MAC Protocols for VANETs

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Ad Hoc Networks Seminar

Based on:

Hamid Menouar and Fethi Filali, EURECOM

Massimiliano Lenardi, Hitachi Europe

A Survey and Qualitative Analysis of MAC Protocols for Vehicular Ad Hoc Networks

IEEE Wireless Communications, pages 30-35, October 2006.

16.02.10

Outline

- What is a VANET?
- Motivation
- Introduction
- Media access in MANETs
- MAC Protocols for VANETs
- Qualitative comparison
- Conclusions

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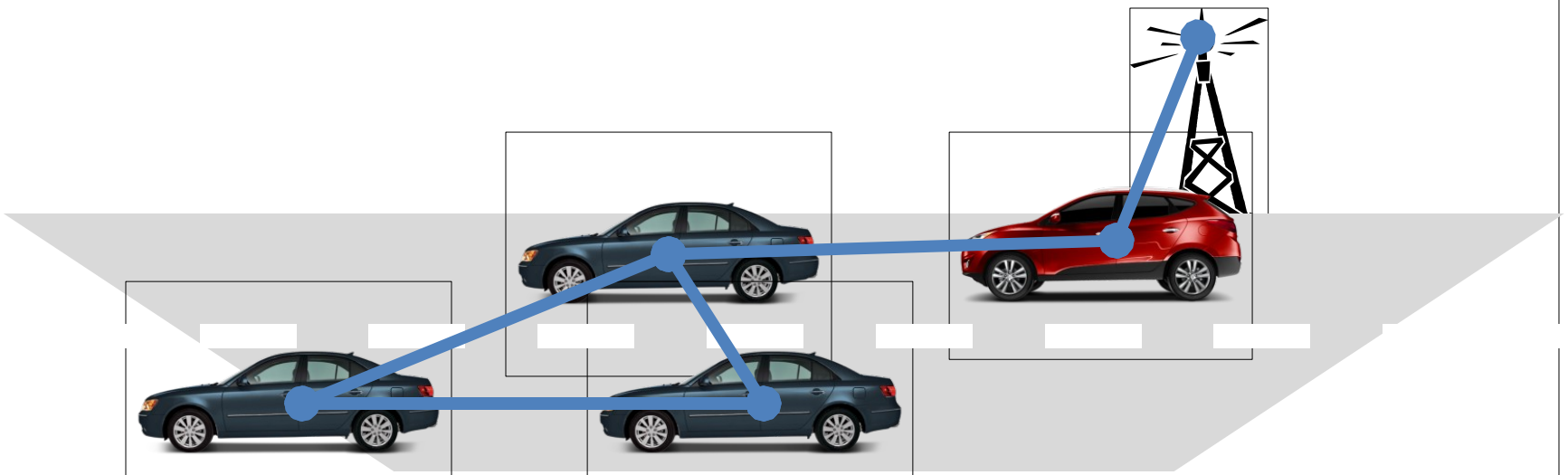
What is a VANET?

- VANET stands for Vehicular Ad-hoc N E Twork
- a special type of MANETs (mobile ad-hoc networks) designed to provide communication between nearby vehicles and between vehicles and road-side equipment



