Vehicular Communications

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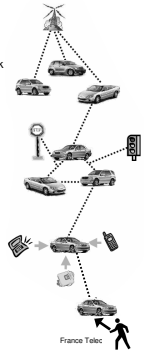
Outline

- Vehicular networks
  - Definitions
  - Characteristics
  - Challenges
  - Actors
  - Applications and services
- Orange activities
  - Orange actual developments
  - Orange R&D activities
- Conclusion
- References

Vehicular networks: definitions

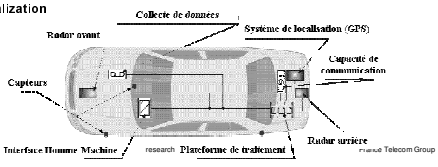
- Connecting vehicle to the infrastructure - V2I to be able to retrieve information (e.g. diagnostics data, **location**, **local traffic information**,…) from the vehicle or to allow vehicle to access network resources (e.g. **Internet access**, …)
- Connecting vehicles to each other - V2V and with the infrastructure allows them to share and exchange information and sensor data among each other and among them and the infrastructure (e.g. for **entertainment**, diagnostics, **safety**, probe data collection, etc.)
- Connecting portable devices to the vehicle allows us:
  - To enhance the vehicle's functionality (e.g. **digital address book as input to the navigation system**, MP3 player to play digital music)
  - To make use of vehicle resources on the portable device (e.g. **better connectivity**, audio system,…)
- Connecting vehicle to pedestrians – V2P (e.g. **pedestrian safety**, make contact between pedestrians desiring to go to a given destination and vehicles capable of transporting pedestrians to the destinations)



Adapted from W. Hollelder (Daimler/Chrysler)

Vehicular networks: definitions

- Smart vehicle
  - **Sensing** and close environment perception using different sensors and cameras.
  - **Processing and storage** capacity on board permits to interpret the large collected information with the purpose of helping the driver to make a decision
  - **Communication** for information exchange and diffusion in the vehicular network itself or with other networks permitting to increase the perception perimeter of e vehicle
  - **Localization**



Vehicular networks: characteristics

- Vehicles have
  - Higher computational capability (+)
  - Almost unlimited energy sources (+)
- Mobility characteristics
  - Topology changes at a very high rate (-)
    - Challenges in all layers
  - Nodes move on predictable trajectories, usually 1-D (+)
- Connectivity
  - Much harder to assure connectivity (-)
  - Must be able to handle network partitions (-)
- Communication
  - Broadcast, multicast, group communication is more common than unicast communication (especially for C2C communications)

Vehicular networks: "challenged networks"

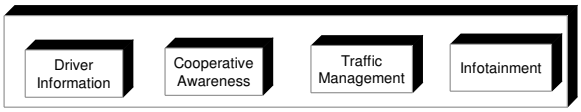
- Technical challenges
  - Mobile wireless environment challenges
    - Scalability will require robust
      - Dynamic channel congestion control methods (power and rate control)
      - Routing, broadcasting and information dissemination
      - Self-organization
    - Reliability and mobility will require robust
      - Handoff and mobility Mgt.
      - Routing and dissemination
      - Time-sensitivity
      - Self-organization
    - Authentication, Authorization and Accounting (AAA)
      - Authentication between participants
      - Access control and authorization for services' access
      - Accounting for the provided services
    - Secure communication
  - GPS technology challenges
    - Lane level accuracy at low cost will be an issue
    - Coverage (outages due to obstructions) will be an issue

Source: Car-to-car consortium

Vehicular networks: "challenged networks"

- Socio-economical/political challenges
  - Frequency allocation: is the allocated frequency sufficient?
  - Standardization development
  - Market introduction (laws, advantages)
  - Set up infrastructure
  - Economical models
  - Driver experience

Vehicular networks: applications and services



Vehicular networks: applications and services

Driver Information | Cooperative Awareness | Traffic Management | Infotainment

Examples:

- Hazard (danger) Warning
- Road Works
- Weather Information
- End of Traffic Jam

Communication Pattern / requirements:

- Event driven
- Many recipients
- Big target area
- Send and Route Sensor Data
- Physical Transport of Information
- Determine Validity of Data
- Ensure Integrity of Data
- Lower to medium penetration rate

