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

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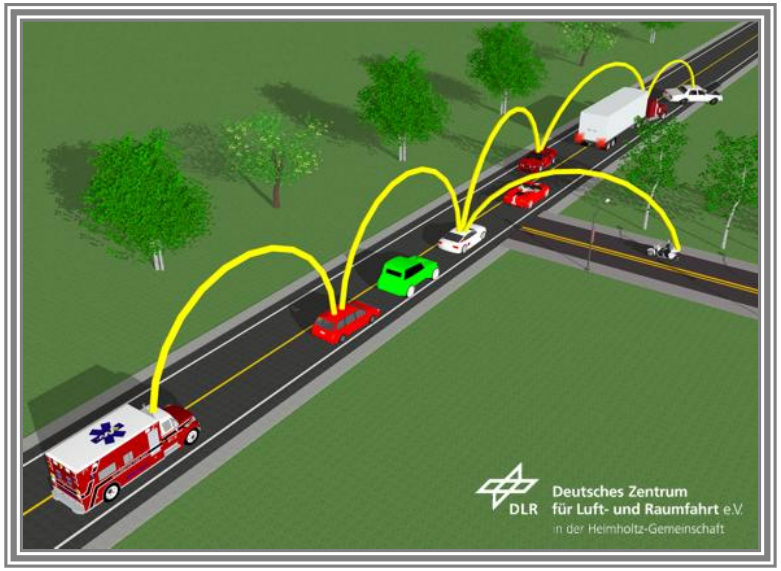
Car-to-Car Communications Objectives

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 CO_2 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 CO_2)
- 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

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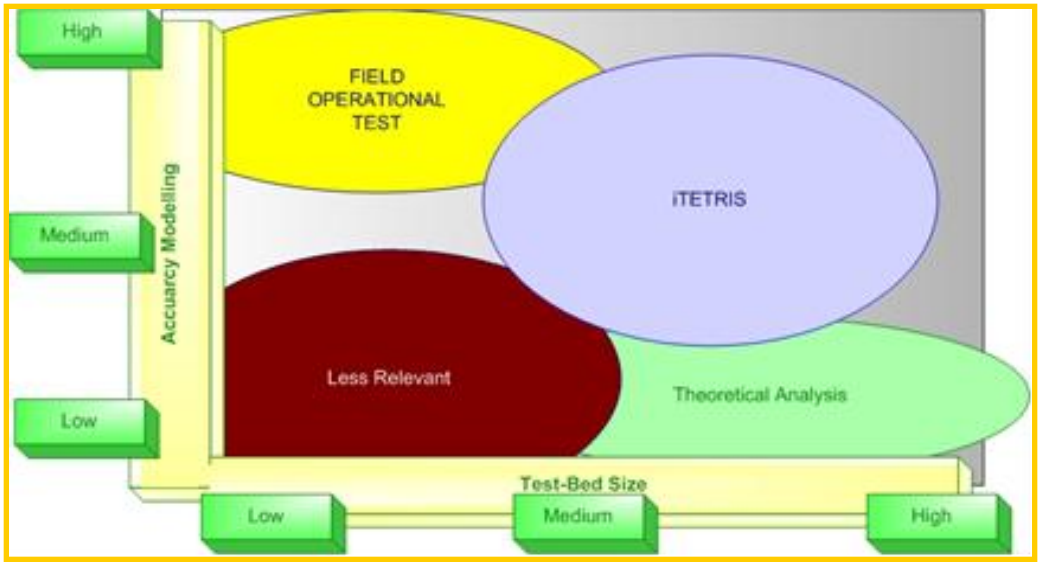
Type of Analysis

- Field-operational tests are very expensive and not reproducible
- Theoretical analyses use abstractions which reduce accuracy

