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

1609.3™

Intelligent Transportation Systems Committee

Sponsored by the
IEEE Vehicular Technology Society

IEEE
3 Park Avenue
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IEEE Std 1609.3™-2007

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

Prepared by the

Intelligent Transportation Systems (ITS) Committee
of the
IEEE Vehicular Technology Society

Approved 23 March 2007

IEEE-SA Standards Board

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Abstract: WAVE Networking Services provides services to WAVE devices and systems. It represents roughly layers 3 and 4 of the OSI model and the IP, UDP, and TCP elements of the Internet model. The services provided include management and data services within WAVE devices.
Keywords: OBU, onboard unit, Provider Service Identifier, PSID, roadside unit, RSU, WAVE, Wireless Access in Vehicular Environments, WSM

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Introduction

This introduction is not part of IEEE Std 1609.3-2007, IEEE Trial-UseStandard for Wireless Access in Vehicular Environments (WAVE)—Networking Services.

A WAVE system is a radio communications system intended to provide seamless, interoperable services to transportation. These services include those recognized by the US National Intelligent Transportation Systems (ITS) Architecture and many others contemplated by the automotive and transportation infrastructure industries. These services include vehicle-to-roadside as well as vehicle-to-vehicle communications. WAVE Networking Services provides data delivery services between WAVE devices, and management services to all layers. This is but one component in the overall WAVE architecture, which includes IEEE Std 1609.1™, IEEE Std 1609.2™, IEEE Std 1609.4™, and IEEE P802.11p™.[a]

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

1. Overview

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 vehicle-to-roadside as well as vehicle-to-vehicle communications. WAVE networking services provide data delivery services between WAVE devices and management services to all layers. This is but one component in the overall WAVE architecture, which includes IEEE Std 1609.1™-2006, IEEE Std 1609.2™-2006, IEEE Std 1609.4™-2006, IEEE Std 802.11™, and IEEE P802.11p™.[1]

1.1 Scope

The scope of this standard is to define services, operating at the network and transport layers, in support of wireless connectivity among vehicle-based devices, and between fixed roadside devices and vehicle-based devices using the 5.9 GHz DSRC/WAVE mode.

1.2 Purpose

WAVE networking services represents layers 3 and 4 of the OSI communications stack. The purpose of this standard is to provide addressing and routing services within a WAVE system, enabling multiple stacks of upper layers above WAVE networking services and multiple lower layers beneath WAVE networking services. Upper layer support includes in-vehicle applications offering safety and convenience to their users.

1.3 Document organization

The document contains both normative and informative text. Clause 1 provides an overview of the document. Clause 2 and Clause 3 contain references, definitions, and abbreviations, respectively. Clause 4 provides 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

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WAVE networking services, which carry user 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 entities. 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. Annex D provides a protocol implementation conformance statement (PICS) proforma.

1.4 Document conventions

Unless otherwise noted, conventions follow those in IEEE Std 802.11, including conventions for the ordering of information within data items as defined in Clause 7.

Numbers are decimal unless otherwise noted, except IP addresses, which are hexadecimal per the conventions defined in RFC 2373. Numbers preceded by 0x indicate hexadecimal numbers, so that 0xFF is equivalent to "FF hexadecimal."

Words in italics refer to data items that are defined as either a field in an interface primitive or as an internal data item.

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.

1.5 System overview

The system described herein supports high-rate, low latency communications between WAVE devices. Generic IPv6 traffic is supported (not IPv4), as well as a specialized short message service. A control channel provides a common channel for signaling. IP application data is restricted to service channels; short message application data may be sent on either type of channel. Applications 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 Clause 4.

1.6 Applicability

This protocol supports wireless communications between any and all WAVE devices. These devices may be mobile, portable, or stationary. The mobile devices include vehicles operating at the 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 ensure interoperability and robust safety/public safety communications among these WAVE devices.

2. Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

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IEEE Std 802.2™ [ISO/IEC 8802-2], IEEE Standard for Information technology—Telecommunications and information exchange between systems—Local and metropolitan area networks—Specific requirements—Part 2: Logical link control.[2, 3]

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 P802.11p, Draft Amendment to STANDARD FOR Information technology—Telecommunications and information exchange between systems—LAN/MAN Specific Requirements—Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) specifications: Wireless Access in Vehicular Environments (WAVE).[4]

IEEE Std 1609.1-2006, IEEE Trial-Use Standard for Wireless Access in Vehicular Environments (WAVE)—Resource Manager.

IEEE Std 1609.2-2006, IEEE Trial-Use Standard for Wireless Access in Vehicular Environments (WAVE)—Security Services for Applications and Management Messages.

IEEE Std 1609.4-2006, IEEE Trial-Use Standard for Wireless Access in Vehicular Environments (WAVE)—Multi-Channel Operation.

IETF Request for Comments: RFC 768, User Datagram Protocol.[5]

IETF Request for Comments: RFC 793, Transmission Control Protocol.

IETF Request for Comments: RFC 1042, Standard for the transmission of IP datagrams over IEEE 802 networks.

IETF Request for Comments: RFC 2460, Internet Protocol, Version 6 (IPv6) Specification.

IETF Request for Comments: RFC 2461, Neighbor Discovery for IP Version 6 (IPv6).

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

IETF Request for Comments: RFC 3513, Internet Protocol Version 6 (IPv6) Addressing Architecture.

3. Definitions and acronyms

3.1 Definitions

For the purposes of this document, the following terms and definitions apply. *The Authoritative Dictionary of IEEE Standard Terms* [B2][6] should be referenced for terms not defined in this clause.

3.1.1 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 WAVE.

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[5]IETF publications are available from http://www.ietf.org/.

[6]The numbers in brackets correspond to those of the bibliography in Annex C.

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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.

3.1.3 control channel (CCH): A radio channel used for exchange of management frames and WAVE Short Messages.

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

3.1.5 EtherType: The Ethernet Type field defined in RFC 1042, used to identify the higher layer protocol above Logical Link Control.

3.1.6 management plane: A collection of functions performed in support of the communication functions provided by the data plane, but not directly involved in passing application data. The management plane provides a path outside the data plane to transfer management information.

3.1.7 networking services: A collection of management plane and data plane functions at the network layer and transport layer, as defined in IEEE Std 1609.3, supporting 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.

3.1.9 notification: An indication of an event of interest, sent to an application.

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.

3.1.13 provider: Initiator of a WBSS, or sender of WSMs. *See also:* **user.**

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

3.1.15 Provider Service Identifier (PSID): A number that identifies a service provided by an application.

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

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.

3.1.19 service channel (SCH): Secondary channels used for application specific information exchanges.

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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.

3.1.21 user: Joiner of a WBSS, or receiver of WSMs. *See also:* **provider**.

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.

3.1.24 WAVE device: 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.)

3.1.25 WAVE management entity (WME): A set of management functions required to provide WAVE networking services.

3.1.26 WAVE Routing Advertisement (WRA): Network configuration information broadcast by the RSU.

3.1.27 WAVE Service Advertisement (WSA): A data structure containing information that announces 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*.

3.1.29 WAVE short message protocol (WSMP): A protocol for rapid, reliable exchange of messages in a rapidly-varying 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

CCH control channel

DHCP Dynamic Host Configuration Protocol

DA Destination Address

DS Distribution System

DSRC Dedicated Short Range Communications

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

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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
OVHI OBU to vehicle host interface
PDU protocol data unit
PHY physical layer
PLME physical layer management entity
PSC Provider Service Context
PSID Provider Service Identifier
PST Provider Service Table
RA receiver address
RCPI Received Channel Power Indicator
RFC Request for Comments
RSU roadside unit
SA source address
SAP service access point
SCH service channel
SME Station Management Entity
SSID Service Set Identifier
TA Transmitter Address
TCP Transmission Control Protocol
UDP User Datagram Protocol
UTC Coordinated Universal Time
WAVE Wireless Access in Vehicular Environments
WBSS WAVE basic service set
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

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4. General description

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 provides an overview 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.

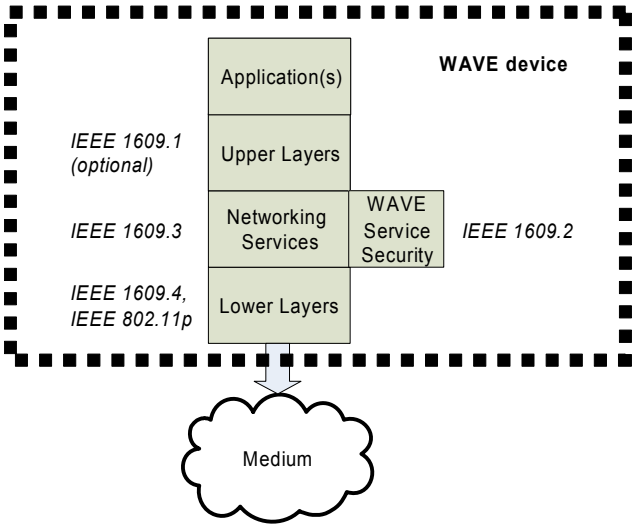

Figure 1—WAVE standards

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.

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

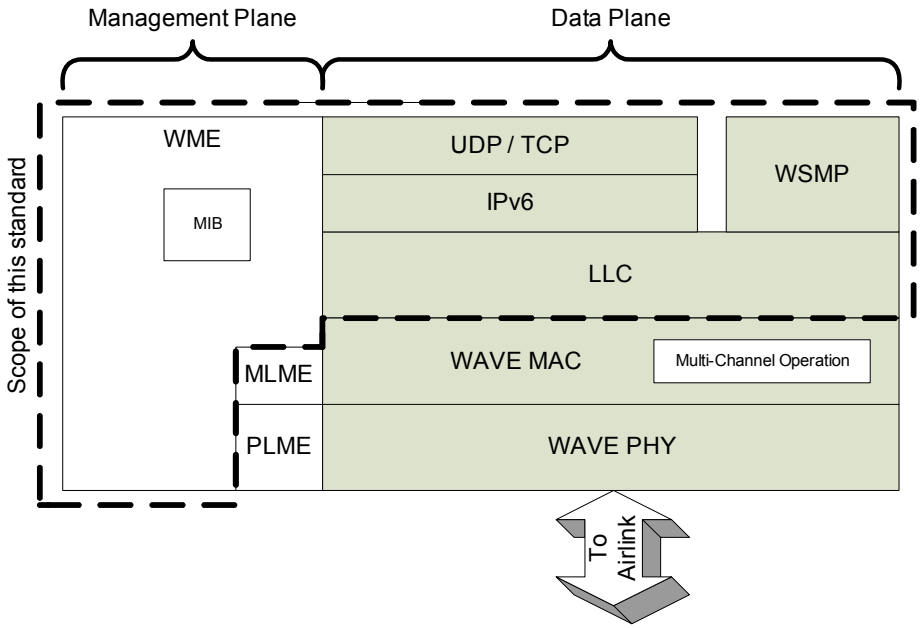

Figure 2—WAVE protocol stack

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.

4.1.1.1 Data services

Data plane components of WAVE networking services are specified in Clause 5, and consist of the following:

— Logical Link Control (LLC)
— Internet Protocol version 6 (IPv6)
— User Datagram Protocol (UDP) and Transmission Control Protocol (TCP)
— WAVE short message (WSM) and protocol (WSMP)

4.1.1.2 Management services

Management plane components of WAVE networking services are specified in Clause 6, and consist of the following:

a) Application registration
b) WBSS management
c) Channel usage monitoring
d) IPv6 configuration
e) Received Channel Power Indicator (RCPI) monitoring

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f) Management information base (MIB) maintenance

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 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.

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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.

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4.2.7 Channel coordination

Transmit and receive operation on WAVE control and service channels is coordinated based on sync intervals that are synchronized using a common system time base that is preferably generated by a global time reference (e.g., UTC/GPS). A sync 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 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.

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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.

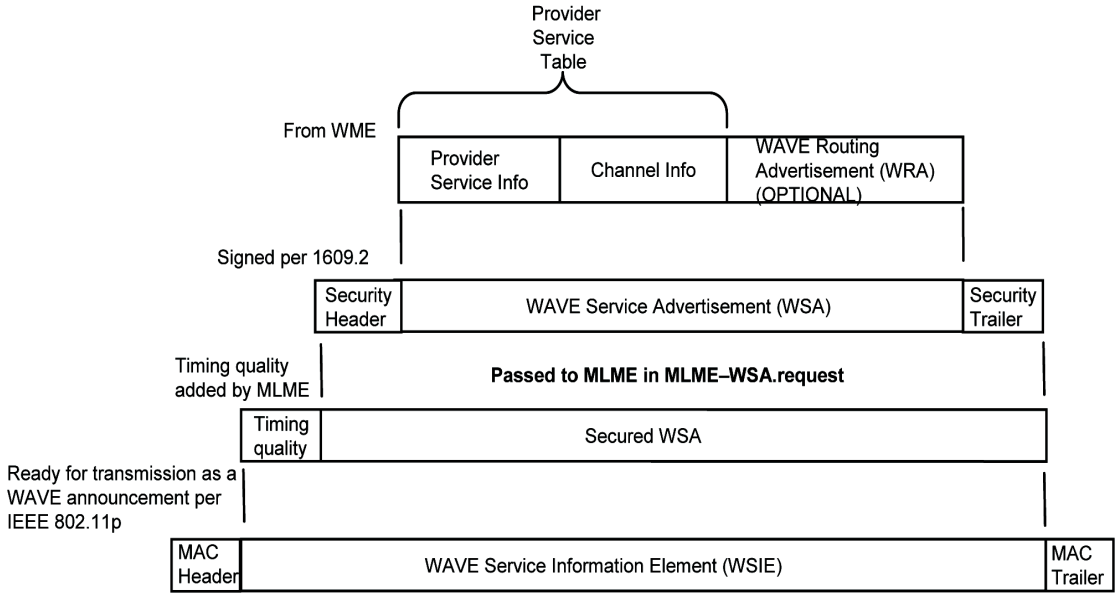

Figure 3—Building the WSIE

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*.

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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.

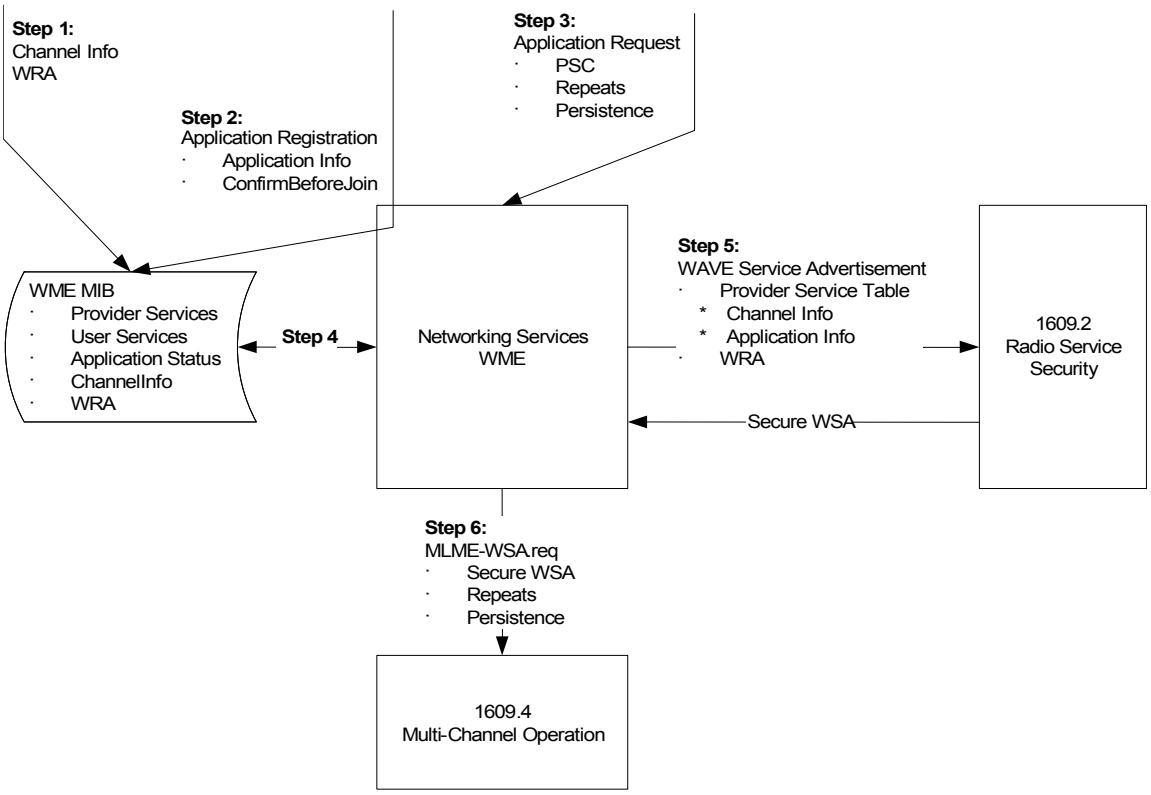

Figure 4—Building the *WSA*

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

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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 provide’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.

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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.

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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.

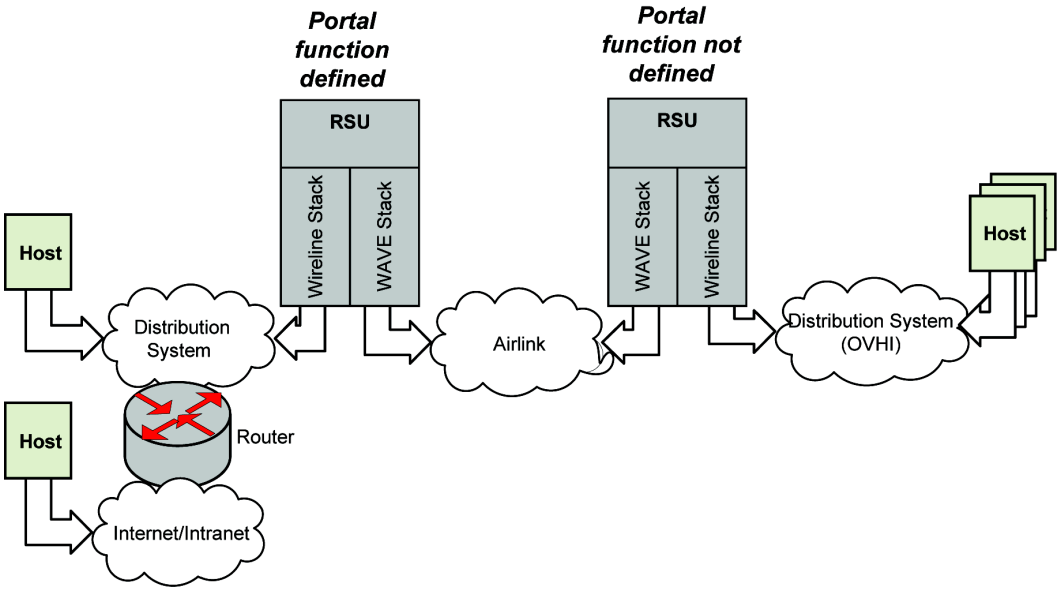

Figure 5—RSU Portal Function

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.

