Vehicular Communication Standards

- DSRC, CALM M5, WAVE AND 802.11p

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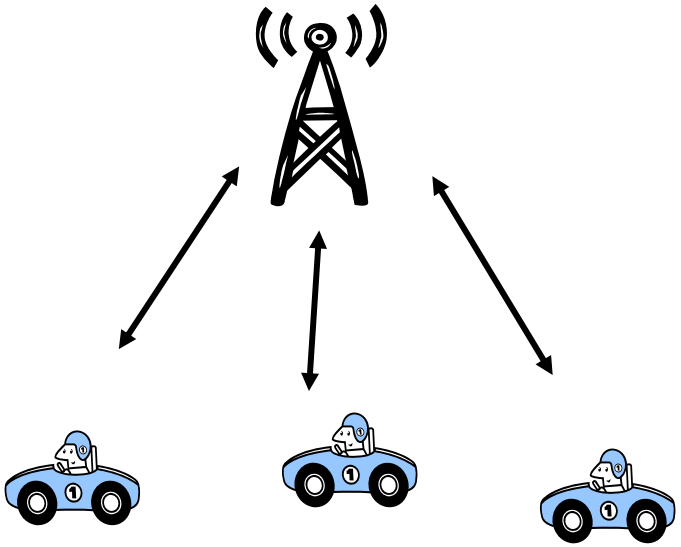
Outline

- Dedicated short-range communication (DSRC)
  - RFID look-alike
  - WLAN look-alike
- WAVE and IEEE 802.11p
- CALM M5 (ISO)
- ETSI's work on ITS

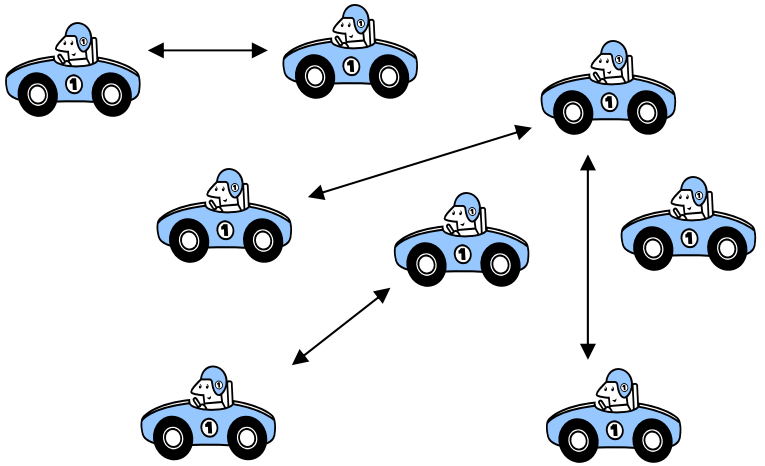
Network topologies

Vehicle-to-infrastructure (V2I)



Centralized with an access point, base station or roadside unit.

Direct vehicle-to-vehicle (V2V)



Ad hoc no central entity.

