Urban networks for Smarter cities

Hervé Rivano
Urbanet team, Inria - Insa Lyon

ICT makes cities smart

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ICT makes cities ~~smart~~ smarter

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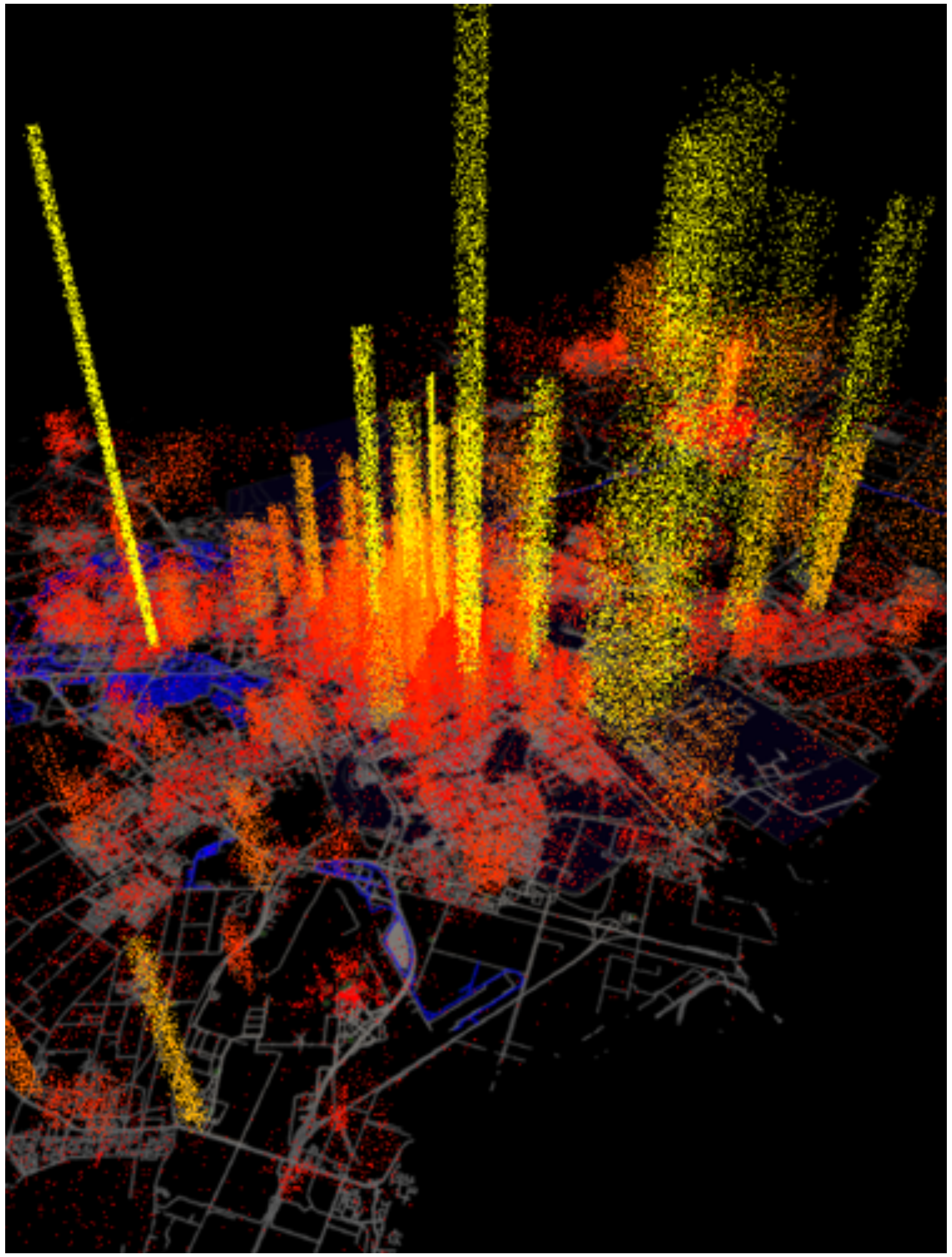
The world is urban

