

An aerial photograph of a multi-lane highway filled with cars, illustrating a congested traffic scenario. Four yellow wireless signal icons, consisting of three concentric arcs, are overlaid on the highway at different points, suggesting the presence of VANET networks. The highway is flanked by green trees and some buildings.

A study of VANET Networks

ENSC 427, Spring 2012

Outline

- Introduction
- DSRC channel allocation
- Standards : IEEE 802.11p + IEEE 1604
- PHY LAYER
- MAC LAYER
- Communication Walkthrough
- Ns-3, Node Mobility, SUMO Traffic Generator
- References

Introduction

The purpose of this project is to conduct a general but informative study of the current trends of *Vehicular Ad Hoc Networks* (**VANETS**) as they relate to *Intelligent Transport Systems* (**ITS**).

Along the way a tutorial will be completed to jump-start those interested in learning more about VANETs and simulating contemporary standards in the open-source network simulator ns-3.

A Study of VANET Networks

Introduction -- Terminology Repository

Vehicular Ad Hoc Networks (**VANETS**)

Intelligent Transport Systems (**ITS**).

Vehicle-2-Vehicle (**V2V**) , Infrastructure-2-Vehicle (**I2V**) ... also (X2V)

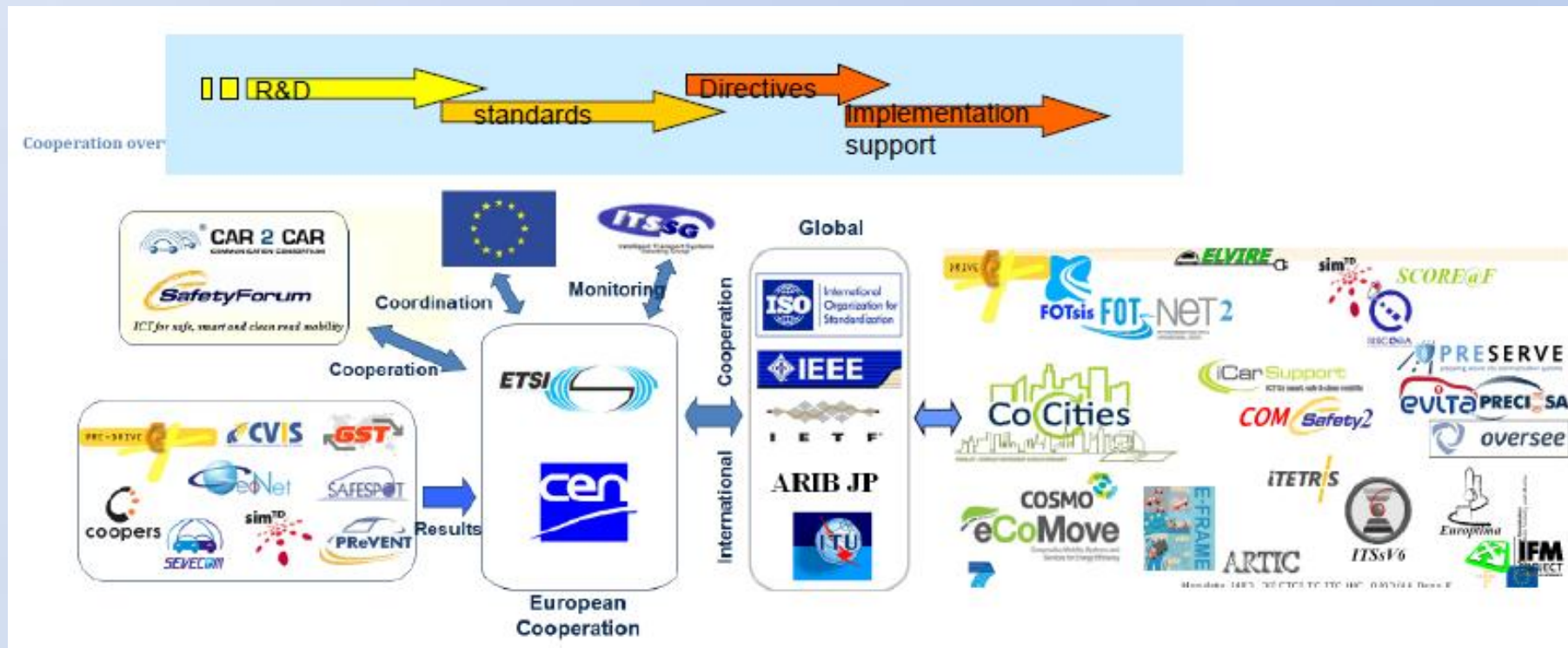
Basic Entities in these networks are: On-board Units (**OBUs**) and Roadside Units (**RSUs**)

