

# Experimental Evaluation for IPv6 over VANET Geographic routing

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# GeoNet and C2CNet

- Geo-scoped communication



- Geo-unicast, Geo-broadcast, Topo-broadcast, Geo-anycast

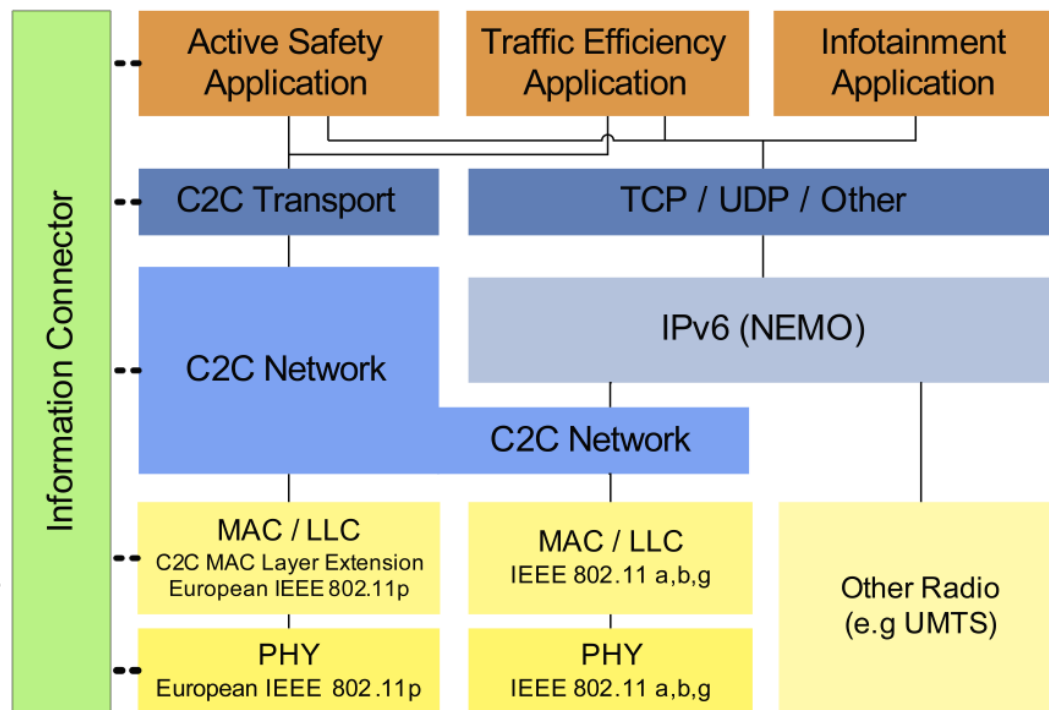
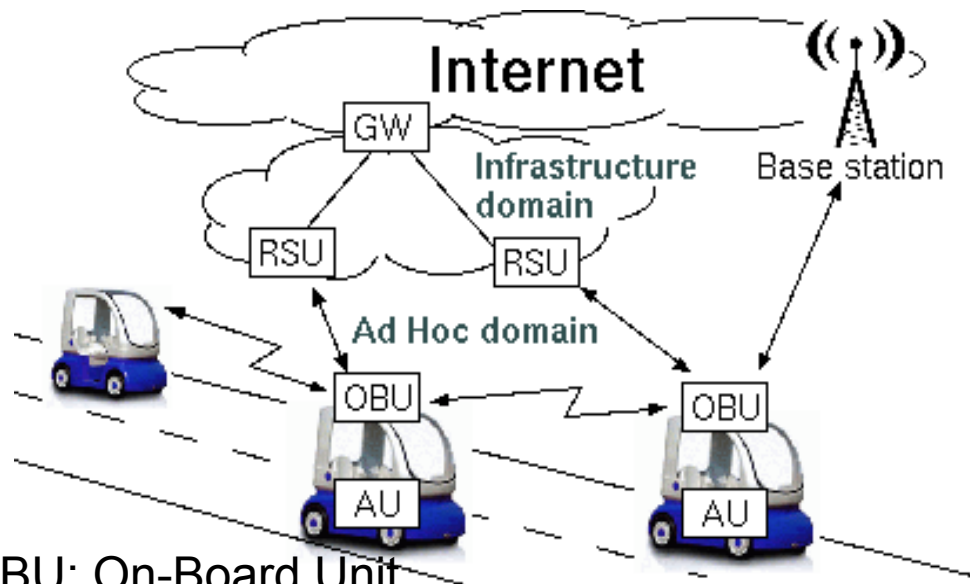
- Specification of C2CNet



- Enabling IPv6 & Implementation



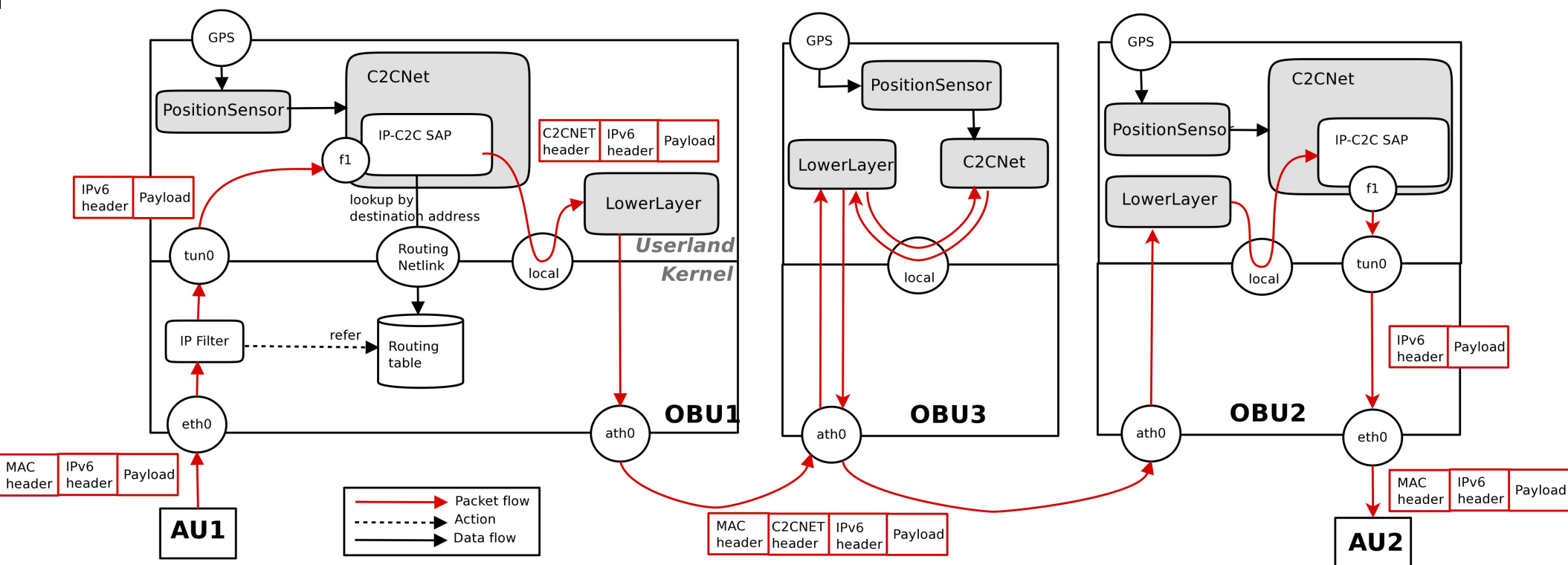
Packet format:



