IEEE Standards for Local and Metropolitan Area Networks: Overview and Architecture

Sponsor

Technical Committee on Computer Communications of the IEEE Computer Society

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Abstract: IEEE Std 802-1990, IEEE Local and Metropolitan Area Networks: Overview and Architecture, provides an overview to the family of IEEE 802 Standards, defines compliance with the family of IEEE 802 Standards, describes the relationship of the IEEE 802 Standards to the Open Systems Interconnections Basic Reference Model [ISO 7498:1984] and explains the relationship of these standards to the higher layer protocols, and provides a standard for identification of public, private, and standard protocols.

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Foreword

(This Foreword is not a part of IEEE Std 802-1990, IEEE Standards for Local and Metropolitan Area Networks: Overview and Architecture.)

This standard is part of a family of standards for Local and Metropolitan Area Networks. The relationship between this standard and the other members of the family is shown below. (The numbers in the figure refer to IEEE Standard numbers.

Relationship Among IEEE Project 802 Working Groups and Technical Advisory Groups

The family of IEEE 802 Standards includes publications, projects, and activities that define standards, recommended practices, and guidelines in the following areas:

- IEEE Std 802*: Overview and Architecture. This document forms part of the 802.1 scope of work.

* 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.

† 802.10 is co-sponsored by the Technical Committee on Computer Communications (which sponsors Project 802) and also the Technical Committee on Security and Privacy.

‡ Formerly IEEE Std 802.1A.
IEEE Std 802 provides an overview to the family of IEEE 802 Standards, defines compliance with the family of IEEE 802 Standards, describes the relationship of the IEEE 802 Standards to the Open Systems Interconnection Basic Reference Model [ISO 7498:1984] and explains the relationship of these standards to higher layer protocols, and provides a standard for identification of public, private, and standard protocols. Standards for internetworking and management are found in other documents in the IEEE 802.1 series. Specifications for layer-specific manageable objects are to be found in sections of ISO 8802-2 [ANSI/IEEE Std 802.2], ISO/IEC 8802-3 [ANSI/IEEE Std 802.3], ISO/IEC 8802-4 [ANSI/IEEE Std 802.4], IEEE Std 802.5, P802.6, P802.9, and P802.11.
The reader of this document is urged to become familiar with the complete family of standards. Readers wishing to know the state of revision should contact the 802.1 Working Group Chair via

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IEEE Standards for Local and Metropolitan Area Networks:
Overview and Architecture

1. Introduction

1.1 Scope and Purpose. This document serves as the foundation for the family of IEEE 802 Standards published by IEEE for Local Area Networks (LANs) and Metropolitan Area Networks (MANs). It contains descriptions of the networks considered as well as a reference model for protocol standards. Compliance with the family of IEEE 802 Standards is defined, and a standard for the identification of public, private, and standard protocols is included.

1.2 Key Concepts. The LANs described herein are distinguished from other types of data networks in that they are optimized for a moderate-sized geographic area, such as a single office building, a warehouse, or a campus. The IEEE 802 LAN is a shared-medium peer-to-peer communications network that broadcasts information for all stations to receive. As a consequence, it does not inherently provide privacy. The LAN enables stations to communicate directly using a common physical medium on a point-to-point basis without any intermediate switching node being required. There is always need for an access sublayer in order to arbitrate the access to the shared medium. The network is generally owned, used, and operated by a single organization. This is in contrast to Wide Area Networks (WANs) that interconnect communication facilities in different parts of a country or are used as a public utility. These LANs are also different from networks, such as backplane buses, that are optimized for the interconnection of devices on a desk top or components within a single piece of equipment.

