

5.9 GHz DSRC Standards Overview and Status

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ABSTRACT

Over the past several years the Institute of Electrical and Electronic Engineers (IEEE) Standards Association has developed standards for the 5.9 GHz Dedicated Short Range Communications protocols, also known as Wireless Access in Vehicular Environments. These standards consist of IEEE 1609 as well as an amendment to the IEEE 802.11 standard or 802.11p. The 1609 standards were published for Trial Use and these as well as the 802.11p draft have been implemented in a variety of test beds to provide lessons learned and feedback into the standards working groups. Based on ongoing testing, the protocols display a strong capability to address the requirements of crash avoidance and transportation mobility applications. The corresponding test results provide information necessary to update the standards after the first trial phase as industry moves toward commercial implementations. In this paper we explore the history and status of the standards as well as anticipated revisions of IEEE 1609 and publication of IEEE 802.11p.

INTRODUCTION

Dedicated Short Range Communications (DSRC) at 5.9 GHz was established at for services involving vehicle to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communications.¹ It is a low latency, short to medium range wireless protocol specifically designed for mobile use. It provides communication capabilities among vehicles and between vehicles and roadside equipment for the purpose of implementing intelligent safety and mobility applications along roadways. This technology utilizes spectrum in the 5.9 GHz range; former proprietary implementations used primarily for electronic toll collection utilize the 915 MHz band.

In 1999, the FCC granted the use of 75 MHz in the 5.9 GHz band for the specific use of vehicle safety and Intelligent Transportation Systems (ITS) applications. This band (5850 – 5925 MHz) is extremely large as compared to similar allocations for wireless applications.

The DSRC physical layer is based on the wireless local area network (WLAN) standard IEEE 802.11a, modified to use 10 MHz channels (rather than 20 MHz) to compensate for outdoor and mobile use wherein the delay spreads are higher. It utilizes orthogonal frequency division multiplexing (OFDM) with 52 subcarriers, 4 of which are pilot channels that are used for phase tracking, while the remaining 48 subcarriers are used for data carriers. The medium access control layer (MAC) is also based on IEEE 802.11, which uses Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA).

The upper layers of the DSRC communications at 5.9 GHz are specified by the IEEE 1609 standards, which define mechanisms for multi-channel operation, networking services using IPv6 and a low-latency WAVE short message protocol (WAVE) utilized primarily for safety messages defined in the standard SAE J2735.

BACKGROUND

The **IEEE 1609 Family of Standards for Wireless Access in Vehicular Environments (WAVE)** defines the architecture, data communications, management structure, security mechanisms and physical access mechanisms for wireless communications in the vehicular environment. The primary physical components defined by these standards are the On Board Unit (OBU) and Road Side Unit (RSU).

WAVE refers to the 802.11p standard working with the 1609 standards to enable DSRC-based safety and mobility applications, more broadly known as Vehicle Infrastructure Integration (VII). These standards will also be the basis for next generation high performance tolling using 5.9 GHz DSRC.

STANDARDS STATUS

In 2006 the IEEE 1609 standards were published for Trial use, and in May of 2008 the standards working group reconvened to incorporate lessons learned from test bed implementations into the standards. IEEE 1609 will also be adding additional standards based on requirements identified from these test beds and will subsequently be published for permanent use.

¹ <http://www.ieee802.org/11/>

Also in May 2008, the IEEE 802.11p amendment passed intra working group letter ballot and is under final revision to be submitted to the standards association for approval and publication. Based on the time frame of the 1609 revisions, the efforts are conveniently aligned from a schedule perspective. The SAE message sets standard (J2735) is continuing to be developed by the applications stakeholders. In summary, the formal IEEE standards include the following:

- **Draft P802.11p: Amendment :** Wireless Access in Vehicular Environments (WAVE)
 - Defines the lower layers (PHY and MAC) of the communications stack as deltas to 802.11
- **IEEE Std 1609.4™-2007:** Trial-Use Standard for WAVE Multi-Channel Operation
 - Provides frequency band coordination and management within the MAC layer
- **IEEE Std 1609.3™-2007:** Trial-Use Standard for WAVE Networking Services
 - Specifies operation and management of the communications stack
- **IEEE Std 1609.2™-2007:** Trial-Use Standard for WAVE Security Services for Applications and Management Messages
 - Specifies security for message signing, data encryption and authentication

STANDARDS OVERVIEW

As summarized above, the IEEE 1609 standards consist of three key specifications: security (1609.2), management services, networking services and a custom messaging protocol used for non-networked applications (1609.3), and RF channel coordination (1609.4). The architecture of the corresponding protocol stack is illustrated in Figure 1.

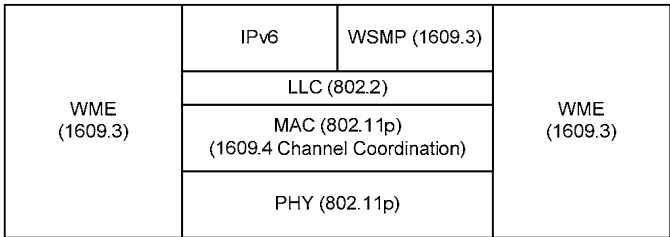


Figure 1 – WAVE Protocol Stack

SECURITY

The security functions defined in the current 1609.2 DSRC standard use Elliptic Curve Cryptography (ECC) or Advanced Encryption Standard (AES), depending on the application. The ECC algorithm is used in conjunction with a certificate strategy defined by the service providers to sign/verify and optionally encrypt/decrypt communications management and data transmissions.

Privacy is also a key consideration in DSRC wherein devices may randomly change their device address (i.e. MAC address) and security certificates over time and distance traveled to prevent vehicle tracking and, more particularly, association of identity with an OBU.

MANAGEMENT SERVICES

The IEEE 1609.3 standard defines critical management services that streamline the data communications for the purpose of reducing latency associated with traditional link setup and discovery processes. Devices offering a service act as providers and any device may act as a service user. Both user and provider applications are registered in the WAVE management entity (WME) so that service availability can be advertised by providers and discovered by users.

All WAVE devices are required to utilize the control channel, where most safety applications are broadcasting WAVE short messages, and services are advertised. A service provider transmits a WAVE service advertisement (WSA) on the control channel that includes a provider service ID (PSID) and network setup information in the case of an IPv6 based service. This enables the rapid establishment of communications without the typical overhead of more traditional communications protocols.

Applications are also prioritized in WAVE such that a higher priority application may pre-empt an ongoing service of low priority. Prioritization is one area of ongoing development in the DSRC community and will be substantially enhanced through the upcoming standards revisions. Figure 2 depicts a simplified representation of the user process flow.