OBU: On-Board Unit  
 RSU: Road Side Unit  
 AU: Application Unit

# Design and Implementation

- Cooperation of three modules (**PositionSensor**, **Lowerlayer** and **C2CNet**)
- IPv6 Unicast Packet -> C2CNet GeoUnicast
- IPv6 Multicast Packet -> C2CNet GeoBroadcast

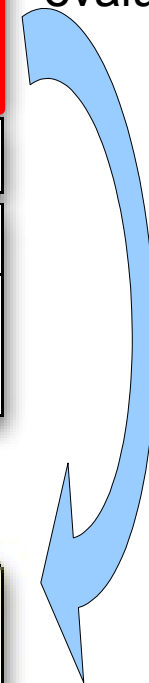


# Evaluation Methodology

- Evaluation of IPv6 over C2CNet
- Evaluation is mapping between configurable parameter and Evaluation Metric

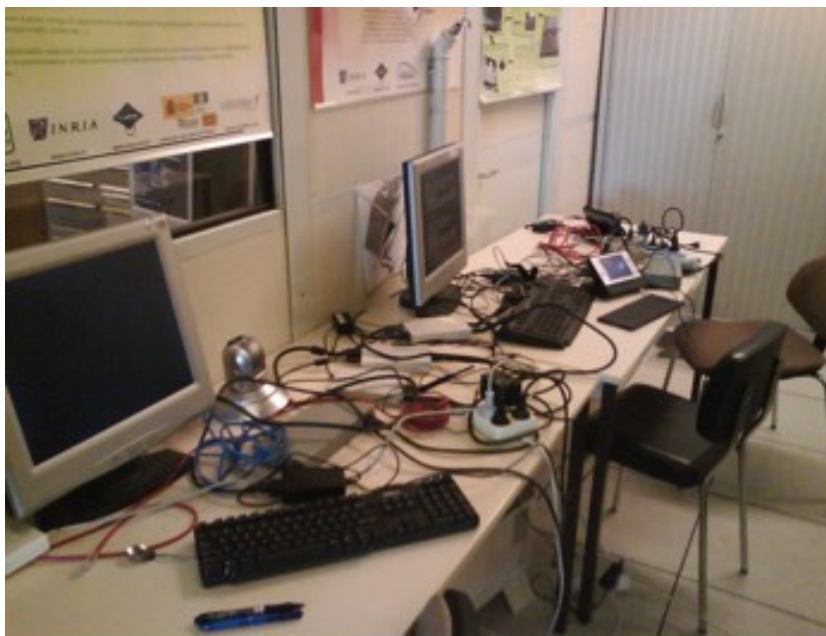
AnaVANET  
(developed tool)  
maps geographic  
parameter with  
evaluation metrics

| Parameters            | Elements   |                                   |                                       |
|-----------------------|--|-----------------------------------|---------------------------------------|
| Test environment      | Indoor   | Outdoor                           |                                       |
|                       |  | Distance                          | Speed                                 |
| Network Configuration | Single hop   |                                   | Multi-hop                             |
| Communication Type    | UDP  | TCP                               | ICMPv6                                |
|                       | packet size, sending bandwidth                       | TCP window size, Max segment size | Packet size, send interval            |
| Evaluation metric     | Packet delivery ratio, throughput, Jitter, Hop count |                                   | Throughput                            |
|                       |  |                                   | RTT, Packet delivery ratio, Hop count |

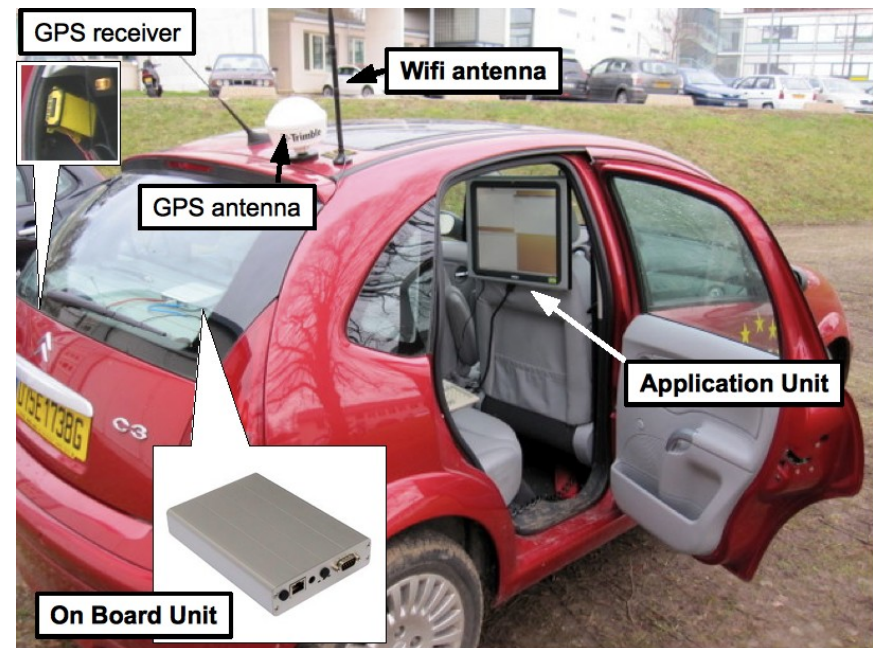


# Testbed

- On Board Unit (Ubuntu, kernel version 2.6.29.6)
  - Model: Alix3d3
  - CPU: AMD PCSi586 CPU 498.128 MHz
  - mini-pci wireless card (Atheros AR5413 802.11abg NIC)
- Application Unit (Ubuntu, kernel version 2.6.31-17)