A MAN is optimized for a larger geographical area than a LAN, ranging from several blocks of buildings to entire cities. As with local networks, MANs can also depend on communications channels of moderate-to-high data rates. Error rates and delay may be slightly higher than might be obtained on a LAN. A MAN might be owned and operated by a single organization, but usually will be used by many individuals and organizations. MANs might also be owned and operated as public utilities. They will often provide means for internetworking of local networks. Although not a requirement for all LANs, the capability to perform local networking of integrated voice and data (IVD) devices is considered an optional function for a LAN. Likewise, such capabilities in a network covering a metropolitan area are optional functions of a MAN.
1.3 Application and Support. The networks are intended to have wide applicability in many environments. The following lists are intended to show some applications and devices and, as such, are not intended to be exhaustive, nor do they constitute a set of required items:

- File transfer
- Graphics
- Word processing
- Electronic mail
- Data base access
- Digital voice
- Office automation
- IVD applications
- Query/response

The networks are intended to support various data devices, such as

- Computers
- Terminals
- Mass storage devices
- Printers and plotters
- Photocopiers and telecopiers
- Image monitors
- Monitoring and control equipment
- Gateways and bridges to other networks
- IVD devices; this includes IVD terminals and any end system capable of IVD functionality in a LAN or MAN capable of networking such devices.

1.4 A Family of Standards. The terms Local Area Network and Metropolitan Area Network encompass a number of data communications technologies and applications of these technologies. So it is with the IEEE 802 Standards. In order to provide a balance between the proliferation of a very large number of different and incompatible local and metropolitan networks on one hand, and the need to satisfy certain applications or cost goals on the other hand, several types of medium access technologies are currently defined in the family of IEEE 802 Standards. In turn, these medium access control (MAC) standards are defined for a variety of physical media. A logical link control (LLC) standard, a secure data exchange standard, and medium access control bridging standards are intended to be used in conjunction with the MAC standards. An architecture and protocols for the management of IEEE 802 LANs are also defined.

1.5 References. The following publications shall be used in conjunction with this standard:

[1] Reserved for future use.¹

¹ When the following IEEE project is approved, it will become a part of this reference section: P802.1B: LAN/MAN Management. Available from IEEE Computer Society Documents, c/o AlphaGraphics, ATTN: P. Thrush, 10215 N. 35th Ave., Suite A & B, Phoenix, AZ 85051.

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3 See Footnote 2.

4 When the following IEEE project is approved, it will become a part of this reference section: P802.1F: Recommended Practices for the Development of IEEE 802 LAN/MAN Management Standards. For availability, see Footnote 1.

5 ISO and ISO/IEC documents are available from ISO Central Secretariat, 1 rue de Varembé, Case Postale 56, CH-1211, Genève 20, Switzerland/Suisse; and from the Sales Department, American National Standards Institute, 1430 Broadway, New York, NY 10018, USA.

6 ISO (IEEE) and ISO/IEC (IEEE) documents are available from ISO Central Secretariat, 1 rue de Varembé, Case Postale 56, CH-1211, Genève 20, Switzerland/Suisse; and from the Service Center, Institute of Electrical and Electronics Engineers, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331.

7 IEEE documents are available from the Service Center, Institute of Electrical and Electronics Engineers, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331.

8 When the following ISO/IEC project is approved, it will become a part of the reference section: JTC1 DTR 10178, Information technology—Telecommunications and information exchange between systems—The structure and coding of link service access point addresses in Local Area Network.
2. Compliance

IEEE 802 compliance shall be with respect to specific IEEE 802 Standards (e.g., 802.3, 802b, 802.1D). Each standard for which compliance is claimed shall be described without ambiguity. Because of the breadth of topics (some mutually exclusive) that are sponsored by the family of IEEE 802 Standards, a claim of compliance with IEEE 802 is meaningless without reference to specific standards within the IEEE 802 family of standards. Therefore, products SHALL NOT say “IEEE 802 compatible” nor use equivalent terms. If they are claiming compliance specifically with this standard, the product shall, as a minimum, say “IEEE Std 802-1990 compatible.” Otherwise, products shall, as a minimum, say “IEEE 802.x compatible” or use equivalent terms, where x is replaced with a numerical designator (e.g., 802.7); or “IEEE 802y compatible” or use equivalent terms, where y is replaced with a letter designator (e.g., 802c); or “IEEE 802.xy compatible” or use equivalent terms, where x and y are replaced respectively with a numerical and a letter designator (e.g., 802.1E).

Describing, advertising, or promoting equipment as conforming to one or more of the family of IEEE 802 Standards is equivalent to making a voluntary statement of compliance.