Vehicular networks: applications and services

Driver Information | Cooperative Awareness | Traffic Management | Infotainment

Examples:

- Mutual awareness
- Collision avoidance
- Merge assistance
- Intersection assistance

Communication Pattern / requirements:

- Low latency
- High reliability (high channel capacity, low packet loss)
- Very frequent messages (every few ms)
- Very high penetration
- Few recipients
- Small target area
- Many applications require same information but with different accuracy and update frequency

Vehicular networks: applications and services

Driver Information | Cooperative Awareness | Traffic Management | Infotainment

Examples:

- Real time traffic information
- Traffic management
- Traffic light assistance
- Intersection management
- Remote control and monitoring (fleet management)

Communication Pattern / requirements:

- Infrastructure support
- Small penetration rate required

Vehicular networks: applications and services

Driver Information | Cooperative Awareness | Traffic Management | Infotainment

Examples:

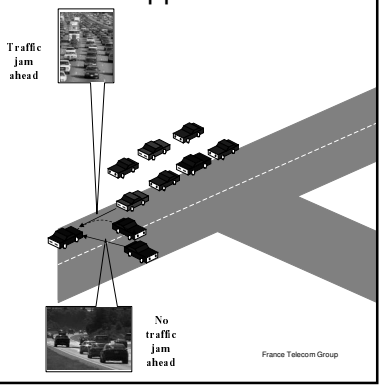
- Mobile office (Internet, email, file transfers ..)
  - Location based services and charging (parking, road usage, local restaurants and gas station, local traffic info, diverse advertising useful for passengers, dynamic map updates, car following ..)
  - Downloading: movie trailers, on-demand recorded radio programs, tourist information may be available on some hotspots and be downloadable to those on-board.
  - Entertainment (video-on-demand, games, chat ..)

Communication Pattern / requirements:

- IP Connectivity
- High bandwidth consumption

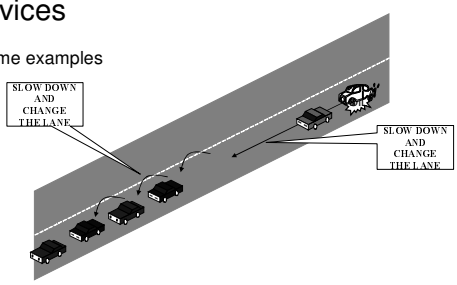
Vehicular networks: applications and services

- Some examples



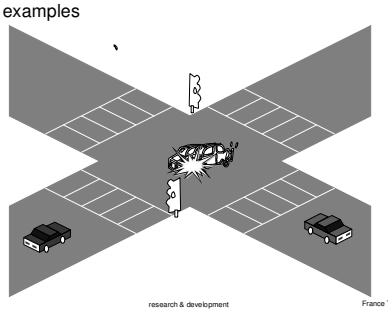
Vehicular networks: applications and services

