

802[®]

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

IEEE Computer Society

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USA

IEEE Std 802[®]-2014
(Revision to
IEEE Std 802-2001)

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IEEE Std 802®-2014

(Revision of
IEEE Std 802-2001)

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

Sponsor

**LAN/MAN Standards Committee
of the
IEEE Computer Society**

Approved 12 June 2014

IEEE-SA Standards Board

Abstract: This standard provides an overview to the family of IEEE 802[®] standards. It describes the reference models for the IEEE 802 standards and explains the relationship of these standards to the higher layer protocols; it provides a standard for the structure of IEEE 802 MAC addresses; it provides a standard for identification of public, private, prototype, and standard protocols; it specifies an object identifier hierarchy used within IEEE 802 for uniform allocation of object identifiers used in IEEE 802 standards; and it specifies a method for higher layer protocol identification.

Keywords: BANs, body area networks, EtherTypes, IEEE 802[®], IEEE 802 architecture, IEEE 802 reference model, LANs, local area networks, MANs, metropolitan area networks, object identifiers, PANs, personal area networks, RANs, regional area networks, protocol development, protocol types

The Institute of Electrical and Electronics Engineers, Inc.
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PDF: ISBN 978-0-7381-9219-2 STD98723
Print: ISBN 978-0-7381-9220-8 STDPD98723

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Introduction

This introduction is not part of IEEE Std 802-2014, IEEE Standard for Local and metropolitan area networks: Overview and Architecture.

This document is the third major revision of the IEEE 802[®] overview and architecture. This revision integrates two earlier amendments, IEEE Std 802a[™]-2003 (covering Ethertypes for prototype and vendor-specific protocol development) and IEEE Std 802b[™]-2004 (covering registration of object identifiers), into the previous major revision of the standard, IEEE Std 802[®]-2001. In addition, there has been extensive rework in this document to bring forward the practice of protocol identification using the EtherType. While the protocol identification mechanism specified by ISO/IEC 8802-2 (IEEE Std 802.2[™], withdrawn) is still used, its use for new standards has been deprecated. Further, material about physical layer addressing and universal addressing has been added along with information about the IEEE Registration Authority (RA) to facilitate user procurement of address assignments.

Since the 2001 revision of this standard, the IEEE 802 standards and working groups have undergone many changes. IEEE Std 802.5[™] was withdrawn; therefore, references to it have been removed from this revision. IEEE Std 802 has also been broadened to include a variety of wireless standards; therefore, a new informative annex has been added to address the variety of IEEE 802 standards (Annex D). Data rates for IEEE 802 standards now range from tens of kilobits per second to hundreds of gigabits per second and encompass copper, optical fiber, wireless, and free-space optical media.

With the diversity of IEEE 802 standards, another goal of this revision was to bring the reference models from these various standards into this standard. This consolidation enables the user to quickly see the differences and similarities of the architecture of IEEE 802 standards. The reference models are included in a new informative annex (Annex B).

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1. Overview

1.1 Scope **General**

~~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~~ This standard contains descriptions of the ~~networks considered~~ published by the IEEE for frame-based data networks as well as a reference model (RM) for protocol standards. ~~Compliance with the family of~~ The IEEE 802[®] Standards architecture is defined, and a ~~standard~~ specification for the identification of public, private, and standard protocols is included.

1.2 Purpose

This standard serves as the foundation for the family of IEEE 802 standards published by IEEE for local area networks (LANs), metropolitan area networks (MANs), personal area networks (PANs), and regional area networks (RANs).

2. Normative references

The following referenced documents are indispensable for the application of this document (i.e., they must be understood and used; therefore, each referenced document is cited in text and its relationship to this document is explained). For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

IEEE Std 802.1D™, IEEE Standard for Local and metropolitan area networks—Media Access Control (MAC) Bridges.^{1, 2}

IEEE Std 802.1Q™, IEEE Standard for Local and metropolitan area networks—Virtual Bridged Local Area Networks.

IEEE Std 802.1AC™, IEEE Standard for Local and metropolitan area networks—Media Access Control (MAC) Service Definition.

ISO/IEC 8802-2:1998 ~~(IEEE Std 802.2-1998™)~~, Standard for Information technology—Telecommunications and information exchange between systems—Local and metropolitan area networks—Specific requirements—Part 2: Logical link control.³ (ISO/IEC version of withdrawn standard IEEE Std 802.2)

¹The IEEE standards referred to in Clause 2 are trademarks owned by The Institute of Electrical and Electronics Engineers, Incorporated.

² IEEE publications are available from The Institute of Electrical and Electronics Engineers (<http://standards.ieee.org/>).

³ ISO/IEC publications are available from the International Organization for Standardization (<http://www.iso.ch/>) and the International Electrotechnical Commission (<http://www.iec.ch/>). ISO/IEC publications are also available in the United States from the American National Standards Institute (<http://www.ansi.org/>).