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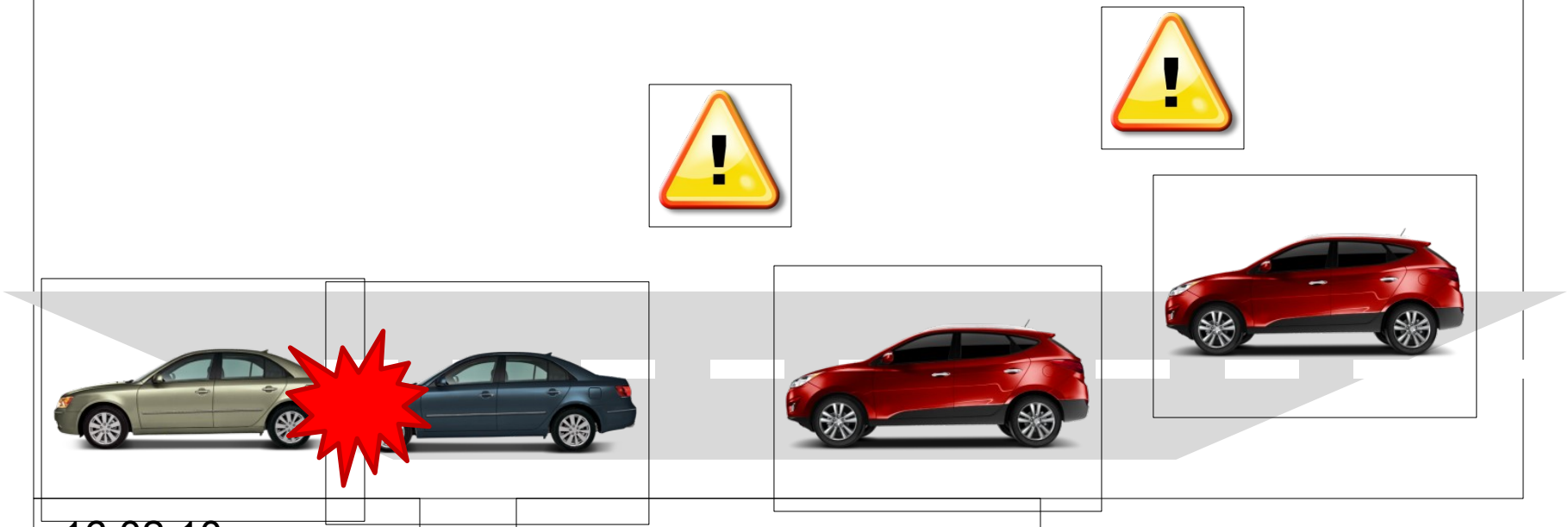
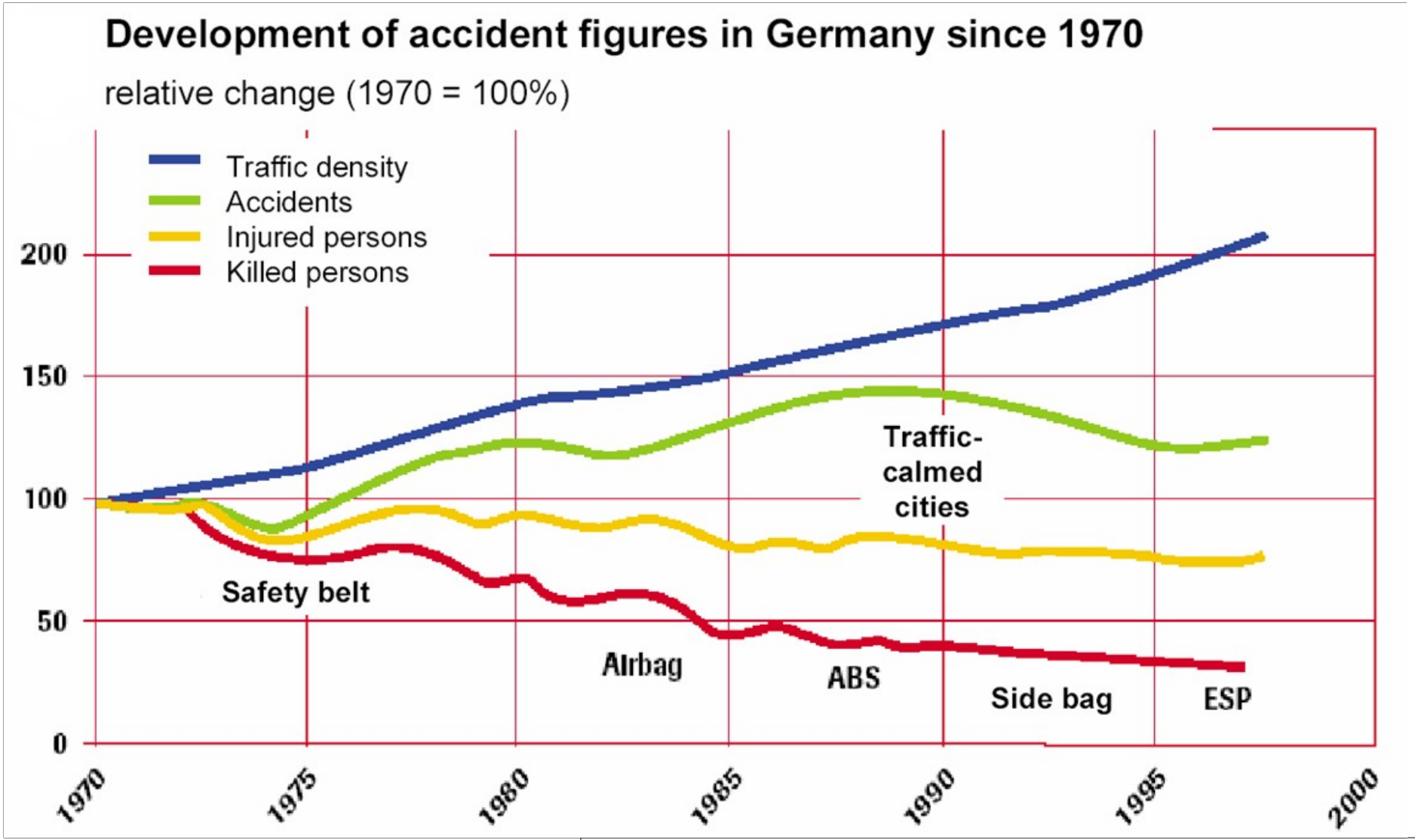
Motivation

Why are VANETs important?

- Active Safety: send warning messages about dangerous traffic situations (an accident, icy road, oil stain, sudden break, etc.)