Indoor Test



Outdoor Test

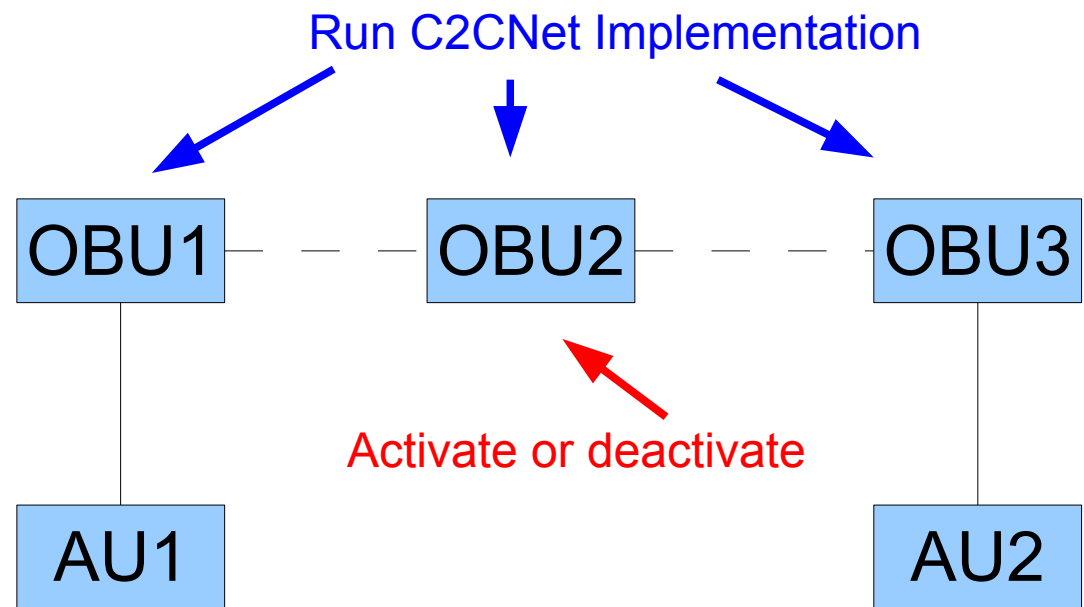
# Indoor Testbed

- **Network configuration** → Single hop / multihop
- **Communication type** → UDP / TCP / ICMPv6



Indoor Testbed  
in INRIA

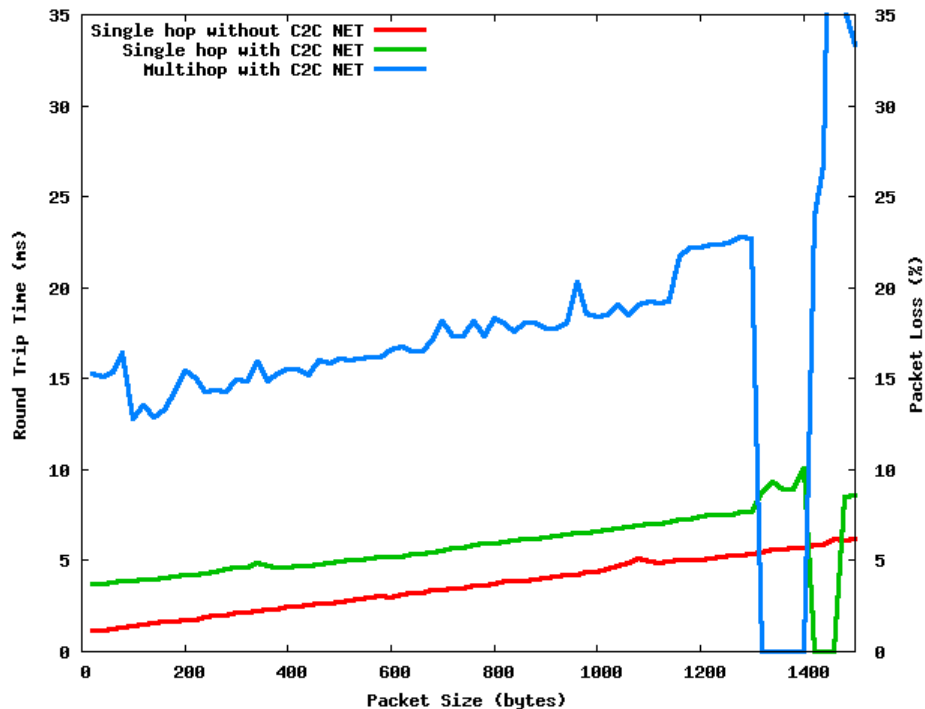
Send UDP or TCP by iperf  
Or ICMPv6 by ping6  
To AU2



# Indoor Test Result

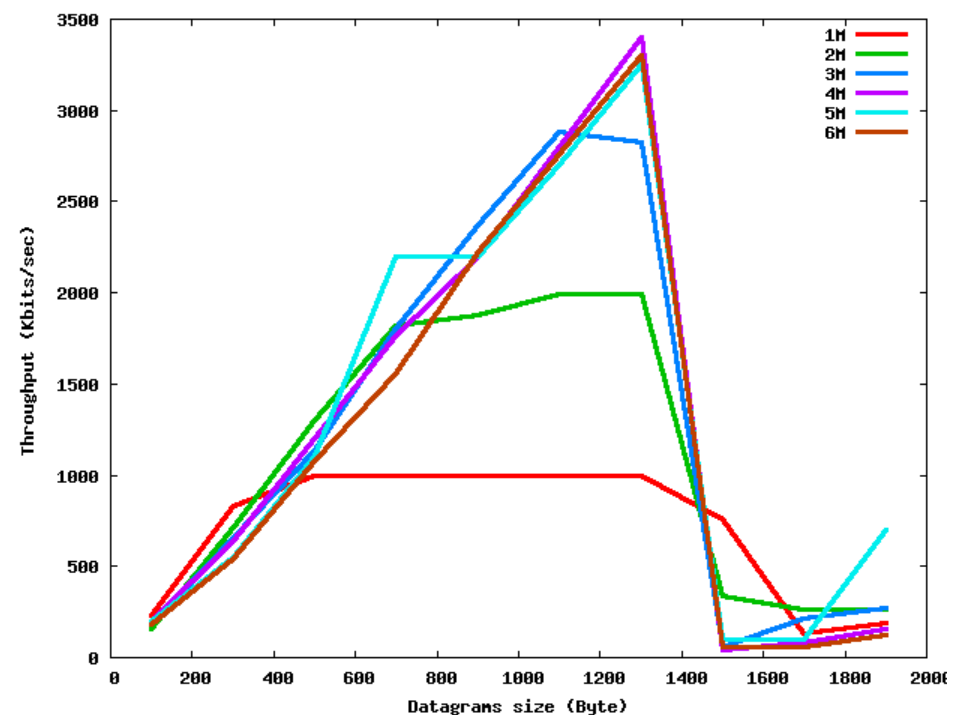
## ● ICMPv6

- C2CNet add 3ms more than without C2CNet in single hop
- Packet fragments when packet size is more than 1300 Bytes



## ● UDP

- Size=1300 Bytes makes less packet loss
- Size>1300 Bytes makes packet fragmentation
- The maximum bandwidth is 3.5 Mbytes/sec