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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 send-ing side	Host via DS to RSU to OBU	0	1	DA (OBU)	BSSID (RSU)	SA (Host or Router)	Not used

[a]RSU-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 l.

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

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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.

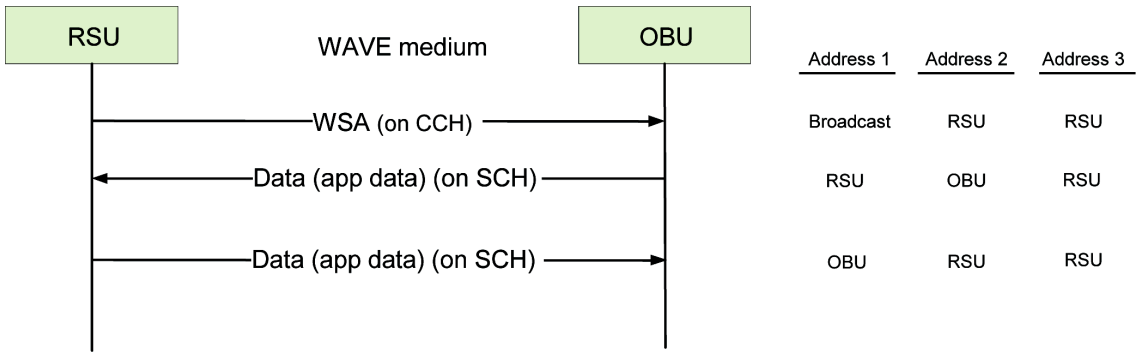

Figure 6—RSU service information exchange scenario

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.

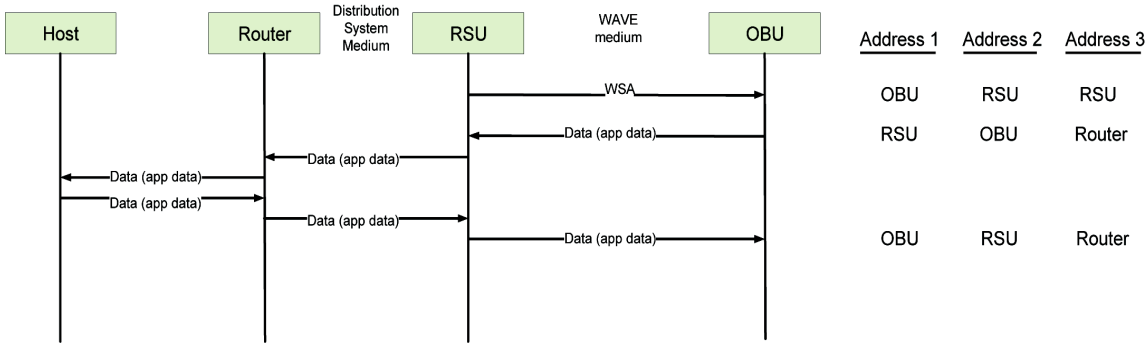

Figure 7—DS host service information exchange scenario

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,

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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.

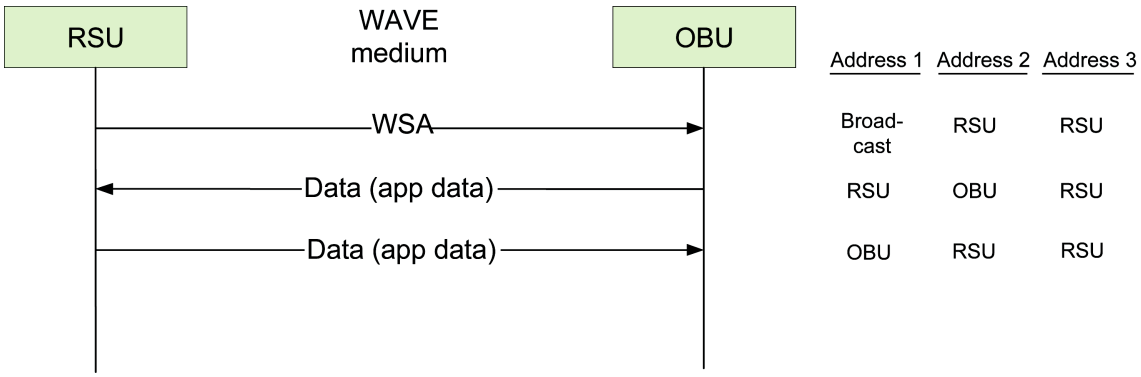

Figure 8—Non-DS host service information exchange scenario

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:

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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

This clause specifies the components of the data plane, which are optimized for air interface efficiency and low latency in support of vehicular applications. The WSMP layer is unique to this standard and supports a mechanism that provides direct control over power, and data rate on a frame-by-frame basis. WSMP also allows applications to identify the radio channel. An IPv6 protocol stack is also provided, with UDP chosen as the primary transport protocol because of its low overhead and latency. The primitives defined for exchanging information between the data plane components are described in Clause 7.

5.1 Logical Link Control (LLC)

WAVE Networking Service shall support the connectionless unacknowledged Type 1 Operation of the LLC as specified in IEEE Std 802.2, the Subnetwork Access Protocol specified in IEEE Std 802, and the standard for transmission of IP datagrams over IEEE 802 networks specified in 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. IPv6 packets for transmission shall have Ethernet Type set to 0x86DD. WSM packets for transmission shall have Ethernet Type set to 0x88DC.

5.2 Internet Protocol version 6 (IPv6)

WAVE networking services shall support the IPv6 as specified in RFC 2460. Related features defined in other RFCs are specified in 6.4.

5.3 User Datagram Protocol (UDP)

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

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 (WSM) Protocol

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.

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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.

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.

6. Management plane services

The following subclauses specify the services 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 are described in Clause 7.

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*.

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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 WBSS management

Upon determining that an application requires service, via a *WSA* request from a remote device or a request from a local application, the WME may initiate a WBSS. No more than one WBSS shall be established or joined by a WAVE device in support of a given application at a given time. There are several processes involved in WME WBSS management. These are illustrated in Figure 9 and specified in 6.2.1 through 6.2.5.

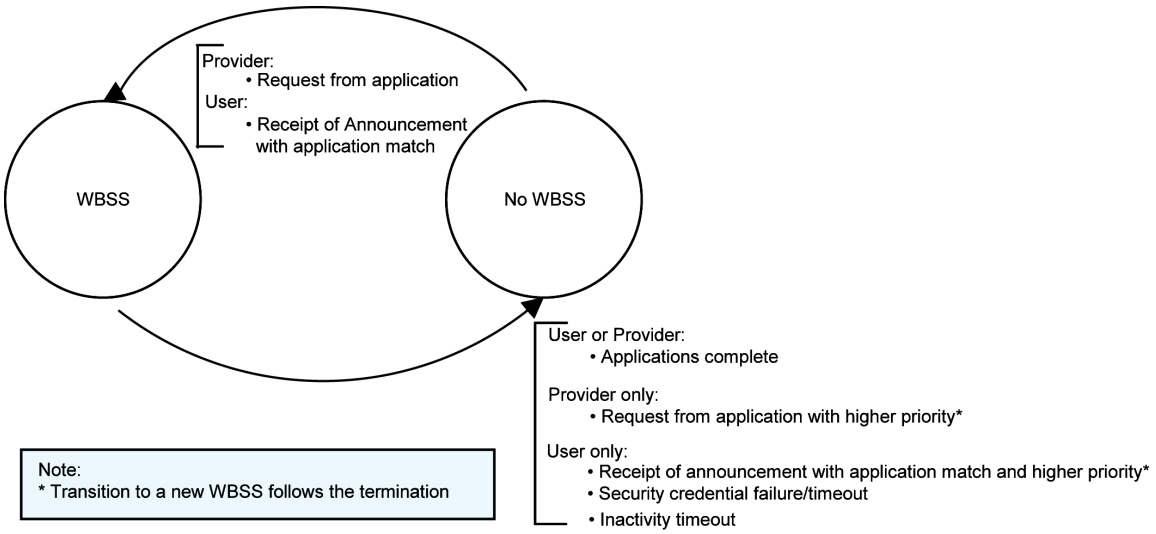

Figure 9—WBSS transitions

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6.2.1 Link establishment

Based on an application request, a WAVE device may establish a WBSS on an SCH, and announce its presence on the CCH for other devices to join that WBSS. WBSSs are initiated based on application priority and the availability of radio resources. This subclause specifies the establishment of a new WBSS; modifications to an existing persistent WBSS are specified in 6.2.2.

Information flows for WBSS initiation are illustrated in Figure 10; processing is specified in 6.2.1.1 and 6.2.1.2.

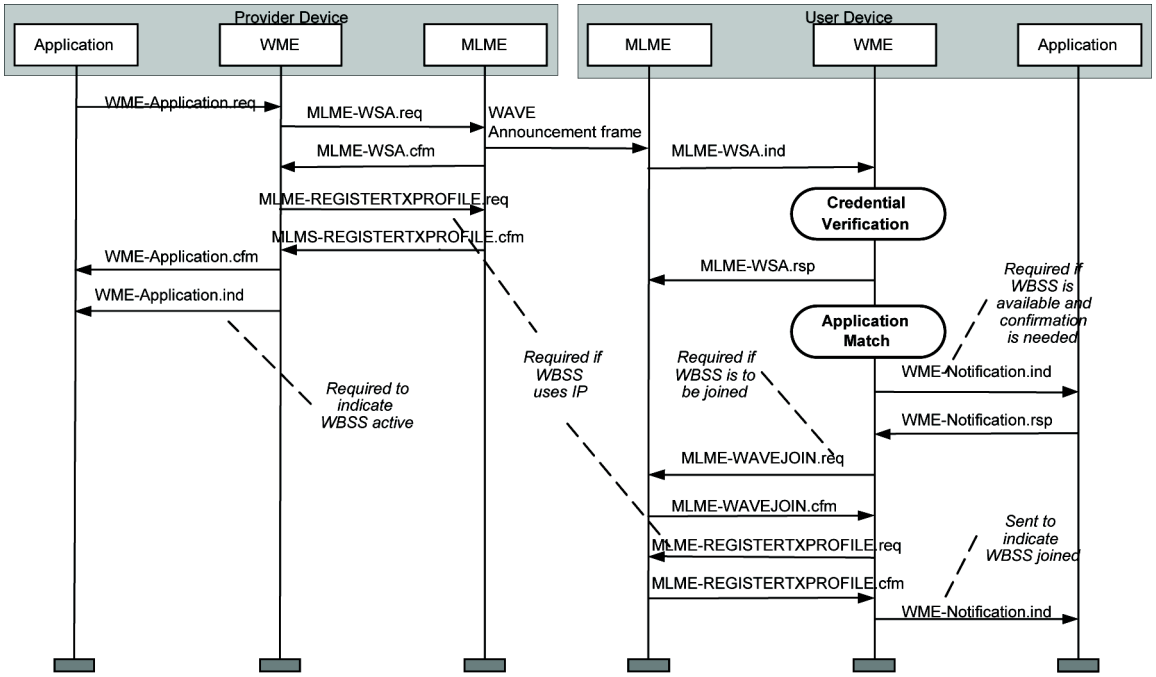

Figure 10—WBSS initiation sequence chart

6.2.1.1 Provider side processing

This subclause specifies the WME processing on the initiation of a WBSS at the request of a provider application. In summary, the request will fail and result in a negative confirmation message in any of the following cases:

— If the request fails WME checks for format, content, or priority.

— If the request fails MLME service-related checks.

— In the case of a request for an IPv6 service, if the request fails MLME transmitter-setup-related checks.

If the request does not fail any of these checks, WME responds with a positive confirmation message, and a notification indicating WBSS active.

Upon receipt of a WME-Application.request with *RequestType* equal to Active from an application in the *ProviderServiceInfo*, the WME shall start the link establishment processing specified here. The WME confirms each WME-Application.request with a WME-Application.confirm indicating whether the request has been accepted by the WME and MLME, or whether the request has been rejected.

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The WME shall initiate WBSSs based on the priority of the requesting application. If the WME accepts the request, it shall generate an MLME-WSA.request as specified in 6.2.1.1.1. If the resulting MLME-WSA.confirm does not indicate a failure and if the MLME-WSA.request contains *IPv6Address* in its *ProviderServiceInfo*, the WME shall also send an MLME-REGISTERTXPROFILE.request populated as specified in 6.2.1.1.2. If either the MLME-WSA.confirm or the MLME-REGISTERTXPROFILE.confirm does not indicate success, the WME shall stop processing the request, and shall indicate the failure to the requesting application in the WME-Application.confirm.

In order to free radio resources to accept a new higher priority WBSS, it may be necessary for the WME to preempt an active lower priority WBSS. Any WBSSs that are preempted by higher priority services shall be ended by the WME as specified in 6.2.4.3.

The WME shall reject requests from applications that are not registered in the *ProviderServiceInfo*, or which have *ChannelNumber* that does not appear in the MIB *ChannelInfo*. The WME shall reject requests for WBSSs that cannot be initiated, e.g., due to lack of available channel resources, or lack of sufficient priority. If the WME rejects the request, it shall generate a WME-Application.confirm indicating the appropriate *ReasonCode* and stop processing the request.

If neither the *WSA* nor the transmit profile registration request results in a failure, the WBSS is established. The WME shall set the application *ApplicationStatus* equal to Active in the *ApplicationStatusTable* entry, set the *ProviderServiceContext* in the *ApplicationStatusTable* entry equal to that in the WME-Application.request, and send the application WME-Notification.indication with *Event* code indicating LinkActive.

6.2.1.1.1 WBSS announcement parameters

The parameters in the MLME-WSA.request shall be set as follows:

SSID. This is the identifier of the WBSS. The default value from the WME MIB is used.

BSSBasicRateSet. The set of data rates must be supported by all devices to join this WBSS. This parameter is set equivalent to the *DataRate* value in the *ChannelInfo* associated with the channel set in the *ServiceChannelNumber* parameter.

OperationalRateSet. This defines the set of all possible data rates used on the WBSS. This parameter contains the *DataRate* value in the *ChannelInfo* associated with the channel set in the *ServiceChannelNumber* parameter. If the *Adaptable* flag is set in the *ChannelInfo* associated with the channel set in the *ServiceChannelNumber* parameter, then the *ChannelInfo* also contains any other data rates supported by the device (as specified in Annex B).

ServiceChannelNumber. This defines the channel of operation for this WBSS. If the *ChannelSelection* of the WBSS request is not Best-available-channel, *ServiceChannelNumber* is set to the channel number indicated by *ChannelSelection*. Otherwise, the *ServiceChannelNumber* is set as follows. The set of possible SCHs is the set of WAVE channels specified in IEEE P802.11p. The WME shall choose the channel that has least recently been received in a *WSA* within the allowed channels for that application, as specified in 6.3.

Secured WSA. This contains the information to be sent announcing the WBSS. The WME composes a *WaveServiceAdvertisement* per 8.1. The *WaveServiceAdvertisement* shall be digitally signed and secured per IEEE Std 1609.2 and the resulting secured *WSA* inserted into the request *Secured WSA*. The service information includes a Provider Service Table consisting of *ProviderServiceInfo* containing the *PstEntry* of the requesting application(s), and the *ChannelInfo* corresponding to any *ChannelNumber*(s) contained in the *ProviderServiceInfo*. If a *WaveRoutingAdvertisement* exists in the WME MIB, it shall be included in the *WaveServiceAdvertisement* to announce the availability of internetwork connectivity.

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Peer MAC address. This contains the destination of the WBSS announcement. This parameter is copied from the WME-Application.request. If *Persistence* is True, *Peer MAC address* shall be set to the broadcast value of all ones (binary).

Repeats. This defines the number of times the MAC will repeat transmission of the WBSS announcement in a control channel interval. This parameter is copied from the WME-Application.request.

Persistence. This defines whether the MAC will repeat transmission of the WBSS announcement each control channel interval. This parameter is copied from the WME-Application.request.

6.2.1.1.2 Transmit profile registration parameters for provider

The parameters in the MLME-REGISTERTXPROFILE.request shall be set as follows:

ServiceChannelNumber is set to the *ServiceChannelNumber* indicated in the corresponding *WSA* as specified in 6.2.1.1.1.

Other parameters are set to the corresponding parameters within the *ChannelInfo* of the *WaveServiceAdvertisement* in the corresponding MLME-WSA.request, with the exception that *PowerLevel* is set to the *TxPwr_Level*.

