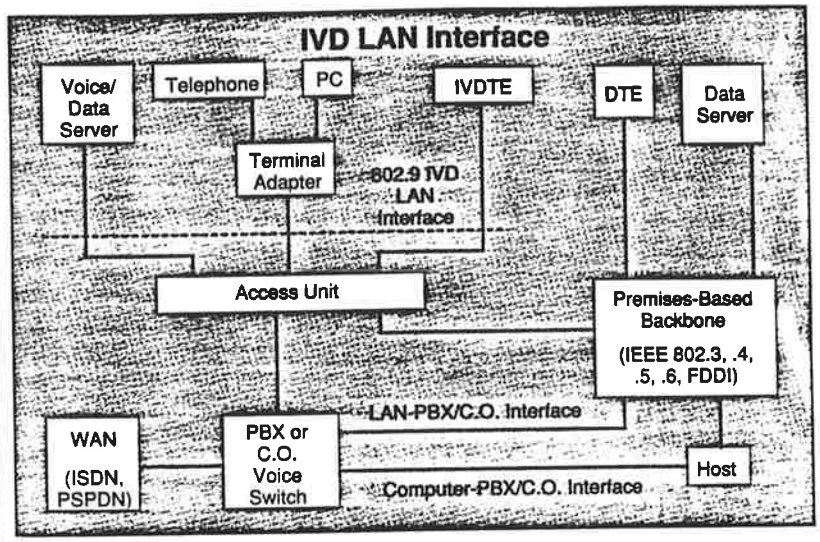

Figure 1 — *The 802.9 may interface between an IVDTE and a standalone LAN, in which case the AU actually provides the services. Or it may act as a gateway by providing the IVDTE with access to another network that provides the required services. If it is a gateway, the AU is attached to a backbone network.*

packet-mode or bursty data. The IEEE 802.9 MAC sublayer for the P-channel is described below.

D-channel: This 16Kbps or 64Kbps channel corresponds to the ISDN D-channel. In an ISDN, the D-channel is used primarily for the exchange of signaling information between the user and network for the provision of user services or *bearer services.* The CCITT Recommendation Q.930 (also named I.450) protocol family is to provide these services for user network signaling. The ISDN D-channel's secondary function is to carry user packet-mode data. The 802.9 D-channel will be used for user network signaling.

The ISDN basic rate interface (BRI) specifies a 16Kbps D-channel, while the primary rate interface (PRI) uses a 64Kbps D-channel. The 802.9 standard probably will support both channel rates to facilitate use of today's ISDN BRI terminals. Internetworking between 16Kbps and 64Kbps D-channels hasn't yet been addressed.

B-channel: This 64Kbps channel is identical to the ISDN B-channel. ISDN bearer services, such as voice, video, and time-sensitive data transfers, are provided on the B-channel. The 64Kbps rate was chosen for the B-channel since it is the rate of a single digital voice channel. Two B-channels are required by the 802.9 standard, which corresponds to the ISDN BRI.

C-channel: The circuit-switched channel has a bit rate that is a multiple of 64Kbps, for services requiring a bit rate greater than that available from a single voice channel. C_m indicates the C-channel's size, where "m" indicates the number of 64Kbps multiples. C-channels are similar to ISDN H-channels, which are higher-rate channels equivalent to predefined number of B-channels. The relationship between 802.9 C-channels and ISDN B- and H-channels is as follows:

C_1 = B = 64Kbps
C_6 = H_0 = 384Kbps
C_{24} = H_{11} = 1.536Mbps
C_{30} = H_{12} = 1.920Mbps

802.9 Protocols

Like other IEEE and ANSI LAN standards, the 802.9 protocol architecture has three parts: data link layer, physical layer, and station management. The IEEE 802.9 protocol architecture is shown and compared to the Open Systems Interconnection (OSI) model in Figure 2.

The 802.9 interface must provide support for different services, depending upon the user application and the channel used. Thus several different protocols are supported, all corresponding to the OSI data link layer.

The P-channel, a packet data channel, will use a new medium access control scheme and frame format defined in the 802.9 standard. Like other IEEE 802 LANs and ANSI's FDDI, the IEEE 802.2 Logical Link Control (LLC) protocol acts as the upper sublayer of the data link layer.

