A Light Architecture for Opportunistic Vehicle-to-Infrastructure Communications

Farah El Ali And Bertrand Ducourthial

(1) University of Technology of Compiègne
(2) CNRS Heudiasyc UMR6599,
Centre de Recherche de Royallieu
B.P. 20529, Compiègne, France (Email: firstname.name@utc.fr)

MOBIWAC 2010
17-18 October

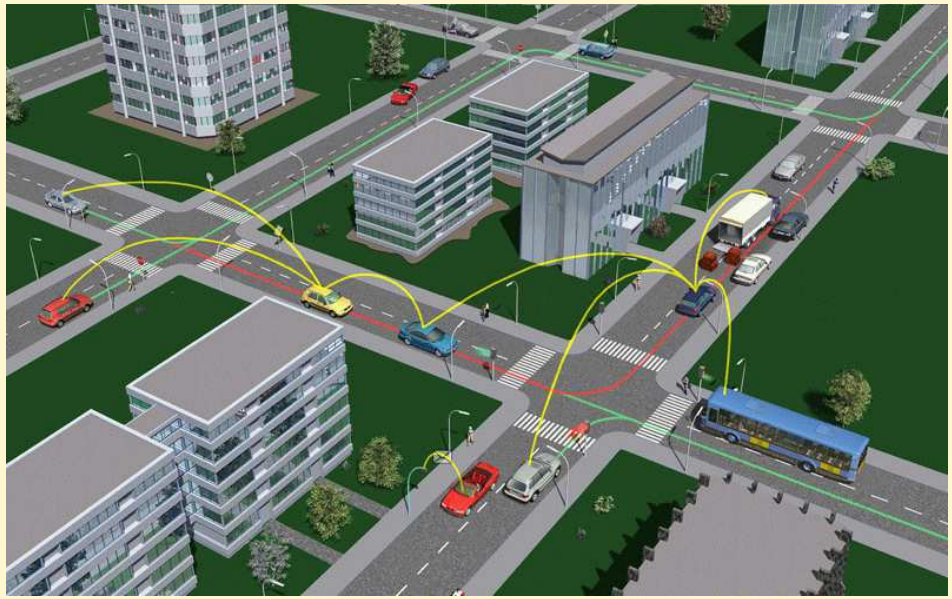
Intelligent Transport Systems (ITS)

Motivations:

- Safety
- Road traffic regulation (Infrastructure)
- New services aboard

Four applications families:

- Vehicle oriented
- Driver oriented
- Passenger oriented
- Infrastructure oriented



Normalization

IEEE → Wave
ISO → Calm
IETF → Mobile IP, IPv6, Nemo
MANET autoconfiguration (Autoconf)
C2C-CC → Specific protocols for VANET
ETSI → Standardization

- Large projects
  - USA (VII, CICAS, IVBSS, Intellidrive...)
  - Europe (CVIS, SafeSPOT, COOPERS, PReVENT, GST, HIGHWAY, FleeNet, SeVeCom, GeoNet ...)
    - Germany (NoW)
    - France (PREDIT)
  - Japan (SmartWay, VICS)
  - India (ITSIndia)
- Need for V2V and V2I

Problems to solve

- Vehicular networks are mobile, highly dynamic ad hoc networks:
  - Message loss
  - Frequent neighborhood change
  - Kind of predictability
- Kind of protocols for V2I
  - IP in V2I communications: seems unavoidable
  - IP in V2V communications: subject of debate

Summary of our proposition 1/2

Inconvenient of using IP in V2V :

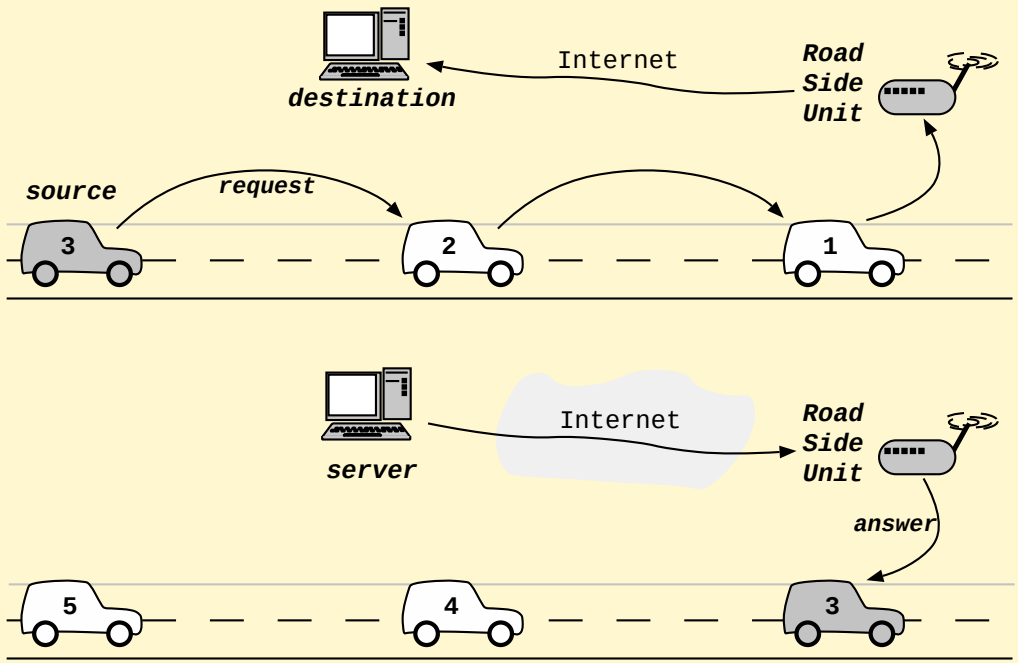
- Overhead control
- Autoconfiguration problems
- Hand-over

  (WAVE $\rightarrow$ no association with the road side unit)

Our proposition :

- VANET specific routing protocol
- IP only for gateway vehicle
- Using predictability (DTN)

Summary of our proposition 2/2



- WiFi or 3G
- V2V until the gateway
- IPv4 or IPv6 only in the last hop
- Any VANET specific routing for gateway discovery

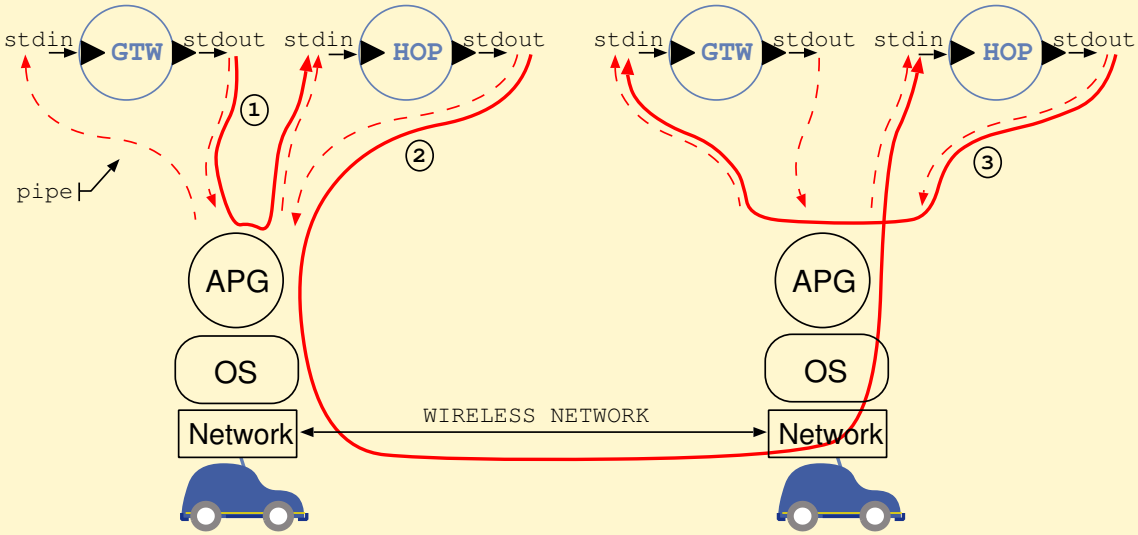
  (Our implementation: Conditional transmissions)

Architecture Components

Airplug

Light middleware for communications in dynamic networks.