Majority of world population in urban areas

•80% in developed countries

•Cities heterogeneity



Over-density challenges societies

•Saturation of public services

- Efficiency - reactivity personalization

•Environnement and public health issues

- Monitoring of the environment

•Transit time explosion and pollution

- Public/private/individual transports

•Seamless Internet connectivity

- < 12% smartphones, > 82% bandwidth

ICT bring a physical-digital continuum

Sensors
- environnement
- activities

Smartphones
- passive tracking
- geolocalised services

Social networks
- active tracking
- direct interaction

Open data
- information redistribution
- digital maps
- real-time statistics

HubCab.org (c) MIT Senseable City
Statistics on cab fares in NYC

Smartness basis is data

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sensed

Smartness basis is data

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Smart-cities rely on sensors

Dense deployment of IoT devices sensing the city
- Configuration/installation cost is an issue
- Wireless networking
- Autonomous devices (battery/harvesting, self-* protocols, …)

Many emergent industrial deployments
- Telemetering (electricity, water, …)
- Vehicule detection (ITS, parking,…)
- Environnemental sensing (pollution, noise, …)

Challenges
- Constrained deployment
  - Social acceptability / Electromagnetic pollution / Robust embedding
- Multi-application network
  - Performance / Privacy / Data ownership
- Urban environment
  - Unstable communications / Resiliency

GPSR [Karp et Kung, 2000]

What can be envisioned ?

Eg: structural health monitoring
•Bridges, skyscrapers, ….
•Maintenance planing

Today's situation
•Big and expensive sensors
•Expert deployment

New frontiers
•Nano-technology designed sensors
•Low-cost, small, inside concrete

New methodology: replace precision by number
•Environmental sensing (pollution, noise, …)
•ITS (Floating car data, fleet management, infrastructure monitoring,…)
•Mitigates data corruption attacks ?

Smartness is data moving

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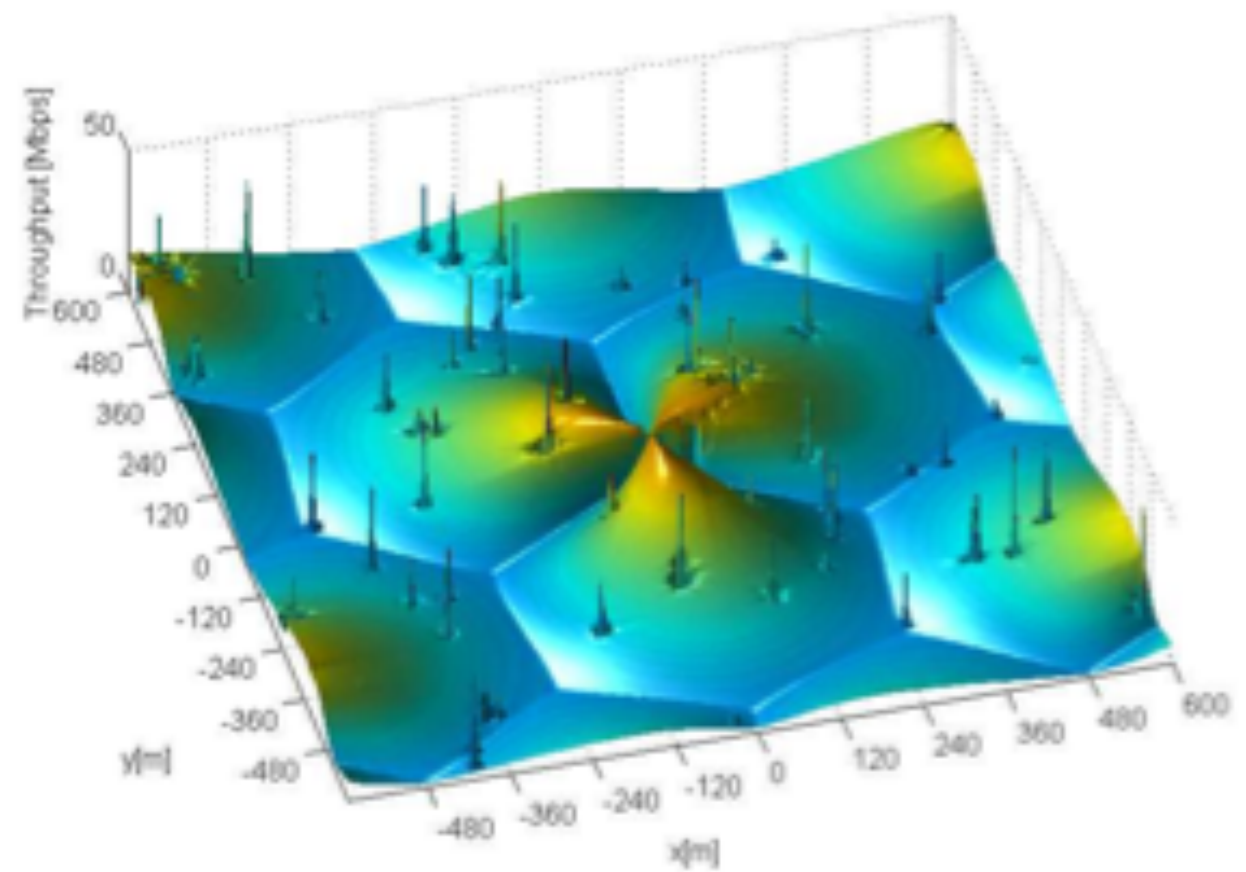
Smartness is data moving