Compliance with one or more of the family of IEEE 802 Standards requires implementation of the mandatory portions of those standards. Components (e.g., cables, connectors, medium-related subsystems) that make use of only a portion of one of the family of IEEE 802 Standards, and thus implement less than the full mandatory set of capabilities, shall indicate which IEEE 802 Standard is used and those portion(s) of the relevant standard that are implemented. These products may be marked as implementing a portion of one of the family of IEEE 802 Standards as appropriate. Such products SHALL NOT say “IEEE 802 compatible” nor use equivalent terms without reference to specific standards within the IEEE 802 family of standards.
3. Reference and Implementation Models

3.1 Introduction. This section defines the IEEE 802 Local and Metropolitan Area Network Reference Model (LAN&MAN/RM) and Implementation Model (LAN&MAN/IM). The intent of presenting these models is

1. To provide an overview of the standard, and

2. To serve as a guide to reading other IEEE 802 Standards.

The IEEE 802 LAN&MAN/RM is patterned after the Open Systems Interconnection Basic Reference Model (OSI/RM) (ISO 7498 [5]). It is assumed that the reader has some familiarity with the OSI/RM and its terminology. The IEEE 802 Standards encompass the functionality of the lowest two layers of the OSI/RM (i.e., Physical Layer and Data Link Layer) and also higher layers as they relate to internetworking and LAN management. The LAN&MAN/RM is similar to the OSI/RM in terms of its layers and the placement of its service boundaries. However, due to the shared-medium nature of the IEEE 802 LANs, there is always a MAC Sublayer.

The OSI/RM is referred to by the IEEE 802 Standards because of the following:

1. The model provides a common vehicle for understanding and communicating the various components and interrelationships of the standards,

2. The model helps define terms,

3. The model provides a convenient framework to aid in the development and enhancement of the standards, and

4. The use of the OSI/RM facilitates a higher degree of interoperability than might otherwise be possible.

Figure 3-1 shows the architectural view of LAN&MAN/RM and its relation to the OSI/RM.

The LAN&MAN/IM is more specific than the LAN&MAN/RM, allowing differentiation between implementation approaches (e.g., of CSMA/CD and token passing). Figure 3-2 shows two implementation views of LAN&MAN/IMs and their relation to the LAN&MAN reference model.

3.2 Reference Model Description. The LAN&MAN/RM maps to the OSI/RM as shown in Fig 3-1. The applicable part of the OSI/RM consists of the lowest two layers: the Data Link Layer and the Physical Layer. These

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9 The numbers in brackets correspond to those of the references listed in 1.5.
IEEE 802 Reference Model (LAN & MAN/RM)

map onto the same two layers in the IEEE LAN&MAN/RM. The MAC Sublayer of the LAN&MAN/RM will always exist between the Physical Layer and LLC Sublayer for shared media topologies. Service access points (SAPs) for addressing endpoints are shown.

3.2.1 Service Access Points (SAPs). Multiple link service access points (LSAPs) provide interface ports to support multiple higher layer users. The MAC Sublayer provides a single interface port to the LLC Sublayer. The Physical Layer provides an interface port to a single MAC station. A user of LLC is identified by, at a minimum, the logical concatenation of the MAC address fields and the LLC address fields (LSAPs) in a frame. See ISO 8802-2:1989 [6] for a description of LSAPs.
3.2.2 LAN/MAN Management. LAN/MAN management provides a set of tools that allow specific management applications to perform management tasks within LAN stations; for example,

(1) Configuration management
(2) Fault management
(3) Performance management
(4) Security management
(5) Accounting management
Management information relating to these application areas is exchanged between stations by means of management protocols; standardized examples of these protocols are CMIP [11], P802.1B [1], and IEEE Std 802.1E [3].

OSI Systems Managements Standards (CMIS [10]; CMIP [11]) define services and protocols for performing system managements in both a WAN and a LAN/MAN environment. CMIP operates over a full 7-layer, connection-oriented protocol stack.

P802.1B [1] defines services and protocols for performing management in a LAN/MAN environment in circumstances where the use of a full 7-layer stack is undesirable or not possible, such as in simple or broken systems. P802.1B operates over the datagram services provided by LLC.

IEEE Std 802.1E [3] defines services and protocols for remote station loading in a LAN/MAN environment. The protocol permits the simultaneous loading of multiple stations by use of the group addressing capability available in 802 technologies.

