The Airplug Software Suite
for studying vehicular networks (and other dynamic networks)

Bertrand Ducourthial
Bertrand.Ducourthial AT utc.fr

Laboratoire Heudiasyc (UMR UTC-CNRS 6599)
Université de Technologie de Compiègne
France

Rescom Summer School 2010

Agenda

Summary

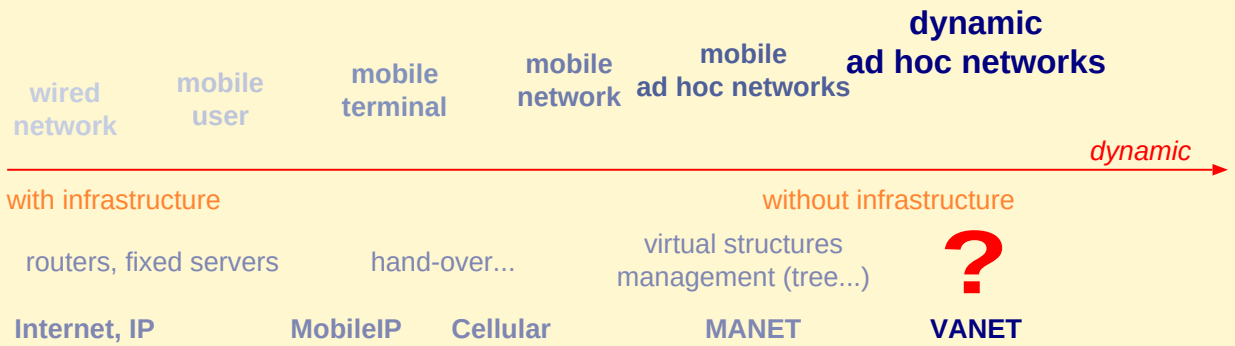
Intelligent Transport Systems

- Motivations
  - Improving transportation in terms of safety, mobility, productivity, environmental impact...
  - main goals : road fatalities, infrastructure management, new on-board services
- ITS applications
  - Infrastructure oriented applications
    for optimizing the infrastructure management
    (transit, freeway, freight, emergency organization...)
  - Vehicle oriented applications
    for increasing the road safety
    (crash prevention, alerts, visibility distance...)
  - Driver oriented applications
    for improving the road usage
    (traffic jam, road work information, payment...)
  - Passenger oriented applications
    for offering new services on board
    (Internet access, distributed games, tourist info...)

Scientific issues

Highly dynamic ad hoc networks

- Next step in networking and distributed alg.



- Impact of the dynamic
  - impact on network layers
    link (2), network (3), transport (4)
  - impact on distributed algorithms
    fault tolerance, data sharing...
  - impact on trusty and security
    who believe ? what information is reliable ?
  - algorithms necessary embedded
    optimizations depending on the context...

Heudiasyc contributions

- Point of view : dynamic networks are different !
  re-thinking networking and distributed algorithms should be addressed simultaneously
- Work done and in progress
  - IEEE 802.11 study fairness, network capability
  - Messages forwarding conditional transmissions
  - Data flow transport transport protocols, V2I arch.
  - Distributed algorithms
    best-effort paradigm, self-stabilization...
    group-membership, data gathering...
  - Trust in distributed data
  - Security in dynamic ad hoc networks
  - Context aware optimizations
  - Airplug software suite and test-bed
- Validation : theory $\leftrightarrow$ practice
  Modeling & proofs
  Simulation & analysis
  Prototyping & road test-beds

Team

- Université de Technologie de Compiègne
  4200 students, master degree (engineer diploma)
  Research master (Intelligent Transport Systems), PhD
  http ://www.utc.fr

- Heudiasyc Lab. from the UTC & CNRS
  Automatic, Computer Science, Networking, Knowledge...
  http ://www.hds.utc.fr

- Vehicular networks team
- Intelligent vehicles team

several equipped cars

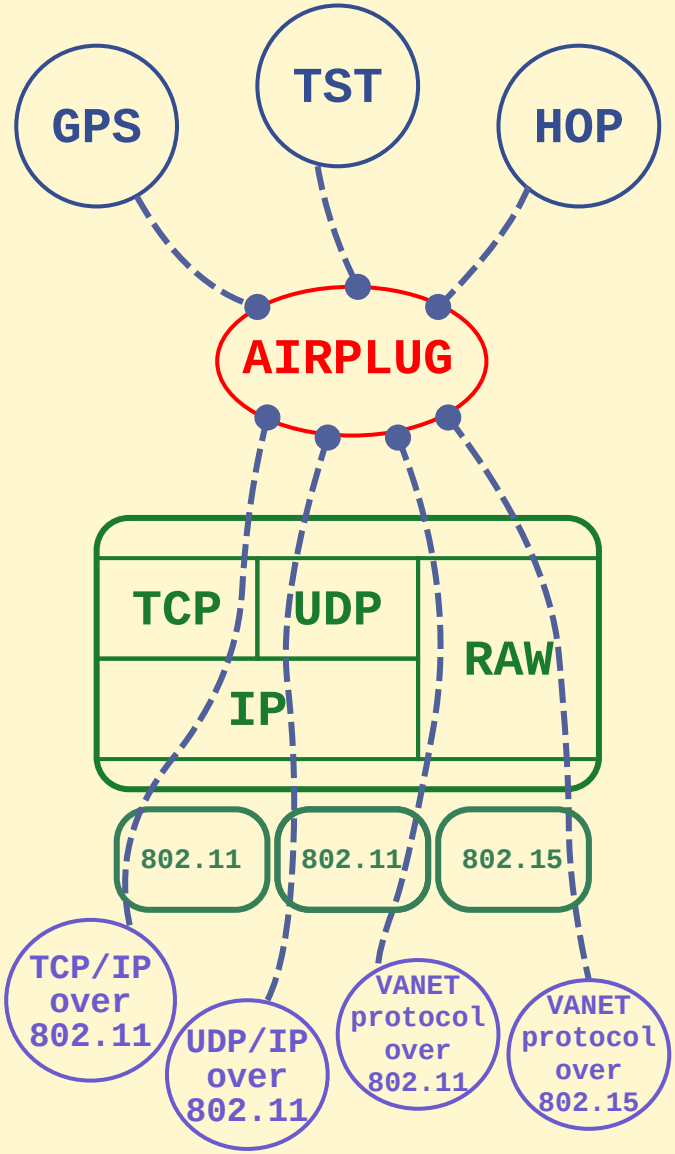
Team projects

- Road anticipating
  Regional grant DIVA, Heudiasyc - CREA 2004-2007
- Network services for com. between mobiles objects
  Industrial grant FTR&D 2004-2008
- Co-operative Systems for Road Safety
  "Smart Vehicles on Smart Roads"
  IP SafeSPOT, 6th PCRD / IST / eSafety 2006-2010
- Distributed applications for dynamic networks
  Regional grant Heudiasyc - LaRIA 2007-2010
- Distributed system for vehicle dynamic evaluation
  Regional grant Heudiasyc - MIS 2008-2011
- Inter-vehicles cooperative perception for road safety
  National project ANR JC, (Heudiasyc) 2008-2011
- Data gathering from VANET to infrastructure
  Industrial grant FTR&D 2008-2010

Summary

Airplug architecture

Process-based architecture

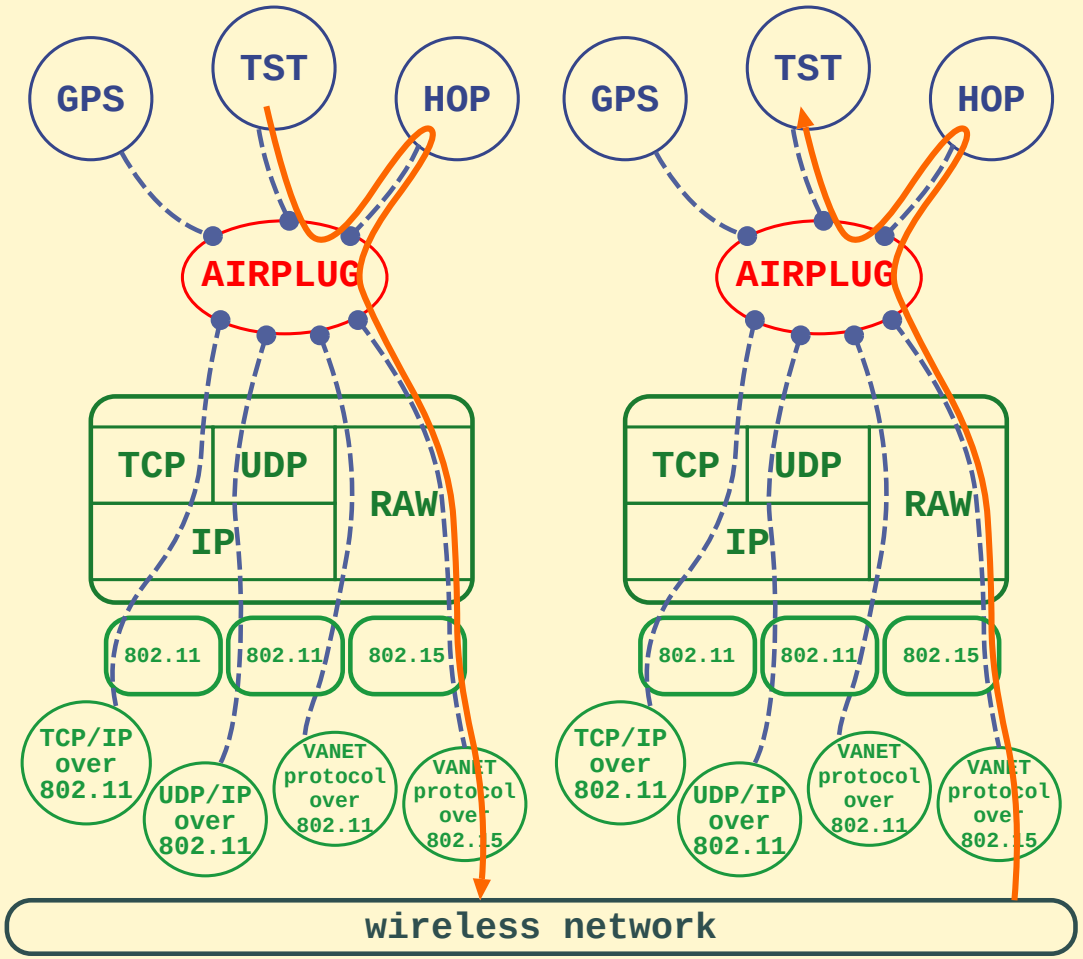


- Posix OS
- core program
  - user-space process
  - networking
- applications
  - user-space process
  - read on stdin
  - write on stdout
  - API close to IEEE WSMP
- ensure tasks and OS independence for robustness
- open to any programming language

Airplug architecture

Facilities for developing new protocols

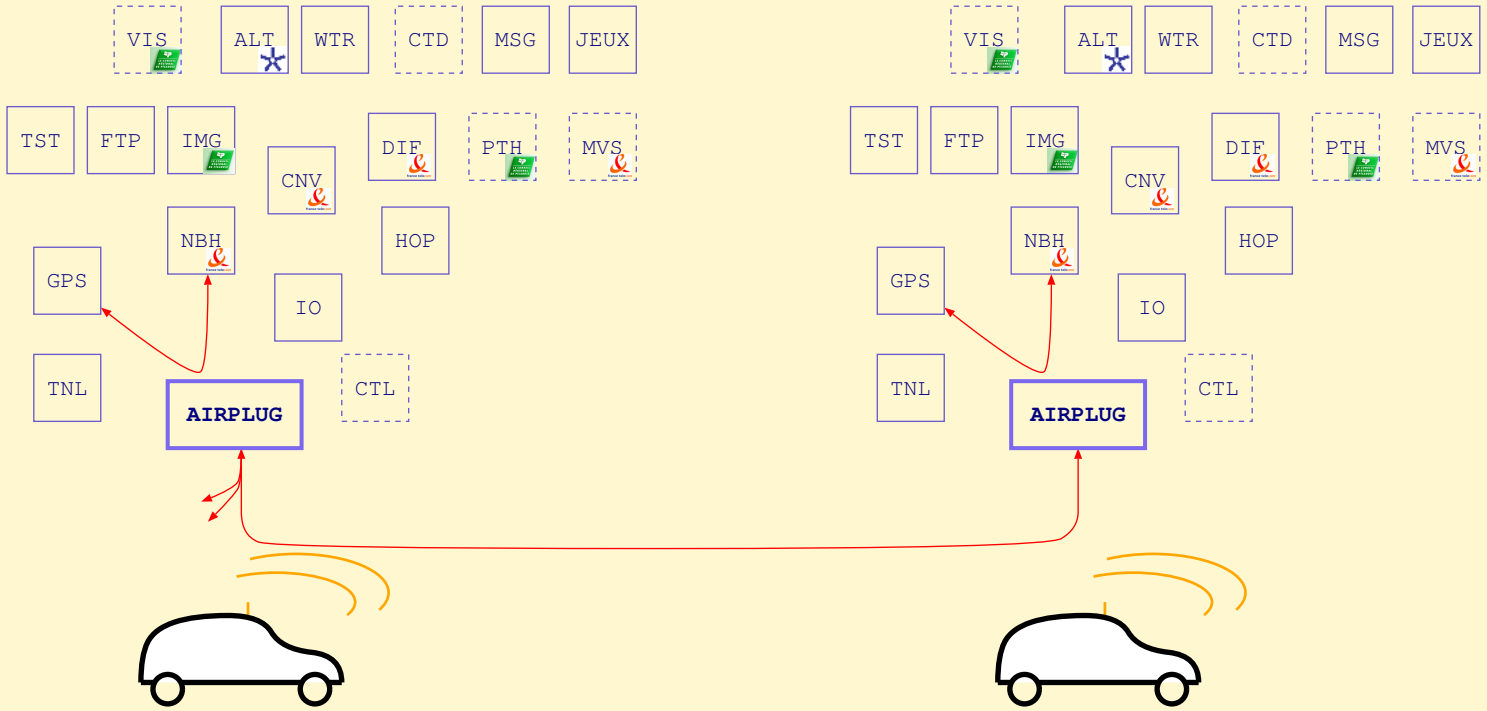
- New protocols developed in user space processes
  - open to new networking solutions
  - cross-layer solutions facilitated



Airplug Software suit

- Airplug software suite

  Applications for infrastructure, vehicles, drivers, passengers...



