5G e a Internet do Futuro

9º Congresso Comité Português da URSI, 04 Dezembro 2015

Connected Vehicles to Smart Cities

Susana Sargento, susana@ua.pt
University of Aveiro, Instituto de Telecomunicações – Aveiro

INSTITUIÇÕES ASSOCIADAS:

instituto de telecomunicações

creating and sharing knowledge for telecommunications

Vehicular Networks: What?

Equip every vehicle with a radio communication system for vehicle-to-vehicle and vehicle-to-roadside communication

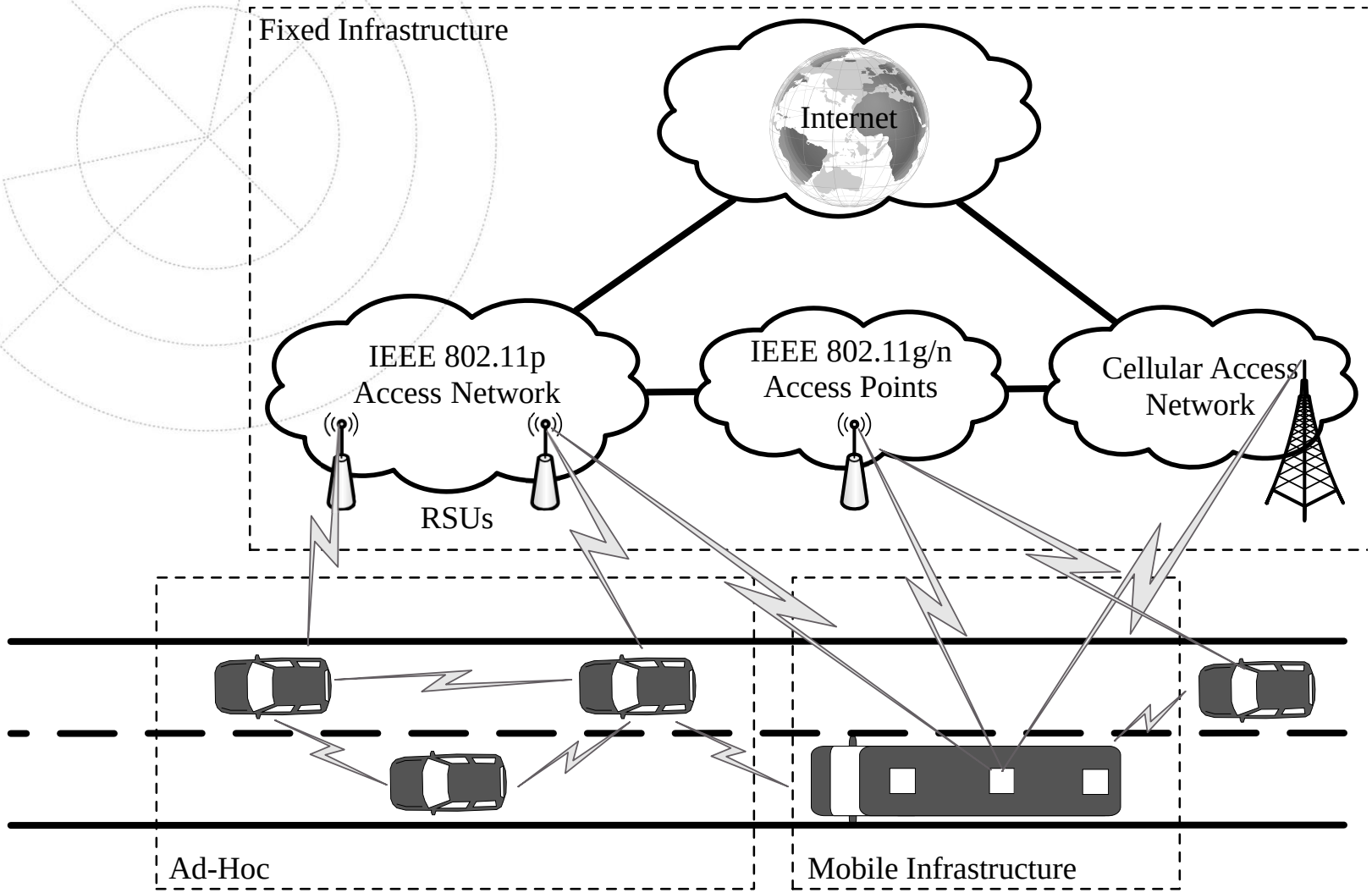
How?