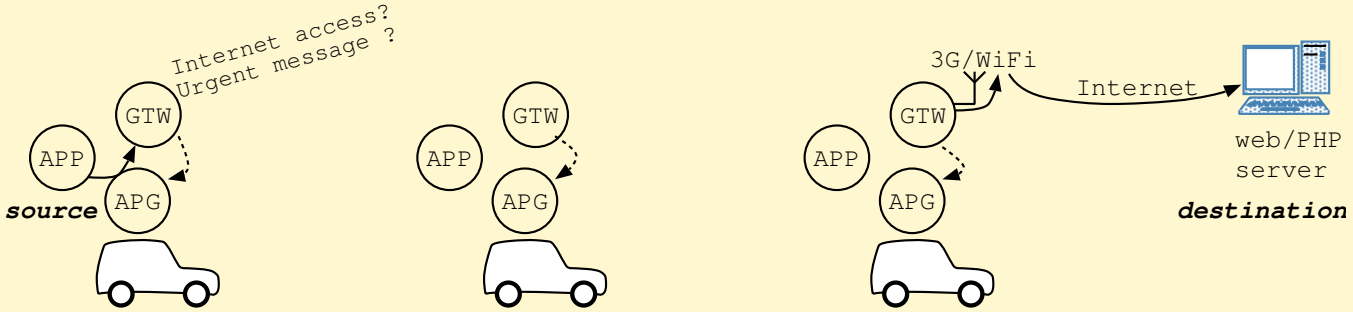
- No addresses
- Local/air
- Subscribing to applications



Architecture Components

GTW: gateway to the Internet

- Periodic scan of interfaces
- Sending the list of available interfaces periodically to all other applications through Airplug
- Gateway through: 3G, WiFi, LAN
- IPv4 or IPv6



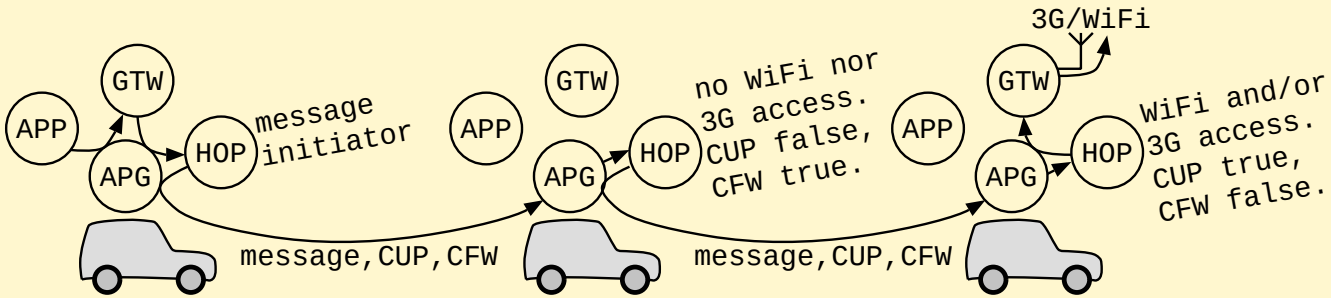
Architecture Components

HOP: Conditional transmissions

Routing technique adapted to dynamic networks (multi-hop retransmissions).

- Receiver only known by conditions
- Messages sent with two conditions: CUP and CFW
- Conditions evaluated at reception

  Identity or addresses, geographic positions, trajectory correlation (in front of, behind...), distance, duration...



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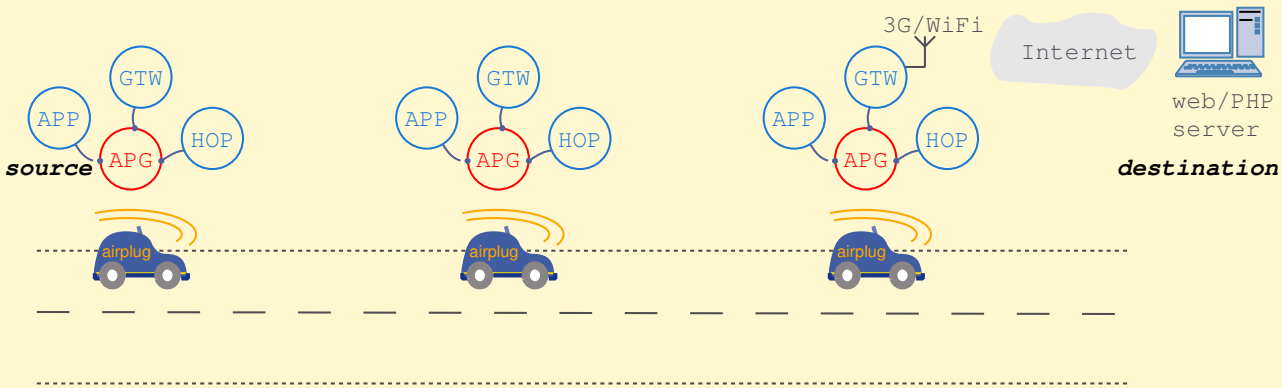

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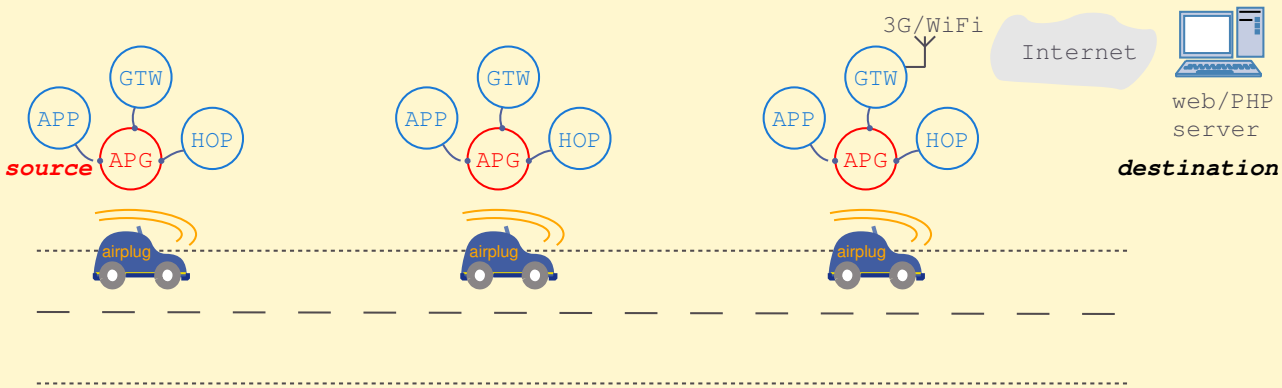

