Cooperative ITS 2020 and the Experimental Evaluation

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Cooperative ITS

Cooperative Systems
Systems where multiple entities share information and tasks to achieve common objectives.

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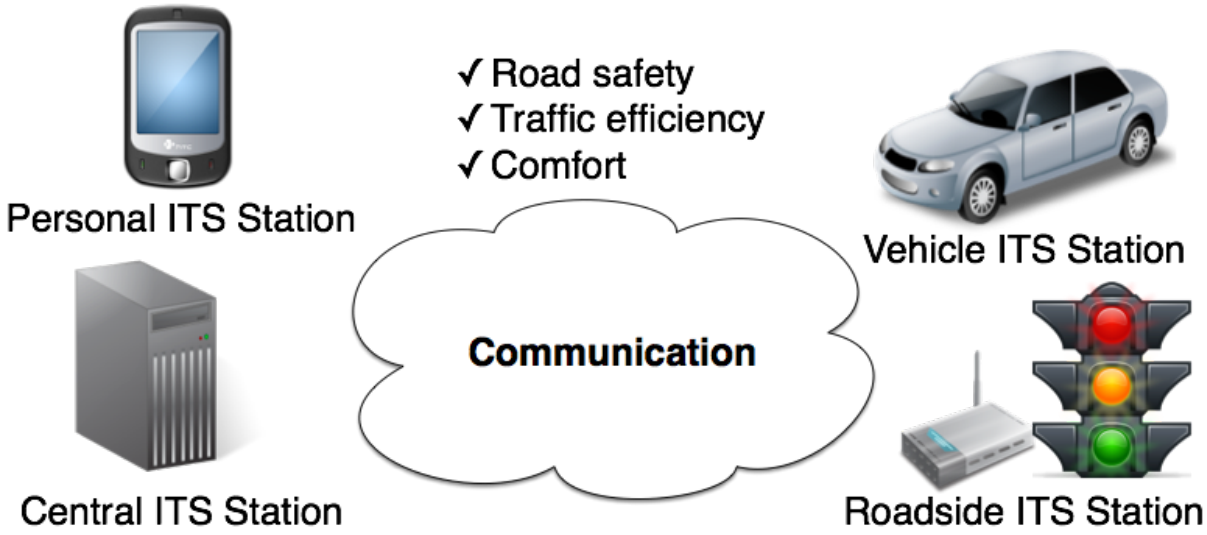
Intelligent Transportation Systems

Systems that realize safe, efficient and comfortable human mobility.

- **Cooperative Intelligent Transportation Systems**
  - Systems where multiple ITS Stations share information to achieve better road safety, traffic efficiency and comfort



Issues on Road Traffic

- Accident
  - 1.2 million dead, 50 million injury, every year
  - 95% are human error

※Road Traffic Death by WHO (2010)

- Energy
  - 95 % of the consumed energy in the road is from oil product in Japan

※Energy White paper 2013

- Global warming
  - 95% of CO2 emission is from the vehicle in Transport sector.

※ Greenhouse effect gas emission 2012
(Ministry of the Environment)

- Traffic jam
  - Japan loses 2.8 million man power (=5 billion hour) every year
  - Corresponds 4.3% of Japanese working population (64 million)

※ Council for Social capital improvement 2012

Cooperative ITS 2020

Before 2020

Probe Information systems

- Center generates valuable transport information
  - Accident, traffic jam, road information, weather information
  - However, it does not reduce human error

After 2020

Automated driving systems

- Computer can replace driver's task
  - Computer have quick response
  - Computer is tireless
  - Computer is careful
  - Computer can process in parallel
  - Progress of Artificial Intelligent (AI)
    - Chess world champion
    - Shogi professional group has lost 2013
  - Progress of Censor technology
  - Progress of Computer vision

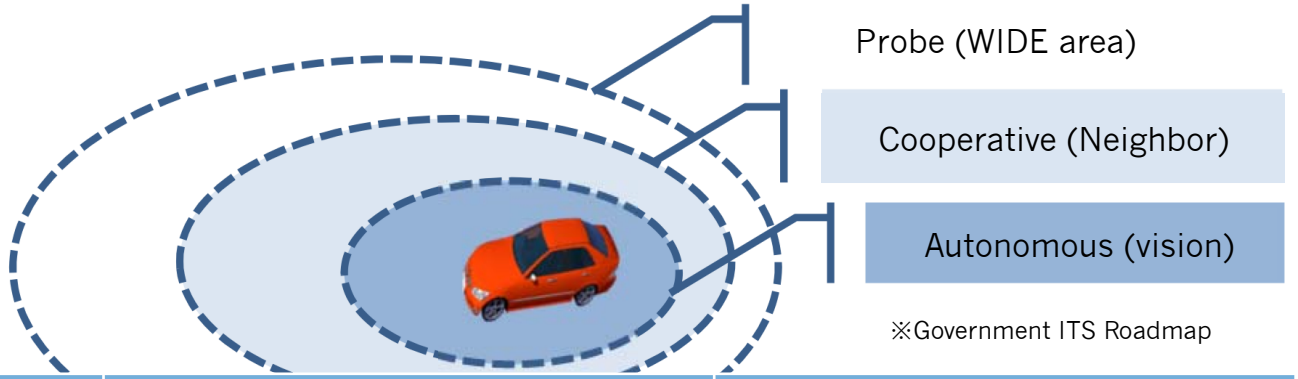
Prospects of Automated Driving

- Government ITS Roadmap (2014.3)
  - World most advanced ITS in 2020
  - Showcase of Automated Driving in Tokyo Olympics games 2020
  - After 2020, Japan becomes a center of innovation about transportation systems
  - **Autonomous** type and **Cooperative** type are assumed
  - Cooperative modules are integrated (added) into Autonomous type

Level	Items on driving	Time	System
Level 1	Any of acceleration, steering, brake	In market	Safety support
Level 2	Some of acceleration, steering, brake	2017	Partially Automated Driving
Level 3	All of acceleration, steering, brake (Manual driving is emergency only)	2020s	
Level 4	All of acceleration, steering, brake (No manual driving)	2030	Automated Driving

Classification

- 3 Type classified by information area
- Cooperative ITS can get wide area information in real-time