collect -process - redistribute

Cellular M2M connectivity



Large scale low power networks
- Ubiquitous covering, quite secure
- Uplink only, very low rate
- No mobility yet (LoRa ?)

Cellular network access unable to scale
- 4G ressources are for mobile Internet
- Provide global clock, traffic management, …
- Unable to handle thousands of devices/cell
- Smartphone background trafic already an issue

What evolutions ?
- Network densification coupled with RAN virtualization for efficiency
- Optimized access envisaged in 5G
    - Ligthweight procedure with piggybacked data
    - One app - one virtualized UE shared among devices
    - Might means lightweight security / not handled by the operator

Impact of femtocells on the network energy consumption

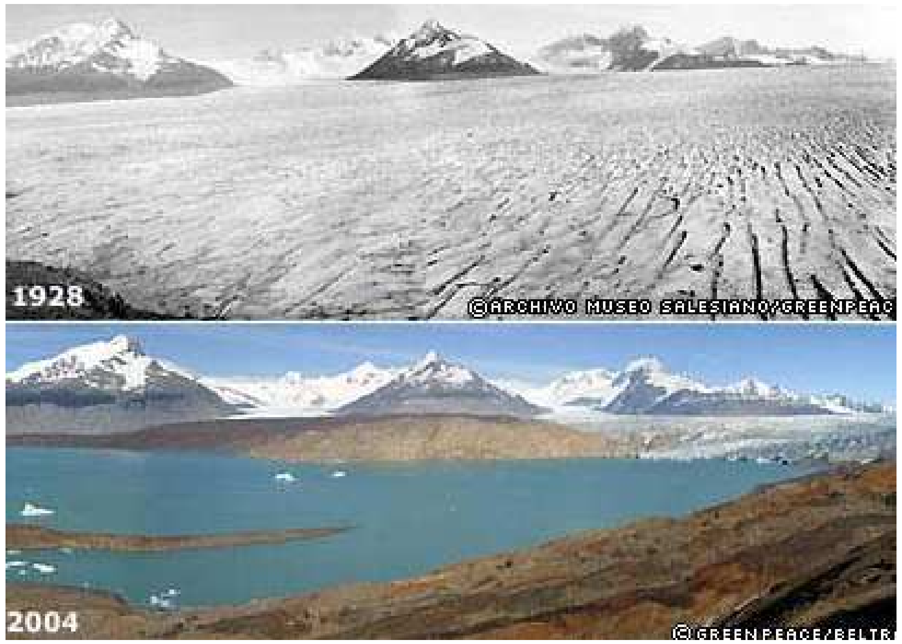
- Telecommunications is a large consumer of energy (e.g. Telecom Italia uses 1% of Italy's total energy consumption, NTT uses 0.7% of Japan's total energy consumption)
- Increasing costs of energy and international focus on climate change issues have resulted in high interest in improving the efficiency in the telecommunications industry

Opportunity:
Small cells have the potential to reduce the transmit power required for serving a user by a factor in the order of 10^3 compared to macrocells.