6.2.1.2 User side processing

The recipient of the service advertisement performs the processing specified below, determining whether the WBSS being announced will be joined by the local device. Figure 11 illustrates the high-level decisions related to generation of service primitives in joining a WBSS. WBSS completion is specified in 6.2.4. If multiple applications from one WBSS are matched, the WME shall process these applications simultaneously based on transmission priority

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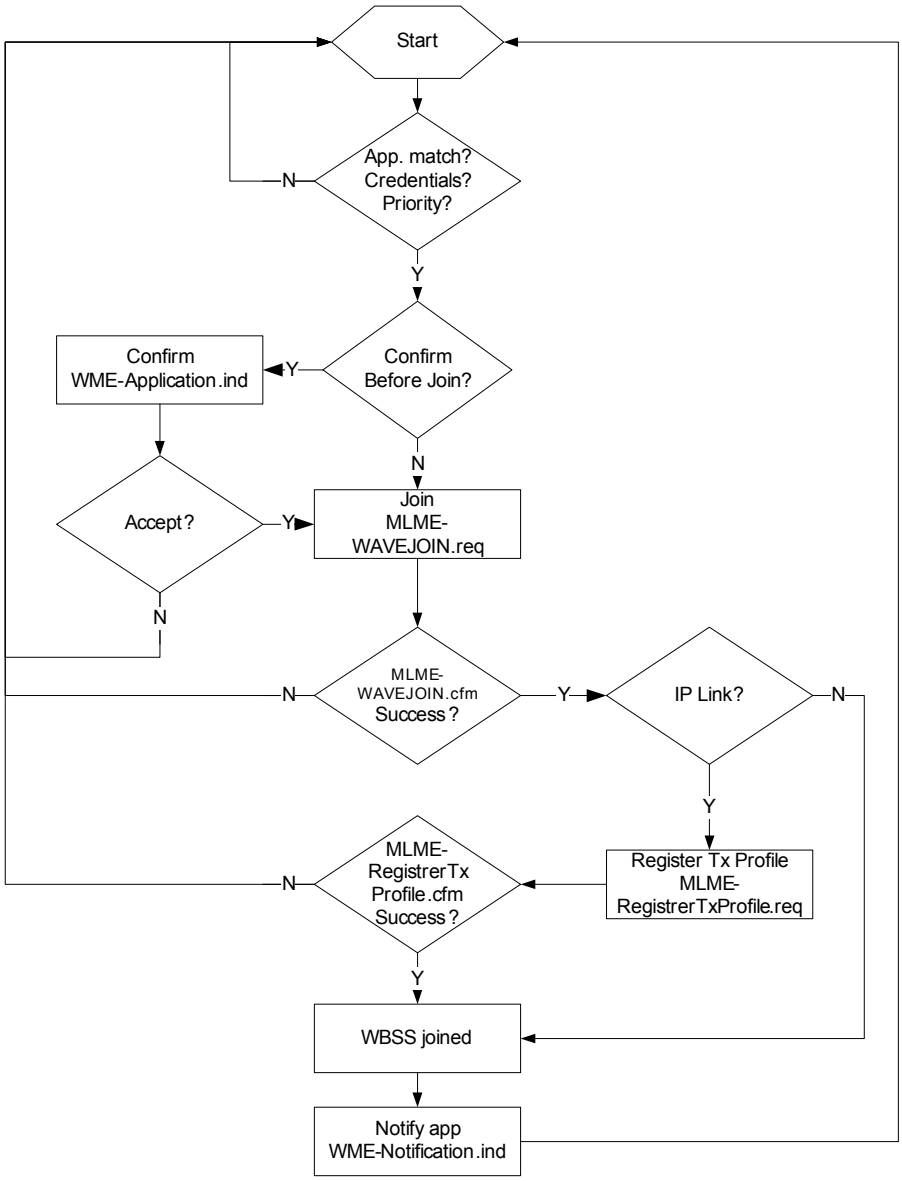

Figure 11—WME user side WBSS join primitives

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WME actions on receipt of an MLME-WSA.indication, coupled with device configuration and WBSS characteristics, are illustrated in Figure 11 and specified in following subclauses. Reference numbers in the text refer to lines in Table 2.

Table 2—MLME-WSA.indication processing

Ref. No.	Application match	Credentials OK	Pre-existing WBSS has priority	Confirm flag set	WME action
1	*	NO	*	*	Don't join
2	No match	*	*	*	Don't join
3	Match	YES	YES	*	Don't join
4	Match	YES	NO	NO	Join
5	Match	YES	NO	YES	Confirm
	KEY:* = Don't care				

The WME shall verify the *Secured WSA* within the received MLME-WSA.indication as specified in IEEE Std 1609.2. The result of the verification is returned to the MLME in a MLME-WSA.response. If the verification results in a failure (Ref. 1) the WME does not process the indication further.

The WME attempts to match each *ProviderServiceIdentifier* in the indication, with those in the WME MIB's *UserServiceInfo*. If multiple applications are matched, the WME shall process applications on a priority basis, with the highest priority application serviced first, based on the *ApplicationPriority* in the received indication. Multiple matched applications with the same *ChannelNumber* may share the WBSS.

If no match is found, the WME takes no action (Ref. 2).

If a match is found, the *ApplicationPriority* of each matched application in the indication's *ProviderServiceInfo* is compared with the *ApplicationPriority* of each application in the *ApplicationStatusTable* with *ApplicationStatus* of Active. If there is an active application with higher priority than any matched application, the WME takes no action (Ref. 3).

If a match is found, and there is no active application or no higher priority active application, and

a) Any of the matched applications was registered with the *ConfirmBeforeJoin* flag not set (Ref. 4), the WME shall join the WBSS as specified in 6.2.1.2.2. In the case of a pre-existing lower priority WBSS, the WME shall first end participation on that WBSS as specified in 6.2.4.3.

b) All of the matched applications were registered with the *ConfirmBeforeJoin* flag set (Ref. 5), the WME shall perform the WBSS confirmation specified in 6.2.1.2.1.

6.2.1.2.1 Confirming a WBSS

When confirming a WBSS, per the decisions specified in 6.2.1.2, the WME shall generate a WME-Application.indication to the matched application. The WME-Application.indication includes *ProviderServiceContext*, *Peer MAC address*, *IPv6Address*, and *Persistence* from the received announcement, if available. If the returned WME-Application.response has a *LinkConfirm* equal to Join WBSS, the WME shall join the WBSS as specified in 6.2.1.2.2. Otherwise, no action is required.

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6.2.1.2.2 Joining a WBSS

When joining a WBSS, based on the decisions specified in 6.2.1.2, the WME shall generate an MLME-WAVEJOIN.request. If the returned MLME-JOIN.confirm does not indicate success, the WME stops processing the WBSS announcement.

If the returned MLME-WAVEJOIN.confirm does indicate success, and if the associated MLME-WSA.request contains *IPv6Address* in its *ProviderServiceInfo*, the WME shall also issue an MLME-REGISTERTXPROFILE.request as specified in 6.2.1.2.2.2. If the returned MLME-REGISTERTXPROFILE.confirm does not indicate success, the WME stops processing the *WSA* associated with the WBSS.

If neither the join request nor the transmit profile registration request results in a failure, the WBSS is joined. The WME shall set the application ApplicationStatus equal to Active, the *ApplicationPriority* and *ProviderServiceContext* equal to those in the received *ProviderServiceInfo*, in the *ApplicationStatusTable*, and send each affected application a WME-Notification.indication with *Event* code indicating LinkActive.

Upon WBSS establishment, if the MLME-WSA.indication includes a *WaveRoutingAdvertisement*, the *WaveRoutingAdvertisement* shall be processed as specified in 6.4.

6.2.1.2.2.1 WBSS join parameters

The parameters in the MLME-WAVEJOIN.request shall be set as follows:

- *BSSID*. This is the address that defines the WBSS. The value of *Peer MAC address* from the associated MLME-WSA.indication is used.
- *SSID*. This is the identifier of the WBSS. The *SSID* value from the associated MLME-WSA.indication is used.
- *OperationalRateSet*. This is the required data rate of the WBSS. The *OperationalRateSet* value from the associated MLME-WSA.indication is used.
- *EDCA Parameter Set*. This is defined in IEEE Std 802.11. The *EDCA Parameter Set* value from the associated MLME-WSA.indication is used.
- *Secured WSA*. This contains the channel information associated with the WBSS. The *Secured WSA* value from the associated MLME-WSA.indication is used.
- *ChannelNumber*. This is the service channel of the WBSS. The *ChannelNumber* value from the *ProviderServiceInfo* within the *Secured WSA* of the associated MLME-WSA.indication is used.
- *TimeStamp*. This is defined in IEEE Std 802.11. The *TimeStamp* value from the associated MLME-WSA.indication is used.
- *Local Time*. This is defined in IEEE Std 802.11. The *Local Time* value from the associated MLME-WSA.indication is used.

6.2.1.2.2.2 Transmit profile registration parameters for user

The parameters in the MLME-REGISTERTXPROFILE.request shall be set equal to the parameters in the *ChannelInfo* associated with the application information within the received *WSA* that was matched to a local application as described in 6.2.1.2. *PowerLevel* is set to the *TxPwr_Level* of the *ChannelInfo*.

6.2.2 Dynamic WBSS

The WME allows provider applications to be added to and removed from the periodic announcements on a persistent WBSS. An example of the information flow is illustrated in Figure 12, and specified in the following subclauses. Additionally, the PSC of an existing application may be modified during the course of an ongoing WBSS, illustrated in Figure 13. This has no direct effect on user applications already

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participating on the service (since it can be expected that they are aware of the application context), but is available for applications considering whether to join the WBSS at other devices.

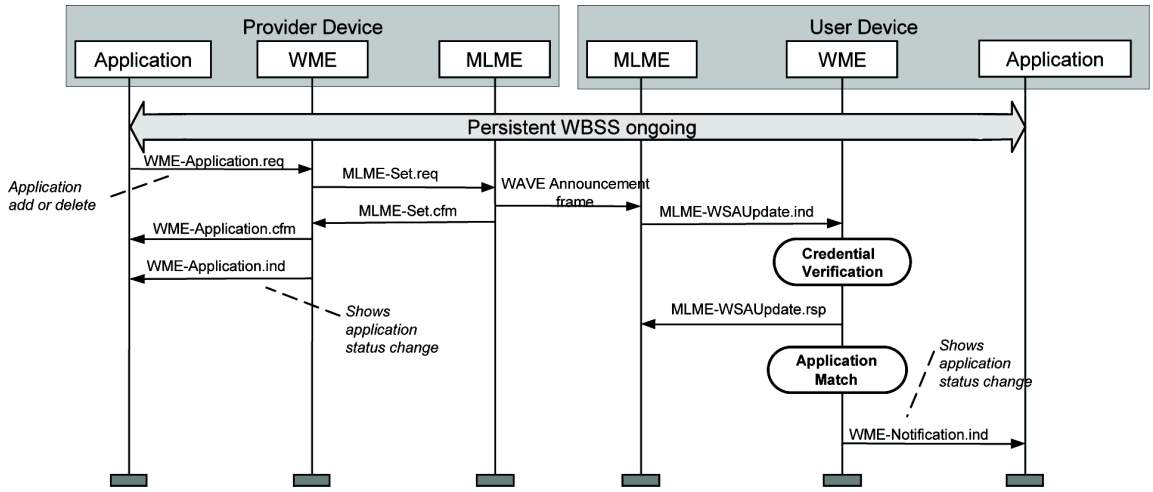

Figure 12—Successful dynamic WBSS update

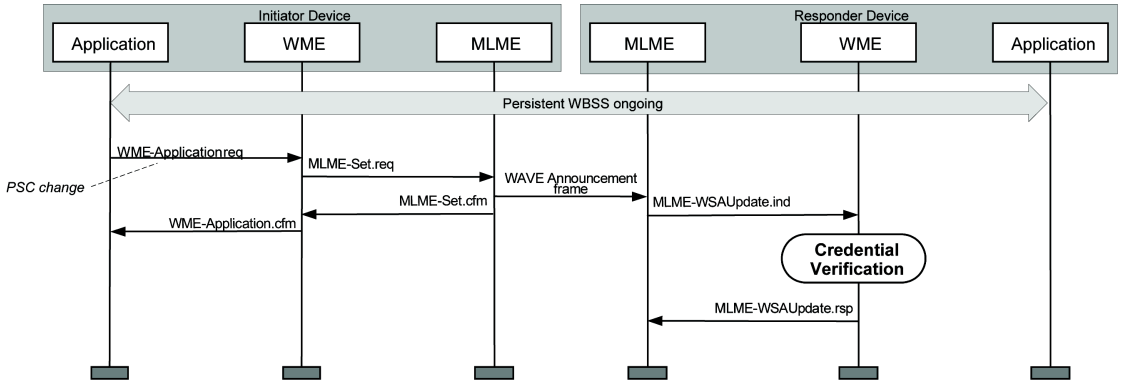

Figure 13—PSC update to ongoing service

6.2.2.1 Provider side processing

Provider services may be added to an ongoing WBSS. If the device is already operating as a provider on a persistent WBSS, and a WME-Application.request is received with *RequestType* equal to Active, *Persistence* equal to True, and *ChannelSelection* either equal to Best available channel or to the *ChannelNumber* of the existing WBSS, the WME shall add the application's *ProviderServiceInfo* to the *WaveServiceAdvertisement* that was used to initiate the WBSS. The *WaveServiceAdvertisement* shall be digitally signed and secured per IEEE Std 1609.2 and the resulting *Secured WSA* inserted into the MLME's MIB via an MLME-Set.request. If the *Repeats* value associated with the new request is higher than that currently associated with the WBSS, it shall also be written to the MLME MIB. The WME shall set the application's ApplicationStatus equal to Active in the ApplicationStatusTable and send the application a WME-Notification.indication with Event code indicating WBSSActive.

Provider services may be removed from an ongoing WBSS. If the device is operating as a provider on a persistent WBSS, with more than one Active application, and a WME-Application.request is received from

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one of those applications with *RequestType* equal to Inactive, the WME shall remove the application's *ProviderServiceInfo* from the *WaveServiceAdvertisement* that was used to initiate the WBSS. The *WaveServiceAdvertisement* shall be digitally signed and secured per IEEE Std 1609.2 and the resulting *Secured WSA* inserted into the MLME's MIB via an MLME-Set.request. If the *Repeats* value associated with the departing application is higher than that of any other application currently associated with the WBSS, the next-highest *Repeats* value (from the other Active applications' WME-Application.requests) shall be written to the MLME MIB. The WME shall set the application ApplicationStatus equal to Inactive in the ApplicationStatusTable and send the application a WME-Notification.indication with Event code indicating WBSSTerminated.

The PSC of an application active on an ongoing WBSS may be modified. If the device is already operating as a provider on a persistent WBSS, and a WME-Application.request is received with *ProviderServiceIdentifier* equal to one of Active status, and with *RequestType* equal to UpdatePSC, *Persistence* equal to True, the WME shall replace the application's *ProviderServiceContext* in the *Secured WSA* and insert it into the MLME's MIB via an MLME-Set.request. The *Secured WSA* need not be re-signed if the secure contents have not changed.

6.2.2.2 User side processing

Changes in the services offered on a joined persistent WBSS (as well as changes in the credentials) will result in an MLME-WSAUpdate.indication to the WME. WME actions on receipt of an MLME-WSA.indication, coupled with device configuration and WBSS characteristics, are illustrated in Table 3. Reference numbers in the text refer to lines in Table 3.

Table 3—MLME-WSAUpdate.indication processing

Ref.	Application match	Credentials OK	Confirm flag set	WME action
1	*	NO	*	Ignore WSAUpdate
2	Fewer matches (service lost)	YES	*	Set application Inactive
3	Same matches (service retained)	YES	*	No action
4	More matches (service gained)	YES	*	Set application Active
	KEY:* = Don't care			

The WME shall verify the *Secured WSA* of a received MLME-WSAUpdate.indication as specified in IEEE Std 1609.2. The result of the verification is returned to the MLME in a MLME-WSAUpdate.response. If the verification result is not a success (Ref. 1), the WME shall take no further action.

The WME attempts to match each *ProviderServiceIdentifier* in the indication, with those in the WME MIB's *UserServiceInfo*. A match is found if the *ProviderServiceIdentifier* of a local application match those in the announcement.

If there are any applications with ApplicationStatus equal to Active in the *ApplicationStatusTable*, which are not matched in the indication (Ref. 2), their status shall be set to Inactive. In the case of no applications matched, all applications going inactive will cause the WME to end operation on the WBSS as specified in 6.2.4.1.

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For any active applications that are matched in the indication (Ref. 3), no action is required. (Note that receipt of a PSC change in an ongoing WBSS does not require WME to send a notification to the active user application.)

If a match is found with an application with inactive status (Ref. 4), the WME shall set that application's status to Active, and send to the application a notification indicating LinkActive. Confirmation is not required, because the device is already operating on the WBSS.

6.2.3 WBSS credentials

The information in the service advertisement is only valid when coupled with time-sensitive security information that is generated during the signing process as described in 6.2.1.1.

6.2.3.1 Provider side processing

The credentials of a transmitted announcement are signed as specified in 6.2.1.1. In addition, for the case of a WBSS initiated by a WME-Application.request with *Persistence* equal to True, the *WaveServiceAdvertisement* shall be freshly signed within the time constraints specified in IEEE Std 1609.2, and the resulting *Secured WSA* inserted into the MLME MIB via an MLME-SET.request for use in announcement transmission.

6.2.3.2 User side processing

The credentials of a *WSA* received within a MLME-WSAUpdate.indication are verified as specified in 6.2.2.2. This verifies system information content validity during the operation of a WBSS, as well as verifying the source of timing information used by the MAC.

6.2.4 WBSS completion

The WME ends its participation in a WBSS based on decisions involving preemption by a higher priority application (6.2.1.2), application completion (6.2.4.1), application deregistration (6.1.2), or channel inactivity (6.2.4.2).

6.2.4.1 Application completion

An application may terminate its participation in a WBSS when it completes its activities. Upon receipt of a WME-Application.request with *RequestType* equal Inactive, the WME shall set the application's ApplicationStatus in the *ApplicationStatusTable* to Inactive. Under conditions described throughout Clause 6, the WME may also set an application's status to Inactive.

When the *ApplicationStatusTable* changes from having one or more applications with ApplicationStatus of Active, to having no applications Active, the WME shall end the current WBSS as specified in 6.2.4.3.

6.2.4.2 Channel inactivity monitoring

The MLME monitors channel activity and generates an internal indication if a channel of interest has been idle longer than a specified time. The timer expiry is indicated to the WME by the MLME as described in IEEE Std 1609.4. This function indicates to the WME that there is no activity on the current channel and that a user device should cease operation on the current WBSS.

Upon receipt of a MLME-CHANNELINACTIVITY.indication, for a WBSS on which it is active as a user, the WME shall end the WBSS as specified in 6.2.4.3.

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6.2.4.3 Ending a WBSS

When ending a WBSS, based on the decisions specified throughout Clause 6, the WME shall generate an MLME-WAVEEND.request, as specified in 6.2.4.3.2 If an MLME-REGISTERTXPROFILE was used in joining or initiating the WBSS, the WME issues an MLME-DELETETXPROFILE.request, as specified in 6.2.4.3.3, prior to sending the MLME-WAVEEND.request. Additionally, for each application with status Active in the WME MIB's *ApplicationStatusTable*, the WME shall generate a notification per 6.2.5.2, with *Event* code indicating LinkTerminated with the appropriate *Reason* code, and set the application's ApplicationStatus in the *ApplicationStatusTable* to Inactive.

6.2.4.3.1 Releasing the IP configuration

If IP configuration processing (6.4) was performed when the WBSS was joined, then the WME shall cease use of the IP configuration parameters upon the ending of the WBSS.

6.2.4.3.2 WBSS end parameters

The parameters in the MLME-WAVEEND.request shall be set to the SSID and BSSID parameter values utilized in the corresponding MLME-WSA.request (provider) or MLME-WAVEJoin.request (user).