- Some examples

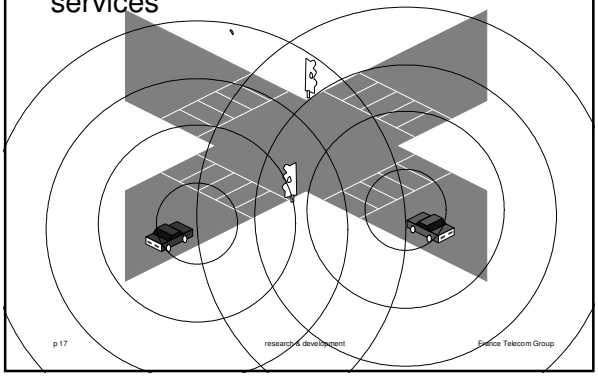


Vehicular networks: applications and services

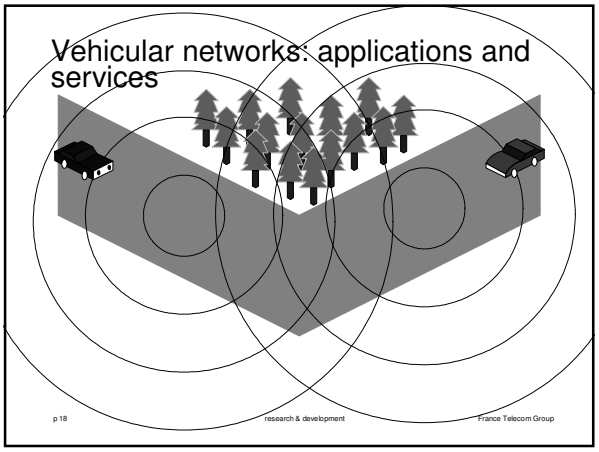
- Some examples



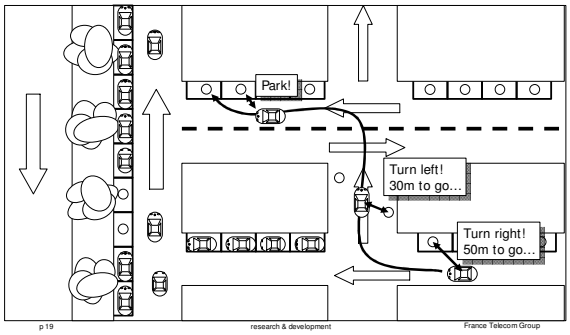
Vehicular networks: applications and services



Vehicular networks: applications and services

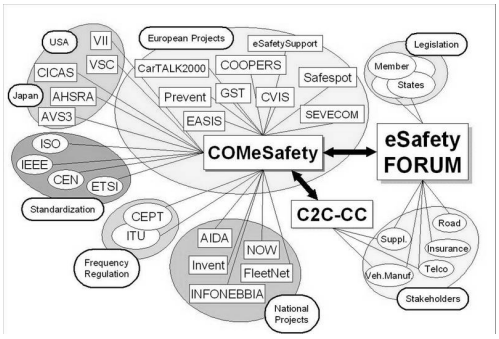


Vehicular networks: applications and services - SmartPark



Courtesy: Matt Grossglauser, EPFL http://smartpark.epfl.ch

Vehicular networks: actors



Vehicular networks: some actors

- Governments
  - USDoT (*US Department of Transportation*) for example
- Industrials
  - Car manufacturers: BMW, Toyota, Chrysler, Daimler Benz, Ford, General Motors, Honda,
  - Manufacturers: NEC, Hitachi,
  - Operators: Orange labs, Deutsche Telekom, Telecom Italia, etc.
  - Software: Dash, Google, TomTom, Microsoft
- Universities
  - UCLA, University de Karlsruhe, University de Stanford, INRETS, etc.

US Research Projects

Old projects

- VSC (Vehicle Safety Communications)
  - DSRC (Dedicated Short Range Communications) for active safety applications

Current projects

- VII (Vehicle Infrastructure Integration) Initiative
  - Advanced v2v and v2i communications for safety and traffic efficiency
- CICAS (Cooperative Intersection Collision Avoidance System)
  - Intersection collision avoidance using v2v and v2i communication

EU Public Funded Projects

Old projects

- Aide
  - Driver Vehicle Interface
- EASIS
  - Electronic architecture
- PReVENT
  - Preventive Safety
- GST
  - On-line Safety service´s

Current projects

- SafeSpot
  - Cooperation for road safety
- CVIS
  - Cooperation for traffic efficiency
- Coopers
  - Seamless services along the travel chain
- SEVECOM
  - Security for cooperative systems
- COMeSafety
  - Coordination
- GeoNet
  - Geographic addressing and routing for vehicular communications

German Public Funded Projects

Old projects

- Fleetnet
  - Development and Demonstration of Car-2-Car communication protocols
- Invent
  - Intelligent traffic and user-friendly technology 3
- Network on Wheels (NOW)
  - Specification of Car-2-Car communication protocols

Current projects

- Aktiv
  - Adaptive and Cooperative Technologies for the Intelligent Traffic
- SIM-TD
  - German FOT

Industry Consortia

USA

- Vehicle Infrastructure Integration Consortium (VIIC)
- Collision Avoidance Metrics Partnership (CAMP)
- Targeted Applications
  - Safety
  - Traffic efficiency
  - Electronic Toll Collect (ETC)
  - Customer Relationship Management (CRM)

