Ambient awareness in smart cities: architectures, protocols and mathematical models (crowds, vehicles and smart grids)

V. Gauthier, Michel Marot, M. Becker & H. Afifi,

outline

- Urban intelligent terminals
- Mathematical tools to estimate crowd mobility and energy optimization
- Dynamic modelling of crowd mobility
- Conclusion

Part I

Improving data dissemination for urban crowds

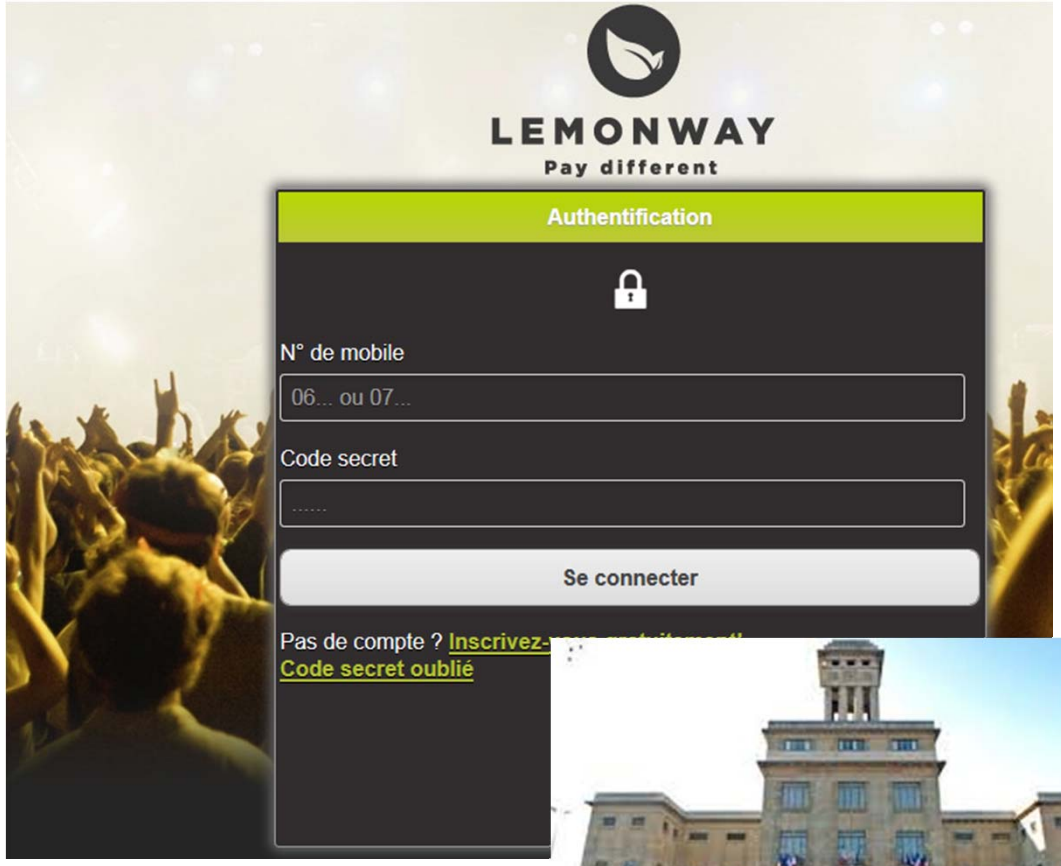
Intelligent terminals in Paris Suburb

Smart charging terminals for EV

Wonderville project:

Partners:
- **Lemon Way**
- **Montreuil city (Paris suburb)**
- **Institut Mines Télécom TSP**

Goals:
- **Smart terminals in the city**
- **Remote payment**
- **Smart data dissemination (services, tourism, pollution, commuting)**



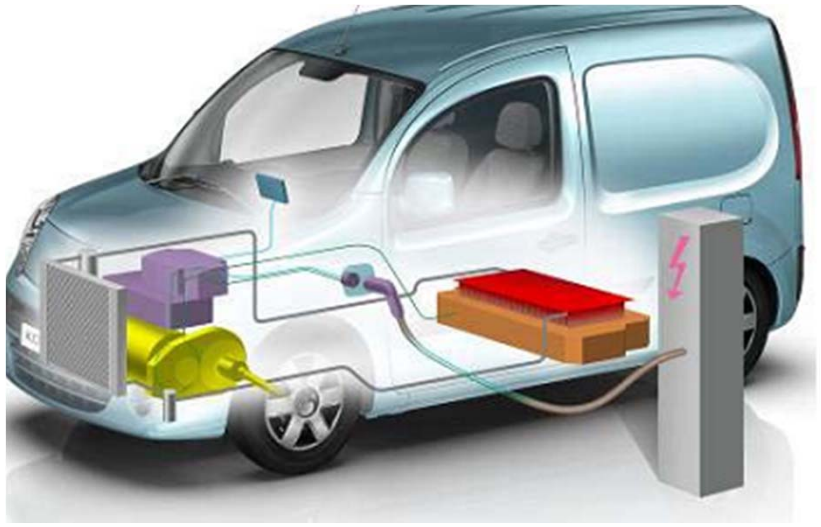
Intelligent terminals

City of Montreuil

- Two way communication
- Can be updated with delay tolerant architectures (DTN)
- Works with vehicular communications (V2I)
- Payment facilities
- Supports adhoc communications