6.2.4.3.3 Transmit profile deletion parameters

The parameters in the MLME-DELETETXPROFILE.request shall be set as follows:

— *ServiceChannelNumber*. This identifies the service channel used in a WBSS, and is set to the value used in the MLME- REGISTERTXPROFILE.request used to initiate the corresponding WBSS.

6.2.5 Application WBSS status maintenance

6.2.5.1 Application status transitions

The WME maintains the status of each registered application, based on supporting WBSS status and application availability (as set by the application). Use of the *ApplicationStatusTable* is specified at appropriate places throughout Clause 6, described below, and illustrated in Figure 14. As a WME MIB item, its contents are shown in Table 4. Besides the application identification and status, this table includes the application priority, notification IP address, and port. The notification address and port are populated based on registration information, and may be used in routing notifications to the application. For applications in the *ProviderServiceInfo*, ApplicationPriority is set equal to the ApplicationPriority in the registration that populated the application's service entry. For applications in the *UserServiceInfo*, ApplicationPriority is set equal to the ApplicationPriority in the *WSA* that triggered joining the WBSS.

Applications by default have status set to Inactive. The WME attempts to match received WSAs (in the MLME-WSA.indication) with locally registered applications in the *UserServiceInfo*, and when a match is found, may initiate a supporting WBSS as specified in 6.2.1.2.

While operating on a WBSS, applications have status set to Active. Active applications may generate traffic for transmission on service channels.

A user application may choose to become Unavailable rather than remove its registration information from the MIB. This is accomplished using the WME-Application.request primitive. Unavailable status indicates a user application does not require the WME to join a WBSS on its behalf. The WME shall treat an application with ApplicationStatus equal to Unavailable as if it is not present in the *UserServiceInfo*.

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Upon receipt of WME-Application.request requesting Inactive or Unavailable status the WME shall set the status of the requesting application in the *ApplicationStatusTable* to the requested value, and performs other operations as specified in 6.2.2 and 6.2.4.1. Also, depending on current WBSS availability, the WME sets the status of an application to Active or Inactive as specified throughout Clause 6.

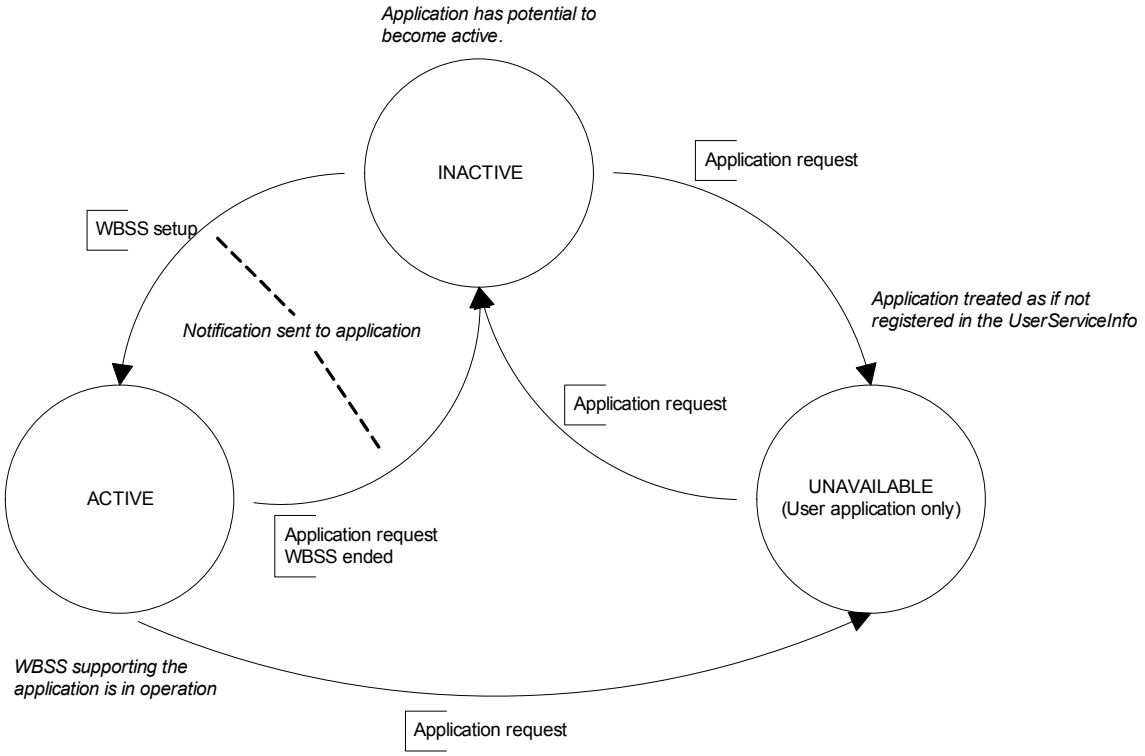

Figure 14—Application status

6.2.5.2 Application notifications

The WME notifies applications when it changes their WBSS status. The WME-Notification.indication primitive is used to notify the affected application. The *Event* code LinkActive shall be sent when setting an application's ApplicationStatus to Active. The *Event* code LinkTerminated shall be sent when setting an application's ApplicationStatus to Inactive. The appropriate *Reason* value, specified in 7.5 and defined in Table 4, shall be sent.

Table 4—Values of the *Reason* parameter

Return value	Condition
Unspecified	Used when no other reason code is appropriate
ApplicationRequested	Used when WBSS goes active, or is ended due to an application request
ChannelInactivity	Used when a WBSS is ended due to channel inactivity
ApplicationComplete	Used when a WBSS is ended due to no active applications
PriorityPreemption	Used when a WBSS is ended due to a new, higher-priority WBSS
SecurityCredentialFailure	Used when a WBSS is ended due to failure of the provider's security credentials

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6.3 Channel usage monitoring

The WME keeps track of SCHs that are in use by nearby WAVE devices, so that, when called upon to do so (see 6.2.1.1), it can choose a WBSS SCH that is less likely to be congested. How this is to be done is not specified in this standard. An example would be that for each possible SCH, the WME keeps track of the most recent time at which a *WSA* was received that used each available SCH. When the application requests the best available channel, the WME would then use the least recently used SCH.

NOTE—Some channels may be reserved for public safety only applications.[7]

6.4 IPv6 configuration

The IPv6 information used by an RSU is provided by a network administrator. The OBU derives the information that allows it to operate on an infrastructure network from a device (RSU) connected to that network. Device link-local addresses are derived locally by any WAVE device and may be used without any external configuration information.

Each WAVE device shall support link-local, global, and multicast IPv6 addresses on its WAVE interface per RFC 2373, for both transmission and reception.

The link-local address is derived from the device MAC address per RFC 2462.

The derivation of the global address of the RSU may occur through any means, such as administrative entry, and is not specified here.

The OBU WME shall calculate its global IPv6 address via a stateless configuration procedure. This is the procedure described in RFC 3513, except the OBU uses its MAC address in conjunction with the *IpPrefix* received in the *WaveRoutingAdvertisement* in the MLME-WSA.indication from an RSU, rather than in a Router Advertisement message.

OBUs shall accept IPv6 packets addressed to pre-defined Host multicast addresses per RFC 2462. RSUs shall accept IPv6 packets addressed to pre-defined Router multicast addresses per RFC 2462. In addition, WAVE devices shall support multicast addresses for application traffic.

[7]Notes in text, tables, and figures are given for information only and do not contain requirements needed to implement the standard.

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6.5 Received Channel Power Indicator (RCPI) polling

WAVE allows an application to initiate a query of received signal strength, indicative of channel quality, at a remote device, with the measurement report returned to the requesting application. The resulting information flow is illustrated in Figure 15.

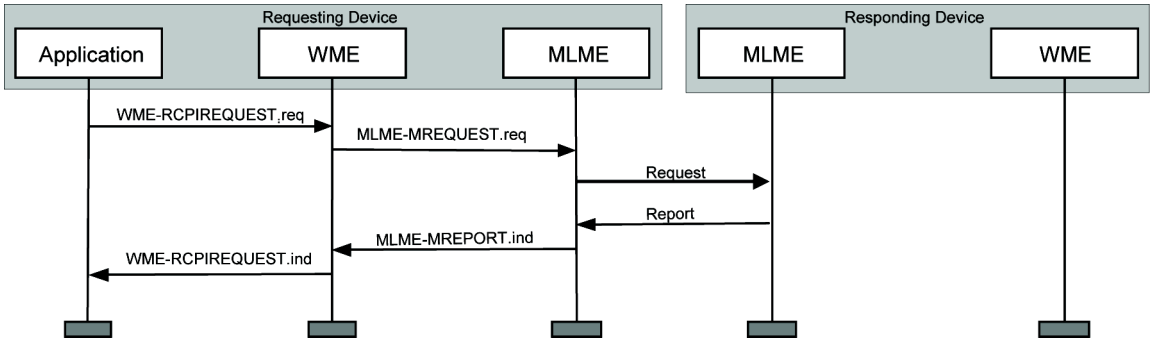

Figure 15—RCPI information flow

If WME supports RCPI, it shall ignore a WME-RCPIREQUEST.request with a Peer MAC Address equal to the broadcast address. Otherwise, upon receipt of a WME-RCPIREQUEST.request, the WME shall generate an MLME-MREQUEST.request. The WME shall insert a Dialog Token, incremented modulo 255, for each MLME-MREQUEST.request.

On receipt of an MLME-MREPORT.indication, the WME shall generate a WME-RCPIREPORT.indication. The WME-RCPIREPORT.indication shall be passed to the application associated with the original WME-RCPIREQUEST.request, as determined by the Dialog Token value.

Note that on the responding device, the reporting is handled by the MLME so WME action is not required. See IEEE P802.11p for specification of MLME operation.

6.6 MIB maintenance

The WME shall maintain a MIB containing the configuration and status information identified in Annex A and specified in Annex B.

7. Service primitives

Service access points (SAPs) are shown in Figure 16 to support communications between WAVE networking services entities and other WAVE entities in the same device. The WSM SAP and WME SAP are specific to this standard. Where there are no unique requirements to this specification, e.g., in the case of the Transport Service Access Point (TSAP), the SAP is specified by reference to the defining standard. No unique management SAPs are defined for the upper data protocols; where necessary, upper protocols may use the WME SAP to access WME services.

The primitives used on each interface are summarized in Table 5 and described in 7.1 through 7.4. The details of the parameters used within primitives are provided in 7.5. The implementation of the primitives and their exchange protocols are not specified, but are left as design decisions.

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Where error indications or failure responses are considered critical to Networking Service operation, they are specified. Otherwise, they are left undefined, as a choice for the implementer.

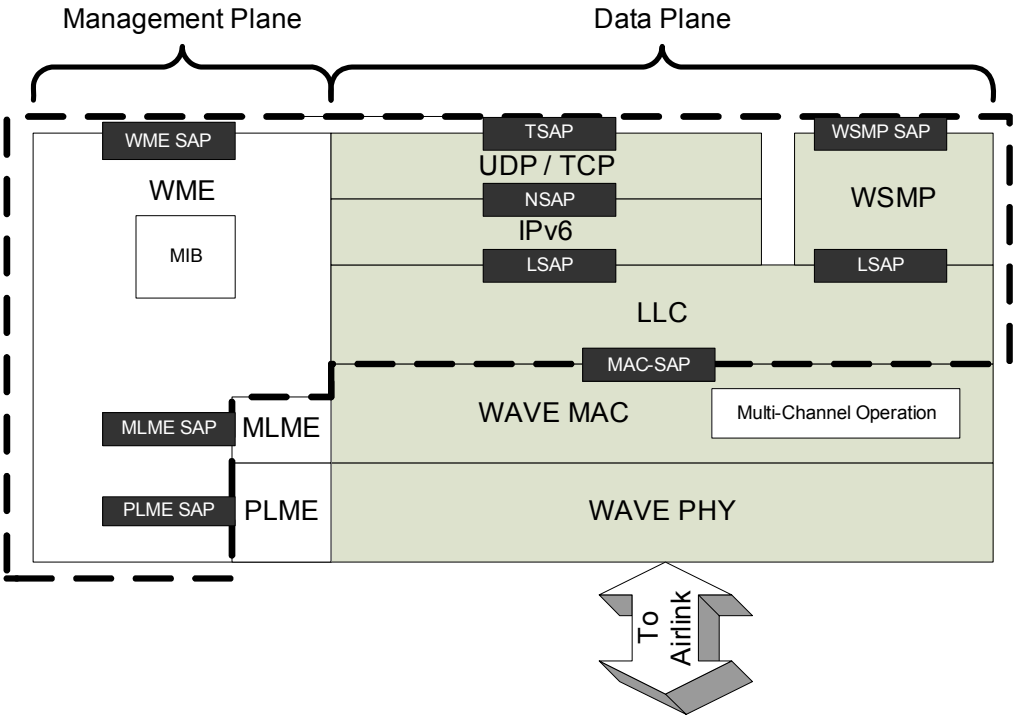

Figure 16—Service access points

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Table 5—Summary of primitives

SAP	Primitive	Specified in
WSMP	WSM-WaveShortMessage.request	7.1.1
	WSM-WaveShortMessage.indication	7.1.2
WME	WME-Application.request	7.2.1
	WME-Application.confirm	7.2.2
	WME-Application.indication	7.2.3
	WME-Application.response	7.2.4
	WME- Notification.indication	7.2.5
	WME-ApplicationRegistration.request	7.2.6
	WME-ApplicationRegistration.confirm	7.2.7
	WME-Get.request	7.2.8
	WME-Get.confirm	7.2.9
	WME-Set.request	7.2.10
	WME-Set.confirm	7.2.11
	WME-RCPIREQUEST.request	7.2.12
	WME-RCPIREQUEST.indication	7.2.13
LSAP	DL-UNITDATA request	IEEE Std 802.2
	DL-UNITDATA indication	IEEE Std 802.2
MLME	MLME-CHANNELINACTIVITY	IEEE Std 1609.4
	MLME-DELETETXPROFILE	IEEE Std 1609.4
	MLME-MREPORT	IEEE Std 802.11h
	MLME-MREQUEST	IEEE Std 802.11h
	MLME-REGISTERTXPROFILE	IEEE Std 1609.4
	MLME-WSA	IEEE Std 1609.4
	MLME-WAVEEND	IEEE Std 1609.4
	MLME-WAVEJOIN	IEEE Std 1609.4
	MLME-GET	IEEE Std 1609.4
	MLME-SET	IEEE Std 1609.4

7.1 WSMP SAP

The WSM primitives may allow applications to send and receive WSMs.

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7.1.1 WSM-WaveShortMessage.request

7.1.1.1 Function

The WSM-WaveShortMessage.request primitive is used by an application to request sending a WAVE short message.

7.1.1.2 Semantics of the service primitive

The parameters of the WSM-WaveShortMessage primitive are as follows:

WSM-WaveShortMessage.request
(
ChannelInfo,
WsmVersion,
SecurityType,
ProviderServiceIdentifier,
TransmissionPriority,
Length,
Data,
Peer MAC address
)

7.1.1.3 When generated

The WSM-WaveShortMessage.request primitive is generated by the application layer to request sending a WAVE short message.

7.1.1.4 Effect of receipt

Upon receipt of the WSM-WaveShortMessage.request primitive, the WSMP delivers the WAVE short message to the LLC.

7.1.2 WSM-WaveShortMessage.indication

7.1.2.1 Function

The WSM-WaveShortMessage.indication primitive indicates that a WAVE short message has been received for a local application.

7.1.2.2 Semantics of the service primitive

The parameters of the WSM-WaveShortMessage.indication primitive are as follows:

WSM-WaveShortMessage.indication
(
ChannelInfo,
WsmVersion,
SecurityType,
ProviderServiceIdentifier,
Transmission Priority,
Length,
Data,
Peer MAC address
)

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7.1.2.3 When generated

The WSM-WaveShortMessage.indication primitive is generated by the WSMP to deliver a WSM to a registered application. The *SecurityType* value indicates the security processing (defined in IEEE Std 1609.2) applied to the message by the sending application.

7.1.2.4 Effect of receipt

The WAVE Short Message is processed as determined by the receiving application.

7.2 WME SAP

The WME primitives allow applications to access WME functions (registration/deregistration, WBSS initiation and joining, application status changes, MIB access, and RCPI measurement) and also allow the WME to notify applications. Designers are not constrained on their implementation of the WME SAP. For example, they may choose to implement the SAP in the form of function calls or in the form of messages passed through the IP protocol layer.

Note that the identification of the application receiving or sending a WME primitive is not explicitly shown as part of the primitive.

7.2.1 WME-Application.request

7.2.1.1 Function

The WME-Application.request primitive allows a provider application to request the initiation of a WBSS, or a user application to control whether or not to be notified of a WBSS, or either type of application to end a WBSS.

7.2.1.2 Semantics of the service primitive

The parameters of the WME-Application.request primitive are as follows:

```
WME-Application.request(
    ProviderServiceIdentifier,
    ProviderServiceContext,
    RequestType,
    Peer MAC address (optional),
    Repeats (optional),
    Persistence,
    ChannelSelection (optional)
    )
```

7.2.1.3 When generated

The WME-Application.request primitive is generated by an application to request a WBSS establishment, or request a change to the application's WBSS status, or a change to the PSC of an active service. When the *RequestType* equals Active, then the Peer MAC Address, *Repeats*, *Persistence*, and *ChannelSelection* parameters are included. Use of Peer MAC Address, *Repeats*, and *Persistence* are specified in IEEE Std 1609.4; use of *ChannelSelection* is specified in 6.2.1.1.1.

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7.2.1.4 Effect of receipt

Upon receipt of the WME-Application.request primitive, the WME attempts to establish a WBSS, or sets the application Inactive (and possibly ends its operation on a WBSS), or sets the application status to Unavailable, or updates the application's PSC, depending on the *RequestType*, as specified in this document. The *SecurityType* value indicates the security processing (defined in IEEE Std 1609.2) expected of the receiving application.

7.2.2 WME-Application.confirm

7.2.2.1 Function

The WME-Application.confirm primitive is used to indicate the status of an application request.

7.2.2.2 Semantics of the service primitive

The parameters of the WME-Application.confirm primitive are as follows:

```
WME-Application.confirm(
    ResultCode
    )
```

7.2.2.3 When generated

The WME-Application.confirm primitive is generated in response to, and indicates the result of, a WME-Application.request.

7.2.2.4 Effect of receipt

The requesting application may take action based on the *ResultCode* value.