Airplug Software suit

Nom	Fonction	Développeur	État
ALT	transmission d'alerte	Y. Khaled	opérationnel
APG	Airplug + libapgtk	B. Ducourthial	opérationnel
BAS	application répartie de base	A. Buisset	opérationnel
BTP	Basic Transport Protocol	F. El Ali	en cours
BTH	Com. avec un téléphone Bluetooth	T. Lehmann et F. Birot	à finaliser
CHV	Discussions vocales	groupe d'étudiants	opérationnel
CNV	détection de convoi	Y. Khaled	opérationnel
COL	collecte répartie	A. Buisset	en test
DDS	diffusion optimisée	B. Ducourthial	opérationnel
DFF	diffusion fiable	A. Buisset, F. El Ali	en cours
EMU	émulateur de réseaux	A. Buisset	opérationnel
FTP	transfert de fichiers simple	Y. Khaled	à finaliser
GPS	lecture/génération GPS	B. Ducourthial	opérationnel
GRP	groupe dynamique	A. Buisset, S. Khalfallah	opérationnel
GTW	passerelle vers l'infrastructure	F. El Ali	opérationnel
HOP	transmission conditionnelle	Y. Khaled	opérationnel
IMG	transfert d'images	R. Kassab	à finaliser

Airplug Software suit

Nom	Fonction	Développeur	État
IO	*input/output*	B. Ducourthial	opérationnel
LRD	calcul du meilleur chemin	groupe d'étudiants	opérationnel
MVS	message virtuellement stationnaire	M. Bouassida	à tester
NET	application de contrôle	A. Buisset	opérationnel
NBH	détection de voisinage	N. Eude	opérationnel
PRV	prévisibilité de route	Y. Khaled et A. Potelle	opérationnel
PTH	maintien de chemin	F. El Ali	en cours
MAP	cartographie	A. Buisset	opérationnel
MSG	messagerie instantanée	S. Khalfallah	opérationnel
SCT	passerelle Scoot'R	F. El Ali	opérationnel
SYB	détection de faux nœuds	V. Duong	en cours
SER	service d'entraide réparti	groupe d'étudiants	opérationnel
RMT	accès distant via tunnel	B. Ducourthial	opérationnel
TAB	tableau blanc partagé	groupe d'étudiants	opérationnel
TOF	téléchargement opportuniste de fichiers	groupe d'étudiants	à tester
TST	mesure de perf.	B. Ducourthial	opérationnel
UNI	unison	S. Pomportes et F. Petit	opérationnel
VID	transfert de vidéo	G. Delbary	à finaliser
WFM	*wave for manet* (collecte)	A. Buisset	opérationnel
WTR	alertes météo	Y. Khaled	opérationnel

Complete research platform

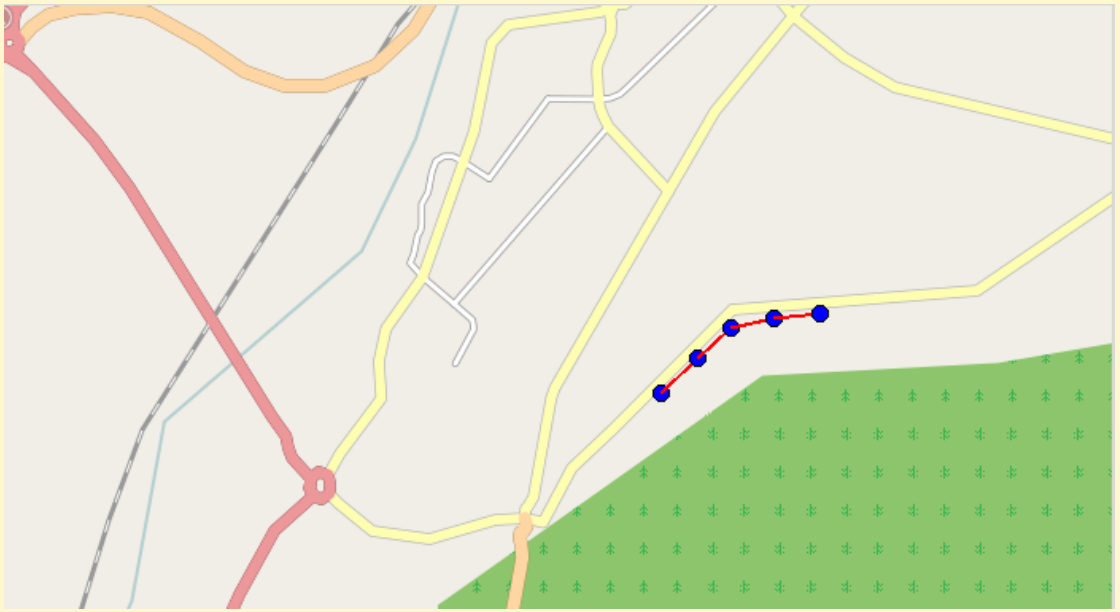
- On the road : airplug-road [VTC 2009]
  - in Compiègne
  - 2005 • in Michelin circuit near Clermont-Ferrand
  - 2007 • test-bed with 6 cars with France Telecom R&D
  - 2009 • test-bed with 7 cars with France Telecom R&D

Complete research platform

- On the road : airplug-road [VTC 2009]
- In the laboratory : airplug-lab
  - GPS position replaying
  - new trajectories derived $\rightsquigarrow$ convoys
  - out of range messages filtered (soon)

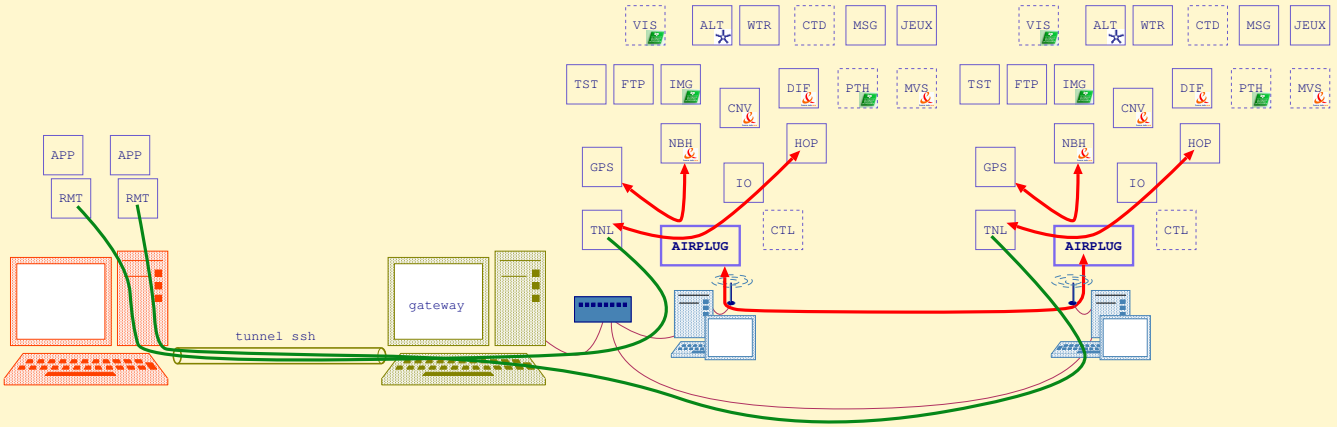
Complete research platform

- On the road : airplug-road [VTC 2009]
- In the laboratory : airplug-lab
- In a computer : airplug-emu [ICCCN 2010]
  - using shell facilities
  - emulation of vehicular networks



Complete research platform

- On the road : airplug-road [VTC 2009]
- In the laboratory : airplug-lab
- In a computer : airplug-emu [ICCCN 2010]
- Remotely : airplug-rmt
  - RMT : an application for controlled remote access to the applications
  - portability of the applications
    transparent use either stand-alone, remotely or locally
  - heterogeneous vehicular networks emulation



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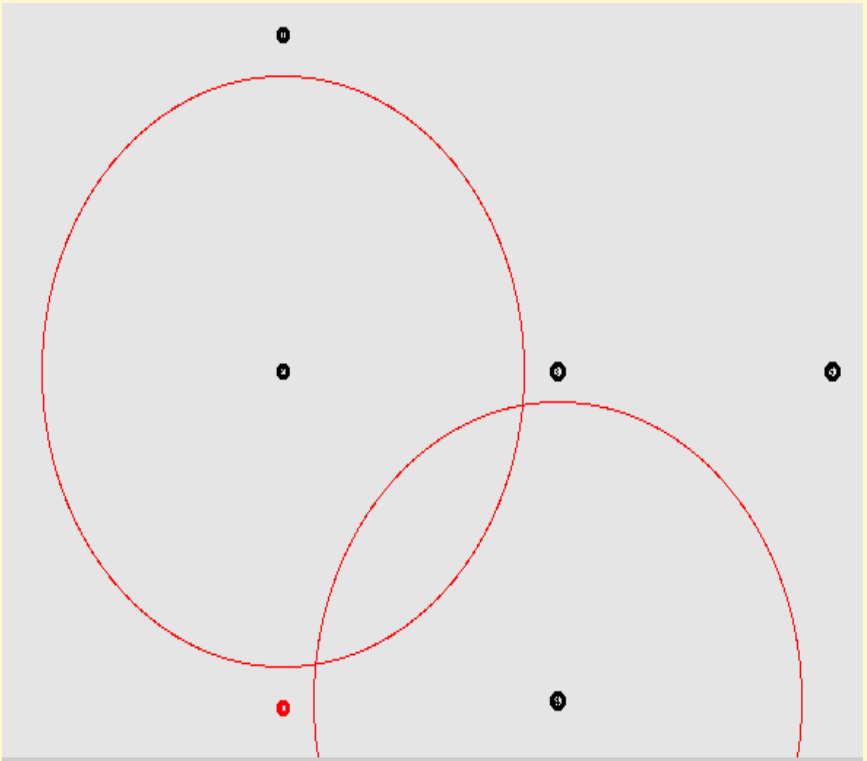
- In Network Simulator : airplug-ns [VTC 2010]