Motivation



Source: http://events.ccc.de/congress/2006/Fahrplan/attachments/1216-vanet.pdf

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Motivation

And there is more:

- traffic conditions
  - improve traffic efficiency
  - reduce traffic congestions
- driving comfort
  - driver assistance
  - news/info/entertainment applications
- economical reasons
  - 80% of innovation in new cars is electronics
  - ABS & ESP Market: 3 billion € in 2010
  - VANETs Market: estimated to reach 1 billion $ in 2012 [3]

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Introduction

Properties of VANETs:

- decentralized
- self-organizing
- network nodes = cars

MANETs

Introduction

Cellular Networks

- mobile
- centralized

MANETs

- mobile
- decentralized

VANETs

- mobile
- decentralized
- nodes = cars

Source: http://petsymposium.org/2005/workshop/talks/VANET-privacy-final-official.ppt

Introduction

Differences to MANETs:

- restricted mobility (highways and roads)
- fast topology changes (network nodes move at high speeds)
- no power and storage limitations
- nodes are aware of their position (via GPS)

Requirements:

- high reliability

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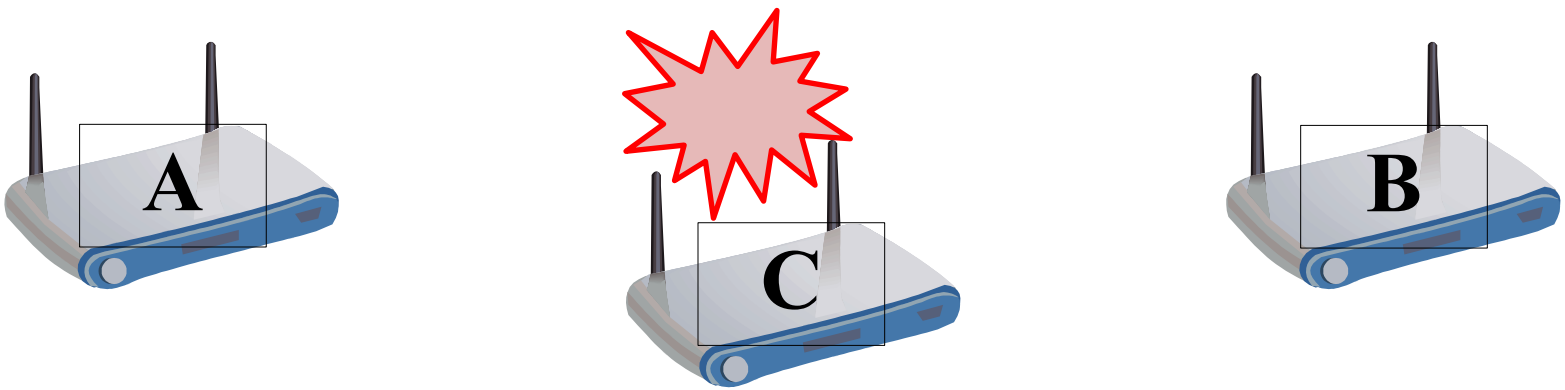
Media access in MANETs

Major problems

- transmission collisions
- hidden terminal problem
- exposed terminal problem

Transmission collisions

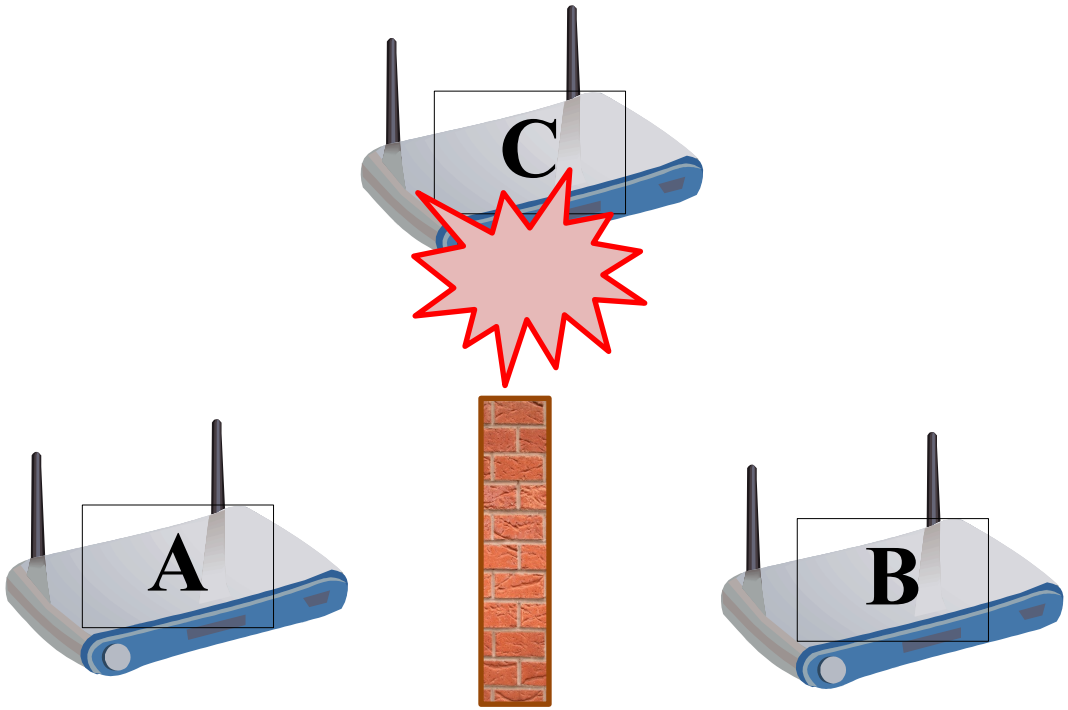
- shared communication medium
- two terminals (A,B) try to transmit at the same time to a third terminal (C)
- solution: terminals should be aware of ongoing transmissions