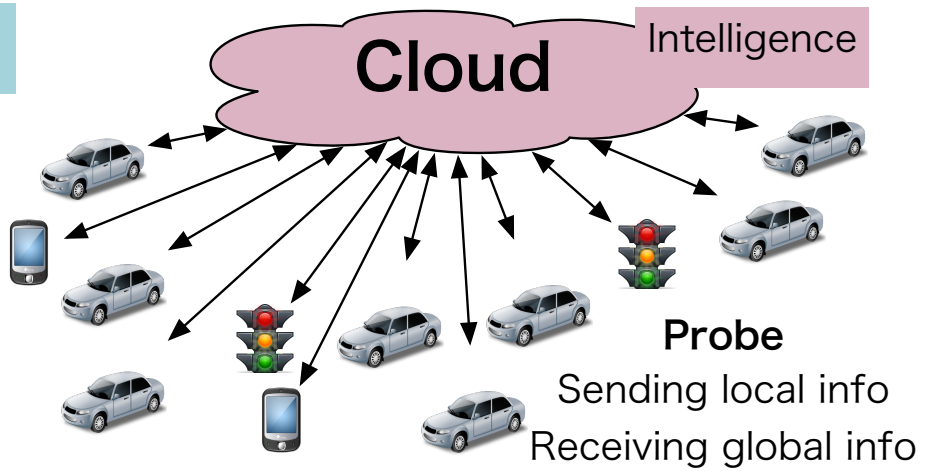


	Probe (WIDE area)	Cooperative (Neighbor)	Autonomous (vision)
Point	Wide area but not realtime	Wide area and real time	Recognition by computer vision and Real time
Issue	• Cloud • Big data • Open Data • Data Anonymity	Real-time communication in highly dynamic network topology with relative speed of 200km/h.	• Computer vision • AI • Sensor • Parallel computing
WIDE	WIDE is working	WIDE should work	(WIDE should collaborate)

Issues in Cooperative ITS

Probe Information Systems

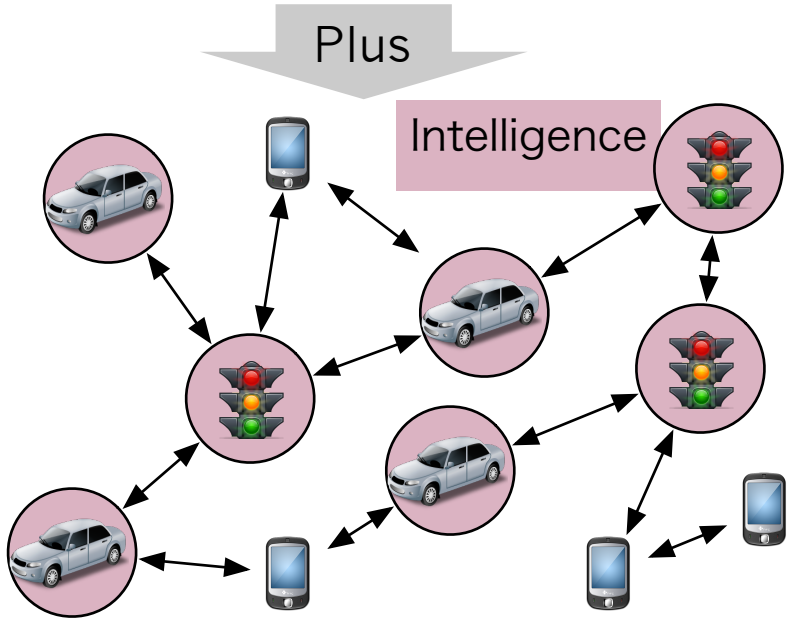
- Cloud
- Big data
- Open Data
- Data Anonymity



Automated Driving Systems

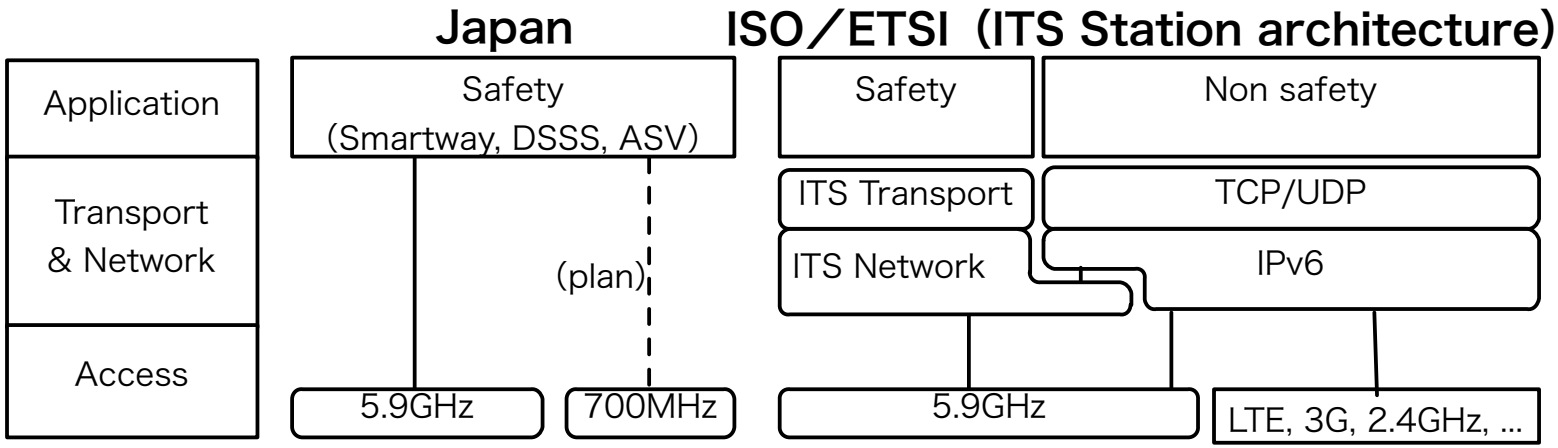
- Distributed Intelligence network architecture for combination with Autonomous node

Real-time Communications
- In Highly dynamic network with relative speed of 200km/h
- Sub millisecond