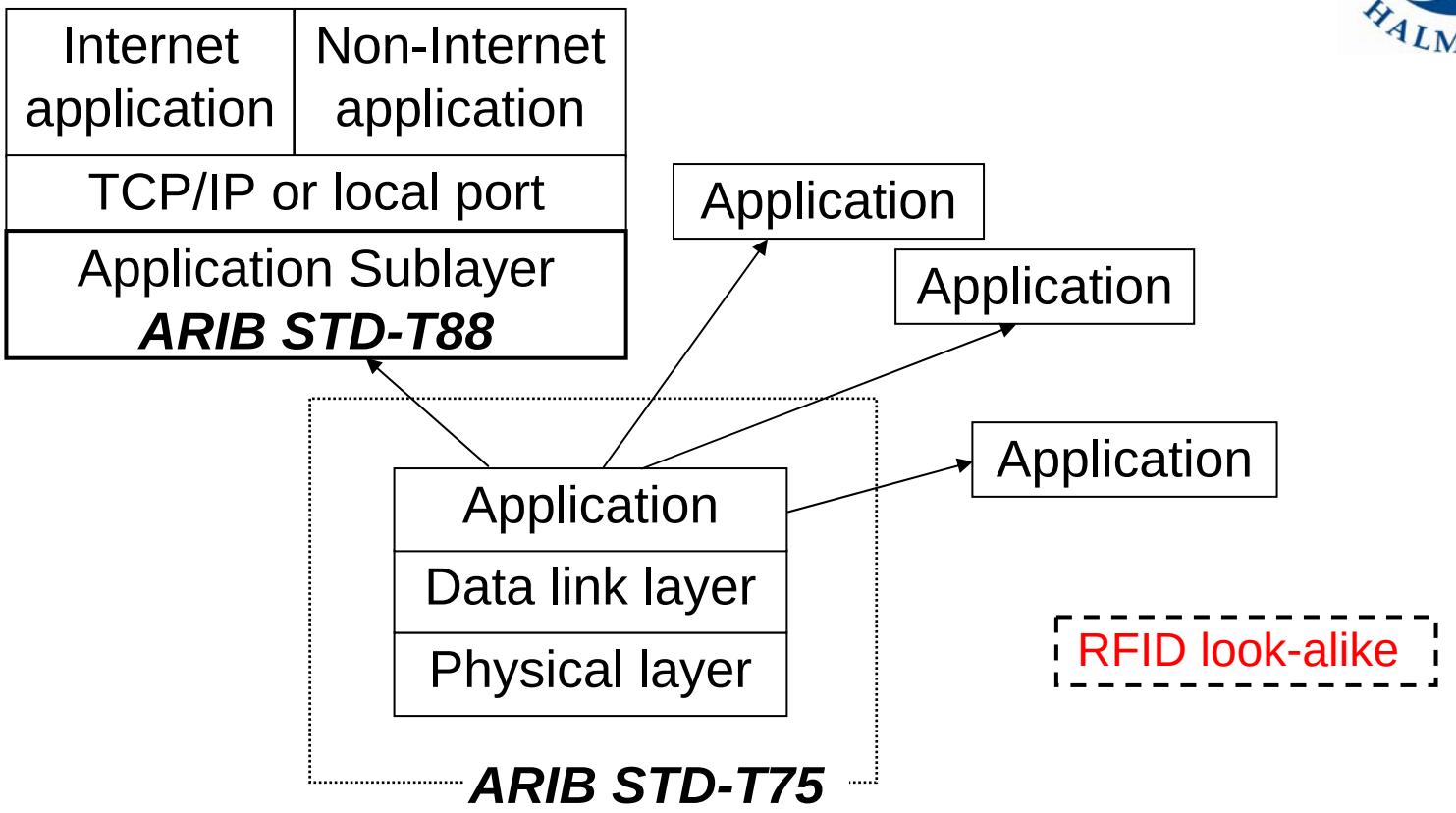
DSRC

- Dedicated Short-Range Communication
- Refers to a plethora of different standards around the world
- From beginning synonymous with a radio frequency identification system (RFID)
- E.g. Europe, Japan, US
  - RFID look-alike
  - WLAN look-alike

RFID

- Transponders (tags) and readers
- Master-slave configuration
- Used from ski passes in the French alps to animal identification and public transport payment
- Passive/active mode
- No worldwide standard
- Uses the following frequency bands <135 kHz, 6 MHz, 13 MHz, 27 MHz, 40 MHz, 433 MHz, 869 MHz, 915 MHz, **2.45 GHz**, **5.8 GHz** and 24 GHz

DSRC standard – Japan



ARIB=Association of Radio Industries and Business

DSRC standard – Europe

- CEN (European Committee for Standardization)
  - CEN is French for ”Comité Européen de Normalisation”
- EN 12834 (2002)
  - Application layer
- EN 12795 (2002)
  - Data link layer
- EN 12253 (2004)
  - Physical layer
- Swedish Standards Institute
  - Approved as a national standard

RFID look-alike

SS-EN 12834 Application layer
SS-EN 12795 Data link layer
SS-EN 12253 Physical layer