[ITU-T Recommendation X.660, Information technology—Procedures for the operation of object identifier registration authorities: General procedures and top arcs of the international object identifier tree.](#)⁴

[IETF RFC 2578, Structure of Management Information Version 2 \(SMIV2\).](#)⁵

2. References

~~The following publications contain provisions which, through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards listed below.~~

~~ISO/IEC 7498-1:1994, Information technology—Open Systems Interconnection—Basic Reference Model: The basic model.~~⁺

~~ISO/IEC 8802-2:1998 (IEEE Std 802.2-1998TM), Information technology—Telecommunications and information exchange between systems—Local and metropolitan area networks—Specific requirements—Part 2: Logical Link Control.~~

~~ISO/IEC TR 11802-1:1997, Information technology—Telecommunications and information exchange between systems—Local and metropolitan area networks—Technical reports and guidelines—Part 1: The structure and coding of Logical Link Control addresses in Local Area Networks.~~

⁴ [ITU-T publications are available from the International Telecommunications Union \(http://www.itu.int/\).](http://www.itu.int/)

⁵ [IETF documents \(i.e., RFCs\) are available the Internet Engineering Task Force \(http://www.rfc-archive.org/\).](http://www.rfc-archive.org/)

~~ISO/IEC TR 11802 2:1999, Information technology—Telecommunications and information exchange between systems—Local and metropolitan area networks—Technical reports and guidelines—Part 2: Standard Group MAC Addresses.~~

~~ISO/IEC 15802 1:1995, Information technology—Telecommunications and information exchange between systems—Local and metropolitan area networks—Common specifications—Part 1: Medium access control (MAC) service definition.~~

~~ISO/IEC 15802 3:1998 (IEEE Std 802.1D 1998TM), Information technology—Telecommunications and information exchange between systems—Local and metropolitan area networks—Common specifications—Part 3: Media Access Control (MAC) Bridges.~~

~~NOTE—Annex A lists, for information, the other LAN/MAN and related standards. Unlike those listed above, they do not contain detailed provisions that are used, by reference, by this standard.~~

3. Definitions, acronyms, and abbreviations

3.1 Definitions

For ~~the purposes of this standard~~document, the following terms and definitions apply. *The* ~~Authoritative Dictionary of IEEE Standards Terms, Seventh Edition [B2],²~~ Dictionary Online should be ~~referenced~~consulted for terms not defined in this clause.⁶

access domain: A set of ~~LAN or MAN~~ stations in an IEEE 802[®] network together with interconnecting data transmission media and ~~related equipment~~functional units (e.g., ~~connectors,~~ repeaters), in which the ~~LAN or MAN~~ stations use the same ~~MAC~~medium access control (MAC) protocol to ~~establish the sequence of stations that are in temporary control of the shared transmission media~~communicate over a common physical medium.

~~**3.1.2 bit-reversed representation:** The representation of a sequence of octet values in which the values of the individual octets are displayed in order from left to right, with each octet value represented as a two-digit hexadecimal numeral, and with the resulting pairs of hexadecimal digits separated by colons. The order of the hexadecimal digits in each pair, and the mapping between the hexadecimal digits and the bits of the octet value, are derived by reversing the order of the bits in the octet value and interpreting the resulting bit sequence as a binary numeral using the normal mathematical rules for digit significance.~~

~~NOTE—The bit-reversed representation is applicable to LAN MAC addresses for use in a Token Ring (IEEE 802.5[®]) or FDDI environment. See Figure 8 for a comparative example of bit-reversed and hexadecimal representation.~~

²~~The numbers in brackets correspond to those of the bibliography in Annex A.~~

⁶ The IEEE Standards Dictionary Online subscriptions are available at ©
http://www.ieee.org/portal/innovate/products/standard/standards_dictionary.html.

bridge, ~~MAC bridge~~: A functional unit that interconnects two or more ~~LANs or MANs~~[IEEE 802[®] networks](#) that use the same data link layer ([DLL](#)) protocols above the ~~MAC~~[medium access control \(MAC\)](#) sublayer, but can use different MAC protocols. [Forwarding and filtering decisions are made on the basis of layer 2 information.](#)

canonical format: The format of a ~~MAC~~[medium access control \(MAC\)](#) data frame in which the octets of any ~~MAC addresses~~[48-bit extended unique identifiers \(EUI-48s\) or 64-bit extended unique identifiers \(EUI-64s\)](#) conveyed in the MAC user data field have the same bit ordering as in the hexadecimal representation.

end station: A ~~device attached to a LAN or MAN, which~~[functional unit in an IEEE 802[®] network](#) ~~that~~ acts as a source of, and/or destination for, [link layer](#) data traffic carried on the ~~LAN or MAN~~[network](#).

~~**3.1.6 Ethernet frame:** A MAC data frame structured in accordance with ISO/IEC 8802-3 and containing an Ethernet type value in the LENGTH / TYPE field.~~

~~**3.1.7 fibre distributed data interface (FDDI) frame:** A MAC data frame structured in accordance with ISO/IEC 9314-2.~~

~~**3.1.8 hexadecimal representation:** The representation of a sequence of octet values in which the values of the individual octets are displayed in order from left to right, with each octet value represented as a two-digit hexadecimal numeral, and with the resulting pairs of hexadecimal digits separated by hyphens. The order of the hexadecimal digits in each pair, and the mapping between the hexadecimal digits and the bits of the octet value, are derived by interpreting the bits of the octet value as a binary numeral using the normal mathematical rules for digit significance.~~

~~NOTE— See Figure 8 for a comparative example of bit reversed and hexadecimal representation.~~