The 802.9 D-channel is essentially the same as the ISDN D-channel. Therefore, the 802.9 access unit will use the same protocol as ISDN, namely the Link Access Procedures on the D-channel (LAPD), described in the CCITT Q.920 (I.440) series recommendations. Control of B- and C-channel services will be accomplished through the ISDN call control procedures, as described in the CCITT Q.930-series recommendations. The D-channel can also support other ISDN services, such as frame relay, frame switching, and packet services, although this has not yet been defined in 802.9.

The B- and C-channels are used to carry bit streams related to the requested bearer services. As in ISDN, a data link layer is not specified for bearer channels since any protocol may be used that has been agreed upon on an end-to-end basis. The B-channel was intended for any 64Kbps isochronous service but its use has grown to provide many circuit-mode services, including switched 56Kbps and 64Kbps digital data and Group 4 fast facsimile. Packet data transfers on the B-channel typically use the CCITT Recommendation X.25 Link Access Procedures Balanced (LAPB) or LAPD. The C-channels, like ISDN H-channels, are wide-band isochronous channels for high-speed packet- and circuit-mode services, such as high-speed data transfers, video services, and image transfers.

Three sublayers in 802.9 accomplish functions corresponding to the OSI physical layer. These sublayers are the Hybrid MUX, Physical Signaling, and Physical Media Dependent.

The Hybrid MUX (HMUX) sublayer multiplexes bits from the B-, C-, D-, and P-channels into a single bit stream between the IVDTE and AU. This sublayer provides the interface between the physical layer and the user/control information.

The Physical Signaling (PS) sublayer provides an interface between the multiplexed bit stream and the actual

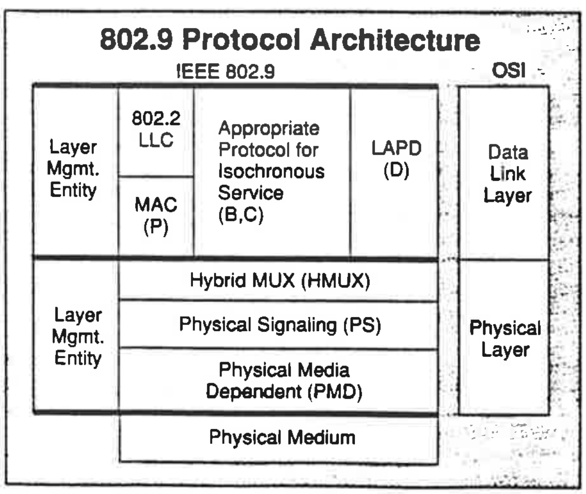

Figure 2 — *Because the 802.9 interface must provide support for different services, several protocols are supported.*

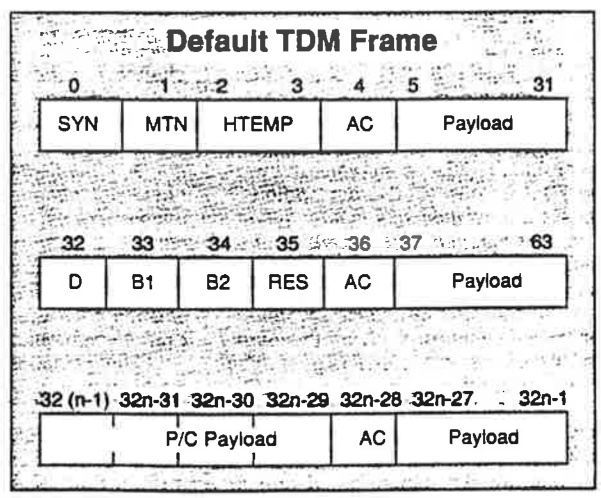

Figure 3 — *The numbers above the fields are the octet number in the frame.*

physical bit stream on the line. The PS sublayer appends maintenance information to the frame, calculates parity and adds the parity bit. It also scrambles the bit stream and appends framing information.

The Physical Media Dependent (PMD) sublayer defines the electrical and mechanical characteristics of the specific medium used, in this case, unshielded twisted-pair. It defines the specific signaling scheme, cable, and connector characteristics, as well as the transmitter's and receiver's electrical properties.

Finally, the Layer Management Entities (LMEs) are part of the interface's overall network management facilities. Each sublayer has a specific interface to its LME. The combination of all LMEs and the inter-LME communication define the network's Management (MT) entity. The network management features of the IVD LAN standard eventually should conform to OSI standards for system and layer management. Furthermore, management of the IVD LAN interface will also conform to the standards for managing the ISDN user network interface.