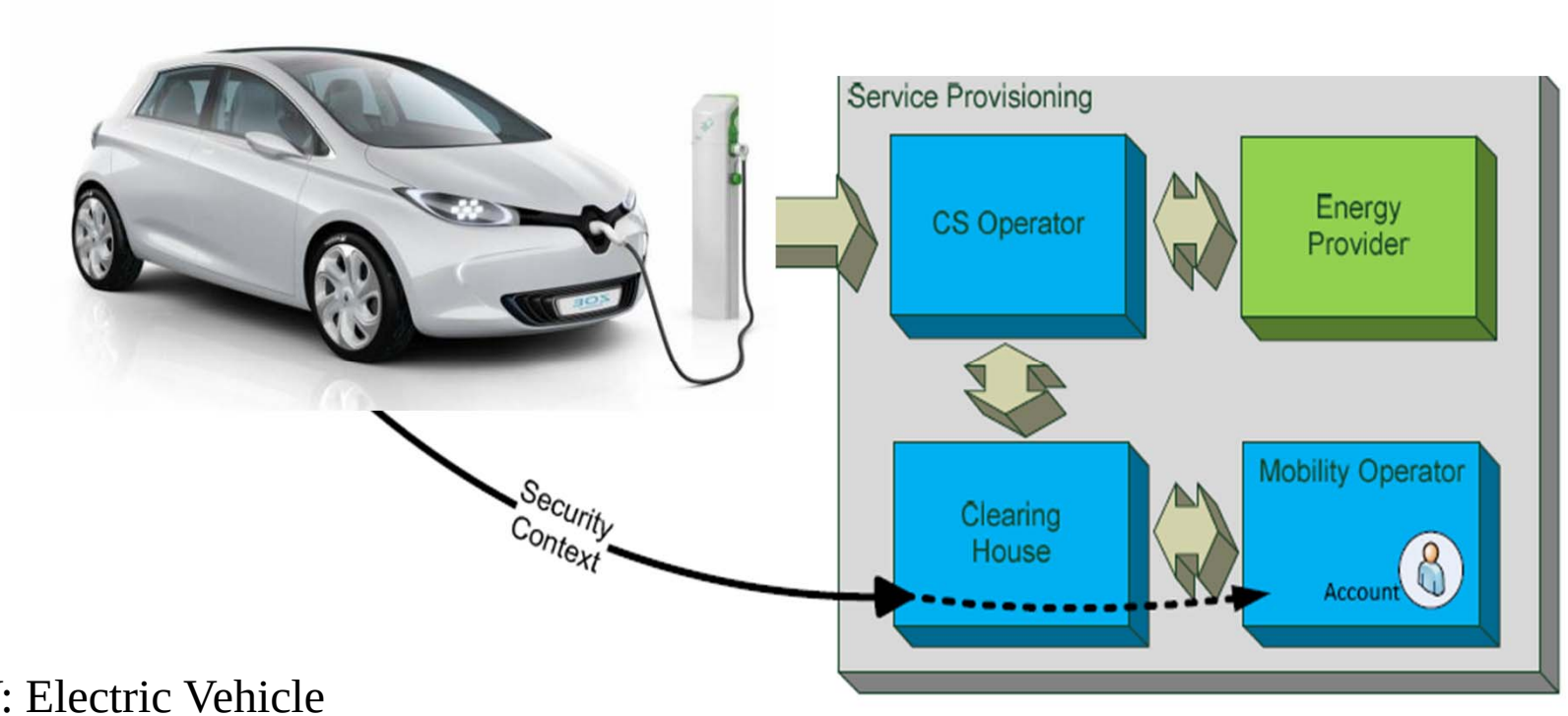
Intelligent terminal for electric vehicles (VELCRI Project)

H. Labiod, JMM Bonin, H. Afifi



Power ≥ 43 kW
400 V triphase, 63 A

Electric charging scenario in Europe



EV: Electric Vehicle
EVSE: Electric Vehicle Supply Equipment

Do we need security?