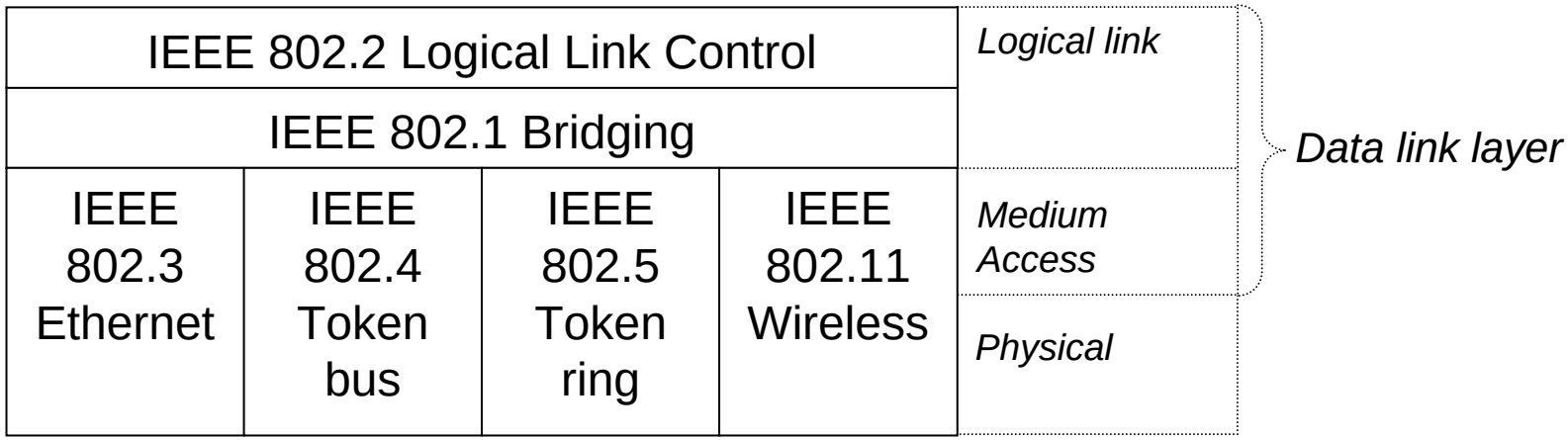
DSRC standard – Europe

- Medium access control
  - Half duplex
  - Time division multiple access
- 10 MHz band at 5.795-5.805 GHz
  - Road Transport and Traffic Telematics (RTTT)
- 500 kbps (DL), 250 kbps (UL)
- Examples of applications: toll collection, freight fleet management, parking management, public transport

RFID look-alike

Wireless Local Area Network

- Wireless local area network (WLAN)
- Synonymous with IEEE 802.11 today



IEEE 802.11 Wireless LAN

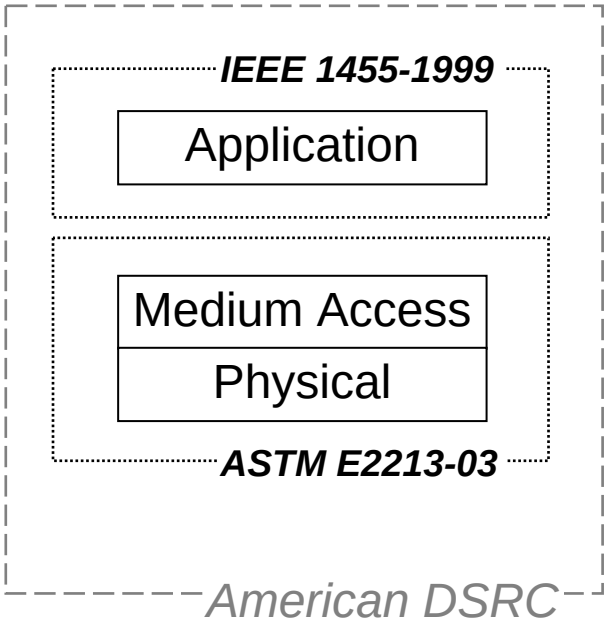
- IEEE 802.11 released 1997
- Latest version 2007 includes all amendments and supplements

Medium access control					802.11e QoS
FHSS 2.4 GHz 1-2 Mbps	DSSS 2.4 GHz 1-2 Mbps	IR 1-2 Mbps	OFDM 5 GHz 6-54 Mbps (802.11a)	DSSS/HR 2.4 GHz 1-11 Mbps (802.11b)	DSSS/ CCK/OFDM/ PBCC 2.4 GHz 1-54 Mbps (802.11g)

Physical layers

DSRC standard – North America

- American Society for Testing and Materials (ASTM)
- ASTM E2213-03
  - Medium access layer
  - Physical layer
- IEEE 1455-1999
  - Application layer



