Vehicular Communications based on WAVE

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Outline

- Motivation

- Wireless Access in Vehicular Environments (WAVE) operation and MAC

- Proposed MAC protocols

- WAVE Communication prototype

- Future work directions

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Motivation

- High # of road accidents → safety applications to reduce fatalities.

- IEEE 802.11p or WAVE – 802.11 extension to support vehicular networks applications

- Safety services → efficient MAC protocols to bound delay

- Working in a project in partnership with Brisa, S.A. (highway concessionary) and Instituto Superior de Engenharia Lisboa

WAVE operation and MAC

■ WAVE operation

➤ 1 Control channel (CCH) and 6 Service channels (SCHs)

➤ Global channel coordination scheme (CCH and SCH intervals)

■ WAVE MAC

➤ Basic MAC (CSMA/CA based) and EDCA mechanism

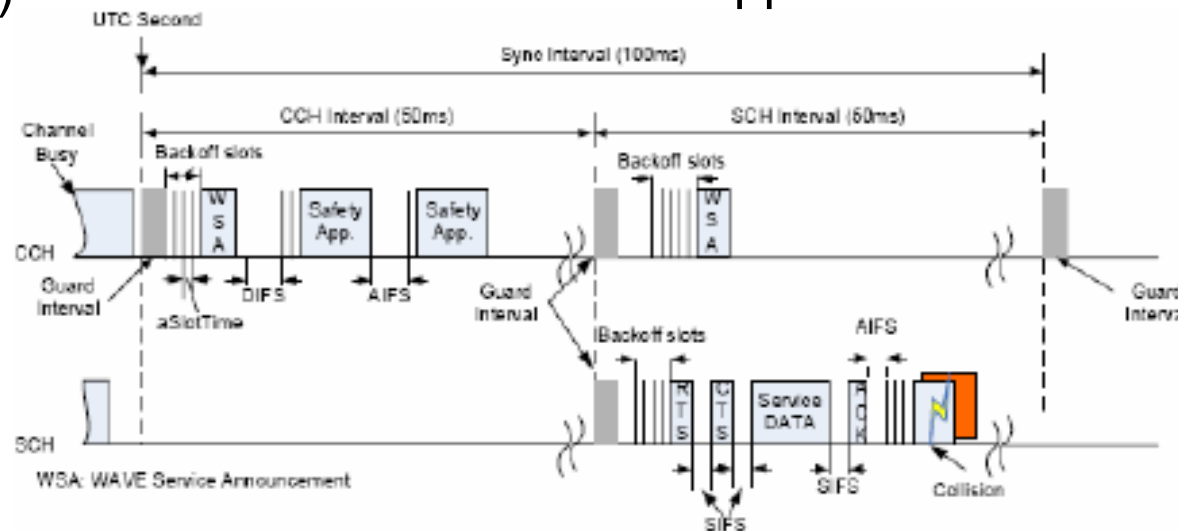➤ Contention based → improve throughput sensitive applications support

Figure 1. Channel access process of IEEE P1609.4/IEEE 802.11p MAC.

V2V MAC Protocol

- A full motorway coverage with road-side units (RSU) might be unfeasible

- Rebroadcast of safety messages done vehicle-to-vehicle (V2V)

- Generating Vehicle transmits frames in one of the safety slots reserved for that purpose.