ISO Standard **PT5**
v2g_security_proposal_20100720

possible attacjs

Confidentiality ⇔ Eavesdropping [R3]

Mutual authentication ⇔ Prevents falsification of bills [R1]-[R3]-[R7]-[R8]

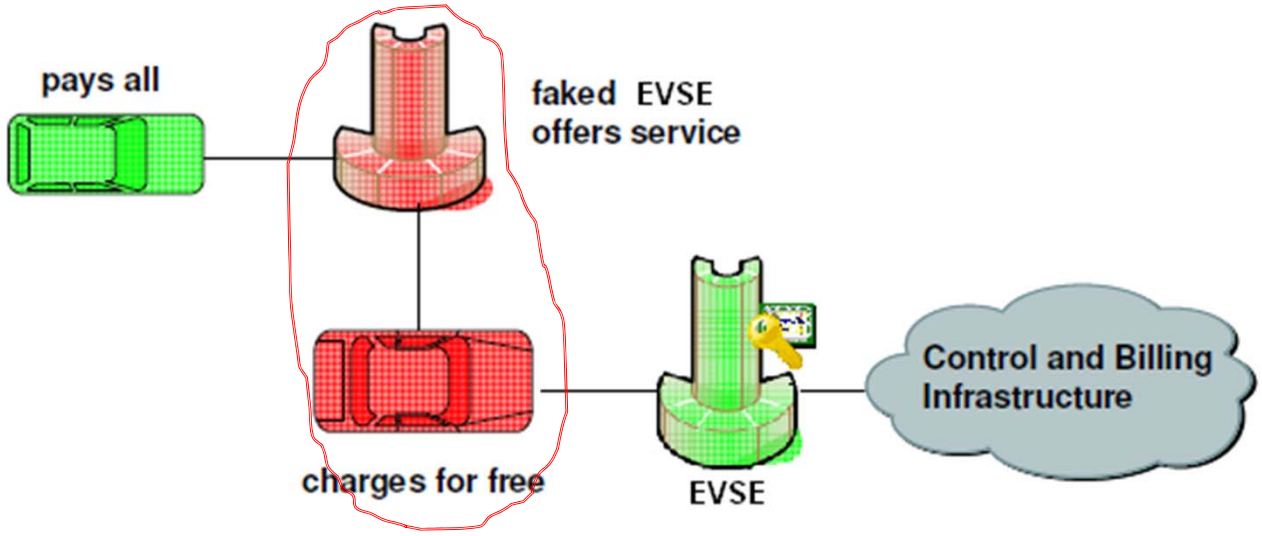
Non-repudiation ⇔ Juridic proof [R2]

Do we need security (2/2)

Possible attacks

DOS ⇔ Man in the Middle
[R1]-[R3]-[R7]-[R8]

Physical attack ⇔ Man in the Middle
[R1]-[R3]-[R7]-[R8]



ISO standard

EV

EVSE

Establishement TLS

Discovery Negociation

Charge plan selection

Charging process

Close all

TLS Session establishment

Exchange of security relevant information, e.g., CRL updates, Certificate Updates

Connection establishment

TLS Session establishment

Service Discovery

Charging Request for ContractID, incl. Vehicule Certificate

Exchange of security relevant information, e.g., CRL updates, Certificate Updates

Token with Charging Plan for ContractID, tariff information (encrypted with vehicle certificate), etc

Token with Charging Plan for ContractID, tariff information (encrypted with vehicle certificate), etc