Problem:
Most femtocells today are not serving users but are still consuming power:

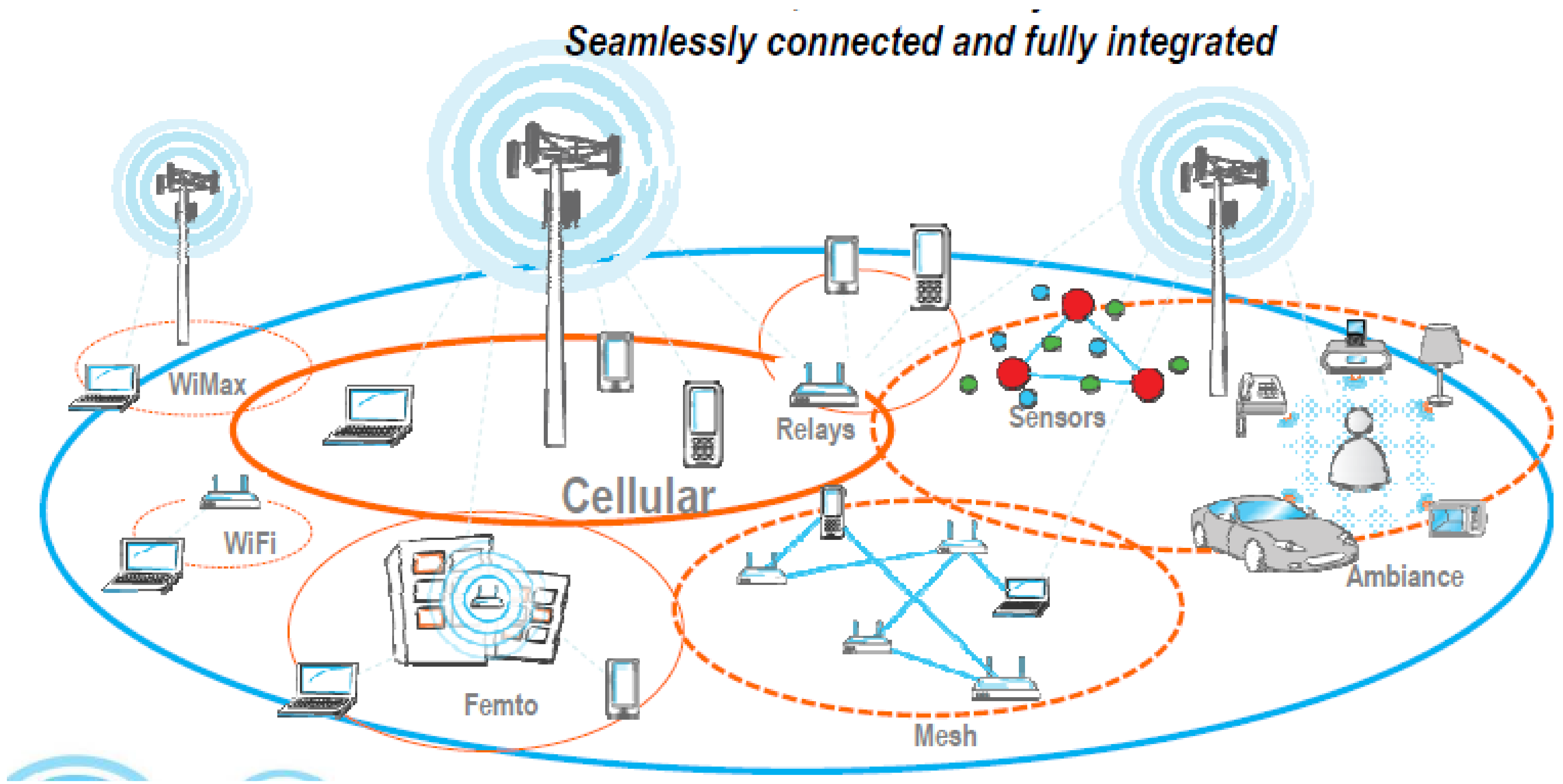
50 Millon femtos x 12W = 600 MW $\longrightarrow$ 5.2 TWh/a

Comparison:
- Nuclear Reactor Sizewell B, Suffolk, UK: 1195MW
- Annual UK energy production: ~400 TWh/a



