ns-3 workshop

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ns-3 scalability constraints in heterogeneous wireless simulations: iTETRIS a case study

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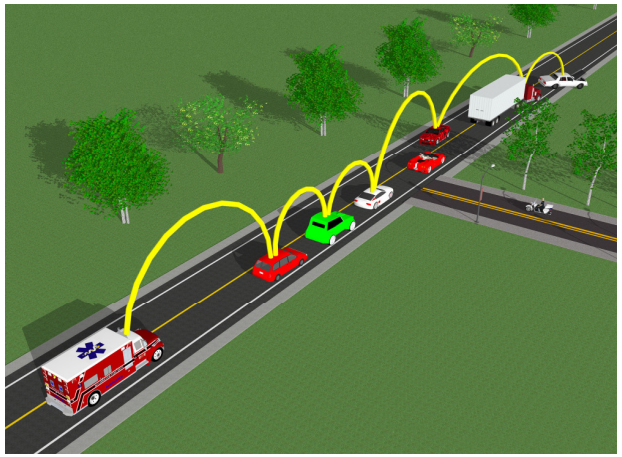
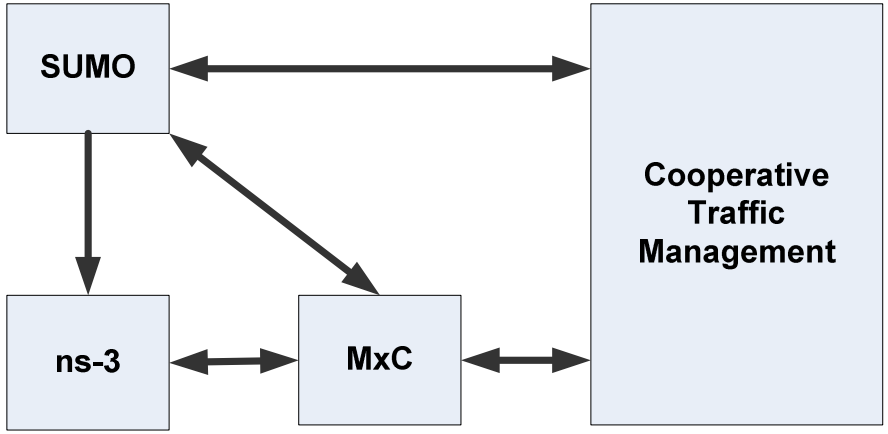
iTETRIS presentation

- iTETRIS (an Integrated Wireless and Traffic Platform for Real-Time Road Traffic Management Solutions)
  - European project funded within the 7th Framework Programme
  - Consortium of different research groups: THALES, CBT, City of Bologne, DLR, Eurecom, Hitachi, Innovalia, Peek Traffic and UMH
- Main iTETRIS objectives
  - Implement an open-source integrated wireless and traffic simulation platform
  - Estimate the impact of cooperative vehicular communications on traffic management
  - Test and optimize V2V and V2I communications and networking protocols
  - Test and optimize cooperative traffic management policies
  - Large scale trials (traffic data of the city of Bologne)