Media access in MANETs

Hidden terminal problem

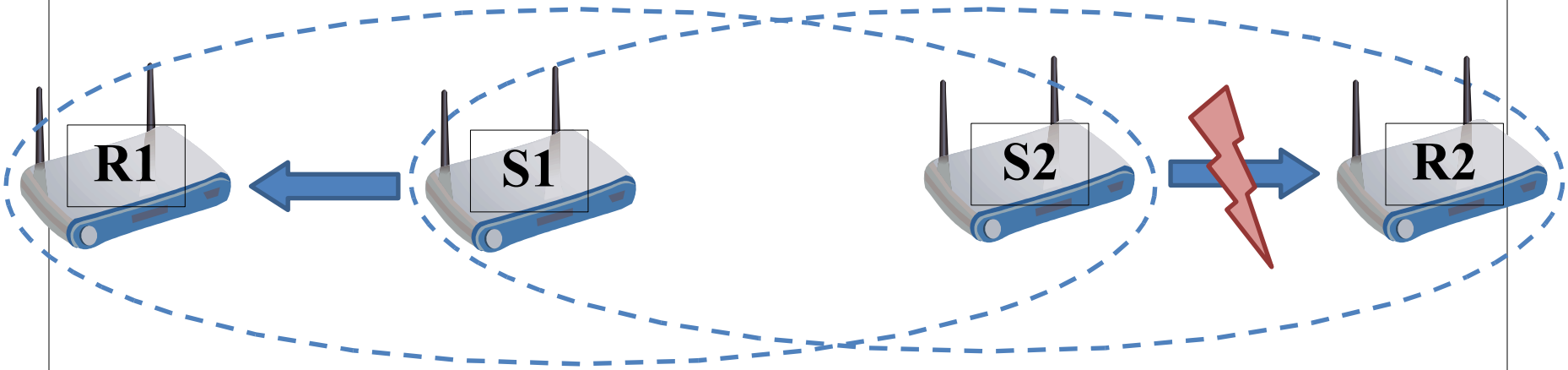
- terminals could be hidden from each other



Media access in MANETs

Exposed terminal problem

- a node (S2) is prevented from sending packets to other nodes (R2) due to a neighboring transmitter.



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MAC Protocols for VANETs

Advantages of VANETs over MANETs:

- restricted mobility (highways and roads)
- no power and storage limitations
- nodes are aware of their position (via GPS)

Disadvantages:

- fast topology changes (network nodes move at high speeds)

Requirements for VANETs:

- reliable communication

MAC Protocols for VANETs

Proposed MAC Protocols:

- IEEE 802.11 Standard
- ADHOC MAC
- Directional antenna – based MAC protocols

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MAC Protocols for VANETs – IEEE 802.11

The IEEE 802.11 Standard

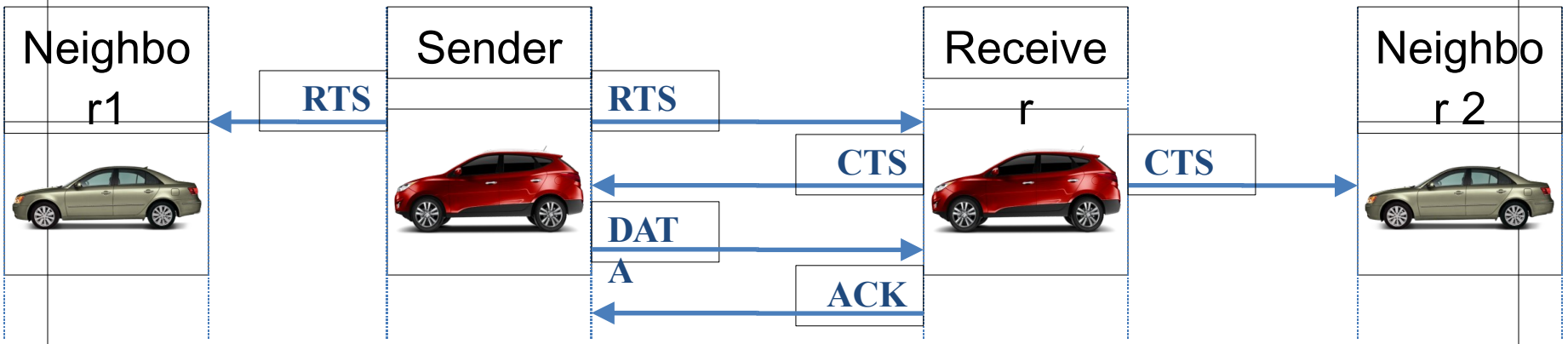
- addresses both the MAC and the Physical Layer
- widely accepted by the network community