# Measurement on VANET

- Communication Metric

- Bandwidth
- RTT
- Jitter
- Packet Delivery Ratio

- Geographic Metric

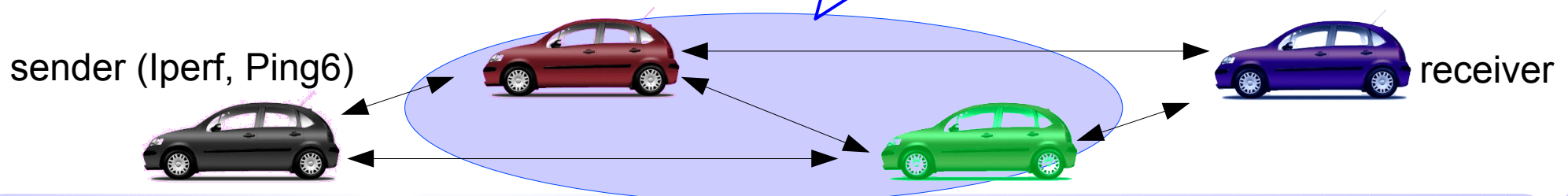
- Hop count
- Speed
- Position
- Distance between cars

- Communication Type

- UDP
- TCP
- ICMPv6

- Issues on Measurement

- Paths unawareness
- Unknown hop performance
- Movement unawareness





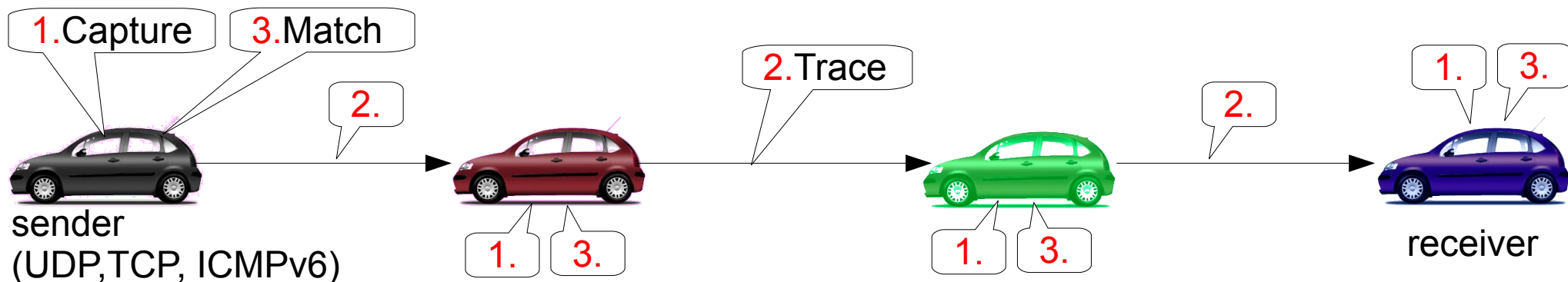
# Packet capturing, tracing and matching

- Requirements

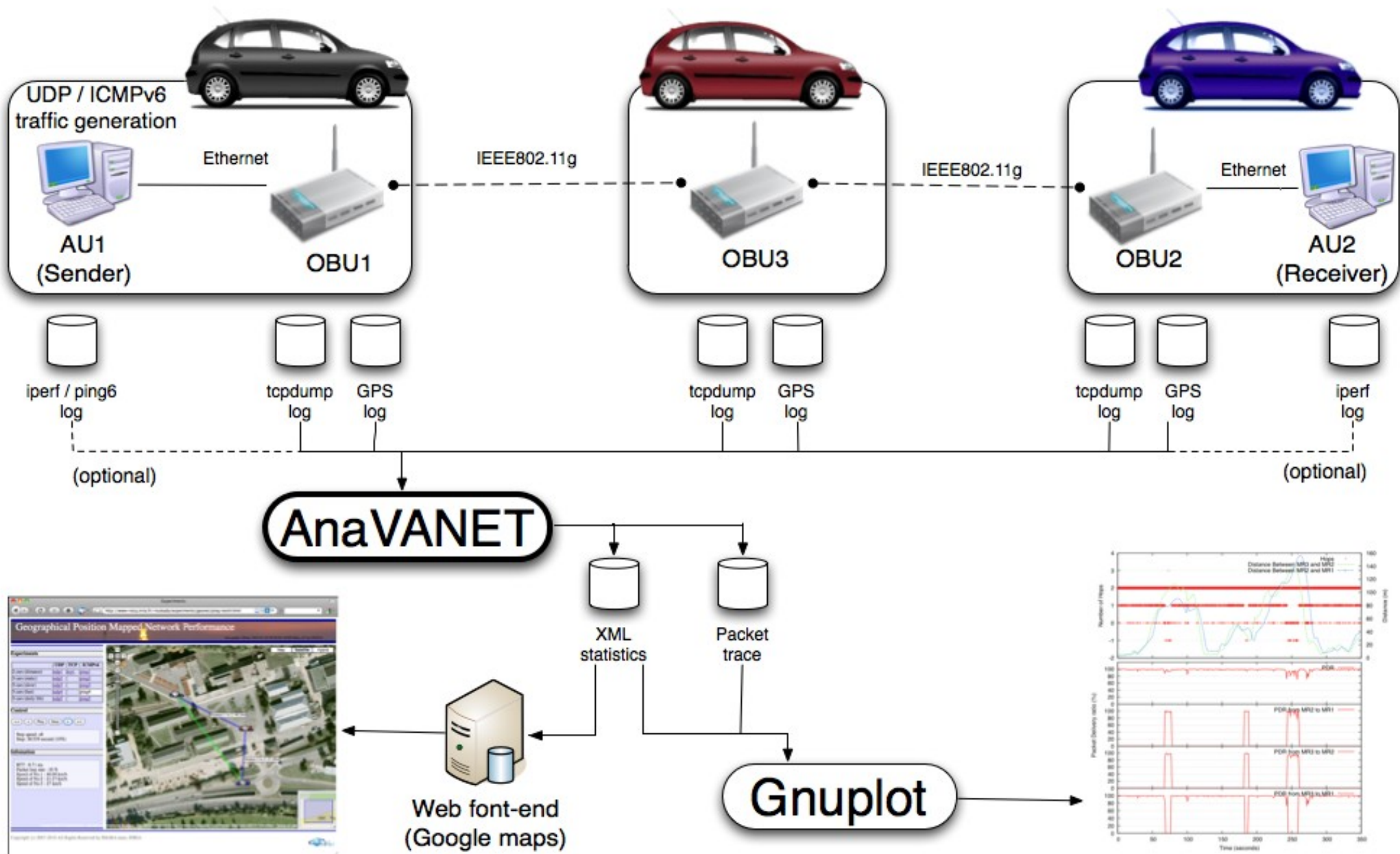
1. Path detection
2. Hop by hop performance measurement
3. Movement awareness

- The system

- Generate Packets with UDP, TCP and ICMPv6, then
- 0. Capture packets at all the nodes,
- 1. Trace them packet by packet
- 2. Match them with location