~~3.1.9 IEEE 802.3[®] frame, 802.3[®] frame: A MAC data frame structured in accordance with ISO/IEC 8802-3 and containing a length value in the LENGTH / TYPE field.~~

~~3.1.10 IEEE 802.5[®] frame, 802.5[®] frame: A MAC data frame structured in accordance with ISO/IEC 8802-5.~~

~~3.1.11 IEEE 802.n[®] frame, 802.n[®] frame: A MAC data frame structured in accordance with ISO/IEC 8802-n.~~

NOTES

~~1— At the time of publication of this standard, relevant specifications, in addition to those cited explicitly in 3.1.9 and 3.1.10, are for n = 4, 6, 9, and 11.~~

~~2— ISO/IEC 8802-12 also defines a MAC protocol, but it does not specify its own MAC data frame format; instead, it uses the IEEE 802.3[®] and IEEE 802.5[®] frame formats.~~

~~3.1.12 IEEE 802[®] LAN, 802[®] LAN: A LAN consisting of an access domain using either a MAC protocol specified in one of the IEEE 802.n and ISO/IEC 8802-n Standards or the FDDI MAC protocol.~~

Ethernet: A communication protocol specified by IEEE Std 802.3™.

EtherType: A 2-octet value, assigned by the IEEE Registration Authority (RA), that provides context for interpretation of a data field of a frame (protocol identification).

filtering: A function in a bridge that is used to determine if a received medium access control (MAC) frame is to be forwarded or discarded on any given outbound port.

forwarding: A function in a bridge that transfers a received medium access control (MAC) frame to one or more outbound ports.

frame: The format of aggregated bits from a medium access control (MAC) sublayer entity that are transmitted together in time.

handover: The process by which a mobile node obtains facilities and preserves traffic flows when traffic is switched from one link to another. Different types of handover are specified based on the way facilities for supporting traffic flows are preserved.

IEEE 802[®] ~~MAN, 802[®] MAN: A MAN~~ **network:** A network consisting of one or more interconnected ~~sub~~networks each using a medium access control (MAC) protocol specified in an IEEE 802[®] ~~or ISO/IEC 8802 MAN~~ standard.

~~NOTE—Part of the data communication capability of an IEEE 802[®] MAN is the provision of a data service equivalent to that provided by an IEEE 802[®] LAN, over the extended geographical area of the MAN.~~

interconnection: ~~The provision of a~~ A data communication path between ~~LAN or MAN~~ stations in an IEEE 802[®] network.

interworking: The use of interconnected ~~LAN or MAN~~ stations in a network for the exchange of data, by means of protocols operating over the underlying data transmission paths.

~~3.1.16 LAN: A computer network, located on a user's premises, within a limited geographical area.~~

~~3.1.17 MAC control frame: A data structure consisting of fields in accordance with a MAC protocol, for the communication of control information, only, in a LAN or MAN.~~

~~NOTE—ISO/IEC 8802-5[®] uses the term “MAC frame” in this sense.~~

local area network (LAN): A network of devices, whether indoors or outdoors, covering a limited geographic area, e.g., a building or campus.

logical link: A logical communication connection between two devices.

medium access control (MAC) data frame: A data structure consisting of fields in accordance with a MAC protocol, for the communication of user data and control information in a ~~LAN or MAN~~ network; one of the fields contains a sequence of octets of user data.

medium access control (MAC) protocol: ~~The~~ A protocol that governs access to the transmission medium in a ~~LAN or MAN~~ network, to enable the exchange of data between ~~LAN or MAN~~ stations in a network.

media-independent control function: A parallel control plane that provides control functions for different medium access control (MAC) and physical layer (PHY) sublayers and provides a media-independent abstraction to higher layer protocols.

media-independent handover function: A function that provides the ability to relocate traffic flows between different medium access technologies and associated physical media.

metropolitan area network (MAN): A ~~computer~~ network of devices, extending over a large geographical area such as an urban area ~~and~~, often providing integrated communication services such as data, voice, and video.

noncanonical format: The format of a ~~MAC~~ medium access control (MAC) data frame in which the octets of ~~MAC addresses~~ 48-bit extended unique identifiers (EUI-48s) or 64-bit extended unique identifiers (EUI-64s) conveyed in the MAC user data field have the same bit ordering as in the bit-reversed representation.

personal area network (PAN): A network of devices extending over a very limited geographical area, used to convey information among a group of participant stations.

private protocol: A protocol whose use and specification are controlled by a private organization.

public protocol: A protocol whose specification is published and known to the public, but controlled by an organization other than a formal standards body.

regional area network (RAN): A network of devices that generally covers a service area that is larger than metropolitan area networks (MANs), typically in sparsely populated areas.

repeater: A device that interconnects segments of the physical medium by retransmitting a copy of the physical layer (PHY) frame.

service data unit: Information that is delivered between layers or sublayers.

single access domain: A set of stations such that, at most, only one can transmit at a given time, with all other stations acting as (potential) receivers.

standard protocol: A protocol whose specification is published and known to the public and is controlled by a standards body.

station: An end station or bridge. See also: bridge; end station.

universal address: A 48-bit extended unique identifier (EUI-48) or 64-bit extended unique identifier (EUI-64) that is used as a unique address.