P802.1F [4] provides guidelines for the development of layer management standards that define managed objects that may be manipulated for management purposes. The guidelines show how layer management standards that are compatible both with the IEEE 802.1 Standards and the standards for OSI management may be developed.

3.2.3 Internetworking. In some cases, the end systems on a LAN have no need to communicate with end systems on other networks (other LANs, WANS, etc.). However, this is not expected to be the norm; there will be many cases where end systems on a LAN will need to communicate with end systems on other networks. To provide full connectivity, it is therefore necessary to consider how to connect a LAN to another network.

Standard methods of internetworking fall into three general categories: an approach based on repeaters, one based on MAC bridges, and one resident in the OSI Network Layer. A repeater is used to extend a LAN when the physical specifications of the technology would otherwise be exceeded. A MAC bridge is a device that processes protocols in the MAC Sublayer and is transparent to LLC and higher layer protocols. Forwarding decisions are based on MAC sublayer information only. In the OSI Network Layer, an internetworking unit (IWU) is a device that processes OSI Network Layer protocols that operate directly above the LLC Sublayer and whose forwarding decisions are based on Network Layer addresses.

IEEE Std 802.1D [2] describes MAC bridge internetworking among IEEE 802 networks. Investigation into Network Layer internetworking as it relates to 802 LANs is under consideration. This work would be complementary to that of other standards bodies.

3.2.4 LLC Sublayer. The LLC Sublayer standard describes three types of operation for data communication between service access points: unacknowledged connectionless (type 1), connection-oriented (type 2), and acknowledged connectionless (type 3).
With type 1 operation, information frames are exchanged between LLC entities without the need for the prior establishment of a logical link between peers. These LLC frames are not acknowledged, nor are there any flow control or error recovery procedures.

With type 2 operation, a logical link is established between pairs of LLC entities prior to any exchange of information frames. In the data transfer phase of operation, information frames are transmitted and delivered in sequence. Error recovery and flow control are provided.

With type 3 operation, information frames are exchanged between LLC entities without the need for the prior establishment of a logical link between peers. However, the frames are acknowledged to allow error recovery and proper ordering. Further, type 3 operation allows one station to poll another for data.

3.2.5 MAC Sublayer. The MAC Sublayer performs access control functions for the shared medium in support of the LLC Sublayer. For different applications, different MAC options may be required. The MAC Sublayer performs the addressing and recognition of frames in support of LLC. MAC also performs other functions, such as frame check sequence generation and checking, and LLC protocol data unit (PDU) delimiting.

3.2.6 Physical Layer. The Physical Layer provides the capability of transmitting and receiving bits between Physical Layer Entities. A pair of Physical Layer Entities identifies the peer-to-peer unit exchange of bits between two MAC users. The Physical Layer provides the capability of transmitting and receiving modulated signals assigned to specific frequency channels, in the case of broadband, or to a single-channel band, in the case of baseband.

3.2.7 Layer and Sublayer Management. The LLC Sublayer, MAC Sublayer, and Physical Layer standards also include a management component that specifies managed objects and aspects of the protocol machine that provide the management view of these resources.
4. Public and Private Network Protocols

4.1 Scope and Purpose. This section describes the functions, features, and protocol format conventions for public and private protocols sharing a single LSAP. All public and private protocols using the IEEE 802 reserved LSAP address assigned for public and private protocol use shall conform to this standard. This section further describes the mechanisms for the coexistence of multiple standard, public, and private network layer protocols within a single 802 station.

A standard protocol is defined to be a protocol whose specification is published and known to the public but controlled by a standards body. A public protocol is defined to be a protocol, whose specification is published and known to the public but controlled by a private organization. A private protocol is defined to be a protocol whose use and specification are controlled by a private organization.

By providing for the coexistence of multiple network layer protocols, the migration of existing LANs to future standard protocols is facilitated, and multiple higher layer protocols are more easily accommodated.

4.2 Basic Concepts. Within a given layer, entities can exchange data by a mutually agreed upon protocol mechanism. A pair of entities that do not support a common protocol cannot communicate with each other. For multiple protocols to coexist within a layer, it is necessary to determine which protocol is to be invoked to process a service data unit delivered by the lower layer.

