

IEEE Standard for Wireless Access in Vehicular Environments (WAVE)— Networking Services

IEEE Vehicular Technology Society

Sponsored by the
Intelligent Transportation Systems Committee



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IEEE Standard for Wireless Access in Vehicular Environments (WAVE)— Networking Services

Sponsor

Intelligent Transportation Systems Committee

of the

IEEE Vehicular Technology Society

Approved 30 September 2010

IEEE-SA Standards Board

Abstract: Wireless Access in Vehicular Environments (WAVE) Networking Services provides services to WAVE devices and systems. Layers 3 and 4 of the open system interconnect (OSI) model and the Internet Protocol (IP), User Datagram Protocol (UDP), and Transmission Control Protocol (TCP) elements of the Internet model are represented. Management and data services within WAVE devices are provided.

Keywords: Provider Service Identifier (PSID), Wireless Access in Vehicular Environments (WAVE), WAVE Short Message (WSM)

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Introduction

This introduction is not part of IEEE Std 1609.3-2010, IEEE Standard for Wireless Access in Vehicular Environments (WAVE)—Networking Services.

This document replaces IEEE Std 1609.3™-2007.

Regulatory bodies can designate particular (radio frequency) channels in Intelligent Transportation Systems allocated spectrum for specific dedicated purposes (e.g., vehicle-to-vehicle safety applications or emergency vehicle preemption). The channel access assignment mechanisms specified in this standard can be configured to satisfy such regulatory requirements.

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IEEE ~~Trial-Use~~ Standard for Wireless Access in Vehicular Environments (WAVE)— Networking Services

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1. Overview

1.1 General

A WAVE system is a radio communications system intended to provide ~~seamless~~-interoperable services to transportation. These services include those recognized by the U.S. National Intelligent Transportation Systems (ITS) Architecture and many others contemplated by the automotive and transportation infrastructure industries. These services include communications between vehicles and roadside ~~as well as vehicle to-vehicle communications units, vehicles and other vehicles, and perhaps communications among other~~ WAVE devices. WAVE Networking Services provide management services and data delivery services between WAVE devices ~~to all layers~~. This is but one component in the overall WAVE architecture, which includes IEEE P1609.1TM [B1],¹ IEEE P1609.2TM,² IEEE Std 1609.4TM, IEEE Std 802.11TM, and IEEE Std 802.11pTM. The WAVE architecture is described in IEEE P1609.0TM.

1.2 Scope

The scope of this standard is ~~to define services, operating at the~~ specification of network and transport ~~layers, in-layer protocols and services that support of multi-channel~~ wireless connectivity ~~among vehicle based devices, and between fixed roadside devices and vehicle based devices using the 5.9 GHz DSRC~~ IEEE 802.11 Wireless Access in Vehicular Environments (WAVE-mode) devices.

¹ The numbers in brackets correspond to those of the bibliography in Annex I.

² Information on references can be found in Clause 2.

1.3 Purpose

WAVE Networking Services represent layers 3 and 4 of the open system interconnect (OSI) communications stack. The purpose of this standard is to provide addressing and routing data delivery services within a WAVE system, providing multiple ~~stacks of upper layers above WAVE networking services and multiple lower layers beneath WAVE networking services~~ higher layer entities access to WAVE communication services. Upper layer support includes in-vehicle applications offering safety and convenience to their users.

1.4 Conformance

Per the *IEEE Style Manual* [B2], this standard includes normative and informative information. Normative text may describe mandatory or optional features. A mandatory feature may have optional as well as mandatory components. For example, a mandatory message may have optional fields. An optional feature may have components that are mandatory if the feature is supported. For example, an optional message might require a certain field. Additionally, a feature may be conditional on support of another feature. For example, if A is supported, at least one of B or C must be supported.

In this standard, features are designated as mandatory, optional, or conditional in the introduction to the subclause specifying the feature. The designation applies to the requirements found in the subclause itself as well as any subordinate subclauses, unless otherwise indicated. The word *shall*, when applied to a component of an optional feature, indicates that the component is mandatory if the feature is supported, i.e., conditional on support for the feature. The protocol implementation conformance statement (PICS) in Annex C summarizes the features and their components.

1.5 Document organization

Clause 1 provides an overview of the document. Clause 2 and Clause 3 contain references, definitions, and abbreviations, respectively. Clause 4 provides a general description of ~~extensive explanatory information about the architecture and behavior of the overall WAVE system, including aspects beyond~~ WAVE Networking Services. Clause 5 specifies the data plane elements of WAVE Networking Services, which carry ~~user~~ higher layer data through the system. Clause 6 specifies the management plane functions that support system operations. Clause 7 defines the primitives used to communicate between WAVE Networking Services and other ~~system~~ internal functional entities. Clause 8 specifies the format of WAVE Service Advertisements and Short Messages. Annex A and Annex B contain a description, and formal definition, of the management information employed by WAVE Networking Services. Annex C provides ~~an informative bibliography and definitions~~ a PICS proforma. Annex D provides ~~a protocol implementation conformance statement (PICS) proforma~~ some examples of Networking Services usage. Annex E contains allocated WAVE Element ID values. Annex F specifies a supplement to the WAVE Short Message Protocol for safety applications. Annex G shows the contents of example WAVE packets. Annex H shows example Provider Service Identifiers. Annex I provides an informative bibliography and definitions.

1.6 Document conventions

Unless otherwise noted, conventions follow those in IEEE Std 802.11, including conventions for the ordering of information within data items as specified in Clause 8 of this standard.

Numbers are decimal unless otherwise noted, except Internet Protocol (IP) addresses, which are hexadecimal per the conventions defined in IETF RFC 2373. Numbers preceded by 0x indicate hexadecimal numbers, so that 0xFF is equivalent to “FF hexadecimal.” Numbers preceded by 0b are binary.

Words in italics refer to data items that are defined as either a field in an interface primitive ~~or as an internal,~~ a field in an over the air message, or a data item in the management information base (MIB).

Descriptive, informative information is generally found at the beginning of a clause or subclause, with normative text following. Figures are used for illustration and are informative unless otherwise noted. [Refer to the IEEE Style Manual \[B2\] for IEEE standards conventions.](#)

[Unless otherwise noted, references to a MIB refer to the WME MIB specified in Annex B.](#)

1.7 System overview

The system described herein supports high-rate, low-latency communications between WAVE devices. Generic Internet Protocol version 6 (IPv6) traffic is supported (not Internet Protocol version 4), as well as a specialized [WAVE](#) Short Message service, [although a given device might not support both protocols](#). A control channel provides a common channel for signaling. IP ~~application~~ data is restricted to service channels; short message data may be sent on either type of channel. Higher layer entities benefiting from the WAVE communications can reside on the WAVE devices or reside on ~~generic~~ devices located on other networks connected to these devices. A more complete description of a WAVE system is provided in IEEE P1609.0.

1.8 Applicability

WAVE Networking Services support wireless communications between any and all WAVE devices. These devices may be mobile, portable, or stationary. The mobile devices include vehicles operating at high speeds ~~occurring~~ on open highways. A common characteristic of WAVE systems is the need for extremely low communications latency (measured in milliseconds) from initially encountering a device that provides services to completing a set of data transfers.

This standard is consistent with the vehicle-to-roadside and vehicle-to-vehicle communications needs of various ITS architectures. Its intent is to enable interoperability and robust safety/public safety communications among these WAVE devices.

2. Normative references

The following referenced documents [and URLs](#) are indispensable for the application of this document ([i.e., they must be understood and used, so 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 P802.11RE ~~Vmb™/D3.0, March 2010~~, IEEE Draft Standard for Information Technology—Telecommunications and Information Exchange Between Systems—Local and Metropolitan Area Networks—Specific Requirements—Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications.¹ ~~Wireless Access in Vehicular Environments (WAVE).~~⁴

IEEE P1609.0™/D0.9, April 2010, IEEE Draft Standard for Wireless Access in Vehicular Environments (WAVE)—~~Resource Manager~~ [Architecture](#).

IEEE P1609.2™/D5, June 2010, IEEE ~~Trial-Use~~ [Draft](#) Standard for Wireless Access in Vehicular Environments (WAVE)—Security Services for Applications and Management Messages.

¹ Numbers preceded by P are IEEE authorized standards projects that were not approved by the IEEE-SA Standards Board at the time this publication went to press. For information about obtaining drafts, contact the IEEE.

[IEEE Std 802[®], IEEE Standard for Local and Metropolitan Area Networks: Overview and Architecture.](#)^{2, 3, 4}

IEEE Std 802.11[™], IEEE Standard for Information Technology—Telecommunications and Information Exchange Between Systems—Local and Metropolitan Area Networks—Specific Requirements—Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications.

[IEEE Std 802.11k[™]-2008, IEEE Standard for Information Technology—Telecommunications and Information Exchange Between Systems—Local and Metropolitan Area Networks—Specific Requirements—Part 11: Wireless LAN Medium Access Control \(MAC\) and Physical Layer \(PHY\) Specifications Amendment 1: Radio Resource Measurement of Wireless LANs.](#)

[IEEE Std 802.11p[™], IEEE Standard for Information Technology—Telecommunications and Information Exchange Between Systems—Local and Metropolitan Area Networks—Specific Requirements—Part 11: Wireless LAN Medium Access Control \(MAC\) and Physical Layer \(PHY\) Specifications Amendment 6: Wireless Access in Vehicular Environments.](#)

IEEE Std 1609.4[™], IEEE Standard for Wireless Access in Vehicular Environments (WAVE)—MultiChannel Operation.

IETF RFC 768, User Datagram Protocol.⁵

IETF RFC 793, Transmission Control Protocol.

IETF RFC 1042, Standard for the Transmission of IP Datagrams over IEEE 802 Networks.

IETF RFC 2460, Internet Protocol, Version 6 (IPv6) Specification

IETF RFC 3513, Internet Protocol Version 6 (IPv6) Addressing Architecture. IETF RFC ~~2461~~ 4861, Neighbor Discovery for IP Version 6 (IPv6).

~~IETF Request for Comments: RFC 2462, IPv6 Stateless Address Autoconfiguration.~~

ISO/IEC 8802-2 [IEEE Std 802.2[™]], IEEE Standard for Information Technology—Telecommunications and Information Exchange Between Systems—Local and Metropolitan Area Networks—Specific Requirements—Part 2: Logical Link Control.

[SAE J2735, Dedicated Short Range Communications \(DSRC\) Message Set Dictionary.](#)⁶

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⁶ SAE publications are available from [the Society of Automotive Engineers, 400 Commonwealth Drive, Warrendale PA 15096, USA](#) (<http://www.sae.org/>).

3. Definitions, acronyms, and [abbreviations](#)

3.1 Definitions

For the purposes of this document, the following terms and definitions apply. ~~The Authoritative Dictionary of IEEE Standard P1609.0 and The IEEE Standards Dictionary: Glossary of Terms & Definitions~~ should be consulted for terms not defined in this clause.⁷

air interface: A radio frequency communication interface, from the physical layer of one device to that of a remote device, such as the interface defined by Wireless Access in Vehicular Environments (WAVE).

~~**3.1.2 application priority:** A priority level associated with an application that determines which application is given precedence by WME in case of a conflict in initiating or joining a WBSS.~~

control channel (CCH): A [single](#) radio channel, [not a service channel](#), intended for the exchange of management frames, [including Wireless Access in Vehicular Environments \(WAVE\) Service Advertisements](#), and WAVE Short Messages. [See also: service channel \(SCH\)](#).

data plane: A set of communication protocols defined to carry higher layer and management data. The data plane consists of protocol stack(s) for the transfer of data through a device for transmission over the air.

Ethertype: The Ethernet Type field defined in IETF RFC 1042, used to identify the protocol above the Logical Link Control.

hexadecimal representation: (From IEEE Std 802®) 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.

higher layer: A functionality (e.g., an application) residing in the context of the Open System Interconnection (OSI) protocol suite reference model, in the management or data plane above the services defined in this standard.

managed Wireless Access in Vehicular Environments (WAVE) device: A WAVE device that supports management through the use of an IEEE 1609 standards-defined management information base.

management ID: Identifier of an IEEE 1609 management entity used to indicate the source and destination of management information. The values are specified in IEEE P1609.0.

management plane: A collection of functions performed in support of the communication functions provided by the data plane but not directly involved in passing higher layer data. The management plane may employ lower layers of the data plane to transfer management information [between devices](#).