Complete research platform

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- In the laboratory : airplug-lab
- In a computer : airplug-emu [ICCCN 2010]
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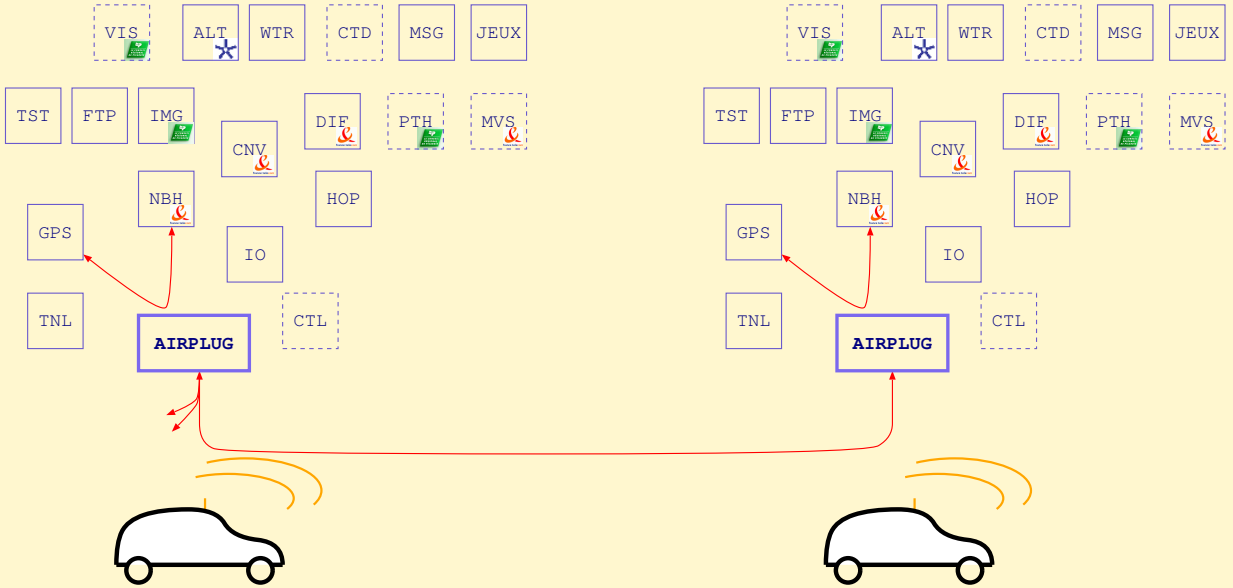
- In Network Simulator : airplug-ns [VTC 2010]
- In all these usages, the same codes are used



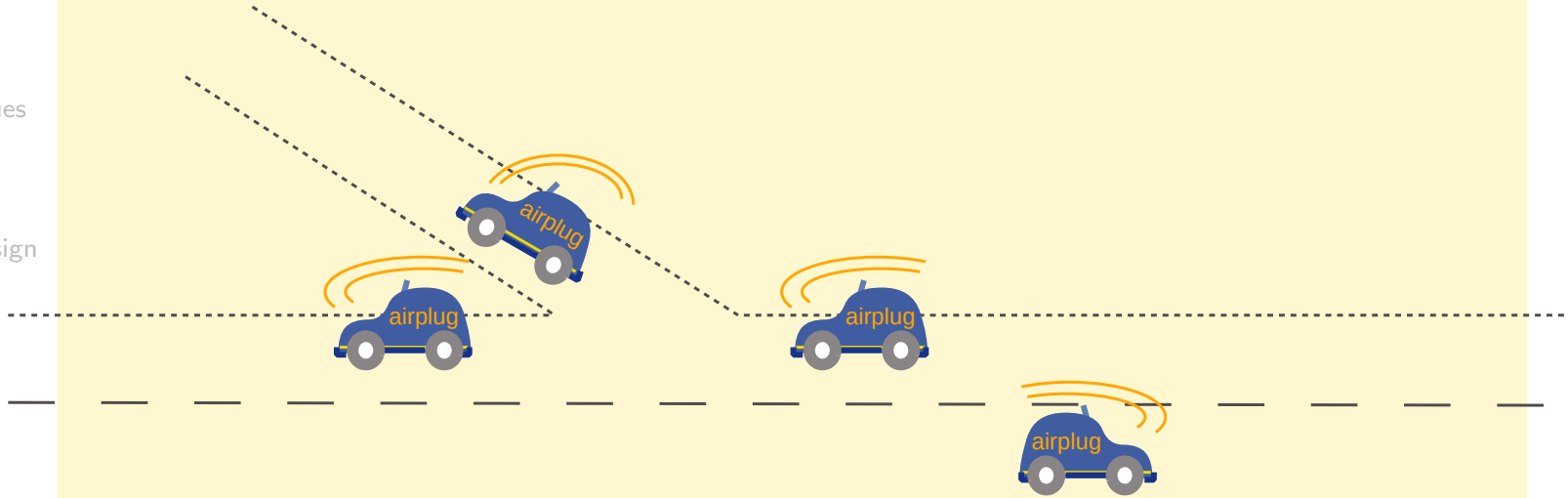
Airplug architecture

Application Programming Interface

- Addressing for dynamic networks [WINITS 2007]
  - area : LCH, AIR, ALL
  - applications :
    - a given application
    - all those that subscribed to the sender app
  - Note : similarities with
    - IEEE WAVE Short Messages Protocol
    - messages-oriented frameworks (eg. JMS)
- Three types of communication
  - to simplify the development
  - *what*, *whatwho*, *whatwhowhere*
  - automatic guessing or safemode
- Libraries for easy developments
  eg. message formating
- Hierarchical makefile for easy installation

Summary

Conditional transmissions



- conditions instead of addresses : more adapted to dynamic networks [IEEE TVT 07]
  - CUP : upward condition
    eg. being back on the sender
    (evaluation by GPS positions correlations)
  - CFW : upward condition
    eg. being not so far from the sender

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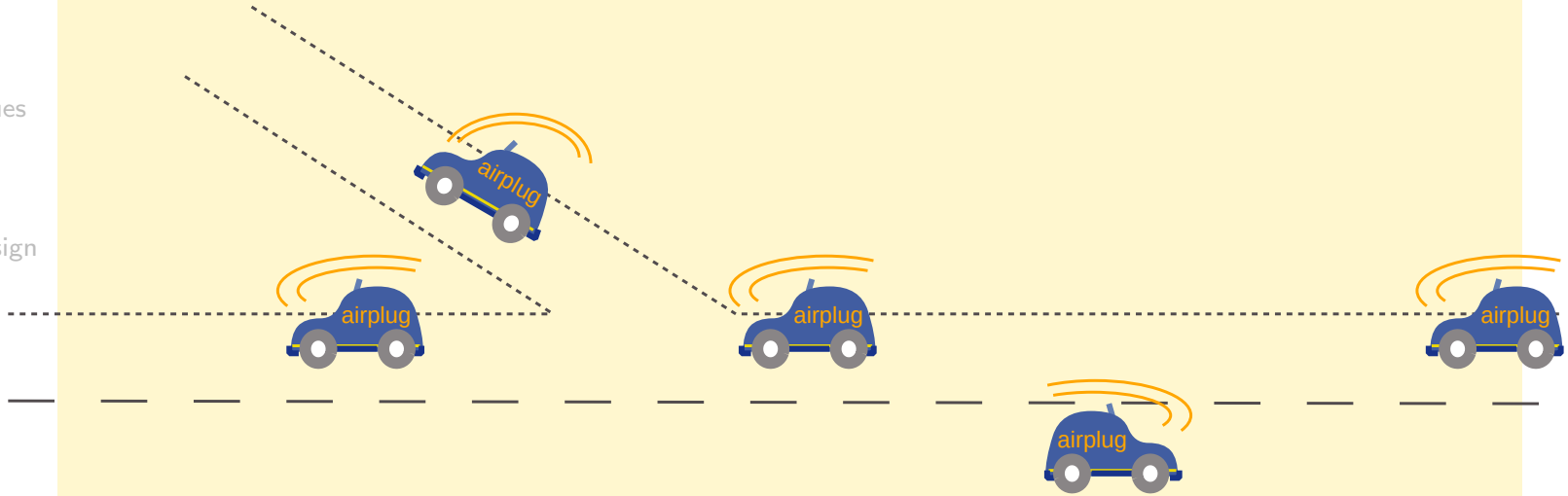

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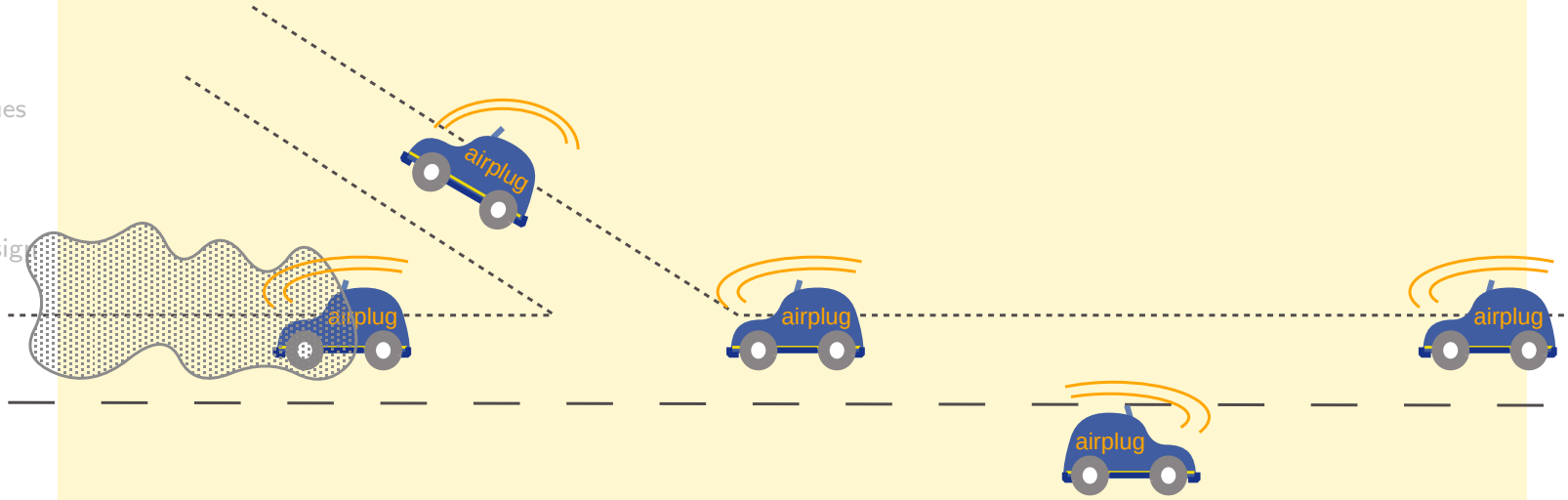

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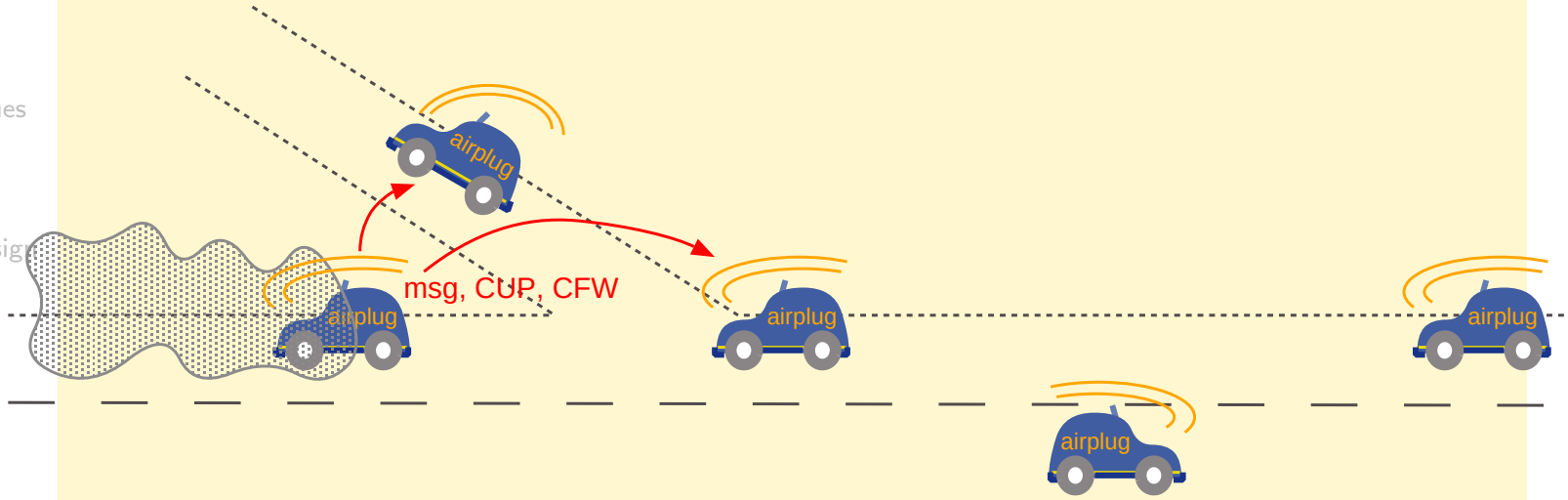