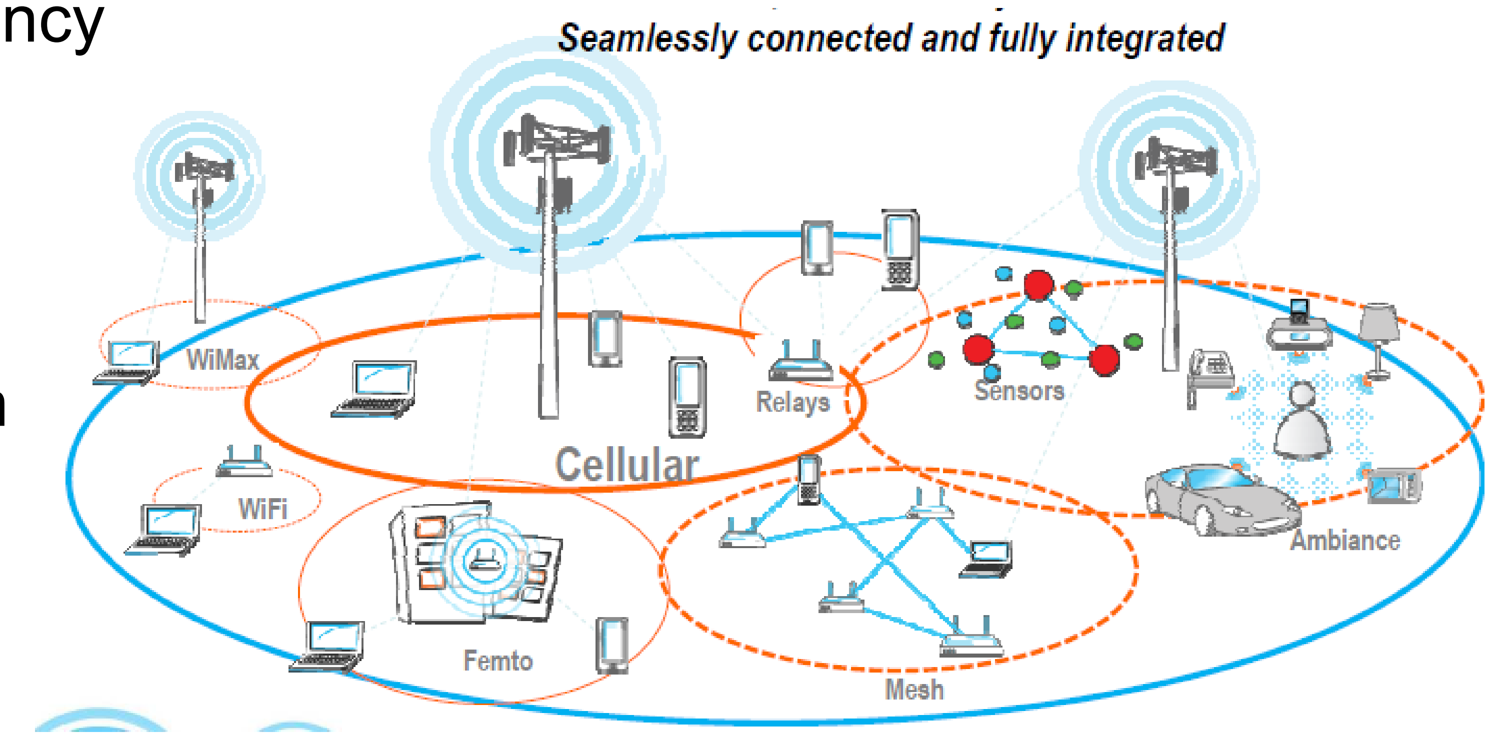
Courtesy of Alcatel-Lucent Bell Labs

Urban capillary networks



Hybrid architectures

Leverage networking opportunities
•Complementarity better than concurrency
•Heterogeneous security policies



Cellular and multihop architectures
•Coverage extension, capacity addition
•Seek connectivity where better
•Trust other players

Network offloading
•Multi-hop gathering and distributing (access)
•Data aggregation and geocasting (capacity)
•Deep authentification and security challenges (makes femtocells easy)