Dedicated Short Range Communications (**DSRC**)

Wireless Access in Vehicular Environments (**WAVE**)

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Introduction -- Current Trends



Reference:

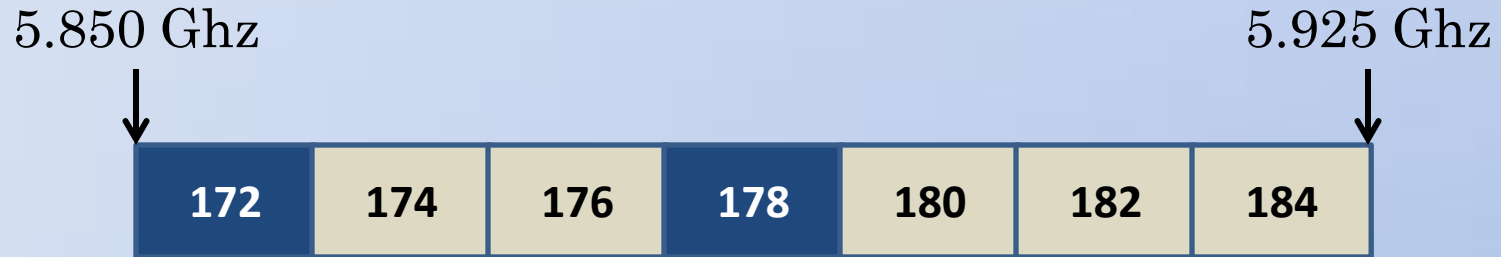
[x] Presentation: "Communications in ITS"

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DSRC



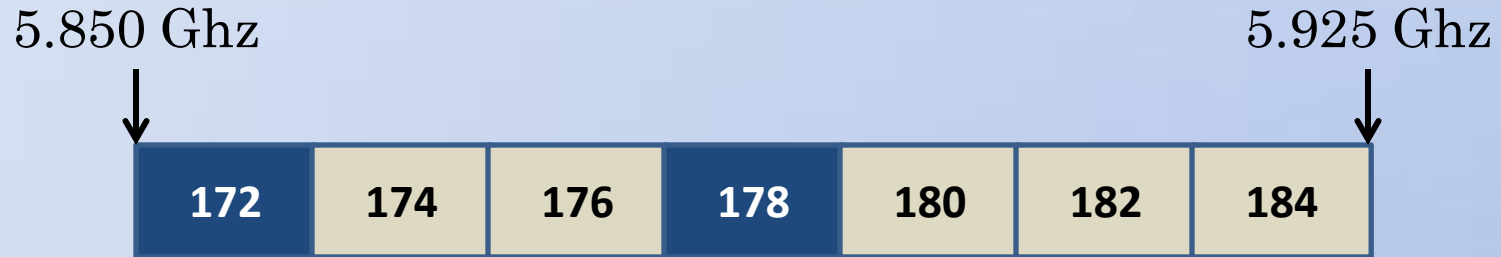
178 : Control CH (CCH)

172 : High Availability and Low Latency
(HALL)

Others : Service CH (SCHs)