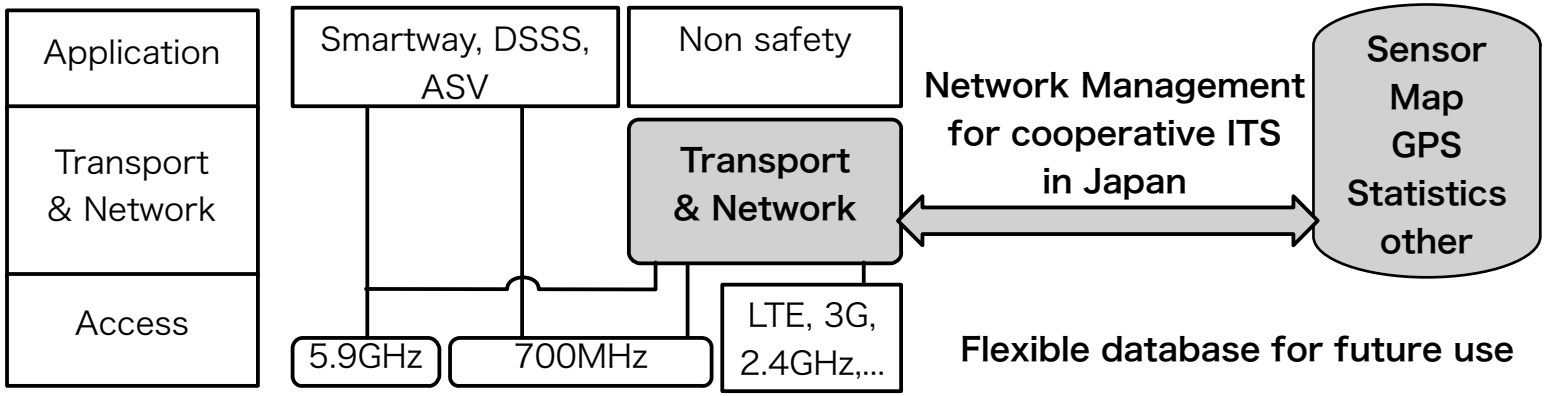


Cooperative ITS in Japan

- Difference in the architecture between Japan and ISO



- Goal



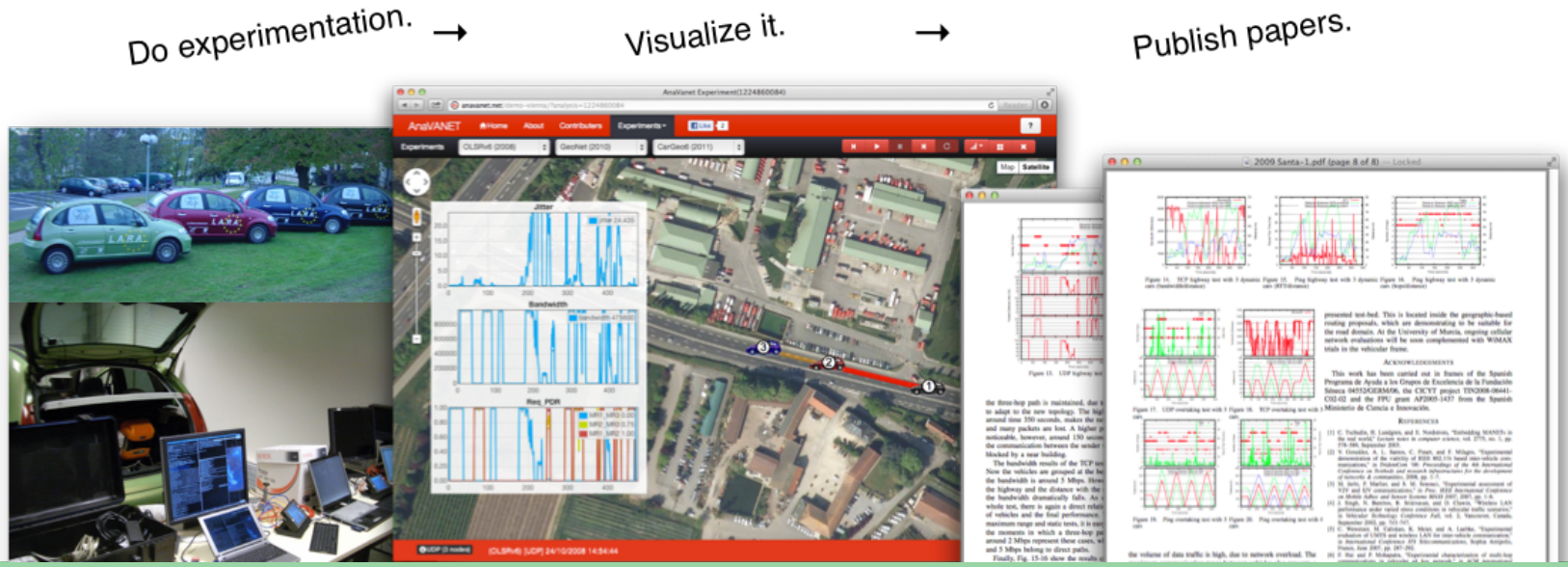
Methodology for experimental evaluation of vehicular networks

1. Manabu Tsukada, José Santa, Satoshi Matsuura, Thierry Ernst and Kazutoshi Fujikawa, "On the Experimental Evaluation of Vehicular Networks: Issues, Requirements and Methodology Applied to a Real Use Case", EAI Endorsed Transactions on Industrial Networks and Intelligent Systems, December 2014.

2. Manabu Tsukada, José Santa, Satoshi Matsuura, Thierry Ernst and Kazutoshi Fujikawa, "AnaVANET: an experiment and visualization tool for vehicular networks", 9th International Conference on Testbeds and Research Infrastructures for the Development of Networks & Communities (TRIDENTCOM 2014), Guangzhou, China, May 2014

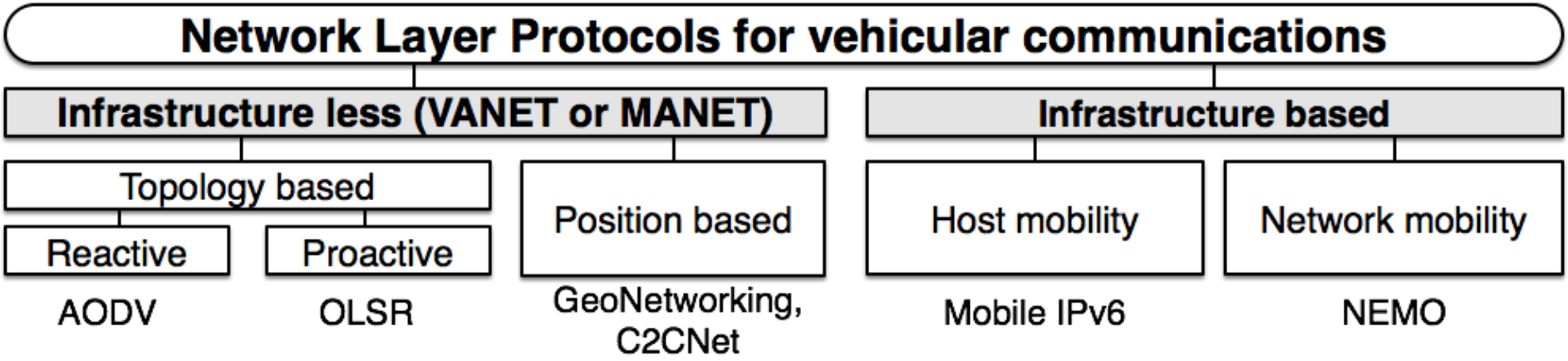
Outline

- Background
- Issue and requirements for VANET evaluation
- Evaluation methodology
- AnaVANET
- Evaluation of NEMO over IPv6 GeoNetworking