Charging Plan Selection via chargePlanID

Charging Plan Selection via chargePlanID

Power Discovery and Delivery

Meter reading $R(t_0)$ for defined charging period t_0

Signed Acknowledgement to accept meter reading $S_{EVCC}\{(ACK[R(t0)]\}$

Meter reading $R(t_n)$ for defined charging period t_n

Signed Acknowledgement to accept meter reading $S_{EVCC}\{(ACK[R(tn)]\}$

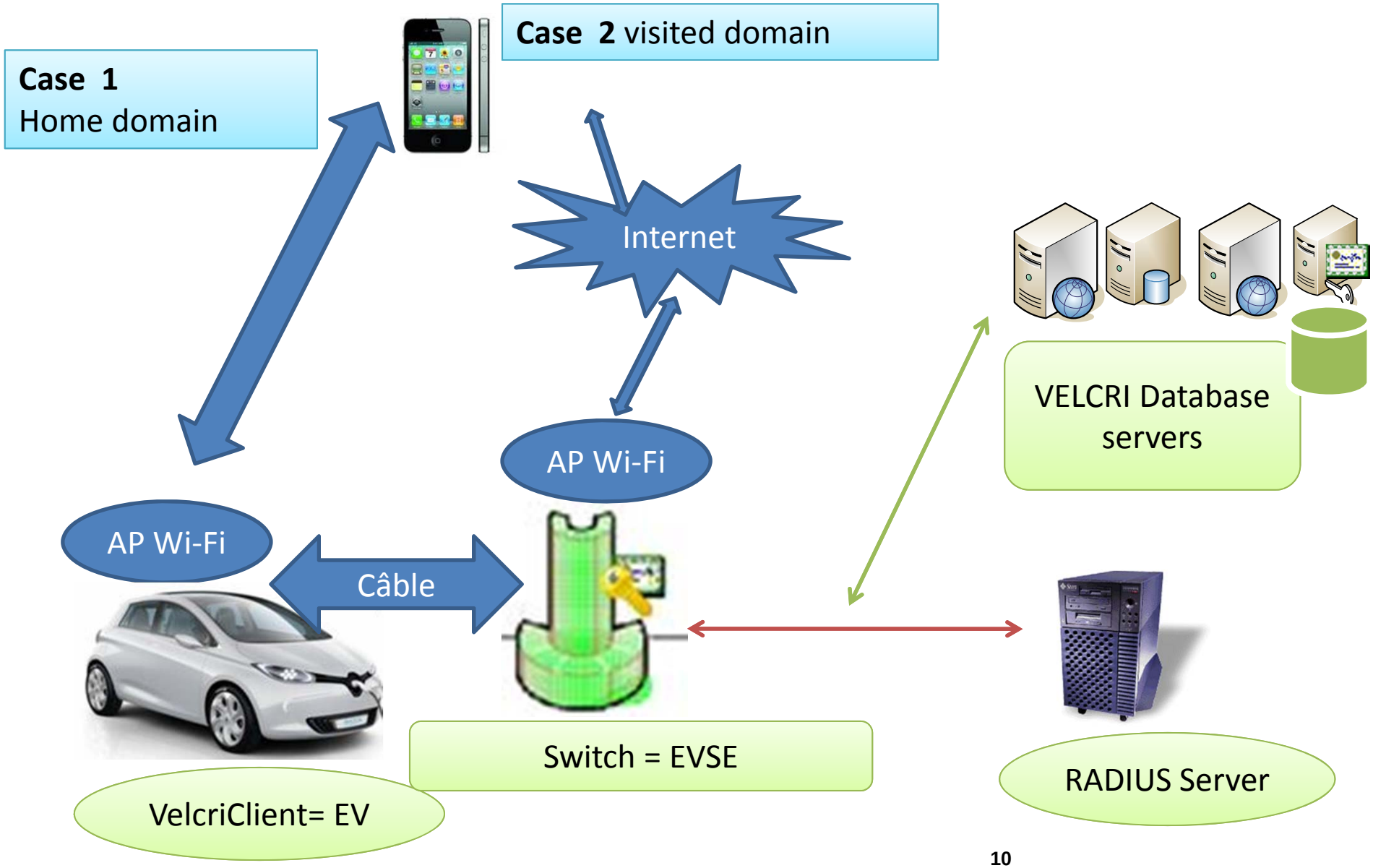
Signed charging records for billing (last signed meter reading $S_{EVCC}\{(ACK[R(tn)]\}$)

Charging Finished

TLS Session termination

TLS Session termination

Prototype Architecture for VELCRI



Application interface (TSP)

Part II

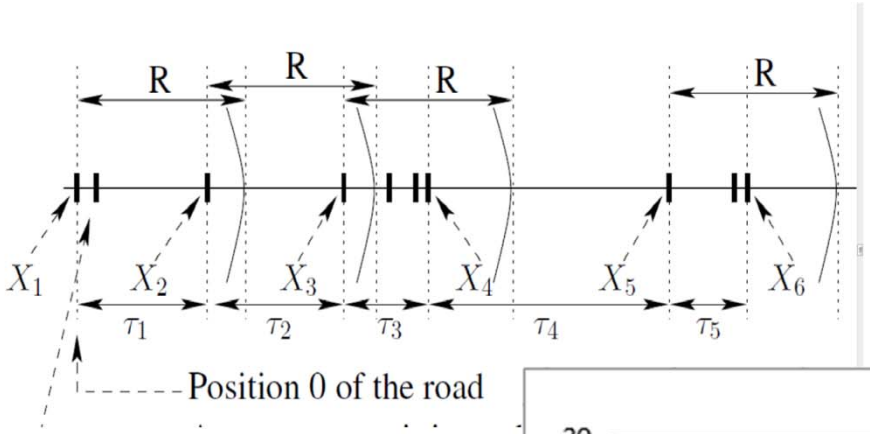
Mathematical approaches of the urban mobiltiy and crowds

- **Based on extensive simulations over two decades**
- **Based on reflexions on the massive human behavior in a large city**
  - We try to find precise models to mathematically estimate some parameters
  - We use real traces to confirm behaviors
  - We compare with simulation
  - Companies use those models essentially for prediction (jams, errors, crowds…)