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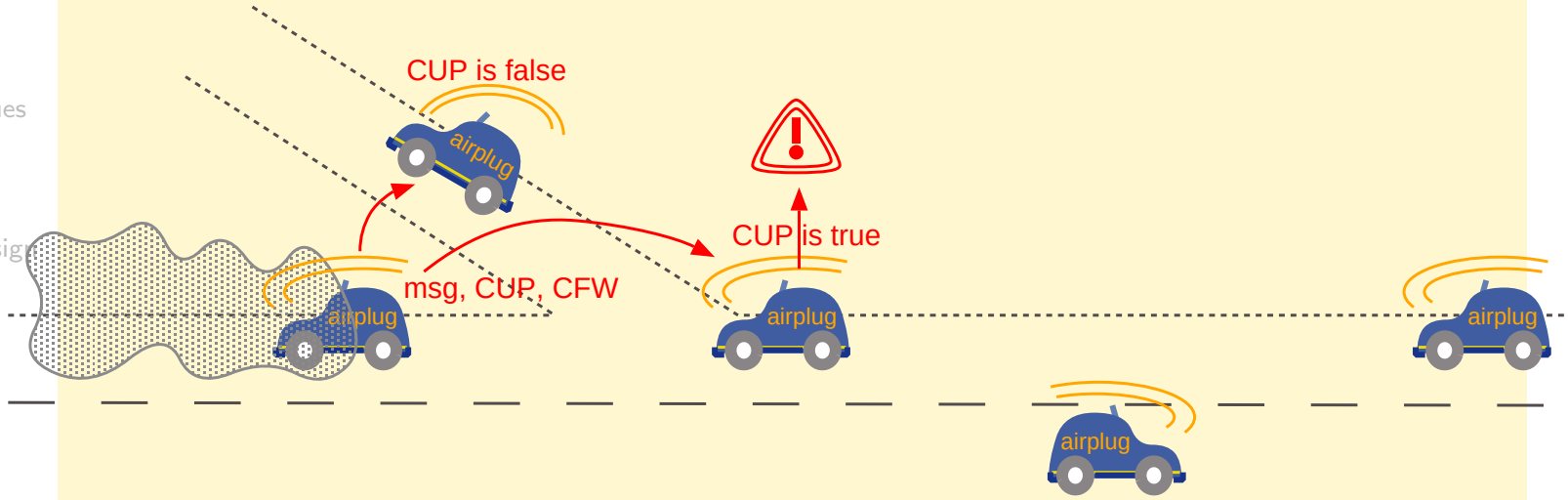

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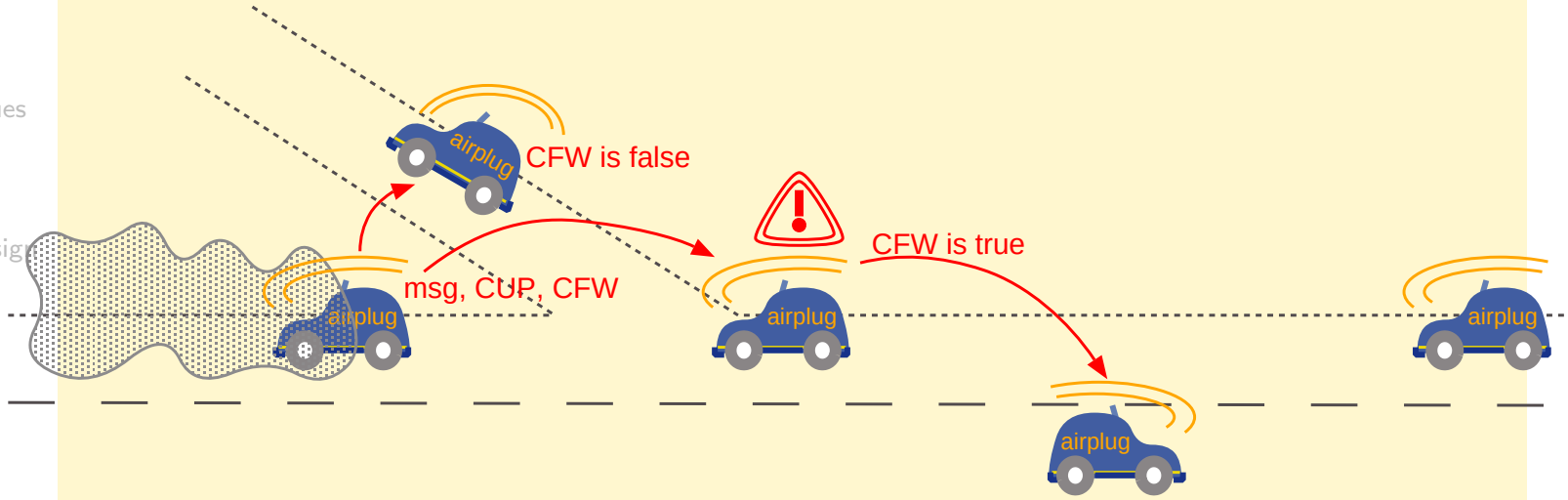

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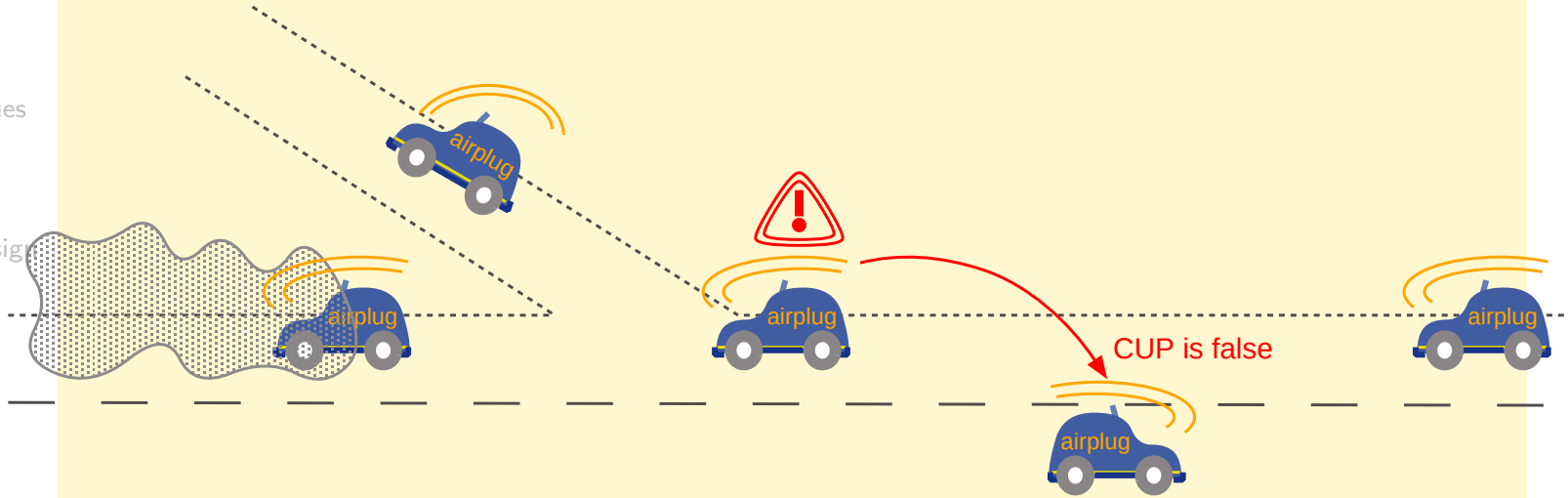

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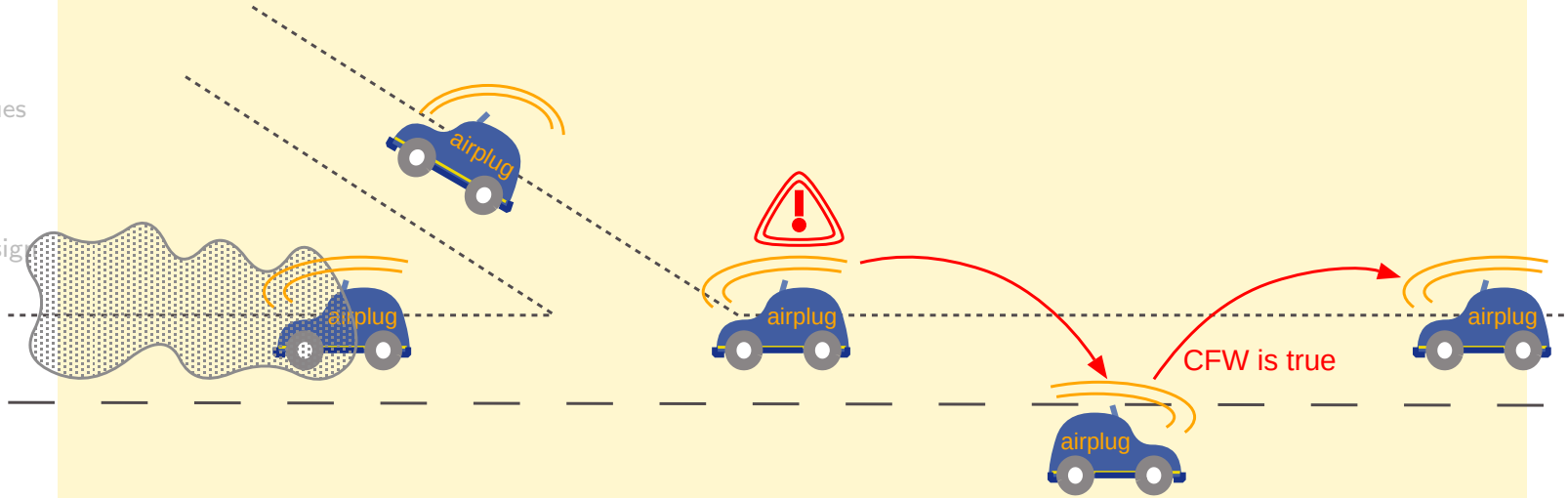

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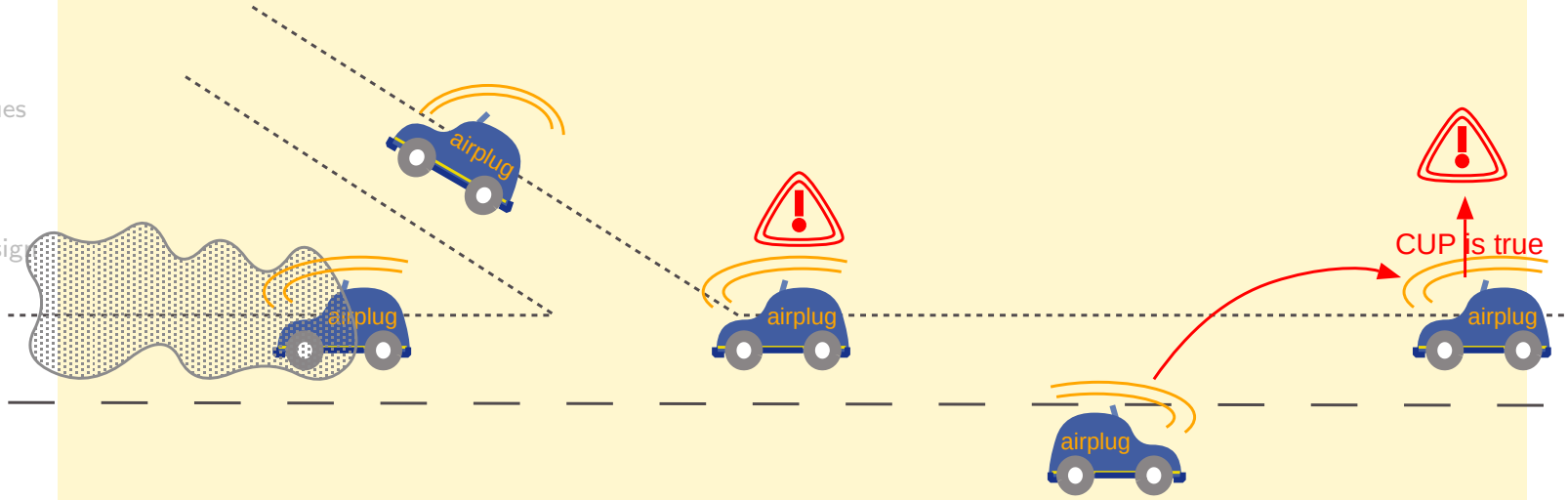

