VANET Protocols
DSRC, WAVE, IEEE 1609, IEEE 802.11p, Priority

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CS 795/895
Vehicular Networks

References

- WAVE Overview
  - R. Uzcategui and G. Acosta-Marum, "WAVE: A Tutorial", *IEEE Communications Magazine,* May 2009.
  - D. Jiang and L. Delgrossi, "IEEE 802.11p: Towards an International Standard for Wireless Access in Vehicular Environments", IEEE VTC-Spring 2008.
- Priority Access (802.11p)
  - S. Eichler, "Performance Evaluation of the IEEE 802.11p WAVE Communication Standard", IEEE VTC Fall 2007.
  - M. Torrent-Moreno, D. Jiang, and H. Hartenstein, "Broadcast Reception Rates and Effects of Priority Access in 802.11-Based Vehicular Ad-Hoc Networks", ACM VANET 2004.

Acronyms

- WAVE
  - Wireless Access in Vehicular Environments
- DSRC
  - Dedicated Short Range Communications
- EDCA
  - Enhanced Distributed Channel Access

History / Development

- **1991** - US Congress created the Intelligent Vehicle Highway Systems (IVHS) program under US DOT
- **1996** - US DOT developed the National Intelligent Transportation Systems Architecture (NITSA)
- **1999** - FCC reserved 75 MHz of bandwidth in the 5.9 GHz band (5.85-5.925 GHz) for dedicated short range communications (**DSRC**)

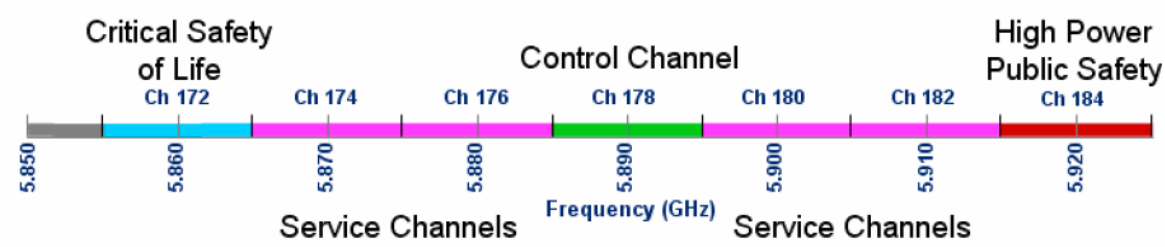
History / Development

- **2004** - IEEE created a task group to develop an amendment to the 802.11 standard to include vehicular environments **(IEEE 802.11p**)
- **2004** - IEEE created a working group to develop specifications to cover the additional layers in the protocol (**IEEE 1609**)
- **2010** - IEEE 802.11p standard released
- **2011** (expected) - IEEE 1609 standard to be released

Outline

- **DSRC**
- WAVE
  - IEEE 1609
  - IEEE 802.11p
- Priority Access

DSRC Channels



75 MHz of bandwidth
5.9 GHz band
Optimal data rate: 6 Mbps

(Jiang, 2008)

Outline

- DSRC
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System Architecture

- RSU - roadside unit
- OBU - on-board (vehicle) unit
- CCH - control channel
  - one CCH
- SCH - service channel
  - several SCHs
- WBSS - WAVE basic service sets
  - think 802.11 APs and SSID (service set identifier)

(Uzcategui, 2009)

