HIDENETS
ghly DEpendable IP-based NETworks and Services

Resilience challenges and solutions in vehicular settings

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Slides are a subset of the full HIDENETS tutorial;
full slide set (~950 slides, 23 MB pdf) available as D7.3 at
http://www.hidenets.aau.dk/Public+Deliverables

HIDENETS – HIghly DEpendable ip-based NETworks and Services

(FP6 STREP, Jan. 2006-March 2009)

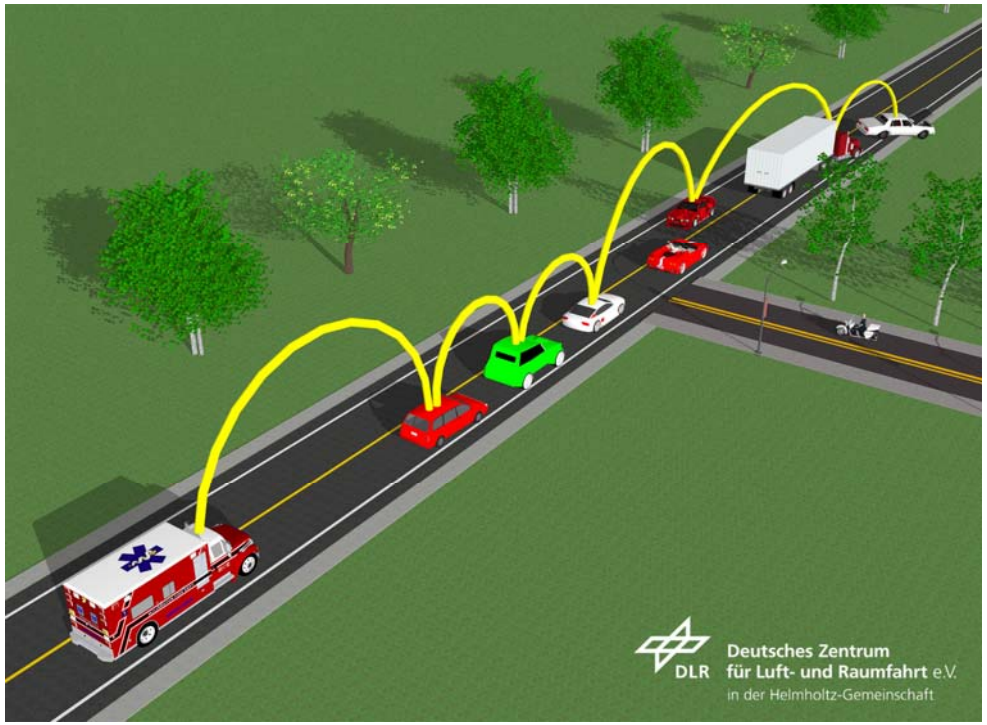
End-to-end resilience solutions for vehicular scenarios

www.HIDENETS.aau.dk

Use Cases: Examples

- Platooning
- Car Accident

[See D1.1 for full list]