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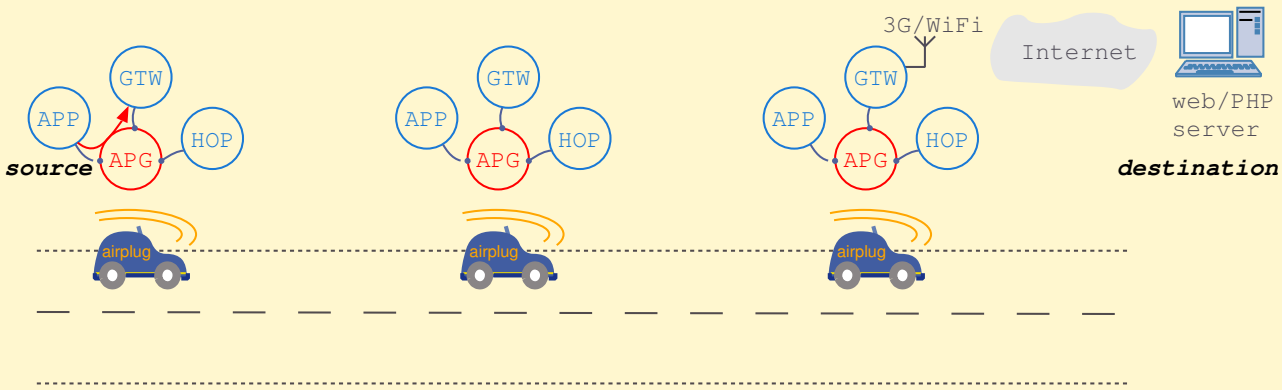

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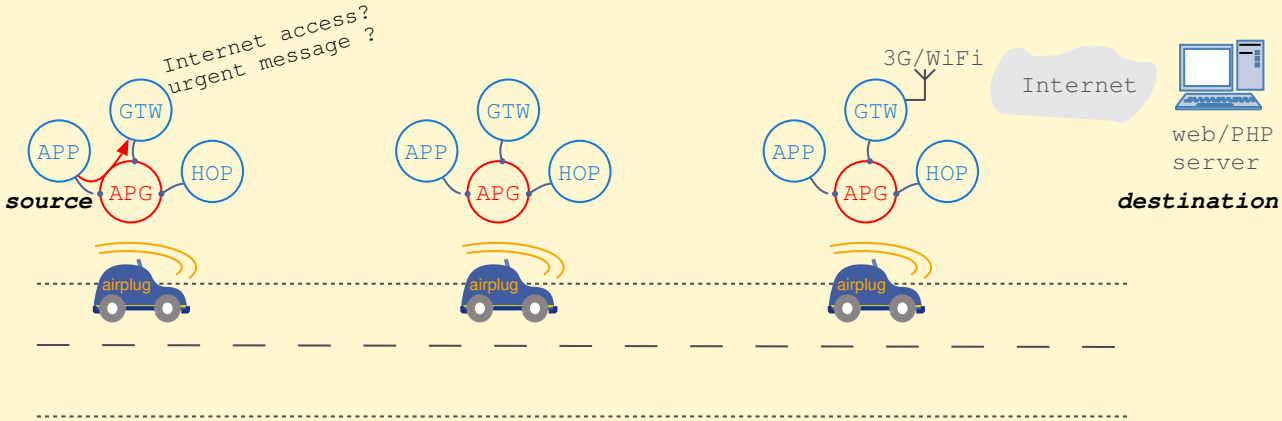

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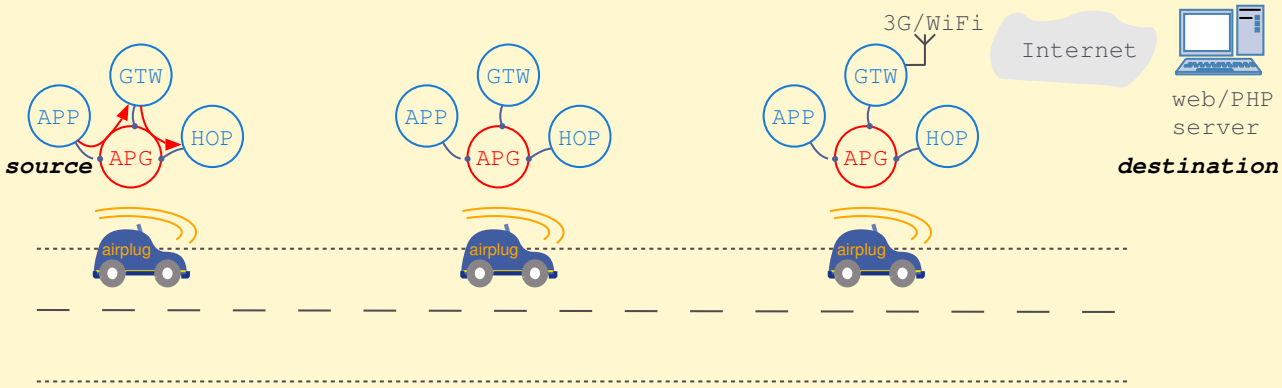

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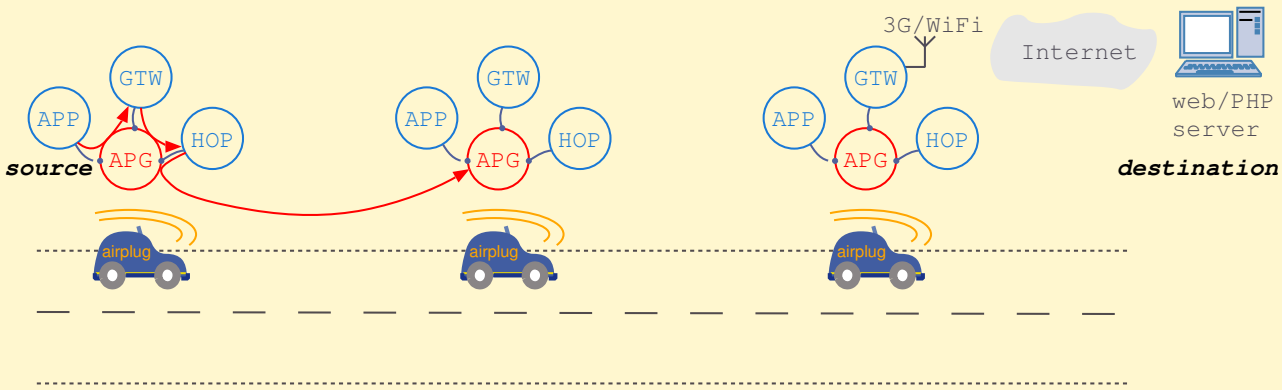

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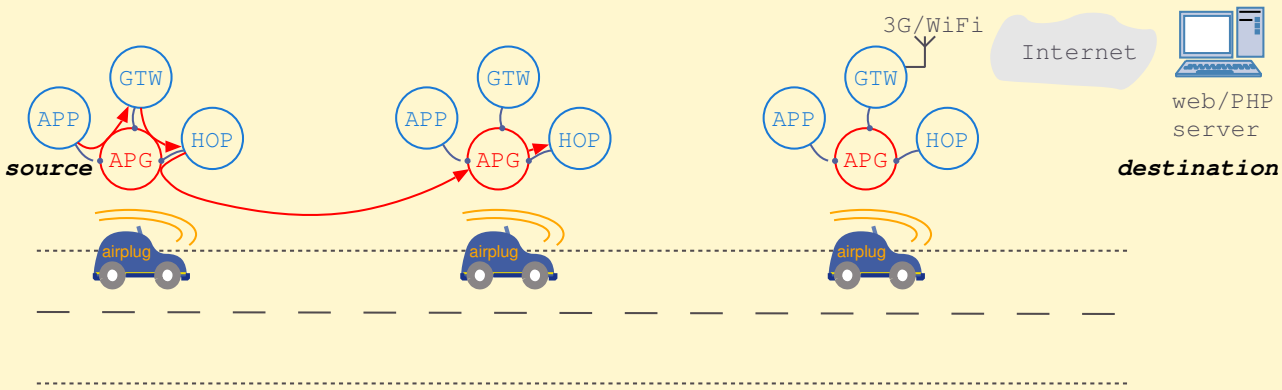

