IEEE P802.11
Wireless Access Method and Physical Layer

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TITLE: "Straw-Man" Protocol Model

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SUMMARY

This contribution attempts to shed some light on the degree of work required to generate a successful 802.11 draft standard. A protocol model is derived from the requirements specified in the PAR and areas for further work are listed wherever possible. Contrasts between the 802.11 PAR and historical 802.4L work have been drawn wherever possible based on existing 802.4L documentation (eg., contributions, meeting notes, IBIS, etc.). The protocol model is also contrasted to other models.

The basic conclusion is that the scope of work of 802.11 is much more encompassing than that defined in the charter of 802.4L. In addition to creation of a PHY, there are now requirements to create a MAC, support voice services, and address markets other than those generally focused on by the 802.4 Token Bus standard. The proposed protocol model and accompanying discussion is an attempt to define some of the issues and provide direction for further contributions. As such, it should be viewed as a "straw-man" proposal that elicits other ideas and helps lead to consensus in the committee.

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1. INTRODUCTION

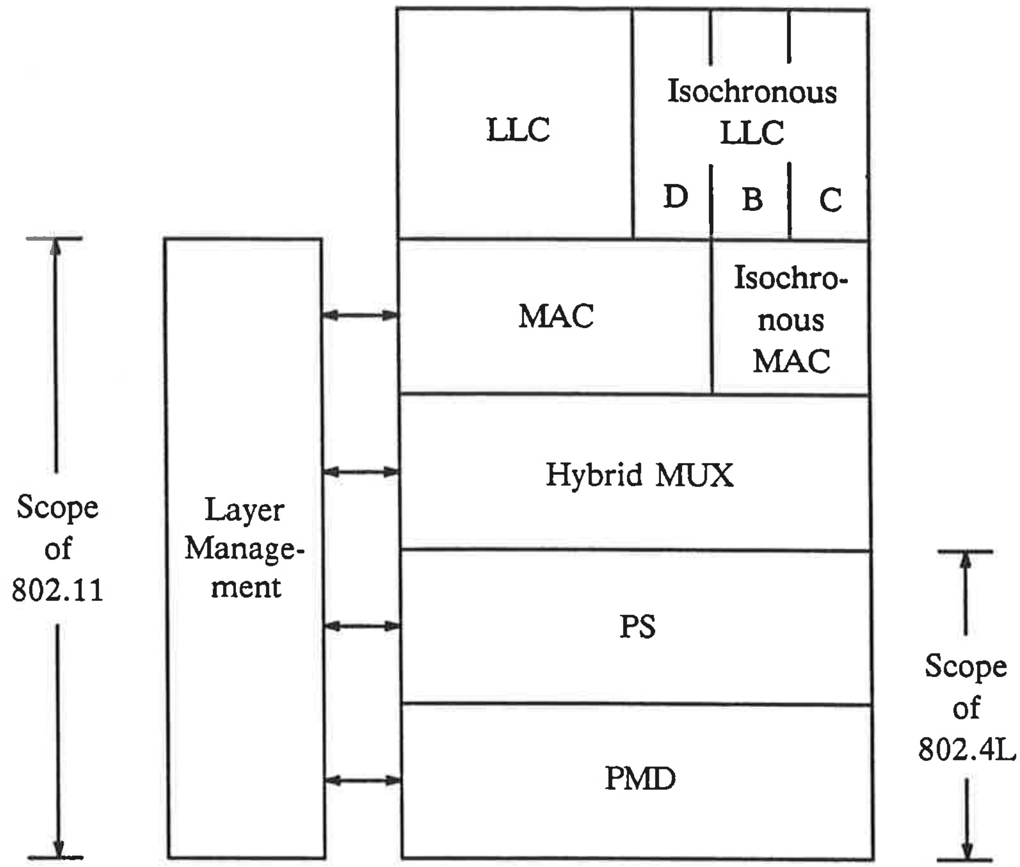
A companion contribution, "Wireless In-Building Network Market Considerations" by Mil Ovan, has shown that a large market exists for wireless LANs that serve the desktops of the office. Some of the important requirements of that market are high capacity in terms of number of users, compatibility with existing wired networks, short response times, support for a variety of data traffic types and patterns, and support for a variety of voice services. The following ideas are presented with this market and its requirements in mind.