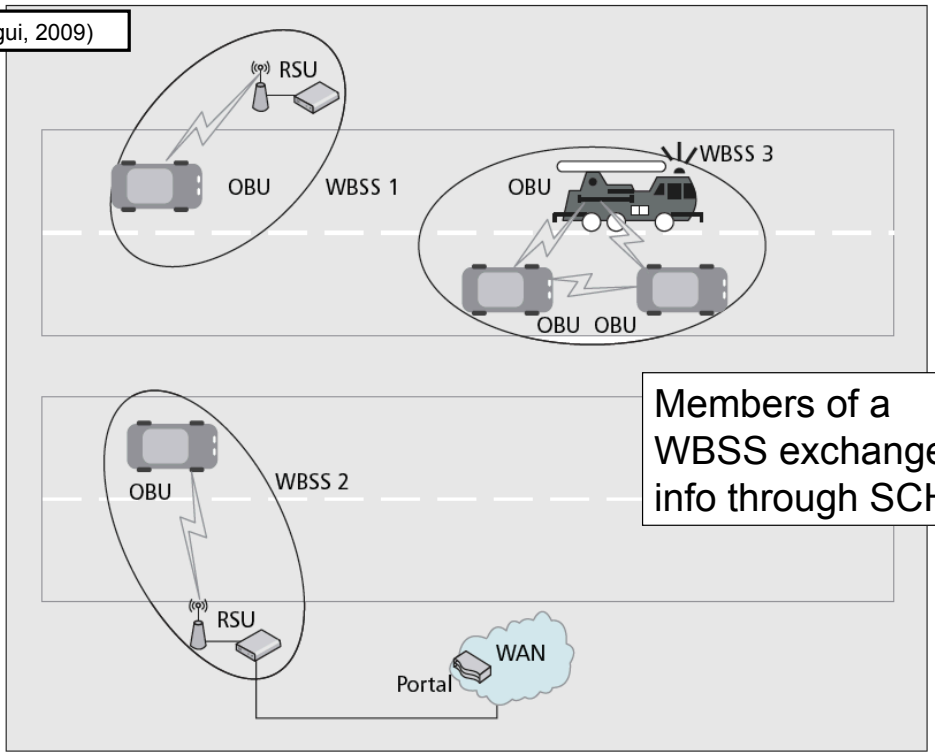
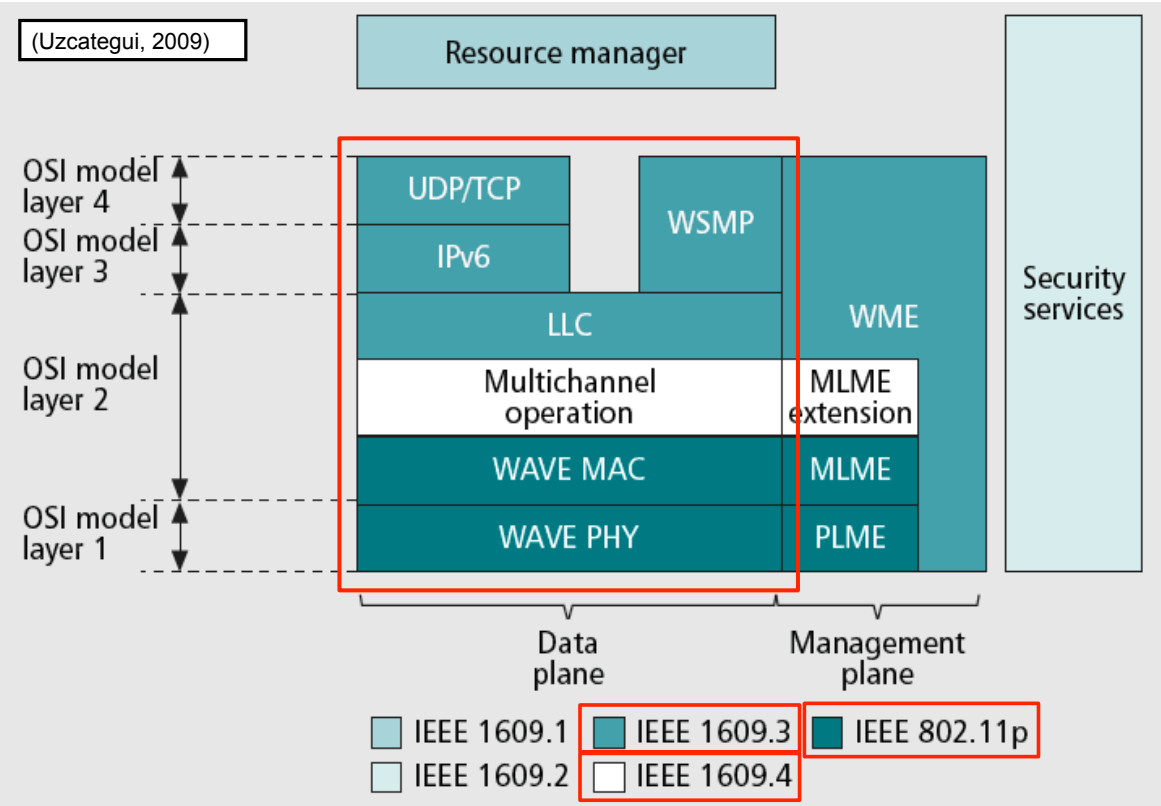


Figure 1. *Illustration of a WAVE system showing the typical locations of the OBUs and RSUs, the general makeup of the WBSSs, and the way a WBSS can connect to a WAN through a portal.*