IEEE 802.11 MAC

- medium access: Distributed Coordination Function (DCF) based on Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA)
- To solve the hidden terminal problem: virtual carrier sensing using a Network Allocation Vector (NAV)

MAC Protocols for VANETs – IEEE 802.11

IEEE 802.11 MAC



RTS (Request To Send)

CTS (Clear To Send)

ACK (Acknowledge)

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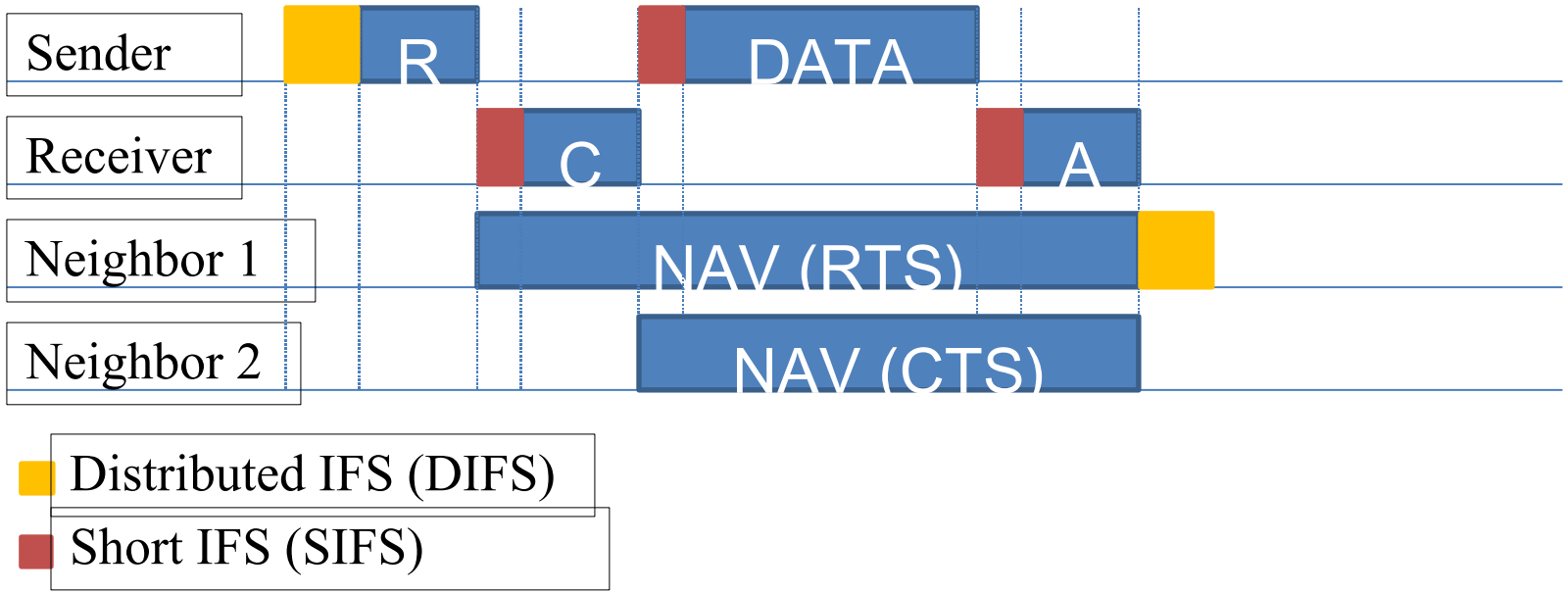
MAC Protocols for VANETs – IEEE 802.11

IEEE 802.11 MAC

- Inter Frame Spaces (IFS) are important
- SIFS < DIFS



MAC Protocols for VANETs – IEEE 802.11

IEEE 802.11p WAVE (Wireless Access in Vehicular Environments)

- an amendment to all IEEE 802.11 protocols
- main goal: adapt the IEEE 802.11 standard for inter-vehicular communications (low latency and high reliability)
- scheduled to be published in November 2010 (according to the official IEEE 802.11 Working Group project timelines)