2. THE PROPOSED MODEL

The model presented in Figure 1 was derived by considering the requirements for an 802.11 draft standard as stated in IEEE P802.11/90–20 Proposal for PAR and by looking at similar models from IEEE 802.9 and FDDI (Attachments A and B respectively). The model includes the data link and physical layers of the ISO model and makes no attempt to define services or the service boundary between the data link and network layers or any layers above. This is largely due to the perception that the work of P802.11 is to define a MAC and PHY layer. This statement is not to be construed as an argument for disregarding consideration of higher layers of the ISO model during discussions of the overall system environment or architecture, but rather as a limiter of the scope of this contribution.

The model in Figure 1 is of an integrated data and voice architecture, more properly of an integrated asynchronous packet and isochronous packet architecture. The B, C, and D channels in the data link layer are meant to reference similar concepts found in 802.9 IVD LAN. These services are for the provision of voice that is compatible with ISDN (B and D channels) and other isochronous services that are multiples of 64 Kbps (C channels -- eg., 384 Kbps for slow-scan video). While inclusion of these services may not be exactly what is meant by the phrase "as well as a service supporting packetized voice" found in the 802.11 PAR, it seems that only voice services equivalent to those found in today's office environment are marketable, and not choosing ISDN for future voice networking would be contrary to the current direction of the telephone industry.

The model does not include the security layer being introduced by P802.10 Secure Data Exchange between the LLC and MAC layers because it is viewed as optional. At the same time the model does not preclude the addition of the security layer. The security layer can be added between LLC and MAC, between D channel and MAC, or between B or C channels and the isochronous MAC. This is true only if the ISDN channels can be converted from bit and byte orientation to packets that easily take the form of MAC Service Data Units (MSDUs). More about this later.



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

Figure 1. Integrated Data and Voice Architecture

3. LLC-MAC SERVICE BOUNDARY

The model proposes two different classes of service at the LLC-MAC boundary: (1) traditional LAN services, and (2) ISDN-like voice (64 Kbps) and other services where guaranteed periodic access is essential (eg., 384 Kbps slow-scan video).

3.1. Traditional LAN Services

These are well-understood and documented in the 802.2-802.5 standards. The 802.11 draft standard should include similar descriptions to assure compatibility with existing standards.

3.2. ISDN-like Services

Voice services are an essential part of the office desktop. ISDN-like services are proposed since compatibility with existing PBX and CENTREX systems is difficult at best and voice service that is less capable than existing PBX or CENTREX services would not have substantial market appeal. ISDN compatibility is desirable simply because it is the method of choice for future voice and low-speed data networks and creating something different than ISDN for voice would surely meet with raised eyebrows and/or hardy guffaws.

The ISDN-like services suggested by the model aren't so well-understood. A radio network cannot support ISDN services as currently specified by CCITT. Radio standards such as GSM, USDC, DECT, and PCN all address ISDN compatibility, but do not completely follow the ISDN recommendations since packetized voice is desired for efficient use of radio capacity. There are also requirements for managing a radio voice network (eg., cellular hand-offs) that are not currently addressed in the ISDN recommendations. The lesson that these radio standards efforts teach is that the bit streams from ISDN can be accumulated into MSDUs that are appropriate for a radio MAC.

The D-channel in ISDN is defined as an asynchronous, packet-based stream whose protocol data units (PDUs) are defined by LAPD. The D channel provides many different services, for example, control for call connection and maintenance and slow-speed data such as those required by RS-232 devices (PADs, terminal servers) and monitoring devices (security, fire alarms). The D-channel tends to behave in the same manner as a slow-speed LAN with little or no regard to priorities or periodic service. So it appears that the traditional MAC services provided by other LAN standards could be used for D channel traffic if the LAPD PDUs are somehow made into 802.11 MSDUs.