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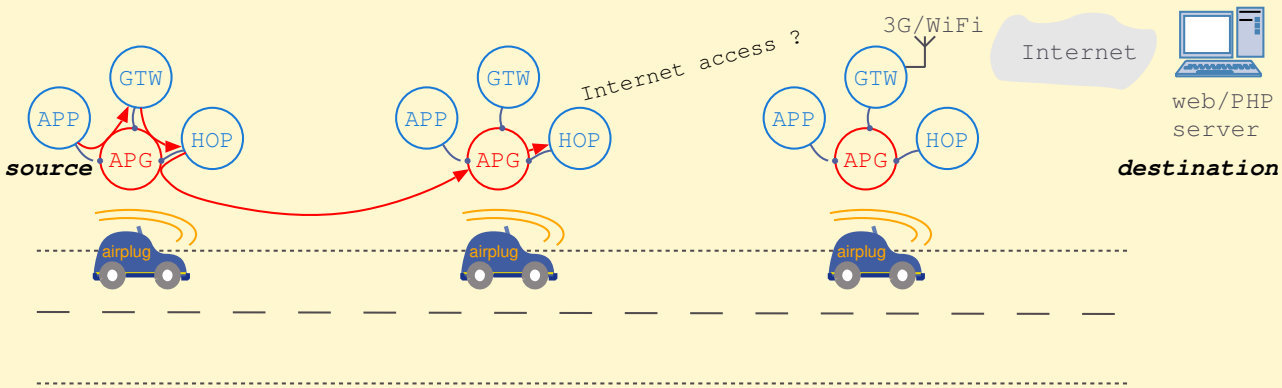

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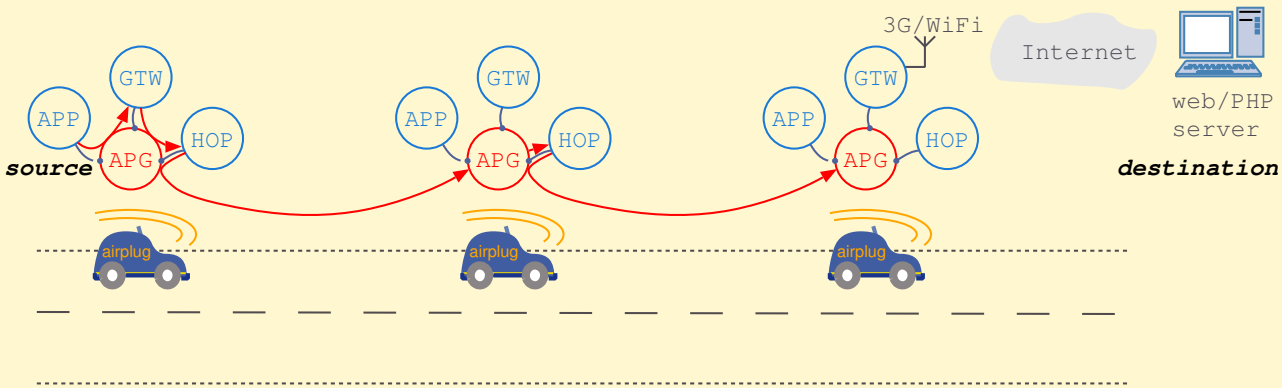

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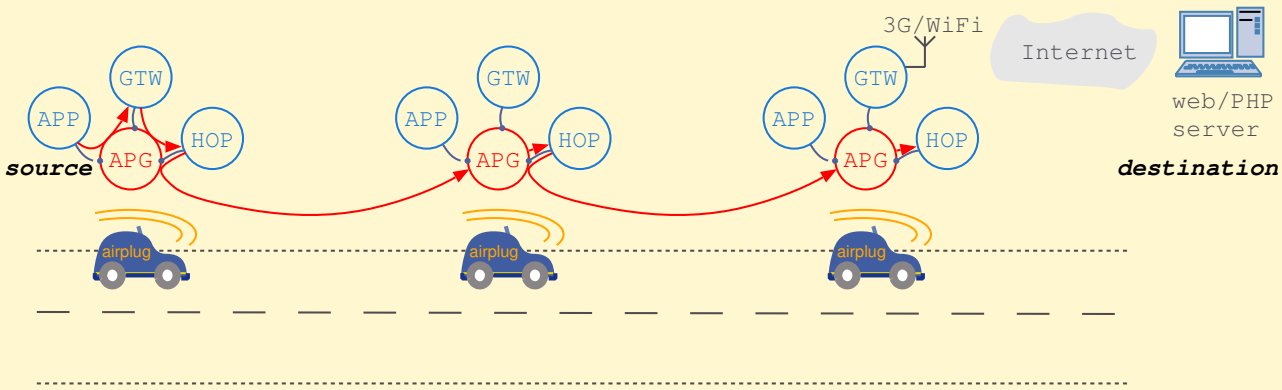

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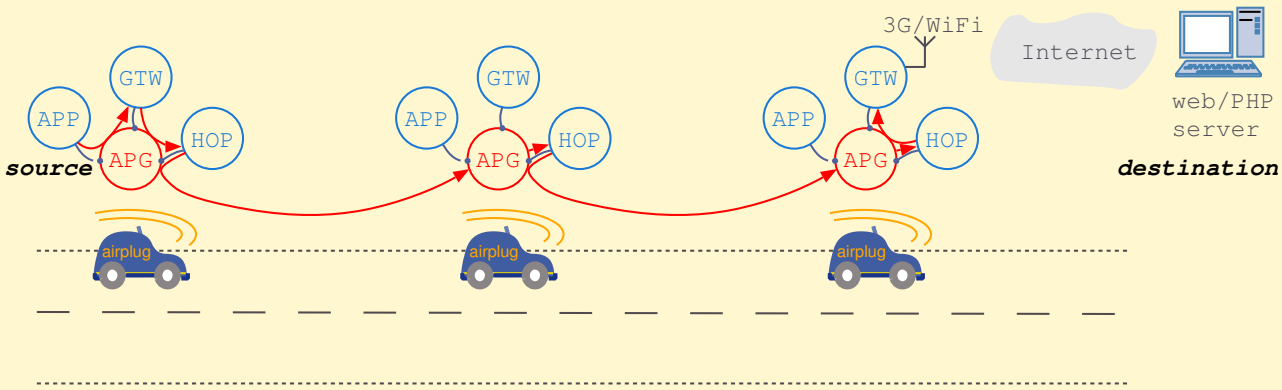

