Standardization of Wireless Vehicular Communications within IEEE and ETSI

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Cooperative ITS

• Traffic efficiency, traffic safety and value-added services
• Can be realized through different wireless access technologies
• Focus here is on road traffic safety using ad hoc networking through IEEE 802.11p
• Two types of messages: time-triggered position messages and event-driven hazard warnings
Frequency bands for cooperative ITS

- **North America**
  - 5.850-5.925 GHz Intelligent Transportation Systems Radio Service
    - 75 MHz
  - 7x10 MHz channels
    - 1 control channel and 6 service channels

- **Europe**
  - 5.875-5.925 GHz (30 MHz + 20 MHz)
    - Road traffic safety
      - 1x10 MHz control channel and 2x10 MHz service channels
    - Traffic efficiency
      - 2x10 MHz service channels
IEEE WAVE/802.11p

Safety applications

SAE J2735
Message sublayer
WSMP

1609.2 Security

IEEE 1609.3
IEEE 1609.4
IEEE 802.2
IEEE 802.11p

MAC sublayer extension
MAC sublayer
PHY layer

Non-Safety applications

Application

Transport (TCP/UDP)

Network (IPv6)

SAE J2735
IEEE 1609.3
IEEE 802.2
IEEE 1609.4
IEEE 802.11p

IETF RFC 793/768
IETF RFC 2460

WAVE = Wireless Access in Vehicular Environment
IEEE 802.11p

- An amendment to the WiFi standard IEEE 802.11
- Ratified in July, 2010
- No access point functionality
  - No authentication or association procedures
- Medium access control (MAC)
  - Carrier sense multiple access with collision avoidance (CSMA/CA)
  - Support for Quality of Service (802.11e)
IEEE 802.11p

• Physical layer of 802.11p
• Derived from the 802.11a
  – Defines 3 different channel widths: 5, 10, and 20 MHz
• Orthogonal Frequency Division Multiplexing (OFDM)
  – 48 data carriers and 4 pilots
  – Subcarrier spacing of 156.25 kHz
  – Symbol interval 8 µs (GI of 1.6 µs)
• 8 different transfer rates
  – 3, 4.5, 6, 9, 12, 18, 24, 27 Mbps
  – BPSK, QPSK, 16-QAM, 64-QAM
IEEE WAVE/802.11p

- 1609.3 WSMP
  - WAVE short message protocol (WSMP)
  - Developed to avoid excessive overhead
  - WAVE Short Messages (WSM)
  - WAVE Service Advertisements (WSA)
- SAE J2735 DSRC message set dictionary
  - 15 message types
  - Basic Safety Message (BSM)
    - ~300B, 10Hz
    - Conveys state information about the sending vehicle
    - Periodic ”Here I am” messages
- 1609.2 Security
IEEE WAVE/802.11p

- **1609.4 Multichannel operation**
  - One Control channel (CCH)
  - Six Service channels (SCH)
Ongoing work in the US

- **SAE J2945.1 Minimum Performance Requirements**
  - To ensure interoperability between nodes
  - E.g., define BSMs sending rate, transmit power control, adaptive message rate control

- **Update of 1609.4 multichannel operation**
  - Move all road traffic safety data to one SCH
ETSId ES 202 663 (V1.1.0): “Intelligent Transport Systems (ITS); European profile standard for the physical and medium access control layer of Intelligent Transport Systems operating in the 5 GHz frequency band”
ETSI TC ITS protocol stack

• Adds a facilities layer in-between transport and applications
• The access technologies do not only focus on *ad hoc* networking
ETSI – Access technologies

• Profile standard of IEEE 802.11p
  – Termed **ITS G5**
  – MAC and PHY
  – ES 202 663
  – Adapting 802.11p to the European spectrum

• Requirement on Decentralized Congestion Control (DCC)
  – TS 102 687
Motivations for DCC

• Adapt the transmit power through transmit power control (TPC) algorithms
• Adapt the packet generation in each node through transmit rate control (TRC)
• The number of nodes in a VANET cannot be restricted
• CSMA as MAC method will have trouble when the number of nodes increases within radio range
  – Unbounded channel access delay (nodes will not be able to transmit packets)
  – Affects the performance of the road traffic safety applications
DCC

- DCC influences three parts of the protocol stack
  - Access technologies
  - Network & Transport
  - Facilities

- Management plane plays a central role

- Cross-layer problem
ETSI – Network and transport

Applications
Facilities
Network & Transport
Access Technologies

Transport
- Basic Transport Protocol
- Transmission Control Protocol
- User Datagram Protocol

Network
- Geonetworking
- Internet Protocol (IPv4, IPv6)
ETSI – Network and Transport

• Geonetworking
  – Media-independent functionality
    • TS 102 636-4-1
    • Does not rely on a specific access technology
  – Media-dependent functionality
    • TS 102 636-4-2
    • Supporting the DCC part

• Basic Transport Protocol (BTP)
  – TS 102 636-5-1
  – Connection-less (best effort delivery)
  – Low overhead
ETSI – Facilities

Facilities

Applications

Facilities

Network & Transport

Access Technologies

Application Support

Information support

Communication support

Application support
• E.g. Station positioning, Service management, Message management, Mobile station dynamics, LDM management, Security access

Information support
• E.g. LDM database, Data presentation, Location referencing, Station type/capabilities

Communication support
• E.g. Addressing mode, Mobility management, GEONET support, Session support
ETSI – Facilities cont’d

• Two central message types
• Cooperative Awareness Messages (CAM)
  – TS 102 637-2
  – Periodic time-triggered position messages
  – ”Here I am”
  – 1-10 Hz, packet length including security up to 800 bytes
• Decentralized Environmental Notification Messages (DENM)
  – TS 102 637-3
  – Event-driven hazard warnings
Local Dynamic Map (LDM)

• The LDM is a database storing and maintaining data
• TR 102 863
• Dynamic data received from other ITS stations through CAM and DENM
• Applications retrieve relevant data from the LDM
ETSI – Applications

• Basic set of applications
• TR 102 638
• Road safety (driving assistance)
  – Emergency vehicle, slow vehicle, wrong way driving, traffic condition, roadwork, etc.
• Traffic efficiency
  – Speed limits notification, enhanced route guidance
Ongoing activities within ETSI

• Revision of CAM and DENM specifications
• Channel specification of the ITS band at 5 GHz
  – How to use the different available frequency channels for cooperative ITS
    – TS 102 724
• Minimum set of standards to be finished mid 2012 to ensure interoperability
Wrap up

• IEEE and ETSI have selected the same MAC and PHY layers for road traffic safety applications
  – IEEE 802.11p
  – ETSI ITS G5 (profile of 802.11p) with requirements on DCC
• Beacons/Hello messages
  – Basic Safety Messages (BSM) defined in SAE J2735
    • Default: 10 Hz, approx. 300 byte
  – Cooperative Awareness Messages (CAM) defined in TS 102 637-2 (revised for the moment)
    • Default: 2 Hz, approx. 800 byte
Wrap up cont’d

• ETSI added a facility layer in-between transport and application layers containing
  – Application-, communication and information support
  – Local Dynamic Map (LDM) concept
• In the US the BSMs will contain path history and path prediction of the transmitting vehicle
  – No map as a foundation
• In Europe the LDM in each vehicle will keep track of the vehicles through the CAMs
• SAE J2945.1 Minimum Performance Requirements
  – Amongst many other things there will probably be an outline of application requirements
Thank you!

Questions?

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