car accident – hazard warning

accident scenario

platooning use case

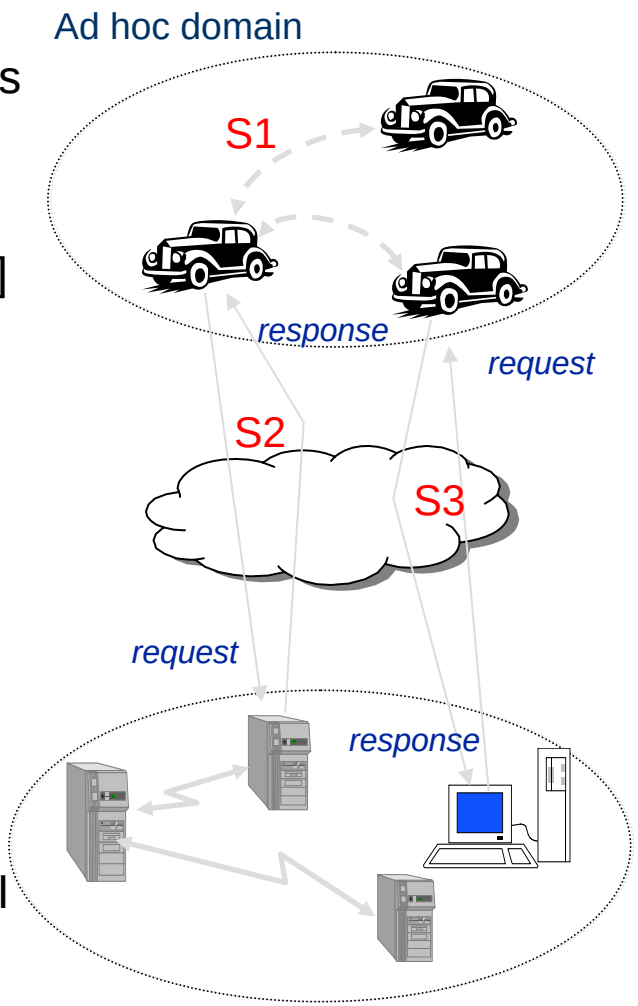
Challenges

- **Challenges** of the C2C/C2I scenarios
  - Dynamicity/mobility: changing topologies and communication characteristics
  - Open systems with (C)OTS components
  - Heterogeneity: different network domains [and different node capabilities]
  - Resource limitations and strong cross-influence between system parts

  + large number of nodes…

- **Fault-categories**
  - **Design-time** and **run-time** faults
  - **Timing** (omission, crash) and value faults
  - **Transient** and **persistent** faults
  - **Accidential** and malicious causes

  Detailed fault models and consequences depend on application type and technical realization