Networking Services: A collection of management plane and data plane functions at the network layer and transport layer, as specified in this standard, supporting Wireless Access in Vehicular Environments (WAVE) communications.

~~3.1.8 non-persistent WBSS: A non-persistent WBSS is one that is announced only when it is established. It would typically be used for a transitory exchange among a group of devices whose membership does not change for the duration of the WBSS.~~

notification: An indication of an event of interest, sent ~~to an application~~ from a management entity to a higher layer entity.

~~3.1.10 onboard unit (OBU): A WAVE device that can operate when in motion and supports the information exchange with roadside units or other OBUs.~~

~~3.1.11 OBU to vehicle host interface (OVHI): An interface on the OBU offering access to WAVE capabilities by other vehicle-based devices.~~

~~3.1.12 persistent WBSS: A persistent WBSS is one that is announced periodically, during each CCH interval. It would typically be used for an ongoing WBSS whose services and device participation may change over the duration of the WBSS.~~

⁷ The IEEE Standards Dictionary: Glossary of Terms & Definitions is available at <http://shop.ieee.org/>.

provider: Advertiser of a Wireless Access in Vehicular Environments (WAVE) service. *See also:* **user**; Wireless Access in Vehicular Environments (WAVE) Service Advertisement.

Provider Service Context (PSC): A field associated with a Provider Service Identifier (PSID) containing supplementary information related to the service. The internal format of the PSC is PSID dependent.

Provider Service Identifier (PSID): ~~A number~~ An octet string that identifies a service provided by ~~an application~~ a higher layer entity.

~~3.1.16 Provider Service Table (PST): A collection of data describing the applications that are registered with and available through a WAVE device, with supporting channel information~~

pseudonymity: A property of a pseudonymous entity. A pseudonymous entity has the property that its permanent or long-lived identities, and its long-term patterns of behavior, cannot be deduced from its network traffic and are only available to appropriately authorized parties.

~~3.1.17 registration: A process for providing application parameters and channel characteristics that will facilitate the management of the communication system in support of the application.~~

~~3.1.18 roadside unit (RSU): A WAVE device that operates only when stationary and supports information exchange with OBUs.~~

service channel (SCH): ~~Secondary channels used for application specific~~ Any channel that is not the control channel, intended for management frames and higher layer information exchanges (Wireless Access in Vehicular Environments (WAVE) Short Message [WSMs] and Internet Protocol version 6 [IPv6] packets). There may be more than one service channel defined in a given spectrum.

service priority: A priority level associated with a service request that determines which service requests are given precedence by the WAVE Management Entity (WME) when assigning channels.

~~3.1.20 transmission priority: A priority level assigned to a packet that is ready for transmission, which determines its treatment at the MAC layer.~~

~~3.1.22 vehicle host:~~ In vehicle device running applications that communicate to external WAVE devices using the WAVE system through the OBU vehicle host interface.

~~3.1.23 WAVE basic service set (WBSS):~~ A set of cooperating WAVE stations consisting of a single WBSS provider and none or multiple WBSS users.

Timing Advertisement frame: A management frame specified in IEEE Std 802.11p used to carry timing information.

~~user:~~ ~~Joiner of a WBSS, or receiver of WSMs~~ One that acts on receipt of a WAVE Service Advertisement. See also: provider: Wireless Access in Vehicular Environments (WAVE) Service Advertisement.

user priority: A priority level assigned to a packet that is ready for transmission, which determines its treatment at the medium access control (MAC) layer.

Vendor Specific Action frame: A management frame specified in IEEE Std 802.11. Despite the name, when the first 36 bits of the *Organization Identifier* are equal to 0x0050C24A4, the contents are specified for use in carrying IEEE 1609 management information including Wireless Access in Vehicular Environments (WAVE) Service Advertisements.

Wireless Access in Vehicular Environments (WAVE) device: A device that is compliant to IEEE P1609.3, IEEE Std 1609.4, and IEEE Std 802.11, operating outside the context of a basic service set. (See IEEE P1609.0 and IEEE Std 802.11p.)

~~A device that contains a WAVE-conformant medium access control (MAC) and physical layer (PHY) interface to the wireless medium. (See IEEE P802.11p and IEEE Std 1609.4.)~~

Wireless Access in Vehicular Environments (WAVE) medium access control (MAC): A WAVE MAC is a medium access control sublayer conformant to IEEE Std 1609.4.

Wireless Access in Vehicular Environments (WAVE) Management Entity (WME): A set of management functions required to provide WAVE networking services.

Wireless Access in Vehicular Environments (WAVE) Routing Advertisement (WRA): Network configuration information broadcast ~~by the RSU~~ as part of a WAVE Service Advertisement.

Wireless Access in Vehicular Environments (WAVE) Service Advertisement (WSA): A data structure containing information including the announcement of the availability of a service. ~~A WSIE is composed of such structures.~~

~~3.1.28 WAVE service information element (WSIE):~~ A field in a WAVE Announcement action frame used to advertise the WAVE services being offered. The WSIE is comprised of a *Secured WSA*, *Timing Quality*, and in the case of the RSU the *WAVE Routing Advertisement*.

Wireless Access in Vehicular Environments (WAVE) Short Message (WSM): A packet consisting of WSM data and a WAVE Short Message Protocol (WSMP) header.

Wireless Access in Vehicular Environments (WAVE) Short Message Protocol (WSMP): A protocol for rapid exchange of messages in a rapidly varying radio frequency (RF) environment where low latency is also an important objective.

~~3.1.30 wireline:~~ A connection via a traditional communications interface other than a wireless interface.

3.2 Acronyms and abbreviations

ACI	access category index
ACM	admission control mandatory
AIFSN	arbitration interframe space number
ASCII	American Standard Code for Information Interchange
ASN	Abstract Syntax Notation
CCH	control channel
CW	contention window
DNS	domain name system
~~DHCP~~	~~Dynamic Host Configuration Protocol~~
~~DA~~	~~Destination Address~~
~~DS~~	~~Distribution System~~
~~DSRC~~	~~Dedicated Short Range Communications~~
EDCA	enhanced distributed channel access
~~FCC~~	~~Federal Communications Commission~~
~~FOT~~	~~Field Operational Testing~~
~~FHWA~~	~~Federal Highway Administration~~
~~GPS~~	~~Global Positioning System~~
IETF	Internet Engineering Task Force
IP	Internet Protocol
IPv6	Internet Protocol version 6
ITS	Intelligent Transportation Systems
LLC	Logical Link Control
LSAP	link service access point
MAC	medium access control
MIB	management information base
MLME	MAC sublayer management entity
~~MTU~~	~~maximum transmission unit~~
~~NSAP~~	~~network service access point~~
~~OBU~~	~~onboard unit~~
~~OVH~~	~~OBU to vehicle host interface~~
OSI	open system interconnect
~~PDU~~	~~protocol data unit~~
PHY	physical layer
~~PLME~~	~~physical layer management entity~~
PICS	protocol implementation conformance statement
PSC	Provider Service Context
PSID	Provider Service Identifier
~~PST~~	~~Provider Service Table~~
~~RA~~	~~receiver address~~
RCPI	Received Channel Power Indicator
RF	radio frequency
RFC	Request for Comments
~~RSU~~	~~roadside unit~~
~~SA~~	~~source address~~
SAE	Society of Automotive Engineers
SAP	service access point
SCH	service channel
~~SME~~	~~Station Management Entity~~
~~SSID~~	~~Service Set Identifier~~
SNAP	Subnetwork Access Protocol
STA	station
TA	~~Transmitter Address~~ Timing Advertisement (frame)
TCP	Transmission Control Protocol
TXOP	transmission opportunity

UDP	User Datagram Protocol
~~UTC~~	~~Coordinated Universal Time~~
<u>VSA</u>	<u>Vendor Specific Action (frame)</u>
WAVE	Wireless Access in Vehicular Environments
~~WBSS~~	~~WAVE basic service set~~
<u>WGS</u>	<u>world geodetic system</u>
WME	WAVE Management Entity
WRA	WAVE Routing Advertisement
WSA	WAVE Service Advertisement
~~WSIE~~	~~WAVE service information element~~
WSM	WAVE Short Message
WSMP	WAVE Short Message Protocol
<u>WSMP-I</u>	<u>WAVE identity supplement</u>
<u>WSMP-S</u>	<u>WSMP safety supplement</u>

4. General description

4.1 Overview

WAVE provides a communication protocol stack optimized for the vehicular environment, employing both customized and general-purpose elements. ~~The components of the protocol stack, as defined in standards, are shown in Figure 1.~~

~~This clause IEEE P1609.0 provides an overview a description of the WAVE system architecture and operations. WAVE components, along with an identification of defining specifications, are illustrated in Figure 1 and described below. The architectural components, including WAVE networking services, lower layers, upper layers, and radio service security, are introduced in 4.1. In 4.2, the different communications methods and device types supported by the system are described. Subclause 4.3 describes how the system operates in performing specific functions.~~

WAVE Networking Services is specified in this standard and consists of data plane layers and the associated management plane entity (WAVE management entity, WME) as shown by the dashed lines in Figure 2. These are introduced in 4.2 and 4.3 and specified in Clause 5 and Clause 6

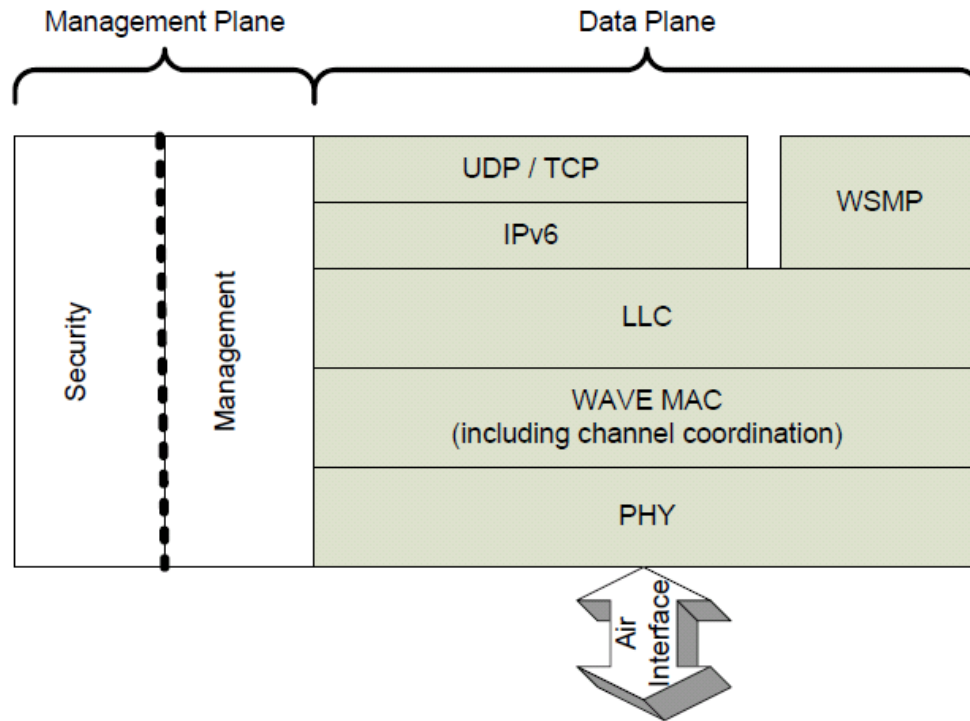


Figure 1—WAVE protocol stack

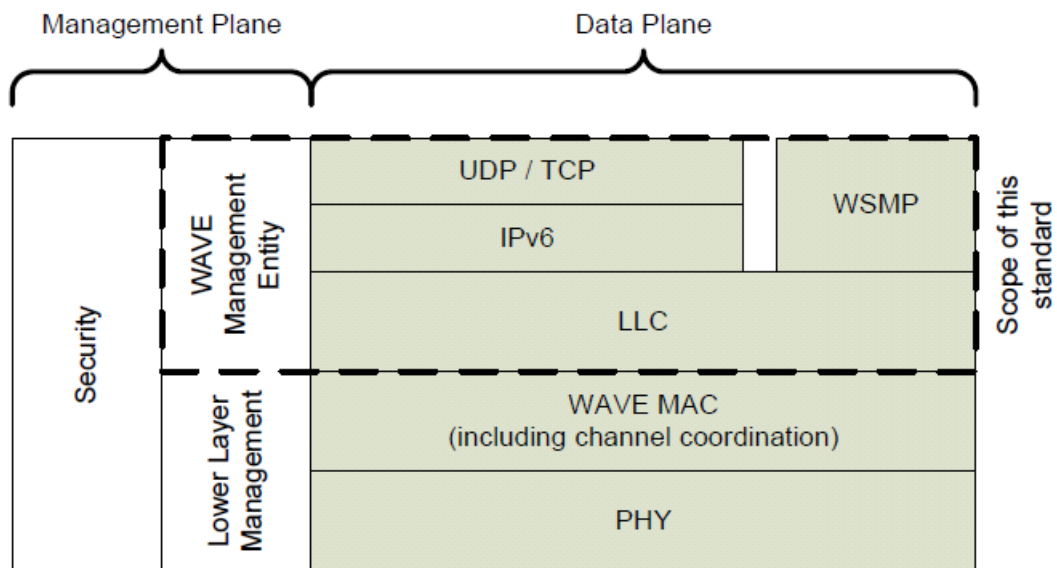


Figure 2—Scope of this standard

4.1 The WAVE system

WAVE networking services provides LLC, network, and transport layer functions. The general WAVE protocol stack, from the perspective of WAVE networking services, is shown in Figure 2. The stack consists of the following:

Data plane, which contains the communication protocols and hardware used for delivering data. The data plane carries traffic primarily generated by, or destined for, applications. It also carries traffic between management plane entities on different machines, or between management plane entities and applications (e.g., for notification). Throughout this document, descriptions assume that all the WAVE protocol entities shown in Figure 2 reside in a single physical device, but this need not be the case.

Management plane, which performs system configuration and maintenance functions. Management functions employ the data plane services to pass management traffic between devices. Specific Management Entities are defined for certain individual layers, e.g., physical layer management entity (PLME), and MAC layer management entity (MLME). The WAVE management entity (WME) is a more general collection of management services. Note that the WME provides its management interface to all data plane entities, including WSMP, though this is not explicitly illustrated in Figure 2 and elsewhere.

The WAVE networking services management and data plane are described in more detail in 4.1.1.

4.1.1 WAVE networking services

WAVE networking services is defined in this specification and consists of the data plane's middle layers and most of the management plane (the WME) as shown by the dashed lines in Figure 2. These are introduced in 4.1.1.1 and 4.1.1.2 and specified in Clause 5 and Clause 6.

4.1.2 Lower layers

Lower layers are the medium access control (MAC) and physical layers (PHY). They are defined in IEEE Std 802.11 as amended by IEEE P802.11p and also in IEEE Std 1609.4 (defining multi-channel operation).

4.1.3 Upper layers

WAVE is intended to provide support for a range of existing and yet-to-be-developed upper layer entities and applications. WAVE provides an interface in support of the functions required by the applications, such as data transfer, WBSS management, system configuration, and notification. The interfaces are defined in terms of primitives in Clause 7.

4.1.4 WAVE service security

WAVE security services provide features such as authentication of control information. The security functions are performed in conjunction with WAVE networking services processing, and specified in IEEE Std 1609.2.

4.1.5 External entities

The WAVE standards, which specifically address communications over the radio medium, can be used in a system that also supports external entities (i.e., not connected to the air interface), such as vehicle-based host processors or remote servers accessed via the Internet.

4.2 Data services

Data plane components of WAVE Networking Services are specified in Clause 5 and consist of the following, not all of which may be present in a given device:

- Logical Link Control

Networking Services includes the LLC sublayer, for both IP and WSMP traffic.

- Internet Protocol version 6, and higher layers such as User Datagram Protocol (UDP) and Transmission Control Protocol (TCP)

Networking Services accepts data from higher layers for transmission over the Internet Protocol stack and delivers received Internet Protocol data to higher layers.

- WSMP

Networking Services accepts data from higher layers for transmission over the WAVE Short Message Protocol and delivers received WSM data to higher layers.

4.2 WAVE system attributes

~~This subclause describes important aspects of the WAVE system, which is provided as a base for better understanding the material in subsequent clauses.~~

4.2.1 Channel types

~~For the purposes of this standard, WAVE distinguishes between two classes of radio channel: a single control channel (CCH), and multiple service channels (SCH). By default, WAVE devices operate on the CCH, which is reserved for short, high priority application and system control messages. Service channel visits are arranged between devices via a WBSS in support of general purpose application data transfers. See IEEE Std 1609.4 for more information.~~

4.2.2 Communication protocols

~~WAVE accommodates two protocol stacks: standard Internet Protocol (IPv6) and the unique WAVE short message protocol (WSMP) designed for optimized operation in the WAVE environment. WAVE short messages (WSMs) may be sent on any channel. IP traffic is allowed only on SCHs. In addition to these traffic types, system management frames are sent on the CCH as described in IEEE Std 1609.4.~~

~~The WSMP allows applications to directly control physical layer characteristics, e.g., channel number and transmitter power, used in transmitting the messages. A sending application also provides the MAC address of the destination device, including the possibility of a broadcast address. WSMs are delivered to the correct application at a destination based on Provider Service Identifier (PSID). WSMs are designed to consume minimal channel capacity and are allowed on both the CCH and SCHs.~~

4.2.3 Communication service types

~~Applications can choose to send their traffic in the context of a WAVE BSS (WBSS, see IEEE P802.11p). If the applications do not employ a WBSS, their communication options are limited to WSMs sent on the CCH. Participating on a WBSS allows applications to use either WSMs or IP traffic on the SCH associated with that WBSS.~~

A WBSS is established to support traffic to/from specific applications, and its presence is announced for other devices with compatible applications to join. A persistent WBSS is announced periodically, and could be used to support an ongoing service of indefinite duration, such as general Internet access. A non-persistent WBSS is announced only on WBSS initiation, and might be used to support a WBSS with limited duration.

More on the use of WBSS in WAVE is found in IEEE Std 1609.4.

4.2.4 Device WBSS roles

Devices take the role of either provider or user on a given WBSS. This is determined by the role chosen by the requesting application. The provider device generates the announcements that inform other devices of the existence of the WBSS and the presence of the associated application service(s). The user role is assumed by any devices that join the WBSS based on receipt of the announcement. A device may change roles as it participates on different WBSSs over time. Application roles are covered in Clause 6. The terms provider and user do not imply any particular behavior of the applications once the WBSS is initiated or joined.

The WBSS announcement indicates the presence of one or more applications providing services. A user of such services joins the WBSS for all of the application services that apply, thus allowing a single device to simultaneously support multiple applications. Also, a service provider could have multiple users joined with the WBSS at any one time, each of which uses any possible combination of the application services being provided.

4.2.5 Priorities

The concept of priority is used in multiple ways. Applications have an application priority level, which is used by WAVE networking services to help decide which applications have first access to the communication services. An example of a conflict would be two applications, each with the concurrent need to announce or join a WBSS on a different channel. In this situation, WME would use application priority to choose which application(s) to service, as specified in Clause 6. In addition, the lower layers use a separate MAC transmission priority to prioritize packets for transmission on the medium. IP packets are assigned the MAC priority associated with the traffic class of the generating application. The MAC priority for WSM packets is assigned by the generating application on a packet-by-packet basis. Any relationship between application and transmission values is within the application, and outside the scope of this standard. See IEEE Std 1609.4 for more on MAC transmission priority.

4.2.6 Device types

WAVE defines two device types: roadside unit (RSU), and onboard unit (OBU). These can be thought of as stationary and mobile devices, respectively. RSUs and OBUs can be either a provider or a user of services. While a unit may switch between being a provider and a user of a particular service, it cannot be both simultaneously.

4.2.7 Channel coordination

Transmit and receive operation on WAVE control and service channels is coordinated based on syne intervals that are synchronized using a common system time base that is preferably generated by a global time reference (e.g., UTC/GPS). A syne interval is composed of a CCH interval followed by a SCH interval. During the CCH interval, all devices monitor the CCH. Devices participating in a WBSS exchange data on the designated SCH for that WBSS. See IEEE Std 1609.4 for more information.

4.3 Management services

Management plane components of WAVE Networking Services are specified in Clause 6 and consist of the following [functions performed by the WAVE Management Entity](#):

- [Service requests and channel access assignment](#)

[The WME processes service requests from higher layers, provides service channel access to satisfy service requests, and causes WAVE Service Advertisements, Timing Advertisements, and general management data to be transmitted.](#)

~~Application registration~~

- [Management data delivery](#)

[The WME accepts management data received over the air, and either processes it or passes it to a designated management entity.](#)

~~WBSS management~~

- [WAVE Service Advertisement monitoring](#)

[The WME monitors and verifies services advertised by other WAVE devices for use by higher layers and management functions.](#)

~~Channel usage monitoring~~

- IPv6 configuration

[The WME configures the local IP protocol stack using data received from other WAVE devices.](#)

- MIB maintenance

[The WME maintains a MIB containing configuration and status information.](#)

~~Received Channel Power Indicator (RCPI) monitoring~~

[Other device management functions may be accessed directly, i.e., not via the Networking Services specified in this standard, via the primitives specified in IEEE Std 802.11 or the MLMEX- SendPrimitive.request specified in IEEE Std 1609.4.](#)

4.3 WAVE system operations

~~This subclause describes fundamental WAVE operations from a system point of view, and provides an introduction to the normative material found in Clause 6. The interactions of the applications and the WAVE networking services' WAVE management entity (WME) are given particular attention.~~

~~The objective of WAVE is to provide communication services to applications. To do so, it provides two communications methods, or protocol stacks: WSMP and IPv6. WSMP is unique to this standard and is expected to be used by specialized applications. Applications using WSMP may initiate a WBSS to make a SCH available for their use, but this is not required since WSMs may be exchanged on the CCH.~~

~~The set of channels on which WBSSs may be initiated is contained in the WME MIB. These channels may be dependent upon the regulatory domain in which the unit is operating.~~

~~An OBU may initiate a WBSS on the channel identified in 6.3 and entered in the WME MIB.~~

~~Prior to initiating or joining a WBSS, an application registers with the WME as described in 4.3.4.~~

4.3.1 Operation without a WBSS

Data exchanges without a WBSS use WSMP on the CCH only. The following is a scenario involving WSMP use without a WBSS:

- a) A source application composes WSM data for transmission, and addresses it to the broadcast MAC address. Based on its configuration, the application selects appropriate radio channel information (power level, data rate) to control the transmission, and passes the resulting WSM request primitive (WSM WaveShortMessage.request) to the WSMP for delivery to the lower layers and subsequent transmission on the CCH.
- b) A receiving device accepts the packet and passes it up the communication stack. WSMP delivers it to locally registered application(s), based on PSID. At this point, the receiving application knows the existence and address of the provider device, and can continue the exchange on the CCH if desired, using either unicast or broadcast addresses, as appropriate.

4.3.2 Operation with a WBSS

A WBSS consists of time and frequency (channel) resources, at some set of participating devices within communication range, allocated to support one or more applications. The WBSS is initiated at the request of the application at one device (the provider), and announced on the CCH.

As described in IEEE Std 1609.4, WAVE supports two types of WBSS: persistent and non-persistent—the distinction being that a persistent WBSS is announced during CCH interval, and a non-persistent WBSS is announced only on initiation. A usage of the persistent WBSS would be to offer an ongoing service to any devices that come into range. A usage of the non-persistent WBSS would be to support an on-demand service. Since an OBU does not need to offer services to devices beyond the local area (i.e., having global IPv6 Prefix), a provider OBU announces only IPv6 link local addresses to identify its service provider hosts.

This prevents any disruption of service provided by the OBU as it moves and its coverage area changes. An RSU identifies its providers via either local or global addresses.

4.3.2.1 The WAVE service information element (WSIE)

Applications offering services to potential user applications are announced on the air interface via a WAVE service information element (WSIE) inside a WAVE announcement frame. The WSIE is composed as shown in Figure 3 and described below.