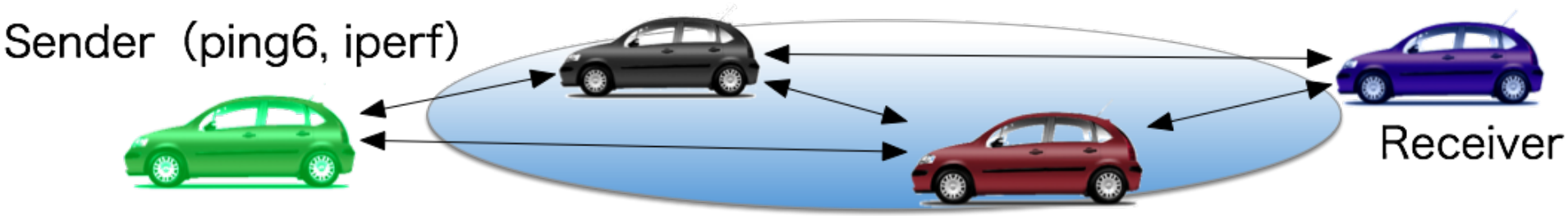
Network Layer Protocols for vehicular Networking

- Vehicle to Vehicle (V2V)
  - wireless communications in dynamic topologies without any infrastructure
  - VANET or MANET
- Vehicle to Infrastructure (V2I)
  - global connectivity of nodes to the Internet
  - Internet Mobility (Mobile IPv6, NEMO)



Issues on vehicular networks evaluation

- Common end-to-end evaluation tools such as ping6 and iperf
  1. Unawareness of communication path
  2. Unawareness of per-hop network performance in the communication path
  3. Unawareness of vehicles' movement

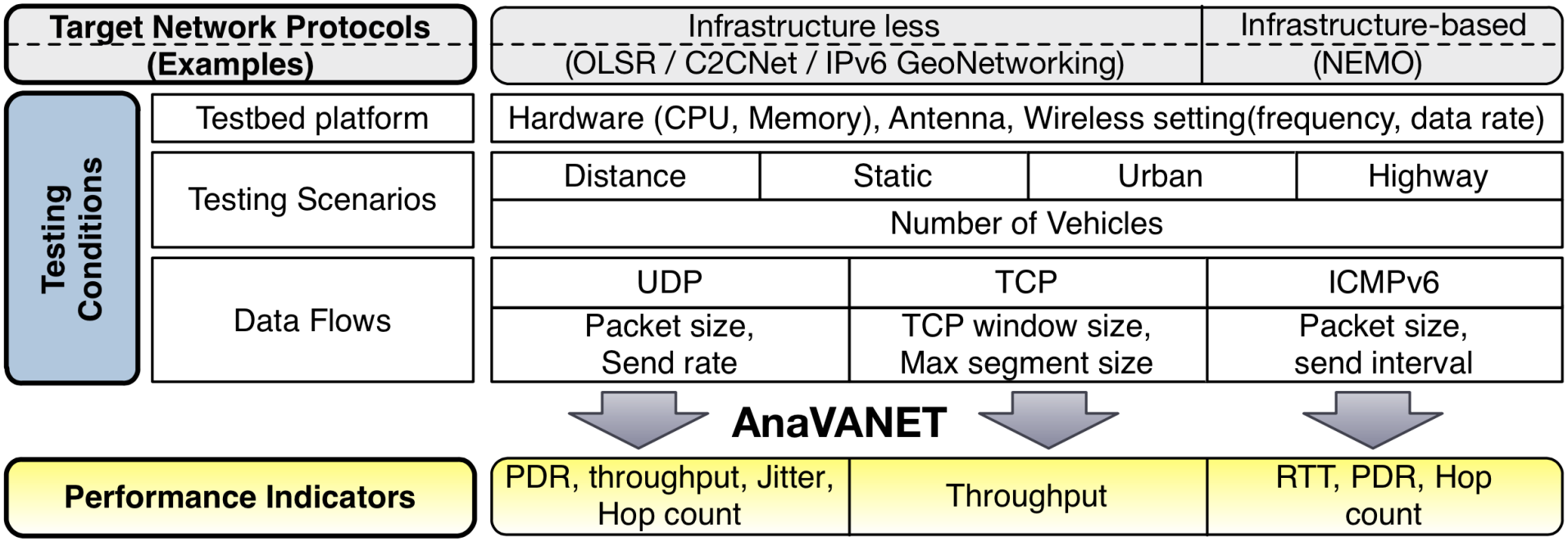


Requirements on vehicular network evaluation

1. Path detection
2. Communication performance in links
3. Geographical awareness
4. Intuitive visualization
5. Independence from network protocols
6. Independence from devices
7. Adaptation to various scenarios
8. Easiness for data collection