The B and C channels are a different story. These are defined as clear channels which can be interpretted to mean that the protocol that defines the meaning and format of the bit stream is unknown at the data link layer. These bits can be assembled into P802.11 MSDUs but carry the constraint of periodic and timely delivery. Some would view this as a requirement for prioritizing between asynchronous and isochronous traffic (Asynchronous Transfer Mode); while others would view this as the need for periodic access (Synchronous Transfer Mode). In either case, the notion of periodic and timely delivery would have to be communicated across the LLC–MAC boundary.

4. MEDIUM ACCESS CONTROL

The LLC layer in the model can provides two types of traffic streams -- asynchronous and isochronous -- to the MAC layer. Each type places different requirements on the access technique. The following paragraphs discuss some of the characteristics and possible areas for exploration for each of the different traffic streams. The division of the discussion into two separate sections is not meant to imply that two MACs are absolutely necessary. It may be that one MAC can provide the services for both types of traffic.

4.1. Asynchronous Traffic

For a long time (approximately 2 1/2 years), the 802.4L committee labored to understand the applicability of the token bus access technique to a radio network. They are to be applauded for their efforts and their resolve in trying to make radios work under the 802.4 MAC. The general conclusion of the 802.4L group is that the 802.4 MAC is inappropriate for radio network, and hence, the need for 802.11.

An appropriate radio MAC for asynchronous traffic would be based on proven radio access techniques such as traditional ALOHA and its derivatives, CSMA, or reservation schemes such as those used in satellites.

The type of traffic generated by the 802 LLC is well-known. The type of traffic generated by the ISDN D channel is similar in nature to 802 LLC except that the format is according to LAPD (derivative of HDLC as is 802 LLC). The convergence of these two protocols to a common MSDU format may have to be addressed as part of defining the MAC frame format. There may also be a few other subtle differences between 802 LLC and the ISDN D channel that need investigation. There have been strong proponents of this type of convergence in 802.9 and other standards forums, so it appears safe to believe that little stands in the way of achieving convergence.

4.2. Isochronous Traffic

The isochronous traffic is connection-oriented in that connection allocation and deallocation procedures, a method for exchanging user information, and maintenance procedures are required. The control functions are generaly handled via traffic in an out-of-band channel. For example, in ISDN the D channel provides the facility for achieving B channel allocation, deallocation, and maintenance, while the B channel provides for the exchange of user information.

The B channels in ISDN carry the truly isochronous traffic. The MAC would have to provide a mechanism for the allocation, deallocation, and maintenance of access to periodic bandwidth that meets the delivery requirements of the isochronous traffic. This could be done via an asynchronous access technique that gives higher prirorities to isochronous traffic or by establishing some permanent periodic bandwidth for the duration of the connection.

At first blush, a system that prioritizes packets might appear desirable based on the fact that other LAN standards (802.4, 802.5) have successfully incorporated access priority schemes. Even further, these schemes have been accomplished via distributed control -- the underlying assumption being that every station in the network could receive the current priority information by monitoring all transmitted tokens or packets. It is usually not safe to assume that all stations in a radio network will receive all transmissions, especially if half-duplex radios or directional antennas are used. This leads to the conclusion that maybe a priority scheme alone is not the best way.

The second alternative of establishing permanent periodic bandwidth is much similar to the current ISDN and other digital cellular standards. The major requirement is a TDMA frame which provides the periodic access for isochronous traffic. Most other integrated data and voice standards committees have chosen to follow this line of development. Examples are the previously-mentioned cellular work, 802.9 IVD LANs, and FDDI II.

A third alternative is to find a compromise between the first and second. This appears to be the direction that 802.6 has taken. Here again the basic assumption is that every station can monitor all the traffic in order to gain access to one or more cells of a TDMA frame. The actual usage of a cell by a station could be based on priorities or permanent allocation.

What seems to be apparent is that properly handling voice and other isochronous traffic is not a simple matter. There is ample evidence of techniques that will work, but making a decision for 802.11 will require a bit of investigation.