- From the set of vehicles that listen to the event, how to choose the one who will rebroadcast the message?
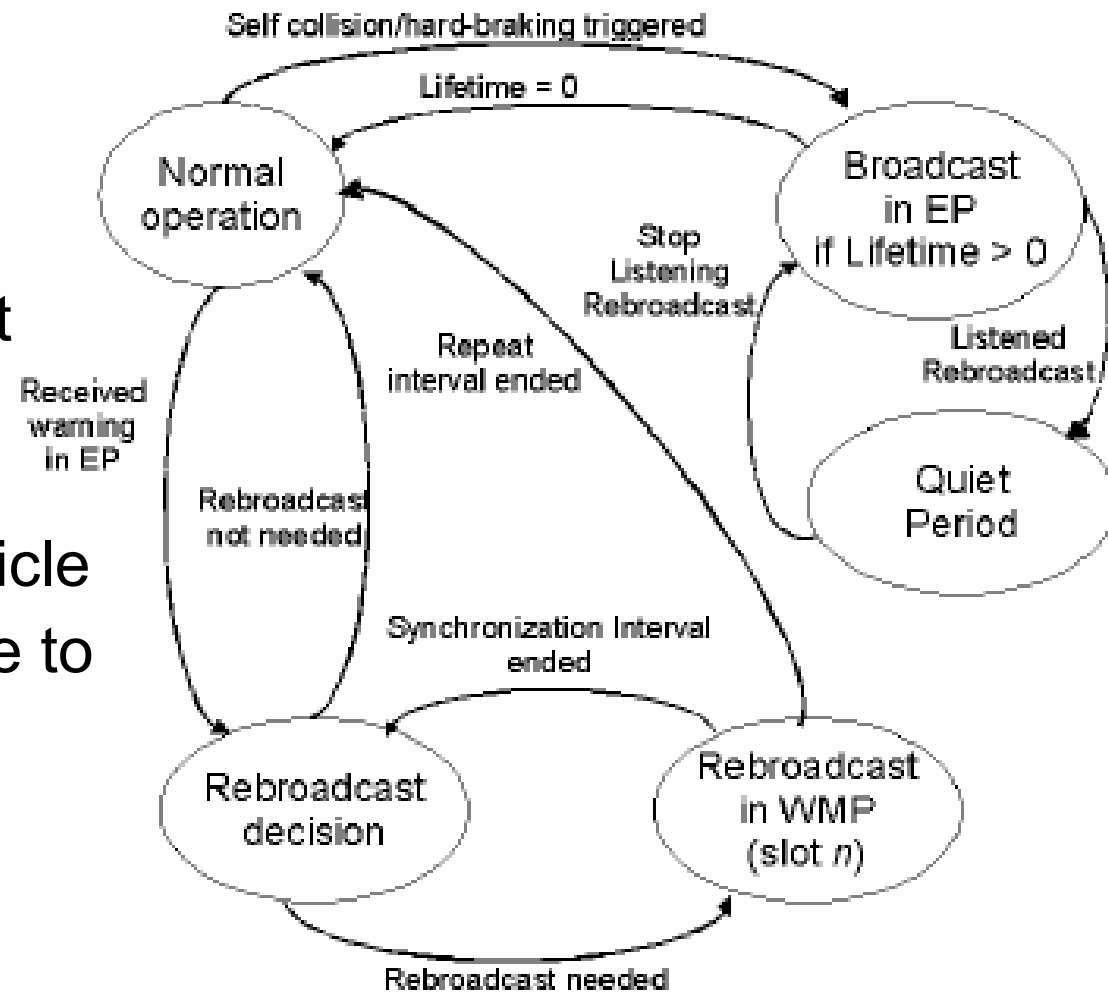
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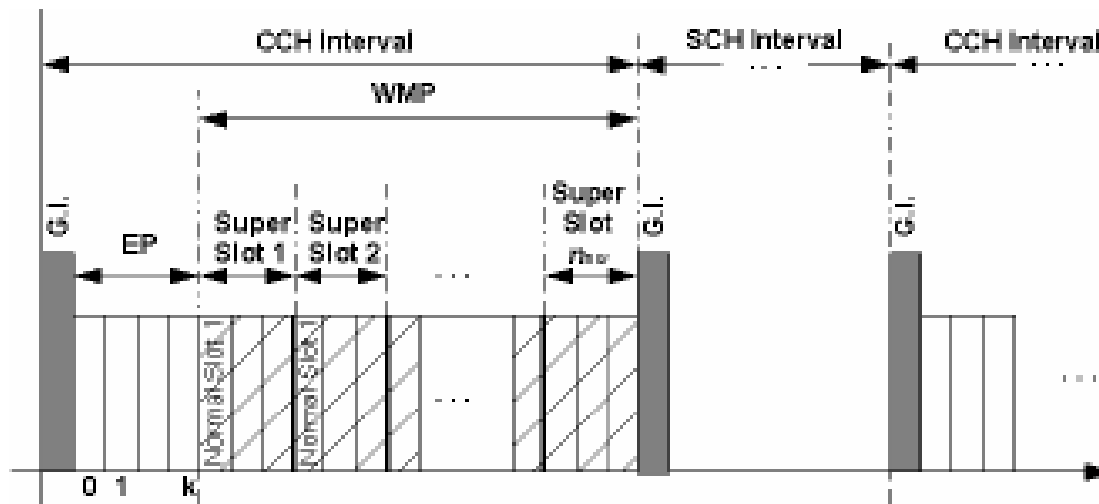# MAC state machine