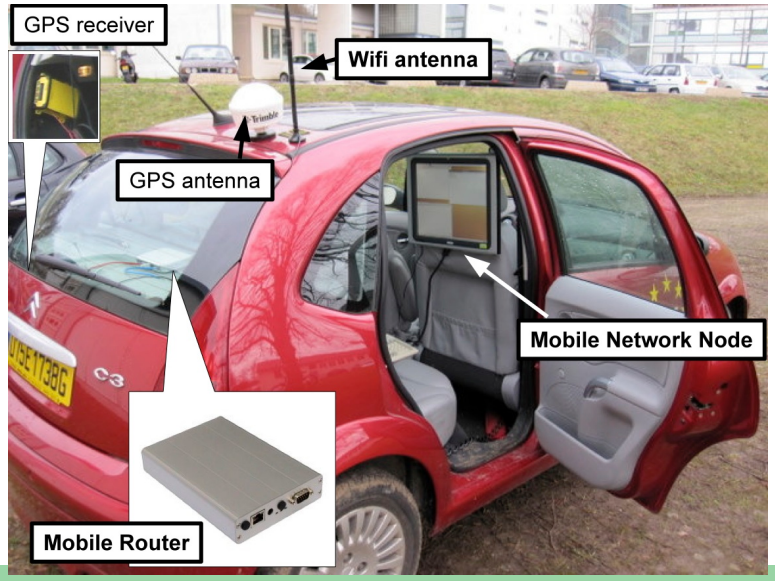
Overview of Evaluation Methodology

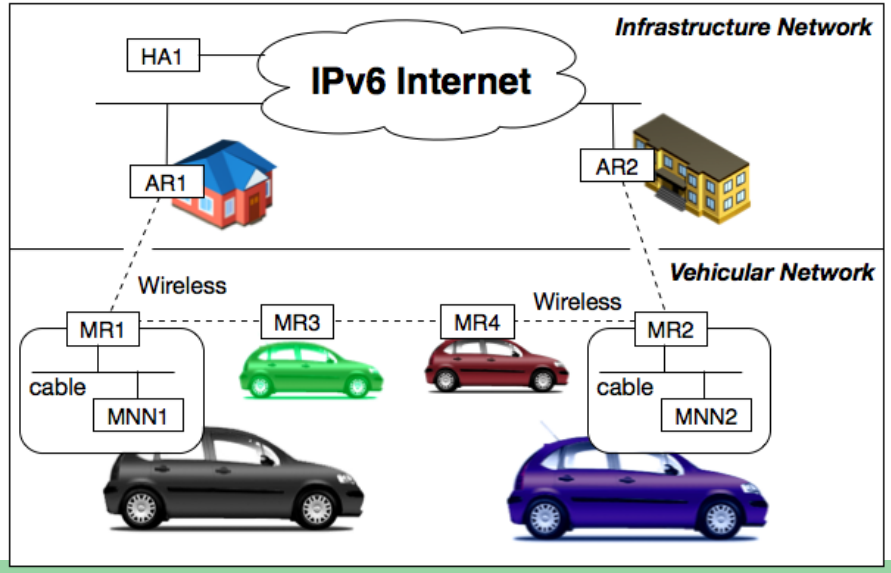
- The evaluation goals are to analyze which **testing conditions** affect which **performance indicators** using **target network protocols.**



Testbed platform

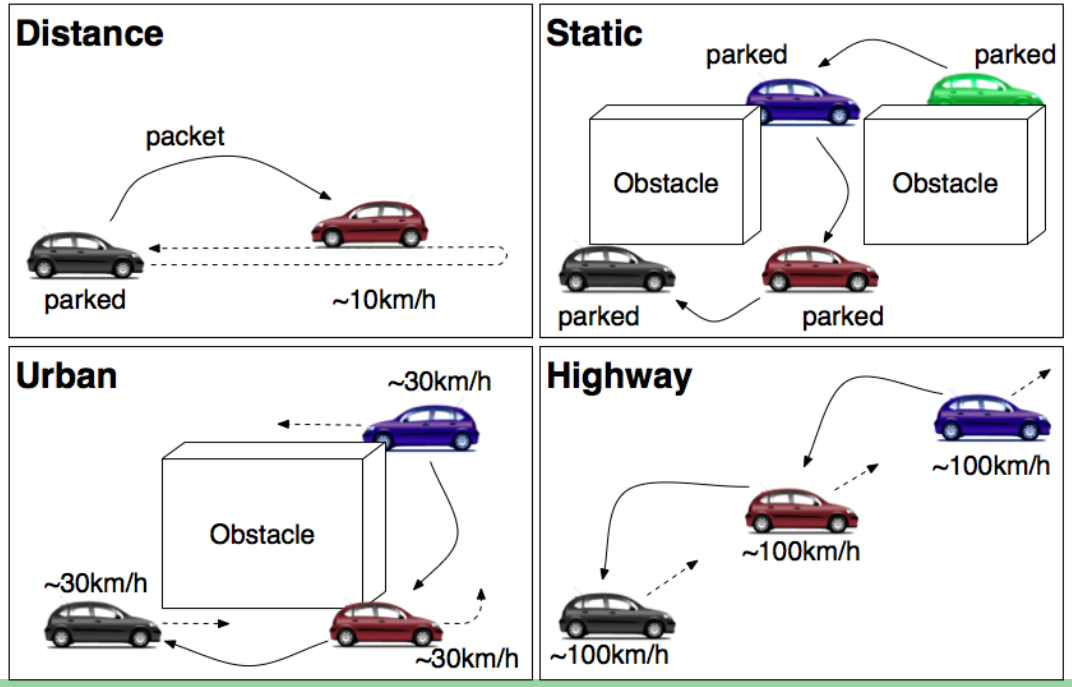
- V2V and V2I network
- ARs and MRs
  - OS: Linux 2.6.29.6
  - Wireless configuration
    - frequency 2.422Ghz
    - Data rate 6 Mbits/s
  - NEMO is supported
  - GeoNetworking is supported





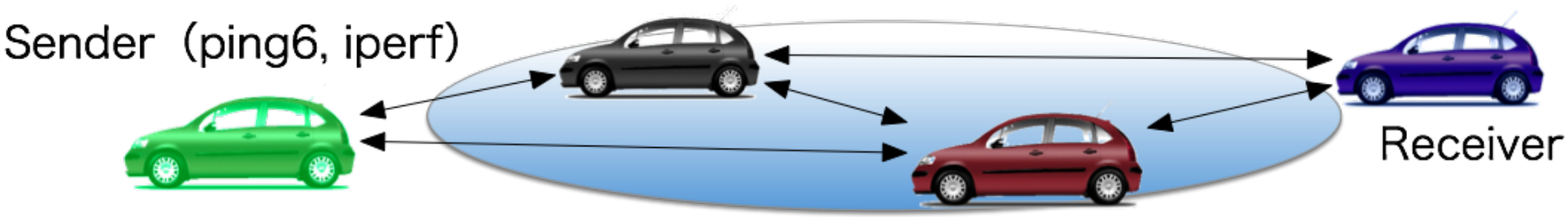
Testing Scenarios

- Location Scenarios
  - INRIA Paris-Rocquencourt installations
- Number of vehicles
  - Up to four vehicles are considered in our case
- Mobility Scenarios



