The WAVE Communications Stack:
IEEE 802.11p,
1609.4 and,
1609.3

September, 2007
WAVE System Components

External Systems

ROAD SIDE UNIT

Covered by WAVE Standards

APPLICATIONS

WAVE Stack

APPLICATIONS

WAVE Stack

External Systems

Optional External Interface

Airlink

Optional External Interface
Protocol Stack

1609.1, et al.

Management Plane

Applications

Data Plane

IETF

WME

UDP / TCP

IPv6

WSMP

1609.3

802.2

802.11p

802.11p

1609.4

1609.3

MLME

WAVE MAC

Multi-Channel Operation

PLME

WAVE PHYS

IETF: Internet Engineering Task Force
LLC: Logical Link Control
MAC: Medium Access Control
MLME: MAC Layer Management Entity
PHY: Physical Layer
PLME: Physical Layer Management Entity
WME: WAVE Management Entity
WSMP: WAVE Short Message Protocol

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802.11p, 1609.4, 1609.3

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**WAVE Standards**

**OSI Reference Model**
- Application, Presentation, Session
- Transport
- Network
- Data Link
- Physical

**WAVE Model**
- IEEE 1609.1, et al.
- IEEE 1609.3
- IEEE 802.2
- IEEE 1609.4, IEEE 802.11
- IEEE 802.11p

**WAVE Standards Scope**
- IEEE 1609.2
- Upper Layers
- Networking Services
- LLC Sublayer
- MAC Sublayer
- PHY Layer

Scope of this discussion
The Standards

- **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
**System Objectives**

- Leverage existing technology
  - E.g., 802.11
- Future-proof technology
  - E.g., IPv6
- Account for freeway-speed units
  - Short and intermittent mobile-roadside connectivity
- Provide mobile-mobile as well as mobile-roadside communication
  - Support a range of traffic types including high priority/low latency and general Internet
- Provide security
  - More later
P802.11p

- Amendment to 802.11
  - In Letter Ballot stage as of 9/07
- Employs OFDM PHY @ 5.9 GHz
  - Defines a WAVE mode of operation
  - 10 MHz and 20 MHz channels
  - Allows communications either with or without a WAVE Basic Service Set (WBSS)
  - Tightens tx frequency specs
  - Adds rx adjacent channel rejection requirements
  - Introduces a random local MAC address
  - Adds an extended temperature range
IEEE Std 1609.4™-2007

• Supplements 802.11 MAC features
• Coordinates operation on Control Channel (CCH) and Service Channels (SCH)
  – CCH intended for broadcast, high priority, and single-use messages
  – SCHs intended for ongoing transactions
• Incorporates P802.11-REVma transmission priority scheme
IEEE Std 1609.3™-2007

• Data Plane
  – Defines use of existing UDP (TCP optional), IPv6, and LLC
  – Adds WAVE Short Message Protocol (WSMP)

• Management Plane
  – WAVE Management Entity (WME)
  – Manages WAVE Basic Service Set (WBSS) participation in support of applications
  – Coordinates IPv6 configuration
Channel Coordination

- Default receive on predefined Control Channel
- Operate on a Service Channel when participating on a WAVE Basic Service Set (WBSS)
- Control and Service Channel intervals are 50 ms
Communications Options

- WAVE Short Message Protocol (WSMP)
  - Used on both Control and Service Channels
    - No setup required
    - Limited to 1400 bytes
    - Limited to WAVE-aware devices

- IPv6
  - Used on Service Channels only
    - When operating on WBSS
  - Allows access to generic applications and networks
Scope of User Communications

- **External Systems**
- **ROAD SIDE UNIT**
  - Applications
  - WAVE Stack
  - Airlink
  - Optional External Interface
- **ON-BOARD UNITS**
  - Applications
  - WAVE Stack
  - Optional External Interface

- **Coverage by WAVE Standards**

- **Signaling**

- **WSM**

- **WSM with forwarding**

- **IPv6**
WAVE Communications Concepts

• Application registration
  – Provider or User role

• Provider Service Identifier (PSID) & Provider Service Context (PSC)
  – PSID allocated by IEEE

• WAVE Basic Service Set (WBSS)
  – WAVE Service Advertisement (WSA)
    • Sent on Control Channel, by Provider role
  – Join, by User role
    • PSID matching
    • Confirm-before-join
  – End
Simplified User-Side Process Flow

- Any device may act as Provider or User
- Device defaults to Control Channel (CCH) monitoring when not joined to a WBSS
- Returns to CCH monitoring when complete
Setup and Joining a WBSS
Current Status

• 802.11p in ballot at Working Group level
• 1609 family implemented and in trial use phase
  – Vehicle Infrastructure Integration (VII) initiative
  – Standards valid approximately through 2008
  – Lessons learned to be incorporated into final standards