7.2.3 WME-Application.indication

7.2.3.1 Function

The WME-Application.indication primitive is used to inform an application of the availability of a new WBSS and request confirmation on whether the application chooses to join the offered WBSS.

7.2.3.2 Semantics of the service primitive

The parameters of the WME-Application.indication primitive are as follows:

```
WME-Application.indication(
    ProviderServiceContext,
    Peer MAC address (optional),
    IPv6Address (optional),
    )
```

7.2.3.3 When generated

The WME-Application.indication primitive is generated by the WME, when a MLME-WSA.indication is received, with a service matching one in the local *UserServiceInfo*, and when the matched application has its *ConfirmBeforeJoin* flag set.

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7.2.3.4 Effect of receipt

Upon receipt of the WME-Application.indication primitive, the application responds with WME-Application.response.

7.2.4 WME-Application.response

7.2.4.1 Function

The WME-Application.response primitive is used by an application to respond to a WME-Application.indication that informs the application of the availability of a new WBSS.

7.2.4.2 Semantics of the service primitive

The parameters of the WME-Application.response primitive are as follows:

```
WME-Application.response(
    LinkConfirm
    )
```

7.2.4.3 When generated

The WME-Application.response primitive is generated in response to a WME-Application.indication.

7.2.4.4 Effect of receipt

The WME will either join or ignore the WBSS based on the value of *LinkConfirm* (see Table 7 for acceptable values for LinkConfirm).

7.2.5 WME-Notification.indication

7.2.5.1 Function

The WME-Notification.indication primitive indicates to a registered application that a WBSS of interest has changed status.

7.2.5.2 Semantics of the service primitive

The parameters of the WME-Notification.indication primitive are as follows:

```
WME-Notification.indication
    (
    Event,
    Reason,
    ProviderServiceContext (optional),
    Certificate (optional),
    IPv6 Address (optional),
    ServicePort (optional),
    Peer MAC address (optional),
    DefaultGateway (optional),
    GatewayMacAddress (optional),
    ChannelInfo (optional),
    BSSID (optional),
    SSID (optional),
    Timestamp (optional),
    Local time (optional),
```

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BSSBasicRateSet (optional),
OperationalRateSet (optional),
EDCA Parameter Set (optional),
RCPI (optional)
)

7.2.5.3 When generated

The WME-Notification.indication primitive is sent when an application's WBSS status has been modified by the WME. For transitions to Inactive or Unavailable status, only *Event* and *Reason* are used. For a transition to Active, the certificate is set equal to the certificate output by the signed WSA verification process as specified in IEEE Std 1609.2. *ProviderServiceContext*, *IPv6Address*, *Port*, *Peer MAC address*, and *ChannelInfo* are set equal to the parameter values in the received *WaveServiceAdvertisement*. *DefaultGateway* and *GatewayMacAddress* are set to those in the *WaveRoutingAdvertisement*, if available. Other parameter values are from the received MLME indication primitive.

7.2.5.4 Effect of receipt

The notification is processed as determined by the receiving application.

The service provider's IPv6 Address and *Peer MAC address*, and the *DefaultGateway* and *GatewayMacAddress*, may be used by the receiving application as described in 4.4.

7.2.6 WME-ApplicationRegistration.request

7.2.6.1 Function

The WME-ApplicationRegistration.request primitive is used by an application to request an application registration.

7.2.6.2 Semantics of the service primitive

The parameters of the WME-ApplicationRegistration.request primitive are as follows:

WME-ApplicationRegistration.request
(
RegistrationAction,
CHOICE (UstEntry, PstEntry) (optional),
NotificationIPv6Address (optional),
NotificationPort (optional)
)

Table 6 describes the application registration parameters. The parameters are listed in the left column. Categories of application are indicated across the top row: applications residing on or off the WAVE device; provider and user type applications; and applications employing the IP or WSM protocol. Each category of application requires a slightly different set of supporting registration parameters, which are indicated in the body of the table. A description of the parameters to be registered and the usage codes are found in the text following Table 6. The final column of the table indicates whether the parameter is transmitted in the provider's service announcement, and if so, whether the parameter is covered by the accompanying security credentials.

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Table 6—Application registration parameters

Service info parameter	Application Category								Included in *WSA*? Secured?
	local (on device)				remote (off device)				
	Provider		User		Provider		User		
	IP	WSM	IP	WSM	IP	WSM	IP	WSM	
PSID	E	E	E	E	E	E	E	E	Signed
Application Priority	E	E	X.1	X.1	E	E	X.1	X.1	Signed
Channel	O	O	X.1	X.1	O	O	X.1	X.1	Not signed
Service IPv6 address	E	X	X	X	E	X	X	E	Not signed
Service port (UDP or TCP)	E	X	X	X	E	X	X	E	Not signed
Service Provider MAC address	O	O	X	X	E	E	X	X	Not signed
Notification IP address	C.1	C.1	C.1	C.1	C.1	C.1	C.1	C.1	X
Notification port	C.2	C.2	C.2	C.2	C.2	C.2	C.2	C.2	X
Confirm before join	X	X	O	O	X	X	O	O	X

KEY:
E Expected to be provided by the application
O Optionally provided by the application
X Not used
X.1 Not used in registration; the parameter is set by the user WME based on provider info in announcement
X.2 Not used in registration; the parameter is set by user application based on provider info in announcement
C.1 Mandatory if IP is used for local notifications, otherwise X
C.2 Mandatory if UDP is used for notifications, otherwise X

Each of the parameters used in application registration is briefly described as follows:

— *ProviderServiceIdentifier* (PSID). Identifies the application; matched between provider and user.

— *Application Priority*. Determines whether an existing WBSS is abandoned for a new one. Must be consistent with the information in the application's certificate.

— *Channel*. Defines the channel of operation for the offered service. The WME will choose if none is provided.

— *Service IP address*. Defines the end point of the offered IP service. Used by a user application in addressing packets. For remote WSM applications, this provides the WME with the ability to deliver the received WSMs.

— *Service port* (UDP or TCP). Defines the end point of offered IP service. Used by a user application in addressing packets. Applications have advanced knowledge of the network protocol they use. For remote WSM applications, this provides the WME the ability to deliver the received WSMs.

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— *Service Provider MAC address*. Defines the end point of an offered service. Used by a user application in addressing packets.

— *Notification IP address*. Address of the application. Used by the WME in delivering notifications. Only needed if IP is used for notifications.

— *Notification port*. UDP port of the application. Used by the WME in delivering notifications. Only needed if UDP is used for notifications.

— *Confirm before join*. A flag used by the user's WME in handling link initiation; default is FALSE.

7.2.6.3 When generated

The WME-ApplicationRegistration.request primitive is generated by an application to request an application registration. *NotificationIPv6Address* and *NotificationPort* are included when adding application information, and provides addressing information for notifications sent to the application.

7.2.6.4 Effect of receipt

Upon receipt of the WME-ApplicationRegistration.request primitive, the application and service information are added to or removed from the WME MIB's *ProviderServiceInfo* or *UserServiceInfo*, depending on the *RegistrationAction*. It is recommended that implementers and operators consider any security implications associated with the installation and registration of applications in their devices.

7.2.7 WME-ApplicationRegistration.confirm

7.2.7.1 Function

The WME-ApplicationRegistration.confirm primitive is used by the WME to respond to an application to requested registration.

7.2.7.2 Semantics of the service primitive

The parameters of the WME-ApplicationRegistration.confirm primitive are as follows:

```
WME-ApplicationRegistration.confirm
    (
    ResultCode
    )
```

7.2.7.3 When generated

The WME-ApplicationRegistration.confirm primitive is generated in response to a WME-ApplicationRegistration.request.

7.2.7.4 Effect of receipt

The requesting application may take action based on the *ResultCode* value.

7.2.8 WME-Get.request

7.2.8.1 Function

The WME-Get.request primitive is generated by an application to retrieve the value of a specific WME MIB attribute.

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7.2.8.2 Semantics of the service primitive

The parameters of the WME-Get.request primitive are as follows:

```
WME-Get.request
    (
    MIBattribute
    )
```

7.2.8.3 When generated

The WME-Get.request primitive is generated by an application to request the value of the specified *MIBattribute*.

7.2.8.4 Effect of receipt

Upon receipt of the WME-Get.request primitive, the WME returns the *MIBattribute* value from the WME MIB.

7.2.9 WME-Get.confirm

7.2.9.1 Function

The WME-Get.confirm primitive returns the result of the WME-Get.request.

7.2.9.2 Semantics of the service primitive

The parameters of the WME-Get.confirm primitive are as follows:

```
WME-Get.confirm(
    Status,
    MIBattribute,
    MIBattributevalue
    )
```

7.2.9.3 When generated

The WME-Get.confirm primitive is used to confirm the result of the WME-Get.request.

7.2.9.4 Effect of receipt

The receipt of the WME-Get.confirm primitive returns the appropriate WME MIB attribute value if *Status* equals success; otherwise, it returns an error indication in the *Status* field. Possible error status values include “invalid MIB attribute” and “attempt to get write-only MIB attribute.”

7.2.10 WME-Set.request

7.2.10.1 Function

The WME-Set.request primitive is generated by an application to set the value of a specific WME MIB attribute.

7.2.10.2 Semantics of the service primitive

The parameters of the WME-Set.request primitive are as follows:

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WME-Set.request(
MIBattribute,
MIBattributevalue
)

7.2.10.3 When generated

The WME-Set.request primitive is generated by an application to request that the value of the specified *MIBattribute* be set to the indicated value. The MIB represents sensitive data; implementers are responsible for protecting sensitive data, though this standard does not specify the means for doing so.

7.2.10.4 Effect of receipt

Upon receipt of the WME-Set.request primitive, the WME returns WME-Set.confirm, and, if it is able, sets the MIB attribute value in the WME MIB.

7.2.11 WME-Set.confirm

7.2.11.1 Function

The WME-Set.confirm primitive returns the result of the WME-Set.request.

7.2.11.2 Semantics of the service primitive

The parameters of the WME-Set.confirm primitive are as follows:

WME-Set.confirm(
Status,
MIBattribute
)

7.2.11.3 When generated

The WME-Set.confirm primitive is used to confirm the result of the WME-Set.request.

7.2.11.4 Effect of receipt

If *Status* equals Success, this confirms that the indicated MIB attribute was set to the requested value; otherwise, it returns an error condition in *Status* field. If this *MIBattribute* implies a specific action, then this confirms that the action was performed. Possible error *Status* values include “invalid MIB attribute” and “attempt to set read-only MIB attribute”.

7.2.12 WME-RCPIREQUEST.request

7.2.12.1 Function

The WME-RCPIREQUEST.request primitive indicates that an RCPI request frame should be generated by the device.

7.2.12.2 Semantics of the service primitive

The parameters of the WME-RCPIREQUEST.request primitive are as follows:

WME-RCPIREQUEST.request(
Peer MAC Address,

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Measurement Request
)

7.2.12.3 When generated

The WME-RCPIREQUEST.request primitive is passed to the WME from a higher layer, when signal strength information is desired from a remote device.

7.2.12.4 Effect of receipt

On receipt, the WME generates an associated MLME-MREQUEST.request to MLME.

7.2.13 WME-RCPIREQUEST.indication

7.2.13.1 Function

The WME-RCPIREQUEST.indication primitive indicates that a RCPI report frame has been received by the device.

7.2.13.2 Semantics of the service primitive

The parameters of the WME-RCPIREQUEST.indication primitive are as follows:

WME-RCPIREQUEST.indication(
Peer MAC Address,
Dialog Token,
Measurement Report Set
)

7.2.13.3 When generated

The WME-RCPIREQUEST.indication primitive is passed from WME to a higher layer upon receipt of an MLME-MREPORT.indication from MLME.

7.2.13.4 Effect of receipt

The requesting application may take action based on the returned information.

7.3 LSAP

LLC primitives, identified by the “DL-UNITDATA” prefix, pass data packets into and out of the LLC layer, and are specified in IEEE Std 802.2.

7.4 MLME SAP

The MLME primitives allow communication between the WME and the MAC layer management entity as specified in the documents referenced in Table 5. The *Secured WSA* used in certain MLME primitives is specified in IEEE Std 1609.2 and Clause 8.

7.5 SAP parameter definitions and frame formats

This subclause provides definitions of the parameters used within networking services exchanges. Subclause 7.5.1 describes the parameters used within the primitives of 7.1 and 7.2. Subclause 8.1 specifies the format

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of the *WAVE Service Advertisement* sent over the air; 8.2 specifies the format of the WAVE Short Message sent over the air.

7.5.1 SAP parameter definitions

Parameters used in networking services WSMP SAP and WME SAP primitives are described in Table 7. Internal representation of parameters is an implementation choice.

Table 7—Parameters used in WME primitives

Name	Type	Valid range	Description
Adaptable	Boolean	0: FALSE 1: TRUE	Indicates whether *DataRate* is interpreted as the minimum rate allowed and, *TxPwr_Level* as the maximum level allowed. If FALSE, parameters are not adaptable.
ApplicationPriority	INTEGER	0.63	63 is the highest value; 0 the lowest.
BSSBasicRateSet	Per IEEE Std 802.11		The minimum set of data rates that may be used on the WBSS.
Certificate	Per IEEE Std 1609.4		A data item used in security processing.
Channel contents	Bit String		Binary flags indicating the presence of individual parameters. 0x0001: *ChannelNumber* 0x0002: *Adaptable* 0x0004: *DataRate* 0x0008: *TxPwr_Level*
ChannelInfo	SEQUENCE		SEQUENCE OF *CitEntry*
ChannelNumber	Per IEEE P802.11p		Used to identify the radio channel of a WBSS.
ChannelSelection	Enumeration	0..255	Used to identify the radio channel, or to allow WAVE to select the best channel. 255 indicates Best-available-channel; otherwise *ChannelNumber* per IEEE P802.11p.
CitEntry	Sequence		*Length*, Channel contents, *ChannelNumber*, *Adaptable*, *DataRate*, *TxPwr_Level*
ConfirmBeforeJoin	Boolean	0: FALSE 1: TRUE	If FALSE, automatically join WBSS on service match. If TRUE, application confirmation required before joining WBSS.

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Table 7—Parameters used in WME primitives (continued)

Name	Type	Valid range	Description
Count	Integer	0..255	Number of table entries following.
Data	Octet String	variable	Application-provided data.
DataRate	Enumeration	1=3 Mbps, 2=4.5 Mbps, 3=6 Mbps, 4=9 Mbps, 5=12 Mbps, 6=18 Mbps, 7=24 Mbps, 8=27 Mbps, 9=36 Mbps, 10=48 Mbps, 11=54 Mbps	Channel data rate.
DefaultGateway	*IPv6Address*		Used in IP configuration.
EDCA Parameter Set	Per IEEE Std 802.11e		Channel access priority parameters.
Event	Enumeration	WBSSTerminated, WBSSActive	Type of event being reported.
GatewayMacAddress	Same as *Peer MAC address* in IEEE P802.11p		Layer 2 address of the *DefaultGateway*.
IpPrefix	Per RFC 3513		Used in IP configuration.
IPv6Address	Per RFC 3513		IP address of the provider application's host.
Length	Integer	Usage/content dependant	Number of octets in the following data.
LinkConfirm	Boolean	0: FALSE 1: TRUE	FALSE indicates the WBSS should be ignored. TRUE indicates the WBSS should be joined.
Local time	Per IEEE Std 802.11		The time at which the start of the announcement was received.
Measurement Report Set	Per IEEE Std 802.11h		Measurement information from a remote device.
Measurement Request	Per IEEE Std 802.11h		A request for measurement info from a remote device.
MIBattribute	Per IEEE Std 802.11		Identifier of an object in the MIB.
MIBattributevalue	Per IEEE Std 802.11		Contents of an object in the MIB.

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Table 7—Parameters used in WME primitives (continued)

Name	Type	Valid range	Description
NotificationIPv6Address	*IPv6Address*		Address where application notifications will be delivered.
NotificationPort	Integer	0..65535	UDP port where application notifications will be delivered.
OperationalRateSet	Per IEEE Std 802.11		The desired set of data rates to be used on the WBSS; a superset of BSSBasicRateSet.
Peer MAC address	Per IEEE P802.11p		Link layer address of a device.
Persistence	Per IEEE Std 1609.4		Used by the MAC in generating announcements. Indicates a persistent link, which is announced periodically.
PrimaryDns	*IPv6Address*		Used in IP configuration
ProviderDeviceAddressing	Boolean		Used in determining the MAC layer addressing methodology. 0: Provider device is same as announcement device 1: Provider device is not the same as announcement device
ProviderContents	Bit String		Binary flags indicating the presence of individual parameters. 0x0001: *ProviderServiceIdentifier* 0x0002: ApplicationPriority 0x0004: *ChannelSelection* 0x0008: *IPv6Address* 0x0010: *ServicePort* 0x0020:*ProviderDeviceAddressing* 0x0040: Peer MAC Address
ProviderServiceContext	Sequence		*Length,* *PSC Contents*

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Table 7—Parameters used in WME primitives (continued)

Name	Type	Valid range	Description
ProviderService-Identifier	Enumeration	0x0000 0001 through 0x7FFF FFFF	Defines an application. 0: system 1: automatic-fee-collection 2: freight-fleet-management 3: public-transport 4: traffic-traveler-information 5: traffic-control 6: parking-management 7: geographic-road-database 8: medium-range-preinformation 9: man-machine-interface 10: intersystem-interface 11: automatic-vehicle-identification 12: emergency-warning 13: private 14: multi-purpose-payment 15: dsrc-resource-manager 16: after-theft-systems 17: cruise-assist- highway-system 18: multi-purpose-information system 19: public-safety 20: vehicle-safety 21: general-purpose-internet-access 22: onboard diagnostics 23: security manager 24: signed *WSA* 25:ACI other values: Reserved NOTE—The values shown here were assigned at the time of original publication. The list will be maintained by the IEEE RAC outside this standard in the future. See http://standards.ieee.org/regauth/rac.html for latest assigned values and forms for requesting new values.
ProviderServiceInfo	SEQUENCE		SEQUENCE OF *PstEntry*
ProviderService-Table	Sequence		Count, *ProviderServiceInfo*, Count, SEQUENCE OF *ChannelInfo*
PSC Contents	Octet String	0 to 31 octets	Used in conjunction with PSID; provides supplementary information related to the service.
PstEntry	Sequence		*Length*, *ProviderContents*, *ProviderServiceIdentifier*, ApplicationPriority, *ChannelSelection*, *IPv6Address* OPTIONAL *ServicePort* OPTIONAL, *ProviderDeviceAddressing* OPTIONAL, Peer MAC Address OPTIONAL

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Table 7—Parameters used in WME primitives (continued)

Name	Type	Valid range	Description
Reason	Enumeration	Unspecified, ApplicationRequested, ChannelInactivity, ApplicationComplete, PriorityPreemption, SecurityCredentialFailure	Provides additional information about the event being reported. See 7.2.5.2.
RegistrationAction	Enumeration	Add provider, Add user, Remove provider, Remove user	Indicates the type of application, and whether it is to be added to or removed from the stored service information.
Repeats	Per IEEE Std 1609.4		Used by the MAC in generating announcements.
RequestType	Enumeration	Active, Inactive, Unavailable, UpdatePSC	Indicates whether the application wishes to start, end, or not be notified of, a WBSS, or to change its announced PSC.
ResultCode	Enumeration	Success, Unspecified Failure, Invalid Parameters, PSID conflict, Insufficient Priority	Indicates the result of a request primitive. Success: Request completed Unspecified Failure: Failure not describe by a more specific result code Invalid parameters: Parameter value out of range, or other syntax error PSID conflict: Can not register application because of a conflicting entry in the service table Insufficient Priority: WBSS not initiated due to an active WBSS with higher priority.
RouterLifetime	Per RFC 2461		Used in IP configuration.
SecondaryDns	*IPv6Address*		Used in IP configuration.
Secured WSA	Per IEEE Std 1609.2		*WSA* plus security header and trailer.
SecurityType	Enumeration	Unsecured, Signed, Encrypted	Describes the WSM contents.
SeparateGateway-Mac	Boolean	TRUE, FALSE	When true, indicates the gateway WAVE device is different from the announcing WAVE device. (0:TRUE, 1:FALSE)
ServicePort	Integer	0..65535	Higher-layer protocol interface; used in addressing an IP-based application.
Status	Per IEEE Std 802.11		Indicates the result of the get/set operation.