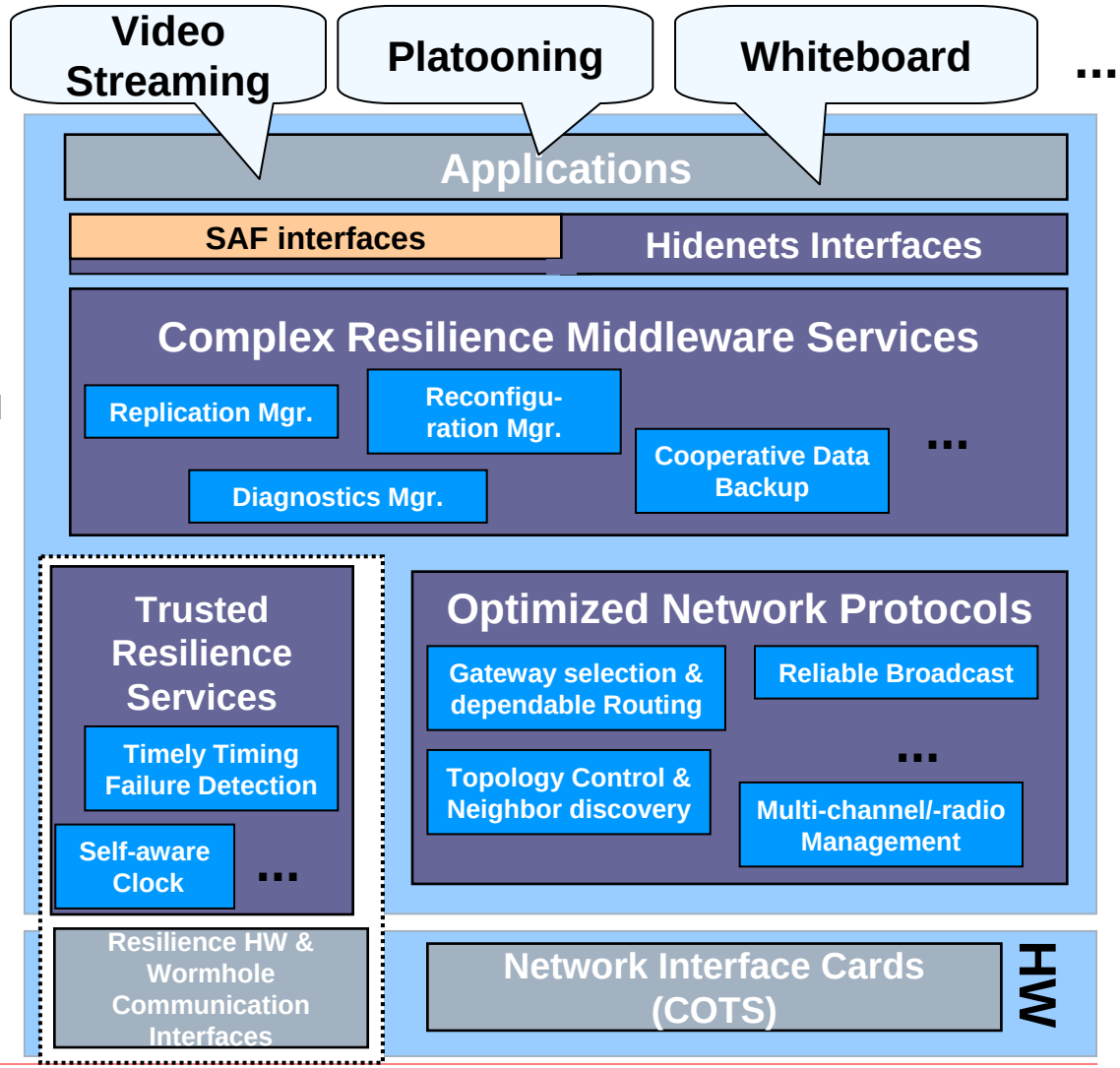
HIDENETS Goals and Results

- Develop and analyze **end-to-end resilience solutions**
  - for scalable distributed applications and mobility aware services
  - in ubiquitous communication scenarios
    - car2car communication with server-based infrastructure support
  - assuming highly dynamic, unreliable communication infrastructures

- **Results**
  - Architectural solutions and resilience services (middleware and communication level)
  - Tools for design and testing during application development
  - Quantitative evaluation methodology and analysis results
  - Experimental proof-of-concept implementations

HIDENETS architecture

- Resilience middleware and communication services
  - Remove burden from application developer → Cost efficiency
  - Dependability via careful specification and verification
- Hybrid architecture, 'trusted' part with
  - stricter timeliness properties
  - 'Critical' functions
  - Separate (physical/virtual) communication links



Resilience services: Examples

- Replication Manager
  - Allows to implement replicated applications with dynamically changing state in the ad-hoc domain
  - Automatic selection of replica nodes based on node properties and communication quality
  - → increased application availability to clients
- Reliable Broadcast
  - Based on hop-by-hop acknowledgments
  - Reduction of message forwarding and ACK events by local strategies based on circuit elimination → avoid broadcast storm problems
- Self-aware clock
  - Provides clock value together with precision bounds wrt. global time
  - Derived e.g. from properties of synchronisation protocol

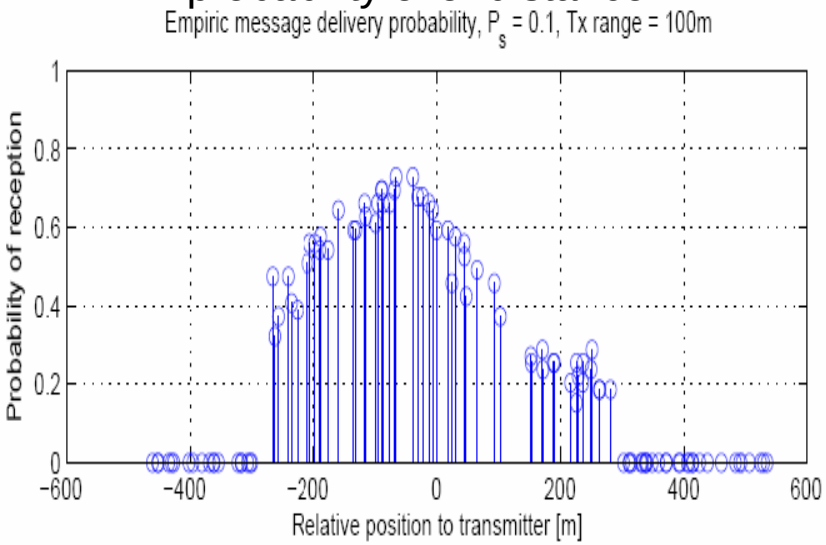
Quantitative evaluation

- Holistic approach aiming at end-to-end metrics, e.g.
  - Probability of successful execution of a series of user activities

- Combining different methodologies
  - Analytic Models: Numerical solutions of Markov /Petri-Net models, queueing models, integral expressions for connectivity metrics, ...
  - Simulations Models: NS2, Matlab, SAN simulations
  - Experimental measurements: actual wireless communication & emulated dynamic topologies

- Three different evaluation types
  - Pointwise evaluation of HIDENETS services
  - Specific use-case driven analysis
  - Workflow for (semi-)automatic end-to-end analysis