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DSRC



WAVE Short Messages (**WSMP**) used on CCH

WSMP and IPv6 protocols used on SCHs

Outline

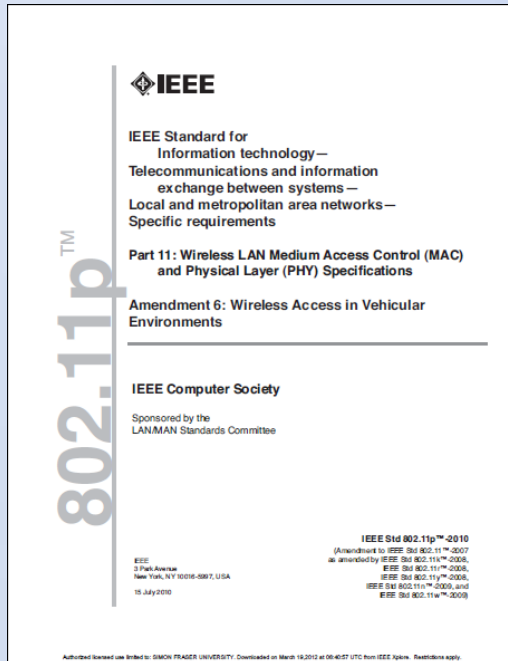
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Standards — IEEE 802.11p

802.11p is an amendment to the 802.11 WLAN standard.

It specifies the PHY layer and MAC Layer



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Standards – IEEE 802.11p + 1604 (WAVE)

		No. of layer	ISO/OSI ref model	Data Plane		Management Plane
Higher Layers	SAE J2735					
	IEEE 1609.1	7	Application	e.g. HTTP	WAVE Application (Resource Manager)	
Network Services		4	Transport	TCP/UDP	WSMP	WAVE Station Management Entity WSME
	IEEE 1609.2 IEEE 1609.3	3	Network	IPv6		
		2b	Data Link	802.2 LLC		
		2a		WAVE MAC		
	Lower Layers	IEEE 1609.4 IEEE 802.11p	1b	Physical	WAVE Physical Layer Convergence Protocol (PLCP)	
		1a	WAVE Physical Medium Dependent (PMD)			

Reference:

[2] “Vehicle Networks, V2X communication protocols” Presentation

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Physical Layer

The random nature of the broadcasting medium leads to time-variant channel characteristics.

- Reflections
- Shadowing and Diffraction
- Doppler Shift

Reference:

[4] *"A survey of V2V channel modeling for VANET simulations"*

[x] *Introduction to Analog & Digital Communications*

Physical Layer

“Multipath propagation and delay dispersion causes frequency selectivity.”

In a static WLAN situation channel fading is less noticeable than in VANETs.

Reference:

[4] *“A survey of V2V channel modeling for VANET simulations”*

[x] *Introduction to Analog & Digital Communications*

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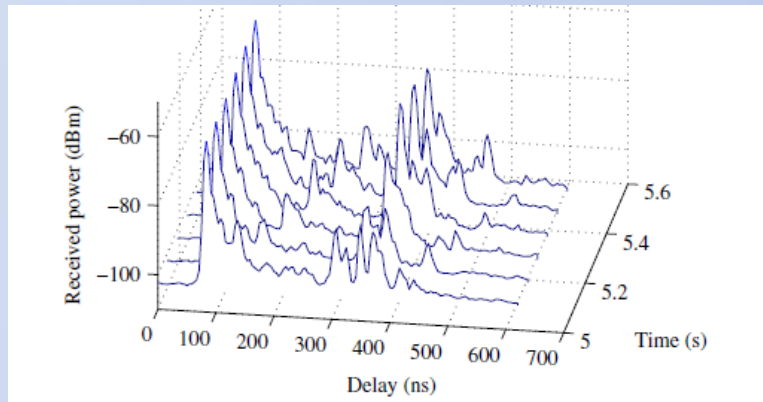
Physical Layer -- Doppler Shift

Car speeds of 90 km/h



Observed
Doppler Shifts
of greater than
1 kHz

Measurement Time (delay) resolution = 4.17ns



Reference:

[7] "Characterization of Vehicle-to-Vehicle Radio Channels from Measurements at 5.2GHz"

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MAC layer

802.11p uses CSMA/CA called Enhanced Distributed Channel Access (**EDCA**).