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Table 7—Parameters used in WME primitives (continued)

Name	Type	Valid range	Description
Transmission Priority	Integer	0..7	The priority of the associated user data, per IEEE Std 1609.4.
TxPwr_Level	Per IEEE P802.11p		Radio transmit control.
UserServiceInfo	SEQUENCE		SEQUENCE OF *UstEntry*
UstEntry	Sequence		*ProviderServiceIdentifier*, *ConfirmBeforeJoin*
WaveRoutingAdvertisement	Sequence		*WRA contents*, *RouterLifetime*, *IpPrefix*, Prefix-Length, *DefaultGateway*, *GatewayMacAddress*, *SeparateGatewayMac*, *PrimaryDns*, *SecondaryDns* OPTIONAL
WaveServiceAdvertisement[a]	Sequence		*Length*, *WaveVersion*, *ProviderServiceTable*, *Length*, *WaveRoutingAdvertisement* OPTIONAL
WaveVersion	Integer	0: Implementation conformant to this standard	Indicates the system version implemented.
WRA contents	Bit String		Binary flags indicating the presence of individual parameters. 0x0001: *RouterLifetime* 0x0002: *IpPrefix* 0x0004: Prefix-*Length* 0x0008: *DefaultGateway* 0x0010: *GatewayMacAddress* 0x0020: *SeparateGatewayMac* 0x0040: *PrimaryDns* 0x0080: *SecondaryDns*
WSMVersion	Integer	0: Implementation conformant to this standard	Indicates the WSM protocol version implemented.

[a]*WaveServiceAdvertisement* and its components are used to compose the MLME-WSA.request, and are illustrated in Figure 12.

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8. Over-the-air frame formats

This clause provides definitions of the formats of over the air frames originating within networking services exchanges. Subclause 8.1 specifies the format of the *WAVE Service Advertisement* sent over the air; 8.2 specifies the format of the WAVE Short Message sent over the air.

Over the air frame formats shall adhere to the following conventions, compatible with those employed by IEEE Std 802.11 and IEEE P802.11p.

The frames are described as a sequence of fields in specific order. Figure 17 depicts the fields/subfields as they appear in the MAC frame and in the order in which they are passed to the physical layer convergence procedure (PLCP), from left to right.

Bits within fields are numbered, from 0 to k, where the length of the field is $k + 1$ bit. The octet boundaries within a field can be obtained by taking the bit numbers of the field modulo 8. Octets within numeric fields that are longer than a single octet are depicted in increasing order of significance, from lowest numbered bit to highest numbered bit. The octets in fields longer than a single octet are sent to the PLCP in order from the octet containing the lowest numbered bits to the octet containing the highest numbered bits.

Any field containing a CRC is an exception to this convention and is transmitted commencing with the coefficient of the highest-order term.

MAC addresses are assigned as ordered sequences of bits. The Individual/Group bit is always transferred first and is bit 0 of the first octet.

Values specified in decimal are coded in natural binary unless otherwise stated.

Reserved fields and subfields are set to 0 upon transmission and are ignored upon reception.

8.1 WAVE Service Advertisement (WSA) format

WSA information passed over the air shall be formatted as illustrated in Figure 17, and described in 8.1.1 through 8.1.4. The Secured *WSA* referenced in IEEE Std 1609.4 consists of the *WaveServiceAdvertisement,* plus security header and trailer as specified in IEEE Std 1609.2.

Control fields are shown shaded. Parameter lengths shown in the illustrations are in bits. Field ordering shall not be changed. “Contents” fields are bit maps indicating which fields are present. This allows optional fields to be left out, and also allows new fields to be added in future versions of the standard.

“Length” fields are always present and indicate the length in octets of the related data, excluding the “length” field itself. Unless otherwise specified, length may equal zero. If the data associated with a “length” does not end on an octet boundary, trailing fill bits shall be added. “Count” fields indicate the number of instances of provider or channel information.

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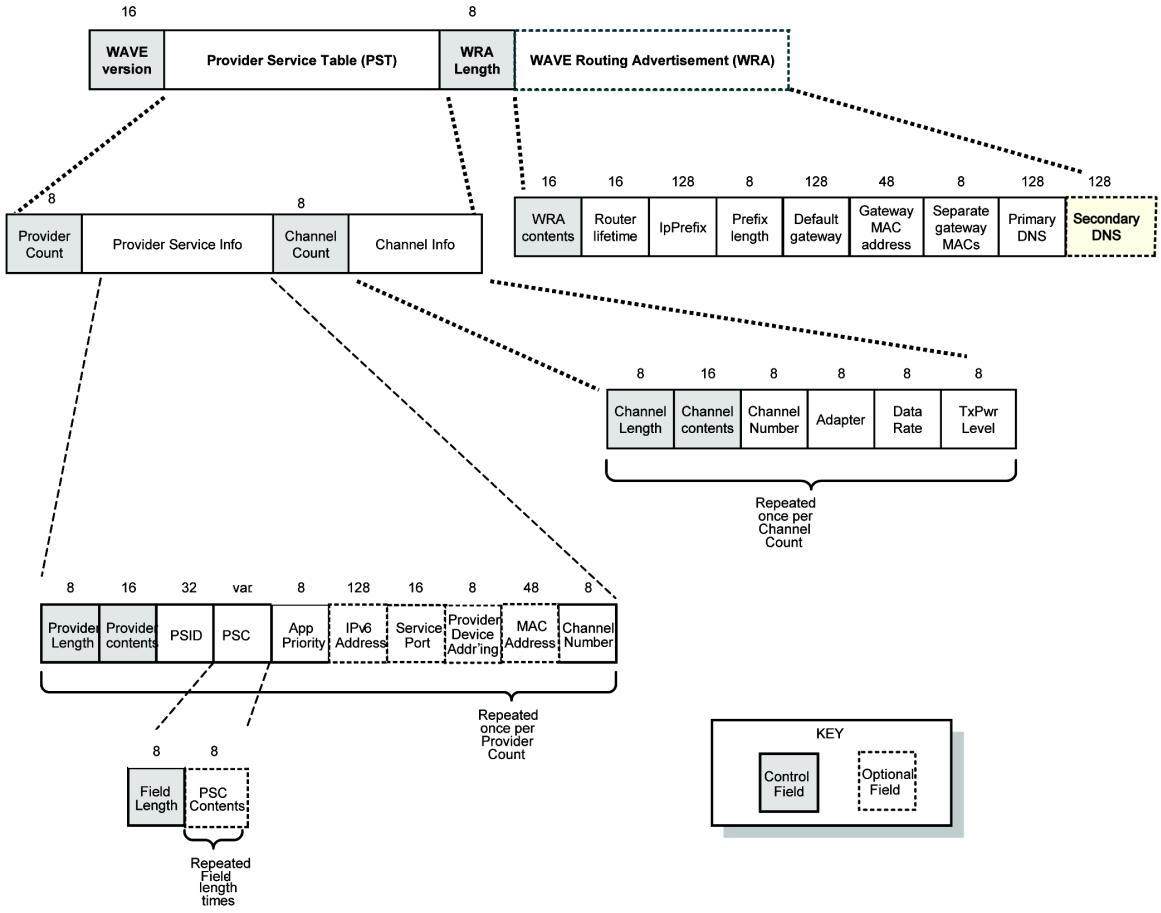

Figure 17—*WaveServiceAdvertisement* format

8.1.1 WAVE Version

For this standard, the value of the *WAVE Version* is 0. All other values are reserved. The revision level will be incremented only when a fundamental incompatibility exists between a new revision and the prior edition of the standard. A device that receives a frame with a higher revision level than it supports will discard the frame.

8.1.2 Provider Service Table

As depicted in Table 7, the PST consists of an 8-bit *Provider Count*, a variable length *ProviderServiceInfo*, an 8-bit *Channel Count*, and a variable length *ChannelInfo*.

Provider Count is 8 bits and indicates the number of instances of *PstEntry* found within the *ProviderServiceInfo* and has a range of 1 to 32.

PstEntry is specified in 8.1.2.1.

Channel Count is 8 bits and indicates the number of instances of *CitEntry* found within the *ChannelInfo* and has a range of 1 to 32.

CitEntry is specified in 8.1.2.3.

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8.1.2.1 PstEntry

There may be multiple instances of *PstEntry* in the *WSA*, as indicated by *Provider Count*. Each provides a definition of one provider service and contains the fields listed in 8.1.2.1.1 through 8.1.2.1.5.

8.1.2.1.1 Provider Length

Provider Length is 8 bits with a range of 9 to 64 and indicates the length in octets of this instance of *PstEntry* (excluding Provider Length itself).

8.1.2.1.2 Provider Contents

Provider Contents is a bit string, where the value of each bit indicates the presence or absence of a specific optional field in this instance of *PstEntry* as specified below. A bit value of 0 indicates the field is not present; a bit value of 1 indicates the field is present.

B0	**B 15**
Provider Contents	

BIT	Optional Field
B0–B8	Reserved
B9	Peer MAC Address
B10	ProvideDeviceAddressing
B11	ServicePort
B12	IPv6Address
B13	ChannelSelection
B14	Application Priority
B15	ProviderServiceIdentifier

8.1.2.1.3 Provider Service Identifier

Provider Service Identifier identifies the provider application offering service. *Provider Service Identifier* takes values from 0x0000 0001 through 0x7FFF FFFF.

8.1.2.1.4 Provider Service Context

Provider Service Context consists of an 8-bit *PSC Field Length* followed by a variable length *PSC Contents*.

PSC Field Length indicates the length in octets of the following *PSC Contents* field. *PSC Field Length* takes values from 0 through 31.

PSC Contents provides supplementary information related to the service with which it is associated. *PSC Contents* is an octet string of length 0 through 31, as indicated by *PSC Field Length*.

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8.1.2.1.5 Application Priority

Application Priority is an 8-bit field ranging in value from 0 to 63, where 0 is the lowest value and 63 is the highest value. It indicates the priority of the provider application, and is used by networking services in prioritizing communications.

8.1.2.2 IPv6 Address (optional)

IPv6 Address is the 128-bit IPv6 address of the device hosting the provider application and is formatted per RFC 3513. This is present when the provider service employs IP addressing.

8.1.2.2.1 Service Port (optional)

Service Port is the 16-bit port number of the provider application, and takes values from 0 to 65 535. Present when the provider service employs IP addressing.

8.1.2.2.2 Provider Device Addressing (optional)

Provider Device Addressing is 8 bits in length, is coded as in Table 8, and indicates whether the device transmitting the *WSA* is also the device hosting the provider application. Present when the provider service employs IP addressing.

Table 8—Provider Device Addressing parameter coding

Value	Meaning
0	Provider device is same as announcement device
1	Provider device is not the same as announcement device

8.1.2.2.3 MAC Address (optional)

MAC Address is the 48-bit MAC address of the device hosting the provider application. This is present if different from the MAC address of the device transmitting the *WSA*.

8.1.2.2.4 ChannelNumber

ChannelNumber indicates the *ServiceChannelNumber* of the WBSS on which the service is being provided. The same *ChannelNumber* shall also appear in exactly one *CitEntry*. It is 8 bits in length and coded as specified in IEEE P802.11p.

8.1.2.3 CitEntry

There may be multiple instances of *CitEntry* in the *WSA*, as indicated by *Channel Count*. Each indicates the characteristics of one channel associated with one or more *PstEntry* and contains the fields listed in 8.1.2.3.1 through 8.1.2.3.6.

8.1.2.3.1 Channel Length

Channel Length is 8 bits with a range of 6–255, and indicates the length in octets of this instance of *CitEntry* (excluding *Channel Length* itself). Note that in this version of the standard there are no optional *CitEntry* fields, so *Channel Length* will be set to 6.

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8.1.2.3.2 Channel Contents

Channel Contents is a bit string, where the value of each bit indicates the presence or absence of a specific optional field in this instance of *CitEntry*. A bit value of 0 indicates the field is not present; a bit value of 1 indicates the field is present. Note that in this version of the standard there are no optional *CitEntry* fields, so all bits are currently reserved.

8.1.2.3.3 ChannelNumber

ChannelNumber indicates the *ServiceChannelNumber* of the WBSS on which the service is being provided. The same *ChannelNumber* shall not appear in two instances of *CitEntry* in the same *WSA*. It is 8 bits in length and coded as specified in IEEE P802.11p.

8.1.2.3.4 Adaptable

Adaptable is 8 bits long and indicates whether *Data Rate* and *TxPwr_Level* are boundary values or fixed values. A value of 1 indicates *Data Rate* is interpreted as the minimum rate allowed and *TxPwr_Level* as the maximum level allowed. A value 0 indicates that *Data Rate* and *TxPwr_Level* are interpreted as fixed values.

8.1.2.3.5 Data Rate

Data Rate indicates the data rate used on the channel. It is coded as specified in IEEE P802.11p. If *Adaptable* is set, *Data Rate* is interpreted as the minimum rate allowed and any higher rate is also allowed.

8.1.2.3.6 TxPwr_Level

TxPwr_Level indicates the transmit power used on the channel. It is coded as specified in IEEE P802.11p. If *Adaptable* is set, *TxPwr_Level* is interpreted as the maximum power allowed, and any lower power is also allowed.

8.1.3 WRA Length

WRA Length is 8 bits with a range of 0–255, and indicates the length in octets of *WAVE Routing Advertisement*.

8.1.4 WAVE Routing Advertisement (optional)

WAVE Routing Advertisement provides information about infrastructure internetwork connectivity, allowing receiving devices to be configured to participate on the advertised IPv6 network. As depicted in Figure 17, the *WAVE Routing Advertisement* contains the fields specified in 8.1.4.1 through 8.1.4.8. If the *WAVE Routing Advertisement* is present, all fields are mandatory unless otherwise indicated.

8.1.4.1 Router Lifetime

Router Lifetime is 16 bits and indicates the duration for which the *Default Gateway* and associated information is valid. It is coded and interpreted as specified in RFC 2461.

8.1.4.2 IpPrefix

IpPrefix is 128 bits and indicates the IPv6 subnet prefix of the link, as described in RFC 3513.

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8.1.4.3 Prefix Length

Prefix Length is 8 bits and indicates how many of the higher-order bits of *IpPrefix* are significant, as described in RFC 3513.

8.1.4.4 Default Gateway

Default Gateway is the 128-bit IPv6 address of a router that provides internetwork connectivity to the subnet.

8.1.4.5 Gateway MAC Address

Gateway MAC Address is the 48-bit MAC address associated with the *Default Gateway*.

8.1.4.6 Separate Gateway MACs

Separate Gateway MAC is 8 bits in length, is coded as in Table 9, and indicates whether the device transmitting the *WSA* is also the device acting as default gateway.

Table 9—Separate Gateway MACs parameter coding

Value	Meaning
0	Default gateway device is not the announcement device
1	Provider device is also the announcement device

8.1.4.7 Primary DNS

Primary DNS is the 128-bit IPv6 address of a device that can provide DNS lookup for the subnet devices.

8.1.4.8 Secondary DNS (optional)

Secondary DNS is the 128-bit IPv6 address of an alternate device that can provide DNS lookup for the subnet devices.

8.2 WSM format

WSM information passed over the air shall be formatted as illustrated in Table 10 and described in 8.2.1 through 8.2.8. Lengths are in octets.

Table 10—WSM format

1	1	1	1	1	4	2	Variable
WSM Version	Security Type	Channel Number	Data Rate	TxPwr_ Level	Provider Service Identifier	WSM Length	WSM Data

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8.2.1 WSM Version

For this standard, the value of the *WSM Version* is 0. All other values are reserved. The revision level will be incremented only when a fundamental incompatibility exists between a new revision and the prior edition of the standard. A device that receives a frame with a higher revision level than it supports will discard the frame.

8.2.2 Security Type

Security Type indicates the security processing of the WSM Data. It is set as specified in Table 11.

Table 11—Security Type parameter coding

Value	Meaning
0	Unsecured
1	Signed
2	Encrypted

8.2.3 ChannelNumber

ChannelNumber is used to identify the radio channel used for the WSM. It is coded as specified in IEEE P802.11p.

8.2.4 Data Rate

Data Rate indicates the data rate used for the WSM. It is coded as specified in IEEE P802.11p.

8.2.5 TxPwr_Level

TxPwr_Level indicates the transmit power used for the WSM. It is coded as specified in IEEE P802.11p.

8.2.6 Provider Service Identifier

Provider Service Identifier identifies the application that originated the WSM. *Provider Service Identifier* takes values from 0x0000 0001 through 0x7FFF FFFF.

8.2.7 WSM Length

WSM Length indicates the length in octets of the following *WSM Data* field. *WSM Length* takes values from 1 through *WsmMaxLength*.