Europe

- Car 2 car Communication Consortium (C2C-CC)
- Targeted applications
  - Safety
  - Traffic Efficiency
  - Infotainment
- Note: Less roadside infrastructure expected than in the US

Standardization

- We need standards
  - uniformized vehicular cooperative systems (V2V & V2I)
  - uniformized exchange of information between vehicles and servers in the Internet
- AND ALSO
  - uniformized exchange with anything on the network anywhere Not only in the automotive sector: ITS is just one small portion of all data exchanges
  - Interoperability between communication systems developed in all sectors must be ensured
- The Internet Protocol (IP) is the facto standard
  - ITS communication architectures must interoperate with it
  - IP provides an unification layer of underlying technologies
    - 2G/3G, 802.11 a/b/g, 802.11p, 802.16, satellite, ...

Standardization

USA

- IEEE 1609: Dedicated Short Range Communication (DSRC) –
  - Old name. Released in 2002 by ASTM (American Society for Testing and Materials)
- IEEE 802.11p: Wireless Access for the vehicular Environment (WAVE)
  - New name from 2003
  - Approved 802.11p amendment is scheduled to be published in July 2010

Europe

- Car 2 Car Communication Consortium (C2C-CC)
  - Car manufacturers
- ETSI ERM TG37 (TC ITS)

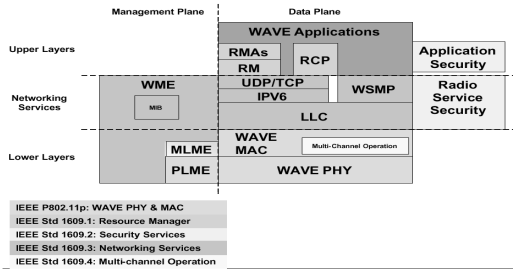
Worldwide Standardization:

ISO TC 204 WG 16 (CALM - Communications Air-interface, Long and Medium range)

COMeSafety and ETSI for coordination and harmonization

WAVE - 802.11p is a Common Radio Base System

Protocol Architecture: USA (ASTM)

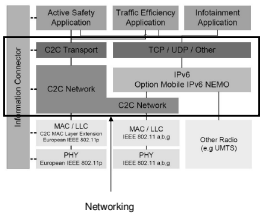


Protocol Architecture: EU (C2C-CC OBU)

- Partial integration of safety and non-safety systems
- Specific features for each Double stack

  (Critical) Safety
  - non-IP
  - geographic distribution for event-driven messages
  - High-frequency beaconing
  - information-centric communication paradigm

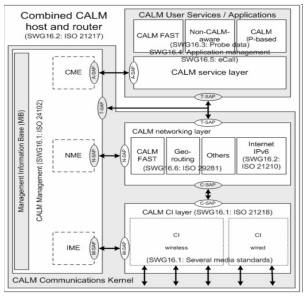
  Infotainment
  - IPv6
  - IPv6 Mobility (NEMO) optional
  - Multiple physical interfaces



Protocol architecture: CALM

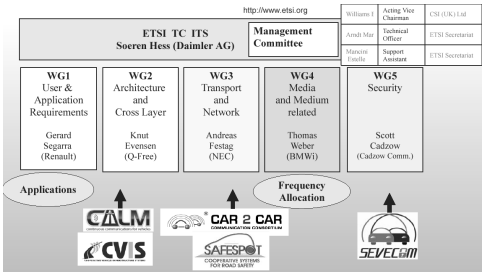
- Scenario diversity
  - Communication architecture allows V2V, V2I and continuous Internet access through multiple radio technologies (potentially used simultaneously)
- Media diversity
  - Cellular (CALM 2G/3G) – cf ISO 21212 & 21213
  - Infrared light (IR) – cf ISO 21214
  - Microwave (CALM M5 => 802.11p) – cf ISO 21215
  - Millimeter waves (CALM MM) – cf ISO 21216
  - Microwaves CEN DSRC
- Networking diversity
  - IPv6 (Internet connectivity, mobility management): ISO 21210
  - Non-IP networking (FAST => time critical applications): ISO 29281
- Medium Selection & Switching
  - Select most appropriate media based on 24102
- CVIS project is a proof of concept of CALM