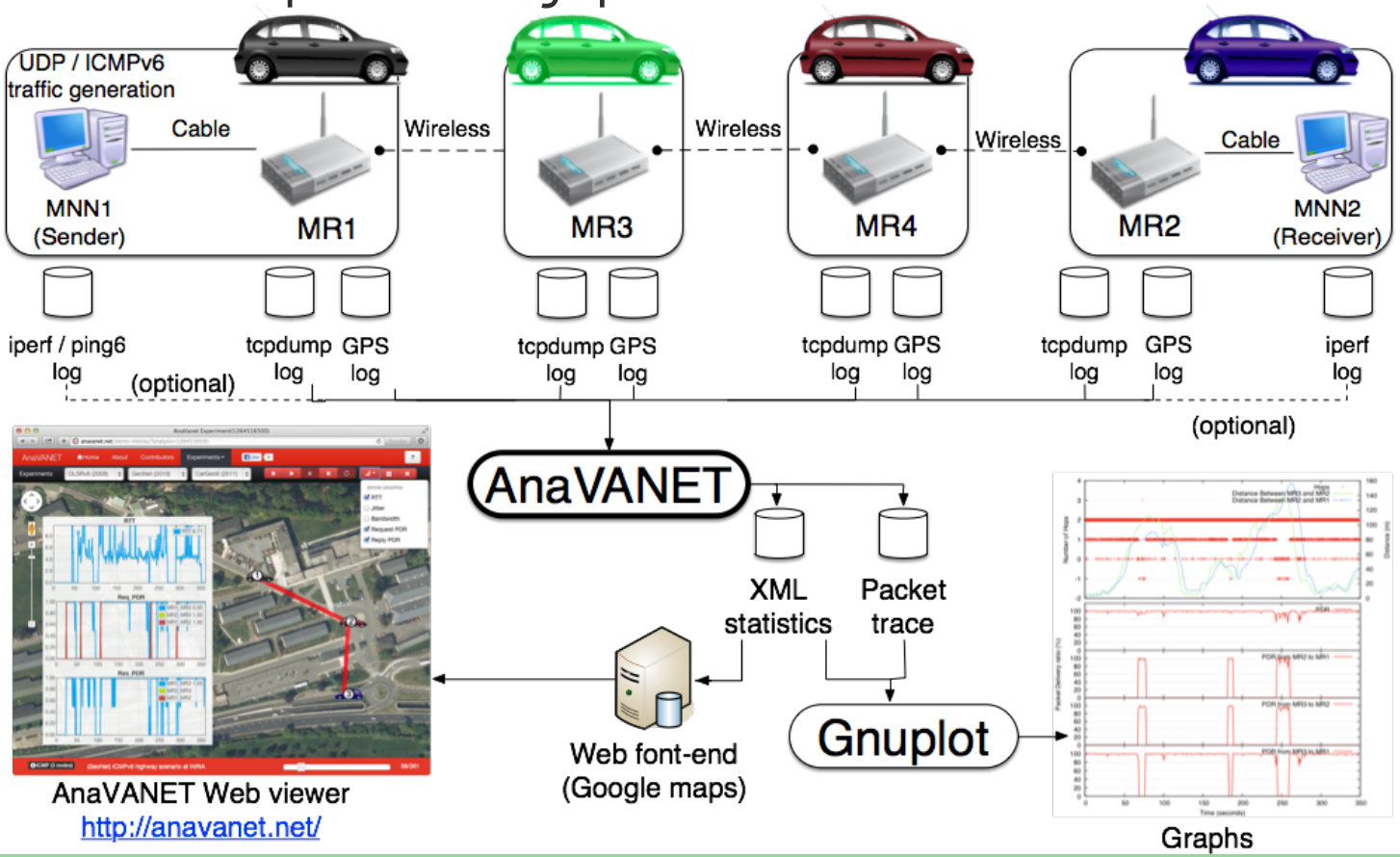
Data Flows and Performance Indicators

- Data Flows
  - UDP
  - TCP
  - ICMPv6
- Performance Indicators
  - Packet Delivery Ratio
  - Round Trip Time
  - Bandwidth
  - Jitter
- Geographic metric
  - Hop count
  - Speed
  - Position of cars
  - Distance between cars