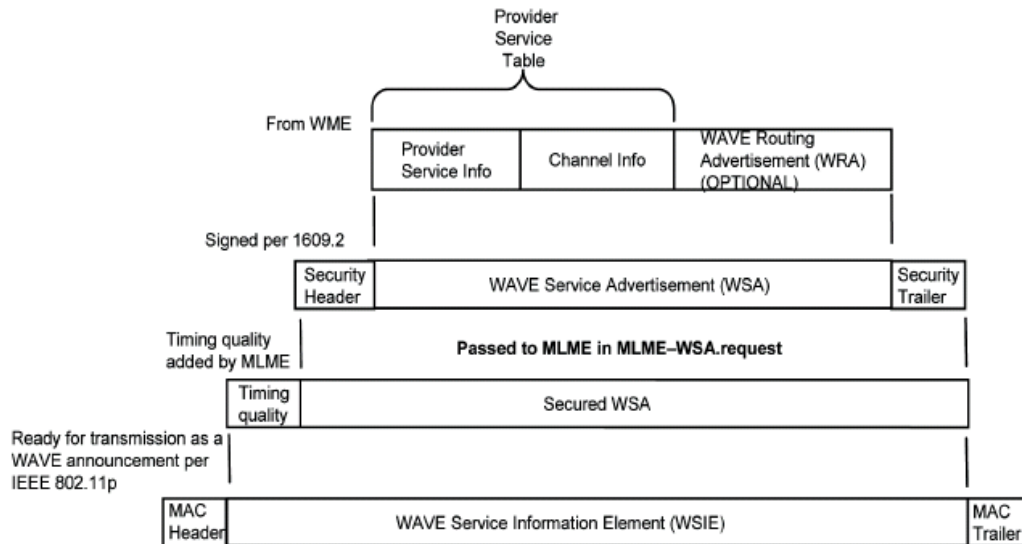


Figure 3—Building the WSIE

The process of creating a WSIE and transmitting it is initiated when an application requests to initiate a WBSS and offer services. On receipt of the WME Application.request, the WME builds an MLME-WSA.request, to start the WBSS. The WSA is built as follows; see Figure 4. Additional details are found in 6.2.1.1, IEEE Std 1609.4, and IEEE P802.11p.

- 1) Prior to operation (e.g., at network configuration), system parameters are loaded into the provider device's WME MIB, including operational channels and their characteristics, and (if applicable) a *WAVE Routing Advertisement (WRA)* containing IP network configuration info.
- 2) Applications register their parameters with the WME; the WME enters the parameters into the WME MIB. Provider services include their channel of operation, address information, and application priority; user services include a *ConfirmBeforeJoin* flag. See 4.3.4 for a discussion of registration.
- 3) A provider application may request a WBSS initiation, including a *ProviderServiceContext*, and the *Repeats* (number of announcement repetitions per CCH visit) and *Persistence* characteristics used by MLME.
- 4) The WME generates a *WAVE Service Advertisement (WSA)*, which will be transmitted to potential service users. The WME collects the application information describing the services being offered, previously registered in its MIB, and channel information describing the WBSS characteristics, also from the MIB, and inserts them into the *WSA*. Additional parameters are set as specified in 6.2.1.1 and 7.2.1. This combination of data is known as the *Provider Service Table*. In addition, if a *WAVE Routing Advertisement (WRA)* exists in the MIB, it is included in the *WSA*.
- 5) The *WSA* is signed, guaranteeing its validity, with security header and trailer added, per IEEE Std 1609.2.
- 6) The secured *WSA* is provided to MLME in the announcement request. MLME adds a parameter reflecting the quality of its timing information, to be used in the receiving devices' synchronization function, with the resulting collection known as a *WAVE service information element (WSIE)*. (The timing information itself is within the MAC header.) At this point, over-the-air headers and footers are added and the frame is ready for transmission.

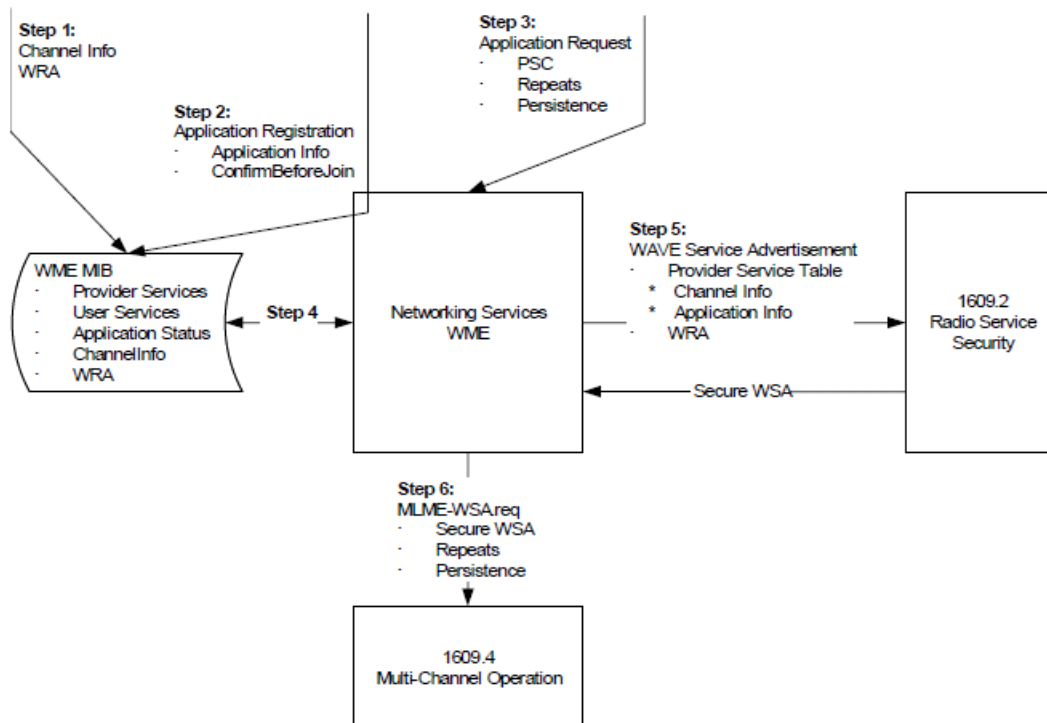


Figure 4—Building the WSA

4.3.2.2 WBSS initiation

This subclause provides a description of WBSS initiation from the application perspective, and ignores some of the detailed processing at lower layers, such as addressing, security credentials, and time synchronization verification. A WBSS is triggered by a provider application via a request to the WME (WME Application.request). The request specifies the provider service context, the persistence, the destination MAC address (individual or broadcast) of the intended recipient devices, the number of announcement repetitions per CCH visit, and the SCH to be used. (Optionally, the request directs the WME to choose the “best available” SCH.) These WBSS parameters are transmitted over the air in a WAVE announcement frame, in the Provider Service Table component of the WAVE service information element (WSIE). See Figure 3 and Figure 17.

After the WAVE Announcement is accepted by the lower layers on the receiving device, the receiving WME checks whether any of the provider applications identified by PSIDs in the WSA are of interest to any locally registered user applications. When a PSID match is found (and assuming the WME’s check of credentials, priority, etc., are satisfied), the WME will take one of two actions, depending again on an application registration parameter. In the simple case, the WME will generate the necessary MAC primitives to cause the local device to join the WBSS and to set lower layer configuration parameters appropriately to

support communications on the WBSS. Alternately, if the application has chosen to do so, it confirms the joining of the WBSS. This gives the user application an additional level of control, for example allowing it to decline to participate in a service if it has recently accomplished any objectives it might have on that WBSS. When it causes the local device to join the WBSS, the WME sends a notification of this fact to the affected application(s).

The announcement frame containing the WSIE is the only WAVE message sent over the air when setting up a WBSS; there is no lower layer over the air coordination used to confirm WBSS initiation.

4.3.2.3 WBSS communications

Upon receipt of the notification from the WME informing it of the WBSS initiation, an application (whether provider or user) is free to generate data packets (WSM or IP) for transmission on the SCH. Any received packets destined for the application will be delivered to the application via the (WSMP or IP) stack. The WBSS remains active at the local device until it is ended as described in 4.3.2.4.

4.3.2.4 WBSS termination

Once a WBSS is active at a device (i.e., initiated by a provider or joined by a user), it remains active at that device until it is locally terminated. There is no protocol exchange over the air interface to confirm the termination of a WBSS. The WME communicates the termination decision to MLME so that it can take action, and also to the affected applications through a notification. The WME terminates participation on a WBSS for any of the following reasons:

- All applications have indicated the completion of their activities on the WBSS, i.e., the WBSS is no longer in use by locally registered applications (6.2.4.1).
- Participation on a conflicting WBSS (e.g., on another channel) is required to support a higher priority application (6.2.1.2).
- A user device may terminate its participation in the WBSS if the lower layer indicates the SCH has been idle (6.2.4.2), implying an irrecoverable loss of the WBSS.

4.3.2.5 Adding and subtracting services from a WBSS

A non-persistent WBSS is announced only when it is initiated by the provider. It uses a unicast or broadcast MAC address for its announcement. Since there is no ongoing announcement, user devices not receiving the announcement are not expected to join the non-persistent WBSS throughout its existence. There is no provision for provider applications to be added to a non-persistent WBSS once it has been initiated.

For a persistent WBSS, on the other hand, the provider MAC generates announcements every CCH interval. Different sets of applications may be offered over time on the same WBSS, i.e., the contents of the announced Provider Service Table may be dynamic. To support this feature, the announcement's destination MAC address is constrained to be the broadcast address. Applications come and go from the provider's WBSS as triggered by the application request primitive. The WME will update the announcement information in the MLME MIB when the *WSA* information changes (as it does when updated security credentials are generated), indicating a change in service. The provider WME ends the persistent WBSS under the conditions described in 4.3.2.4.

Applications come and go from the provider's WBSS as triggered by the application request primitive from the provider application. This is accomplished through the application request primitive (WME-Application.request), with the WME maintaining the active/inactive status of each application. The user device WME will join and end local participation on the WBSS as required based on the application's status.

4.3.3 Addresses and Identifiers in WAVE

There are several addresses and identifiers used to route traffic to devices and applications in the WAVE system. These are described in 4.3.3.1 through 4.3.3.4 and used throughout the document.

4.3.3.1 MAC address

Each device operating in an IEEE 802[®] network, such as IEEE 802.11 or IEEE 802.3, is assigned a MAC (layer 2) address that is used in transferring packets across a data link. A device has one MAC address per physical interface, e.g., a device with both WAVE and Ethernet interfaces will have a MAC address for each. The MAC address is 48 bits. Besides unicast addresses, a broadcast MAC destination address is supported. Use of multicast MAC addressing is permitted, but not required. MAC addresses can change as a result of external (external to this standard) requests.

In WAVE, MAC addresses are used in several ways, but primarily in delivering packets over the air to the addressed physical layer. MAC addresses of service provider devices are included in the service advertisements to facilitate the delivery of packets through WAVE devices that act as portals between external links (e.g., Ethernet) and the WAVE air interface.

4.3.3.2 IP address

Each device operating as an IP host or router has one or more IP (layer 3) addresses. IPv6 distinguishes between the global address type and the link local address type. A given device can have both. Global addresses are assumed globally unique, share a prefix with the network to which they are attached, and allow packets to be routed across multiple interconnected networks. Link local addresses are derived by the device and are not assumed to be globally unique, and can only be used within the scope of a single network, i.e., are not routable. IPv6 also supports special multicast addresses.

IP addresses of service provider devices are included in the service advertisements (if the application uses IP-based services).

4.3.3.3 Protocol/port

Most applications running over IP in a WAVE environment are expected to use UDP (rather than TCP) for their transport layer protocol because it matches well with the connectionless nature of WAVE transmissions. (UDP is not intrinsically more efficient than TCP. It is a matter of the most appropriate Protocol for the job at hand.) In order to deliver an IP packet to an application through UDP (or TCP), its port number must be known. The port number can be chosen by the application from any available in the device.

Port numbers of service provider applications are included in the service advertisements (if the application uses IP-based services).