■ MAC operation

Event features:

➢ EP - Event Period.

➢ Lifetime - rebroadcast time of the event

➢ Safety event ↔ 1 vehicle

➢ Accident → 1st vehicle to disseminate will be the event generator.

➢ Distance of interest, f(event type).

Self collision/hard-braking triggered

Lifetime = 0

Normal operation

Broadcast in EP If Lifetime > 0

Stop Listening Rebroadcast

Listened Rebroadcast

Repeat interval ended

Received warning in EP

Quiet Period

Rebroadcast not needed

Synchronization Interval ended

Rebroadcast decision

Rebroadcast in WMP (slot n)

Rebroadcast needed

Slotted base approach

➤ Which vehicle will rebroadcast the event?

➤ EP - Event Period

➤ WMP - Warning Message Period

➤ EP reserved for generators → no contention, high priority and *k* sub slots for simultaneous generators.

➤ WMP, contention for rebroadcast vehicles, containing Super Slots (SupS), Normal Slots (NS) and Sub Slots (SubS).

I2V MAC Protocol

- Vehicle renewal rate is too low, V2V will take many years until it is really efficient.

- Rebroadcast of safety messages done by RSUs

- Critical issue: coordination between RSUs

IP –
Infrastructure
Period for
RSUs
coordination

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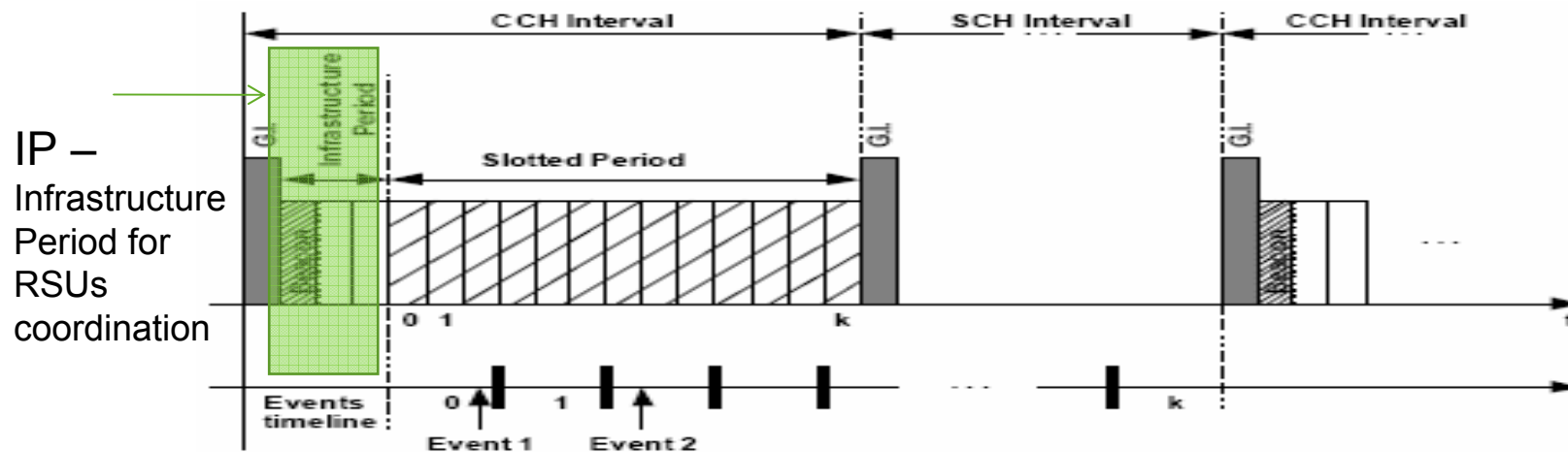
Safety messages within WAVE RSUs

➢ Message's target distance ~ 1km → 3 RSUs needed, each with typical coverage range of 300m.