TDM Frame Structure

A TDM frame is the multiplexed bit stream carried on the wire between an IVDTE and an AU. A single TDM frame carries P-, C-, B-, and D-channel data, as well as additional synchronization, control, and maintenance information. The 802.9 standard supports an ISDN BRI, comprising two B-channels and a single D-channel, which is designated 2B+D. Since each channel in an 802.9 frame operates at 64Kbps while the ISDN BRI D-channel operates at 16Kbps, the 802.9 D-channel will support both rates.

The TDM frame fields are as follows. (Figure 3 shows the default TDM frame structure.)

Synchronization (SYN): Used to establish frame synchronization between the IVDTE and AU for exchanging TDM frames. (The exact coding is not yet determined.)

TDM Maintenance (MTN): Used to initialize the IVDTE and to exchange activation and deactivation information, diagnostic messages, and maintenance messages, such as the number of errors reported. (Again, the exact coding is not yet determined.)

Hybrid Template (HTEMP): Defines the location of the data (or payload) within the TDM frame. It also provides for the allocation of one or more channels of isochronous bandwidth for C-channels. The allocation of isochronous bandwidth determines the bandwidth of the P-channels, since P-channels occupy empty payload space on an ad hoc basis.

Access Control (AC): Defines the access control field for the 802.9 MAC for the P-channel. The 802.9 MAC scheme is discussed below; the REQUEST_BIT and GRANT_BIT described later are carried in this field. The AC field may also be used to identify the payload type and priority. (Exact coding is not yet determined.)

PAYLOAD: Payload area to carry P- and/or C-channel data. Since C-channels will carry isochronous information, time slots within this field usually will be pre-allocated for the C-channels and extra time slots will be used to carry nonisochronous P-channel data.

D: The 16Kbps or 64Kbps D-channel. The D-channel may be restricted to conveying only signaling information. All information in this channel will be packetized according to the call control procedures of the Q.930-series recommendations.

B1 and B2: One octet from each of the two ISDN B-channels. These two octet positions in the TDM frame are really assigned merely to carry payload information. The 802.9 standard, however, must support two B-channels and the default TDM frame places the B-channels in these octet positions.

Reserved (RES): Reserved channel; its use is to be determined.

A TDM frame is generated 8,000 times per second, or once every 125 microseconds; this corresponds to the sampling rate necessary to digitize human voice. Each 8-bit octet represents a single 64Kbps channel, corresponding to the bit rate of a single digital voice channel.

The smallest supported TDM frame contains 64 octets (or 256 bits); 8,000 frames per second, then, yields a line rate of 4.096Mbps. The TDM frame for the 4.096Mbps interface defaults to a bandwidth of 3.456Mbps for the C- and P-channel payload.

Some attention has already been paid to operating at higher speeds, particularly 16Mbps. For these higher-speed applications, the TDM frame will grow in 32-octet increments; this will yield incremental line rate increases of 2.048Mbps. As shown in Figure 3, each additional 32-octet block would carry 31-octets of payload, adding an additional 1.984Mbps of user data payload.

Consider a 256-octet TDM frame. At a rate of 8,000 frames per second, the line rate is 16.384Mbps. The payload for C- and P-channels would occupy 54 octets of the first 64 octets in the frame, and 31 octets of each remaining block of 32. Thus, the payload fields would comprise 240 octets [54 + (6 x 31)] and have a bandwidth of 15.36Mbps. Note that P- and C-channel payload would occupy 94 percent of the bandwidth of a 16Mbps channel. (Remember that this does not include the B- and D-channel data.)

Details for coding the non-default TDM frame are still undetermined.

802.9 MAC Frame

Flag	SID	FC	DA	SA	PDU	FCS	Flag

Figure 4 — *The MAC frame for the P-channel consists of five fields. The Service Identifier Number (SID), Frame Control (FC), Destination and source addresses (DA and SA), the Protocol Data Unit (PDU), and the Frame Check Sequence (FCS).*

MAC Frame Structure

P-channel data will be carried in an 802.9 MAC frame. Figure 4 shows the fields of the MAC frame, which are described below:

Flag: This one-octet bit pattern "01111110" is used to delimit the frame's start and end. (Depending upon the final choice of line code, the exact bit pattern for this delimiter might be changed by the final draft of the standard.)