Turn cars, buses, boats and trucks into mobile WiFi hotspots.

Vehicles are the network elements and build the moving network

Manage real-time and delay-tolerant data in a smart way

Vehicular Networks: How?

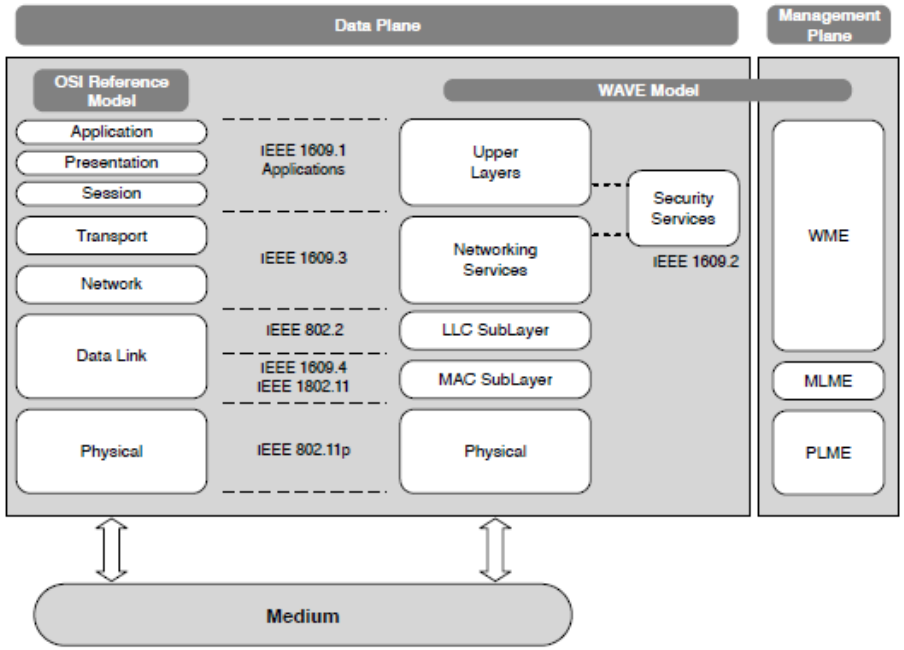


Build the Network

- Technology
- Connection to the Infrastructure
- Connection Management
- Mobility
- Routing
- Delay-Tolerant Communications
- Security
- Cloud Information System

Comm. Technology: DSRC - IEEE 802.11p and WAVE

- Improves transmission range
- Reduces the amount of necessary overhead when joining a BSS in 802.11
- IEEE 802.11p/1609.4 specify MAC sub-layer functionalities
  - Channel routing, coordination of access to the channels, channel switching, time synchronization

