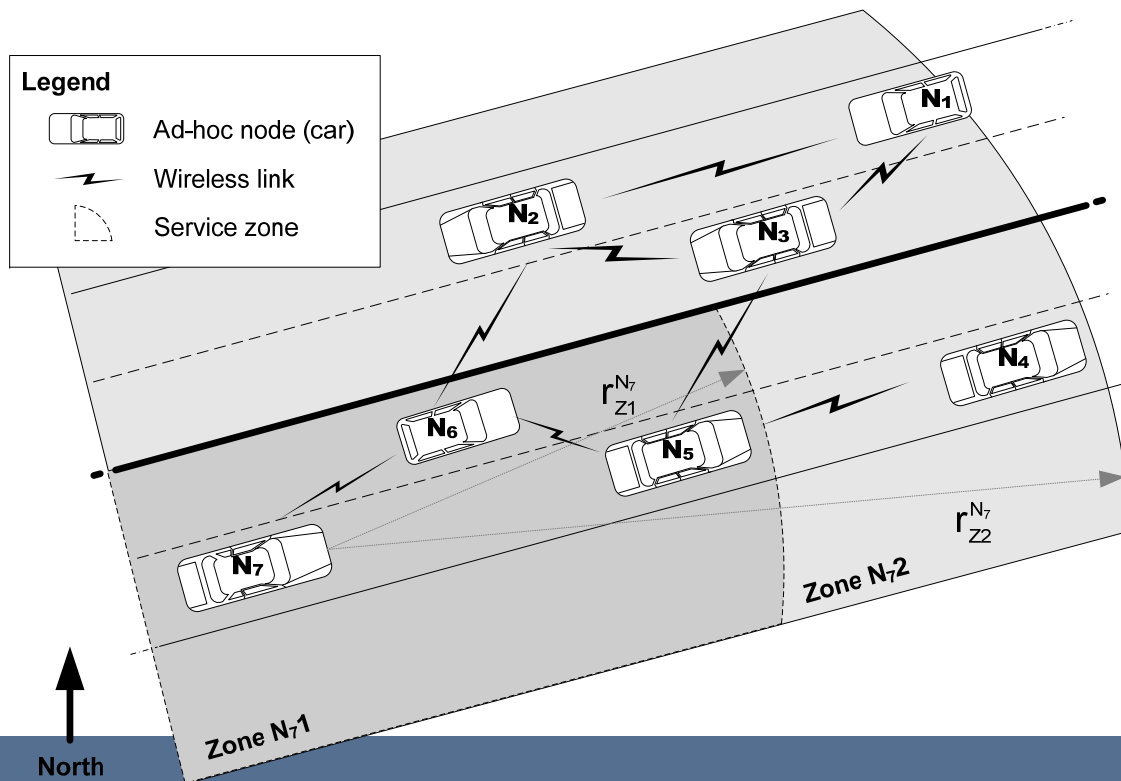


# Car-to-car communication (CC2C)

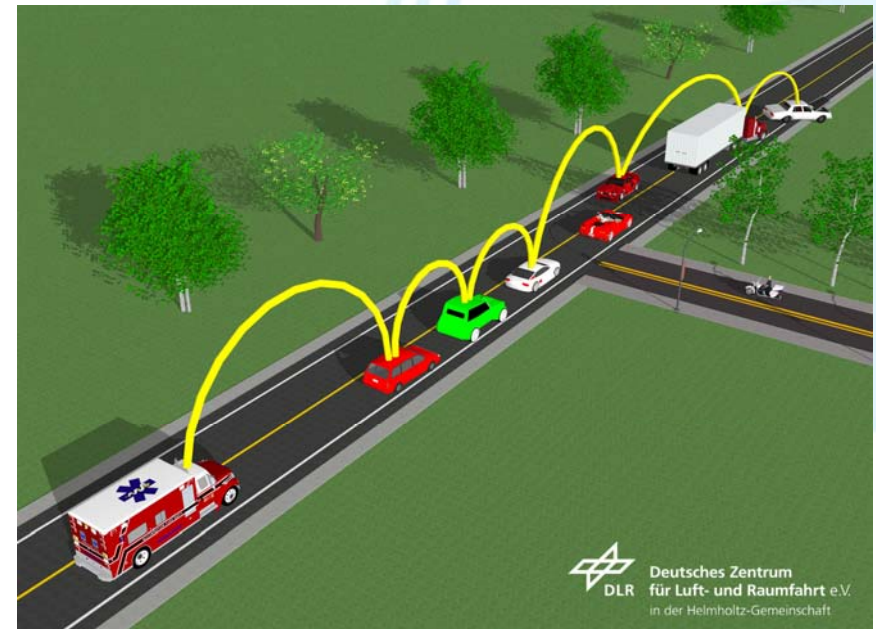


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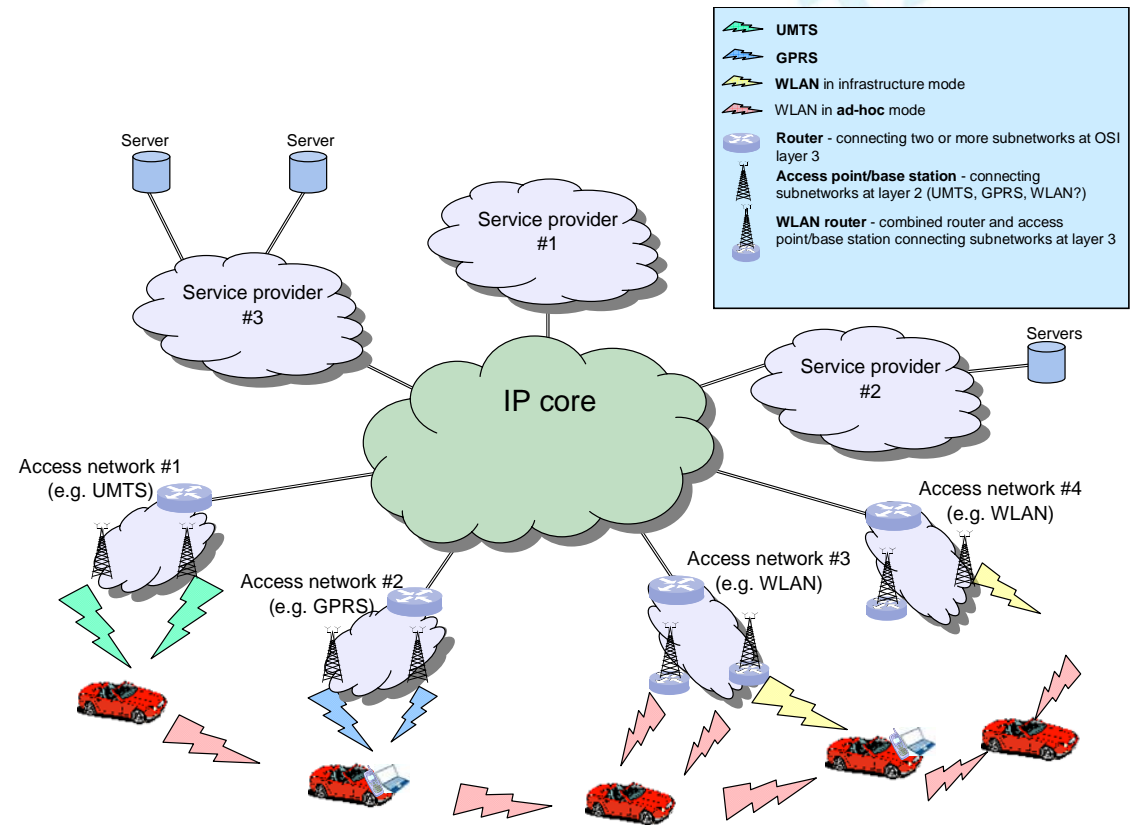
## Outline

- **What is it?**
  - Car-to-Car Communication (C2CC) and Car-to-Infrastructure Communication (C2IC)
- **Why do we need it?**
  - Infotainment and office on move
  - Platooning
- **How can we achieve it?**
  - Challenges and currently available technology