5. HYBRID MUX

The Hybrid MUX serves several purposes. One purpose is to combine asynchronous packets, isochronous packets, and access control packets from the MAC into a stream of bits or bytes that can be delivered to the PS layer. Another purpose is to receive bits or bytes from the PS layer and distribute them to the proper destinations in the MAC. In addition, synchronization or other maintenance information may have to be communicated between the MAC, Hybrid MUX and PS layers.

6. PHYSICAL SIGNALLING

The purpose behind proposing this layer is the perception that a TDMA frame is necessary and that synchronization and maintenance of the TDMA frame would largely be handled at this level. It would be desirable that a TDMA frame structure and its control would be independent of different radio signalling techniques. The vernacular concerning frames may be a bit confusing. The important point to consider is that a TDMA frame conveys one or more MAC frames, i.e., a TDMA frame is not to be viewed in the same light as a MAC frame. Therefore, a TDMA frame requires its own procedures for management as do MAC frames.

The management of a TDMA frame consists largely of delimiting the frame boundaries, providing low-level maintenance checks between synchronized devices, and assuring that any TDMA frame information (eg., synchronization pattern, maintenance fields, etc.) are error protected.

In the 802.9 draft standard, scrambling and descrambling have also been included at this level. The implication is that the same scrambling technique can be used for any modulation technique defined in the PMD layer. This may or may not be possible for our standard, but we should strive to make scrambling common.

7. PHYSICAL MEDIUM DEPENDENT

This layer is ripe with contentious issues -- spread-spectrum vs. narrowband, licensed vs. unlicensed, frequency allocation, modulation schemes, antenna designs, etc. The work of 802.4L focused largely on the spread-spectrum related issues including chip rates, conformance to FCC regulations, modulation techniques, transceiver design, propagation, interference, and attenna design. There is a wealth of information regarding proposals and decisions in the 802.4L documents.

The current focus of the 802.11 committee is on spread-spectrum technology. Spread-spectrum has many advantages chief of which are that the FCC has ruled on its use, it is unlicensed, and the technology is well-known. Its major limitations rise from the inability to achieve high bit rates (> 2 Mbps) under existing FCC rules and the fact that interference can be a problem. These are significant problems in serving the desktop market.

A second focus of the committee is on acquiring a favorable ruling from the FCC so that unlicensed spectrum in the range of 70-140 MHz is allocated for either spread-spectrum or narrowband use. Comments and responses on FCC General Docket 90-314 have been the major vehicle so far for soliciting this allocation. The benefit to this approach is tremendous in that the 802.11 committee would be able to pretty much do whatever it wants for achieving high capacity and controlling interference. The disadvantage is that no one can predict when, if ever, such an allocation would be granted.

Another possibility is the DTS band at 18 GHz. Its advantages are that the FCC has ruled on its use, 100 MHz of spectrum is available (precisely what 802.11 has requested in its comments to the FCC docket) in 10 MHz increments, and narrowband technology can be used to achieve high bit rates. Its perceived disadvantages are the fact that it is licensed and 18 GHz technology is expensive. The ability to achieve high capacities in terms of bit rates (and consequently number of users) plus the use of licensing to control interference make this a good option for the desktop market.

The current discussions in 802.11 may be headed in three directions -- each having its advantages and disadvantages. Therefore, the philosophy of the model is to allow any one of these to work with the higher layers, thereby creating a standard that is flexible enough to address different markets.

8. LAYER MANAGEMENT

The Layer Management part of the 802.11 draft standard must conform to the 802.1F Guidelines for the Development of Layer Management Standards and be consistent with 802.1B LAN/MAN Management. Largely, this task consists of learning the syntax necessary to specify and define managed objects. This may appear as a simple task on the surface; however, more than one committee has found dealing with management issues to be quite time-consuming.

9. OTHER OBSERVATIONS

The above discussion has made no attempt to address conformance testing. The 802.11 PAR does seem to imply different degrees of conformance because of the phrases "minimally conformant network" and "full conformance". Precisely what these phrases mean in terms of conformance testing are unknown and will eventually have to be defined.