Service Identification (SID): This one-octet field will identify the type of service provided on the P-channel. More specifically, it defines the type of data link layer frame used as the IEEE 802.2 LLC, ISDN LAPD, or X.25 LAPB. Other service types are being investigated, including a type called LAPD', which consists of a LAPD frame without the 16-bit Frame Check Sequence (FCS) field. (The LAPD FCS would be unnecessary since the 802.9 MAC frame has its own FCS.)

Frame Control (FC): This one-octet field indicates the type of MAC frame, such as information or control, and the frame's priority.

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Destination Address (DA) and Source Address (SA): Specify the station or stations intended to receive this frame and the address of the sending station, respectively. The address fields are 48 bits long and conform to other IEEE 802 48-bit addresses (see Figure 5). The first address bit transmitted (the least significant bit) in the DA field is called the individual/group (I/G) bit. The I/G bit indicates if this address specifies an individual station or a group of stations. In the SA field, the I/G bit is set to 0.

The universal/local (U/L) bit is next to be transmitted. If it is set to 0, it indicates that the specified address is part of an addressing plan that is administered locally in the network. If it is set to 1, it denotes that the addressing plan is administered by a central authority, such as the IEEE.

The remaining 46 bits contain the actual station address. A 46-bit field yields roughly 64 trillion possible station addresses.

Protocol Data Unit (PDU): This field contains MAC control information or user data from a higher layer. The maximum size hasn't been defined yet.

Frame Check Sequence (FCS): A four-octet field containing the remainder from the CRC-32 calculation, which is used to detect bit errors.

In all likelihood, MAC frames will be longer than 27 octets. Thus, 802.9 MAC frames will be carried in more than a single PAYLOAD field within the 802.9 TDM frames.

P-Channel Access Control

The 802.9 standard defines a point-to-point P-channel between each IVDTE and the access unit to which they are attached (see Figure 5). Each P-channel's bandwidth will vary with the services offered to the user by the individual IVDTE. The bandwidth available for the operation of a given P-channel will depend upon how much of the payload fields reserved for P- and C-channels are dedicated to the isochronous C-channels.

The P-channel access control scheme is a simple request/grant protocol. The simplicity is partly because the IVDTEs share access to the AU, but do not share access to a medium. Other 802 MAC schemes have peer systems sharing a common medium; the 802.9 standard has an intelligent AU to arbitrate access. The only shared resource is the AU itself. The request/grant protocol is associated only with the transmission of 802.9 MAC frames on the P-channel. The AU governs and controls the transmission of MAC frames from an IVDTE to the AU. The intended IVDTE receiver may or may not govern and control the transmission of MAC frames from the AU. When a station receives permission to transmit, it may send one complete MAC frame.

Figure 6 illustrates the operation of the request/grant protocol. When an IVDTE is ready to send a frame, it sets the REQUEST_BIT to 1 in the Access Control (AC) field of the TDM frame.