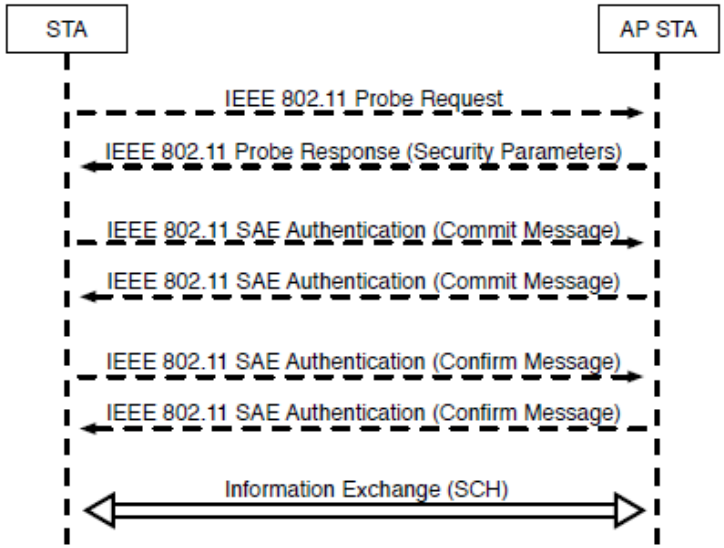


Channel	172	174	176	178	180	182	184
	SCH	SCH	SCH	CCH	SCH	SCH	SCH
Frequency (Ghz)	5.86	5.87	5.88	5.89	5.9	5.91	5.92

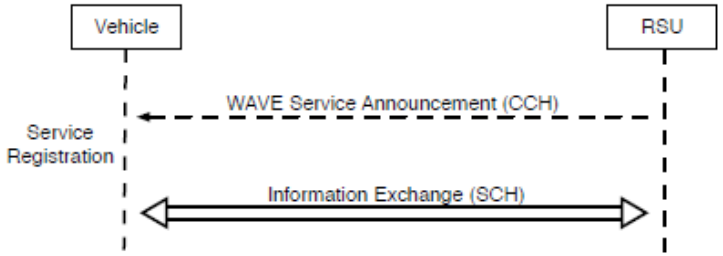
Comm. Technology: MAC Layer, Joining

- Network is formed by sending a beacon message that contains information about the network services and the required information to join the network

2-3 sec in Wi-Fi; 10-20 msec in WAVE



(a) Traditional Wi-Fi



(b) IEEE 802.11p

Communication Technology: Bandwidth

Available bandwidth and maximum range

	Continuous	Alternating
3M	2.65	1
6M	4.96	1.94
9M	7	2.72
12M	8.79	3.59
18M	11.4	4.71
24M	14.2	5.81
27M	15.1	6.1

Bandwidth measurements (Mbps)

Modulation [rate (Mbps)]	Max. (m)
½ BPSK [3M]	1140.02
¾ BPSK [4.5M]	1062.84
½ QPSK [6M]	628.28
¾ QPSK [9M]	533.55
½ 16-QAM [12M]	507.15
¾ 16-QAM [18M]	483.12
½ 64-QAM [24M]	412.69
¾ 64-QAM [27M]	386.67

Maximum range (m)

Hardware and Network Mechanisms

Innovative use of the 5.9 GHz band reserved for vehicles (well beyond safety applications)

- GPS + 802.11p + WiFi + GPRS + 3G/4G
- Smart connection manager for heterogeneous networks
- Seamless handovers
- Multi-hop vehicular mesh networking
- M2M Delay tolerant data management
- Security mechanisms for connected vehicles.

What we achieved: city network!

A network of connected vehicles:

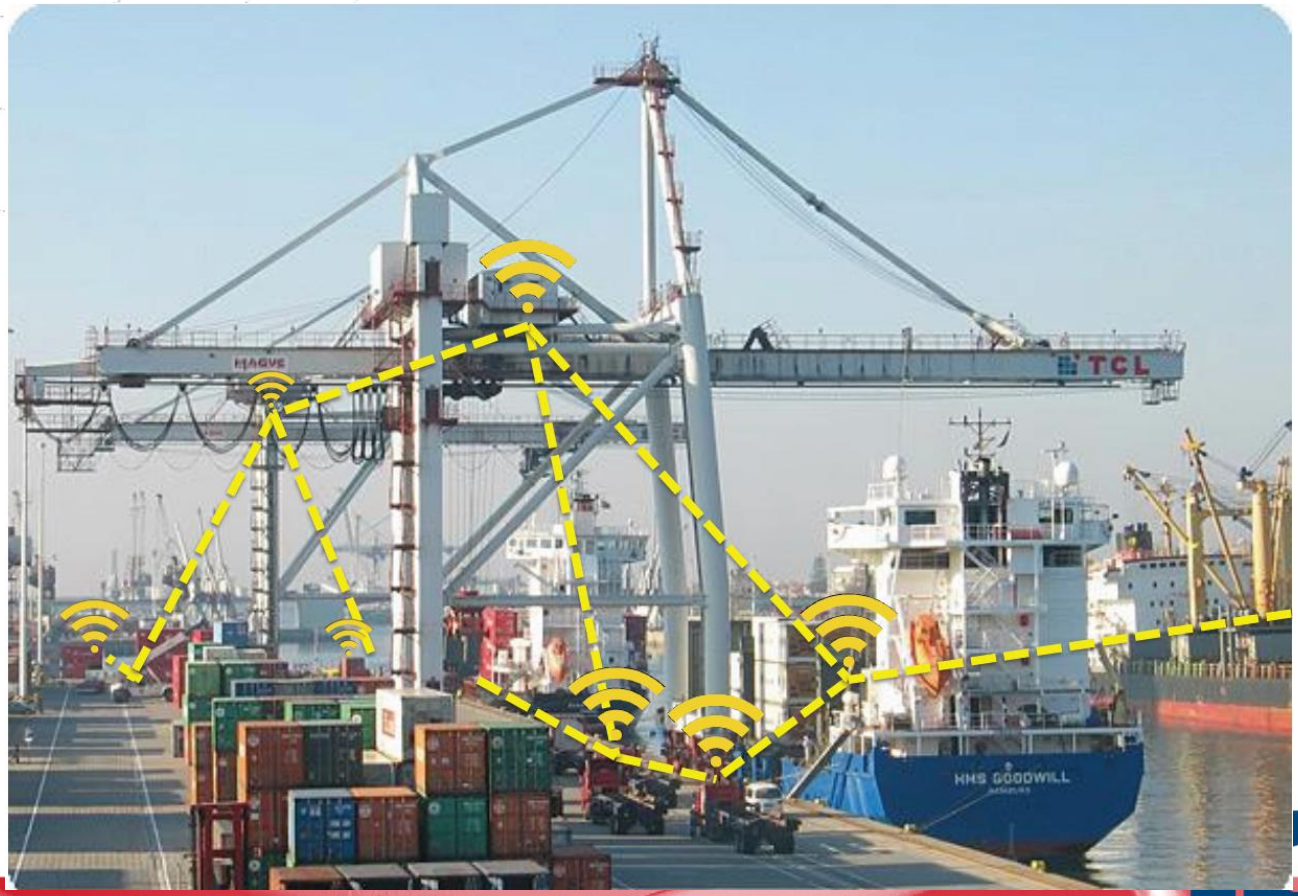
- Secure, reliable and **low-cost** way to **expand wireless coverage** for everyone: Internet access in the STCP buses
- Enable the **Internet of Things** and **improve urban life**: transmission of information from sensors in the street, garbage containers, cameras

A day in a vehicular network
http://youtu.be/0YwDMe8Kbgw

What we achieved: harbor network!

A network of connected trucks, cars, tow boats and vessels:

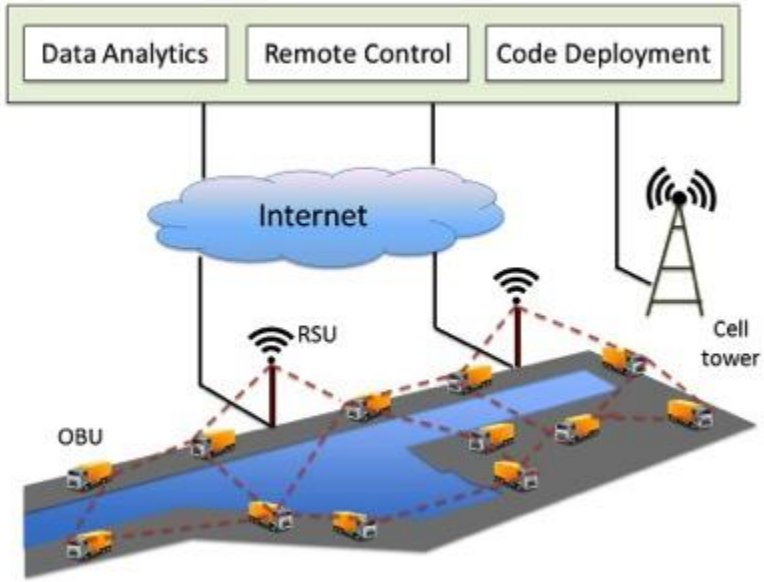
- Secure, reliable and **low-cost** way to integrate information from containers, trucks, ships, drivers, etc. and improve harbor logistics

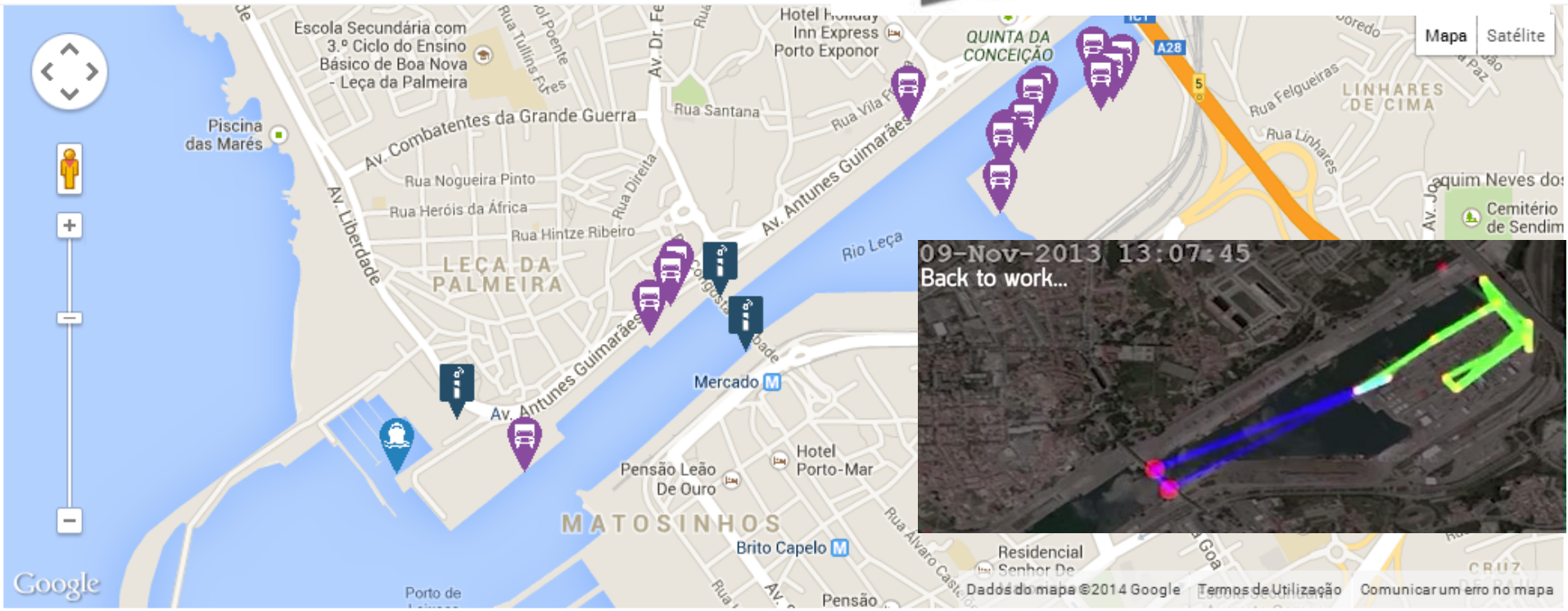


Harbor Pilot: the network

25 trucks, Tow boats, Patrol vessels
Road side units
Plug and play units for vehicles