→ Large-scale long-term **simulations** are required



The iTETRIS project

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

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Project Details

Partners

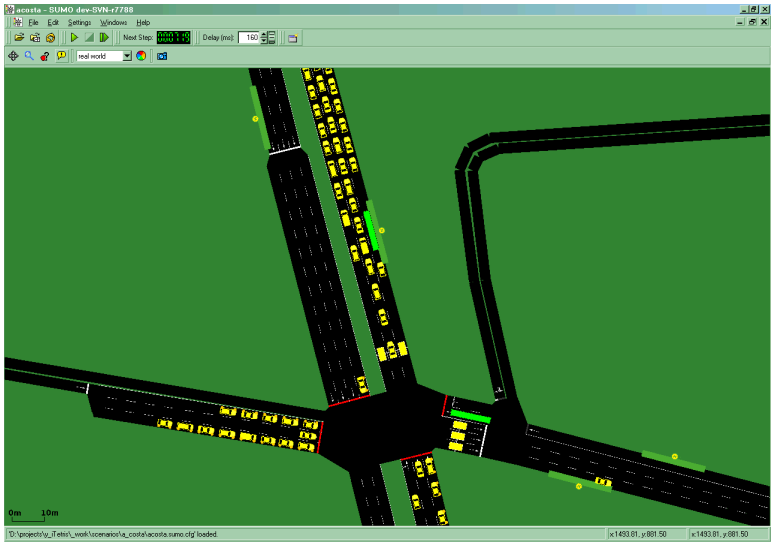
- Peek Traffic B.V. (The Netherlands)
- CBT Comunicacion & Multimedia (Spain)
- City of Bologna (Italy)
- German Aerospace Center – DLR (Germany)
- Hitachi Europe SAS (France)
- Innovalia Association (Spain)
- Institut Eurecom (France)
- Thales Communications (France)
- Universidad Miguel Hernandez (Spain)