WLAN look-alike

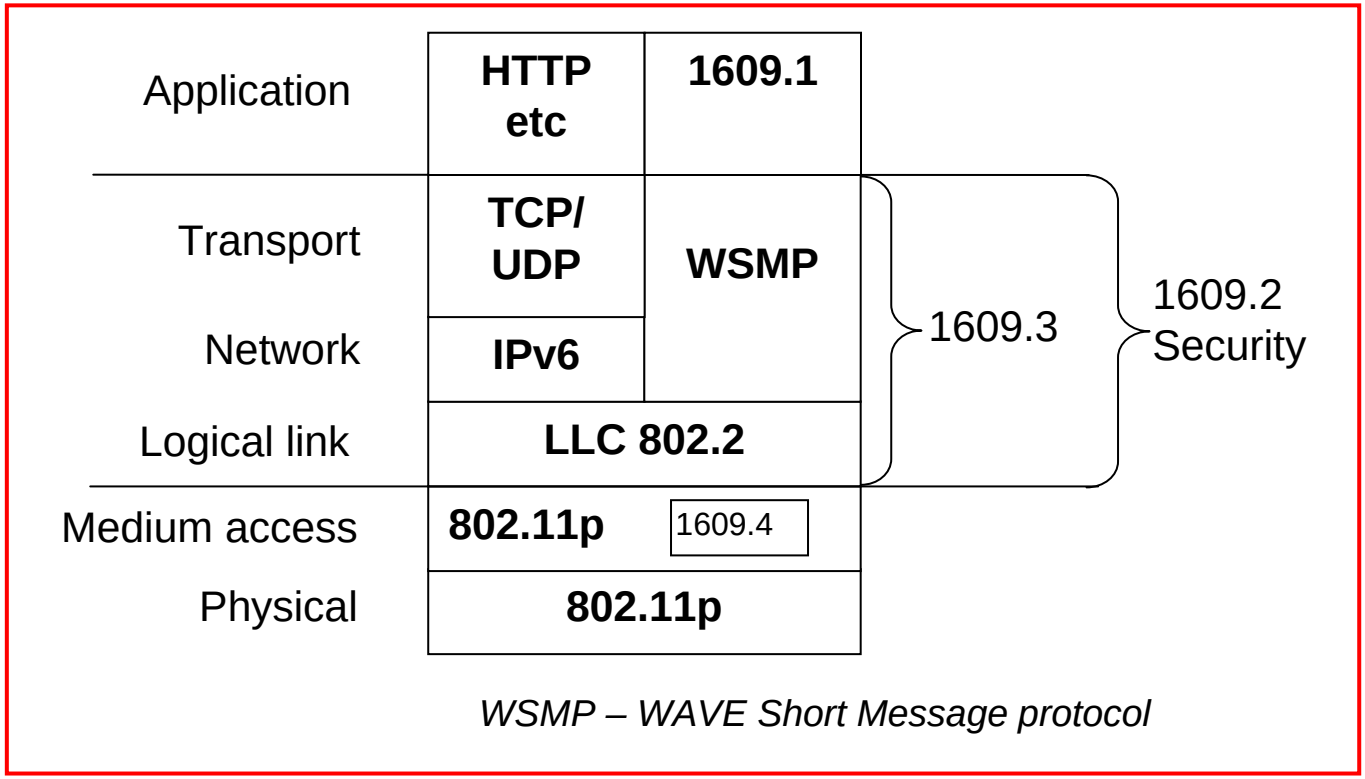
DSRC standard – North America

- The WLAN standard 802.11 with physical layer extension 802.11a
  - Minor changes to fit a high-speed vehicle environment
  - 10 MHz channels at a carrier frequency of 5.850-5.925 GHz (in total a 75 MHz wide band)
  - 3, 4.5, 6, 9, 12, 18, 24 and 27 Mbps

WLAN look-alike

WAVE protocol stack

WAVE = Wireless Access in Vehicular Environment



WAVE = IEEE 802.11p, 1609.1, 1609.2, 1609.3 and 1609.4

WAVE – 1609.1

- 1609.1 (October 2006)
  - Application layer
  - Onboard units (OBU)
  - Roadside units (RSU)
  - OBU supports a wide range of applications at a low cost
    - No need for interpreting messages requiring less processing, memory and management
    - Serves as a mailbox carrying data between RSUs or from RSU to other onboard systems
    - Future applications can be developed without changing the OBU