iTETRIS simulation platform

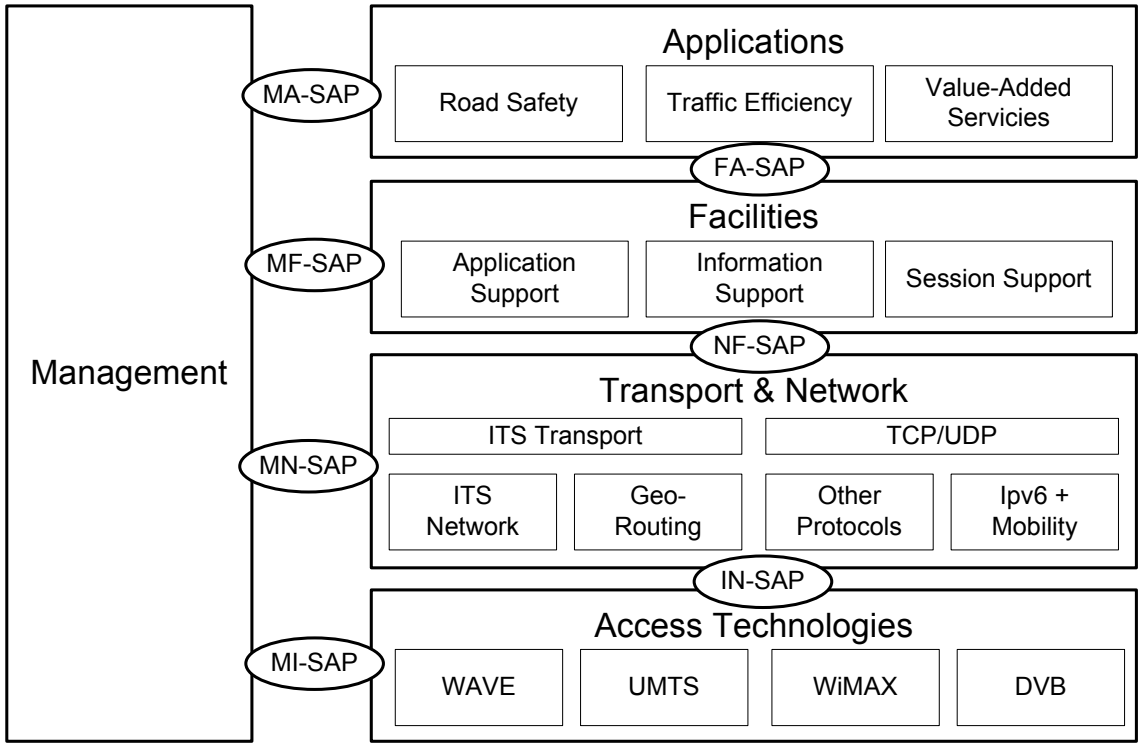
- Integration of two widely used open source platforms
  - ns-3 (Network Simulator 3)
  - SUMO (Simulation of Urban MObility)
- CTMC (Cooperative Traffic Management Centre)
  - Decision on routing traffic flows
  - Inform vehicles using the MxC functional block



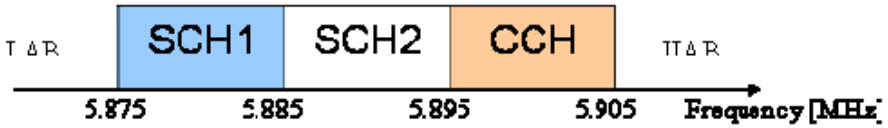
- MxC (Message eXchange Communications)
  - Also provides the CTMC with traffic condition estimates (derived from V2X communication)

iTETRIS wireless platform architecture

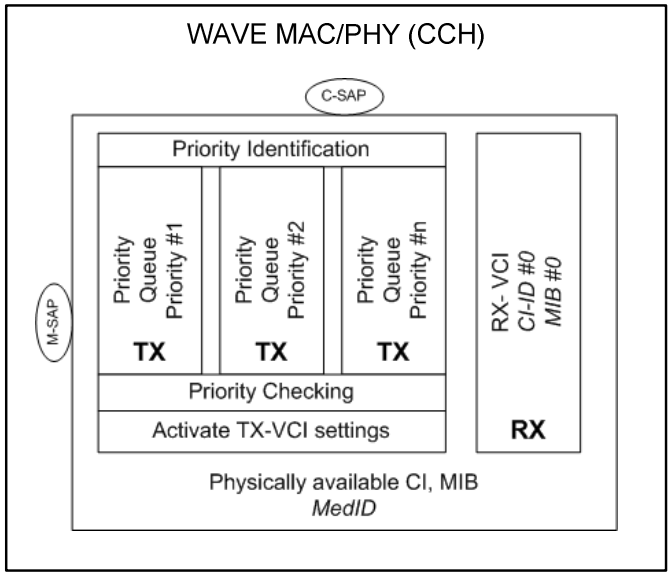
- The iTETRIS wireless platform will follow the European ITS communications architecture determined by COMeSafety.
  - This architecture has many similarities with the CALM architecture developed under the ISO.