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

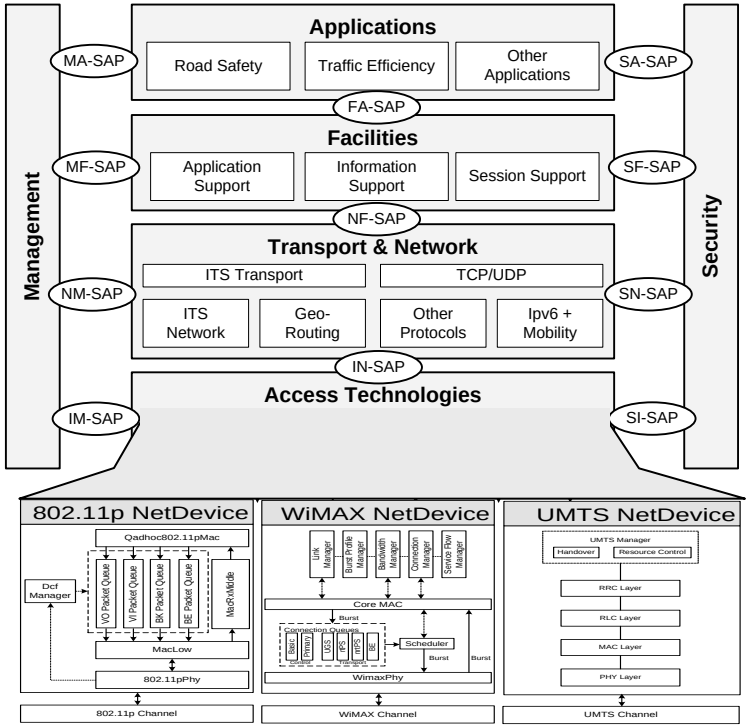
Traffic Simulation

- 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



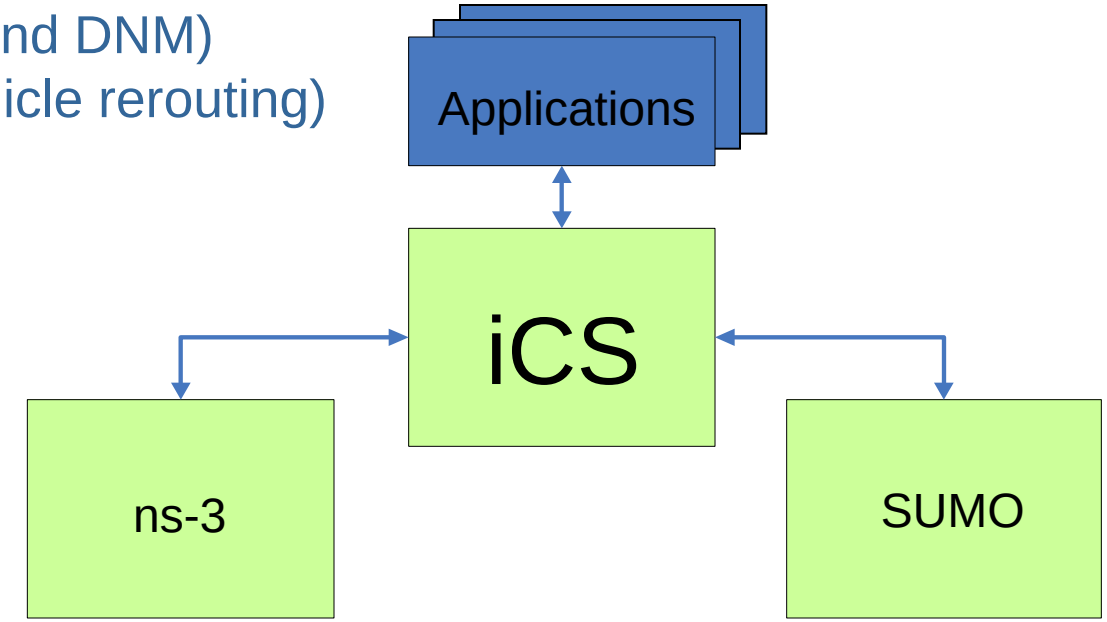
Network Simulation

- Discrete-event network simulator **ns-3** (http://www.nsnam.org/)
- 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