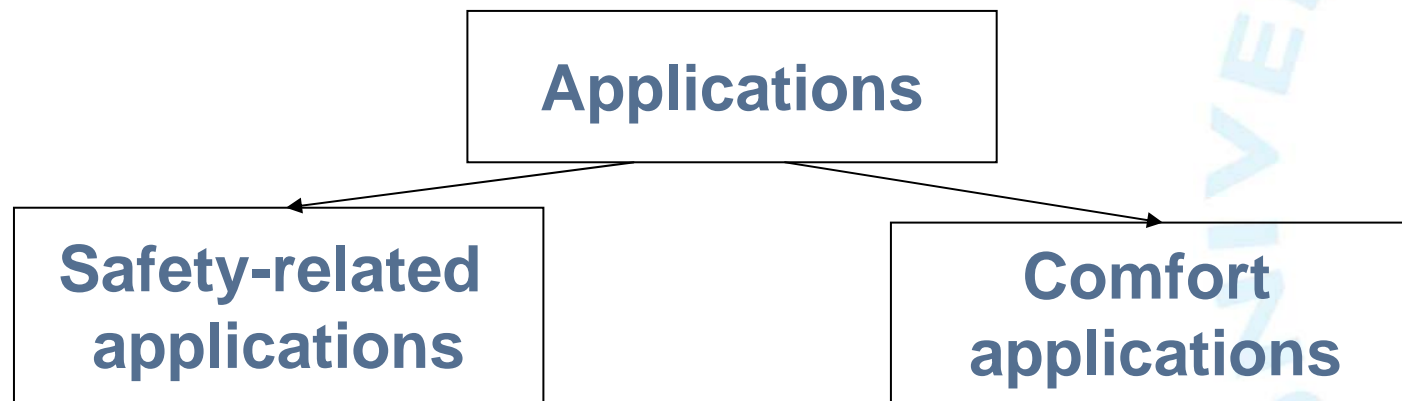
## Network architecture and terminology

- Mobile node: Any node communicating via wireless technologies and protocols so that it can potentially move without losing connection
- Ad-hoc network: When mobile nodes communicate or are ready to communicate directly without an infrastructure, i.e. within the ad-hoc domain
- Gateway: A node equipped for interfacing with another network that uses different protocols



## Applications

Integrating a network interface, GPS receiver, different sensors and on-board computer gives an opportunity to build a powerful car-safety system, capable of gathering, processing and distributing information.



- Assistance (navigation, cooperative collision avoidance and lane-changing...)
- Information (speed limit...)
- Warning (road condition warnings, emergency braking alarms...)

- Information (POI localization, current traffic info...)
- Interactive communication (online games, instant messaging...)
- Office applications

## Infotainment and office work on move

Addresses a scene where people use their normal pc applications while on move as

- Passengers in cars, taxis, trains or even pedestrians

Use of applications for

- Checking emails
- Browsing of websites
- Accessing to a company's intranet
- Download and upload of documents
- Telephoning via VoIP
- Playing online games (with people in surrounding car)
- Watching TV or video
- Collecting tourist information about passing scenery

Use of a multitude of devices and applications in and outside vehicles by users with different preferences

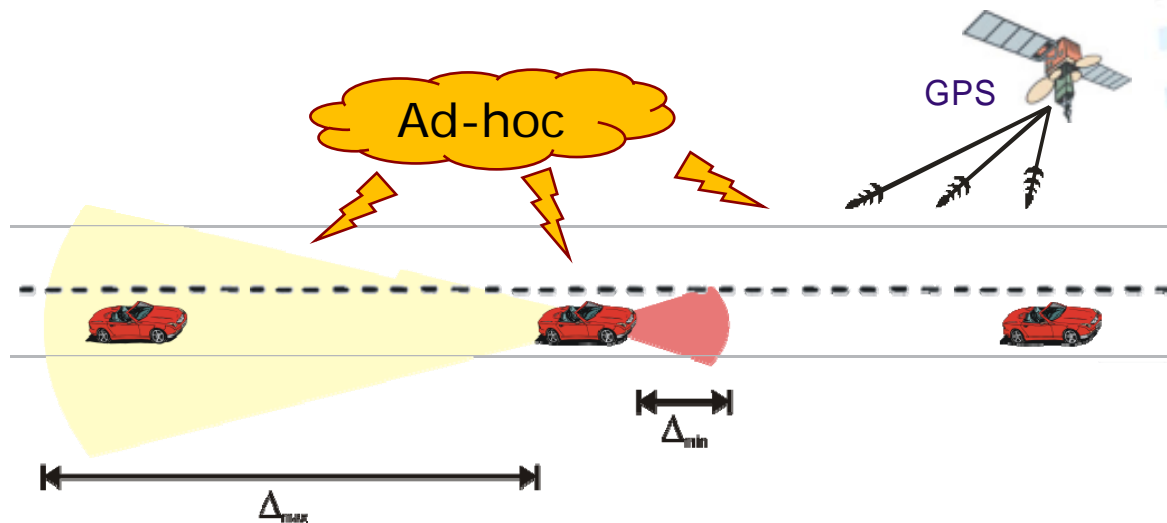
## Infotainment and office work on move

### Challenges

- Entertainment Applications require
  - Realtime requirements
  - Video and TV additionally need large receiver buffer to cope with temporarily timing faults and out of order messages
- Office Applications may need
  - Session completeness
  - Correctness of messages
  - Web-shopping additionally require security requirements like authentication and encrypted communication
- Tourist information is not a time critical application but requires appropriate filtering of relevant information

## Platooning - Description

- A platoon is a group of at least 2 vehicles driving in cooperation
- Vehicles of a platoon communicate to each other in a ad hoc network



## Platooning – Motivations

What kind of benefit could platooning facilitate?