~~**3.1.22 octet:** A sequence of eight bits, the ends of the sequence being identified as the most significant bit (MSB) and the least significant bit (LSB).~~

~~NOTE—This identification of the ends of the sequence defines an unambiguous mapping from octet values, via binary numerals, to the integers 0–255, and hence a mapping also from octet values to the expressions of those integers as numerals in hexadecimal notation. See: Hexadecimal Representation.~~

3.2 Acronyms and abbreviations

<u>BS</u>	<u>base station</u>
<u>CID</u>	<u>company identifier</u>
<u>CPE</u>	<u>customer-premises equipment</u>
<u>CS</u>	<u>convergence sublayer</u>
<u>C-SAP</u>	<u>control service access point</u>
<u>DLL</u>	<u>data link layer</u>
<u>EPD</u>	<u>EtherType protocol discrimination</u>
<u>EPON</u>	<u>Ethernet passive optical networks</u>
<u>EUI-48</u>	<u>48-bit extended unique identifier</u>
<u>EUI-64</u>	<u>64-bit extended unique identifier</u>
<u>HLPDE</u>	<u>higher layer protocol discrimination entity</u>

I/G	individual/group
IM	implementation model
IP	Internet Protocol
LAN	local area network
LLC	logical link control ~~(ISO/IEC 8802-2)~~
LPD	LLC protocol discrimination
LSAP	link service access point ~~(ISO/IEC 8802-2)~~
LSB	least significant bit
MAC	medium access control, media access control ³⁷
MA-L	MAC address – large MA-M MAC address – medium
MAN	metropolitan area network
MA-S	MAC address – small
MCPS	MAC common part sublayer
MCPS-SAP	MAC common part sublayer data service access point

⁷ Both forms are used, with the same meaning. This standard uses “medium”.

MIB	management information base
MICF	media-independent control function
MICLSAP	media-independent control link service access point
MICPSAP	media-independent control physical service access point
MICSAP	media-independent control service access point
MIH	media-independent handover
MIHF	media-independent handover function
MLME	MAC sublayer management entity
MSAP	MAC service access point
M-SAP	~~MAC~~ management service access point
MSB	most significant bit
NCMS	network control and management system
OAM	operations, administration, and maintenance
OID	object identifier
OLT	optical line terminal

ONU	optical network unit
OSI/ RM	Open Systems Interconnection basic reference model(~~ISO/IEC 7498-1~~)
OUI	organizationally unique identifier
PAN	personal area network
PDU	protocol data unit
PHY	physical layer (OSI reference model and IEEE 802[®] reference model)
PHY	physical layer device or entity (IEEE 802.3[™] reference model)
PICS	protocol implementation conformance statement
PLME	physical layer management entity
PMD	physical medium dependent
PhSAP	physical service access point
RA	Registration Authority
RAN	regional area network
RM	reference model
RSTP	rapid spanning tree protocol

[SAP](#) [service access point](#)

SNAP Subnetwork Access Protocol

SNMP Simple Network Management Protocol (~~RFC 1157~~⁴)

[SSF](#) [spectrum sensing function](#)

[SS/MS](#) [subscriber station/mobile subscriber station](#)

U/L universally or locally administered

[VLAN](#) [virtual local area network](#)

WAN wide area network

[WLAN](#) [wireless local area network](#)

[WPAN](#) [wireless personal area network](#)

[WRAN](#) [wireless regional area network](#)

~~CMIP common management information protocol (ISO/IEC 9596-1)~~

~~CSMA/CD carrier sense multiple access with collision detection (ISO/IEC 8802-3)~~

~~DQDB distributed queue dual bus~~

⁴See A.1 for information on obtaining RFCs.

FDDI	fibredistributed data interface (ISO/IEC 9314)
ISDN	integrated services digital network
ISLAN	integrated services LAN (ISO/IEC 8802-9) LAN
MOCS	managed object conformance statement

4. Family of IEEE 802 standards

4.1 Key concepts

IEEE 802 networks use frame-based communications over a variety of media to connect various digital apparatus regardless of computer technology and data type. However, the scope of IEEE 802 standards is not limited to the physical layers (PHYs) and data link layers (DLLs).

The basic communications capabilities provided by all IEEE 802 standards are frame based with source and destination addressing and asynchronous timing. In a frame-based system, the format is a variable-length sequence of data octets. ~~LANs and MANs are packet-based, as opposed to either cell-based or isochronous. That is, the basic unit of transmission is a sequence of data octets, which can be of any length within a range that is dependent on the type of LAN; for all LAN types, the maximum length is in excess of 1000 octets.~~ By contrast, cell-based communication transmits data in fixed-length units in specified time intervals while isochronous communication transmits data as a steady stream of octets, or groups of octets, at equal time intervals.

User and management data flowing within IEEE 802 networks can be secured by a variety of authentication, secure key exchange, and encryption mechanisms that are described in the various IEEE 802 standards. In addition, IEEE 802 standards specify mechanisms by which a station is able to discover neighboring networks information that may include IEEE 802 and non-IEEE 802 technologies. IEEE 802 standards also specify mechanisms to achieve service discovery (e.g., support for Internet or virtual private network service) and session continuity (e.g., a voice over Internet Protocol (IP) or multimedia session) in a heterogeneous networking environment when stations, while either stationary or in motion, have a choice of connecting to multiple access networks.