Protocol architecture: CALM

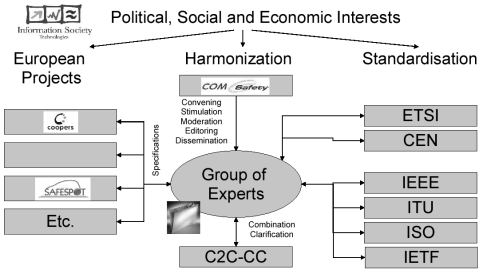


- SWG 16.0 Architecture
- SWG 16.1 Media
- SWG 16.2 Networking
- SWG 16.3 Probe Data
- SWG 16.4 Application Management
- SWG 16.5 Emergency Communications
- SWG 16.6 Non-IP Networking
- SWG 16.7 Security and Lawful Intercept

Protocol architecture: ETSI TC ITS

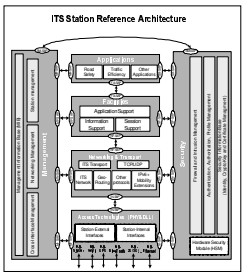


Protocol architecture: COMeSafety: Coordination

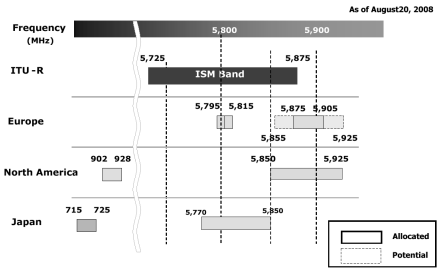


Protocol architecture: COMeSafety: Coordination

- Proposed European ITS Communication Architecture
  - Joint development: ETSI TC ITS COMeSafety+ R&D projects

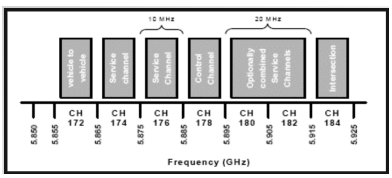


Spectrum allocations



IEEE 802.11p

- PHY/MAC Layers
  - The standard is based on IEEE 802.11a PHY layer and IEEE 802.11 MAC layer
  - Seven 10 MHz channels at 5.9GHz
    - one control channel and six service channels



IEEE 802.11p

- PHY/MAC Layers
  - 802.11a vs. 802.11p
    - 802.11a is designed for high data rate multimedia communications in **indoor** environment with **low user mobility**
    - DSRC PHY uses a variation of OFDM modulation scheme to multiplex data
      - high spectral efficiency, simple transceiver design and avoids multi-path fading
      - Data rates from 3 up to 27 Mbps
      - Transmit power level are changed to fit requirements of outdoor vehicular communications
      - **communication ranges up to 1000 meters**

Parameters	DSRC/802.11p	802.11a
Information data rate Mb/s	3, 4.5, 6, 9, 12, 18, 24 and 27	6, 9, 12, 18, 24, 36, 48 and 54
Modulation	BPSK, QPSK, 16-QAM, 64-QAM	BPSK, QPSK, 16-QAM, 64-QAM
Coding rate	1/2, 1/3, 3/4	1/2, 1/3, 3/4
Number of subcarriers	52 (=48+4)	52 (=48+4)
OFDM symbol duration	8µs	4µs
Guard time	1.6µs	0.8µs
FFT period	6.4µs	3.2µs
Preamble duration	32µs	16µs
Subcarrier frequency spacing	0.15625MHz	0.3125MHz

IEEE 802.11p

- PHY/MAC Layers
  - MAC layer of DSRC is inspired from the IEEE 802.11a and IEEE 802.11e
    - CSMA/CA
    - QoS issues included (4 classes)

IEEE 802.11p

- Proactive algorithms (table-driven)
  - better performance in terms of delay but they need a considerable amount of control traffic (e.g., OLSR)
- Reactive algorithms (on-demand)
  - minimize the number of broadcast packets by creating routes only on demand (e.g., AODV)
- Several studies demonstrate that neither of the two protocol classes outperform the other in every vehicular scenarios.