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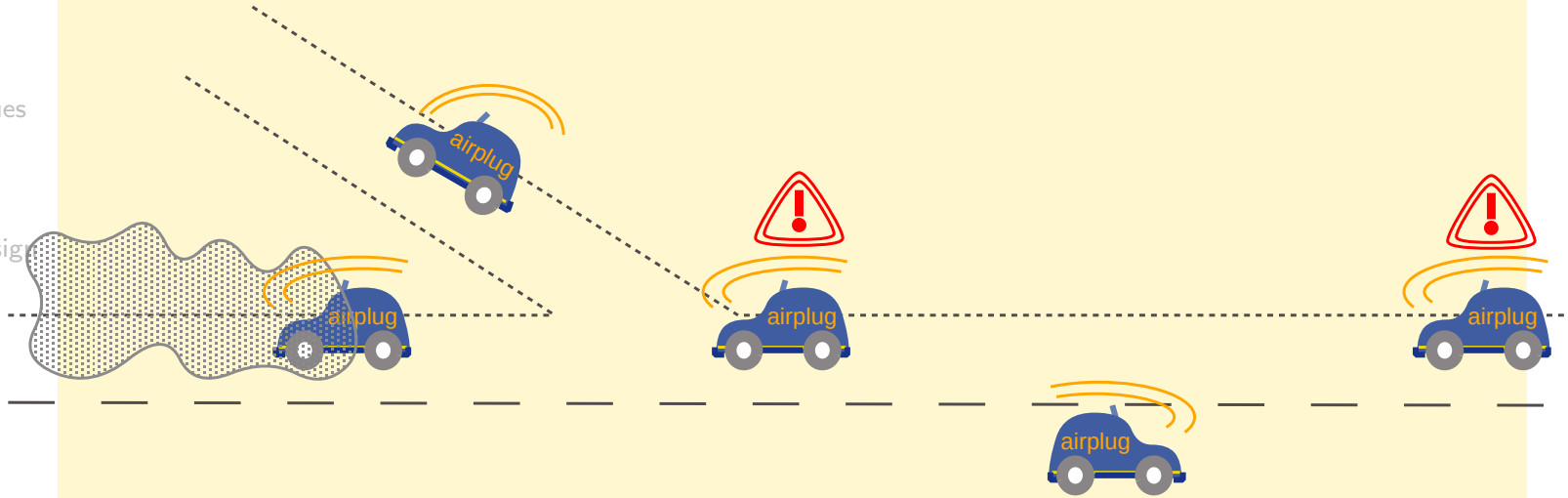

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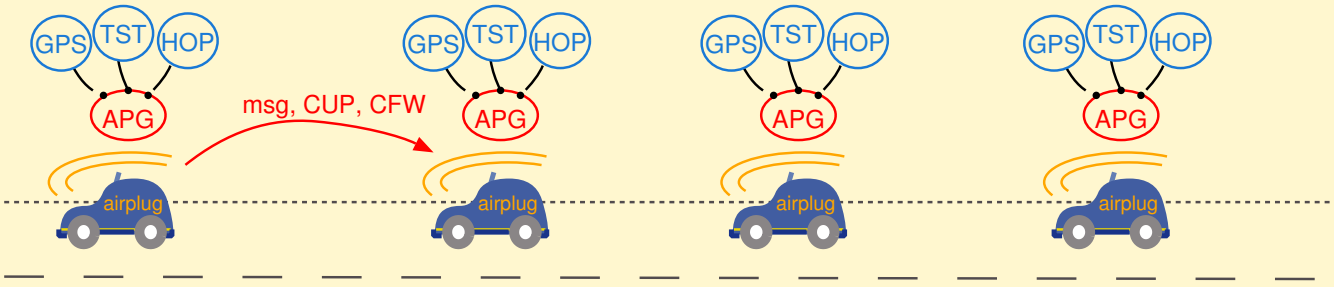
Network performances

Testbed



- GPS : read GPS receiver and send positions locally
- TST : send and receive packets through HOP ; perform measures
- HOP : conditional transmissions
- convoys up to 7 vehicles [CFIP 2007, VTC 2009]

Network performances

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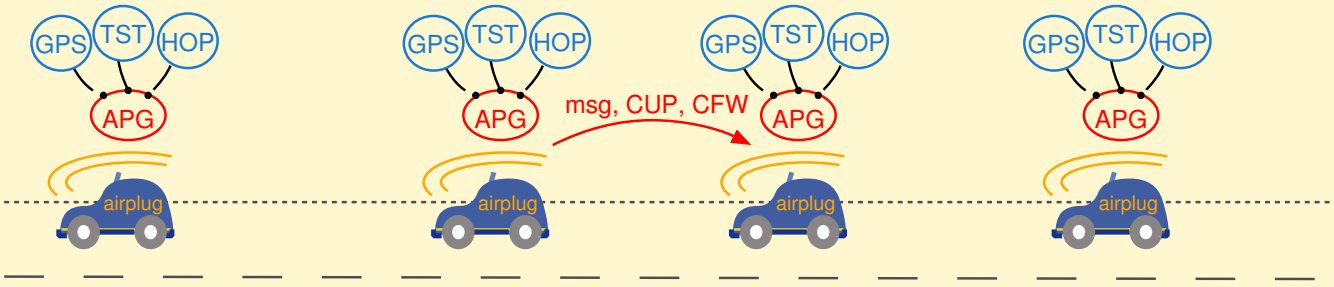

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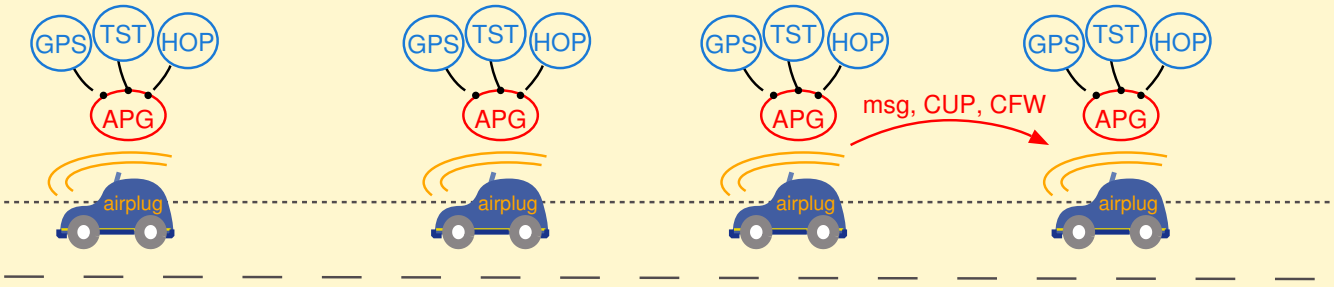

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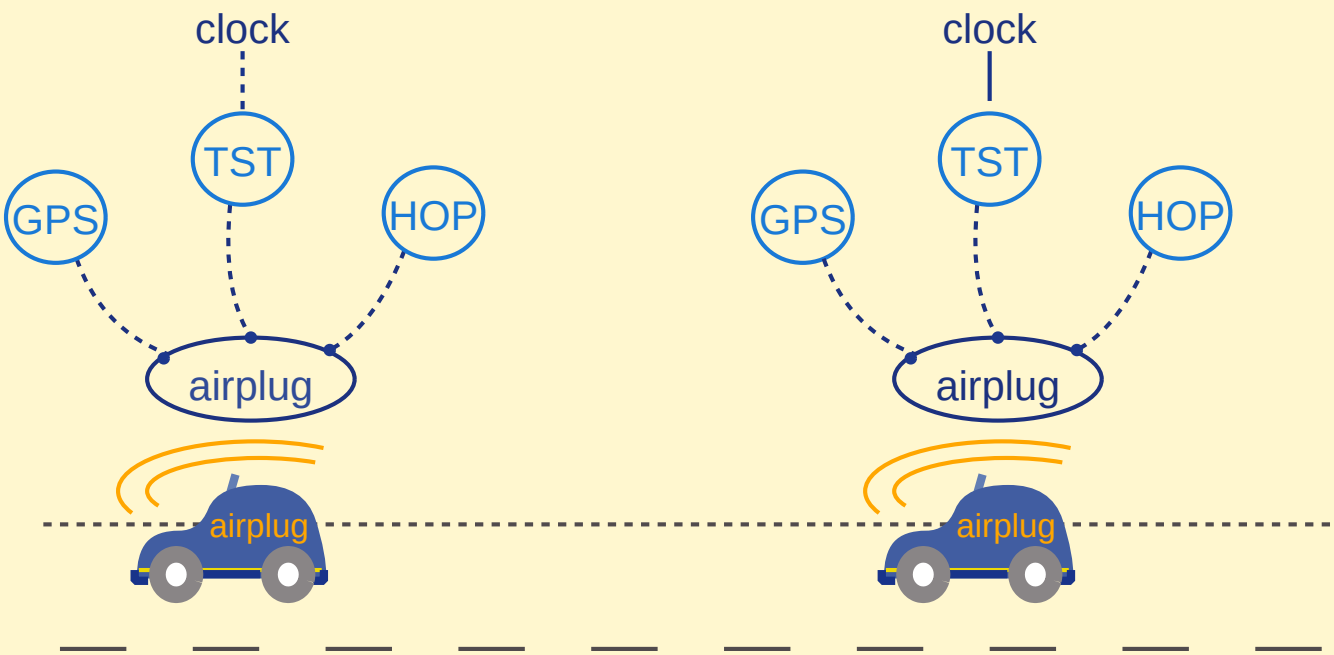

- combination of hardware clock and GPS time

Network performances

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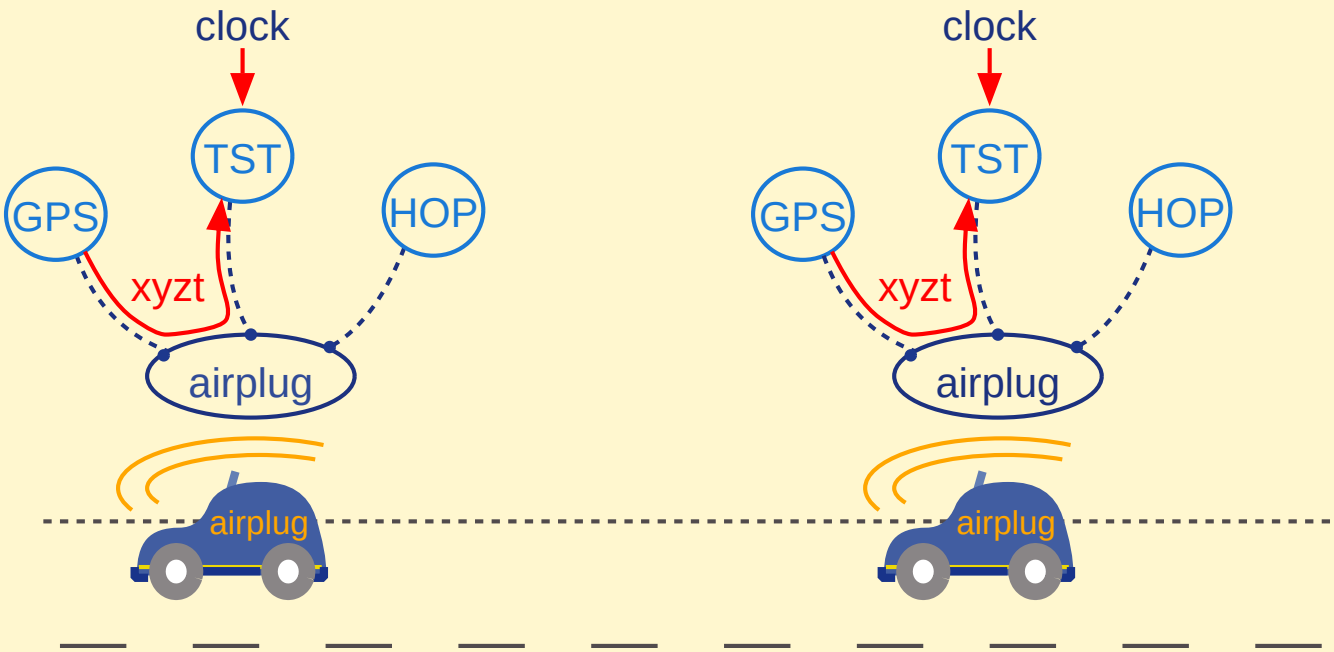