8.2.8 WSM Data

WSM Data contains the application data being transferred. *WSM Data* is an octet string of length 1 through *WsmMaxLength*.

8.3 WSM encoding

The WSM encoding conventions are the same as those used for the *WSA*, specified in 8.1.

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Annex A

(normative)

WME MIB table

The contents of the WME MIB are illustrated in Table A.1. Table A.1 uses the names of the parameters used throughout the body of this standard; the ASN.1 definitions of these names are in Annex B.

Table A.1—WME MIB contents

MIB item	Table entry	Contents
WaveRoutingAdvertisement		*RouterLifetime*, *IpPrefix*, Prefix-*Length*, *DefaultGateway*, *GatewayMacAddress*, *SeparateGatewayMac*, *PrimaryDns*, *SecondaryDns*
AddressInfo	SEQUENCE OF AddressEntry	MAC Address
LocalInfo		SSID, *OperationalRateSet*, NumberOfChannelsSupported, RegistrationPort, WSMForwarderPort, WsmMaxLength
ProviderServiceInfo	SEQUENCE OF *PstEntry*	*ProviderServiceIdentifier*, Application Priority, IPv6 Address, *ServicePort*, *ProviderDeviceAddressing*, MAC Address, *ChannelSelection*

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Table A.1—WME MIB contents (continued)

UserServiceInfo	SEQUENCE OF *UstEntry*	*ProviderServiceIdentifier*, *IPv6Address*, *ServicePort*, *ConfirmBeforeJoin*,
ChannelInfo	SEQUENCE OF *CitEntry*	*ChannelNumber*, *Adaptable*, *DataRate*, *TxPwr_Level*
ApplicationStatusTable	SEQUENCE OF AstEntry	*ProviderServiceIdentifier*, *ProviderServiceContext*, ApplicationType, ApplicationStatus, ApplicationPriority, *NotificationIPv6Address* *NotificationPort*

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Annex B

(normative)

ASN.1 encoding of the WME MIB

```
-- ************************************************************************
-- * IEEE P1609 Management Information Base
-- ************************************************************************
IEEE1609dot3-MIB DEFINITIONS ::= BEGIN
IMPORTS
 MODULE-IDENTITY, OBJECT-TYPE, Integer32, Unsigned32 FROM SNMPv2-SMI
 MacAddress, TruthValue, TimeStamp FROM SNMPv2-TC
 MODULE-COMPLIANCE, OBJECT-GROUP FROM SNMPv2-CONF
 ifIndex FROM RFC1213-MIB
 Ipv6Address, Ipv6AddressPrefix FROM IPV6-TC;

-- ************************************************************************
-- * MODULE IDENTITY
-- ************************************************************************
ieee1609dot3v1mib MODULE-IDENTITY
LAST-UPDATED "200610170000Z"
ORGANIZATION "IEEE P1609"
CONTACT-INFO
"WG E-mail: stds-p1609@ieee.org
Chair: Tom Kurihara
Postal: 3800 N. Fairfax Drive, #207
Arlington, VA USA 22203-1759
Tel: +1 703-516-9650
Fax: +1 703-516-4688
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Fax: +1 413 527 9146
E-mail: LRA@tiac.net"
DESCRIPTION
"The MIB module for IEEE P1609.3 entities.
iso(1) iso-identified-organization(3) ieee(111)
```

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```
standards-association-numbered-series-standards(2) wave-stds(1609) dot3(3)
v1mib(1)"
REVISION "200610170000Z"
DESCRIPTION
"Consistent with the forthcoming 1609.3 D21."
::= { ieeeP1609 3 1}
ieeeP1609 OBJECT IDENTIFIER ::=
{1 iso-identified-organization (3) ieee (111)
standards-association-numbered-series-standards (2) wave-stds (1609)}

-- ********************************************************************
-- This MIB includes system related info, as well as application-related info.
-- System related info:
--    Network Information (Routing Advertisement)
--    Address Information (local MAC addresses)
--    Local Information (e.g., default local parameters)
-- Application related info:
--    Provider Services  (registered application info)
--    User Services  (registered application info)
--    Channel Information (parameters about the usable radio channels)
--    Application Status Table (dynamic indication of each registered application's status)
dot3systemMib OBJECT IDENTIFIER ::= { ieee1609dot3v1mib 1 }
dot3applicationMib OBJECT IDENTIFIER ::= { ieee1609dot3v1mib 2 }

-- ********************************************************************
-- * WAVE Network Information (Routing Advertisement)
-- ********************************************************************
-- WAVE Network Information
dot3NetworkInfo OBJECT IDENTIFIER ::= { dot3systemMib 1}
-- DEFINED AS "Parameters controlling operation in the WAVE IP network";

dot3routerLifetime OBJECT-TYPE
      SYNTAX  INTEGER (0..65535)
      UNITS "seconds"
      MAX-ACCESS read-write
      STATUS current
      DESCRIPTION
      "Duration for which the IP information is valid, per RFC 2461."
::= { dot3NetworkInfo 1 }
```


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```
dot3ipPrefix OBJECT-TYPE
      SYNTAX  Ipv6AddressPrefix
      MAX-ACCESS read-write
      STATUS current
      DESCRIPTION
      "Most significant portion of the IP address."
::= { dot3NetworkInfo 2 }

dot3ipPrefixLength OBJECT-TYPE
      SYNTAX  INTEGER (1..128)
      MAX-ACCESS read-write
      STATUS current
      DESCRIPTION
      "Number of significant bits in the IP refix."
::= { dot3NetworkInfo 3 }

dot3defaultGateway OBJECT-TYPE
      SYNTAX  Ipv6Address
      MAX-ACCESS read-write
      STATUS current
      DESCRIPTION
      "IPv6 address of the default gateway."
::= { dot3NetworkInfo 4 }

dot3gatewayMacAddress OBJECT-TYPE
      SYNTAX  MacAddress
      MAX-ACCESS read-write
      STATUS current
      DESCRIPTION
      "MAC address of the default gateway."
::= { dot3NetworkInfo 5 }

dot3separateGatewayMac OBJECT-TYPE
      SYNTAX  TruthValue
      MAX-ACCESS read-write
      STATUS current
      DESCRIPTION
      "When true, indicates the gateway WAVE device is different
      from the announcing WAVE device."
::= { dot3NetworkInfo 6 }
```

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```
dot3primaryDns OBJECT-TYPE
      SYNTAX  Ipv6Address
      MAX-ACCESS read-write
      STATUS current
      DESCRIPTION
      "Address of the primary DNS server."
::= { dot3NetworkInfo 7 }

dot3secondaryDns OBJECT-TYPE
      SYNTAX  Ipv6Address
      MAX-ACCESS read-write
      STATUS current
      DESCRIPTION
      "Address of the secondary DNS server."
::= { dot3NetworkInfo 8 }


-- ************************************************************************
-- * End of WAVE Network Information
-- ************************************************************************
-- ************************************************************************
-- ************************************************************************
-- * WAVE Address Information
-- ************************************************************************

dot3AddressInfo OBJECT-TYPE
      SYNTAX SEQUENCE OF Dot3AddressEntry
      MAX-ACCESS not-accessible
      STATUS current
      DESCRIPTION
      "Interface address attributes."
::= { dot3systemMib 2}

dot3AddressEntry OBJECT-TYPE
      SYNTAX Dot3AddressEntry
      MAX-ACCESS not-accessible
      STATUS current
      DESCRIPTION
      "The addresses associated with an interface."
```

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```
      INDEX {dot3AiIndex}
::= { dot3AddressInfo 1}

Dot3AddressEntry ::= SEQUENCE {
      dot3AiIndex INTEGER,
      macAddress MacAddress}

dot3AiIndex OBJECT-TYPE
      SYNTAX  INTEGER (0..127)
      MAX-ACCESS not-accessible
      STATUS current
      DESCRIPTION
      "Table index."
::= { dot3AddressEntry 1 }

macAddress OBJECT-TYPE
      SYNTAX  MacAddress
      MAX-ACCESS read-only
      STATUS current
      DESCRIPTION
      "MAC address."
::= { dot3AddressEntry 2 }

-- ************************************************************************
-- * End of WAVE Address Information
-- ************************************************************************
-- ************************************************************************
-- * WAVE Local Information
-- ************************************************************************
-- WAVE Local Information
dot3LocalInfo OBJECT IDENTIFIER ::= { dot3systemMib 3}
-- DEFINED AS "Parameters controlling operation in the WAVE RF network";

dot3Ssid OBJECT-TYPE
      SYNTAX  OCTET STRING
      MAX-ACCESS read-write
      STATUS current
      DESCRIPTION
      "Default identifier of a WBSS announced by the device"
::= { dot3LocalInfo 1 }
```

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```
dot3OperationalRateSet OBJECT-TYPE
      SYNTAX  OCTET STRING (SIZE(1..126))
      MAX-ACCESS read-write
      STATUS current
      DESCRIPTION
      "This attribute specifies the set of data rates at which the station
      may transmit data, per 802.11."
::= { dot3LocalInfo 2 }

dot3NumberOfChannelsSupported OBJECT-TYPE
      SYNTAX  INTEGER (0..200)
      MAX-ACCESS read-write
      STATUS current
      DESCRIPTION
      "Number of simultaneous channels on which the device may operate."
::= { dot3LocalInfo 3 }

dot3RegistrationPort OBJECT-TYPE
      SYNTAX  INTEGER
      MAX-ACCESS read-write
      STATUS current
      DESCRIPTION
      "UDP port number used for registration of external applications."
::= { dot3LocalInfo 4 }

dot3WaveForwarderPort OBJECT-TYPE
      SYNTAX  INTEGER
      MAX-ACCESS read-write
      STATUS current
      DESCRIPTION
      "UDP port number used by the WSM forwarding function."
::= { dot3LocalInfo 5 }

dot3WsmMaxLength OBJECT-TYPE
      SYNTAX  INTEGER
      MAX-ACCESS read-write
      STATUS current
      DESCRIPTION
      "Maximum size in octets of the variable length portion of a WSM,
```

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```
      including Data.
      The default value is 1400."
::= { dot3LocalInfo 6 }

-- ************************************************************************
-- * End of WAVE Local Information
-- ************************************************************************

-- ************************************************************************
-- * WAVE Provider Service Info
-- ************************************************************************
dot3ProviderServiceInfo OBJECT-TYPE
      SYNTAX SEQUENCE OF Dot3PstEntry
      MAX-ACCESS not-accessible
      STATUS current
      DESCRIPTION
      "Provider Service Info."
::= { dot3applicationMib 1}

dot3PstEntry OBJECT-TYPE
      SYNTAX Dot3PstEntry
      MAX-ACCESS not-accessible
      STATUS current
      DESCRIPTION
      "Information registered by a provider application."
      INDEX {dot3PstIndex}
::= { dot3ProviderServiceInfo 1}

Dot3PstEntry ::= SEQUENCE {
      dot3PstIndex INTEGER,
      dot3PstProviderServiceIdentifier Unsigned32,
      dot3PstProviderServiceContext OCTET STRING,
      dot3PstApplicationPriority INTEGER,
        dot3PstIpv6Address Ipv6Address,
      dot3PstPort INTEGER,
      dot3PstProviderDeviceAddressing INTEGER,
      dot3PstMacAddress MacAddress,
      dot3PstChannelSelection INTEGER}

dot3PstIndex OBJECT-TYPE
```

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```
      SYNTAX  INTEGER (0..127)
      MAX-ACCESS not-accessible
      STATUS current
      DESCRIPTION
      "Table index."
::= { dot3PstEntry 1 }

dot3PstProviderServiceIdentifier OBJECT-TYPE
      SYNTAX  Unsigned32 (0..4294967295)
      MAX-ACCESS read-only
      STATUS current
      DESCRIPTION
      "PSID."
::= { dot3PstEntry 2 }

dot3PstProviderServiceContext OBJECT-TYPE
      SYNTAX  OCTET STRING (SIZE(0..31))
      MAX-ACCESS read-only
      STATUS current
      DESCRIPTION
      "PSC."
::= { dot3PstEntry 3 }

dot3PstApplicationPriority OBJECT-TYPE
      SYNTAX  INTEGER (0..63)
      MAX-ACCESS read-write
      STATUS current
      DESCRIPTION
      "Priority level associated with the application."
::= { dot3PstEntry 4 }

dot3PstIpv6Address OBJECT-TYPE
      SYNTAX  Ipv6Address
      MAX-ACCESS read-write
      STATUS current
      DESCRIPTION
      "IP address associated with the application service."
::= { dot3PstEntry 5 }

dot3PstPort OBJECT-TYPE
```

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```
      SYNTAX  INTEGER
      MAX-ACCESS read-write
      STATUS current
      DESCRIPTION
      "Application layer port number used by the transport layer,
      associated with the application service."
::= { dot3PstEntry 6 }

dot3PstProviderDeviceAddressing OBJECT-TYPE
      SYNTAX INTEGER
      { provider-device-is-the-same-as-announcement-device(1),
      provider-device-is-not-the-same-as-announcement-device(2) }
      MAX-ACCESS read-write
      STATUS current
      DESCRIPTION
      "Link layer address associated with the provided service."
::= { dot3PstEntry 7 }

dot3PstMacAddress OBJECT-TYPE
      SYNTAX MacAddress
      MAX-ACCESS read-write
      STATUS current
      DESCRIPTION
      "Link layer address associated with the provided service."
::= { dot3PstEntry 8 }

dot3PstChannelSelection OBJECT-TYPE
      SYNTAX INTEGER (0..255)
      MAX-ACCESS read-write
      STATUS current
      DESCRIPTION
      "An indication of the applications' desired channel of operation,
      per 802.11, or, with a value of 255, permission to use the
      'best available' channel."
::= { dot3PstEntry 9 }

-- ************************************************************************
-- * End of Provider Service Info
-- ************************************************************************
-- ************************************************************************
```

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```
-- * WAVE User Service Info
-- ************************************************************************
dot3UserServiceInfo OBJECT-TYPE
      SYNTAX SEQUENCE OF Dot3UstEntry
      MAX-ACCESS not-accessible
      STATUS current
      DESCRIPTION
      "User Service Info."
::= { dot3applicationMib 2}

dot3UstEntry OBJECT-TYPE
      SYNTAX Dot3UstEntry
      MAX-ACCESS not-accessible
      STATUS current
      DESCRIPTION
      "Information registered by a user application."
      INDEX {dot3UstIndex}
::= { dot3UserServiceInfo 1}

Dot3UstEntry ::= SEQUENCE {
      dot3UstIndex INTEGER,
      dot3UstProviderServiceIdentifier Unsigned32,
      dot3UstIpv6Address Ipv6Address,
      dot3UstPort INTEGER,
      dot3UstConfirmBeforeJoin TruthValue}

dot3UstIndex OBJECT-TYPE
      SYNTAX  INTEGER (0..127)
      MAX-ACCESS not-accessible
      STATUS current
      DESCRIPTION
      "Table index."
::= { dot3UstEntry 1 }

dot3UstProviderServiceIdentifier OBJECT-TYPE
      SYNTAX  Unsigned32 (0..4294967295)
      MAX-ACCESS read-only
      STATUS current
      DESCRIPTION
      "PSID."
```


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```
::= { dot3UstEntry 2 }

dot3UstIpv6Address OBJECT-TYPE
      SYNTAX  Ipv6Address
      MAX-ACCESS read-write
      STATUS current
      DESCRIPTION
      "IP address associated with the application service."
::= { dot3UstEntry 3 }

dot3UstPort OBJECT-TYPE
      SYNTAX  INTEGER
      MAX-ACCESS read-write
      STATUS current
      DESCRIPTION
      "Application layer port number used by the transport layer,
      associated with the application service."
::= { dot3UstEntry 4 }

dot3UstConfirmBeforeJoin OBJECT-TYPE
      SYNTAX TruthValue
      MAX-ACCESS read-write
      STATUS current
      DESCRIPTION
      "Defines whether the WME will confirm the service with this
      application before joining a WBSS."
::= { dot3UstEntry 5 }

-- ****************************************************************
-- * End of User Service Info
-- ****************************************************************
-- ****************************************************************
-- * WAVE Channel Info
-- ****************************************************************
dot3ChannelInfo OBJECT-TYPE
      SYNTAX SEQUENCE OF Dot3CitEntry
      MAX-ACCESS not-accessible
      STATUS current
      DESCRIPTION
      "Channel Info."
```

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```
::= { dot3applicationMib 3}

dot3CitEntry OBJECT-TYPE
      SYNTAX Dot3CitEntry
      MAX-ACCESS not-accessible
      STATUS current
      DESCRIPTION
      "Channel parameters."
      INDEX {dot3CitIndex}
::= { dot3ChannelInfo 1}

Dot3CitEntry ::= SEQUENCE {
      dot3CitIndex INTEGER,
      dot3CitChannelNumber INTEGER,
      dot3CitAdaptable TruthValue,
      dot3CitDataRate INTEGER,
      dot3CitTxPower INTEGER}

dot3CitIndex OBJECT-TYPE
      SYNTAX  INTEGER (0..127)
      MAX-ACCESS not-accessible
      STATUS current
      DESCRIPTION
      "Table index."
::= { dot3CitEntry 1 }

dot3CitChannelNumber OBJECT-TYPE
      SYNTAX INTEGER (0..200)
      MAX-ACCESS read-only
      STATUS current
      DESCRIPTION
      "Channel number associated with the application service."
::= { dot3CitEntry 2 }

dot3CitAdaptable OBJECT-TYPE
      SYNTAX  TruthValue
      MAX-ACCESS read-only
      STATUS current
      DESCRIPTION
      "Defines whether the power and data rate values should be treated
```


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```
      as adaptable."
::= { dot3CitEntry 3 }

dot3CitDataRate OBJECT-TYPE
      SYNTAX INTEGER (2..127)
      MAX-ACCESS read-only
      STATUS current
      DESCRIPTION
      "Data rate associated with the application service, per 802.11."
::= { dot3CitEntry 4 }

dot3CitTxPower OBJECT-TYPE
      SYNTAX INTEGER (0..64)
      MAX-ACCESS read-only
      STATUS current
      DESCRIPTION
      "Transmit power associated with the application service, per 802.11p."
::= { dot3CitEntry 5 }


-- ************************************************************************
-- * End of Channel Info
-- ************************************************************************
-- ************************************************************************
-- ************************************************************************
-- * WAVE Application Status Table
-- ************************************************************************
dot3ApplicationStatusTable OBJECT-TYPE
      SYNTAX SEQUENCE OF Dot3AstEntry
      MAX-ACCESS not-accessible
      STATUS current
      DESCRIPTION
      "Application Status Table."
::= { dot3applicationMib 4}

dot3AstEntry OBJECT-TYPE
      SYNTAX Dot3AstEntry
      MAX-ACCESS not-accessible
      STATUS current
      DESCRIPTION
```