# AnaVANET: Experiment Evaluation tools



# Output examples

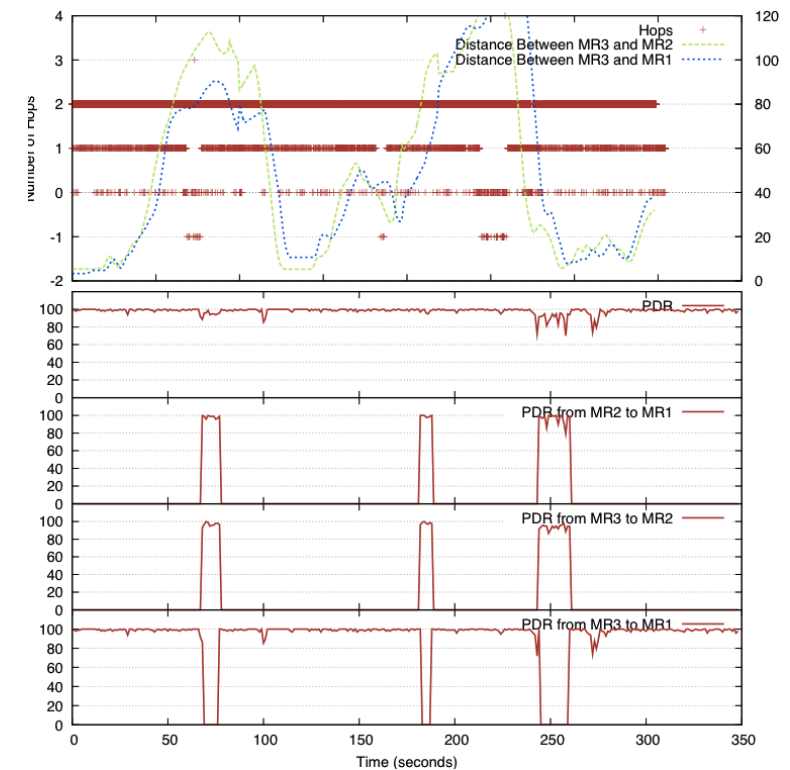
- Google Maps shows metrics with...

- Movement
- Distance
- Obstacle



- Graphs generated by gnuplot shows...