4.3.3.4 Application identification

Applications are higher layer entities that employ the WAVE communications stack. From the point of view of networking services, each application is uniquely identified by a Provider Service Identifier (PSID).

The PSID and Provider Service Context (PSC) of service provider applications are included in the service advertisements. Received PSIDs are compared to those registered at the receiving user devices to determine whether a WBSS is of potential interest to the user devices. The PSC is associated with a PSID and contains supplementary information, e.g., version number, specific to that service. It can be used by the user application to determine whether the WBSS should be joined.

4.3.4 Application registration

In order to operate in a WAVE environment, an application registers with the WME, using the interface primitives in 7.2.6. Applications register as either service providers (applications that can initiate a WBSS) or

service users (applications that can join a WBSS) or both.

4.4 Distribution system (DS) portal at roadside unit

IEEE Std 802.11 describes a portal function between the wireless network and a distribution system (e.g., wireline local area network). All addresses mentioned in this subclause are MAC addresses. For OBU and RSU all addresses mentioned in this subclause are WAVE MAC address. This standard supports a system configured with portal function at the RSU, between the WAVE network and a wired network. It does not explicitly support, but also does not preclude, a portal function at the OBU, connecting the WAVE network to the OBU to vehicle host interface (OVHI). Figure 5 illustrates the support for portals in this standard.

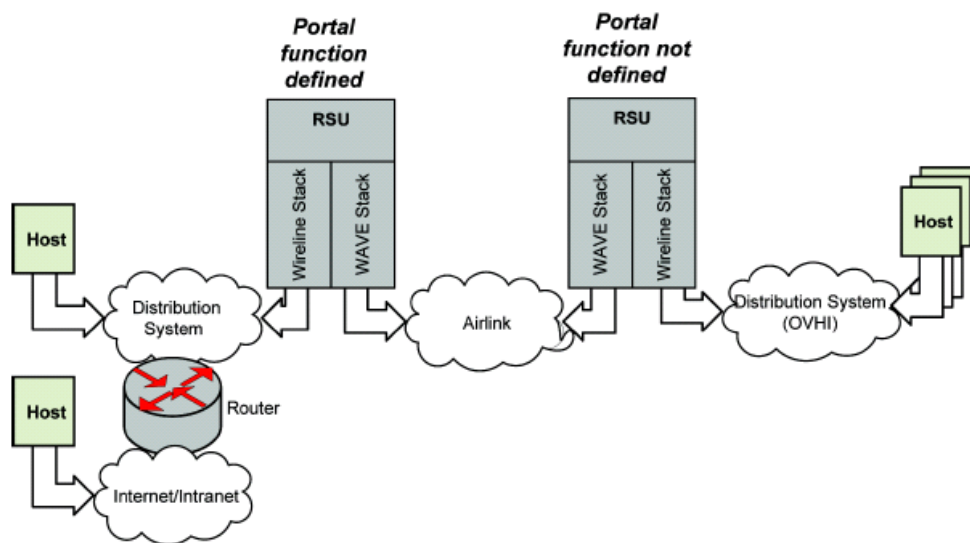


Figure 5—RSU Portal Function

The portal approach operates at the Data Link layer of the protocol stack, and thus employs MAC addressing for packet delivery. Three packet delivery and addressing scenarios are accommodated, accounting for four possible device roles: transmitter and receiver (on the wireless link), and packet source and destination (if different from the transmitter or receiver). The transmitter and source roles can be performed by the same device, depending on whether a portal is employed on the sending side. Likewise, the receiver and destination roles can be performed by the same device, depending on whether a portal is employed on the receiving side. These roles are indicated in the packet header by the FromDS and ToDS flags, which respectively indicate whether the source is different from the transmitter and the destination different from the receiver.

The use of the parameters in the MAC header is specified in IEEE Std 802.11 and summarized for the WAVE application in Table 1. The BSSID is assumed in this discussion to be equivalent to the address of the RSU. Note that the fourth scenario (involving an OVHI Host and both DS flags set) is not explicitly supported by this standard and is not shown in the table.

Table 1—Use of IEEE 802.11 MAC header fields

		ToDS	FromDS	Address 1	Address 2	Address 3	Address 4
				MAC of receiver	MAC of transmitter (for ack)		
No-DS	OBU-OBU, RSU-OBU, OBU-RSU ^a	0	0	DA	SA	BSSID	Not used
DS-on receiving side	OBU to RSU to Host via DS	1	0	BSSID (RSU)	SA (OBU)	DA (Host or Router)	Not used
DS-on sending side	Host via DS to RSU to OBU	0	1	DA (OBU)	BSSID (RSU)	SA (Host or Router)	Not used

^aRSU-RSU communications are not specifically addressed by this standard though they are not prohibited by it either.

The first scenario involves a packet passed only on the WAVE link, i.e., no DS, either from RSU to OBU, OBU to RSU, or OBU to OBU. In this case, both ToDS and FromDS are 0, and only the SA and DA are used. The SA indicates the transmitter of the packet, to which the DA responds with an acknowledgement!

In the second scenario, the OBU generates a packet for a Host reached via a distribution system (e.g., Ethernet) connected to the RSU. In this case, ToDS is set, the OBU inserts its own MAC address in Address2 and the RSU's address (BSSID) in Address1. Address3 is set to the Host's address if the Host is on the DS; it is set to the Router's address if the Host is reached via the Router. The RSU acknowledges the packet on the WAVE interface and relays it to the DS for delivery to the Host or Router.

In the third scenario, the Host behind the RSU generates a packet for the OBU. Now, the FromDS flag is set, Address1 is set to the OBU's address (or broadcast address), and Address2 is set to the RSU's address (BSSID). Address3 is set to the address of the Host if the Host is on the DS; it is set to the Router's address if the Host is reached via the Router.

The three flows are described in more detail in the following paragraphs.

Scenario 1: Service advertised by RSU or OBU, No-DS

In the first scenario (illustrated in Figure 6), a WAVE device (here assumed to be an RSU) offering a service sends the advertisement to the broadcast (or multicast) MAC address. *ProviderDeviceAddressing* in the *WAVE Service Advertisement* is set to "Provider device is same as announcement device". Any packets sent in response to the announcing device carry the address of the responder. After this exchange, packets can be addressed with unicast addresses in both directions.

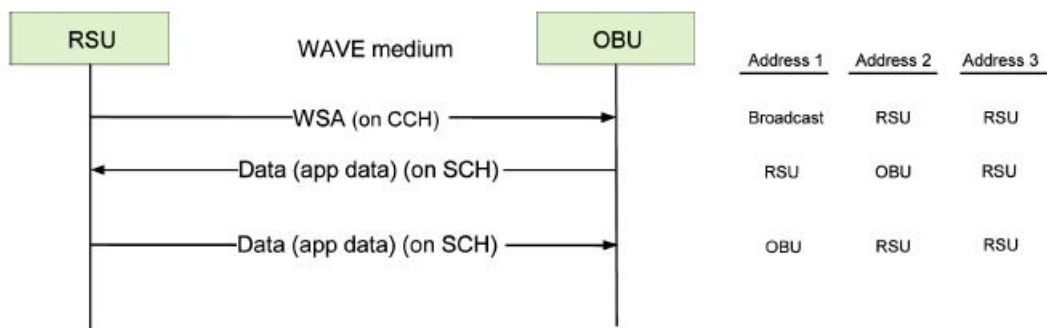


Figure 6—RSU service information exchange scenario

Scenario 2: Service advertised by RSU, provider host on DS

In this case, illustrated in Figure 7, the RSU generates the broadcast (or multicast) *WAVE Service Advertisement*, including the IP and MAC addresses of the provider host, and port number of the provider application. *ProviderDeviceAddressing* is set to “Provider device is not the same as announcement device.” Any responding device sets to the provider host device address in the Address3 field of the MAC header, inserting the received RSU address in Address1, and its own address is Address2, and setting the ToDS flag as shown in the second scenario in Table 1. The RSU relays the packet over the DS to the Host.

After receiving the response, the Host can transmit to the OBU over the DS. The RSU, as DS portal, relays the packets on the WAVE airlink, setting the FromDS flag, as shown in the third scenario of Table 1. Address1 is set to the received OBU address; Address2 is set to the received RSU address; Address3 is set to the Host’s own address.

Subsequent packets between the two devices are sent similarly.

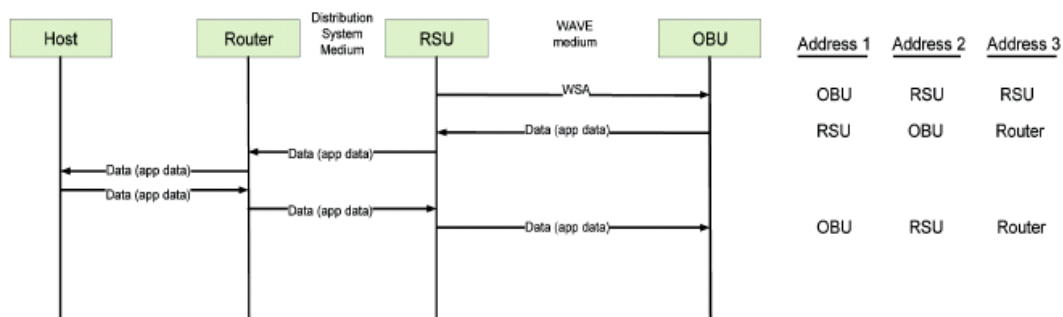


Figure 7—DS host service information exchange scenario

Scenario 3: Service advertised by RSU, provider host beyond DS

In this case, illustrated in Figure 8, the RSU generates the broadcast (or multicast) *WAVE Service Advertisement*, including the IP address of the provider host, the port number of the provider application, and the MAC addresses of the router providing egress from the DS. *ProviderDeviceAddressing* is set to “Provider device is not the same as announcement device.”

Any responding OBU replies using the provider's IPv6 address, setting the ToDS flag as shown in the second scenario in Table 1. The OBU inserts the router device address in the Address3 field of the MAC header, the received RSU address in Address1, and its own address is Address2. The packet is relayed to the router on the DS by the RSU portal function, and is ultimately delivered to the provider via layer 3 routing.

The Host can then communicate with the OBU via the OBU IPv6 address. The packet reaches the RSU over the DS via layer 3 routing. The RSU portal function relays the packet to the WAVE airlink using the FromDS flag, as shown in the third scenario of Table 1. Address1 is set to the previously received OBU address; Address2 is set to the RSU's own address; Address3 is set to the router's address received over the DS.

Subsequent packets between the two devices are sent similarly.

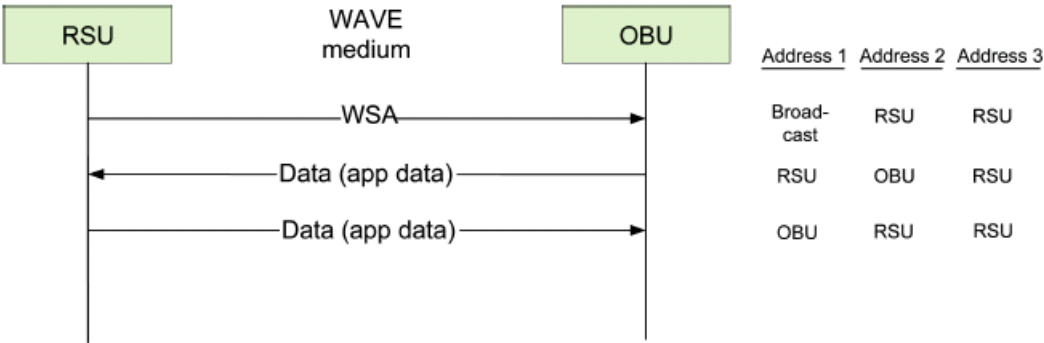


Figure 8—Non-DS host service information exchange scenario

4.5 IPv6 Neighbor Cache

IPv6 has provisions for neighbor discovery in which a Neighbor Cache is populated with IP addresses and associated MAC addresses of devices within communications range. This is accomplished via a multicast response mechanism, as specified in RFC 2461, and generates a substantial amount of traffic on the channel. For WAVE implementations, it is desirable to keep traffic on the control channel to a minimum, so alternate methods for generating the Neighbor Cache are defined. Note that neighbor discovery is not precluded in cases where it might be needed.