When the AU sees an incoming

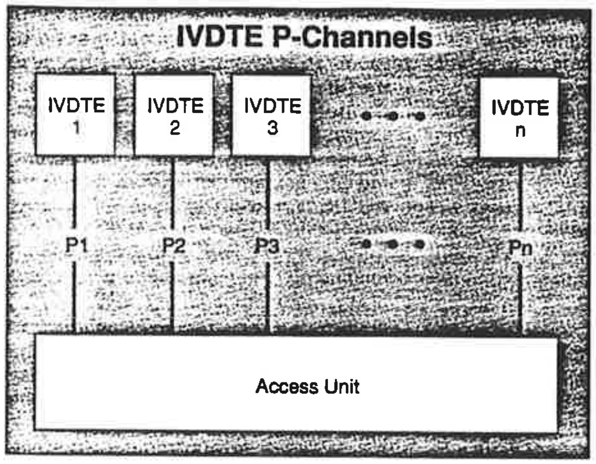

Figure 5 — *Each IVDTE attached to the access unit has a P-channel defined.*

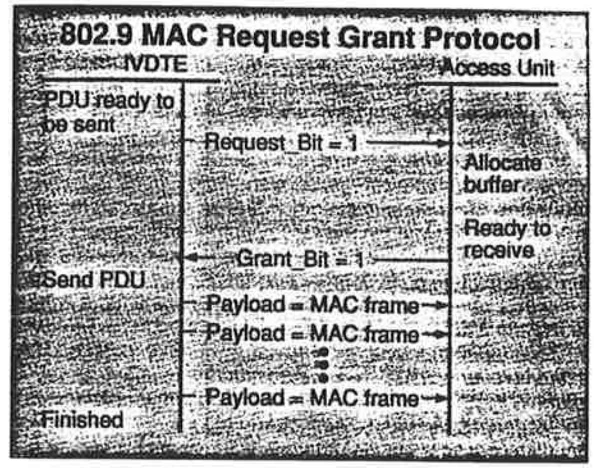

Figure 6 — *A single MAC frame may be sent in multiple Payload fields of 802.9 TDM frames. Each line above is one TDM frame.*

REQUEST_BIT, it ensures that adequate buffer space is available to accommodate P-channel MAC frames. When ready to receive a MAC frame, the AU sets the GRANT_BIT to 1, which is also carried in a TDM frame's AC field. If buffers in the AU are available for each P-channel, all IVDTEs theoretically could send 802.9 MAC frames simultaneously; however, because data traffic from the IVDTEs is bursty, it is unlikely that all IVDTEs will be ready to transmit at once. Therefore, AUs may be designed with fewer receive buffers than the number of P-channels; in this case, some IVDTEs may incur some delay before receiving permission to transmit.

When the IVDTE sees the GRANT_BIT set, it may send one complete MAC frame. A single MAC frame may be sent in multiple Payload fields of 802.9 TDM frames. This scenario would be reversed if the AU's transmissions are controlled by the IVDTE.

Physical Layer Features

The 802.9 standard specifies two unshielded twisted-pair wires between the IVDTE and AU. It also recommends a maximum length of 450 meter telephone-grade cable with a 0.5 mm diameter to operate at 4.096Mbps; another cable specification will be provided for higher speeds.

As recently as six years ago, even 1Mbps transmission over UTP was touted as impossible; today, rates of 100Mbps have been achieved. The sacrifice for high speed is distance. ANSI T1.601's ISDN BRI standard for the local loop supports a bit rate of 160Kbps (or 80Kbaud) over distances up to about 18,000 feet. The 802.9 standard supports a much higher bit rate at a much shorter distance.

To decrease the probability of electromagnetic interference and to ensure that receiver functions, such as clock recovery, work properly, the TDM frame bit stream is scrambled prior to transmission. The 802.9 scrambling algorithm is similar to the one used over the U reference point (the local loop) in the ISDN BRI.

An eight-pin module connector has been specified for the UTP cable connecting the IVDTE and the AU, as specified in ISO standard 8877. This same connector is specified for ISDN BRI (CCITT Recommendation I.430) and the IEEE 802.3 type 1Base5 (Starlan) standard. Pin assignments will be as follows:

Pin , Function
1 IVDTE Transmit
2 IVDTE Transmit
3 IVDTE Receive
4 (Unused)
5 (Unused)
6 IVDTE Receive
7 (Reserved)
8 (Reserved)

The IVDTE will use pins one and two to transmit to the AU. It will use pins three through six to receive from the AU. Pins four and five are unused; pins seven and eight are reserved for other applications. These assignments are the same as 1Base5 standard.

The standard does not require that the AU remotely feed power to the IVDTE, but pins seven and eight may be used for this purpose. Furthermore, the AU may supply phantom power over pins one and two and three through six, although the standard does not specify this. The standard does state, however, that any further 802.9 work with respect to powering of the IVDTEs should be as consistent as possible with the ISDN BRI standard.

Status of the Standard

The IEEE 802.9 Working Group has been preparing new drafts of the standard every few months for the past several years. Although this standard is evolving, the major framework described here should remain much the same as it nears its final stages. This article is based upon Draft 10 dated July 8, 1990. Draft 11 may be available by the time this article appears.

The 802.9 standard is expected to go to letter ballot by early 1991 and could be adopted as an IEEE/ANSI standard by the end of 1991 or early 1992. Products supporting this standard could appear around the same time. The number of 802.9 products will depend in large part upon the availability of ISDN service, IVDTE hardware, and IVD applications. ❑

Thank You
Allan Cobb of York University Academic Computing Services, chair of the 802.9 Working Group, gave me insight into the 802.9 standard and its status. Kwame Boakye of AT&T Paradyne, chair of the 802.9 MAC/LLC Task Group, also provided information.

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