Standard network layer protocols have been assigned reserved LSAP addresses. These addresses permit multiple standard network layer protocols to coexist at a single MAC station. One half of the LSAP address space is reserved for such assignment. Private protocols are accommodated two ways. One way is by local assignment of LSAPs, for which half the LSAP address space is available. Thus users can agree to use locally assigned LSAPs for either an instance of communication or a type of communication. The second way is through the use of a particular LSAP value that has been designated as the sub-network access protocol (SNAP) SAP, reserved for public and private protocol usage.

The LSAP that has been reserved for use by the SNAP defines a single SAP for standard, public, and private protocol usage. To permit multiple public and private network layer protocols to coexist in one MAC station,
each public or private protocol using SNAP must employ a protocol identifier that enables SNAP to discriminate among these protocols.

Subsection 4.3 defines the format and administration of network layer protocol discriminators used by public and private protocols, and defines minimal restrictions on the format of PDUs of these protocols needed to ensure coexistence.

4.3 Protocol Data Unit (PDU) Format. All SNAP PDUs shall conform to the format shown in Fig 4-1 and form the entire content of the LLC Information Field.

In Fig 4-1, the Protocol Identification Field is a 40-bit field whose format and administration are described in 5.3. The Protocol Data Field is a field whose length, format, and content are defined by a public or private protocol specification. Each public or private protocol begins its PDU format with the Protocol Identification Field. Section 5 describes the form and means of acquisitions of protocol identifiers.

In addition, the LSAP address reserved for SNAP has the bit pattern 01010101.

<table>
<thead>
<tr>
<th>Fig 4-1 PDU Format</th>
</tr>
</thead>
<tbody>
<tr>
<td>PROTOCOL IDENTIFICATION</td>
</tr>
<tr>
<td>40 BITS</td>
</tr>
</tbody>
</table>
5. Universal Addresses and Protocol Identifiers

The IEEE makes it possible for organizations to employ unique individual LAN MAC addresses, group addresses, and protocol identifiers. It does so by assigning Organizationally Unique Identifiers, which are 24 bits in length. Because the assignment of the Organizationally Unique Identifier in effect reserves a block of each derivative identifier (i.e., blocks of individual LAN MAC addresses, group addresses, and protocol identifiers), the address space of the Organizationally Unique Identifier is chosen to be large. Though the Organizationally Unique Identifiers are 24 bits in length, their true address space is 22 bits. The first bit can be set to 1 or 0 depending on the application. The second bit for all assignments is 0. The remaining 22 bits, which cannot be changed by the assignee, result in $2^{22}$ (approximately 4 million) identifiers.

The universal administration of LAN MAC addresses began with the Xerox Corporation administering Block Identifiers (Block IDs) for Ethernet addresses. Block IDs were assigned by the Ethernet Administration Office and were 24 bits in length (3 octets). An organization developed addresses by assigning the remaining 24 bits. For example, the address as represented by the six octets A-B-C-D-E-F comprises the Block ID, A-B-C, and the locally assigned octets D-E-F. The multicast bit is the least significant bit (LSB) of the first octet, A.

The IEEE Project 802, because of its work on standardizing LAN technologies, has assumed the responsibility of defining procedures for the universal administration of addresses for IEEE 802 LANs (e.g., CSMA/CD [7], Token Bus [8], and Token Ring [9]). It will honor the assignments made by the predecessor administration office. The Block ID is referred to as the Organizationally Unique Identifier by the IEEE.

5.1 Organizationally Unique Identifier

5.1.1 Concept. Organizationally Unique Identifiers allow a general means of assuring unique identifiers for a number of purposes. Currently, the IEEE assigns Organizationally Unique Identifiers to be used for generating LAN MAC addresses and protocol identifiers. Assuming correct administration by the assignee, the LAN MAC addresses and protocol identifiers will be universally unique.

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10 Interested applicants should contact the IEEE Standards Office, Institute of Electrical and Electronics Engineers, Inc., 445 Hoes Lane, Piscataway, NJ 08855-1331.
The Organizationally Unique Identifier is 24 bits in length and its bit pattern is shown below. Organizationally Unique Identifiers are assigned as 24 bit values with both values (0,1) being assigned to the first bit and the second bit being set to 0. The second bit of the Organizationally Unique Identifier being set to 0 indicates that the assignment is universal. Organizationally Unique Identifiers with the second bit set to 1 are locally assigned and have no relationship to the IEEE-assigned values (as described herein).