Mobility is added value

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Leverage « free » mobility

Leverage mobility: crowdsourcing

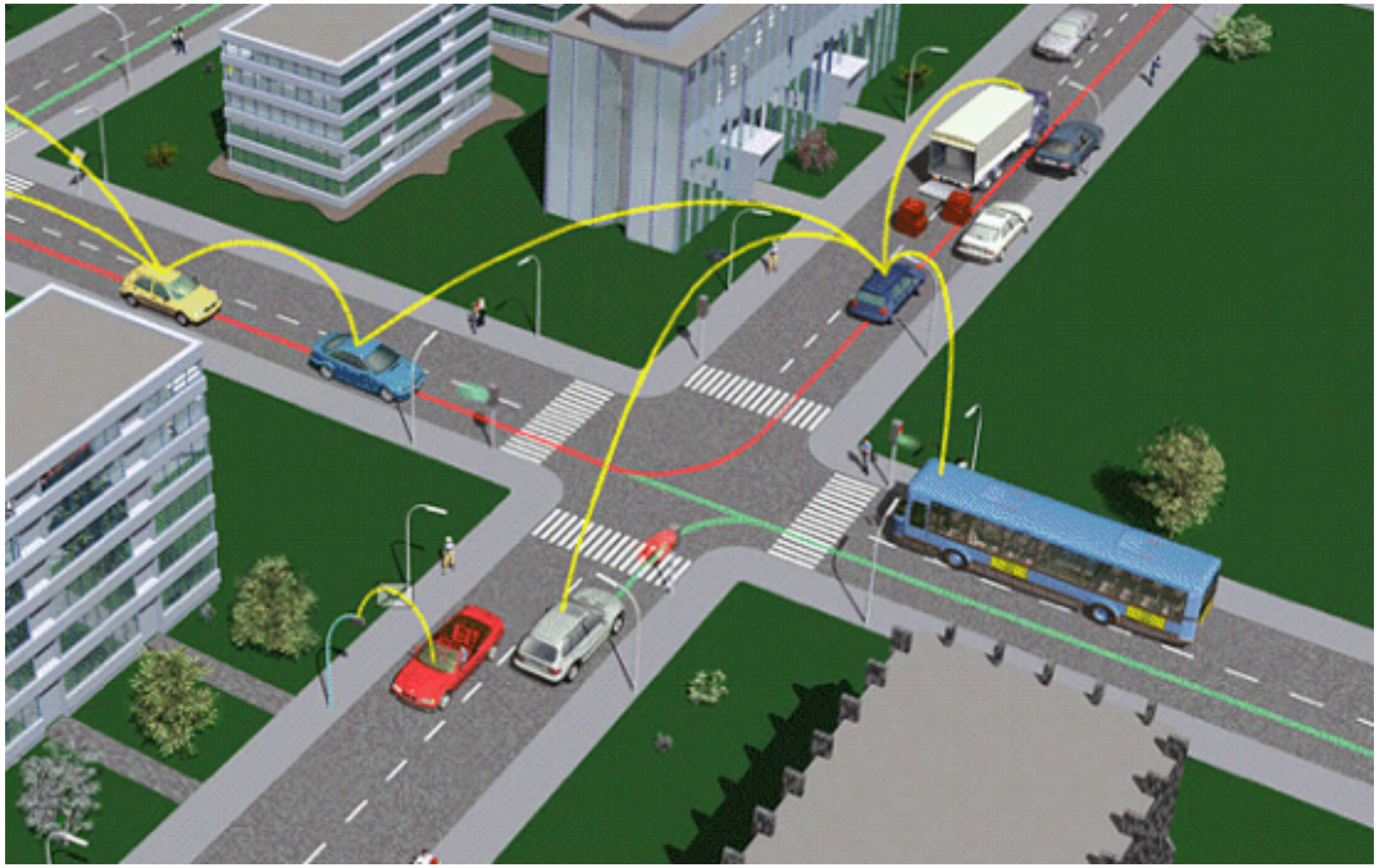
Many sensors are moving in the city
- Smartphones
- Cars / public transportations

Many low-precision vs few high-quality

Mobile sensors vs dense deployment

Sense where the citizens are

Already in play for basic ITS
- GPS with trafic information, Google waze
- Community informations on public services
- Rogue players mitigation by consensus ?