- All history of experiments



<http://www.geonet-project.eu/demonstration/geonet/>

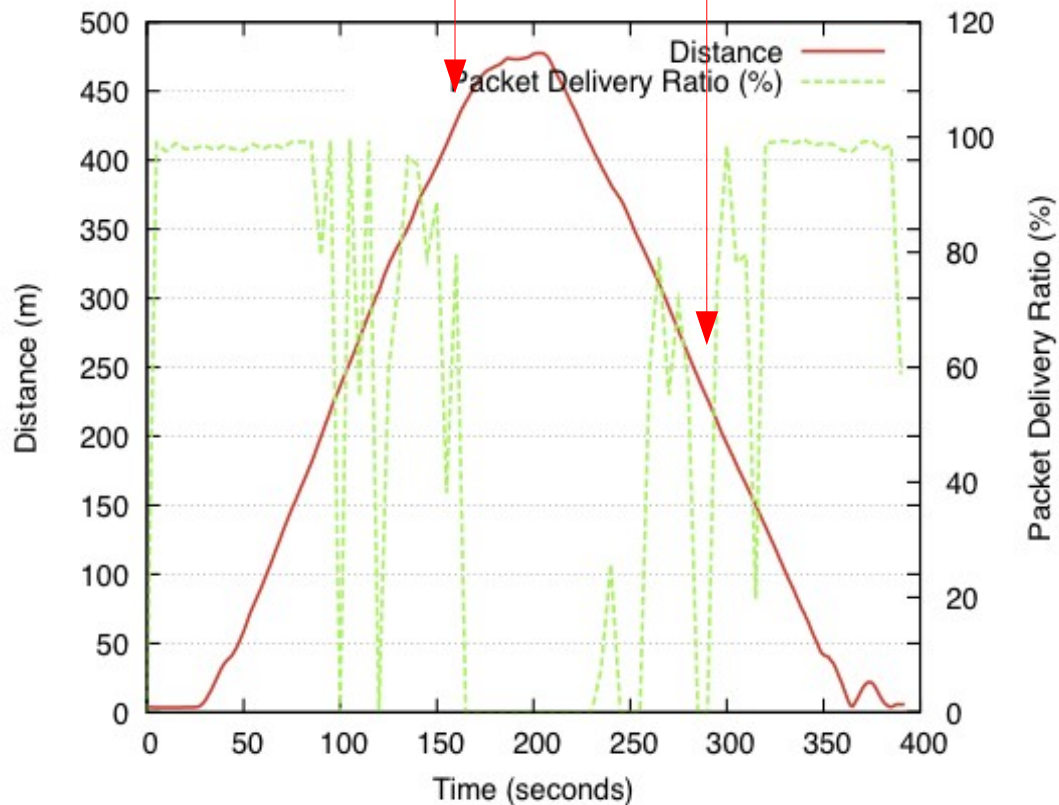
# Distance Test

- UDP Test

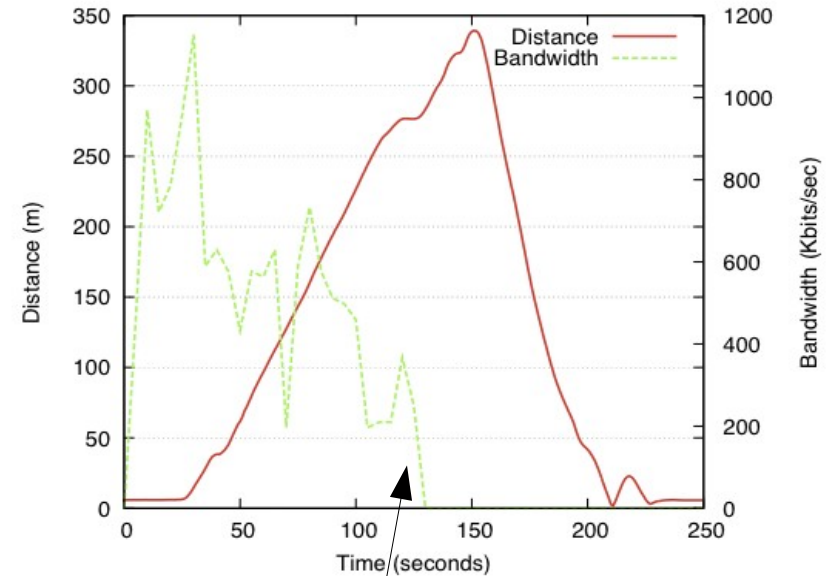
- Radio range is 450 meters

Packet delivery ratio recover  
At 250 meters

Packet delivery ratio is very  
robust until 450 meters



- TCP Test



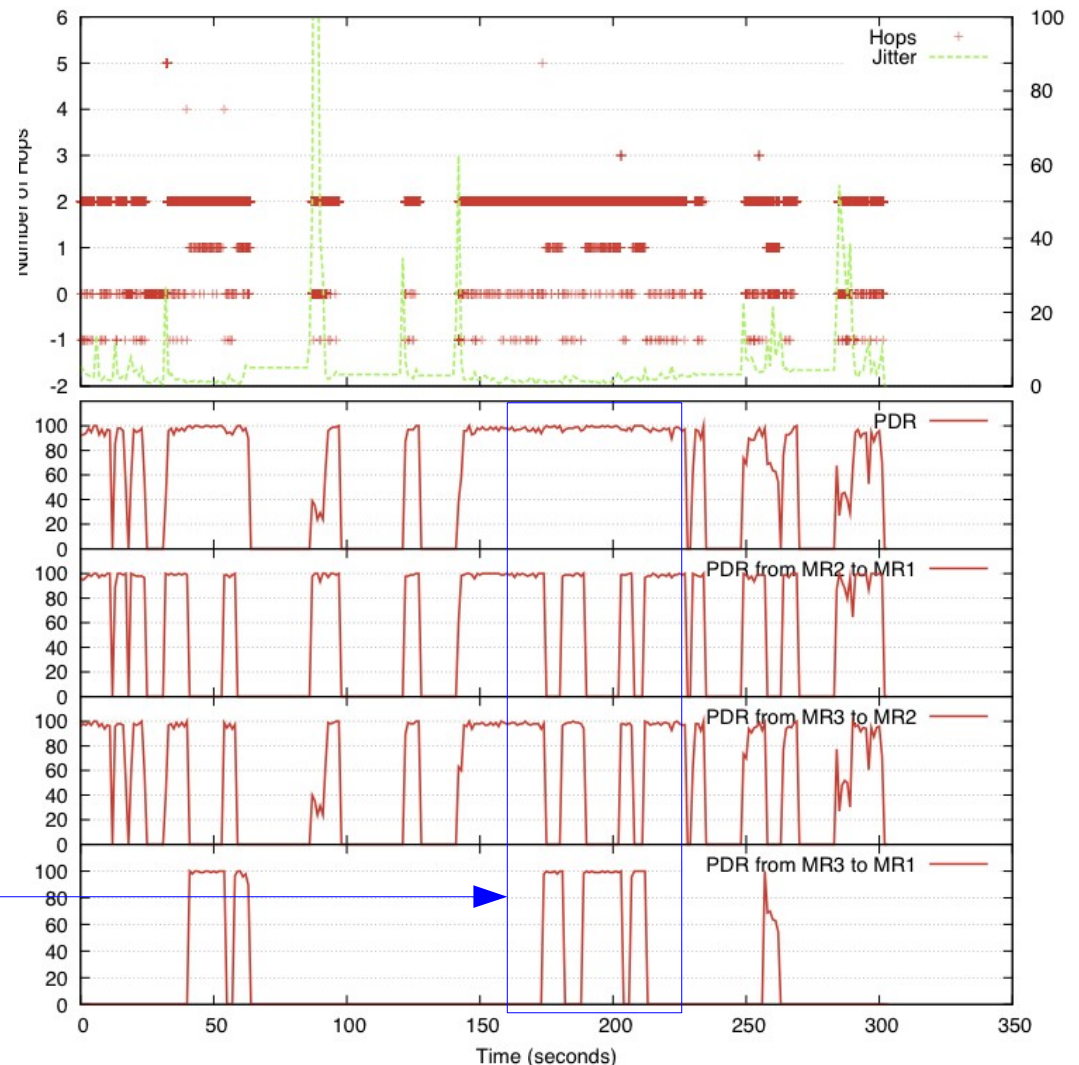
Bandwidth decreases gradually  
until 270 meters. And it doesn't  
come back

# Dynamic test (~30Km/h)

- 1 floor buildings does not always block radio
- INRIA is not best place to emulate urban environment

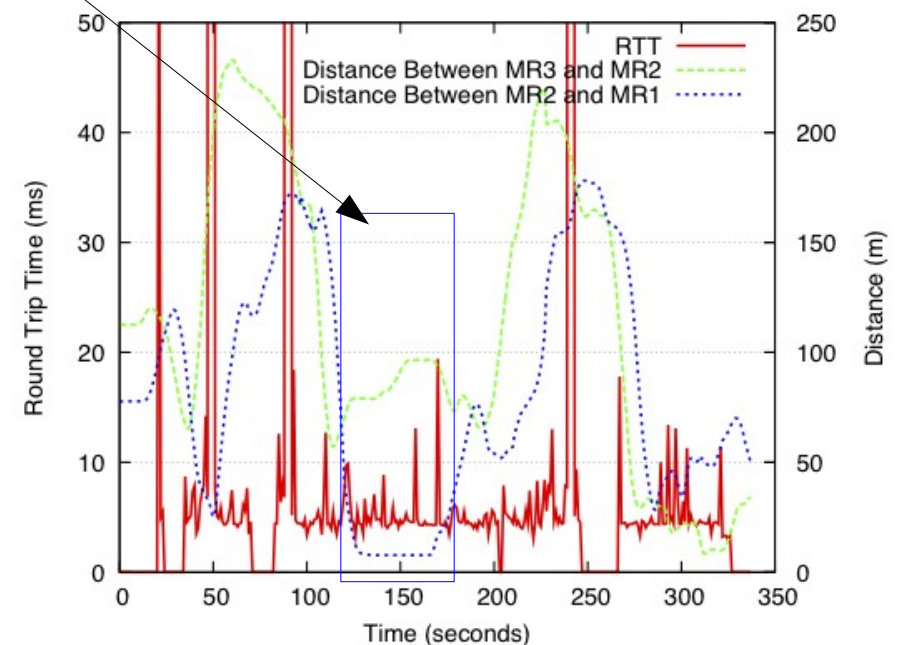
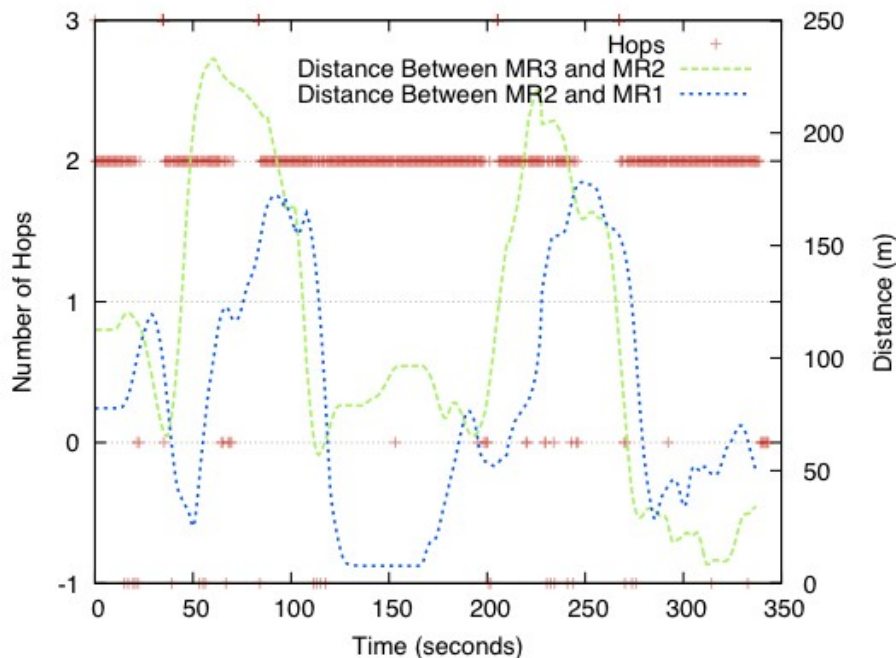
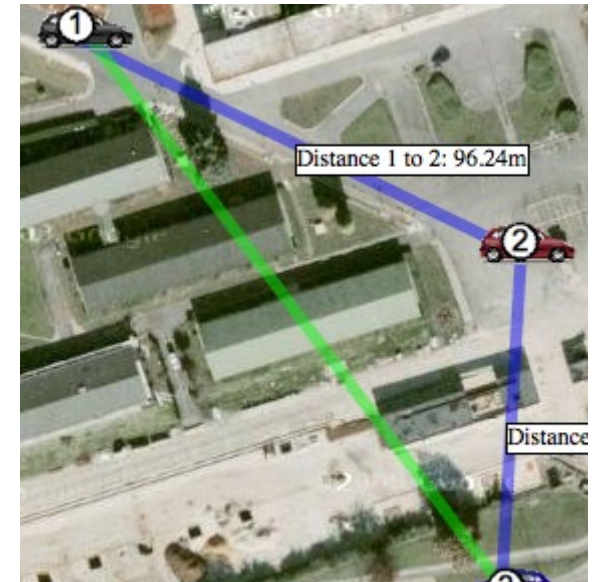