The Organizationally Unique Identifier is defined in Fig 5-1.

### 5.1.2 Representation of an Organizationally Unique Identifier

The Organizationally Unique Identifier shall be represented as a string of three octets. The illustrative representation of the Organizationally Unique Identifier is defined to be a string of hexadecimal numbers with each octet being displayed as two hexadecimal digits. The octets are displayed from left to right, in the order that they are transmitted on the LAN medium. The LSB (bit “a” in Fig 5-2) corresponds to the Individual/Group (I/G) Address Bit (when the Organizationally Unique Identifier is contained in a LAN MAC address).

The bit significance of the Organizationally Unique Identifier is defined in Fig 5-2.
5.2 48-Bit Universal LAN MAC Addresses

5.2.1 Concept. The concept of universal addressing is based on the idea that all potential members of a network need to have a unique identifier (if they are going to coexist in the network). The advantage of a universal address is that a node with such an address can be attached to any LAN in the world with an assurance that its address is unique.

A 48-bit Universal Address consists of two parts. The first 24 bits correspond to the Organizationally Unique Identifier as assigned by the IEEE, except that the assignee may set the first bit to 1 for group addresses or set it to 0 for individual addresses. The second part, comprising the remaining 24 bits, is administered locally by the assignee. In the 48-bit LAN MAC address, an example of which is shown in Fig 5-3, the Organizationally Unique Identifier is contained in octets 0, 1, 2 and the remaining octets 3, 4, 5 are assigned locally. This address, including its Organizationally Unique Identifier, is used throughout this document to describe the illustrative representation (in hexadecimal) of LAN MAC addresses and protocol identifiers.

The I/G Address Bit (1st bit of octet 0) is used to identify the destination address either as an individual or as a group address. If the I/G Address Bit is 0, it indicates that the address field contains an individual address. If this bit is 1, the address field contains a group address that identifies one or more (or all) stations connected to the LAN. The all-stations broadcast address is a special, predefined group address of all 1's.

The Universally or Locally Administered (U/L) Address Bit (2nd bit of octet 0) is the bit directly following the I/G Address Bit. This bit indicates whether the address has been assigned by a local or universal administrator. Universally administered addresses have this bit set to 0. If this bit is set to 1, the entire address (i.e., 48 bits) has been locally administered.

Varying the last 24 bits allows the assignee approximately 16 million unique individual addresses and 16 million unique group addresses that no other organization can have (i.e., universally unique). The IEEE intends

Fig 5-3
Universal Address

Octet: 0 1 2 3 4 5
0011 0101 0111 1011 0001 0010 0000 0000 0000 0000 0001

First bit transmitted on the LAN medium.
(Also the I/G Address Bit.)

The hexadecimal representation is: AC-DE-48-00-00-80
IEEE Std 802-1990
LOCAL AND METROPOLITAN AREA NETWORKS:

not to assign additional Organizationally Unique Identifiers to any organization unless the organization has exhausted this address block. Therefore, it is important for the IEEE to maintain a single point of contact with each assignee to avoid complicating the assignment process. It is important to note that in no way should these addresses be used as product identifiers for the purpose of aiding company inventory procedures.

The method that an assignee uses to assure that no two of its devices carry the same address will, of course, depend on the assignment or manufacturing process, the nature of the organization, and the organization’s philosophy. However, the users of networks worldwide expect to have unique addresses. The ultimate responsibility for assuring that user expectations and requirements are met, therefore, lies with the organization offering such devices.

The IEEE asks that organizations not misuse the assignments of the last 24 bits and thereby unnecessarily exhaust the block. There are sufficient identifiers to satisfy most needs for quite some time, even in volume production; however, no address space is infinite.