The early IEEE 802 local area network (LAN) wired technologies used shared-medium communication, with information broadcast for all stations to receive. That approach has evolved over the years, but in ways that preserve the appearance of simple peer-to-peer communications behavior for end stations. In particular, the use of bridges, as described in 5.3.2, for interconnecting IEEE 802 networks is now widespread. These bridges allow the construction of networks with much larger numbers of end stations and much higher aggregate throughput than would be achievable with a single shared-medium. End stations attached to such a bridged IEEE 802 network can communicate with each other just as though they were attached to a single shared-medium; however, the ability to communicate with other stations can be limited by use of management facilities in the bridges, particularly where broadcast or multicast transmissions are involved. A further stage in this evolution has led to the use of point-to-point full duplex communication in LANs, either between an end station and a bridge or between a pair of bridges.

Some IEEE 802 technologies, in particular wireless-based technologies, are inherently shared-medium communication systems. They too have been augmented over time. Many wireless local area networks (WLANs) support mobile node mobility and hence dynamic topologies. These additional facilities may, depending on the IEEE 802 technology in use, restrict bridged LAN interconnects to the static topology nodes within the wireless portion of a heterogeneous technology LAN.

~~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.~~ An IEEE 802 LAN is a peer-to-peer communication network that enables stations to communicate directly on a point-to-point, or point-to-multipoint, basis without requiring them to communicate with any intermediate stations that perform forwarding or filtering above the PHY. ~~switching nodes.~~ LAN communication takes place at moderate to high data rates and with short transit delays, on the order of a few milliseconds or less.

A LAN 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. [LANs are useful for deployment on a variety of scales, whether indoors or outdoors, including covering a scale up to a large building or campus environment.](#)

[A metropolitan area network \(MAN\) is optimized for a larger geographical area than is 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. A MAN might be owned and operated by a single organization, but it is usually used by many individuals and organizations. MANs might also be owned and operated as public utilities. They often provide means for internetworking of local networks.](#)

[Personal area networks \(PANs\) are used to convey information among a small group of participant stations. Unlike a LAN, a connection made through a PAN typically involves little or no infrastructure or direct connectivity to the world outside the connection. This approach allows small, power-efficient, inexpensive solutions to be implemented. In the context of the family of IEEE 802 standards, PANs are implemented with wireless technology and are, therefore, sometimes referred to as wireless personal area networks \(WPANs\).](#)

[Regional area networks \(RANs\) generally cover a service area that is larger than the MANs. A RAN is similar to a MAN in that it is typically owned and operated by a single organization, but it is usually used by many individuals and organizations. For wireless regional area networks \(WRANs\), the unique propagation characteristics of the frequency bands in which they operate, typically from 30 MHz to 1 GHz, require a specialized design of the PHY and the medium access control \(MAC\) that can absorb long channel impulse responses and large propagation delays. In some cases, operation in these bands is subject to coordination with existing users, e.g., television broadcast.](#)

[IEEE 802 networks can also be used to perform the task of an access network, i.e., to connect end stations to a larger, heterogeneous network, e.g., the Internet.](#)

The early IEEE 802 standards for LAN and MAN technologies were all based on the use of copper or optical fiber cables as the physical transmission medium. However, in addition to the use of cable-based media, today's IEEE 802 standards include technologies, radio and optical, that use free space as the physical transmission medium. IEEE 802 standards for wireless networks include wireless LANs, MANs, RANs, and PANs. These technologies also target usage scenarios for both fixed and mobile wireless. These IEEE 802 network solutions address challenges of mobility, higher error rates, and potentials for signal loss and interference that are inherent to using wireless medium.

~~A MAN is optimized for a larger geographical area than is 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. A MAN might be owned and operated by a single organization, but it 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 primarily aimed at deployment on the scale of a large building or a campus, LANs are also frequently applied in smaller areas, such as small offices or single laboratories, and increasingly in homes. At the small scale application level, a LAN is different from the type of network, such as a data bus or backplane bus, that is optimized for the interconnection of devices on a desktop or of components within a single piece of equipment. However, desktop scale applications of LANs are also possible, particularly where the nature of the application is more suited to peer-to-peer communication among autonomous components, as opposed to a system structure with more centralized control.~~

The original IEEE 802[®] LAN technologies used shared medium communication, with information broadcast for all stations to receive. That approach has been varied and augmented subsequently, but in ways that preserve the appearance of simple peer-to-peer communications behavior for end stations. In particular, the use of bridges (see 6.3.2) for interconnecting LANs is now widespread. These devices allow the construction of networks with much larger numbers of LAN end stations, and much higher aggregate throughput, than would be achievable with a single shared medium LAN. End stations attached to such a bridged LAN can communicate with each other just as though they were attached to a single shared medium LAN (however, the ability to communicate with other stations can be limited by use of management facilities in the bridges, particularly where broadcast or multicast transmissions are involved). A further stage in this evolution has led to the use of point-to-point full-duplex communication in LANs, either between an end station and a bridge or as a typically high-speed link between a pair of bridges.

An optional function that may be offered by a LAN or a MAN is the provision of local networking of isochronous bearer services that are compatible with, or higher-speed versions of, Integrated Services Digital Networks (ISDN) as defined by the ITU-T I-series Recommendations, to support voice, video, and data devices and terminals. These services are based on the use of end-user-to-end-user isochronous bearers that will span the supporting Integrated Services LAN (ISLAN) or MAN and an intervening ISDN-conformant WAN. Typically, the information streams for packet and isochronous services are multiplexed over the same physical media. In addition, capabilities are specified for a single integrated management of these various streams.