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```
      "Status of an application."
      INDEX {dot3AstIndex}
::= { dot3ApplicationStatusTable 1}

Dot3AstEntry ::= SEQUENCE {
      dot3AstIndex INTEGER,
      dot3AstProviderServiceIdentifier Unsigned32,
      dot3AstProviderServiceContext OCTET STRING,
      dot3AstApplicationType INTEGER,
      dot3AstApplicationStatus INTEGER,
      dot3AstApplicationPriority INTEGER,
      dot3AstNotificationIpv6Address Ipv6Address,
      dot3AstNotificationPort INTEGER}

dot3AstIndex OBJECT-TYPE
      SYNTAX  INTEGER (0..127)
      MAX-ACCESS not-accessible
      STATUS current
      DESCRIPTION
      "Table index."
::= { dot3AstEntry 1 }

dot3AstProviderServiceIdentifier OBJECT-TYPE
      SYNTAX  Unsigned32 (0..4294967295)
      MAX-ACCESS read-only
      STATUS current
      DESCRIPTION
      "PSID."
::= { dot3AstEntry 2 }

dot3AstProviderServiceContext OBJECT-TYPE
      SYNTAX  OCTET STRING
      MAX-ACCESS read-only
      STATUS current
      DESCRIPTION
      "PSC."
::= { dot3AstEntry 3 }

dot3AstApplicationType OBJECT-TYPE
        SYNTAX  INTEGER {
```

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```
                provider(1),
                user(2)
                     }
      MAX-ACCESS read-only
      STATUS current
      DESCRIPTION
      "Application type."
::= { dot3AstEntry 4 }

dot3AstApplicationStatus OBJECT-TYPE
        SYNTAX  INTEGER {
                inactive(1),
                active(2),
                unavailable(3)
                     }
      MAX-ACCESS read-only
      STATUS current
      DESCRIPTION
      "Current status."
::= { dot3AstEntry 5 }

dot3AstApplicationPriority OBJECT-TYPE
      SYNTAX  INTEGER (0..63)
      MAX-ACCESS read-only
      STATUS current
      DESCRIPTION
      "Application priority."
::= { dot3AstEntry 6 }

dot3AstNotificationIpv6Address OBJECT-TYPE
      SYNTAX  Ipv6Address
      MAX-ACCESS read-write
      STATUS current
      DESCRIPTION
      "IP address associated with the application notification
      reception function."
::= { dot3AstEntry 7 }

dot3AstNotificationPort OBJECT-TYPE
      SYNTAX  INTEGER
```

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```
      MAX-ACCESS read-write
      STATUS current
      DESCRIPTION
      "Application layer port number used by the transport layer,
      associated with the application notification reception function."
::= { dot3AstEntry 8 }

-- ****************************************************************
-- * End of Application Status Table
-- ****************************************************************
-- ****************************************************************
-- * End of 1609.3 MIB
-- ****************************************************************
END
```


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Annex C

(informative)

Supplemental bibliography and definitions

C.1 Bibliography

[B1] IEEE Std 802.1D™, IEEE Standard for local and metropolitan area networks Medium Access Control (MAC) Bridges.

[B2] IEEE 100, *The Authoritative Dictionary of IEEE Standards Terms,* Seventh Edition.

[B3] IETF Request for Comments: RFC 1157, A Simple Network Management Protocol (SNMP).

[B4] IETF Request for Comments: RFC 2463, Internet Control Message Protocol (ICMPv6) for the Internet Protocol Version 6 (IPv6) Specification.

[B5] IETF Request for Comments: RFC 3315, Dynamic Host Configuration Protocol for IPv6 (DHCPv6).

[B6] ISO/IEC 8824-1, Information Processing Systems—Open Systems Interconnection—Specification of Abstract Syntax Notation One (ASN.1).[8]

[B7] ISO/IEC 8825-2, Information Processing Systems—Open Systems Interconnection—ASN.1 Encoding Rules: Specification of Packed Encoding Rules.

[B8] National ITS Architecture, available at: http://www.iteris.com/itsarch/.

C.2 Definitions

The following definitions are from *The Authoritative Dictionary of IEEE Standards Terms* [B6], provided here as an aid to the reader. Additional explanation is provided to tailor the definition slightly to this standard. Such additions are provided for explanatory purposes, not to alter the core definition from *The Authoritative Dictionary of IEEE Standards Terms* [B2].

C.2.1 Onboard equipment (OBE)

From *The Authoritative Dictionary of IEEE Standards Terms* [B2]:

onboard equipment (OBE) Equipment located within a vehicle that supports the information exchange with roadside equipment (RSE). (SCC32) 1455-1999

As applied to this standard:

This former terminology is what this standard now refers to as “onboard unit” (OBU), which is essentially the radio with the IEEE Std 802.11 and IEEE 1609 protocol stack. The change is intended to reflect that there is an evolving transition from totally self-contained OBUs (which when they were a totally self-contained system could properly be referred to as the onboard equipment), to an onboard system of which the OBU is but a part. There will be onboard

[8]ISO publications are available from the ISO Central Secretariat, Case Postale 56, 1 rue de Varembé, CH-1211, Genève 20, Switzerland/Suisse (http://www.iso.ch/). ISO publications are also available in the United States from the Sales Department, American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036, USA (http://www.ansi.org/).

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networks, computers, and other devices that need to identified as an entity of the total communications system and this overall set is now being referred to as the "onboard equipment," or OBE to distinguish it form the radio itself that is now the OBU.

C.2.2 Roadside equipment (RSE)

From *The Authoritative Dictionary of IEEE Standards Terms* [B2]:

roadside equipment (RSE) Equipment located at a fixed position along the road transport network, providing communication and data exchange with the onboard equipment (OBE). (SCC32) 1455-1999

As applied to this standard:

This former terminology is what this standard now refers to as "roadside unit" (RSU), which is essentially the radio with the IEEE 802.11 and IEEE 1609 protocol stack. The change is intended to reflect the need to change from OBE to OBU, maintaining this same ability to distinguish between the radio and the rest of the communication system that uses the radio.

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Annex D

(normative)

Protocol Implementation Conformance Statement (PICS) proforma[9]

D.1 General

The supplier of a protocol implementation that is claimed to conform to IEEE Std 1609.3 shall complete the following protocol implementation conformance statement (PICS) proforma.

A completed PICS proforma is the PICS for the implementation in question. The PICS is a statement of which capabilities and options of the protocol have been implemented. The PICS can have a number of uses, including use by the following:

a) Protocol implementer, as a checklist to reduce the risk of failure to conform to the standard through oversight.

b) Supplier and acquirer, or potential acquirer, of the implementation, as a detailed indication of the capabilities of the implementation, stated relative to the common basis for understanding provided by the standard PICS proforma.

c) User, or potential user, of the implementation, as a basis for initially checking the possibility of interworking with another implementation (note that, while interworking can never be guaranteed, failure to interwork can often be predicted from incompatible PICS proformas).

d) Protocol tester, as the basis for selecting appropriate tests against which to assess the claim for conformance of the implementation.

D.2 Abbreviations and special symbols

D.2.1 Symbols for status column

M	mandatory
O	optional
O.<n>	optional, but support of at least one of the group of options labeled by the same <n> is required
pred:<N>	conditional symbol, including predicate identification

D.3 Instructions for completing the PICS proforma

D.3.1 General structure of the PICS proforma

The first parts of the PICS proforma, implementation identification and protocol summary, are to be completed as indicated with the information necessary to identify fully both the supplier and the implementation.

[9] *Copyright release for PICS proformas:* Users of this standard may freely reproduce the PICS proforma in this annex so that it can be used for its intended purpose and may further publish the completed PICS.

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The main part of the PICS proforma is a fixed questionnaire, divided into subclauses, each containing a number of individual items. Answers to the questionnaire items are to be provided in the rightmost column, either by simply marking an answer to indicate a restricted choice (usually Yes or No) or by entering a value or a set or a range of values. (Note that there are some items where two or more choices from a set of possible answers may apply. All relevant choices are to be marked in these cases.)

Each item is identified by an item reference in the first column. The second column contains the question to be answered. The third column contains the reference or references to the material that specifies the item in the main body of this standard. The remaining columns record the status of each item, i.e., whether support is mandatory, optional, or conditional, and provide the space for the answers (see also A.3.4). Marking an item as supported is to be interpreted as a statement that all relevant requirements of the subclauses and normative annexes, cited in the References column for the item, are met by the implementation.

A supplier may also provide, or be required to provide, further information, categorized as either additional information or exception information. When present, each kind of further information is to be provided in a further subclause of items labeled A<I> or X<I>, respectively, for cross-referencing purposes, where <I> is any unambiguous identification for the item (e.g., simply a numeral). There are no other restrictions on its format or presentation.

The PICS proforma for an implementation consists of A.4.1 through A.4.5 corresponding to the network services implemented.

A completed PICS proforma, including any additional information and exception information, is the PICS for the implementation in question.

NOTE—Where an implementation is capable of being configured in more than one way, a single PICS may be able to describe all such configurations. However, the supplier has the choice of providing more than one PICS, each covering some subset of the implementation's capabilities, if this makes for easier and clearer presentation of the information.

D.3.2 Additional information

Items of *additional information* allow a supplier to provide further information intended to assist in the interpretation of the PICS. It is not intended or expected that a large quantity of information will be supplied, and a PICS can be considered complete without any such information. Examples of such additional information might be an outline of the ways in which an implementation can be set up to operate in a variety of environments and configurations, or information about aspects of the implementation that are outside the scope of this standard but have a bearing upon the answers to some items.

References to items of additional information may be entered next to any answer in the questionnaire and may be included in items of e*xception information*.

D.3.3 Exception information

It may happen occasionally that a supplier will wish to answer an item with mandatory status (after any conditions have been applied) in a way that conflicts with the indicated requirement. No preprinted answer will be found in the Support column for this. Instead, the supplier shall write the missing answer into the Support column, together with an X<I> reference to an item of exception information, and shall provide the appropriate rationale in the exception information item itself.

An implementation for which an exception information item is required in this way does not conform to this standard.

NOTE—A possible reason for the situation described above is that a defect in this standard has been reported, a correction for which is expected to change the requirement not met by the implementation.

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D.3.4 Conditional status

The PICS proforma contains a number of conditional items. These are items for which both the applicability of the item itself and its status if it does apply, mandatory or optional, are dependent upon whether or not certain other items are supported.

Where a group of items is subject to the same condition for applicability, a separate preliminary question about the condition appears at the head of the group, with an instruction to skip to a later point in the questionnaire if the N/A answer is selected. Otherwise, individual conditional items are indicated by a conditional symbol in the Status column.

A conditional symbol is of the form "<pred>:<N>", where "<pred>" is a predicate as described below, and "<N>" is one of the status symbols M or O.

If the value of the predicate is true, the conditional item is applicable, and its status is given by S: the support column is to be completed in the usual way. Otherwise, the conditional item is not relevant and the N/A answer is to be marked.

A predicate is one of the following:

a) An item-reference for an item in the PICS proforma—the value of the predicate is true if the item is marked as supported, and is false otherwise.

b) A Boolean expression constructed by combining item-references using the Boolean operator OR—the value of the predicate is true if one or more of the items is marked as supported, and is false otherwise.

Each item referenced in a predicate, or in a preliminary question for grouped conditional items, is indicated by an asterisk in the Item column.

D.4 PICS proforma—IEEE Std 1609.3

D.4.1 Implementation identification

Supplier	
Contact point for queries about the PICS	
Implementation Name(s) and Version(s)	
Other information necessary for full identification, e.g., name(s) and version(s) of the machines and/or operating system(s), system names	

NOTE 1—Only the first three items are required for all implementations. Other information may be completed as appropriate in meeting the requirement for full identification.

NOTE 2—The terms Name and Version should be interpreted appropriately to correspond with a supplier's terminology (e.g., Type, Series, Model).

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D.4.2 Protocol summary

Identification of protocol standard	IEEE Std 1609.3 Networking Services
Identification of amendments and corrigenda to this PICS proforma that have been completed as part of this PICS	
Have any exception items been required? (See A.3.3; the answer Yes means that the implementation does not conform to IEEE Std 1609.3)	
Date of statement (dd/mm/yy)	

D.4.3 Normative section

Item	Feature	Value	Reference	Status	Conformance
N1	Data plane services/protocols				
N1.1	Logical Link Control (LLC)	Per IEEE Std 802.2. Receives and sends traffic per RFC 1042 and IEEE Std 1609.4.	5.1	M	☐Yes ☐No
N1.2		IPv6 packets set to 0x86DD.	5.1	M	☐Yes ☐No
N1.3		WSM packets set to 0x88dc.	5.1	M	☐Yes ☐No
N1.4	Internet Protocol version 6 (IPv6)	Per RFC 2460	5.2	O	☐Yes ☐No
N1.5	User Datagram Protocol (UDP)	Per RFC 768	5.3	O	☐Yes ☐No
N1.6	Transmission Control (TCP)	Per RFC 793	5.4	O	☐Yes ☐No
N1.7	WAVE Short Message Protocol (WSMP)	Unicast	5.5	M	☐Yes ☐No
N1.8		Broadcast	5.5	M	☐Yes ☐No
N1.9		Forwarding Function	5.5	O	☐Yes ☐No
N1.10	WSMP	Data Length Verification sent to LCC	5.5	M	☐Yes ☐No
N1.11	WSMP	Send WSM receipt	5.5	M	☐Yes ☐No
N2	Management plane services				

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N2.1	Application registration	Register applications and populate MIB tables:	6.1	M	☐Yes ☐No
N2.1.1		*ProviderServiceInfo* (*PstEntry*)	6.1	M	☐Yes ☐No
N2.1.2		*UserServiceInfo* (*UstEntry*)	6.1	M	☐Yes ☐No
N2.1.3		*ApplicationStatusTable*	6.1	M	☐Yes ☐No
N2.2	Removing registration entries	Delete service from MIBs	6.1.2	M	☐Yes ☐No
N2.2.1		Terminate WBSS with no active applications	6.1.2	M	☐Yes ☐No
N2.2.2		No more than one WBSS of given application	6.2	M	☐Yes ☐No
N2.3	Device roles		6.2		
N2.3.1		Provider	4.2.4, 6.2	O.2	☐Yes ☐No
N2.3.2		User	4.2.4, 6.2	O.2	☐Yes ☐No
N2.4	WBSS Management		6.2		
N2.4.1	WBSS provider	Establish on SCH and announce its presence on CCH	6.2.1.1	N2.3.1: M	☐Yes ☐No
N2.4.2	WBSS provider	WSA parameters	6.2.1.1.1	N2.3.1: M	☐Yes ☐No
N2.4.3	WBSS provider	Priority processing	6.2.1.1	N2.3.1: M	☐Yes ☐No
N2.4.4	Secured WSA	Processing per IEEE Std 1609.2	6.2.1.1.1, 6.2.1.2.2, and 6.2.3.1	M	☐Yes ☐No
N2.4.5	WBSS user	*WSA* recipient determines validity and accepts to join	6.2.1.2	N2.3.2: M	☐Yes ☐No
N2.4.6	WBSS user	Join parameters	6.2.1.2.2.1	N2.3.2: M	☐Yes ☐No
N2.4.7	WBSS user	Transmit profile registration	6.2.1.2.2.2	N2.3.2: M	☐Yes ☐No
N3	Dynamic WBSS	Provider applications to be added or removed from periodic announcements on persistent WBSS.	6.2.2	M	☐Yes ☐No
N3.1		Provider processing	6.2.2.1	N2.3.1:M	☐Yes ☐No
N3.2		User processing	6.2.2.2	N2.3.2:M	☐Yes ☐No

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N4	WBSS completion				
N4.1		Higher priority application	6.2.4, 6.2.1.2	M	☐Yes ☐No
N4.2		Application deregistration	6.2.1, 6.2.4	M	☐Yes ☐No
N4.3		Application completion	6.2.4	M	☐Yes ☐No
N4.4		Channel inactivity	6.2.4	M	☐Yes ☐No
N4.5		WAVEEND and delete TXProfile	6.2.4.3	M	☐Yes ☐No
N4.6		Reason code	6.2.4.3, 6.2.5.2	M	☐Yes ☐No
N4.7		Release IP Configuration	6.2.4.3.1	M	☐Yes ☐No
N5	Application status transitions	Maintains status of each registered applications based on WBSS status and application availability.	6.2.5.1	M	☐Yes ☐No
N6	Application notifications	WME notifies applications on its WBSS status changes and reason codes.	6.2.5.2	M	☐Yes ☐No
N7	Channel usage monitoring	WME tracking of each SCH/*WSA* used	6.3	M	☐Yes ☐No
N8	IPv6 configuration				
N8.1		Support for link-local, global and multicast addresses per RFC 2373 and RFC 2462.	6.4	M	☐Yes ☐No
N8.2		Derivation of global IPv6 address using *IpPrefix*.	6.4	N2.3.1: M	☐Yes ☐No
N9	Received Channel Power Indicator (RCPI) polling	Provides capability for RCPI query and report.	6.5	O	☐Yes ☐No
N9.1		RCPI Requestor	6.5	N2.3.1:O	☐Yes ☐No
N9.2		RCPI Responder	6.5	N2.3.2:O	☐Yes ☐No
N10	MIB maintenance	Per Annex A	6.6	M	☐Yes ☐No
N11	WSMP SAP	Allows applications to send and receive WSMs	7.1	O	☐Yes ☐No
N12	WME SAP	Allows applications to access WME functions and to be notified	7.2	O	☐Yes ☐No
N13	LSAP	Per IEEE Std 802.2	7.3	O	☐Yes ☐No
N14	MLME SAP	Per IEEE Std 1609.4 and IEEE Std 802.11h	7.4	O	☐Yes ☐No

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N15	WME	Primitives parameters per Table 7	7.5.1	M	☐Yes ☐No
N16	Over the Air Frame Formats	Per IEEE Std 802.11 and IEEE P802.11p	8.0	M	☐Yes ☐No
N17	*WSA* format	Per Figure 17	8.1	M	☐Yes ☐No
N18	WSM encoding	Per Table 10	8.2	M	☐Yes ☐No

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