Route change doesn't have negative impact to overall packet delivery ratio

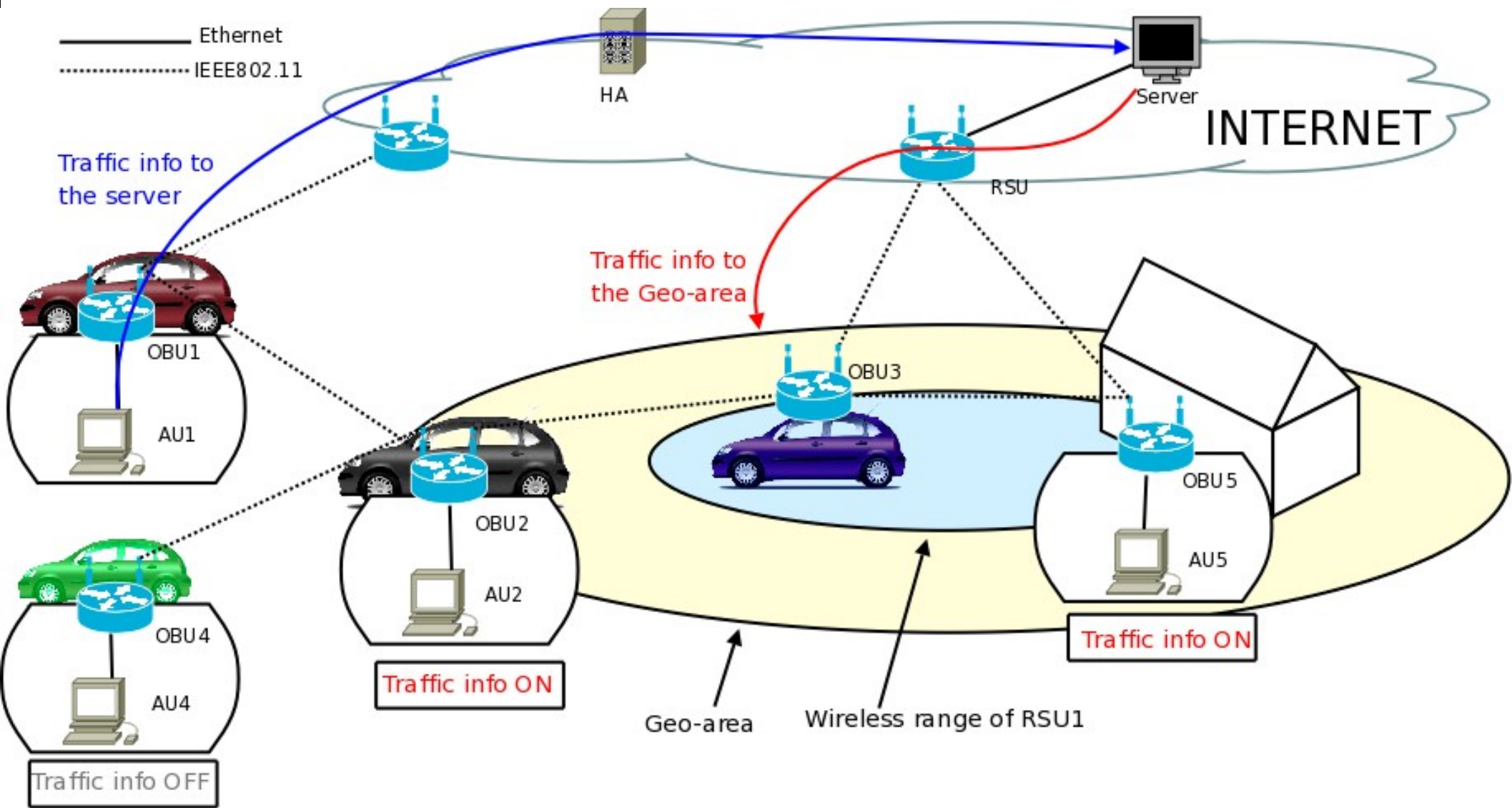


# Dynamic test (~100km/h)

- Packets take single hop (two hop for request and reply) most of the time of the test
- Network is stable when vehicles stop at the traffic light



# Demonstration Scenario for GeoNet



# Conclusion and Future works

- Conclusion
  - IPv6 over C2CNet is designed and implemented
  - AvaVANET is developed in order to evaluate IPv6 over C2CNet with various geographic parameter
  - Indoor test is performed to evaluate pure network performance avoiding unexpected traffic
  - 4 scenarios are performed in outdoor testbed
  - IPv6 over C2CNet adds 3 ms more than IPv6 only on RTT in ICMPv6
  - Bandwidth reaches to 3500 Kbps in best condition
  - For one hop comm., radio range is around 500 meters
- Future works
  - Evaluation with Multicast, NEMO, MCoA
  - Evaluation with real application