WAVE Protocols

Protocols	Standard document	Purpose of the standard	OSI model layer numl
WAVE PHY and MAC	IEEE 802.11p	Specifies the PHY and MAC functions required of an IEEE 802.11 device to work in the rapidly varying vehicular environment	1 and 2
Multichannel operation	IEEE 1601.4	Provides enhancements to the IEEE 802.11p MAC to support multichannel operation	2
WAVE networking services	IEEE 1609.3	Provides addressing and routing services within a WAVE system	2, 3, and 4
WAVE resource manager	IEEE 1609.1	Describes an application that allows the interaction of OBUs with limited computing resources and complex processes running outside the OBUs in order to give the impression that the processes are running in the OBUs	N/A
WAVE security services	IEEE 1609.2	Covers the format of secure messages and their processing	N/A

(Uzcategui, 2009)



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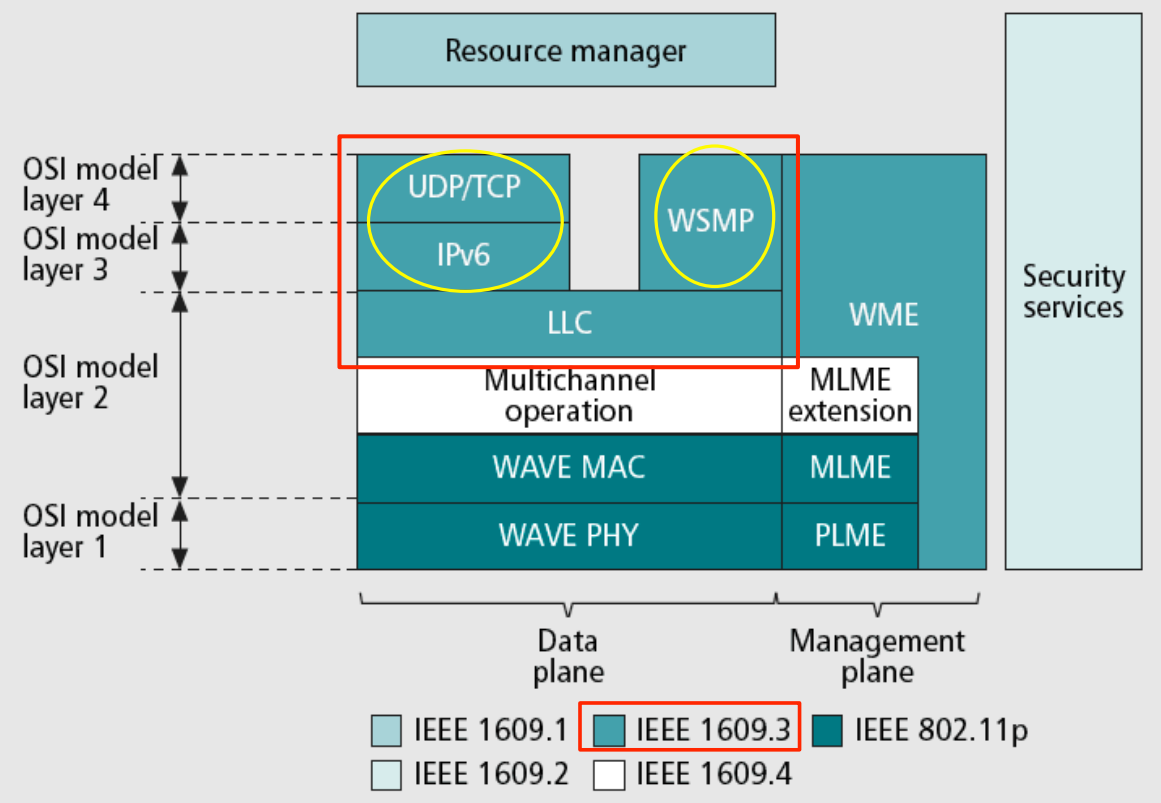
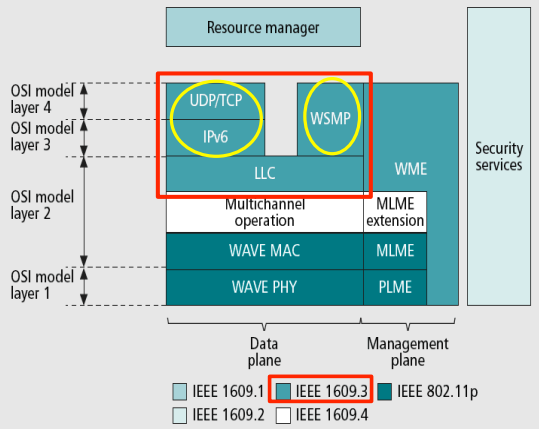