5.2.2 Representation of a 48-Bit Address. The 48-bit address (universal or local) is represented as a string of six octets. The octets are displayed from left to right, in the order that they are transmitted on the LAN medium, separated by hyphens. Each octet of the address is displayed as two hexadecimal digits. The bits within the octets are transmitted from left to right, as shown in Fig 5-4. In the display of octets, the first bit transmitted of

**Fig 5-4**

Universal Address Representation

<table>
<thead>
<tr>
<th>LSB</th>
<th>MSB</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Diagram of octet transmission" /></td>
<td></td>
</tr>
</tbody>
</table>

Legend:
I/G—Individual/Group Address Bit
U/L—Universally or Locally Administered Address Bit
each octet on the LAN medium is the LSB of that octet (e.g., I/G Address Bit = LSB). The Organizationally Unique Identifier is contained in octets 0, 1, 2 with octets 3, 4, 5 being administered by the assignee.

As an example, consider the address as shown in the previous section (48-bit Universal LAN MAC Addresses): AC-DE-48-00-00-80. The first octet transmitted is AC and the last octet transmitted is 80. The first bit transmitted is the low order bit of AC, a 0; therefore, the example is an individual address. The last bit transmitted is the high order bit of 80, a 1.

5.3 Protocol Identifier

5.3.1 Concept. IEEE 802 has assigned a single LSAP address to SNAP for private and public protocol multiplexing and demultiplexing among multiple users of a data link. This reserved LSAP is called the SNAP/SAP and is defined to be (starting with the LSB): 01010101. All SNAP PDUs contain a Protocol Identification Field. An organization uses its Organizationally Unique Identifier to identify, using a universal unique value, its own protocols.

The protocol identifier is 40 bits in length and follows the logical link control header in a frame. The first 24 bits of the protocol identifier correspond to the Organizationally Unique Identifier in exactly the same fashion as in 48-bit LAN MAC addresses. The remaining 16 bits are locally administered by the assignee. In the protocol identifier, an example of which is shown in Fig 5-5, the Organizationally Unique Identifier is contained in octets 0, 1, 2 with octets 3, 4 being locally assigned.

Protocol Identification Fields may be assigned universally or locally. All identifiers assigned by the IEEE will have the X bit set to 0. Values with the X bit set to 1 are locally assigned and have no relationship to the IEEE-assigned values. They may be used, but there is no assurance of uniqueness.

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**Fig 5-5**

**Protocol Identifier**

<table>
<thead>
<tr>
<th>Octet:</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0011 0101 0111 1011 0001 0010 0000 0000 0000 0001</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X bit</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M bit</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Legend:

- M = 0: (M=1 is reserved)
- X = 0: Globally Administered Protocol Identification
- X = 1: Locally Administered Protocol Identification

The hexadecimal representation is: AC-DE-48-00-80
5.3.2 Representation of a Protocol Identifier. The protocol identifier is represented as a string of five octets separated by hyphens. The octets are displayed left to right in the order that they are transmitted on the LAN medium. Each octet is displayed as two hexadecimal digits. The M bit of the first octet is the first bit of the Organizationally Unique Identifier and is least significant (as shown in Fig 5-6).

As an example, consider the protocol identifier AC-DE-48-00-80 (as developed from the Organizationally Unique Identifier used in 5.3). Both the M and X bits are properly set to zero in the first octet AC. The order of transmission of the protocol identifier on the LAN medium is octet AC first, followed by octet DE, octet 48, octet 00, and octet 80. The order of bit transmission within each octet depends on the MAC, as discussed in the following section.

5.4 Bit-Ordering and Different MACs. The transmission of data for IEEE 802.3 and 802.4 LAN media occurs LSB first. This is true for the entire packet, LAN MAC address fields (source and destination), MAC-specific fields (e.g., length field in IEEE 802.3 LANs), and the MAC Information Field.

On an IEEE 802.5 LAN medium, the LAN MAC address fields (source and destination) are transmitted such that the first bit on the medium is the I/G Address Bit group, in a similar fashion to that of IEEE 802.3 and 802.4 LAN media. The MAC Information Field, however, is transmitted most significant bit (MSB) first on an IEEE 802.5 LAN medium. The MAC Information Field is defined to be that part of the frame starting directly after the MAC header and including all the data up to, but not including, the frame check sequence (e.g., LLC header information, such as the Protocol Identifi-
cation Field, is contained in the MAC Information Field). For frames that originate within the MAC (e.g., MAC-embedded management frames) the ordering of bits within the MAC Information Field is defined by the IEEE 802.5 MAC specification (IEEE Std 802.5-1989 [9]).