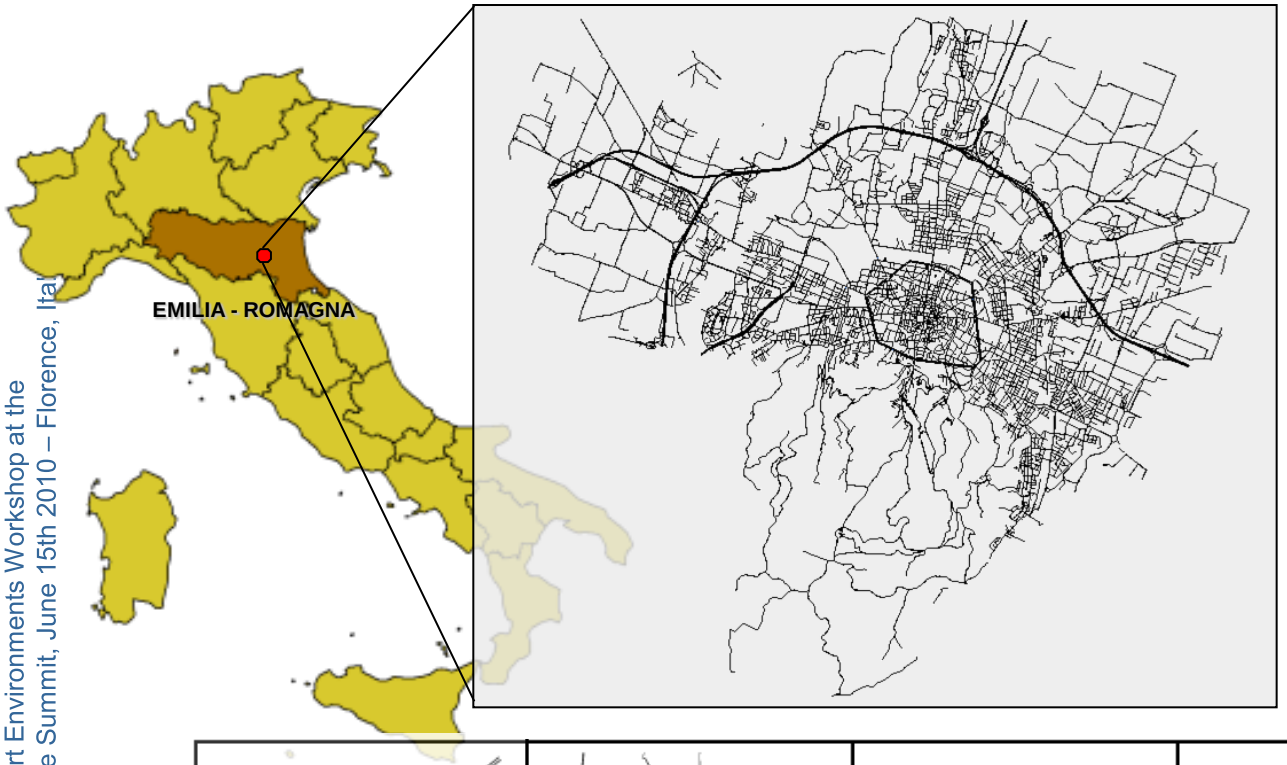


iTETRIS Control System (iCS)

- 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

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

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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

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Traffic Management Scenario 3

Inner city ring-way

Problems:

- Traffic condition analysis
- Induction loop malfunctioning or road yards

Goals:

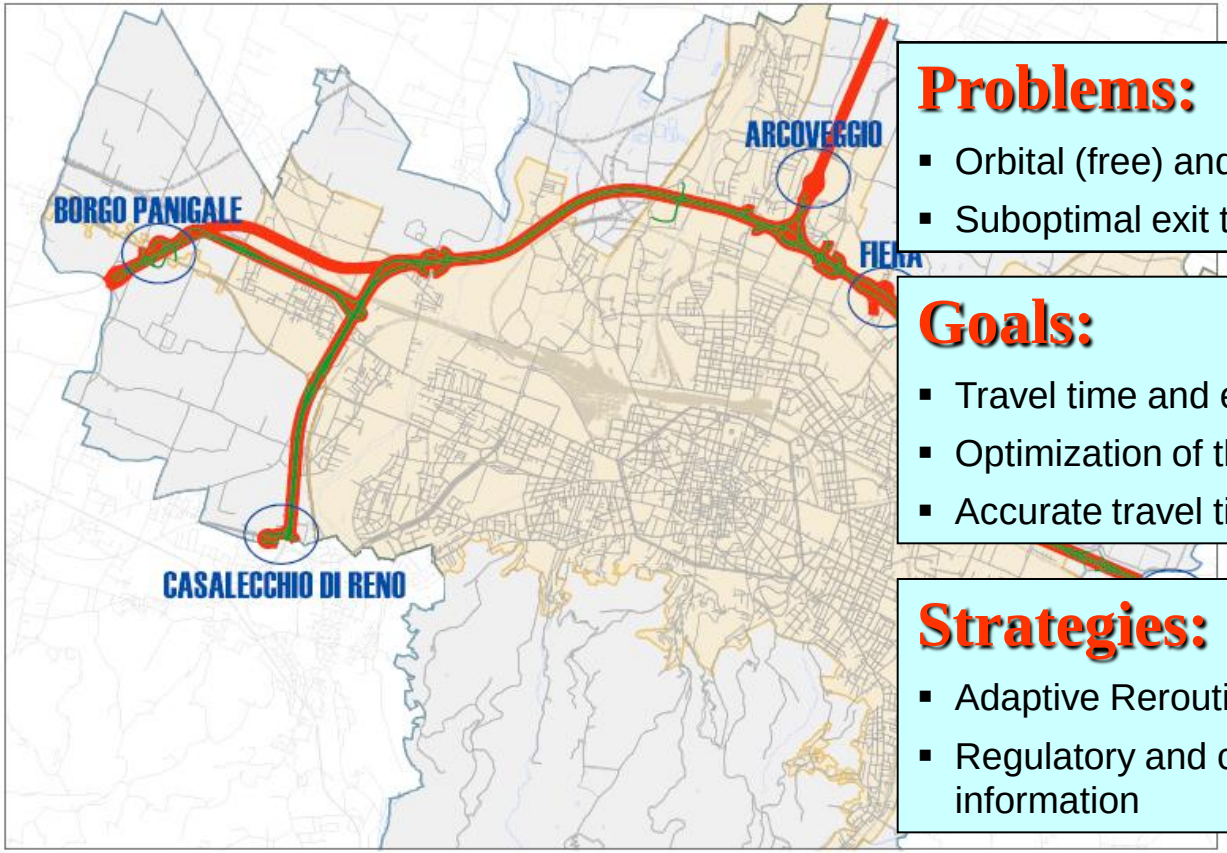
- Local traffic congestion detection and regional adaptation in real time
- Travel time estimation for alternative routes