Vehicular networking models

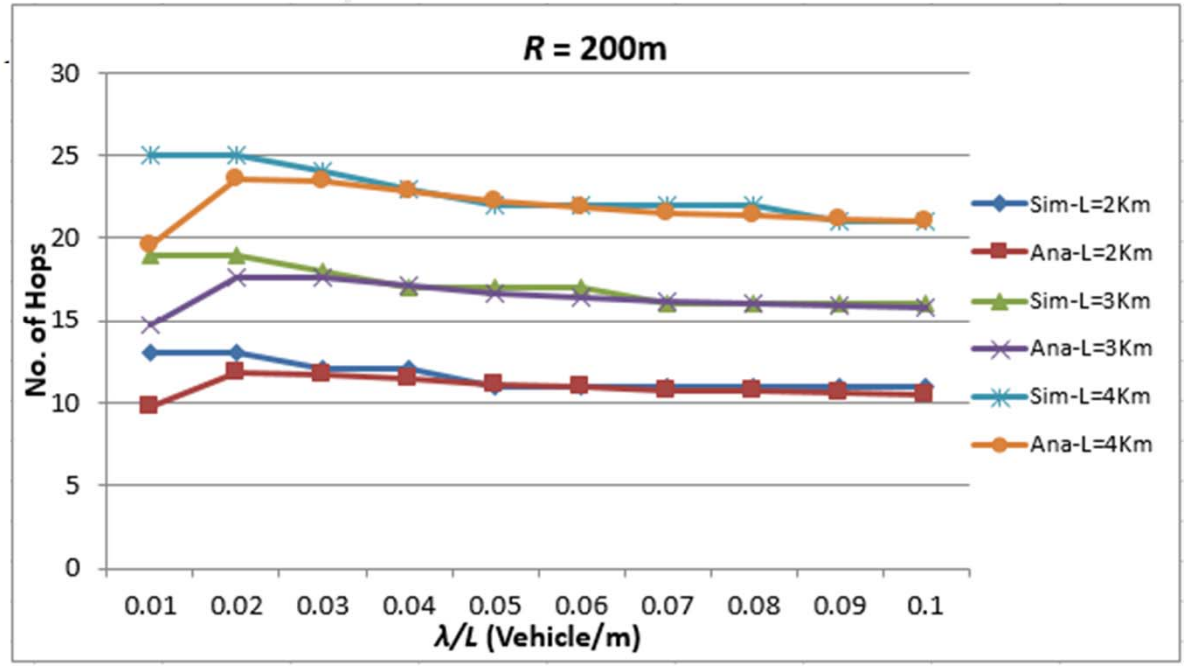
- Two contributions on the modelling of intra vehicle communication in a broadcast scenario

Prof. Michel Marot (TSP)



Using Poisson models to represent Vehicles on a line (fixed snapshot)

Model is precise and avoides hours of simulation



We replace simulation by probabilistic models

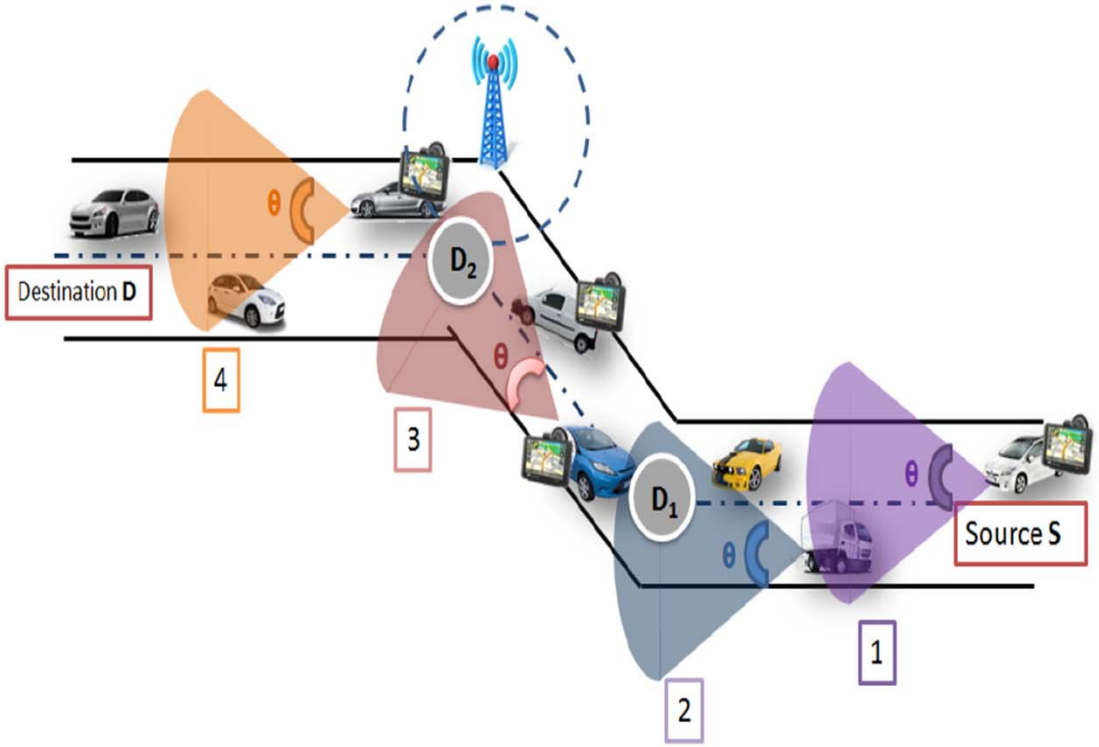
Vehicular Network Modeling: on going work