MAC Protocols for VANETs – IEEE 802.11

IEEE 802.11 PHY (Physical) Layer

Name	Year	Band (GHz)	Throughput (Mbps)
802.11a	1999	5	54
802.11b	1999	2.4	11
802.11g	2003	2.4	54
802.11n	2009	2.4/5	600

MAC Protocols for VANETs

Proposed MAC Protocols:

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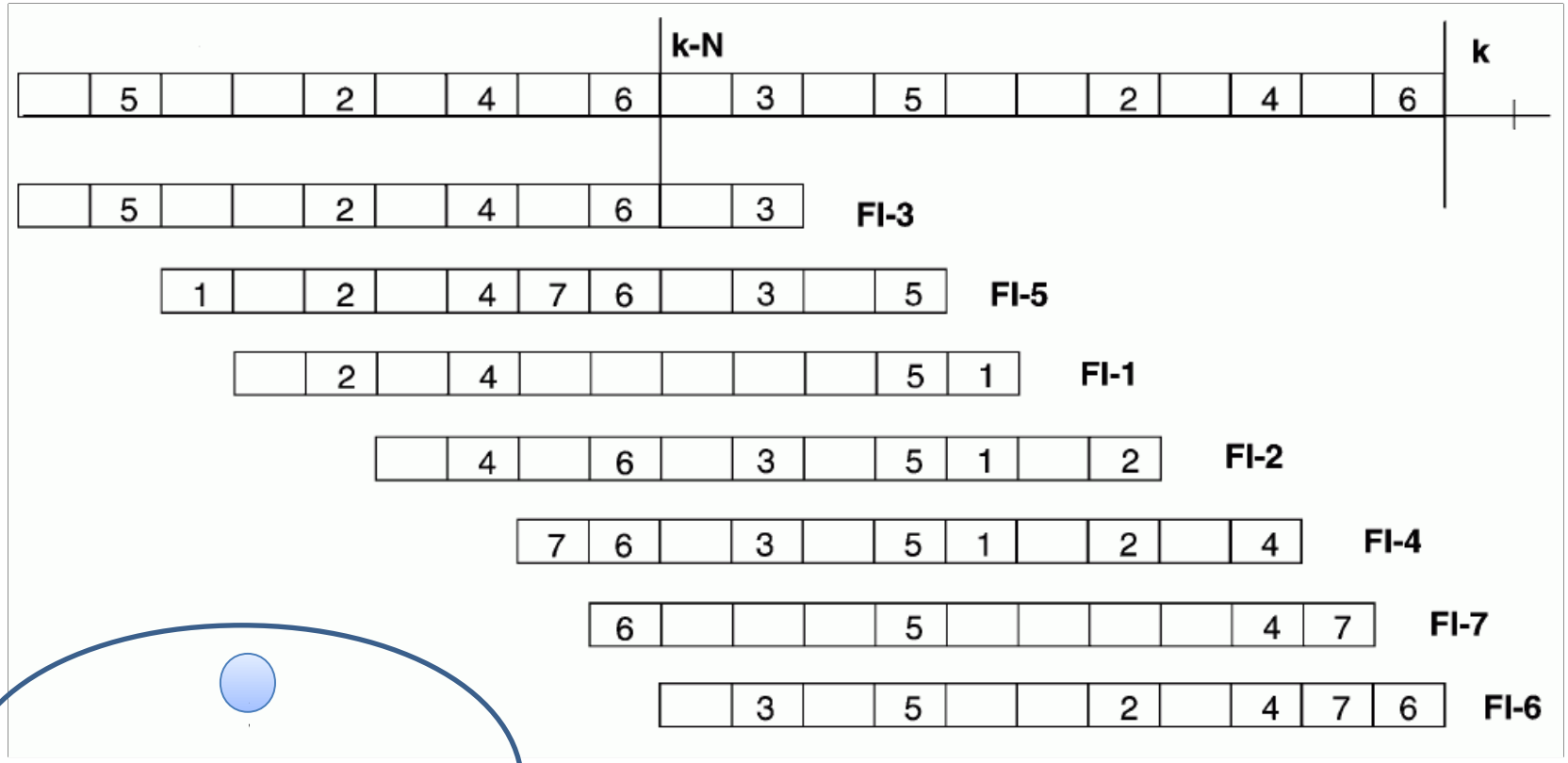
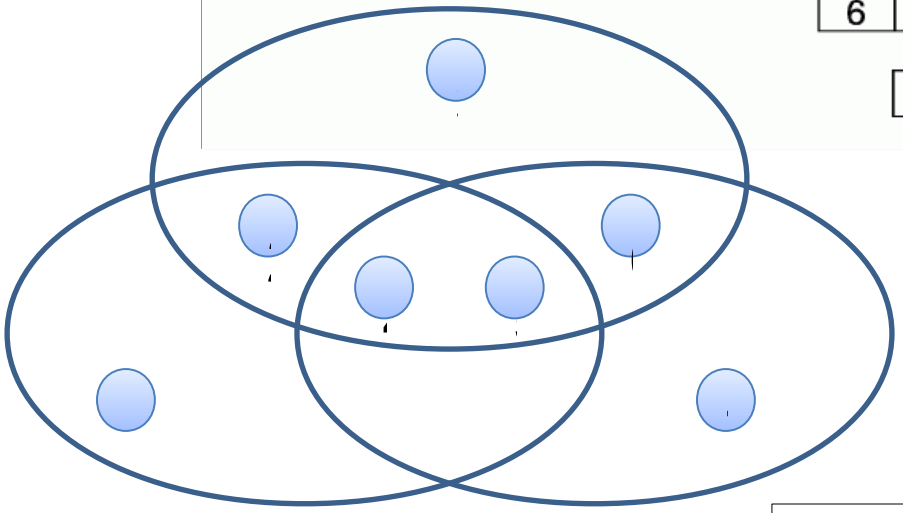
MAC Protocols for VANETs – ADHOC MAC