4.2 Application and support

[IEEE 802](#) ~~The~~ networks are intended to have wide applicability in many environments. The primary aim is to provide for ~~moderate~~ [low](#)-cost devices and networks, suitable for [consumer](#), commercial, educational, governmental, and industrial applications. ~~Low-cost alternatives are possible for some networks, and application in other environments is not precluded.~~ 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. [IEEE 802 networks can be found in the following environments:](#)

- Client/server applications
- Database access
- Desktop publishing
- Electronic mail
- File transfer
- Graphics
- [Handover services](#)
- Multimedia
- Office automation
- Process control

- Robotics
- [Telecommunication](#)
- Text processing
- Transaction processing
- ~~Integrated Services (voice, video and data) applications~~
- [IEEE 802](#) ~~The~~ networks are intended to support various data devices, such as the following:
 - Bridges, routers, and gateways
 - Computers
 - Image and video monitors
 - Mass storage devices
 - Monitoring and control equipment
 - Photocopiers and facsimile machines
 - Printers and plotters
 - Terminals
 - Wireless terminals

- ~~Integrated Services devices, including ISDN terminals and end systems supporting combined voice, video, and data applications~~

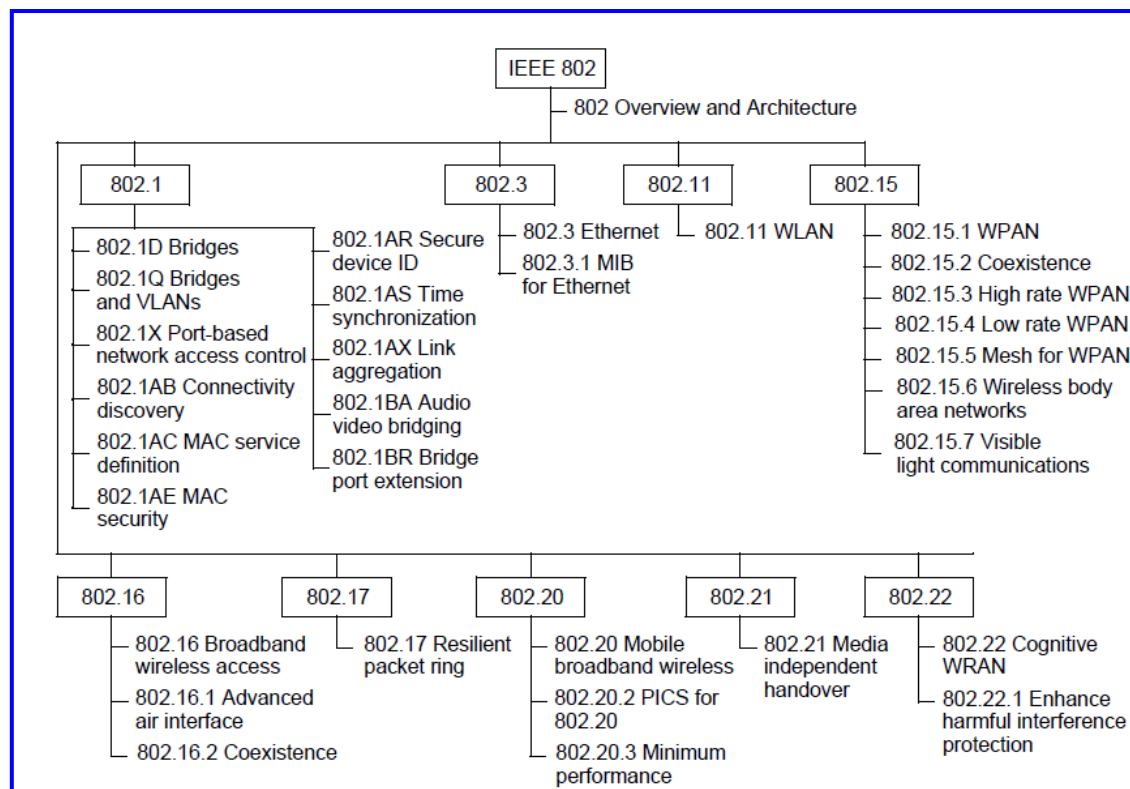
4.3 An international family of standards

The terms *LAN*, *MAN*, *PAN*, and *RAN* 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 the one hand, and the need to accommodate rapidly changing technology and to satisfy certain applications or cost goals, on the other hand, several types of medium access technologies are currently specified in the family of IEEE 802[®] standards. In turn, these MAC standards are specified for a variety of physical media. A ~~logical link control (LLC) standard~~ secure data exchange standard and MAC bridging standards are intended to be used in conjunction with the MAC standards. ~~In some ISLAN and MAN standards, provisions are made for optionally conveying isochronous bearer services in support of continuous voice, video, and synchronous data applications.~~ An Architecture and protocols for the management of IEEE 802[®] ~~LANs~~ networks are also specified defined.