- Beginning of answer: z transform of the number of hops in the longest shortest path in a connected component (for $\lambda R > \ln(4)$ only):

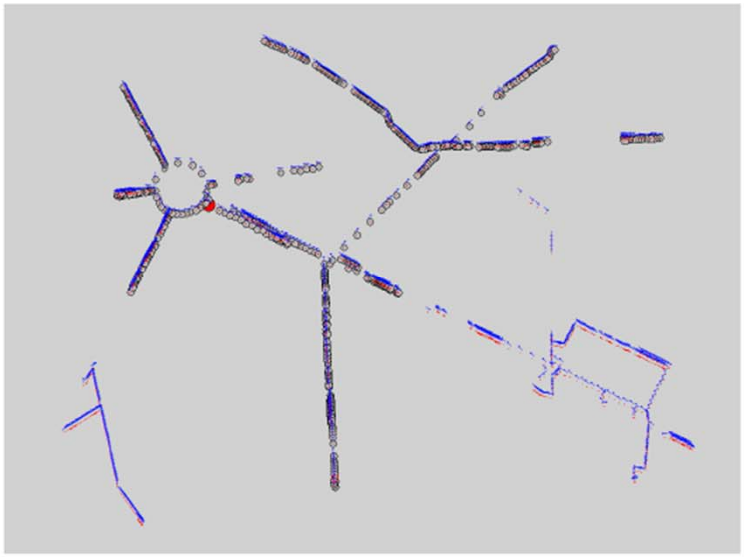
$$
\begin{aligned}
M1(z) \quad = \quad & \frac{1}{\rho z^2 \left(1 + \sqrt{1-4\rho' z^2} - 2ze^{\frac{1}{2}\lambda R\left(\sqrt{1-4\rho' z^2}-1\right)}\right)} \times \\
& \Big[\sqrt{1-4\rho' z^2}\left((\rho'+\rho-1)z^3 + 3(1-\rho'-\rho)z^2 - (2-\rho'-\rho)z + 1\right) \\
& + e^{\frac{1}{2}\lambda R\left(\sqrt{1-4\rho' z^2}-1\right)}\left(2(1-\rho')z^3 - 2(1-\rho-2\rho')z^2 - z - 1\right. \\
& \qquad \left. + (z-1)\sqrt{1-4\rho' z^2}\right) \\
& + z^3(\rho'+\rho-1) - z^2(\rho'+\rho+1) + z(2-\rho'-\rho) + 1\ \Big]
\end{aligned}
$$

... where $\rho = \lambda R e^{-\lambda R}$ and $\rho' = e^{-\lambda R}$.

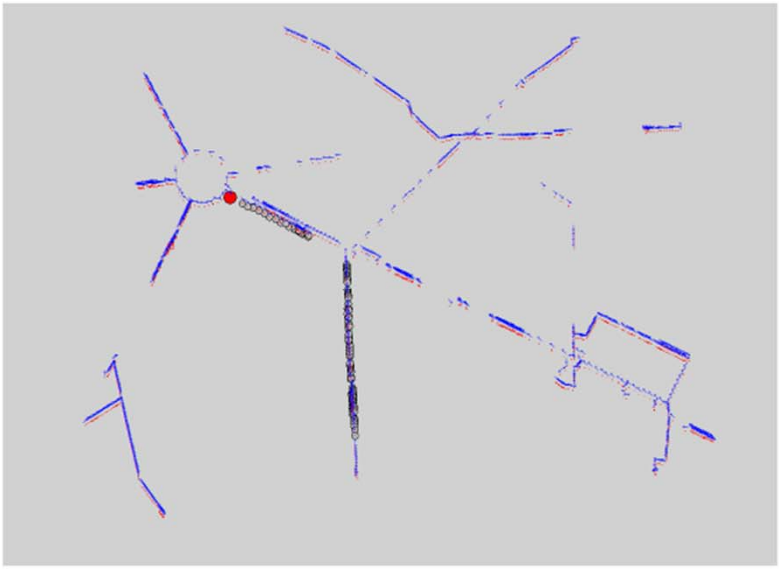
V2V with Beamforming and angular precision