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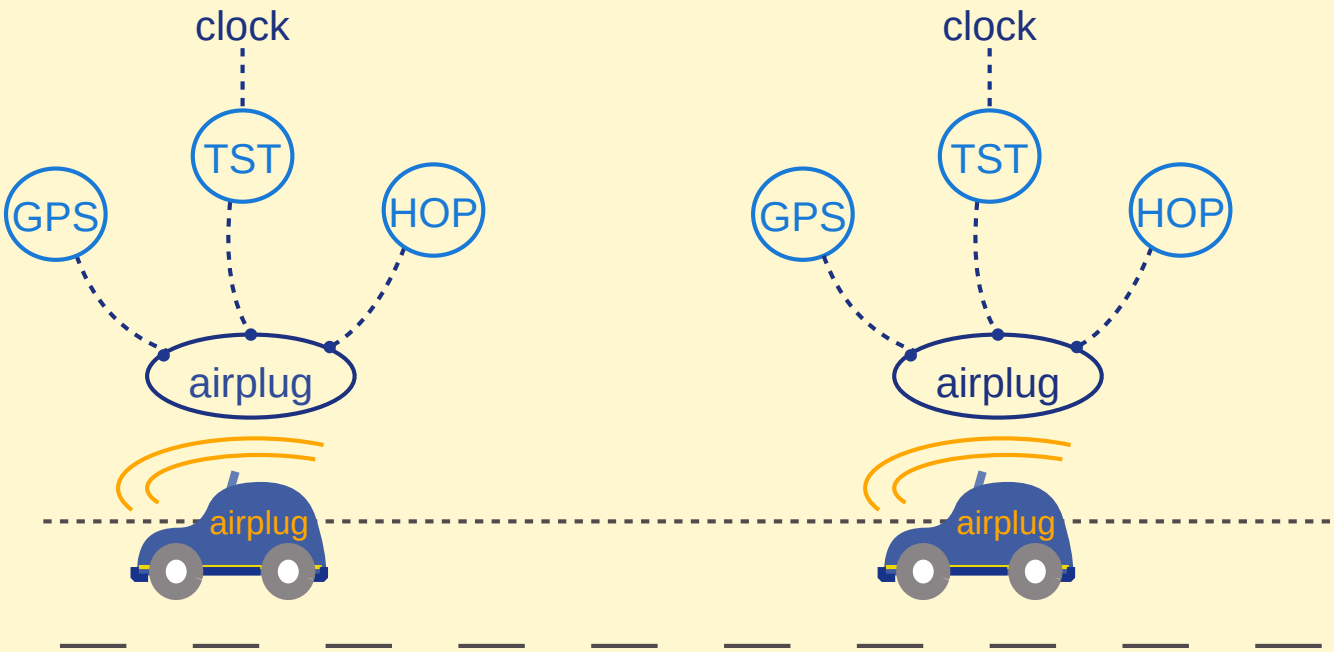

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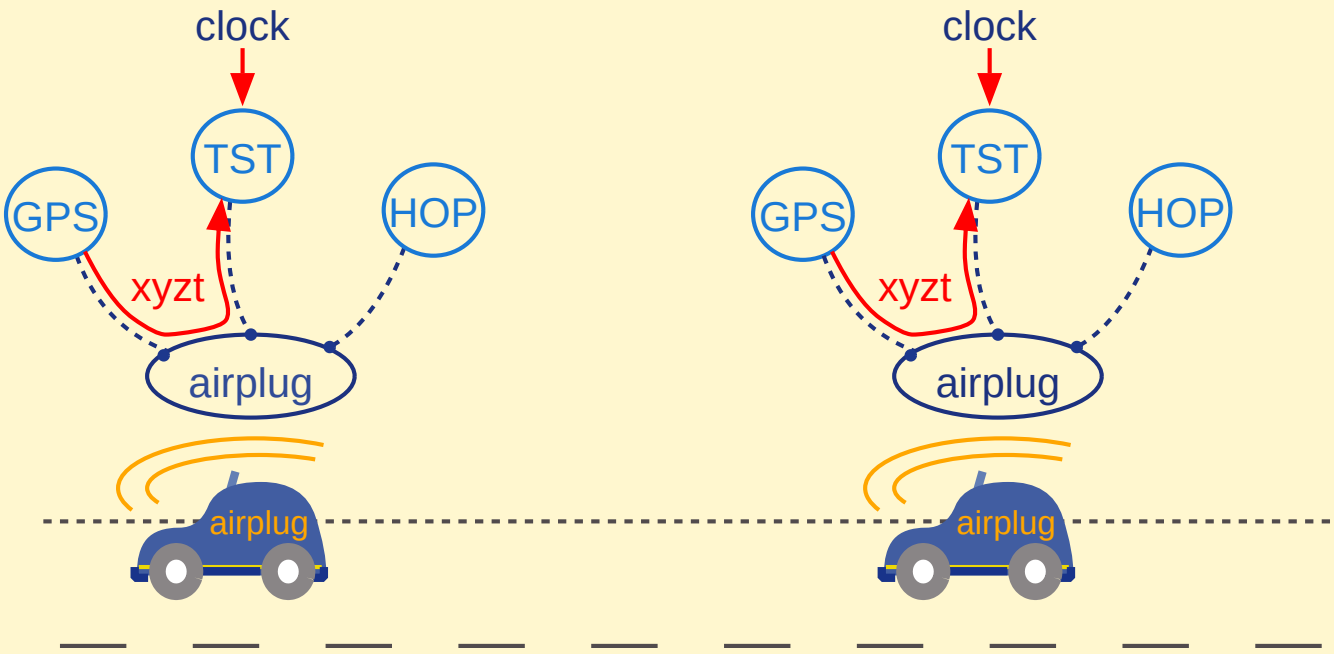

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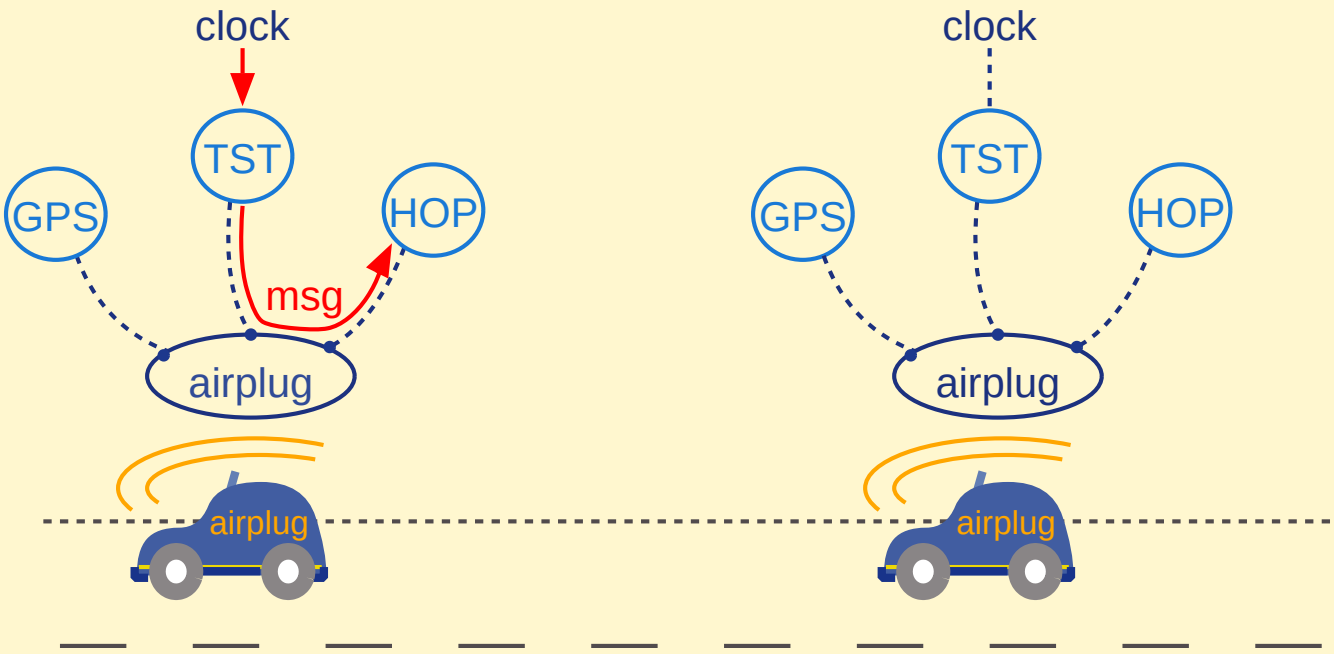

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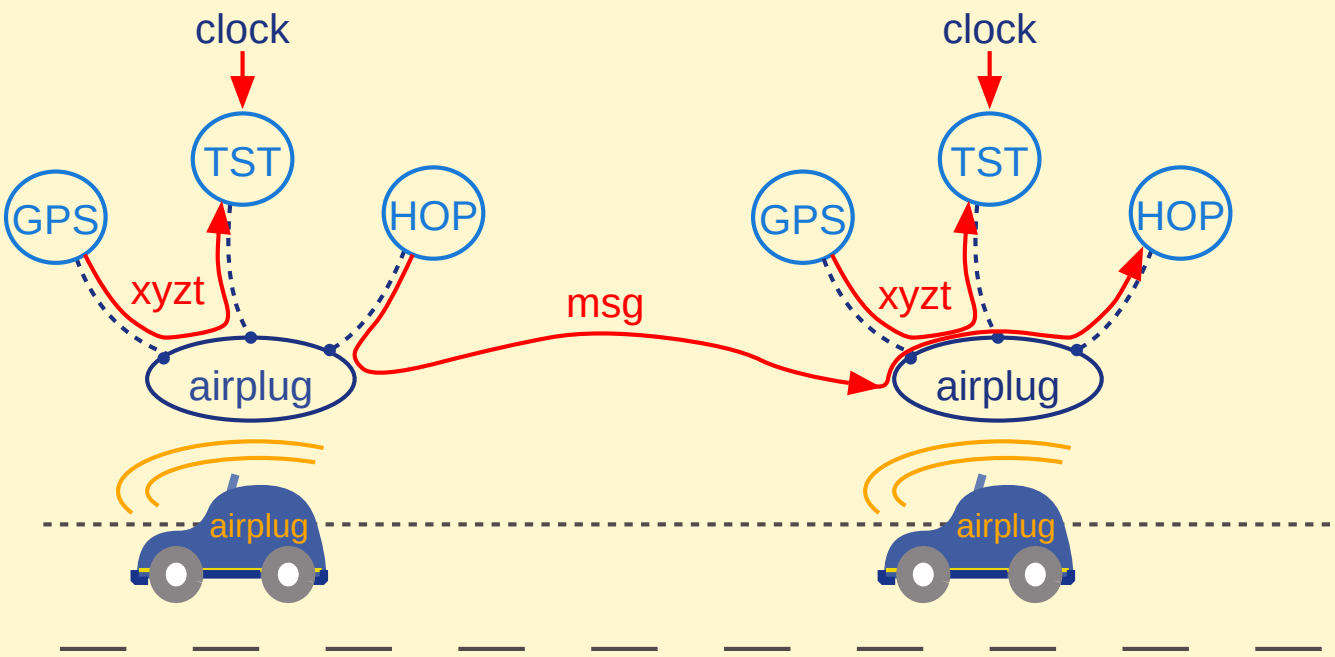

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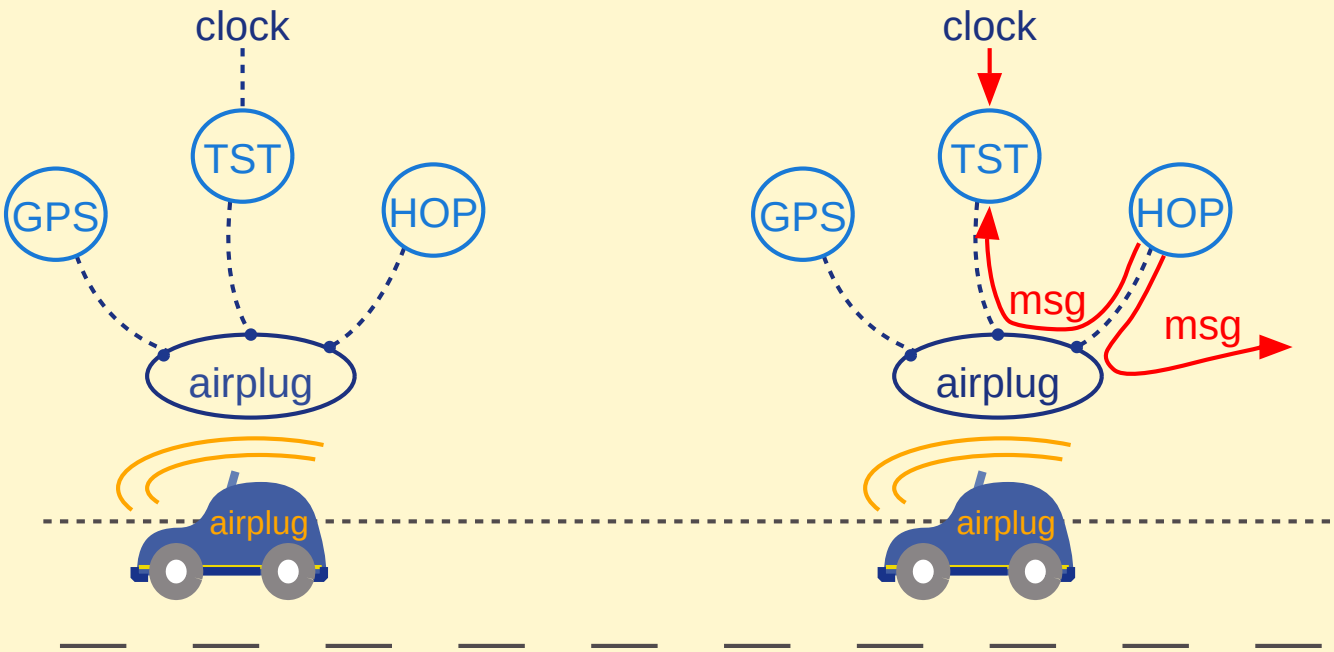