Example: Geocast reception probability over distance



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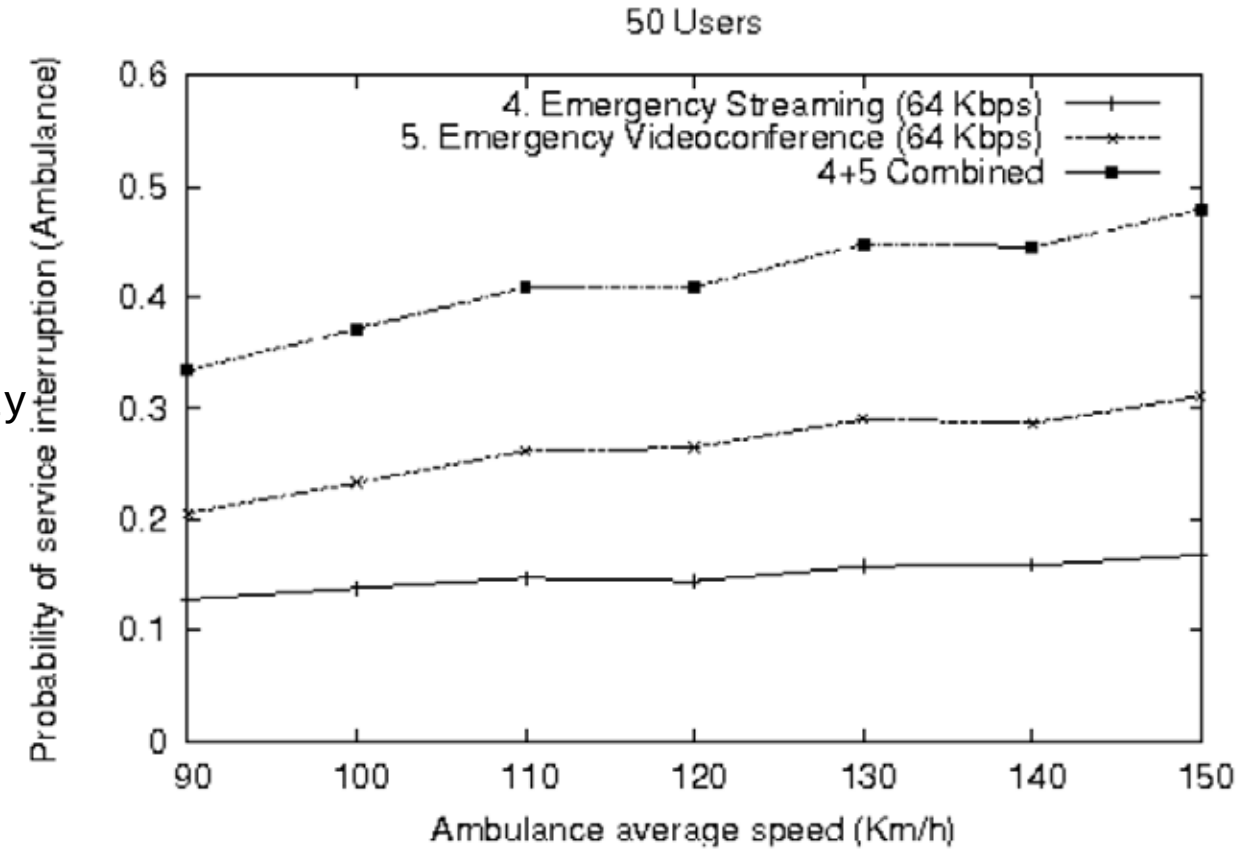
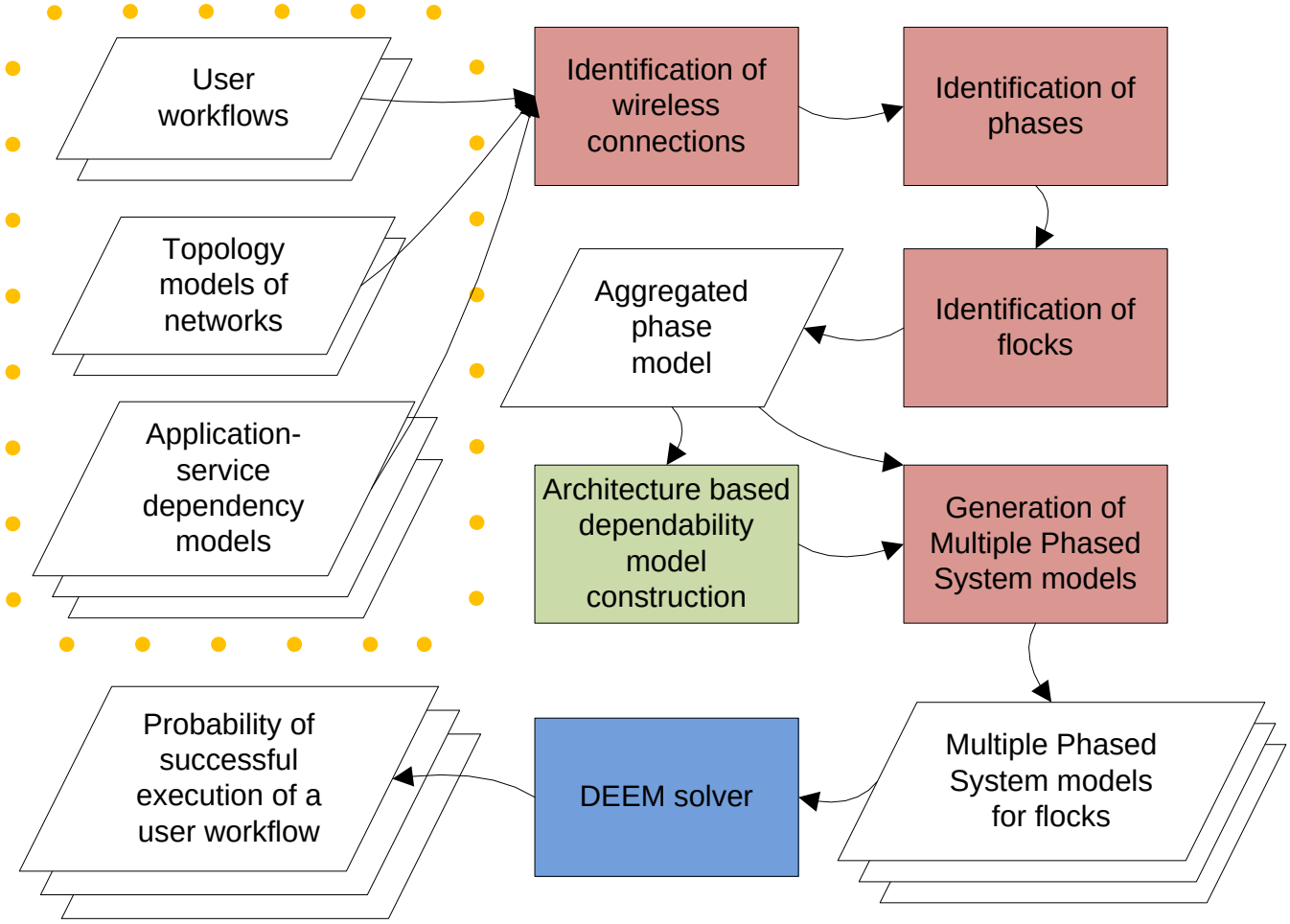
Use-case-driven analysis example