Channel use coordination is thus distributed where high priority messages have more likelihood to be transmitted no matter which node they originate from.

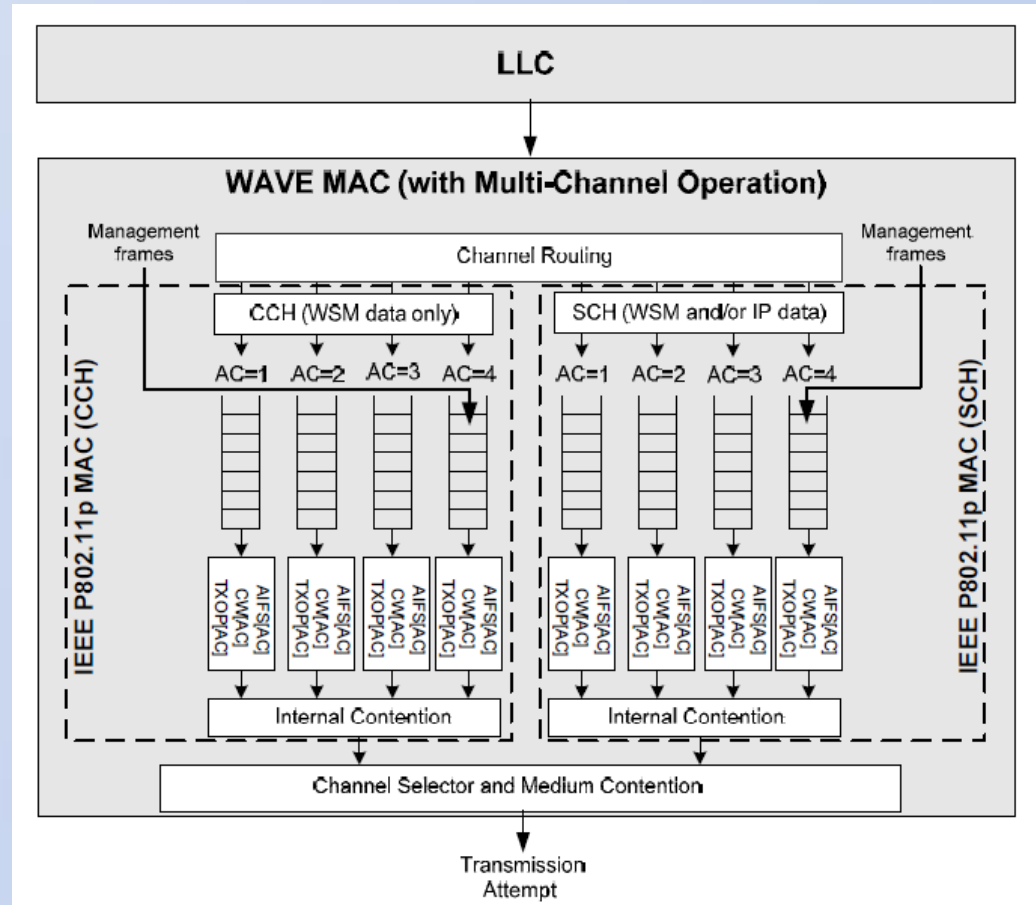
Issues have been raised about the oscillatory nature of the algorithm.