Comparison of omni and directional dissemination of accidents in Champs Elysees

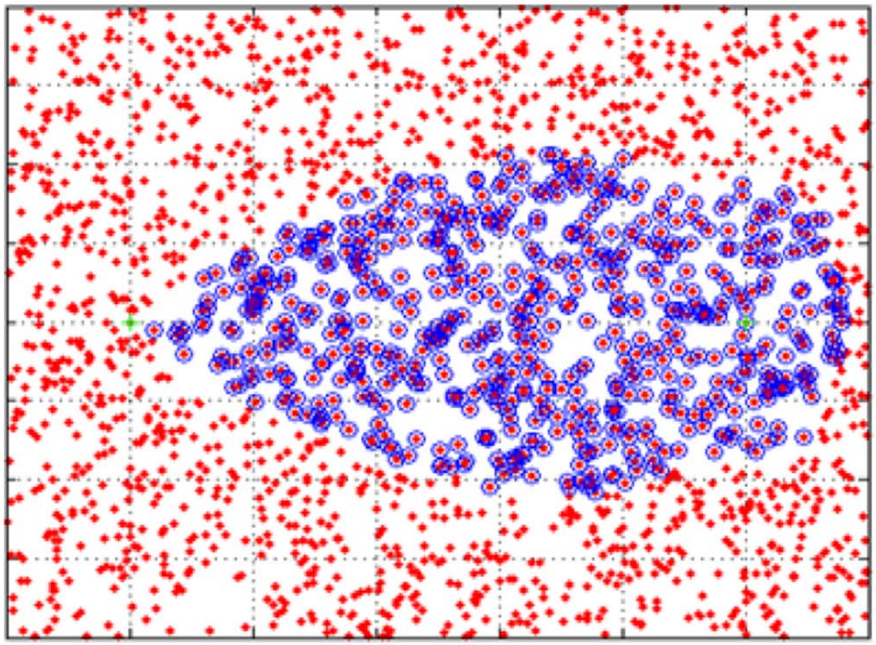


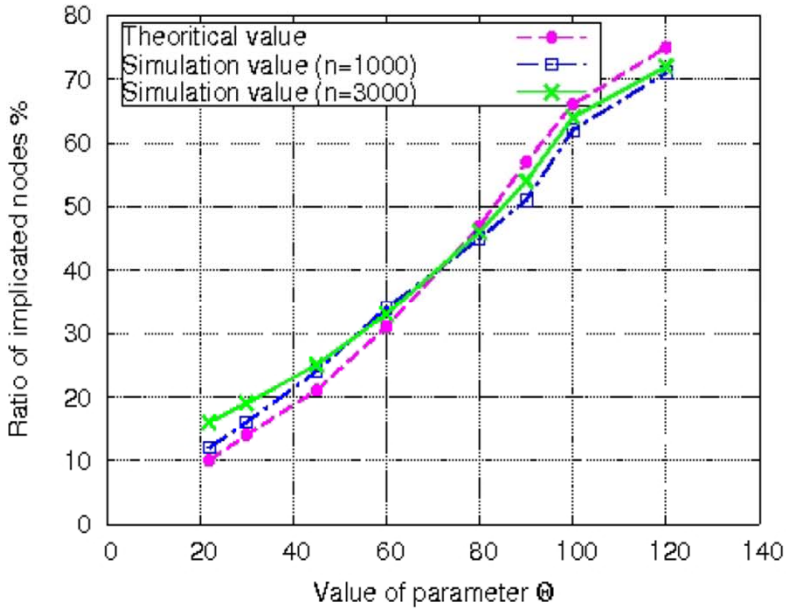
Omni directional



With beamforming

Mathematical Model results





TELECOM SudParis

Understanding Human Mobility in Cities Through Digital Traces

MINES TELECOM
INSTITUT Mines-Télécom

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Understanding Human Mobility in Cities Through Digital Traces

