Context-Awareness in Car-to-Car Communications on the example of iTETRIS

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Car-to-Car Communications Objectives

Safety:
- Mitigation of accident severity (passive safety)
- Prevention of accidents (active safety)
- Avoidance of hazardous situations (preventive safety)

Efficiency:
- Reduction of travel times
- Reduction of fuel/energy consumption
- Reduction of CO₂ emission
- Reduction of noise emission

Infotainment/Comfort:
- Increasing comfort of driving
- Additional information services

Monetary:
- Cost reduction (e.g. less sensors, less road infrastructure maintenance)
- “Competitive edge”: Prevailing over competitors
Context is a key to Car-to-Car Communications for Traffic Management

- Distributed Traffic Jam Detection (smart information dissemination)
- Travel Time Estimation based on (Extended) Floating Car Data
- Contextual Bus Lane Management (e.g. for electric vehicles, low CO₂)
- Individual Limited Access Control (e.g. road closure for emission category)
- Regulatory and Contextual Speed Limit Information (e.g. green light speed advice)
- Traffic Light Adaptation (e.g. queue length, emergency vehicle approaching) etc.

iTETRIS focus on Traffic Management perspective!
Problems of Evaluation

Problems:

- Local-scope geographic adaptation shift problem to adjacent uninspected areas
- Short-term adaptation shift problem to a later point in time

→ Large-scale (at least whole city-area), long-term (1-2 hours) evaluation required
Field-operational tests are very expensive and not reproducible

Theoretical analyses use abstractions which reduce accuracy

→ Large-scale long-term simulations are required
iTETRIS targets large-scale long-term evaluations of performance and effect of V2X communications for traffic management.

- Development of a holistic closed-loop simulation environment
- Development of general traffic management strategies
- Development of data distribution strategies for V2V+V2I communications
- Evaluations with realistic traffic flows
Partners

Peek Traffic B.V. (The Netherlands)
CBT Comunicacion & Multimedia (Spain)
City of Bologna (Italy)
German Aerospace Center – DLR (Germany)
Hitachi Europe SAS (France)
Innovalia Association (Spain)
Institut Eurecom (France)
Thales Communications (France)
Universidad Miguel Hernandez (Spain)

Project details

- Duration: 30 months (07/2008 – 12/2010)
- Budget/EC Funding: 4.42 M€ / 2.96 M€
- Website: www.ict-itetris.eu
- Contact: Thales Communications coordinator@ict-itetris.eu
Traffic Simulation

- Microscopic open-source traffic simulator **SUMO** (http://sumo.sourceforge.net)
- Simulation of realistic traffic flows with multiple vehicle classes (cars, busses, electric vehicles, etc.)
- SUMO allows simulation of up to 500,000 vehicles in real-time
- Extensions for:
  - Emission modeling: CO$_2$, NO$_x$, particles, noise, fuel consumption, etc.
  - Adaptive Vehicle Rerouting/ Traffic Light Control: closed-loop simulations
Network Simulation

- Discrete-event network simulator **ns-3** ([http://www.nsnam.org/](http://www.nsnam.org/))
- Good scalability, modularity and multi-technology support (ns-2 not capable of simulating more than 8000 nodes)
- Ongoing NSF funded project
- Optimizations:
  - More effective interfering packet list management
  - Interference range reduction
  - Packet rate reduction
- Extensions:
  - Implementation of IEEE 802.11p, ETSI TC ITS profile standard, UMTS, WiMAX and DVB-H
iTETRIS Control System (iCS)

- Synchronizes the individual simulators in time and space
- Integrates information-related facility layer components
- Provides interfaces to applications to:
  - Retrieve information from ns-3 (e.g. CAM, DNM) and SUMO (e.g. ego vehicle position, traffic light status)
  - Control ns-3 (e.g. send DNM) and SUMO (e.g. vehicle rerouting)
Traffic Management Scenarios

- City of Bologna
- ~373,000 inhabitants
- ~170 controlled intersections
- ~1000 induction loops
- Realistic traffic flows from origin-destination (OD) matrices and induction loop data

A. Costa  Ringway  Imerio  Highway
Traffic Management Scenario 1

Pasubio – A. Costa

**Problems:**
- Events such as a football match or a concert
- Context-dependent reachability of the hospital

**Goals:**
- To manage the traffic in an area that offers few alternative routes
- Emergency vehicle priority

**Strategies:**
- Adaptive Traffic Light Control
- Adaptive Rerouting
- Regulatory and contextual speed limit information
- Contextual bus lanes management
- Limited Access
Traffic Management Scenario 2

Irnerio - Open Market Fair

**Problems:**
- Traffic condition analysis when road traffic is modified due to open market fair
- Induction loop malfunctioning or road yards

**Goals:**
- Traffic congestion detection in real time
- Travel time estimation

**Strategies:**
- Adaptive Traffic Light Control
- Adaptive Rerouting
- Regulatory and contextual speed limit information
- Contextual bus lanes management
- Limited Access
Traffic Management Scenario 3

Problems:
- Traffic condition analysis
- Induction loop malfunctioning or road yards

Goals:
- Local traffic congestion detection and regional adaptation in real time
- Travel time estimation for alternative routes

Strategies:
- Adaptive Traffic Light Control
- Adaptive Rerouting by covering the ring way clockwise or anti-clockwise
- Regulatory and contextual speed limit information
- Contextual bus lanes management
- Uplink via RSU/UMTS for regional context-aware management
Traffic Management Scenario 4

**Orbital + Highway**

**Problems:**
- Orbital (free) and Highway (toll)
- Suboptimal exit to the city center

**Goals:**
- Travel time and emission reduction
- Optimization of the orbital congestion
- Accurate travel time estimation

**Strategies:**
- Adaptive Rerouting
- Regulatory and contextual speed limit information
Additional sensors of other vehicles and the environment (i.e. road-side units) significantly improve the representation of the situation.

Accurate representation of the real situation does allow for communication adaptive to the situation specific needs (e.g. prioritization of safety relevant information).
Data Dissemination for V2V/V2I communications

- Development of next generation reliable & contextually dynamic vehicular communication protocols for V2V+V2I
- Delay- and Disruption-Tolerant Networks (DTN) with store-and-forward functionality over multiple radio access technologies
- Geo-unicast, geo-anycast and geo-broadcast communication protocols
Opportunistic Broadcast

- Periodical Broadcast:
  - Difficulty to choose the right rebroadcast period
- Store and forward:
  - Increasing vehicle density $\rightarrow$ Too many retransmissions
  - Message disseminated far away from the event
- Solution: Combine both ideas $\rightarrow$ Opportunistic broadcast
  - Vehicle switches between two states
  
- Store and forward: 
  - Number of neighbors $\leq N_1$
  - Number of neighbors ahead $= 0$
- Periodical mode: 
  - Number of neighbors $> N_2$

Total number of retransmissions
Average time being unaware of notification

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Future usage of the iTETRIS platform:

- Performance evaluations of communication protocols
- Evaluation of the effect of traffic management applications
- Simple integration of novel context-aware applications and scenarios
- Open to future enhancements (open-source)
- Validating measurements from Field Operational Tests (FOTs)
- Work will be continued and extended in FRESCO project

Feel free to visit our website http://www.ict-itetris.eu or contact one of the project members directly
Thank you for your attention!

Questions?

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