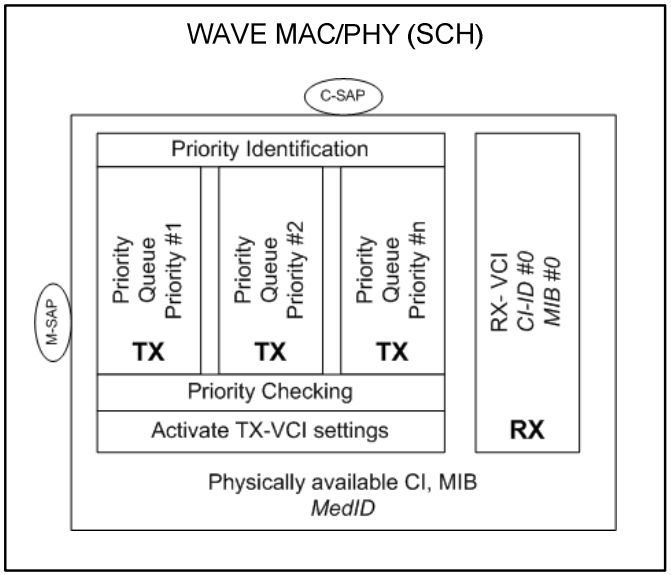


- Spectrum divided into three 10MHz sub-channels



- WAVE MAC/PHY for CCH and SCH





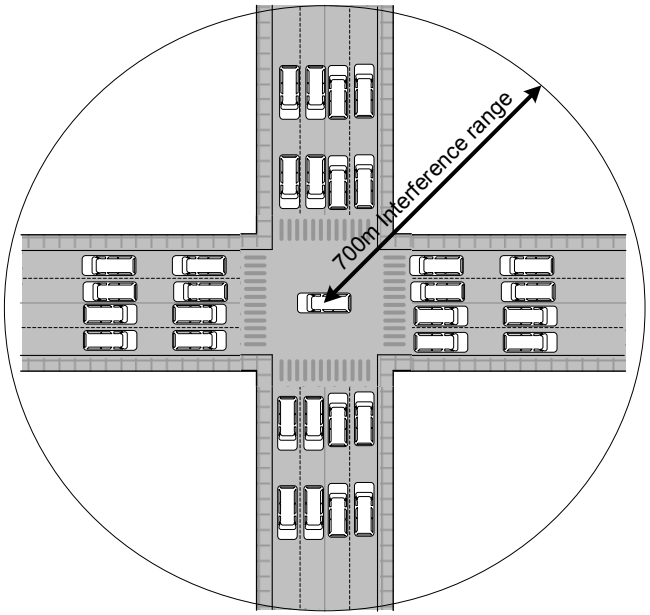
ns-3 scalability capabilities

- ns-3 advantages over ns-2
  - Good scalability, modularity and multi-technology (from the beginning)
- ns-3 performance for large scale simulations
  - Capable to simulate large amount of nodes (20000 nodes or more)
  - High execution times for large and dense scenarios
  - Work needed to achieve feasible runtimes for iTETRIS
    - Paralellization techniques (planned for June 2009)
    - Simplification of ns-3 communication modules
- Factors directly impacting on simulation performance
  - Total number of vehicles
  - Traffic density
  - Implementation accuracy
  - Interference range
  - Packet generation rate

Impact of number of vehicles and vehicle density

- Scenario under evaluation
  - 802.11 one-hop periodic broadcast

Parameter	Value
Nodes' speed	70km/h (maximum)
Mobility model	RandomWalk2dMobilityModel
Propagation model	LogDistancePropagationLoss
Interference range	700m (default)
Packet tx rate	10 packets/second (default)
Data rate	6Mbps
Simulation time	40s