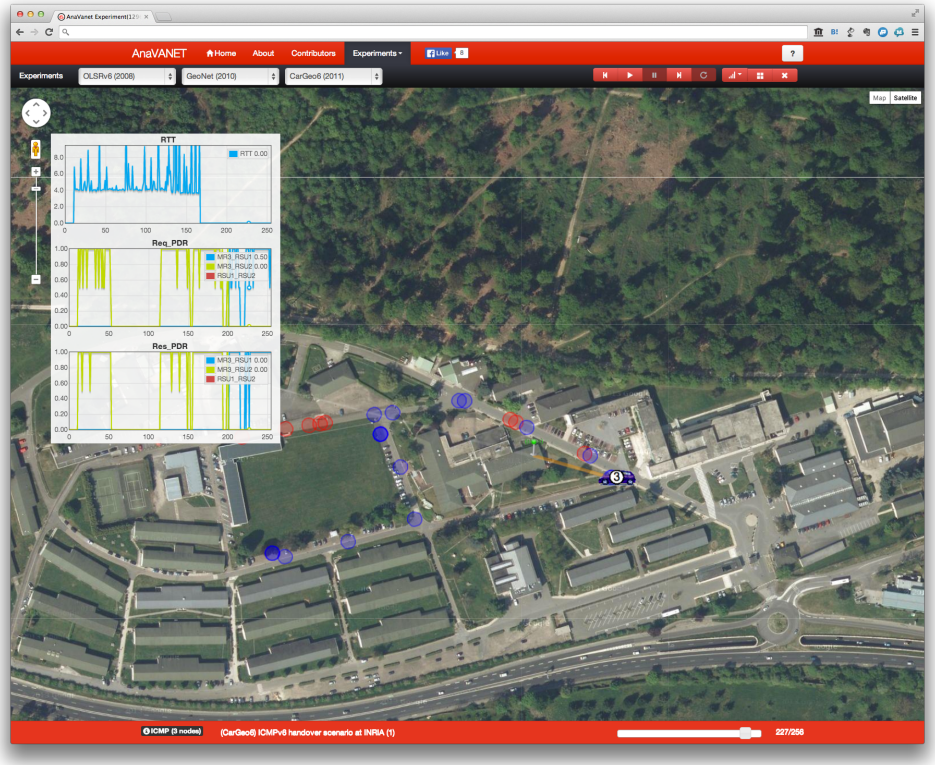
Overview of the AnaVANET system

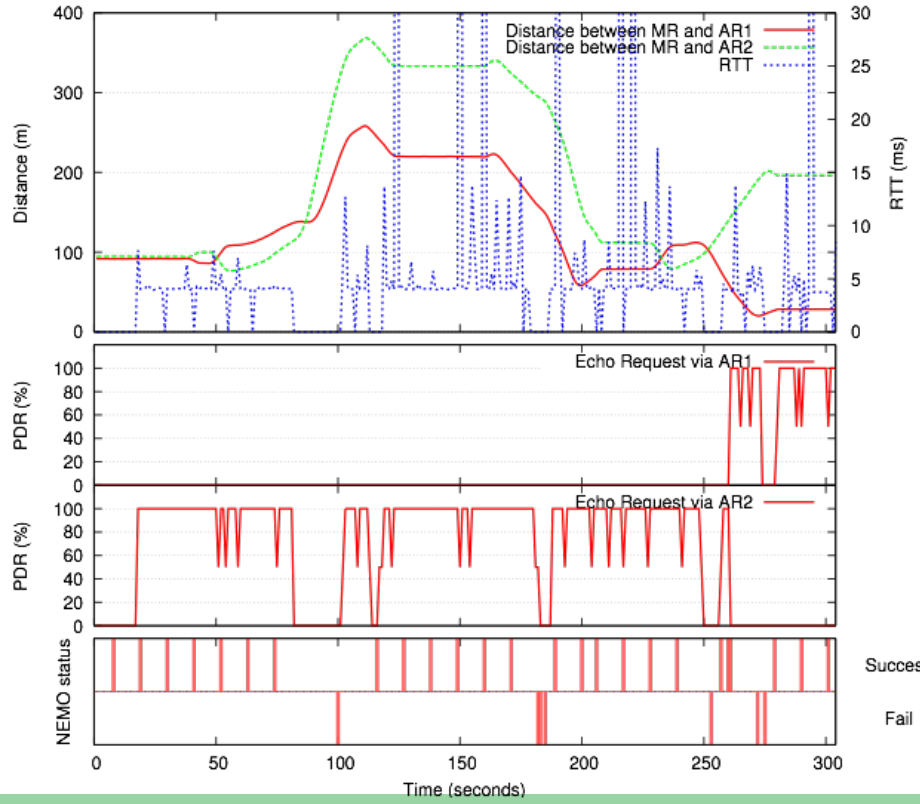
- Generate packets with UDP, TCP and ICMPv6
- Capture packets in all the nodes
- Trace them packet by packet



Output examples

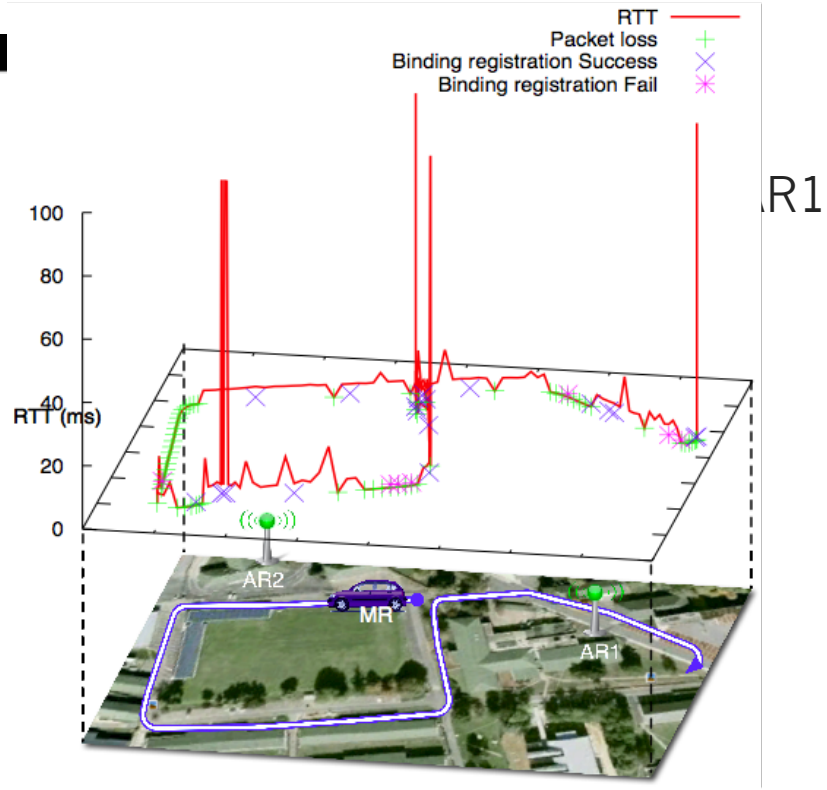
- Google maps shows the performance indicators with
  - Movement
  - Distance
  - Obstacles



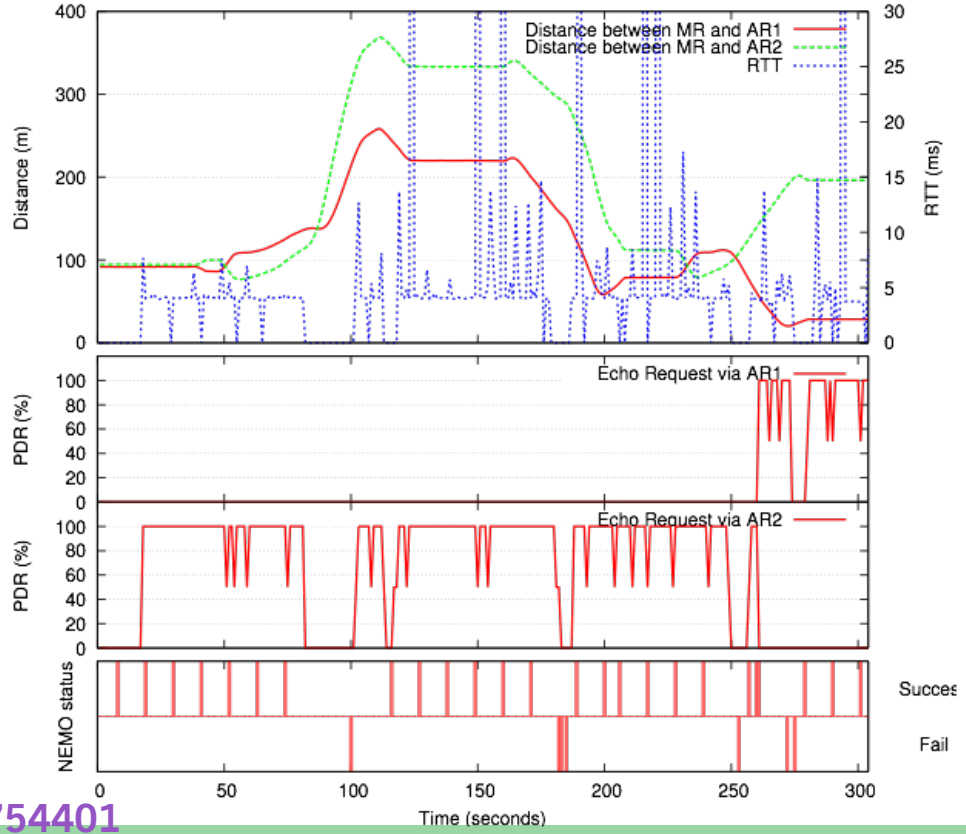


IPv6 GeoNetworking using NEMO (ICMPv6)