➢ Rebroadcast done until message's lifetime counter = zero.

➢ **Problem**: 3 "simultaneous" events lead to beacon transmission by several RSUs in the following IP – Infrastructure period.

✓ 5 IP slots (3 – coordination between RSUs + 2 – message dissemination through several RSUs)

▪ **Coordination for "simultaneous" events**

➢ using position of safety event from the vehicle(s) and RSUs' unique identifier solves IP contention;

➢ 2 events leading to same Slotted Period (SloP) slot scheduled → vehicle position field in beacon solves SloP contention;
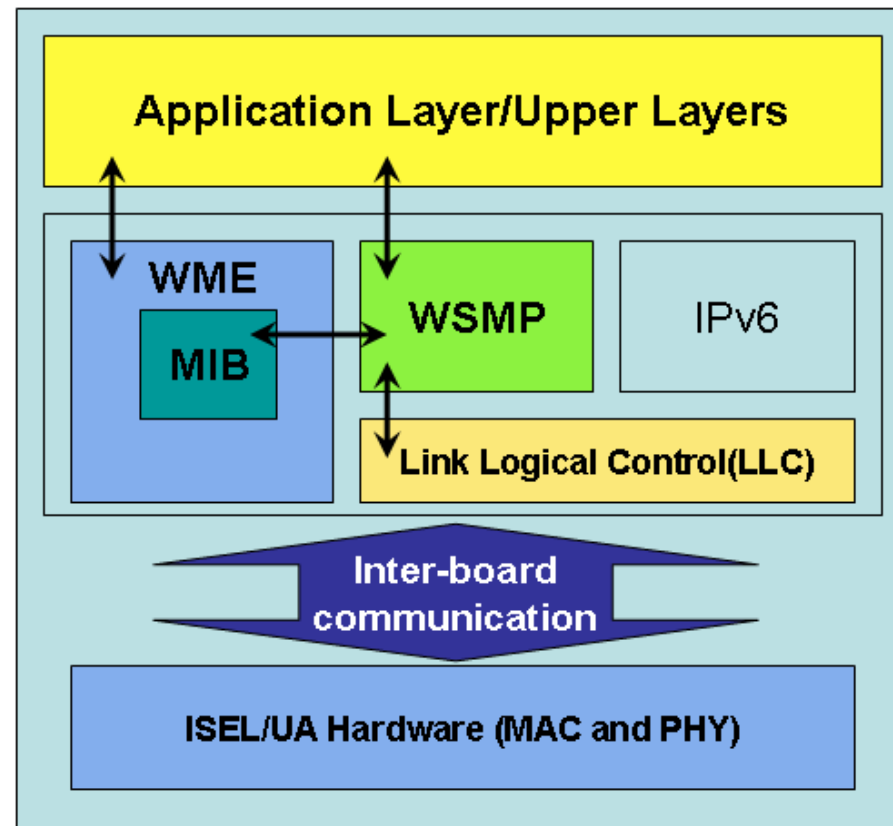
Safety messages within WAVE RSUs

- **Message dissemination**
  - ➤ beacon field controlling the message's target distance and informing the RSU if it shall disseminate the event;

  - ➤ the new RSU beacon sent in one of the 2 final IP slots;

- **Model evaluation**
  - ➤ using lowest WAVE OFDM rate – 3 Mbps, WAVE warning message ~ 500 bits, SIFS = 32µs and GI = 4µs
  - → 226 slots in SloP

  - ➤ 113 events can be dealt by two adjacent RSUs;

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WAVE communication prototype

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Future Work

- **Make miniaturized prototype.**

- **Continue MAC implementation according to IEEE 1609.4 and IEEE802.11p**

- **Evaluate proposed MAC protocols through simulation and real testbeds**
  - On safety applications
  - On infotainment applications and distributed traffic routing

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The end...

Thanks for your attention