Reference:

[1] IEEE 802.11p -2010 MAC and PHY Layer Specifications

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MAC layer



Reference:

[1] IEEE 802.11p -2010 MAC and PHY Layer Specifications

[x] IEEE 1609.4

Outline

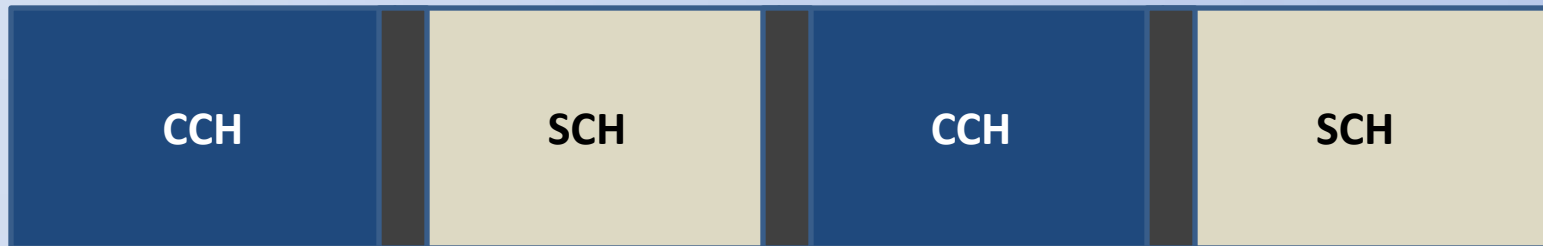
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Walkthrough

1. When a car starts-up it randomly generates MAC and IP addresses. The addresses also change during a drive to prevent tracking.
2. The OBU listens to the CCH, beacons safety apps first
3. Initiation of two-way communication on CCH, then switches to SCH

Walkthrough

4. SCH and CCH intervals change at 10 Hz



Possible Improvements

As explained in reference [8], a ITS network is a real-time system and requires a deterministic upper-bound on communication delay.

It recommends using Self-Organizing Time Division Multiple Access (**STDMA**)

Reference:

[8] *Evaluation of the IEEE 802.11p MAC method for Vehicle-to-Vehicle Communication*

Possible Improvements

By using STDMA nodes are guaranteed a time slot in the CCH interval.

Requires GPS or some other means to provide the timing synchronization.

Reference:

[8] *Evaluation of the IEEE 802.11p MAC method for Vehicle-to-Vehicle Communication*

Possible Improvements

Another reference has a similar approach called Sync-MAC, similar to slotted CSMA.

By synchronizing and also observing which intervals are busy there is a *better packing* of transmissions.

Reference:

[x] Qualcomm Presentation

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Simulation Project

Objectives :

- Use mobility data from SUMO traffic generator
- Use actual GIS data
- And apply the improvement to MAC protocol and compare performance metrics

Reference:

[1] IEEE 802.11p -2010 MAC and PHY Layer Specifications

[5] *Introduction to Analog & Digital Communications*

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Simulation Project -- OpenStreet View

The screenshot displays the OpenStreetMap website interface. On the left, there is a search bar with the text "Where am I?" and a "Go" button. Below the search bar, there are examples of search terms: "Alkmaar", "Regent Street, Cambridge", "CB2 5AQ", or "post offices near Lünen". A red banner below the search bar states: "The OpenStreetMap database is currently in read-only mode while essential database maintenance work is carried out." Below the banner, there is a "Scheduled service notice" indicating that the database will be in read-only mode from April 1st to April 4th. The main map area shows a detailed view of Vancouver, British Columbia, with various streets and landmarks labeled. The map is overlaid with a grid of orange lines representing the VANET network. On the right side of the map, there are navigation controls including a compass, a zoom slider, and a "Standard" map style selector. At the bottom right of the map, there are links for "Permalink" and "Shortlink".

Export Close

Area to Export

49.387

-123.258 -122.741

49.104

[Manually select a different area](#)

Format to Export

- OpenStreetMap XML Data
- Map Image (shows standard layer)
- Embeddable HTML

Export

Reference:

[1] Thesis Project *Tracking Vehicular Motion-Position Using V2V Communication*

[x] *Evaluation of Vehicular Ad Hoc Network protocol and applications through simulations*

Simulation Project -- Channel Model

A realistic 802.11p channel model has been created that is more realistic than the default wireless model in the ns-3 package.

PhySim-WiFi

Reference:

[x] PhySim-WiFi ns-3 manual