Citizen empowerment - Democracy issue
- Need a large basis of users to be effective
- Equal right to participate or equal weight in the decision ?

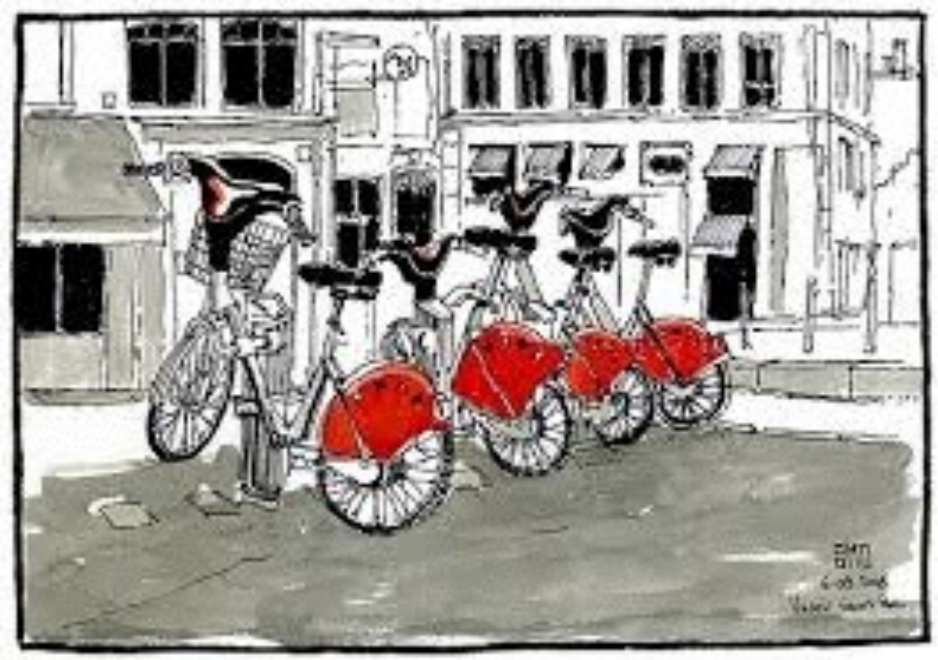
An example: smart urban biking

« Bikability » of cities : strong trend (mayor of Phoenix, USA)
•Contributes on health and decongestion

City wide bike sharing services are spreading
•73,5k 2008, 236k 2011, 517k 2014

Enablers for urban biking
•Infrastructure for confort and security. Dedicated lanes ~ 2M$/km
•Institutional informations, education. Top-down
•Enrollment in community (go from pioneering to citizenship)

Some market solutions
•« self-quantifying » applications
    •For sport geeks
•Community applications
    •Road state, path comfort, localization of stolen bikes
•Institutional applications
    •Bike sharing stations availability
    •Open Data strategy