- 64 bytes in 0.5s interval
- RTT is about 5ms
- Binding registrations are lost in the south road
-



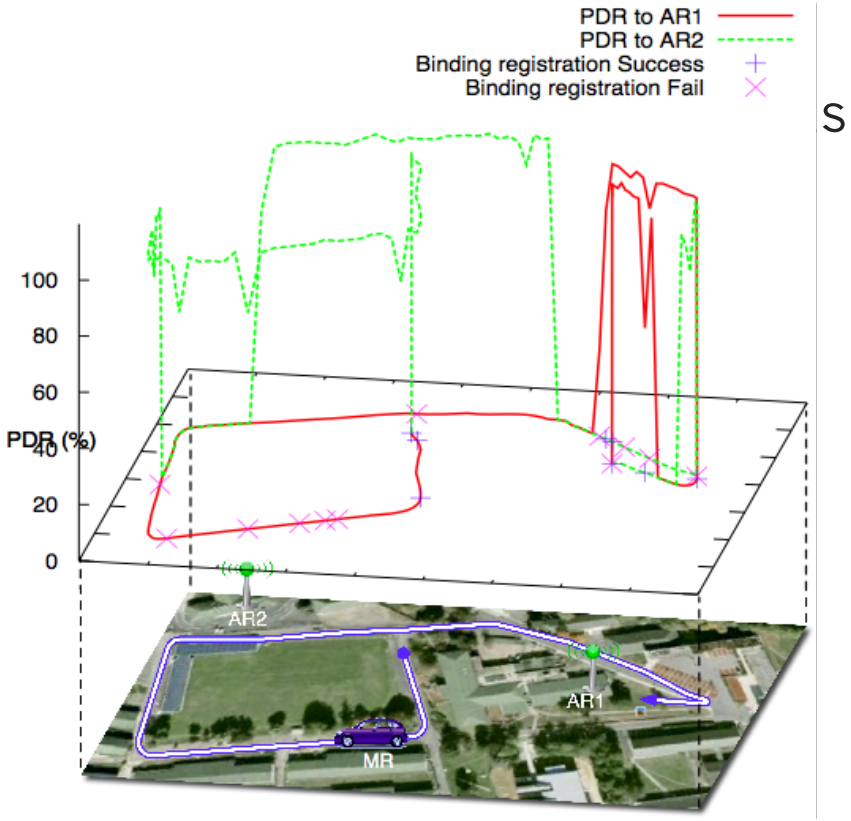
R1



http://anavanet.net/demo-vienna/?analysis=1296754401

IPv6 GeoNetworking using NEMO (UDP)

- 1250 Bytes packet with 1 Mbps rate
- UDP packets are lost during 4 seconds in handover



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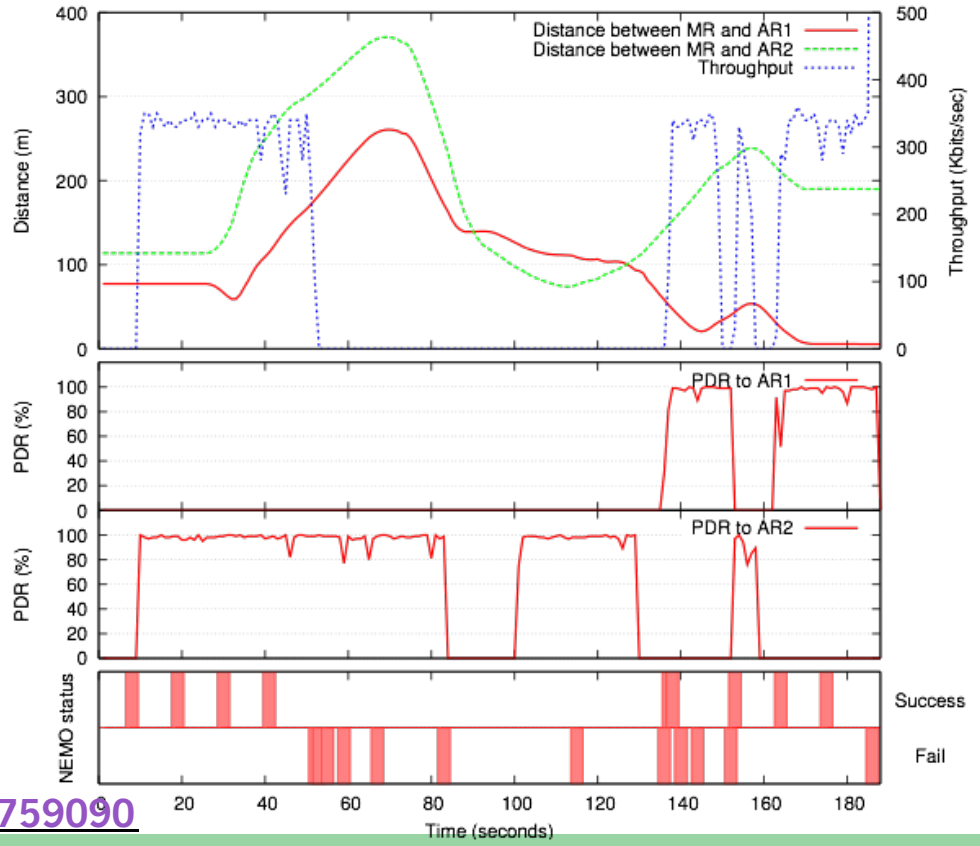

http://anavanet.net/demo-vienna/?analysis=1296759090

Summary

- **Cooperative ITS 2020**
  - Automated Driving is necessary
  - Distributed Intelligence network architecture for combination with Autonomous node
- **AnaVANET: tools for experimental evaluation of VANET**
  - Analysis of evaluation of vehicular networks
  - Evaluation methodology
  - Analysis of metric impacts the network performance
  - Performance indicators
  - Design and Implementation of AnaVANET
  - Evaluation of IPv6 GeoNetworking using NEMO

Thanks

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