Benefits for Drivers:

- Drivers of subsequent platoon vehicles don't need to steer or control, but can use time for other things like reading
- Subsequent platoon vehicles can reduce gas consumption by driving in the slipstream of preceding vehicles

Benefits for general public

- Efficient use of road space
- Reduction of traffic jams and air pollution

## Platooning – Communication Strategies

Strategies for the intra platoon communication



Communication is established from neighbor to neighbor



Every member receives and send information from/to the entire platoon

## Platooning - Challenges

### Challenges and faults to be mastered

- Timeliness : larger delays of message transmission lead to safety problems
  - Multi hop communication is required in larger platoons
- Omission Faults: a car fails to send or receive a message
- Throughput: quick and efficient sharing of scarce radio resources with cars in vicinity
- Value Faults: transmission error rate need to be Actuator commands (brake commands)
- Trustworthiness: information distributed inside a platoon need to be true

## Unique characteristics of vehicle networks

- Rapid topology changes and frequent fragmentation, resulting in small effective network diameter
- Virtually no power constraints
- Variable, highly dynamic scale and network density
- Driver might adjust his behavior reacting to the data received from the network, inflicting a topology change

## Wireless access technologies

Most relevant communication technologies

- Communication to infrastructure
  - Cellular (UMTS/GPRS) , WIMAX and WLAN
- Ad-hoc communication
  - WLAN (the 802.11 family of protocols, especially 802.11p)
- Combined wireless access
  - Different interfaces in a single, uniform system → redundancy + application performance
  - ISO TC 204 WG16, called CALM M5 (Continuous Air Interface for Long and Medium range)

## Spectrum issues

- 5.9 GHz DSRC (Systems-Dedicated Short Range Communications) is the emerging communication technology that offers standardized ITS products
- In the US the FCC has already allocated 75 MHz of spectrum at 5.9 GHz band
- In Europe a continuous spectrum of 75 MHz is not available in DSRC band
  - Proposal: 2 x 10 MHz for primary use of safety critical applications at 5.9 GHz range + additional spectrum at either 5 GHz or in 5.8 GHz band for non-safety critical and commercial application
  - → Potential for world-wide harmonization

## Networking issues

### Broadcasting and message dissemination

- The foreseen applications will require a vast amount of information to be broadcasted: potential use of narrow band solutions like FM radio; wider bandwidth solutions like DAB, DVB, DVB-H; satellite broadcasting
- Location-aware broadcasting

### Routing issues

- Frequent network partitioning
- “carry and forward” approach instead of traditional routing

### Security and privacy

- Trust (vehicles are able to trust the messages they receive), resiliency (resiliency for interference), efficiency (e.g. real-time message authentication)
- Anonymity must be preserved. Example: 802.11p introduces dynamically assigned MAC addresses

## Current projects and standardization

### Europe

- Car2Car Communication consortium – a non-profit organization initiated by European vehicle manufactures in 2004. Goal: an open European standard for C2CC systems based on WLAN components and guarantee European-wide inter-vehicle operability
- CarTALK, PROMOTE-Chauffeur, SAFESPOT, FleentNet, HIDENETS, Network on Wheels ...

### USA

- Vehicle Safety Communication (VSC) Consortium – since 2002 working on development of DSRC standards, protocols and applications; adopt 802.11p

### Japan

- Approach: the public sector builds the basic services for information and safety → more attractive to buy the on-board unit
- 2 main initiatives: vehicle-based (Advanced Safety Vehicle) and infrastructure-based (Advanced cruise-assist Highway System) cooperative systems. Combination of two: Smartway

## Economic issues

- There are two mechanisms that lead to a successful market introduction for consumer technologies:
  - A visible added value of the technology to a customer
  - A regulative order that does not leave alternatives, requires its use
- It was estimated that in order to make the network usable, at least penetration of 10% is needed
- Need to introduce C2CC and C2IC together. The fixed nodes can be installed independently from the market penetration rate. That way all the users can get some functionality from the start.

## Conclusions

- We have listed some open research challenges that need to be addressed in order to complete the standardization process
- Some economical and legal issues remain unsolved
- The technology promoted by the car industry will inevitably lead to one universal standard, based on WLAN/ CALM M5/ IEEE 802.11p