IEEE 802.11p

- Traditional MANETs routing protocols require an explicit route establishment phase before the data transmission begins
- They are not adequate to low delivery-latency requirement for safety applications
- Routing protocols for VANETs
  - should rely on packet forwarding based on geographic location of sender and receiver
  - should be broadcast oriented

IEEE 802.11p

- Position-based unicast routing (geographical forwarding)
  - these routing protocols exploit the availability of accurate location information
  - more suited to dense networks and to frequent network disconnections (e.g., GPSR)
- Geocast routing
  - a kind of multicast routing where the destination nodes are characterized by their geographical coordinates
  - in VANETs nodes interested in notifications of traffic congestions or warnings are located in the same place

IEEE 802.11p

- Broadcast
  - Majority of applications for VANETs rely on broadcast dissemination of information in the applications area
  - Blind flooding is the first approach to achieve broadcasting since it does not require local or global topology information
  - Broadcasting has a strong influence on network performance
    - Serious redundancy, contention and collision problems can occur as a result of flooding
  - An efficient broadcast protocol should minimize the total number of packet retransmissions, while at the same time preserving network connectivity

IEEE 802.11p

- Broadcast
  - A trade-off between robustness and redundancy should be found
  - Different approaches:
    - probability-based
      - a node forwards the packet with a probability p which depends on network scenario
    - location-based
      - the idea is to select as relays those nodes that permit to cover the widest additional area
    - neighbor-based
      - the nodes decide whether broadcasting the message or not on the status of their neighbors
    - cluster-based
      - nodes are grouped into small clusters each one managed by a particular node called cluster-head which has the task of retransmitting broadcast messages

Offres existantes

Gestion de flotte

- **Orange Fleet Advanced** / Evolution (Machine To Machine)

« Avec Fleet Advanced, optimisez la gestion de votre flotte de véhicules et vos interventions comme vos livraisons. Vous bénéficiez d'une solution clés en main basée sur un abonnement mensuel fixe. »

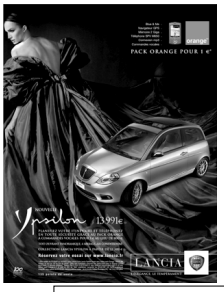
- **Principe** : un boitier qui combine le positionnement par satellite du véhicule (GPS) et un module de communication mobile (GPRS) permet de connaitre en permanence la position des véhicules d'une flotte.
- **Personnalisation** aisée pour intégrer des fonctions spécifiques adaptées aux besoin du client

Navigation sur mobile

- **Orange Maps** : service de guidage et de navigation multimode (à pied, en voiture) disponible sur mobile GPS

- Une offre destinée à se démocratiser avec la généralisation des mobiles GPS dès 2009

Offres existantes



Blue and me (Microsoft) + Fiat or Lancia + Orange (Networks access + smartphone)

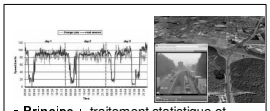
The system offers Bluetooth and USB connectivity to mobile phones and personal media players. It provides also hands-free system controlled by voice commands.

Nouvelles offres pour 2009

La "livebox" pour automobile

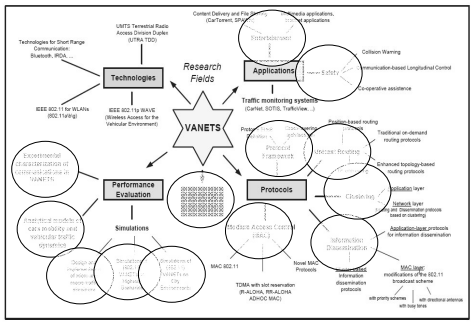
- **Principe** : un modem/routeur 3G/3G+ qui relie l'habitacle du véhicule (réseau local wifi) à l'Internet haut-débit mobile
- Permet au de retrouver des services en lignes (internet, mail, tchat, jeux), sur l'ensemble des terminaux compatibles wifi (PC, assistants personnels, lecteurs multimédias, consoles de jeux portables)

L'information trafic temps réel



- **Principe** : traitement statistique et anonyme des données de signalisation existante sur les flottes mobiles . **Transposition** en information trafic sur les axes routiers observés
- Permet une information trafic à **bas couts**, disponible sur l'**ensemble du territoire** (axes structurants)

Orange Labs activities



Thank you

- Contact

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