In a WAVE system, the population of the Neighbor Cache is accomplished based on the information in received packets that contain both MAC and IP addresses. Upon joining a WBSS, a user host participating in a non-routed service (i.e., one where packets to the service provider do not transit a router) adds an entry to its Neighbor Cache for the service provider, if possible. If the service is routed, the user host adds an entry to its Neighbor Cache for the gateway router, if possible. In addition, a WAVE device learns Neighbor Cache associations from ICMPv6 and IPv6 PDUs received from a link-local IPv6 address by associating the source IP address with the SA MAC address from the MAC header.

4.6 Security considerations

IEEE Std 1609.2 provides WAVE security services. The services applicable to this document include the following:

- a) Signing of service advertisements
- b) Validation of service advertisements

Other aspects of security are outside the scope of WAVE and are expected to be provided by system implementers (e.g., protection of sensitive data stores and configuration items such as the MIB).

5. Data plane services

5.1 General

This clause specifies the components of the [Networking Services](#) data plane, which are optimized for air interface efficiency and low latency in support of vehicular applications. ~~The WSMP layer is unique to specified in this standard and supports a mechanism that provides direct control over power, and data rate on a frame-by-frame basis. WSMP. For WSMs, the channel, transmit power, and data rate are set by higher layers on a per-message basis. Networking services also allows applications to identify the radio channel. An specifies the use of the Internet Protocol IPv6 protocol stack is also provided, with UDP chosen as the primary and supports transport protocol because of its low-overhead protocols such as UDP and latency. TCP. For IP datagrams, the channel, transmit power, and data rate to be used are stored in a transmitter profile. A Networking Services implementation shall support either IPv6 or WSMP or both.~~

[Figure 3 and Figure 4 illustrate the flow of information associated with IP and WSM data, respectively.](#) The primitives defined for exchanging information between the data plane components are described in Clause 7.

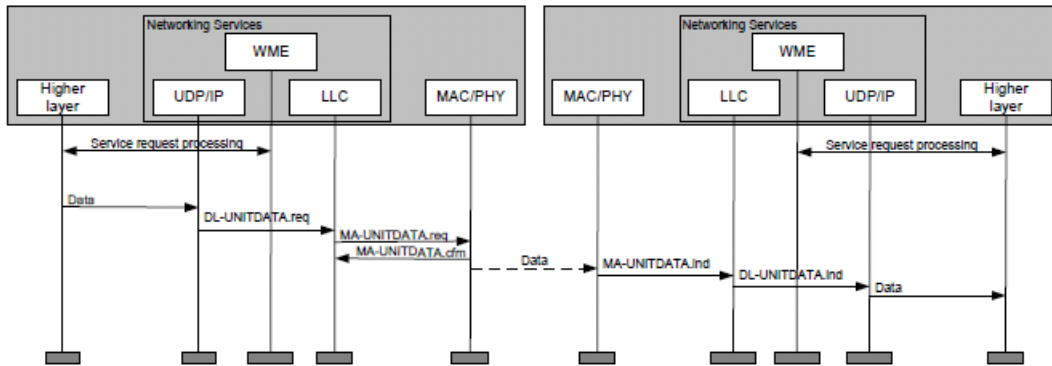


Figure 3—IP data flow

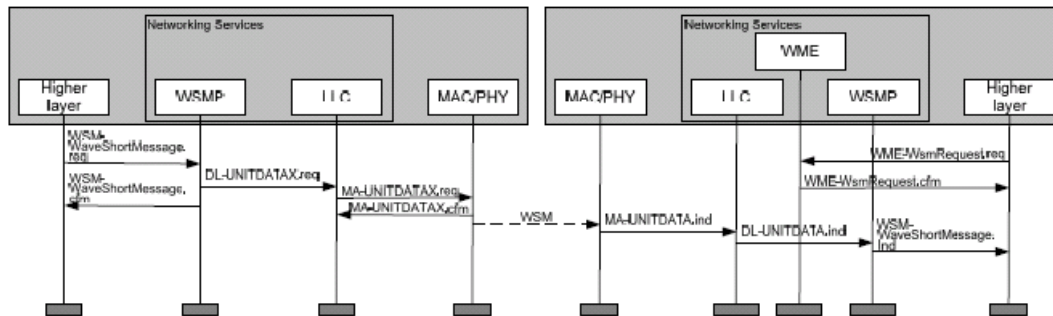


Figure 4—WSM flow

5.2 Logical Link Control

A WAVE Networking Services implementation shall support the connectionless unacknowledged Type 1 Operation of the LLC as specified in ISO/IEC 8802-2 [IEEE Std 802.2™], the Subnetwork Access Protocol (SNAP) specified in IEEE Std 802, and the standard for transmission of IP datagrams over IEEE 802 networks specified in IETF RFC 1042. Different Ethernet Type (*Ethertype*) values identify the different network layer protocols used in WAVE. ~~WAVE use of EtherType is also described in IEEE Std 1609.4. IPv6 type packets received from the lower layers with an Ethernet Type value of 0x86DD are delivered to the IPv6 protocol. WSM packets received from the lower layers with an Ethernet Type of 0x88DC are delivered to the WSM protocol.~~

When the LLC receives an MAC service data unit via an IEEE 802.2 MA-UNITDATA.indication primitive, it checks the *Ethertype* in the SNAP header and extracts the packet. If the *Ethertype* value is 0x86DD, the LLC delivers the packet to IPv6. If the *Ethertype* value is 0x88DC, the LLC delivers the packet to WSM. In either case, the packet is delivered to the higher layer via the IEEE 802.2 DL-UNITDATA.indication primitive.

~~When IPv6 packets for uses an IEEE 802.2 DL-UNITDATA.request primitive to request transmission shall have Ethernet Type set of a packet, the LLC protocol shall set the *Ethertype* to 0x86DD. WSM packets for It~~

will encapsulate the packet in LLC and SNAP headers and pass the data to the lower layers using an IEEE 802.11 MA-UNITDATA.request primitive. Similarly, when WSMP uses a DL-UNITDATA.request primitive (see 7.5) to request transmission of a packet, the LLC protocol shall ~~have Ethernet Type~~ set the *Ethertype* to 0x88DC. It will encapsulate the packet in LLC and SNAP headers and pass the data to the lower layers using an IEEE 1609.4 MA-UNITDATA.request primitive. An example of the LLC and SNAP headers is shown in Figure 5.

To allow higher layer control of WAVE Short Message transmit parameters, the LLC service access point has been extended for WAVE Short Messages as specified in 7.5.

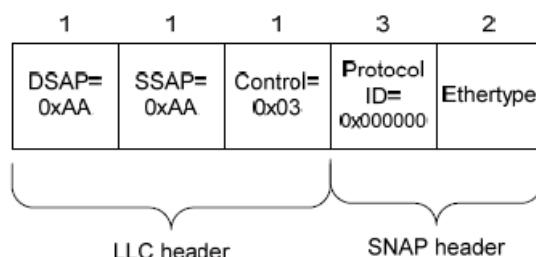


Figure 5—LLC and SNAP headers

5.3 Internet Protocol version 6

~~WAVE networking services shall~~ Support for IPv6 is conditionally mandatory as specified in 5.1. An IPv6 implementation shall comply with IETF RFC 2460. Related features defined in other RFCs are specified in 6.5. IP traffic is sent and received through the LLC sublayer as specified in 5.2.

5.3 User Datagram Protocol (UDP)

~~WAVE networking services shall support UDP as specified in RFC 768.~~

5.4 Other IP-based protocols

WAVE devices may implement any Internet Engineering Task Force (IETF) protocol, but care should be taken not to compromise interoperability with other WAVE devices. Examples of IETF protocols are UDP (IETF RFC 768) and TCP (IETF RFC 793).

5.4 Optional protocols, including Transmission Control Protocol (TCP)

~~WAVE networking services may support TCP as specified in RFC 793. Manufacturers may elect to implement any suitable IETF specification to enhance the performance or capabilities of their devices under the condition that such additions do not compromise interoperability with other WAVE devices.~~

5.5 WAVE Short Message Protocol (WSMP)

5.5.1 General

Support for WSMP is conditionally mandatory as specified in 5.1. Acceptance of a received frame at the MAC layer is determined by the destination address; delivery of a received WAVE Short Message to a higher layer entity is determined by PSID. A WSM may be accepted by one or more destination devices, depending on the type of MAC-level addressing (e.g., individual or group) used. Note that MAC addresses may be changed for pseudonymity as specified in IEEE Std 1609.4.

Within a receiving device, the message will be delivered by WSMP to any higher layer entities with interest in the associated PSID. Interest is indicated via the WSM service request procedure specified in 6.2.2.1.4. Higher layer entities take responsibility for message signing and authentication (per IEEE P1609.2) and for providing the channel information for transmission. The WSMP header is specified in 8.3.

5.5.2 WSM transmission

On receipt of a WSM-WaveShortMessage.request from a higher layer, WSMP shall calculate the length of the WSMP header and verify that the length of that WSMP header combined with the accompanying *WSMData* is less than the value of the WME MIB parameter *WsmMaxLength*. Upon successful verification of *WsmMaxLength*, WSMP shall generate the WSMP header per the format specified in 8.3 for inclusion in an LLC DL-UNITDATA.request (see 7.5.2). Upon failed verification of *WsmMaxLength*, the WSM is not passed and the failure is indicated in the resulting WSM-WaveShortMessage.confirm.

DL-UNITDATA.request parameters are set as follows:

<u><i>source_address</i></u>	<u>Set to the IEEE 802.11 <i>dot11StationID</i> for the WAVE interface.</u>
<u><i>destination_address</i></u>	<u>Set to the <i>Peer MAC address</i> from the WSM-WaveShortMessage.request. <i>data</i></u>
<u><i>priority</i></u>	<u>Set as described in the subsequent discussion.</u>
<u><i>Channel Identifier</i></u>	<u>Set to the <i>User Priority</i> from the WSM-WaveShortMessage.request.</u>
<u><i>DataRate</i></u>	<u>Set to the <i>Channel Identifier</i> from the WSM-WaveShortMessage.request.</u>
<u><i>TxPwr_Level</i></u>	<u>Set to the <i>DataRate</i> from the WSM-WaveShortMessage.request.</u>
<u><i>WsmExpiryTime</i></u>	<u>Set as described in the subsequent discussion.</u>
	<u>Set to the <i>WsmExpiryTime</i> from the WSM-WaveShortMessage.request.</u>

The *data* parameter consists of a WAVE Short Message, which is formed from the WSMP header described earlier in this subclause and the *Data* from the WSM-WaveShortMessage.request, as described in 7.3.2.

Transmit Power Level, received in the WSM-WaveShortMessage.request, is converted to *TxPwr_Level* in the DL-UNITDATA.request as follows. *TxPwr_Level* is set to the index of the highest value of IEEE 802.11 MIB *Dot11PhyTxPowerEntry* that does not exceed *Transmit Power Level*. If there is no such value, then the request should be rejected.

5.5.3 WSM reception

On receipt of DL-UNITDATA.indication from LLC ~~WSMP shall pass it to the destination application, as determined by the PSID, in the form of a WSM-WaveShortMessage.indication. The destination application may reside on the WAVE device, or on a separate device, in which case the application registration will have indicated how to perform delivery via the UDP/IP stack, using the address and port number from the UserServiceInfo.~~ with the *WAVE Element ID* in the WSMP header indicating WAVE Short Message, WSMP shall pass the received information to the destination higher layer entity or entities, with the destination

entity determined from the WSMP header *ProviderServiceIdentifier* and the MIB *WsmServiceRequestTable*. On receipt of DL-UNITDATA.indication from LLC with the *WAVE Element ID* in the WSMP Header indicating a WSMP WAVE element besides WAVE Short Message (e.g., WSMP safety supplement [WSMP-S]), WSMP shall pass the received information to the appropriate entity, as indicated by the reference listed in Annex E. In either case, the WSM-WaveShortMessage.indication primitive is used to deliver WSM information to higher layer entities. Annex E specifies WSMP WAVE *Element ID* values; Annex F specifies functionality for WSMP-S. A *WsmVersion* value higher than that specified in 8.2.5.8.3 may cause WSMP to fail to parse the message.