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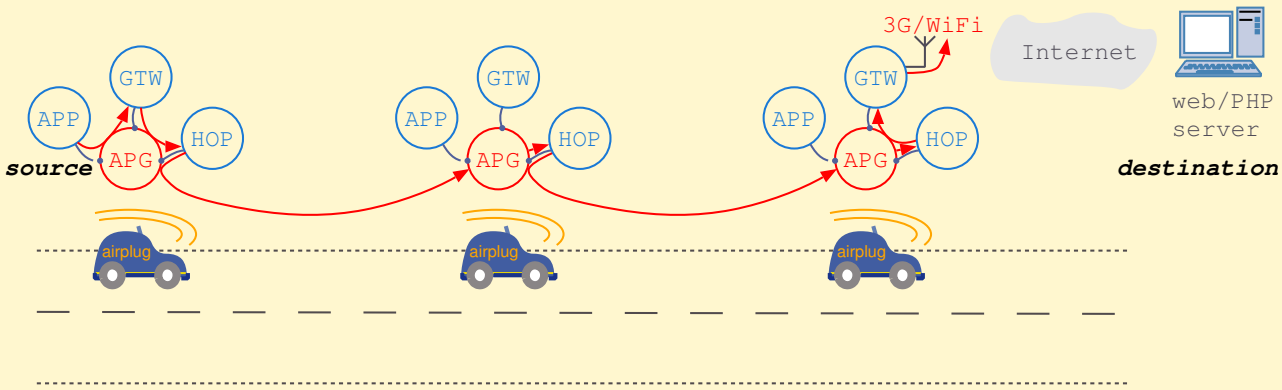

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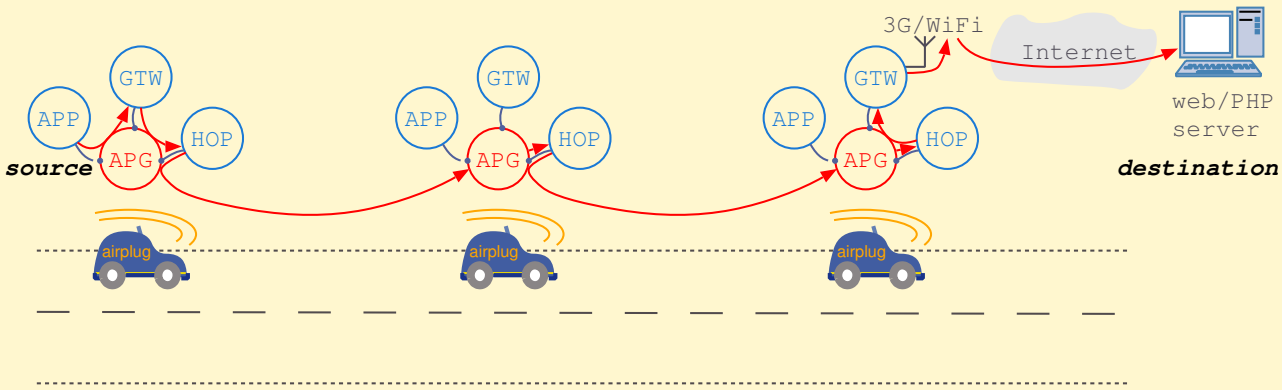

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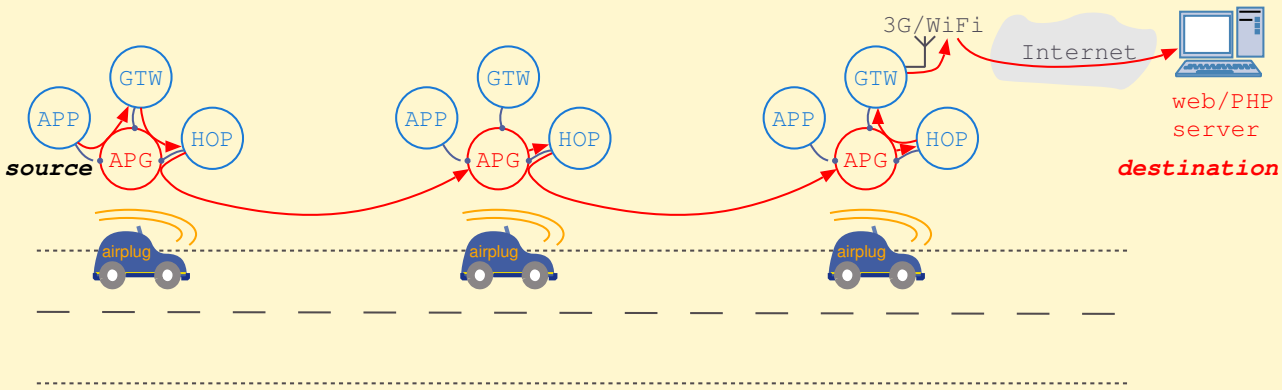
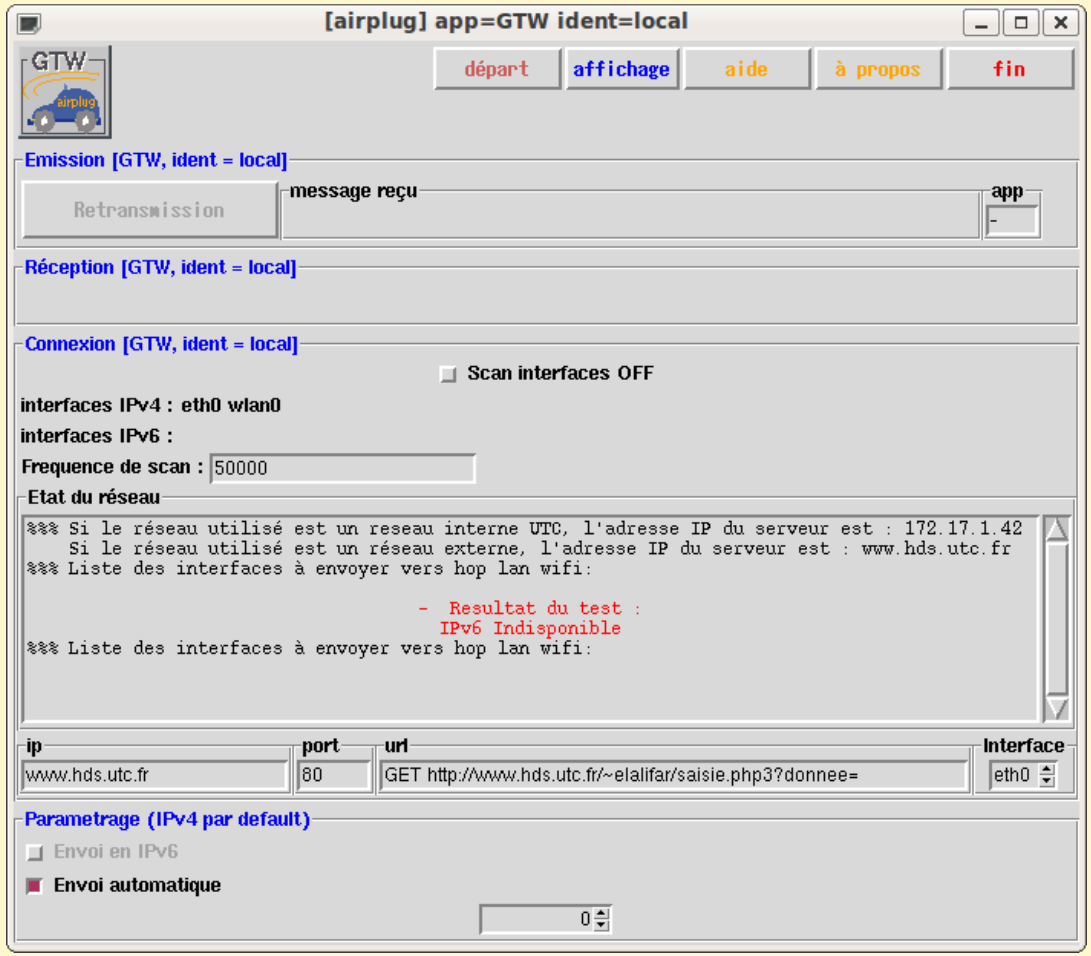