- combination of hardware clock and GPS time

Groups service for inter-vehicles applications

- Specific groups based applications
  - some services are based on collaboration
    driving, diagnostic, perception, infotainment...
  - collaboration $\rightsquigarrow$ group
    $\rightsquigarrow$ to be maintain as long as possible
  - no collaboration with far vehicles
    either useless (driving, diagnostic, perception...)
    or inefficient (chat, games...)
    $\rightsquigarrow$ constraint on the diameter
- GRP : best-effort group service [SPAA 2010]
  Movies screenshots with EMU :
  http ://www.hds.utc.fr/~ducourth/airplug/doku.php
- Performance evaluation under ns-2
  BN : break numbers

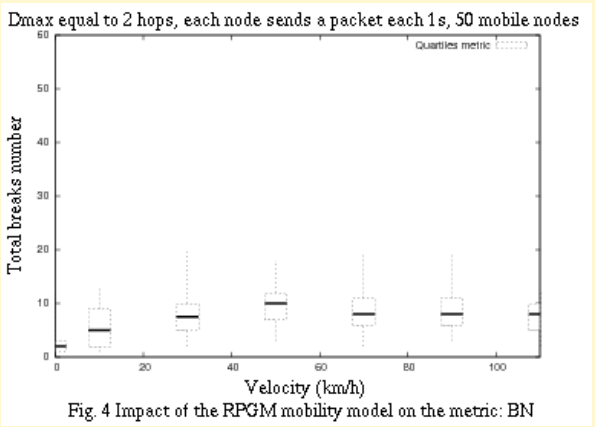
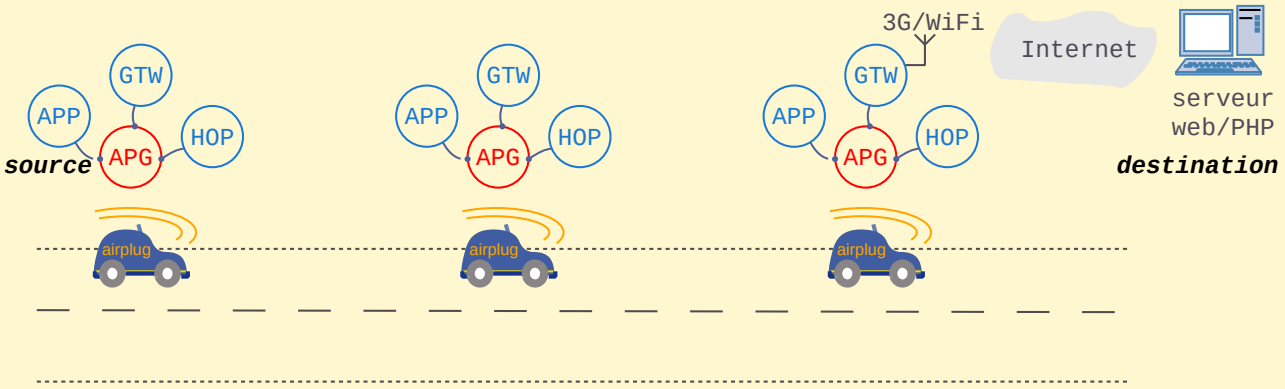


Fig. 4 Impact of the RPGM mobility model on the metric: BN

V2I oportunistic communications

- Sending data from the vehicles to a web server
- GTW [CFIP 2009]
  - V2V : conditional transmission
  - V2I : IPv4, IPv6, WiFi hot-spot, 3G



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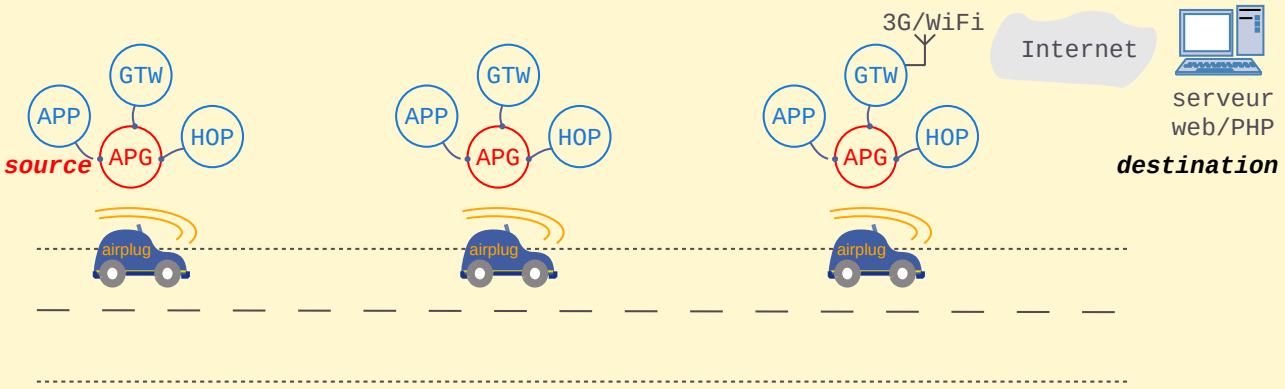

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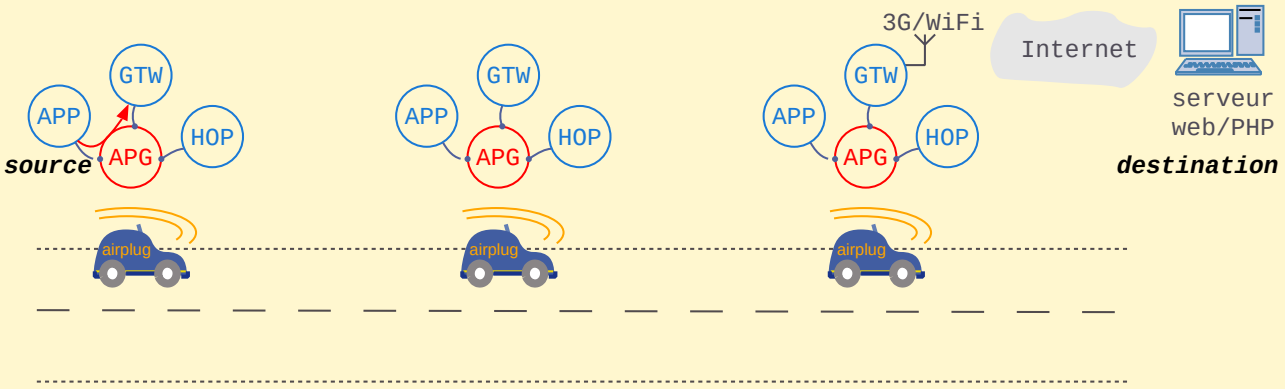

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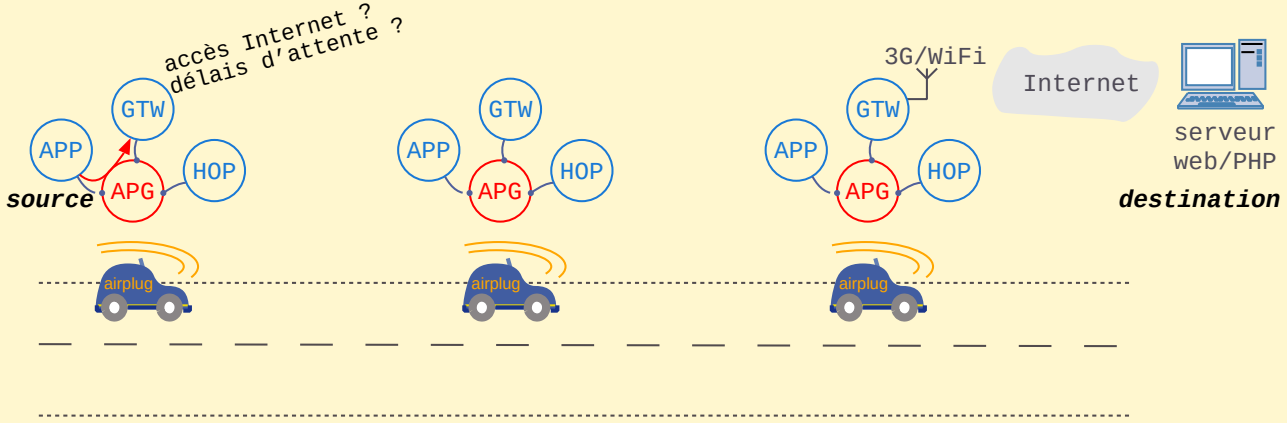

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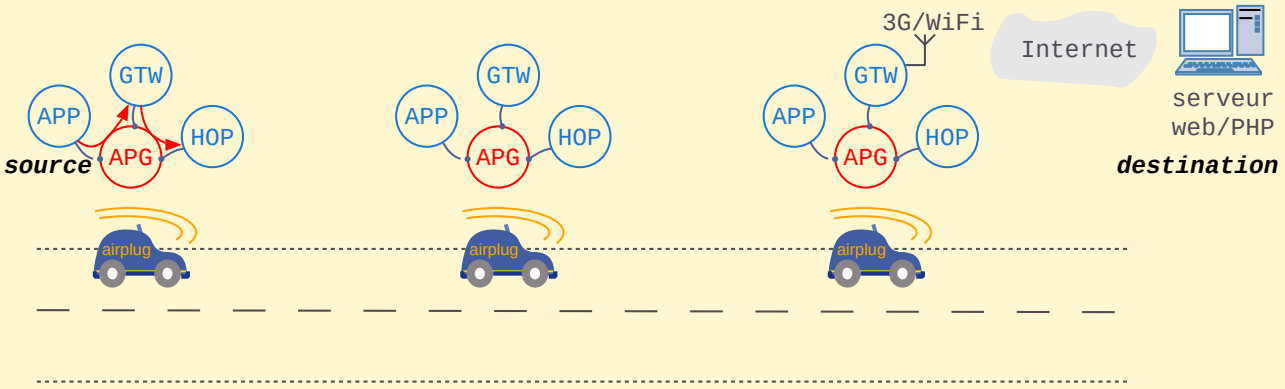

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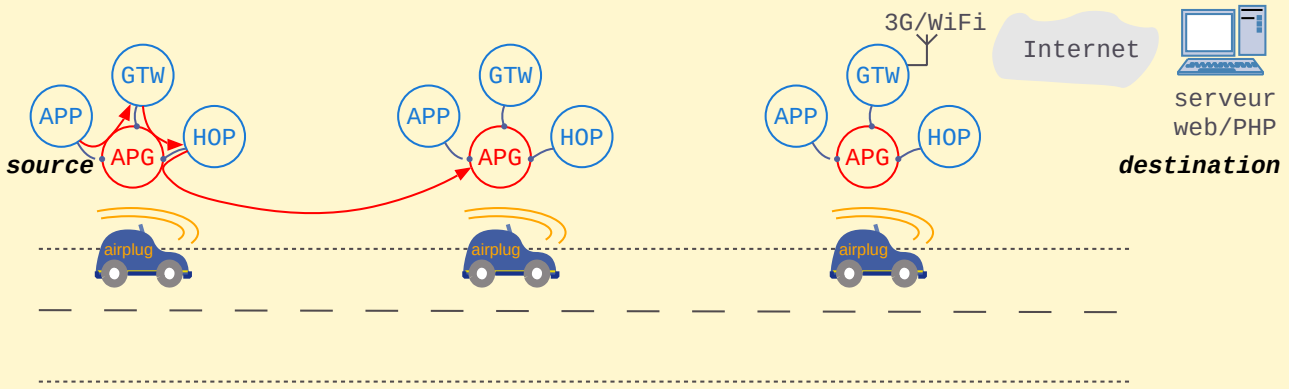