~~WAVE short messages can be delivered to multiple destinations. Applications take responsibility for message signing (per IEEE Std 1609.2) and providing the channel information for transmission.~~

~~Implementations of WSMP shall support a WSM forwarding function as specified in the following paragraphs:~~

~~On receipt of WSM-WaveShortMessage.request, WSMP shall verify the length of WSM Data is less than the value of the WME MIB parameter WsmMaxLength. The WSM-WaveShortMessage.request may be received from a local application or from a remote application via the forwarding function's UDP port, as specified in the WME MIB. Upon verification of WsmMaxLength, WSMP shall pass it to the LLC layer for air interface transmission by means of DL-UNITDATA.request. Otherwise, WSM Data is not passed.~~

6. Management plane ~~services~~

6.1 General

The following subclauses specify the ~~services~~ networking functions associated with the management plane. ~~In general, introductory and descriptive information is found in the higher level subclauses with requirements following.~~ The primitives ~~defined~~ for exchanging information between the WME and other ~~system components~~ internal functional entities are described in Clause 7. Use of the WME-Notification.indication primitive (e.g., notifying a higher layer that a service request has been matched to an available service, or that an SCH has been assigned) is not explicitly specified, but it is left as choice for implementers.

Networking Services management functions provide the means to control transmit parameters (data rate and power) of data plane traffic; the data rates and power levels for transmitting management frames are specified in IEEE Std 1609.4.

6.1 Application registration

~~Before they will be supported by management plane services, e.g., WBSS establishment, or IP based data plane services, applications register with the WME. An application residing off the WAVE device may need to be registered as a user application so that WME can forward received WSM data to the correct IP address and port. The registration information is used as specified in 7.2.6 to populate three MIB structures as specified in the list below. See Annex A and Annex B for a specification of MIB contents.~~

- ~~— *ProviderServiceInfo*. This MIB structure contains the application information that is used (in conjunction with the application's request and the pre-configured channel information) to generate the announcements that will initiate and advertise a WBSS in support of the application's service offering. Each registered provider application has an entry *PstEntry* in this table. In the case of OBUs, only link-local addresses (as defined in RFC 3513) shall be accepted in the *IPv6Address* of the *PstEntry*.~~
- ~~— *UserServiceInfo*. This MIB structure is used in detecting whether a received service advertisement is of~~

~~interest to applications supported by the local device. It is not sent over the air. Each registered user application has an entry *UstEntry* in this table.~~

- ~~—*ApplicationStatusTable*. This MIB structure shall be initialized at registration, and used locally in the maintenance of the WBSSs that support application traffic. Each registered application has an entry in this table.~~

~~In addition, information about the radio channels available for use by the device are entered directly into the MIB (i.e., not through the registration process), in the form of the *ChannelInfo*.~~

~~Each application registers with a unique PSID.~~

6.1.1 Adding registration entries

~~Upon receipt of WME *ApplicationRegistration.request*, with *RegistrationAction* indicating an addition, the WME verifies that a unique record is being requested. For a *PstEntry*, the request shall be accepted if the *ProviderServiceIdentifier* in the request does not already exist in the WME MIB *ProviderServiceInfo*. For a *UstEntry*, the request shall be accepted if the *ProviderServiceIdentifier* in the request does not already exist in the WME MIB *UserServiceInfo*.~~

~~If a registration request is accepted, WME shall send a WME *ApplicationRegistration.confirm* to the requesting application indicating the result. If a registration request is not accepted, WME shall send a WME *ApplicationRegistration.confirm* to the requesting application indicating the reason for the rejection.~~

~~When a WME *ApplicationRegistration.request* is accepted, WME shall place the contained service information (*PstEntry* or *UstEntry*) in the appropriate WME MIB structure.~~

~~In conjunction with the service table entry, each registered application has a corresponding *ApplicationStatusTable* entry, which is added and removed at the same time as the application's service table entry, and maintained as specified in 6.2.5. If present, the *NotificationIPv6Address* and *NotificationPort* from the WME *ApplicationRegistration.request* shall be placed in the *ApplicationStatusTable* entry. If present, the *ApplicationPriority* from the WME *ApplicationRegistration.request* shall be placed in the *ApplicationStatusTable* entry.~~

6.1.2 Removing registration entries

~~Upon receipt of WME *ApplicationRegistration.request* with *RegistrationAction* indicating a removal, the WME shall delete any WME MIB service information with the same *ProviderServiceIdentifier*. If the *ApplicationStatusTable* changes from having one application with *ApplicationStatus* of *Active*, to having no applications *Active*, the WME ends the current WBSS as specified in 6.2.4.~~

6.2 Service requests and channel access assignment

6.2.1 General

The WME accepts service requests of several types from higher layer entities. To satisfy service requests, the WME may provide access to SCHs and may cause management messages to be periodically transmitted. Providing SCH access entails causing the device transceiver to be tuned to a specific channel during one or more channel intervals, via request to the MAC sublayer management entity (MLME).

For convenience, two WAVE device roles are defined. The provider role is assumed by a device transmitting WAVE Service Advertisements (WSAs) indicating its availability for data exchange on one or more SCHs. The user role is assumed by a device monitoring for received WSAs, with the potential to participate in the

SCH data exchange. A WAVE device may assume one, both, or neither role.

The various service request types, the resulting channel access assignments, and the messages automatically generated are summarized in Table 1.

Table 1—Service request summary

<u>Service request type</u>	<u>Reference</u>	<u>Primary purpose</u>	<u>Resulting channel/interval assignment</u>	<u>Message generation</u>
<u>Provider</u>	<u>7.4.2.2</u>	<u>Service advertisement/ SCH participation</u>	<u>SCH in SCH interval, or SCH in SCH and CCH intervals</u>	<u>VSA frame containing WSA</u>
<u>User</u>	<u>7.4.2.4</u>	<u>Service availability notification/ SCH participation</u>	<u>SCH in SCH interval, plus optionally SCH in CCH interval</u>	<u>none</u>
<u>WSM</u>	<u>7.4.2.6</u>	<u>Received message delivery</u>	<u>none</u>	<u>none</u>
<u>CCH</u>	<u>7.4.2.8</u>	<u>Control channel participation</u>	<u>CCH in CCH or SCH interval or both</u>	<u>none</u>
<u>Management data</u>	<u>7.4.2.10</u>	<u>Management data distribution</u>	<u>CCH or SCH; CCH or SCH interval or both</u>	<u>VSA frame</u>
<u>Timing advertisement</u>	<u>7.4.2.13</u>	<u>Time distribution</u>	<u>CCH or SCH; CCH or SCH interval or both</u>	<u>Timing Advertisement (TA) frame</u>

To facilitate the specification, a distinction is made between single-physical layer (PHY) devices and multi-PHY devices (see IEEE Std 1609.4). A single-PHY device is a WAVE device not capable of simultaneous operation on multiple radio channels. A multi-PHY device is a WAVE device capable of simultaneous operation on multiple radio channels. A switching device has at least one PHY that is capable of switching between channels (e.g., SCH and CCH). Depending on the characteristics and usage of the WAVE device at a given time, it might support any number of channel usage models, including the following:

- Operation only on the CCH (e.g., by a single-PHY device). See Figure 6(a).
- Operation only on an SCH (e.g., by a single-PHY device).
- Alternating operation on CCH and SCH, in CCH intervals and SCH intervals, respectively (a switching device). See Figure 6(b).
- Simultaneous operation on CCH and one or more SCHs (by a multi-PHY device).
- The capabilities of the WAVE device should be considered by the WME in assigning channel access to satisfy requested services.

Several examples of channel access (applicable to a single-PHY WAVE device) are illustrated in Figure 6. The first option shows continuous operation on the CCH. The second option shows alternating operation on the CCH and an SCH during the CCH interval and the SCH interval, respectively, where SCH access is provided based on a request from a higher layer. The third option shows a variation where SCH access is provided on an immediate and extended basis at the request of the higher layer, with SCH operation during some CCH intervals. Networking Services may make channel access assignments based on the service requests described in this subclause, resulting in any of the following:

- Alternating operation with SCH access during SCH intervals, and CCH access during CCH intervals
- Immediate or extended SCH access during SCH and CCH intervals
- CCH access during CCH and/or SCH intervals (used for example to override immediate or

[extended SCH access in support of user service requests](#))

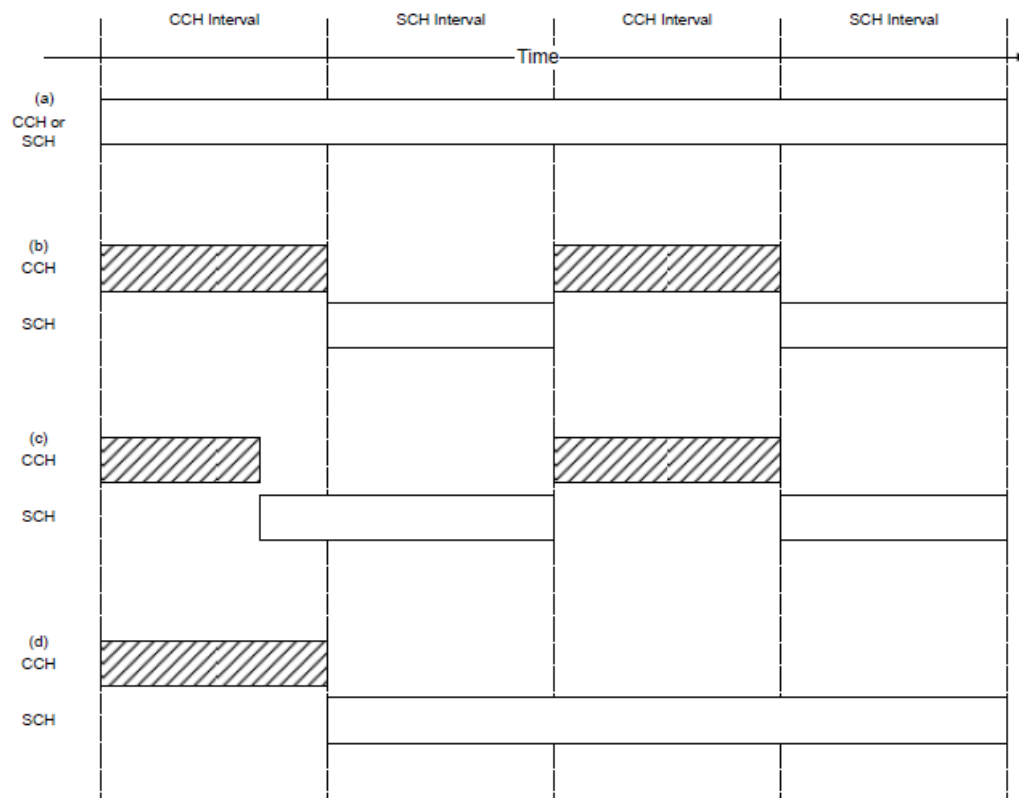


Figure 6 —Channel access options: (a) continuous, (b) alternating, and (c) immediate and extended

[Examples of information flows associated with channel access under different scenarios are shown in Annex D.](#)

[6.2.2 Service requests](#)

[This subclause generally describes internal device operation and is, therefore, optional. The WME maintains information about requested and available services for use in determining channel access assignments. Requested service information is maintained in the MIB *ProviderServiceRequestTable*, *UserServiceRequestTable*, *WsmServiceRequestTable*, and *CchServiceRequestTable*. Service requests may be made through the WME service access point \(SAP\) as described in 7.4, or via other mechanisms \(e.g., preloaded information for static services\).](#)

[Figure 7 illustrates actions available via service request primitives.](#)

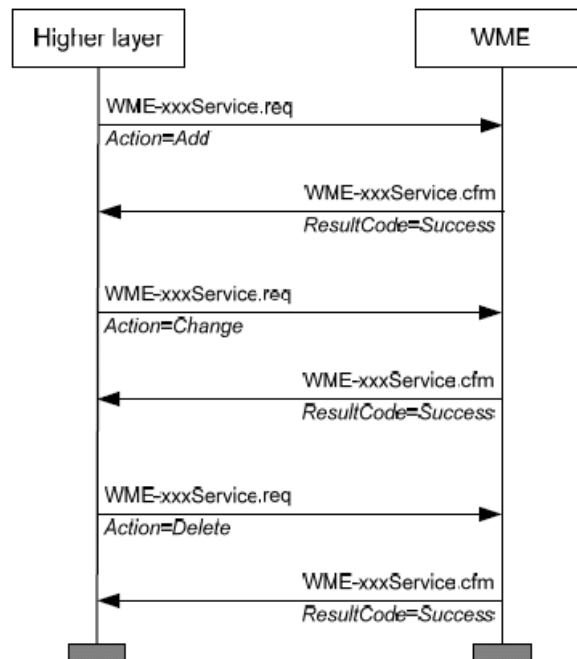


Figure 7—Service request information flow

6.2.2.1 Adding service requests

6.2.2.1.1 General

A service request may be of the form WME-ProviderService.request, WME-UserService.request, WME-WSMService.request, WME-CchService.request, WME-ManagementDataService.request, or WME-TimingAdvertisementService.request as described in 7.4.