ADHOC MAC

- based on a circuit switching method: Time Division Multiple Access (TDMA)
- uses UMTS Terrestrial Radio Access Time Division Duplex (UTRA-TDD) as PHY Layer
- uses the Reliable Reservation ALOHA (RR-ALOHA) protocol:
  - the medium is divided into several repeated time frames
  - each frame is divided into N time slots

MAC Protocols for VANETs – ADHOC MAC





Source: [5]

MAC Protocols for VANETs

Proposed MAC Protocols:

- IEEE 802.11 Standard
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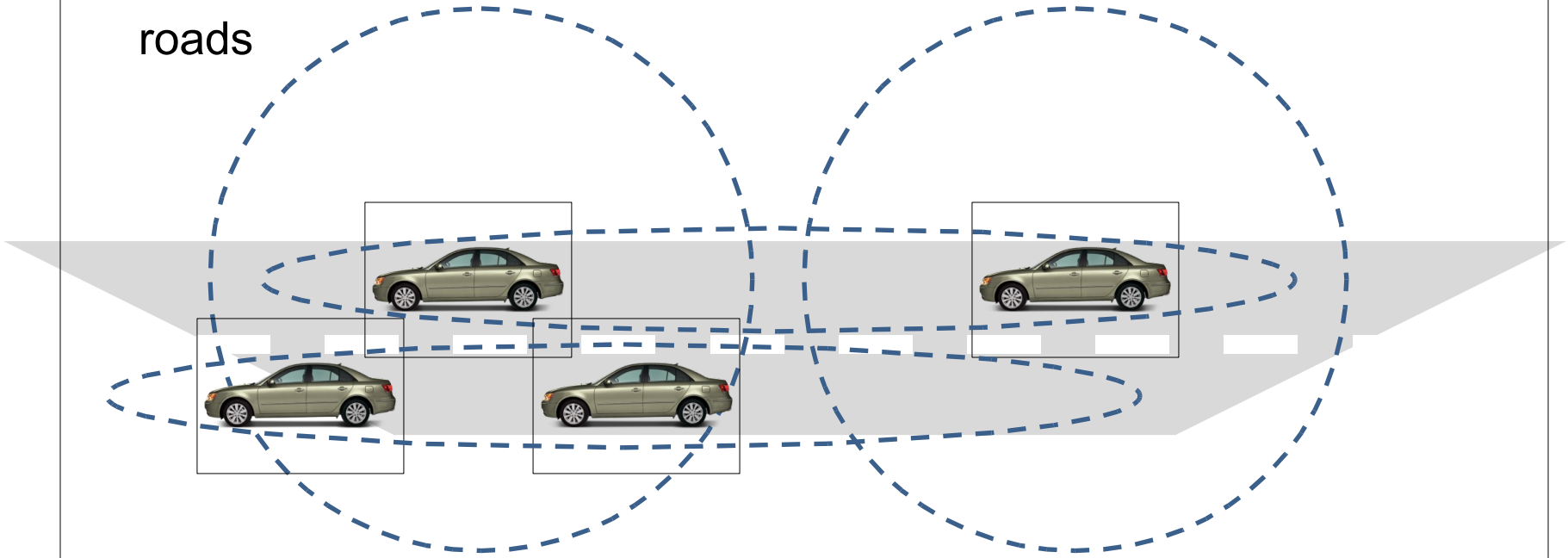
MAC Protocols for VANETs – Directional

Directional antennas-based MAC protocols

- increase the coverage and special reuse, therefore leading to greater channel capacity
- can be a good solution for VANETs because cars move only on roads