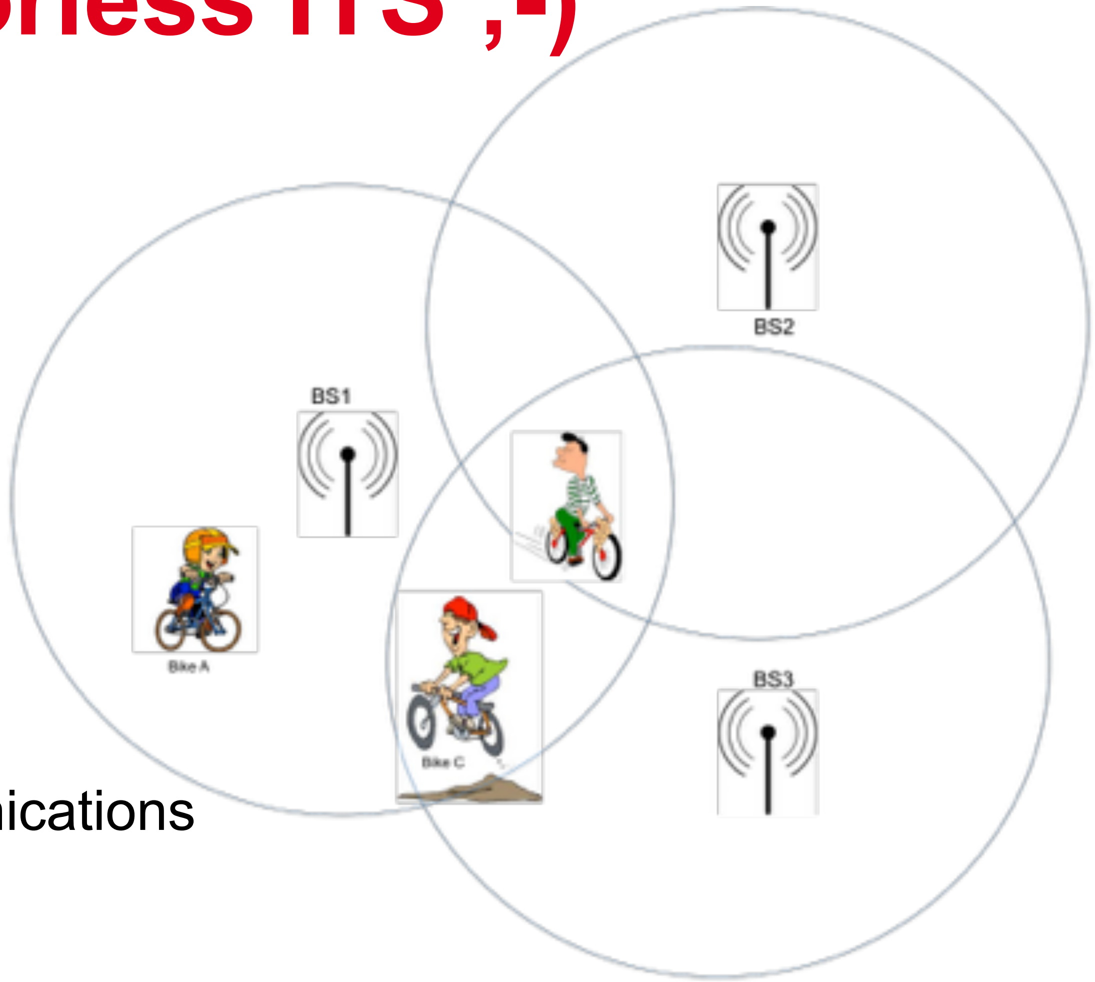
Instrumented bike - Motorless ITS ;-)

Technology enables today
•Light, low-cost, low-power bike instrumentation
•Sensing effort, position
•Non-intrusive in the mechanics (e.g. Connected bike at CES)

Leverage bike sharing infrastructures
•City-wide community from scratch

A real capillary networking scenario with opportunistic communications
•802.11p: bike <> bike
•802.11: bike <> infrastructure (stations)/home

Many information available
•Self-* : raw data collected by user’s smart-phone/watch
•Realtime system status : positions, station availability
•Decision algorithms : aggregated statistics on travels, state of road
•Tomorrow : pollution, surrounding trafic, …



Urban networking issues

Network architecture evolution to cope with density

- Heterogeneous and hybrid capillary networks
- User-centric approach but first vulnerability is the user

Dedicated sensor deployment is expensive (cost and time) —> crowdsourcing

- Distributes the share on users (cynical)
- Empowers citizens and keep scalable (optimistic)

« For citizens » => « with citizens »

- Need for approval of a community

Several level of informations at once

- Dense low cost vs sparse high precision
- Mobility is information

Privacy and security issues are huge !

- Smart devices = first entry point to your private sphere
- Freedom is at play - Democracy needs equality

Local and national initiatives

TUBA

- Foster collaboration between corporate and public actors with urban data
- Large corporates and academics back innovative SME
- Involve citizens in testing new services - showroom - competitions

Inria Project Lab « City Lab »

- Vertical approach
- Foster collaborative research within Inria

EquipEx Sense City

- Connected « mini-city »
- From nano-sensor development to urban scale systems
- IFFSTAR Marne la Vallée

Teaching initiatives

- Several « smart cities » master
- Technology - urbanism - design - political science - …

Thanks

team.inria.fr/urbanet/

www.citi-lab.fr/team/urbanet/