6.2.2.1.2 Provider service request

A provider service request indicates to the WME that a higher layer wishes to have WSAs generated on its behalf and SCH access provided. Acceptance of a WME-ProviderService.request results in the population of a corresponding *ProviderServiceRequestTableEntry* in the MIB and consideration of the service request in determining channel access assignments. The device sending the WSA performs the provider role; a device accepting the WSA performs the user role.

In addition to advertising SCH-based services, the provider service request may be used to advertise local CCH channel configuration information (e.g., enhanced distributed channel access [EDCA] parameter set) in the WSA. Although not explicitly described in this document, the WSA may also be used to distribute system information (e.g., *Country String* in the WSA header extension). In these cases, there may or may not be service information in the WSA.

6.2.2.1.3 User service request

A user service request indicates to the WME that a higher layer entity has an interest in available services meeting specified criteria. The request indicates the action to be taken when the WME recognizes such available services, including assigning SCH access. A user service request may be employed by a higher layer entity desiring unilateral service channel access (either alternating or extended) without regard to available services, through the *UserRequestType* of Auto-access Unconditionally. Acceptance of a WME-UserService.request results in the population of a corresponding *UserServiceRequestTableEntry* in the MIB and in consideration of the service request in determining channel access assignments.

6.2.2.1.4 WSM service request

A WSM service request indicates to the WME that a higher layer entity wishes to receive WSMs addressed to a particular PSID. Acceptance of a WME-WSMService.request results in the population of a corresponding *WsmServiceRequestTableEntry* in the MIB and causes Networking Services to deliver any received WSMs with matching *ProviderServiceIdentifier* to the requesting higher layer entity.

6.2.2.1.5 CCH service request

A CCH request indicates that a higher layer entity requires ongoing CCH access during particular channel intervals (see IEEE Std 1609.4), e.g., for WSM activity or for WSA reception. Acceptance of a WME-CchService.request results in the population of a corresponding *CchServiceRequestTableEntry* in the MIB and in consideration of the service request in determining channel access assignments.

The CCH request indicates whether it applies to the CCH interval, the SCH interval, or both. A CCH service request indicating “CCH interval” does not affect decisions to assign SCH access during the SCH interval, but it can be used to prevent assigning SCH *ImmediateAccess* or *ExtendedAccess* (see 6.2.3) during the CCH interval based on a user service request with lower service priority.

6.2.2.1.6 Management data service request

A management data service request indicates to the WME that another management entity wishes to have Vendor Specific Action frames transmitted on its behalf and, possibly, SCH access provided. Acceptance of a WME-ManagementDataService.request results in the consideration of the service request in determining channel access assignments and in generating VSA requests to the MLME.

6.2.2.1.7 Timing advertisement service request

A timing advertisement service request indicates to the WME that another management entity wishes to have Timing Advertisement frames transmitted on its behalf and, possibly, channel access provided. Acceptance of a WME-TimingAdvertisementService.request results in the consideration of the service request in determining channel access assignments and in generating TA requests to the MLME.

6.2.2.2 Changing service requests

Upon receipt of any service request with *Action* equal to Change, the corresponding service information is updated in the MIB and in the WME channel access assignment function. Changing of an ongoing WAVE Service Advertisement is covered in more detail in 6.2.4.2.2.

6.2.2.3 Deleting service requests

Upon receipt of any service request with *Action* equal to Delete, the corresponding service information is removed from the MIB and from the WME channel access assignment function. Additional processing is specified in 6.2.3.7 and 6.2.4.5.

6.2.3 Channel access assignment

6.2.3.1 General

Each of the features specified in the subclauses of 6.2.3 are optional. Networking Services assigns local radio channel resources in support of service requests. This includes assigning radio resources to particular service channels to provide data communication opportunities for the requesting entities. The primitive exchanges related to channel access assignment for provider and user service requests are illustrated in Figure 8 and described here and in more detail in the following subclauses. Additional flows are depicted in Annex D.

Figure 8 illustrates the provider WME initiating WSA broadcast and SCH access, followed by the user joining the provider on the SCH. The first step is signing the WSA information via the WaveSecurityServices-SignedWsa.request. The provider WME then initiates WSA broadcasts on the CCH via the MLMEX-VSA.request and alternating SCH access via the MLMEX-SCHSTART.request. The user, monitoring the CCH, receives the WSA, indicated by the MLMEX-VSA.indication, recognizes a service of interest, and begins alternating SCH access via the MLMEX-SCHSTART.request. In each case, if the service employs IP, the MLMEX-REGISTERTXPROFILE.request is also used. Subsequently, higher layer traffic may be exchanged between the devices on the SCH.

The status of each service (e.g., satisfied or not) is maintained in a status field in its request table in the MIB.

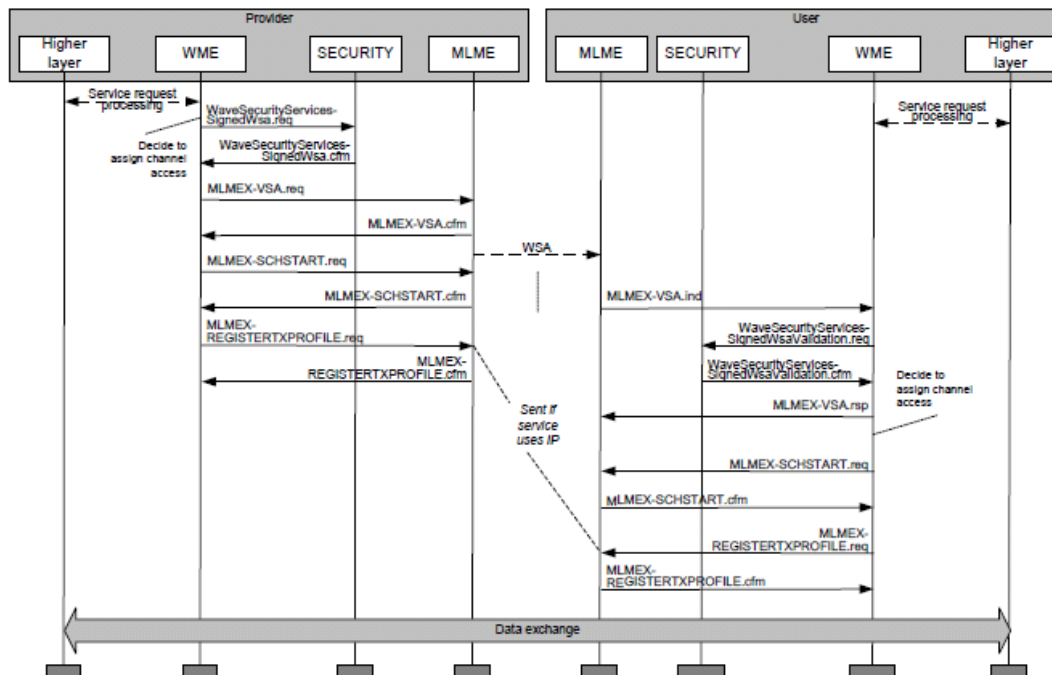


Figure 8—Example information flow for channel access assignment

6.2.3.2 Channel access assignment algorithm

By default, WAVE devices operate on the control channel. Access to service channels is determined by the WME based on service requests and other criteria. The channel access assignment algorithm is not specified, but the following criteria should be considered by algorithm developers:

- Number of channels that can be simultaneously accessed by the device's radio equipment
- Service requests (6.2.2)
- Available services (6.4) matching user service requests
- The relative priorities of the requested services
- The *Channel Access* of the service, i.e., the channel intervals in which it is active

In general, the access assignment algorithm should give precedence to requests with higher *ServicePriority*. CCH service requests with a higher *ServicePriority* should take precedence over lower priority assignments that would interfere with ongoing CCH operation. In this case, SCH access in support of a user service request may be assigned but without the requested *ImmediateAccess* or *ExtendedAccess*.

Other factors may be considered, such as the following:

- The geographic proximity to the transmitter of the WSA
- Link quality associated with the transmitter of the WSA
- Service duration

After channel access has been assigned, certain events such as the following should cause the assignment to be ended. Refer to 6.2.3.7:

- Service has been deleted (6.2.2.3)
- User service request no longer matching an available service (6.4)
- Need to satisfy a service request with higher service priority
- Loss of lower layer synchronization indicated by receipt of MLMEX-SCHEND.indication per IEEE Std 1609.4
- Other factors, such as poor *Link Quality* (6.4.3)

6.2.3.3 Assignments in support of provider service requests

When service channels are assigned to fulfill provider service requests, in addition to causing MAC sublayer generation of Vendor Specific Action frames by sending an MLMEX-VSA.request as specified in 6.2.4.2, the WME triggers MAC sublayer processing by sending an MLMEX-SCHSTART.request to start service channel access.

If the WME-ProviderService.request includes *IPv6Address*, indicating a need for IPv6 communications, the WME also sends a MLMEX-REGISTERTXPROFILE.request. Refer to Figure 8.

MLMEX-SCHSTART.request parameters are set as follows:

<u><i>Channel Identifier</i></u>	<u>This defines the channel assigned. Set to the channel indicated by the MIB <i>ProviderChannelInfoTableEntry</i>.</u>
<u><i>OperationalRateSet</i></u>	<u>Not used.</u>
<u><i>EDCA Parameter Set</i></u>	<u>If present, insert values from MIB</u>

ProviderChannelInfoTableEntry associated with the channel.

<u><i>ImmediateAccess</i></u>	<u>Set to FALSE.</u>
<u><i>ExtendedAccess</i></u>	<u>Set to 0.</u>

MLMEX-REGISTERTXPROFILE.request parameters are set as follows:

<u><i>Channel Identifier</i></u>	<u>Set equal to <i>Channel Identifier</i> in the MLMEX-SCHSTART.request.</u>
<u><i>Adaptable</i></u>	<u>From the MIB <i>ProviderChannelInfoTableEntry</i> associated with the channel.</u>
<u><i>TxPwr Level</i></u>	<u>Set to the index of the highest value of IEEE 802.11 MIB <i>Dot11PhyTxPowerEntry</i> that does not exceed the MIB <i>ProviderChannelInfoTransmitPowerLevel</i>. If there is no such value, then the service request should be rejected.</u>
<u><i>DataRate</i></u>	<u>From the MIB <i>ProviderChannelInfoTableEntry</i>.</u>

6.2.3.4 Assignments in support of user service requests

Channel access is assigned by the WME, e.g., to satisfy a user service request when the WME detects a suitable match between a MIB *AvailableServiceEntry* and a *UserServiceEntry*. When channel access is assigned to satisfy a user service request, the WME sends an MLMEX-SCHSTART.request, with parameters set as follows. Refer to Figure 8:

<u><i>Channel Identifier</i></u>	<u>From the MIB <i>UserAvailableChannelNumber</i> and <i>UserAvailableOperatingClass</i>.</u>
<u><i>OperationalRateSet</i></u>	<u>From the MIB <i>UserAvailableServiceTableEntry ChannelInfo</i>.</u>
<u><i>EDCA Parameter Set</i></u>	<u>If present, insert values from MIB <i>UserAvailableServiceTableEntry ChannelInfo</i>.</u>
<u><i>ImmediateAccess</i></u>	<u>From the MIB <i>UserServiceRequestTableEntry</i>, as modified in 6.2.3.2.</u>