This contribution has also made no attempt to address the subjects of Basic System Architecture (BSA) and Extended System Architecture (ESA). This is largely due to the perception that discussion of these topics would best be handled as a separate contribution(s).

The current model has not defined a boundary between MAC and PHY. This is due in large part to not being able to decide whether the HMUX layer should reside in the MAC or PHY. Further discussions are needed to decide which is the case.

In conclusion, the proposed model is meant as a "straw-man" proposal to elicit ideas and discussion. As with all work in standards organizations, every proposal is subject to compromise. It is hoped that this contribution will both open up areas for discussions and focus the committee.

Attachment A

IVD LAN INTERFACE MODEL

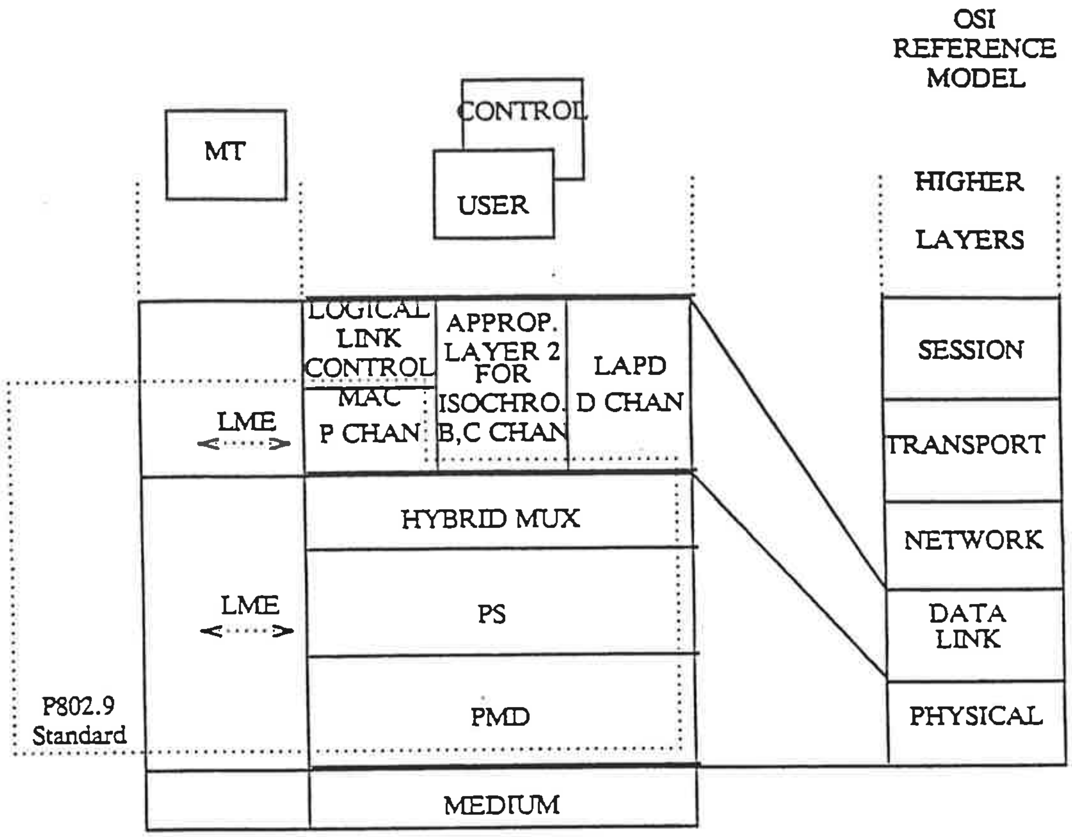


Figure 2-3. Relationship of IVD LAN Interface Model to OSI Reference Model.

The packet and isochronous channels are multiplexed at the Hybrid MUX 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 Physical 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 (MT) entity.

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

2.3.1 Data Link Layer

The role of the Data Link Layer 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.

- Frame Delimiting: The capability to indicate where the Data Link PDU begins and ends. This involves the recognition of a sequence of bits or octets transmitted over a physical medium as a frame.
- Transparency: The capability to transfer a PDU regardless of content, format or coding.

FDDI Architecture