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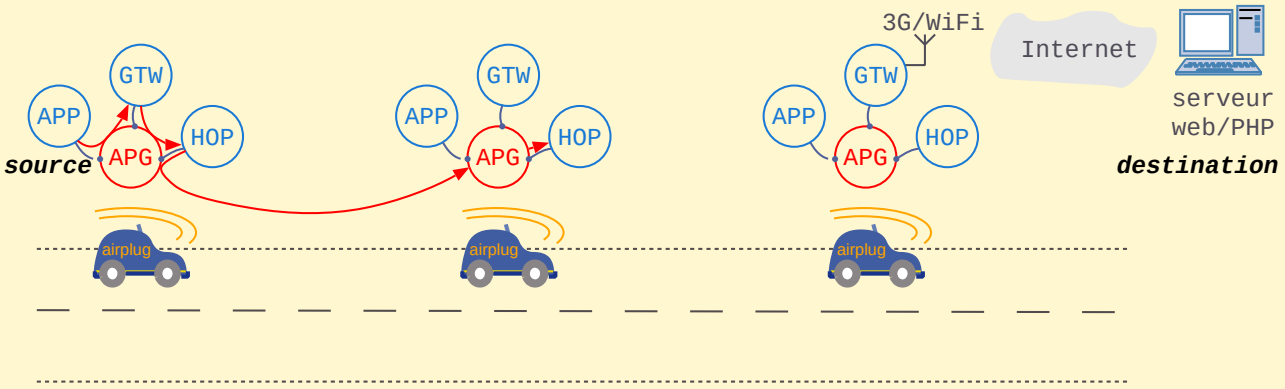

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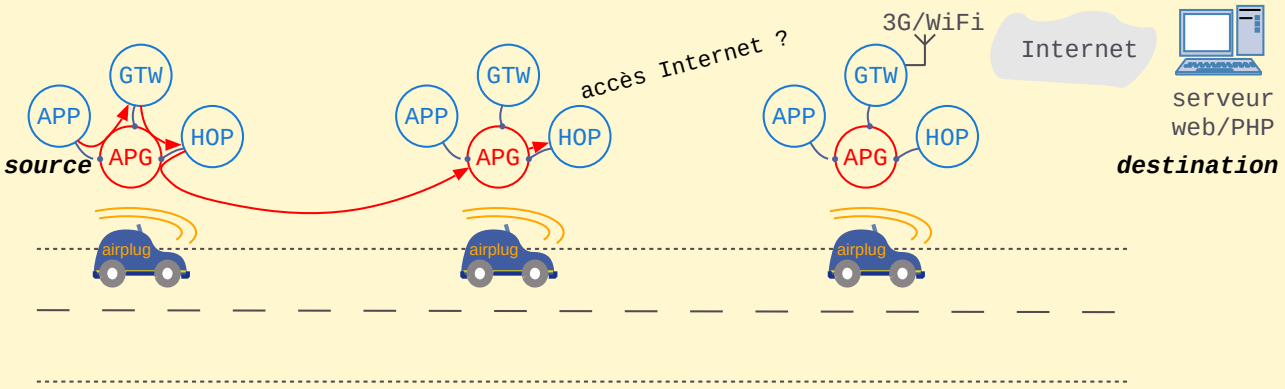

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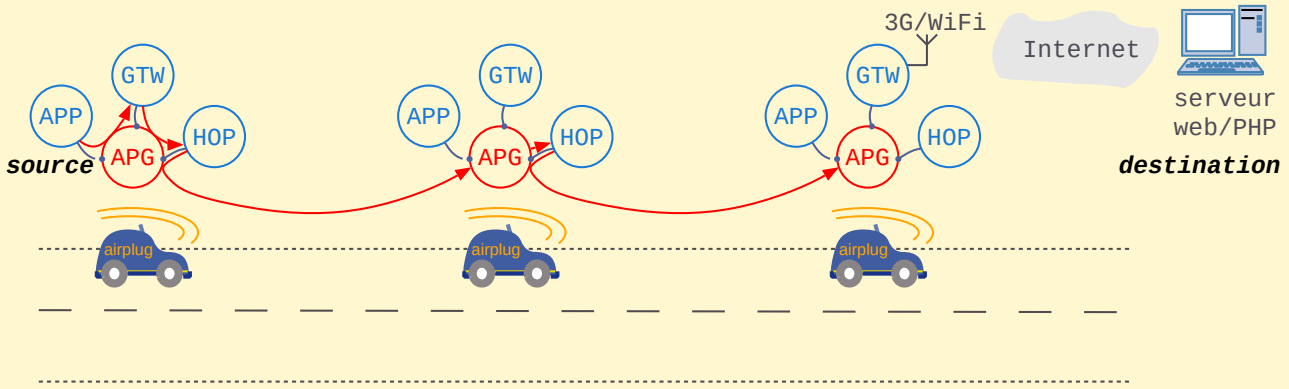

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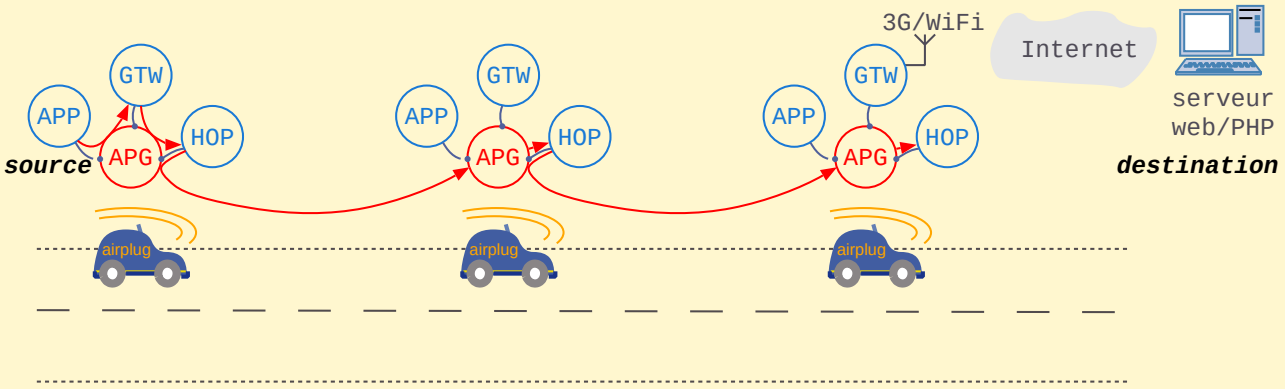

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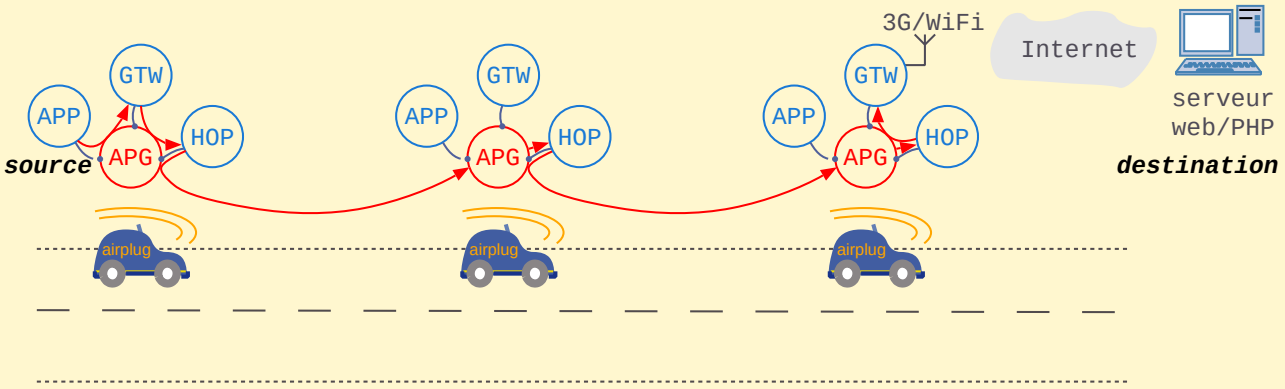

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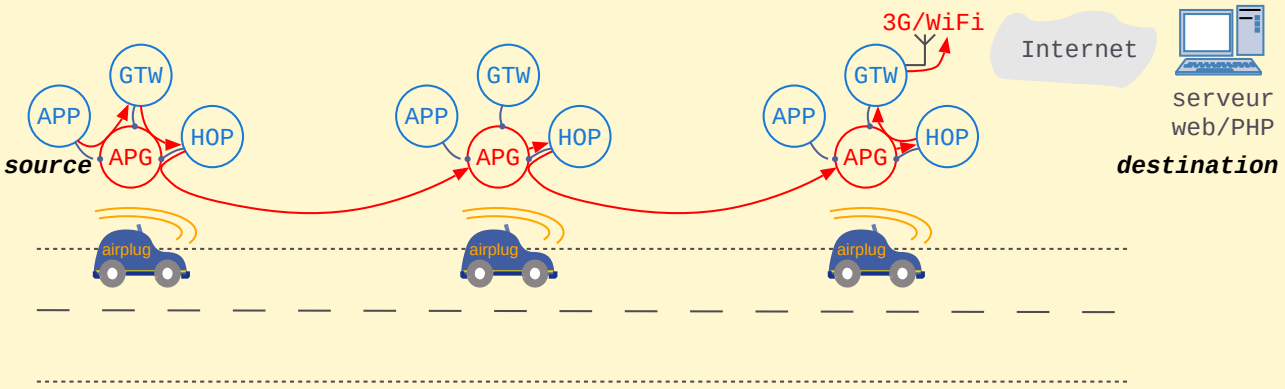

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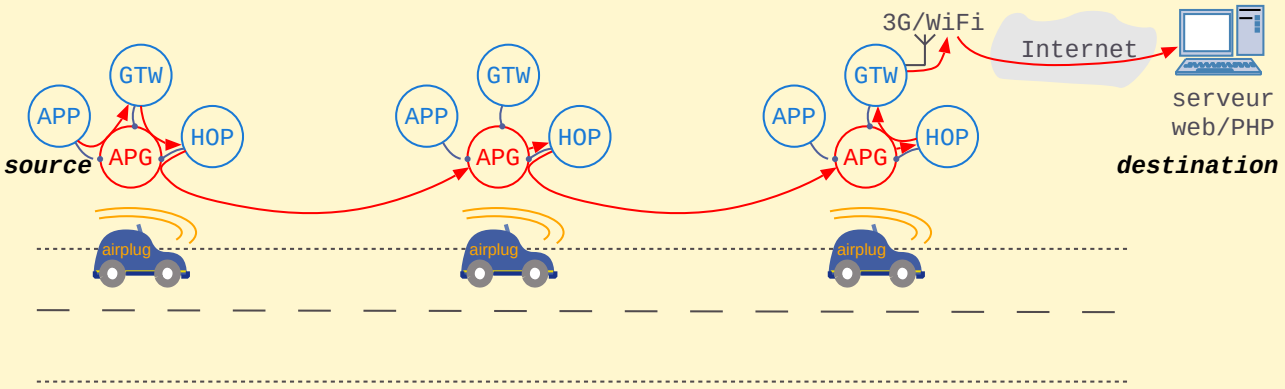

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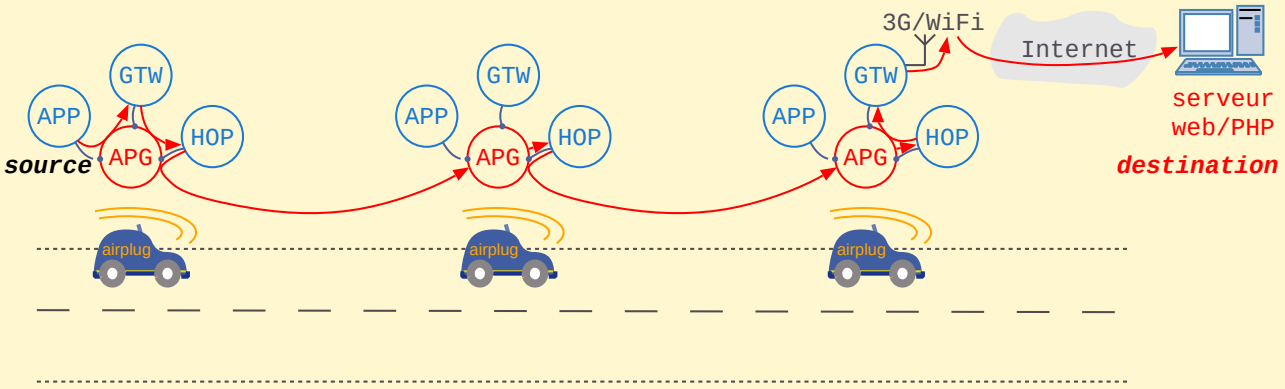

Summary

Conclusion

- The Airplug Software Suite
  a platform for studying dynamic networks
  - on the road Airplug-road
  - on the lab Airplug-lab
  - on the emulator EMU Airplug-emu
  - on Network Simulator Airplug-ns
  - + remote access
- Used by research teams and for teaching
- Large set of applications developed and tested
- Easy to design new protocol or application
  Nb : Tcl/Tk recommended if compatibility with ns-2 required
- Available on demand
- http ://www.hds.utc.fr/~ducourth/airplug