The IEEE 802[®] standards have been developed and applied in the context of ~~an increasingly~~ a global data communications industry. IEEE 802 standards are recognized to be international standards in their own right. In addition, some IEEE 802 standards have progressed to become standards within ISO/IEC JTC 1 Joint Technical Committee 1 Information Technology, of the International Organization for Standardization and the International Electrotechnical Commission see Clause 2 and Annex A. This global context is recognized in that most IEEE 802[®] Standards are progressed to become also international (ISO/IEC JTC 1), International Telecommunication Union Telecommunication Standardization Sector (ITU-T), International Telecommunication Union Radio communication Sector (ITU-R), and a wide variety of national body standards development organizations.

4.4 IEEE 802 standards

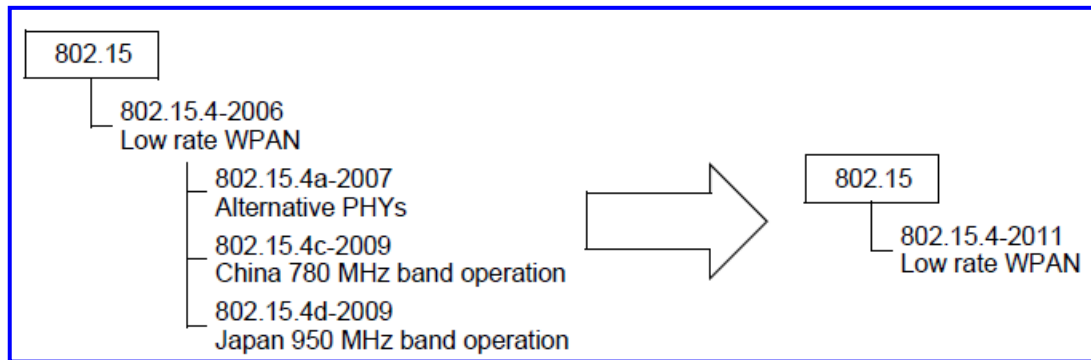
The IEEE 802 LAN/MAN Standards Committee sponsors a large number of standards projects. The current state of IEEE 802 standards and recommended practices is illustrated in Figure 1. The IEEE 802 committee is very active; therefore, for the latest status of the IEEE 802 working groups and standards, refer to [http:// www.ieee802.org](http://www.ieee802.org).



(New)

Figure 1—Current family of IEEE 802 standards and recommended practices

At any given time, an IEEE 802 standard may have one or more amendments related to it. Each amendment, once approved, is considered to be part of the base standard. At a future time, these amendments are incorporated into the base standard so that a new single document can be issued. This process is illustrated in Figure 2 for IEEE Std 802.15.4TM-2011,⁸ which incorporated the amendments IEEE Std 802.15.4aTM-2007, IEEE Std 802.15.4cTM-2009, and IEEE Std 802.15.4dTM-2009 into the base standard IEEE Std 802.15.4-2006.



(New)

Figure 2— Issuance of IEEE Std 802.15.4-2011 from previous base standard and amendments

⁸ See Annex D for a list of approved IEEE 802 standards that were current when this standard was completed.

5.—Compliance

~~NOTE—IEEE policy with respect to claims of compliance, conformance, or compatibility with IEEE standards can be found in the Trademark Policy statement in the front matter. This clause will be deleted in the next revision of this standard.~~

5. Reference ~~and implementation~~ models (RMs)

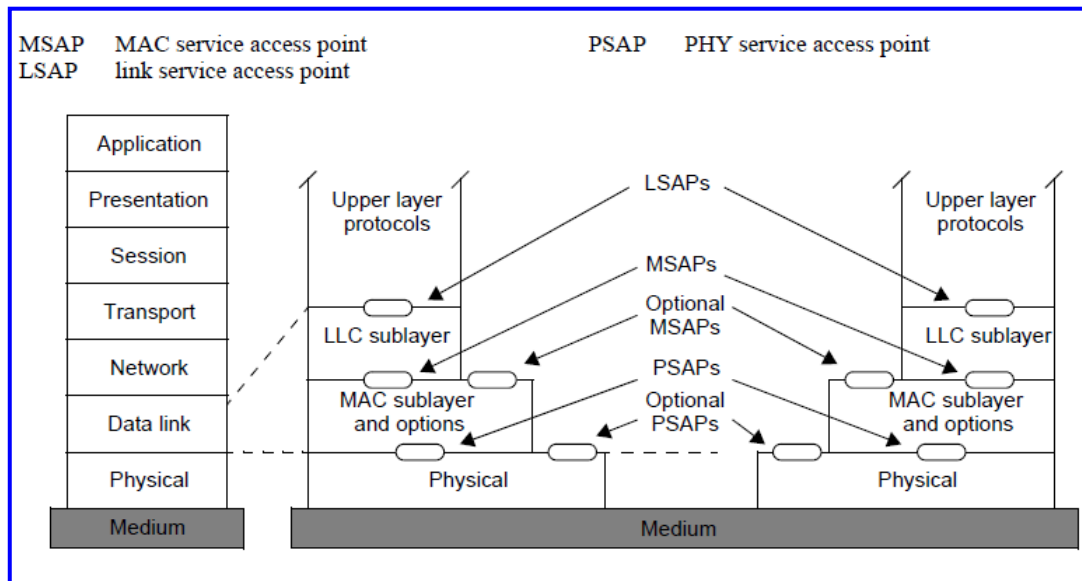
5.1 Introduction

~~This clause defines The IEEE 802[®] LAN and MAN RM (LAN&MAN/ RM) and implementation model(LAN&MAN/IM). The intent of presenting these models is as follows:~~