WAVE – 1609.2, 1609.3

- 1609.2 (July 2006)
  - Secure message formats
- 1609.3 (April 2007)
  - Provide addressing and routing services
  - WAVE short message (WSM)
  - WSM protocol (WSMP)
  - Allows application direct control to physical layer characteristics

WAVE – 1609.4

- Multichannel operation
- One control channel (CCH)
  - Only WSMP
- Multiple service channels (SCH)
  - Both IP and WSMP

IEEE 802.11p

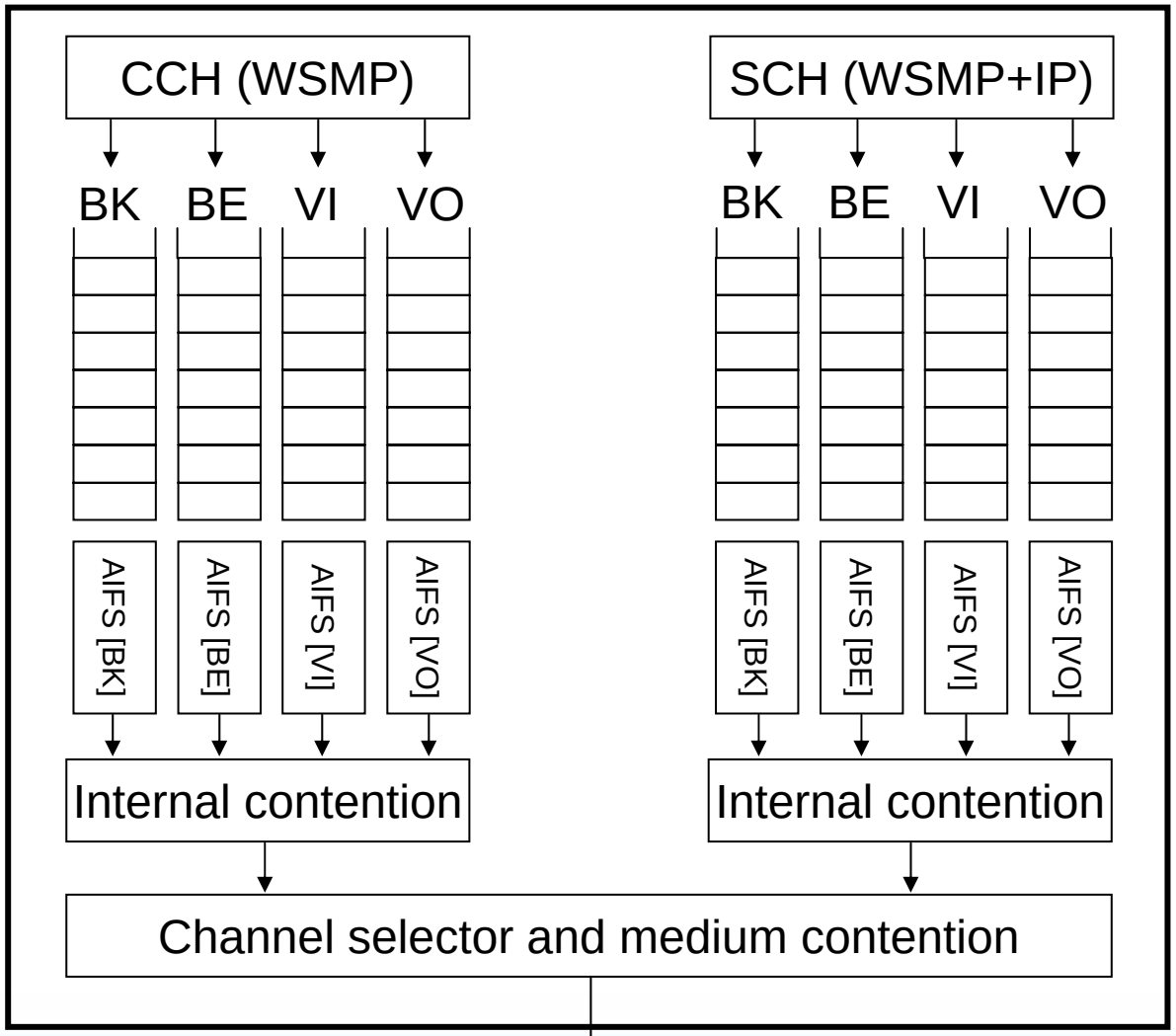
- Unapproved standard (spring 2010)
- PHY and MAC amendment
  - No support for access points
  - Peer-to-peer mode (ad hoc)
- IEEE 802.11a OFDM physical layer
  - 3, 4.5, 6, 9, 12, 18, 24 and 27 Mbps
  - 5.850-5.925 GHz Intelligent Transportation Systems Radio Service (ITS-RS)
  - 1 CCH and 6 SCH