Summary of the architecture 2/2

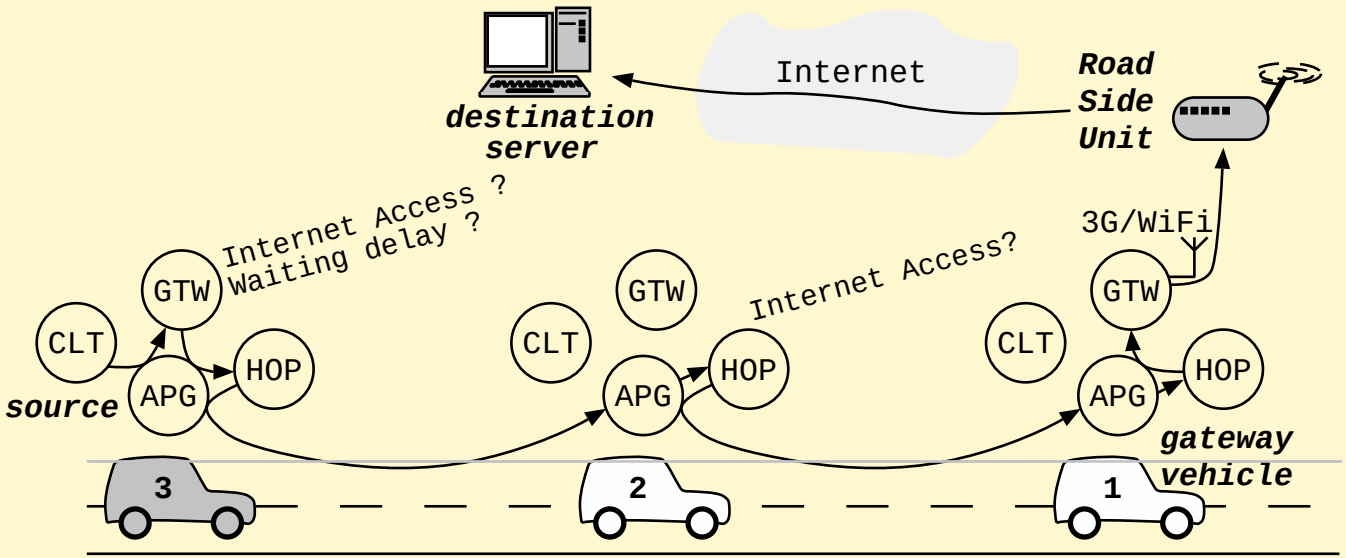
- V2V without IP
- IP communication between the gateway car and the server
- VANET routing
  - conditional transmissions
  - gateway discovery
- privacy respect

Realization: GTW software

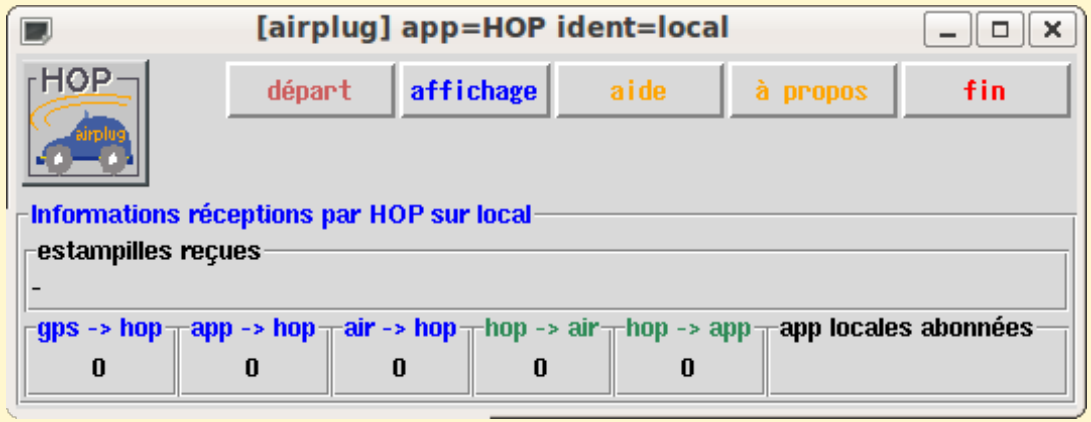
- Written in Tcl/Tk for NS-2 compatibility
- A link between Tcl/Tk and C for communications in IPv6
- Send keywords *3G* or *WiFi* to HOP



Realization: HOP software



- CUP: *WiFi* $\vee$ *3G*
- CFW: $\neg$*WiFi* $\wedge$ $\neg$*3G* $\wedge$ dst<2000 $\wedge$ dur<180