- ~~a) To provide an overview of the standard~~
- ~~b) To serve as a guide to reading other IEEE 802[®] Standards~~

The IEEE 802[®] ~~LAN&MAN/RM is patterned after~~ derived from the Open Systems Interconnection (~~OSI~~) basic reference model (OSI/RM), ISO/IEC 7498-1:1994 [B7]⁹. It is assumed that the reader has some familiarity with the OSI/RM and its terminology. The IEEE 802[®] ~~Standards encompass~~ standards emphasize the functionality of the lowest two layers of the OSI/RM, i.e., ~~Physical layer~~PHY and ~~Data-Link-layer~~DLL, and the higher layers as they relate to ~~LAN~~network management. The ~~LAN&MAN/IEEE 802~~ RM is similar to the OSI/RM in terms of its layers and the placement of its service boundaries. Figure 3 shows the architectural view of IEEE 802 RM for end stations and its relation to the OSI/RM. A variation of the model applies within bridges, as described in 5.3.2.

⁹The numbers in brackets correspond to those of the bibliography in Annex A.



(New)

Figure 3—IEEE 802 RM for end stations

For the mandatory [packet data](#) services supported by all [LANs and MANs](#) [IEEE 802 networks](#), the [Data Link layer-DLL](#) is structured as two sublayers, with the [logical link control \(LLC\)](#) sublayer, [described in 5.2.2](#), operating over a MAC sublayer. ~~In addition, some IEEE 802[®] LAN technologies provide direct support by the MAC sublayer for an alternative Ethernet sublayer operating at the same place in the architecture as does LLC; for the other IEEE 802[®] LAN technologies, the equivalent, described in 5.2.3, functionality is provided by encapsulation of the Ethernet sublayer information within LLC Protocol Data Units (PDUs), using the Subnetwork Access Protocol specified in Clause 10 of this Standard.~~

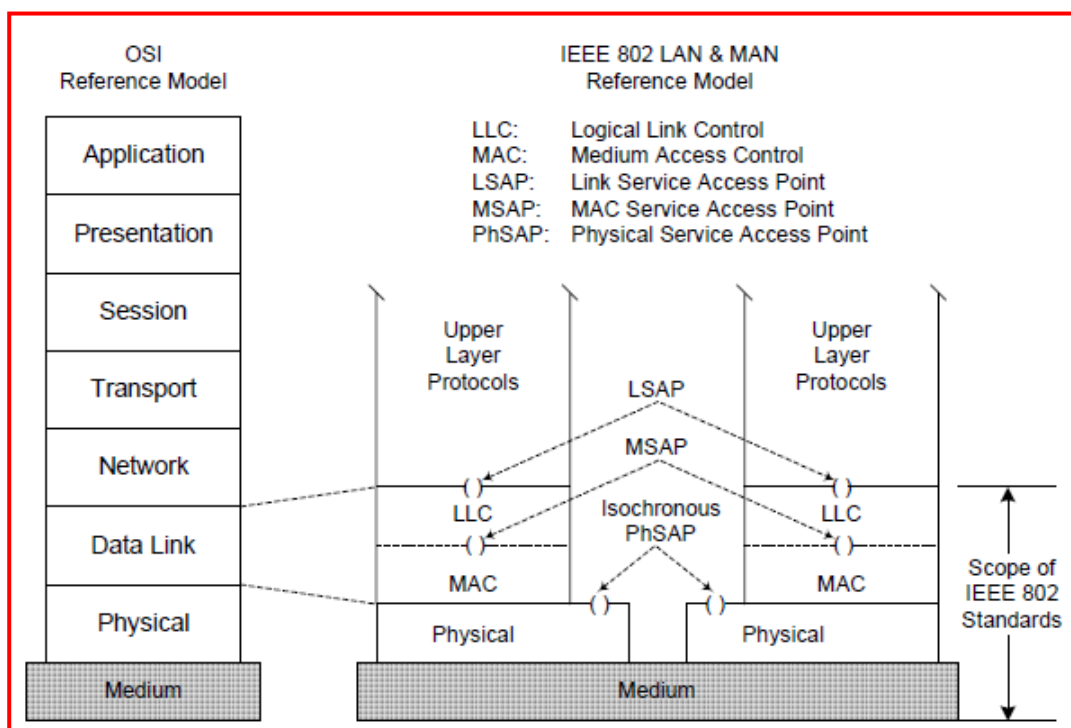
~~Optionally, some Integrated Service LANs and MANs may also support ITU-T compatible isochronous bearer services at the Physical layer.~~

[Each IEEE 802](#) has RMs that are more detailed in order to describe the structure for that specific standard. The RMs for the IEEE 802 standards are given in [Annex B](#).

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

- a) ~~The OSI/RM provides a common vehicle for understanding and communicating the various components and interrelationships of the standards.~~
- b) The OSI/RM helps define terms.
- c) The OSI/RM provides a convenient framework to aid in ~~the development and enhancement of the standards.~~
- d) ~~The use of the OSI/RM facilitates a higher degree of interoperability than might otherwise be possible.~~

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



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Figure 1—IEEE 802[®] RM for end stations (LAN&MAN/RM)