# Fin

- Thank you for attention
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  - Ines Ben Jemaa (INRIA Paris - Rocquencourt)
  - Hamid Menouar (HITACHI Europe)
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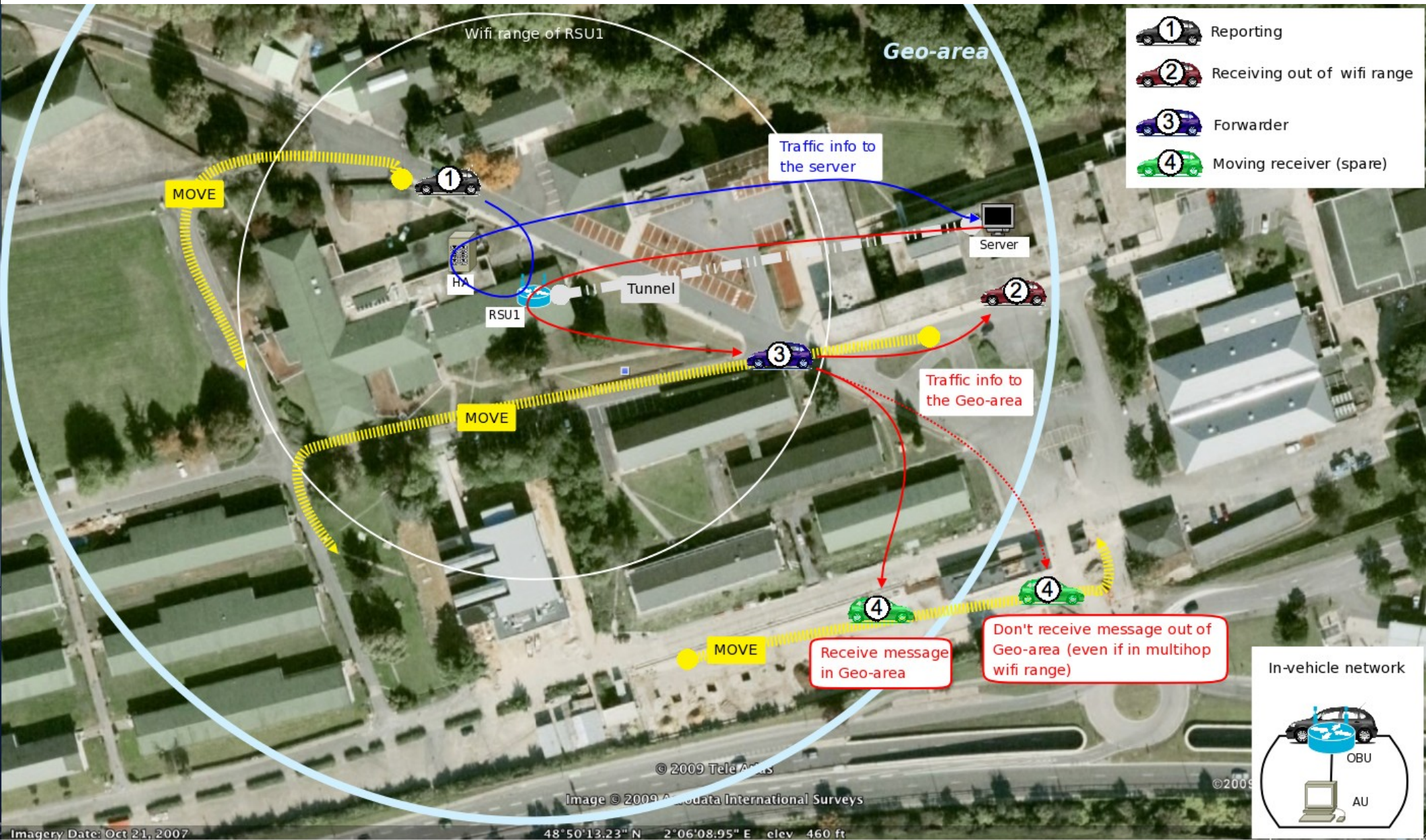


INRIA

HITACHI  
Inspire the Next

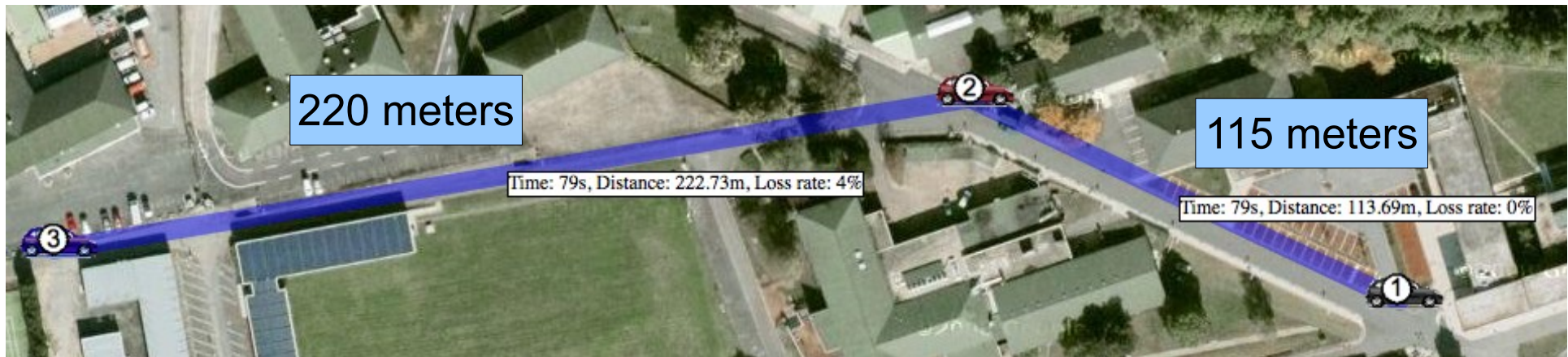
NEC

# Demonstration Scenario



# Static test

- Packet Delivery Ratio is 90.18%
- RTT is 5.81 ms, when it is stable
- RTT varies from 4.6 ms to 5080 ms (very unstable because of route change)



| Test                 | Metric                 | Minimum | Average | Maximum | Standard deviation |
|----------------------|------------------------|---------|---------|---------|--------------------|
| UDP<br>3 vehicles    | PDR (%)                | 21.88   | 90.18   | 98.13   | 14.99              |
|                      | Bandwidth (Kbps)       | 274.56  | 901.95  | 998.4   | 151.31             |
|                      | Jitter (ms)            | 1.25    | 2.89    | 39.2    | 5.27               |
| ICMPv6<br>3 vehicles | RTT (ms) all 300 sec   | 4.6     | 477.43  | 5080    | 992.31             |
|                      | RTT (ms) stable 25 sec | 4.74    | 5.81    | 9.66    | 1.46               |