Experimentation: hardware

- netbooks (Ubuntu)
- GPS
- WiFi USB cards
- Antennas
- 3G card

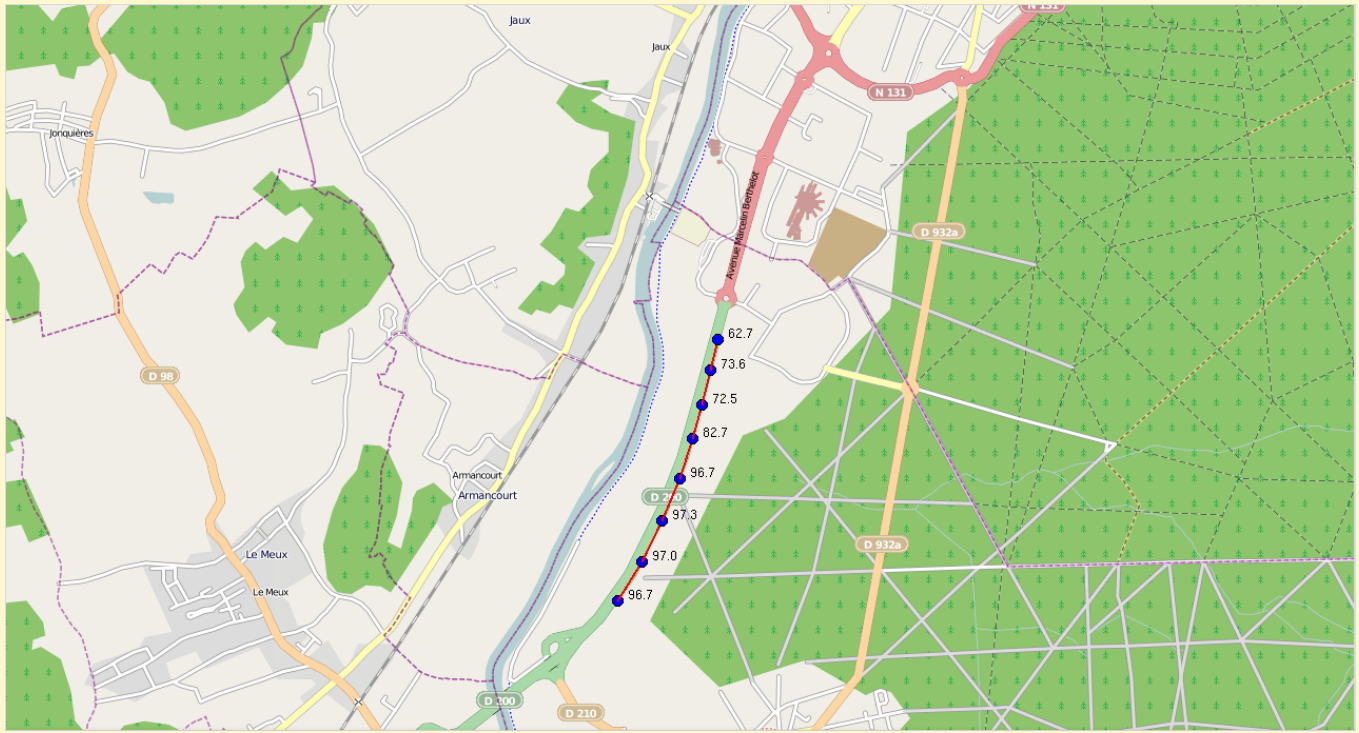
Experimentation: Test bed 1/2



4 to 7 cars, 3 days of experimentation

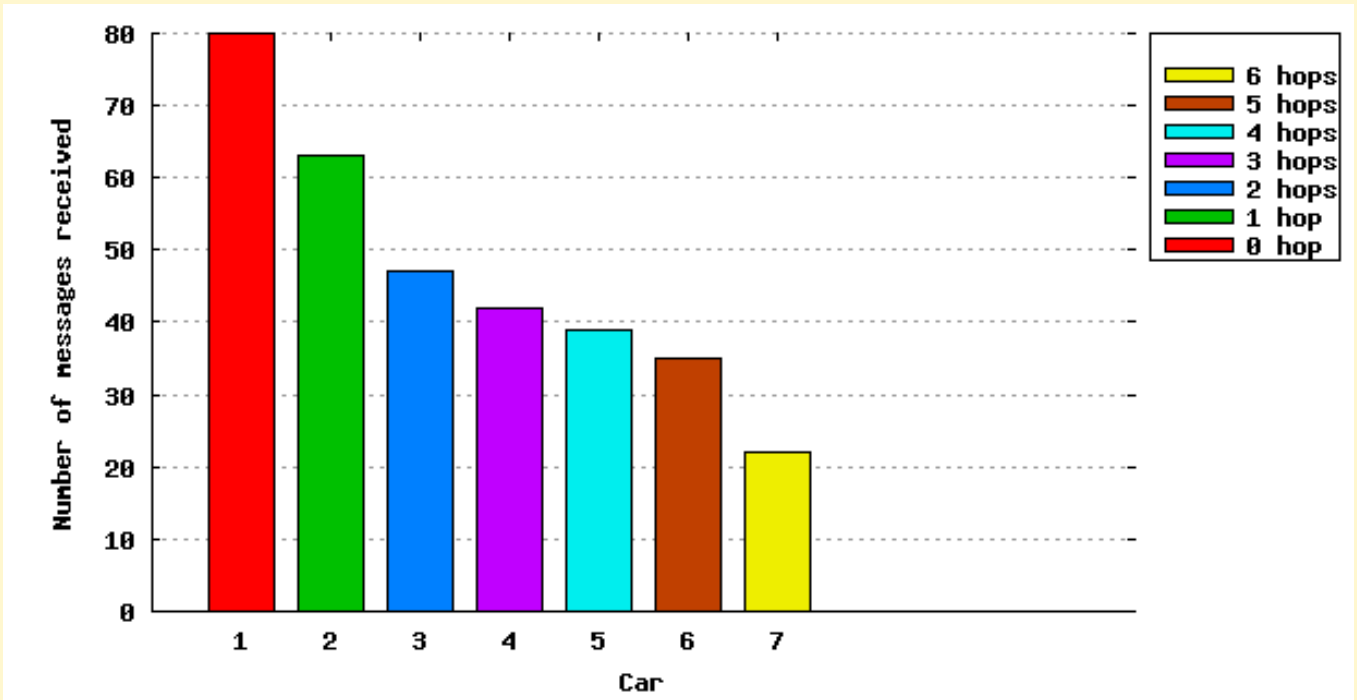
Experimentation: Test bed 2/2

The application used for the validation is a data collect application.



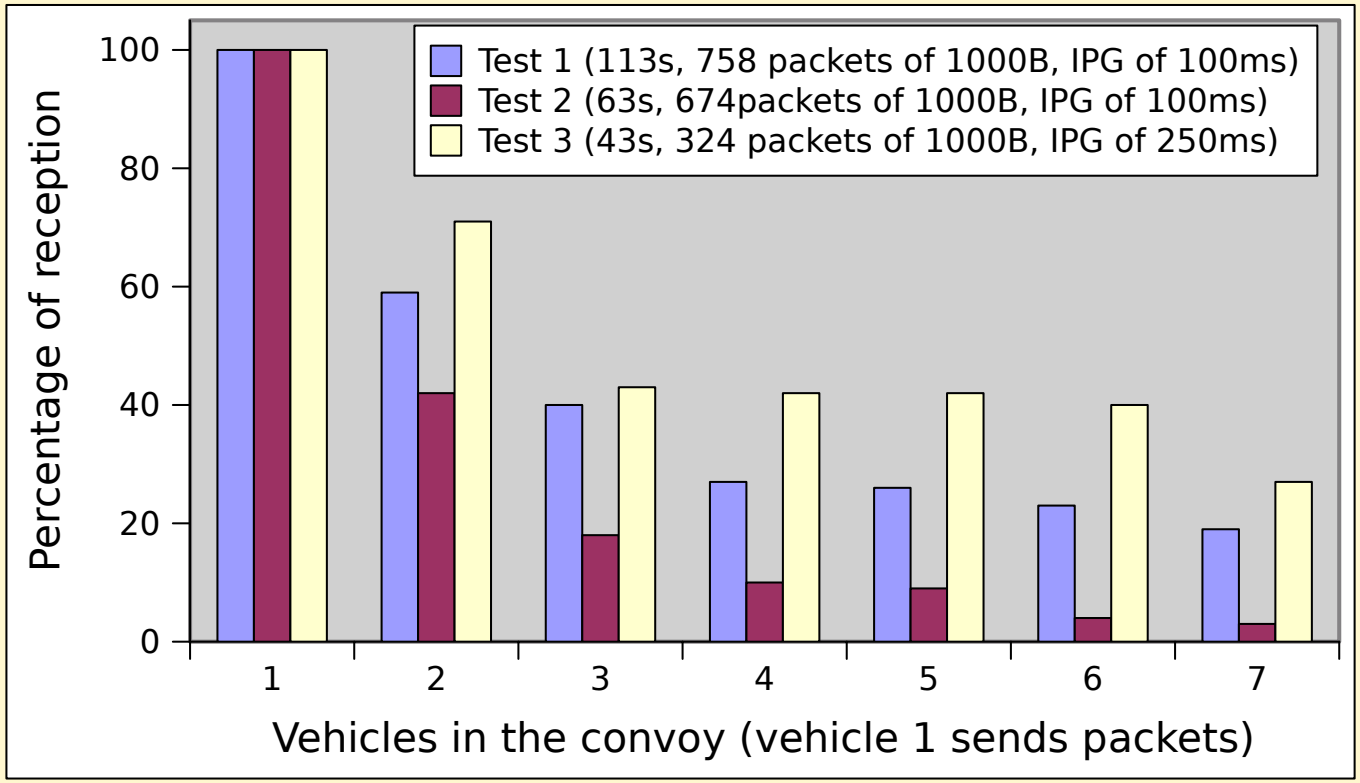
Validation: performances

- IPv6 on LAN
- A hop delay about 30 ms
- Delay gateway-server about 250-350 ms
- Loss rate about 20% per hop