Accident use-case

- Mix of different applications
- Modeled by composition of transient stochastic activity networks
- Application-level metric: probability of successful completion



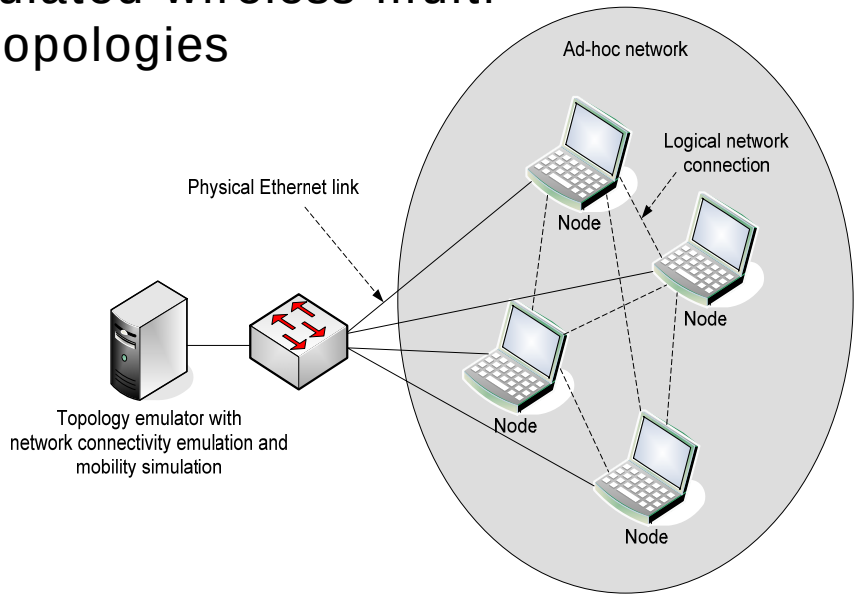
Semi-automatic evaluation workflow



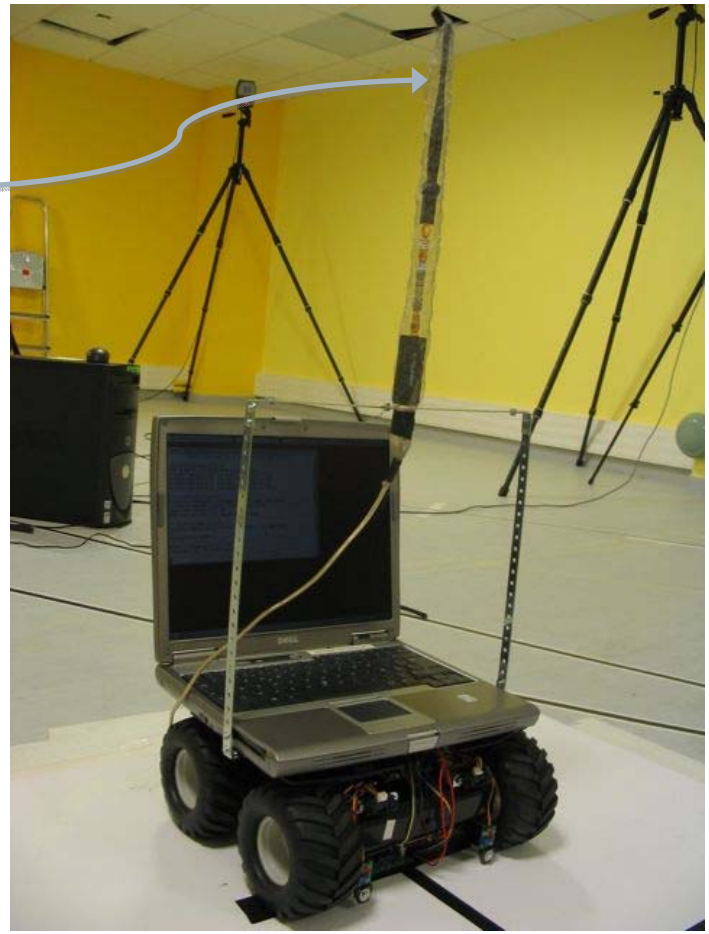
Prototyping Approaches

Mobility and wireless communication

- 'scaled down' WLAN links and real node mobility
  example: DBB testbed
- emulated wireless multi-hop topologies



Attenuator



HIDENETS resilience solutions - Summary

- Resilience services
  - Middleware functions: service replication in ad-hoc domain, cooperative data storage, fault-detection and reconfiguration, intrusion-tolerant agreement, adaptivity
  - Architectural differentiation, wormhole environment: self-aware clock, timing failure detection
  - Enhanced communication protocols (L2-L4): multi-radio and multi-channel management, routing, (reliable) broadcast, cross-layer parameter adaptation, optimized infrastructure connectivity
- Application development support
  - Design patterns, meta models, domain-specific editors
  - Test specifications and verification approaches for mobile scenarios
- Quantitative Evaluation
  - Analytic models (Markovian, SAN), simulations (MATLAB, ns2), experimental
  - Point-wise evaluation of HIDENETS services
  - Application/Use-case specific end-to-end analysis
  - Workflow for semi-automatic dependability analysis
- Prototyping: Four testbeds

Further info and important events

- Technical deliverables are available on the Hidenets web-page: www.hidenets.aau.dk
  - HIDENETS tutorial:
    full slide set (~950 slides, 23 MB pdf) available as D7.3

- HIDENETS public event
  Tue., March 17, 2009, at LAAS-CNRS in Toulouse, France

- Standardization fora
  - Service Availability Forum (SAF)
  - Car-to-car communication consortium (c2ccc)