1609.3 - Networking

- IPv6
  - traditional TCP/UDP transmissions
- WAVE Short-Message Protocol (WSMP)
  - high-priority, time sensitive communications



1609.4 - Multi-Channel

- Channels and Messages:
  - CCH - WAVE announcement frames, WSMs
  - SCH - WSMs, IP data frames
- Data exchanges on an SCH require that stations be a part of the same WBSS.
- All devices are synchronized and listen to the CCH during the same time interval.
- Members of a WBSS listen to the SCH at the same time. The sum of the CCHI and SCHI is the sync interval.
- *We'll look at this in particular later*

Priority Operation

- Based on IEEE 802.11e EDCA

- CCH - predetermined EDCA parameter set
- SCH - WAVE announcement frame contains the EDCA parameter set to be used

- *We'll look at this in particular later*

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  - **IEEE 802.11p**
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802.11p

- Goal is to simplify the 802.11 requirements (especially for BSS) to allow for use by dynamic vehicular networks.

- WAVE mode - a station is allowed to transmit and receive data frames with the wildcard BSSID and without the need to belong to a BSS*, two vehicles can immediately communicate with each other*

(Jiang, 2008)

802.11p

- WBSS - WAVE BSS, transmit on-demand beacon to advertise
  - advertisement contains all the needed information for receiver stations to understand the services offered
  - station can decide to join and complete the joining process by only receiving a WAVE advertisement
  - a station in a WBSS is still in WAVE mode and can still send frames with the wildcard BSSID and receive frames from stations outside the WBSS with the wildcard BSSID.
  - a station cannot be a member of more than one WBSS at a time.

(Jiang, 2008)

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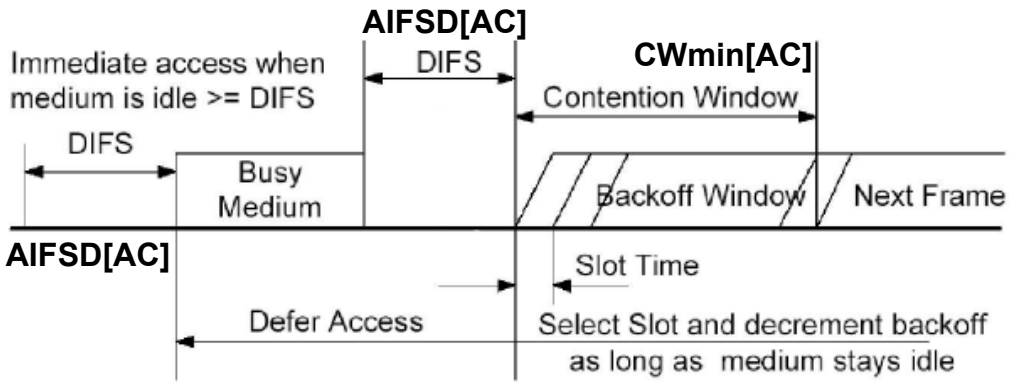
- **Priority Access**

Priority Access

- Based on IEEE 802.11e EDCA
- Four access categories (ACs)
  - ACs contend internally
  - selected packet contends externally
- AIFSD[AC] - replaces DIFS
- CWmin[AC] - replaces CWmin
- AIFSD[AC] = AIFS[AC] * SlotTime
  - SlotTime = 16 us

Recall

IEEE 802.11 Operation



Torrent-Moreno et al., "Broadcast Reception Rates and Effects of Priority Access in 802.11-Based Vehicular Ad-Hoc Networks", ACM VANET 2004.

EDCA Access Categories

- AC0 (AC_BK) – background, lowest priority
- AC1 (AC_BE) – best effort
- AC2 (AC_VI) - video
- AC3 (AC_VO) – voice, highest priority

Priority Parameters

AC	CWmin	AIFSN
AC_BK	15	9
AC_BE	7	6
AC_VI	3	3
AC_VO	3	2

Torrent-Moreno

VANET 2004

- How to give priority access and improved reception rate for important warnings (event-based messages)?
- Priority access can be used to get quicker access to medium.
- Priority really only pays off in a saturated scenario.

Eichler

VTC Fall 2007

- Evaluates performance of different ACs in different traffic conditions using default parameters.
- In high density situations, collision probability is high, especially for AC3 (highest priority).
- To avoid message queue build-up, messages should be culled (re-evaluated)