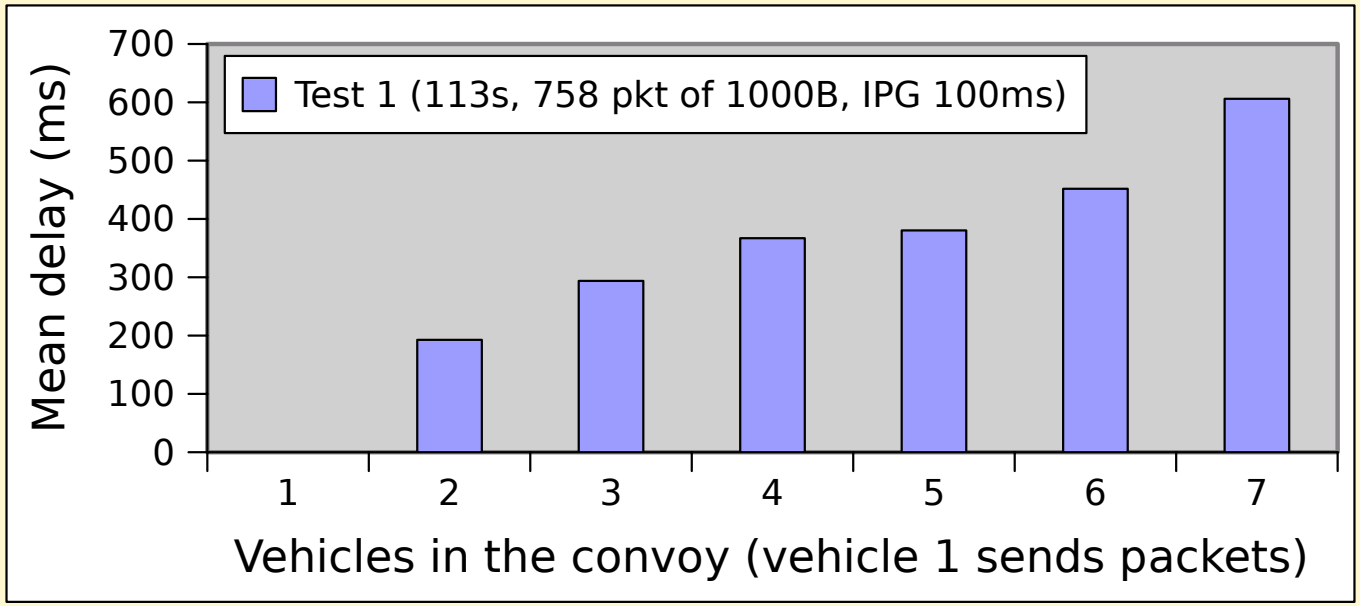
Reception rate per hop in the convoy

- Only 10% of good reception is guarantied after 5 hops.
- Results vary from one test to another due to experimental and environmental conditions.



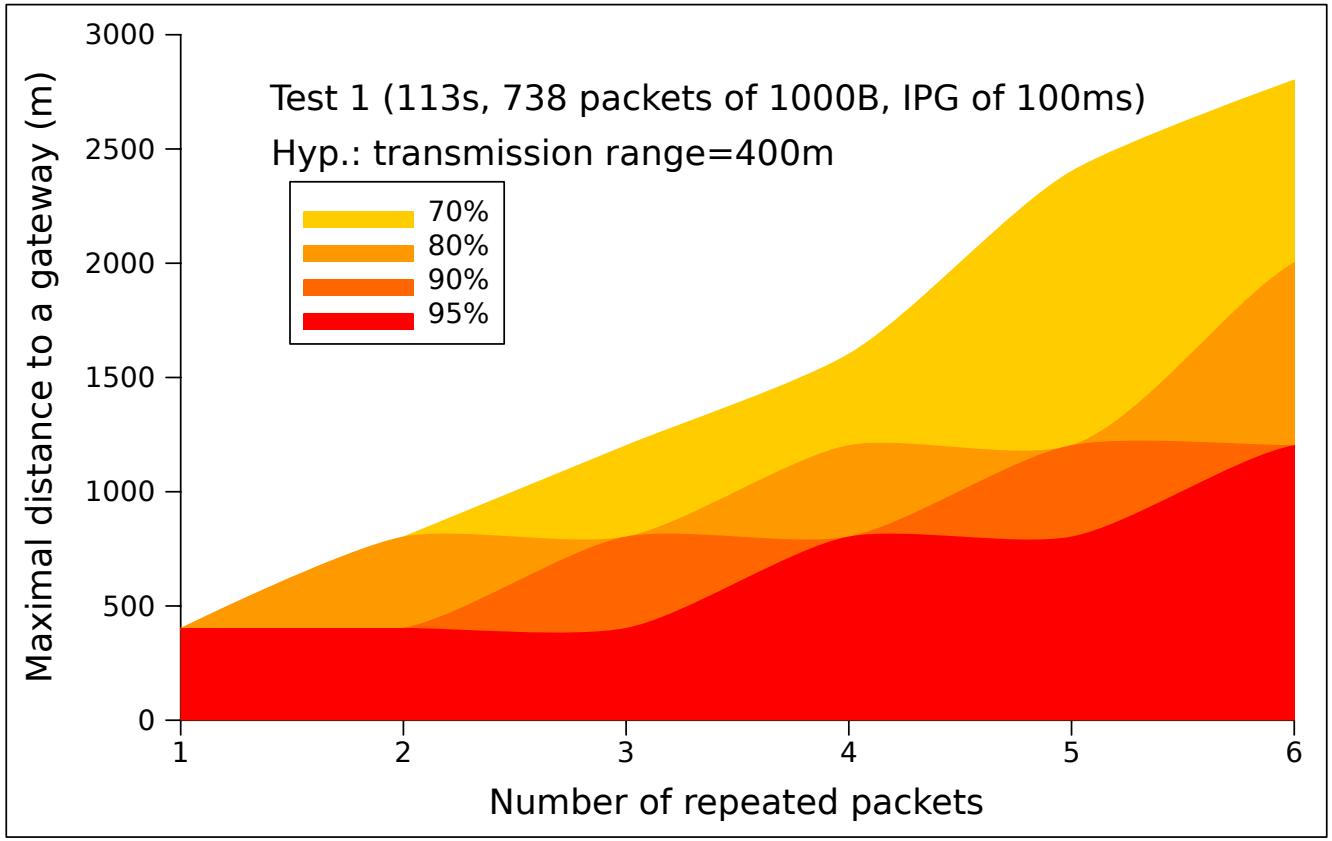
Delay per hop in the convoy

- The delay grows with the number of hops



Admissible distance to an AP

- Max. distance reached in function of the number of repetitions



Conclusion

- Connecting vehicles to the Internet
  - Required by several important ITS applications
  - Dynamic network $\rightsquigarrow$ hard to realize
- Contribution
  - kind of pervasive architecture
  - IP only on the last hop
  - VANET routing — Conditional transmissions
  - Efficient gateway discovery
  - Few control messages
- Validation
  - Implementations and tests on road
  - Interesting performances
- Future work
  - Complete the architecture with I2V
  - Specific transport protocols

http://www.hds.utc.fr/~ducourth/airplug/doku.php