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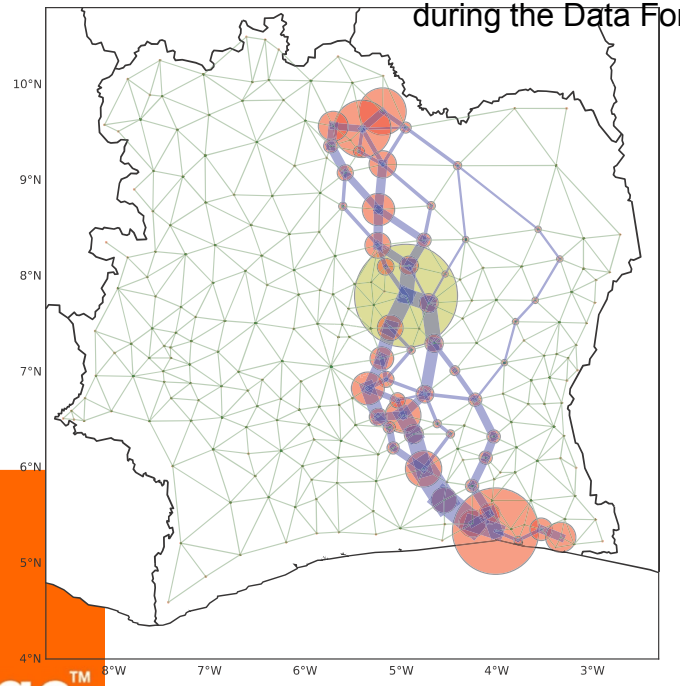
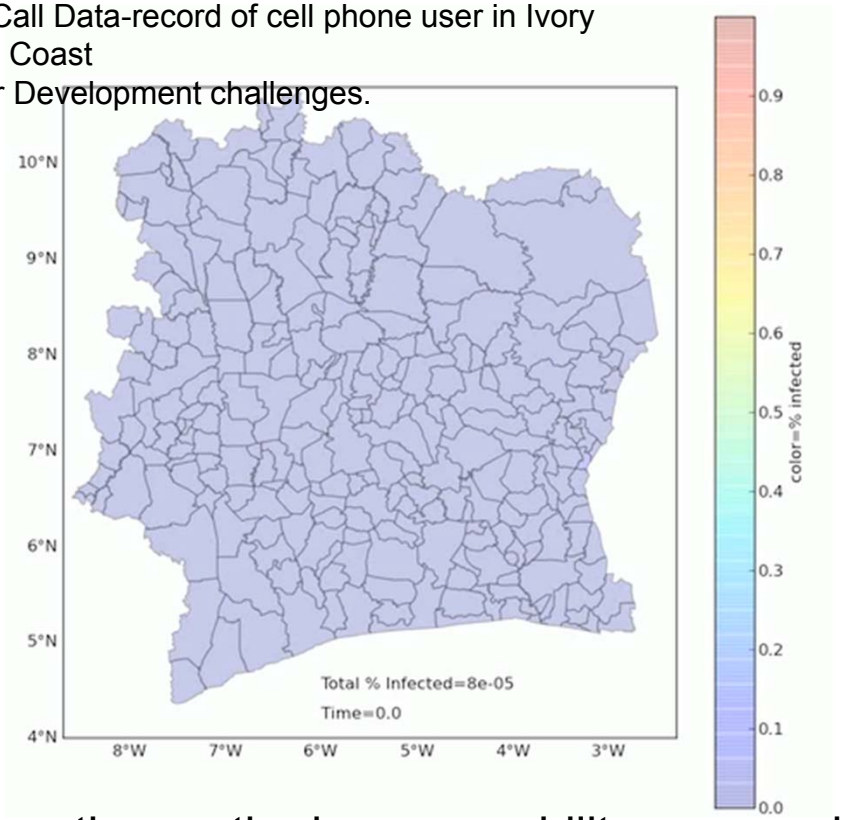
Coarse grain mobility at country scale

Extraction of human mobility from Call Data-record of cell phone user in Ivory Coast
during the Data For Development challenges.





orange™

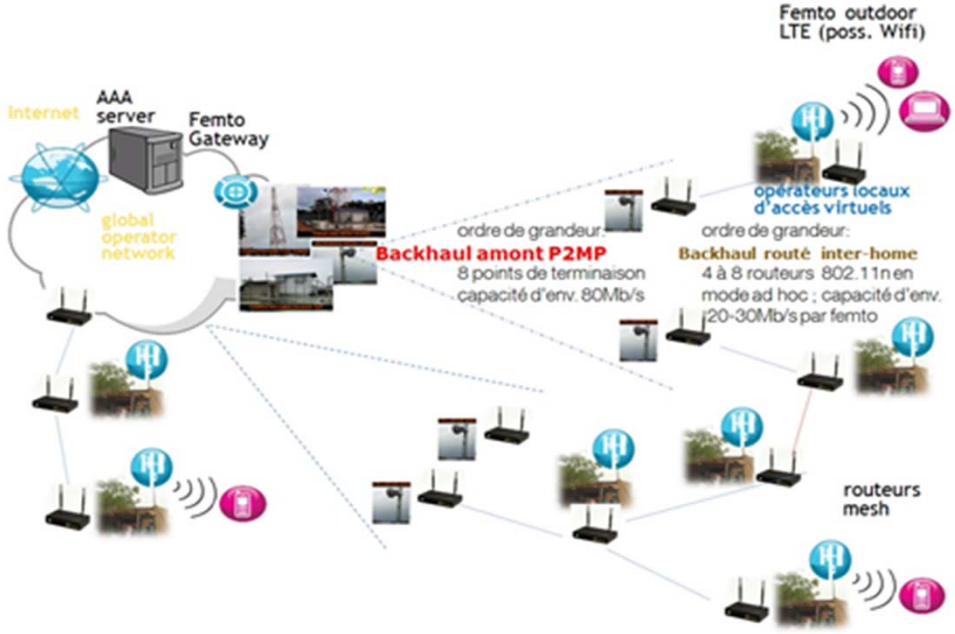
Data for Development D4D Challenge

CDR and information on the human mobility can provide meaningful information about:

1. The diffusion of information through the country
2. Epidemic spreading of diseases at the country scale

Improving flexible bandwidth allocation

- Dynamic planing of femto environment
- LCI4D project



conclusion

- Communications and networking are considered as decisive in ambient urban intelligence
- They contribute to energy savings and planning optimization
- Efforts with city planners and vehicle traffic managers should be undertaken