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:

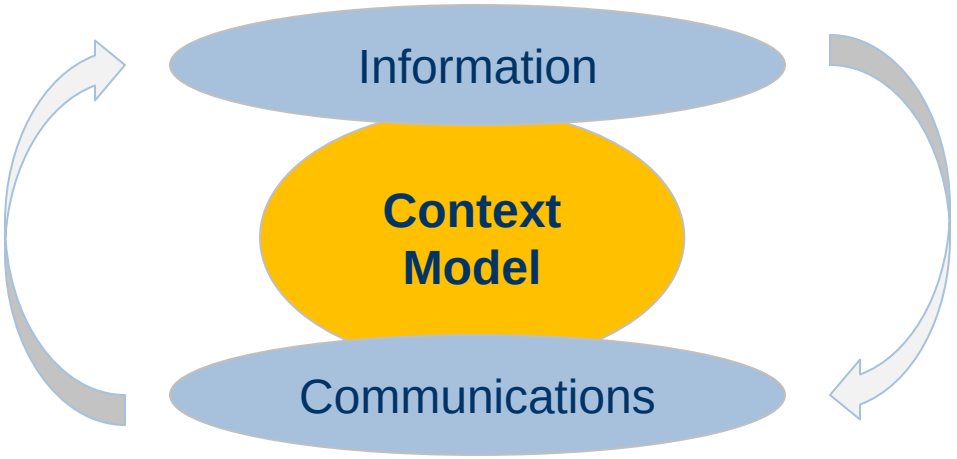
- Travel time and emission reduction
- Optimization of the orbital congestion
- Accurate travel time estimation

Strategies:

- Adaptive Rerouting
- Regulatory and contextual speed limit information

Integration of Context

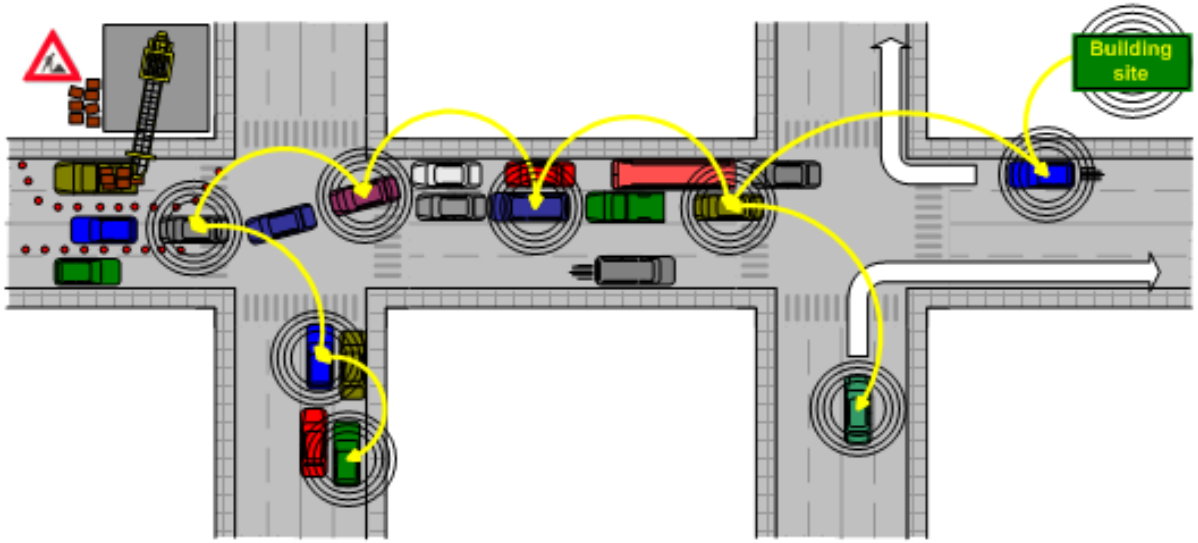
Additional sensors of other vehicles and the environment (i.e. road-side units) significantly improve the representation of the situation



Accurate representation of the real situation does allow for communication adaptive to the situation specific needs (e.g. priorization of safety relevant information)

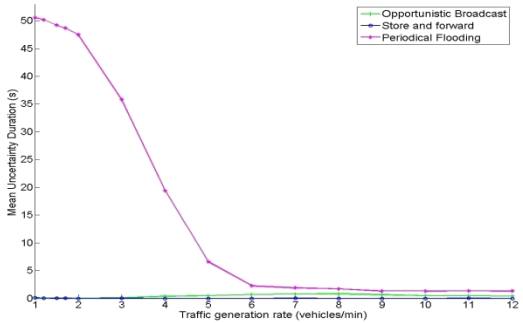
Data Dissemination for V2V/V2I communications

- 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

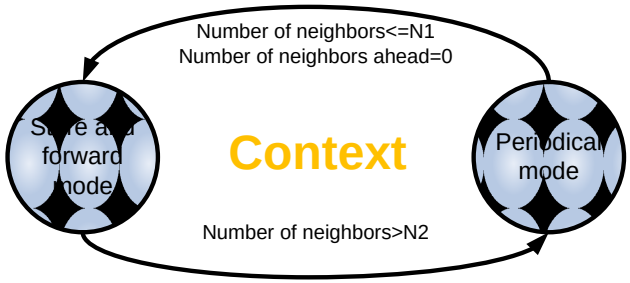


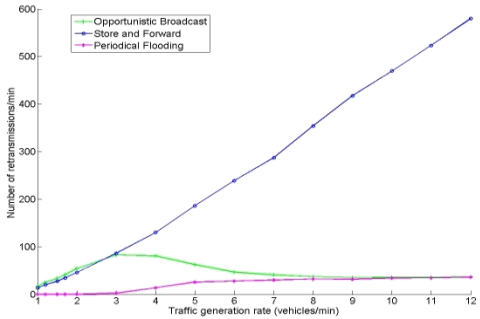
Opportunistic Broadcast

- Periodical Broadcast:
  - Difficulty to choose the right rebroadcast period
- Store and forward:
  - Increasing vehicle density->Too many retransmissions
  - Message disseminated far away from the event
- Solution: Combine both ideas → **Opportunistic broadcast**
  - Vehicle switches between two states



Average time being unaware of notification





Total number of retransmissions

Conclusions

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

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Thank you for your attention!
Questions?

www.ict-itetris.eu

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