WLAN look-a-like

IEEE 802.11p – MAC

- Carrier sense multiple access with collision avoidance (CSMA/CA)
- IEEE 802.11e QoS
  - Provides 4 different priority levels
- Starts listening to the channel during one AIFS
  - Arbitration InterFrame Space
- Channel becomes busy during listening period
  - Perform backoff by selecting a random number
  - Decrement backoff only when channel is free

WAVE – 1609.4

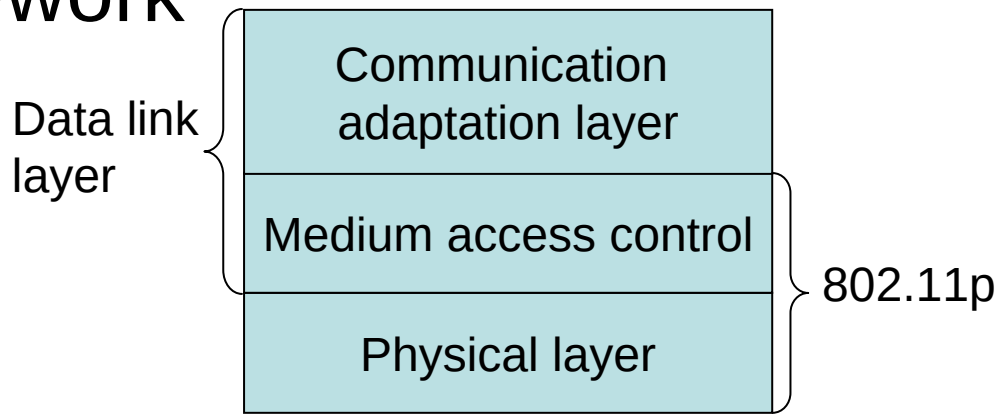


CALM M5

- Continuous communications for vehicles (www.calm.hu)
- M5 – Microwave communications for 5.8-5.9 GHz
- ISO = International Organization for Standardization
- TC204 WG16.1
- Technical Committee 204 – *Intelligent transport systems*
  - Working Group 16 – *Wide area network communications/networks and interfaces*
  - Subworking group 1 (16.1) – *Media related issues*
- ISO 21215

CALM M5 Scope

- IEEE 802.11
  - Selection/Exclusion of functionality
- Communications adaptation layer
- Regulatory framework



ETSI TC ITS

- European Telecommunications Standards Institute (ETSI)
  - Standards for Information and Communication technologies (ICT)
- ITS group formed in December 2007
- 5 working groups
  - **WG4 – Media and medium related issues**
    - Working on a profile of 802.11p suited for the frequency band of Europe
  - 5.875 – 5.905 GHz Safety related applications of Intelligent Transport Systems (ITS) “Cooperative Systems”

Wrap up

- DSRC
  - RFID-look-alike
    - Europe, Japan
    - Application specific (e.g., electronic toll collection)
    - Requires central control
    - Intended for hot spot communication (no networking facilities to the end user)
  - WLAN-look-alike
    - ASTM standard of IEEE 802.11
    - Simple network layer
    - Work has been taken over by IEEE

Wrap up cont'd

- WAVE and 802.11p
  - Whole protocol stack
  - More "advanced" standard
  - No central control
    - All nodes are peers from a lower layer perspective. It is up to the application to distinguish between RSU and OBU
  - Only standard supporting vehicle-to-vehicle communication
- ETSI's and ISO's (i.e. CALM) initiatives are both based on the 802.11p draft

Challenges

- Certain traffic safety applications will require low delay implying direct vehicle-to-vehicle communications
  - Only standard supporting this 802.11p
  - Major problems with unbounded channel access delays when the network becomes overloaded in terms of nodes/injected data traffic

Thank you for your attention!

Questions?

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