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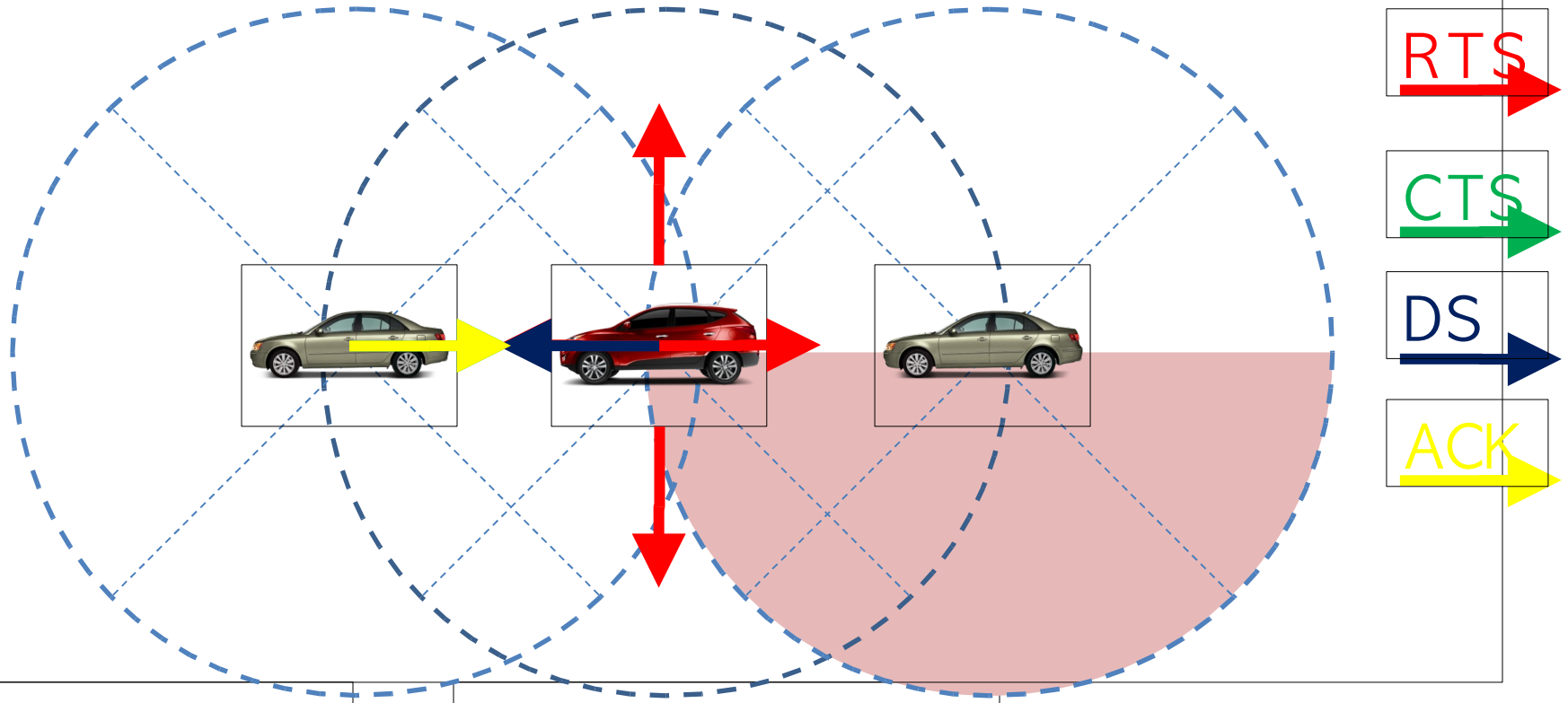
MAC Protocols for VANETs – Directional

Directional MAC (D-MAC)

- each terminal must know its geographic position (easy via GPS)
- Based on IEEE 802.11, uses a 4 way handshake



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Qualitative comparison

	802.11 MAC	ADHOC MAC	D-MAC
Based on	CSMA/CA	RR-ALOHA	CSMA/CA
Implementation maturity	Mature and evolving	Medium	Low
QoS and RT capability	Small	Medium	High
Mobility	Medium evolving to High	Medium	High
Reliability multicast/broadcast	No	Yes	No
Time synchronization	Not needed	Mandatory	Not needed

- IEEE 802.11p could represent a real solution, but waits to be published
- Directional antennas offer high reliability and low latency

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Conclusions

- VANETs have many practical applications, but the most important ones are in terms of active safety
- there are no standardized protocols, but a lot of research is done in this area (http://www.vanet.info/projects)
- VANETs are likely to become the most important realization of mobile ad hoc networks
- what about security?

References

1. Hamid Menouar and Fethi Filali, EURECOM

   Massimiliano Lenardi, Hitachi Europe

   A Survey and Qualitative Analysis of MAC Protocols for Vehicular Ad Hoc Networks

   IEEE Wireless Communications, pages 30-35, October 2006.

2. Florian Dötzer, BMW Group Research and Technology

   Privacy Issues in Vehicular Ad Hoc Networks

   Workshop on Privacy Enhancing Technologies, Dubrovnik, June 2005

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5. F. Borgonovo, A. Capone, M. Cesena and L. Fratta, Politecnico di Milano

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Wireless Networks, *10*, pages 359-366, July 2004.

Conclusions

Thank you for your attention!