The following example is intended to clarify the issue of bit ordering of the protocol identifiers and LAN MAC addresses across different MACs.

The Organizationally Unique Identifier is defined to be as follows:

```
  1st bit       24th bit
       |            |
      a b c d e.................................x y
```

The bit significance of the Organizationally Unique Identifier is defined to be as follows:

```
       LSB       MSB
Octet 0  a b c d e f g h
Octet 1  i j k l m n o p
Octet 2  q r s t u v w x
```

When used in LAN MAC addresses
- Bit “a” of the Organizationally Unique Identifier = I/G Address Bit.
- Bit “b” of the Organizationally Unique Identifier = U/L Address Bit.

When used in protocol identifiers
- Bit “a” of the Organizationally Unique Identifier = M bit.
- Bit “b” of the Organizationally Unique Identifier = X bit.
When viewed on an IEEE 802.3 or 802.4 LAN medium that transmits data LSB first; the Organizationally Unique Identifier portion of the LAN MAC address appears as

\[
\text{abcdefg} \ \text{ijklmnop} \ \text{qrstuvw}x^{11}\n\]

> time

The Organizationally Unique Identifier portion of the protocol identifier appears as

\[
\text{abcdefg} \ \text{ijklmnop} \ \text{qrstuvw}x^{12}\n\]

> time

When viewed on an IEEE 802.5 LAN medium that transmits data in the MAC Information Field MSB first; the Organizationally Unique Identifier portion of the LAN MAC address appears as

\[
\text{abcdefg} \ \text{ijklmnop} \ \text{qrstuvw}x^{13}\n\]

> time

The Organizationally Unique Identifier portion of the protocol identifier appears as

\[
\text{hgfedcba} \ \text{pomljk}i \ \text{fwvuts}r^{14}\n\]

> time

Despite a difference in bit transmission order among the IEEE 802 MACs, all effects of this difference are contained wholly within the MAC Sublayer.

To illustrate, imagine a system composed of a single OSI stack. This stack consists of a LLC Sublayer and a set of OSI upperlayers; beneath this, any of the IEEE 802 MACs can be inserted. A common MAC service interface is used regardless of MAC type.

From this example, the following observations can be made about this system:

1. Octets of the MAC Information Field are ordered the same at the MAC service interface for all IEEE 802 MACs. Although the transmission order for IEEE 802.5 is reversed from the others, the peer IEEE 802.5 MAC again reverses the order, making this difference transparent to LLC and higher layers.

2. In mapping octets between the MAC service interface and the Physical Layer, the IEEE 802.5 MAC must reverse the bit order of a MAC Address

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\(^{11}\) Where “a” is the first bit transmitted and received.

\(^{12}\) See Footnote 11.

\(^{13}\) See Footnote 11.

\(^{14}\) Where “h” is the first bit transmitted and received.
address Field from that of the MAC Information Field. This is a mere implementation detail for the IEEE 802.5 MAC.

5.5 Standard Group Addresses. The previous sections described the assignment of individual and group addresses and protocol identifiers for public or private use by private organizations. There is also a need for standard group addresses to be used with standard protocols. Thus the IEEE, through the IEEE 802.1 Working Group, maintains a pool of these addresses and grants them to qualifying applicants. These standard group addresses come from a block of universally administered LAN MAC addresses derived from an Organizationally Unique Identifier that has been assigned to IEEE 802 by the IEEE Standards Department.

5.5.1 How to Apply for Standard Group Addresses. Application for a standard group address must come from an accredited national or international standards body. It must pertain to an approved or sufficiently advanced draft standard. An official representative of the applying body should write a letter to the chair of IEEE 802 at the following address:

Chair, IEEE 802
IEEE Standards Department
Institute of Electrical and Electronics Engineers, Inc.
445 Hoes Lane, P.O. Box 1331
Piscataway, NJ 08855-1331

The letter should
• Describe the intended use of each address.
• Cite by name and number the standard in which each address will be employed.
• State the status of the standard and its approval schedule (if applicable).

5.5.2 Processing of an Application. Applications will be considered, and assignments made, by the IEEE in consultation with IEEE Project 802. The IEEE Standards Department will maintain the list of assigned standard group MAC addresses as it does the list of assigned LAN LSAPs. This list will be considered public information and will be available on request.