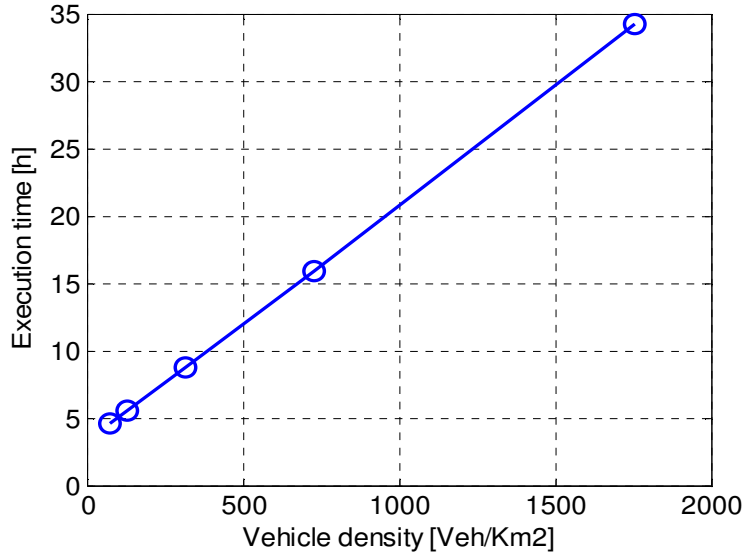
- Influence of vehicle density on simulation performance
  - Close related to number of neighbours (packets to be processed)
- Simulations with different traffic densities

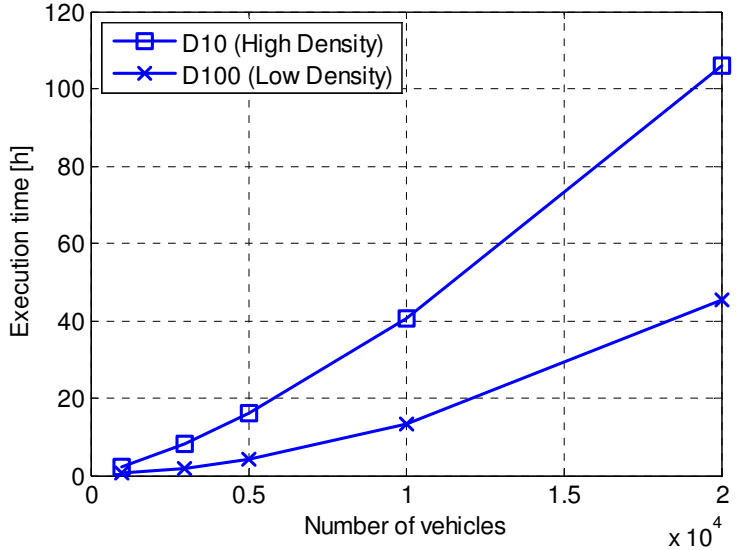
Impact of number of vehicles and vehicle density

- Impact of traffic density on execution time (40s 5000 nodes)
  - Execution time linearly increases with traffic density
- Influence of traffic density and number of vehicles on simulation performance
  - Unworkable execution times for 1h simulation
  - Improvements need to be introduced into the simulator

1h 20000 nodes

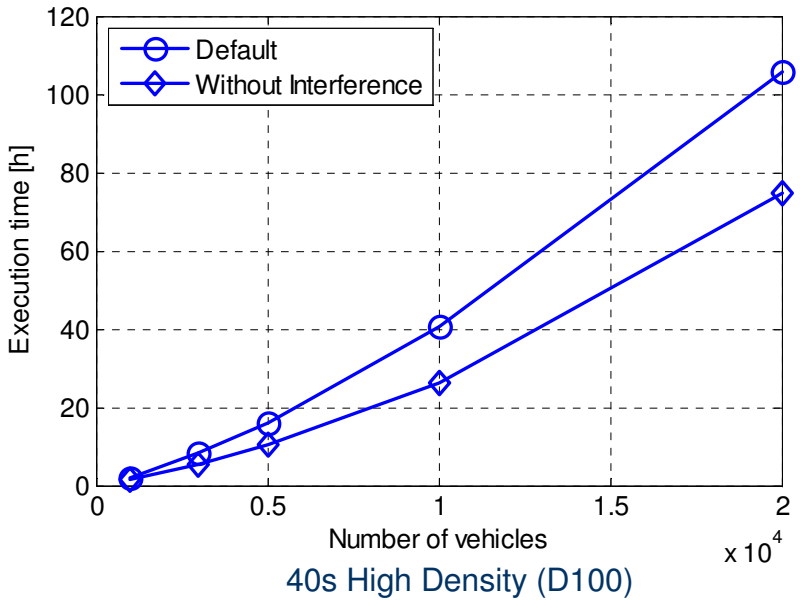
Traffic density	Execution time [days]
High	397
Low	170





Reduction of physical layer accuracy

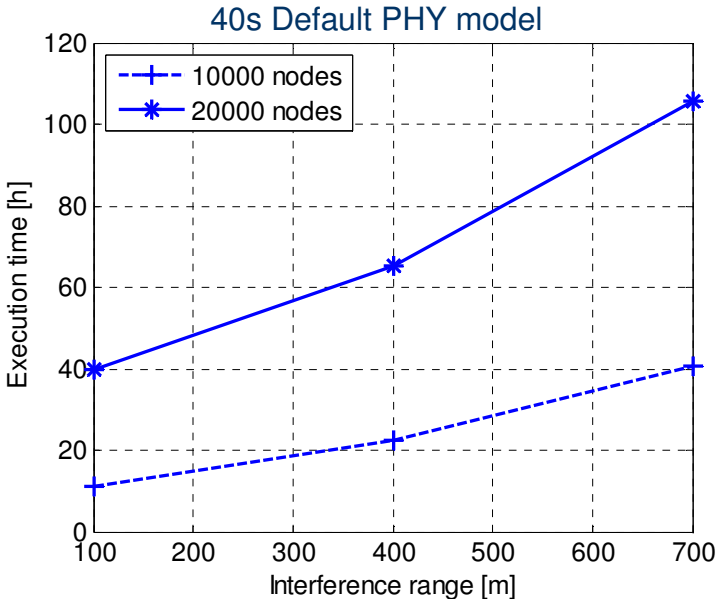
- ns-3 spends most of the time at the physical layer
  - Packets processing and interference calculation
- Simplification of PHY models
  - Removal of interference calculation
- Performance analysis
  - Around 35% of reduction time



40s High Density (D100)

Reduction of interference range and packet rate

- Congestive scenarios
  - Vehicles adapt transmission range and packet rate to reduce interference
- Impact of interference range on simulation performance
  - Execution times increases with interference range
- Impact of packet rate on simulation performance
  - Simulations run 80% faster reducing transmission rate from 10 to 2 packets per second
- Realistic congestive scenario
  - High density (D10)
  - Interference range of 100m
  - 2 packets per second
  - 1h simulation with 20000 nodes would take 30 days
  - Execution time much more feasible for iTETRIS



1h Default PHY 20000 nodes High Density

Interference range	Estimated execution time [days]
700m	397
400m	245
100m	149

Conclusions

- iTETRIS presents demanding requirements in terms of simulation platform scalability
  - Multi-technology platform
  - Large-scale scenarios
  - Long simulation times to obtain valid results
- ns-3 capable of simulating large scale scenarios and high traffic densities
  - Default distribution takes considerable time
- Need for future enhancements for optimization
  - More efficient scheduler
  - Parallelization techniques
  - Staged simulation techniques
  - Grid-based decomposition
  - Code performance improvement
  - Further suggestions and proposals