Latency in the order 10 msec
Wireless coverage larger than 600m





Total vehicles displayed (online in the last 2 minutes): 18

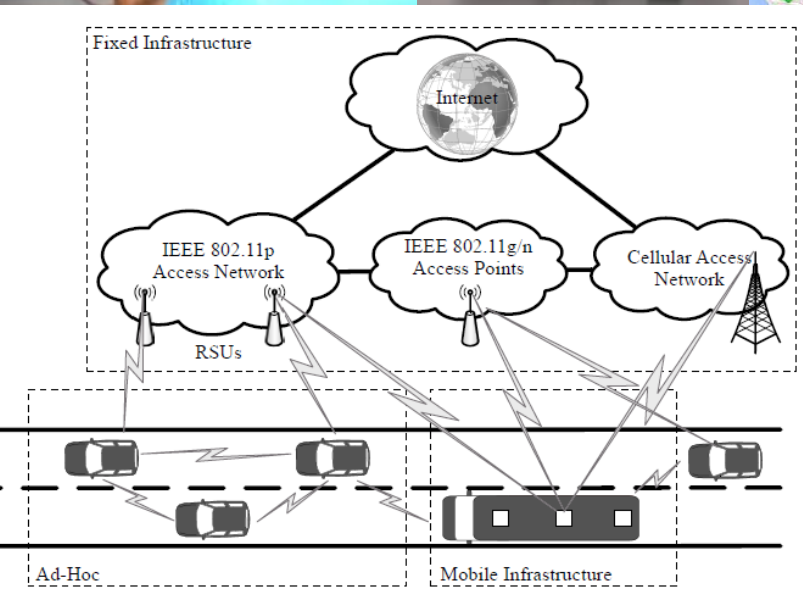
Largest Vehicular Network Worldwide!

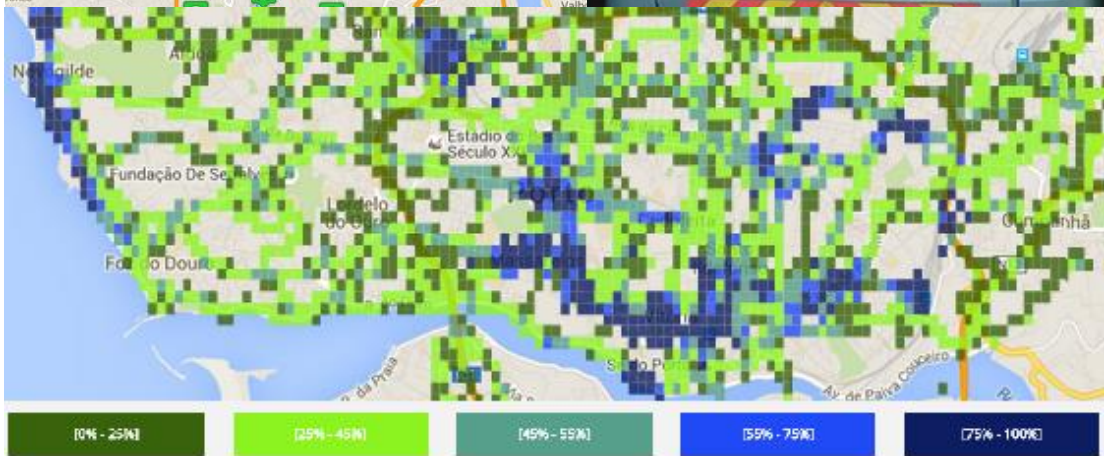
CityNet

WiFi Internet access in urban transport

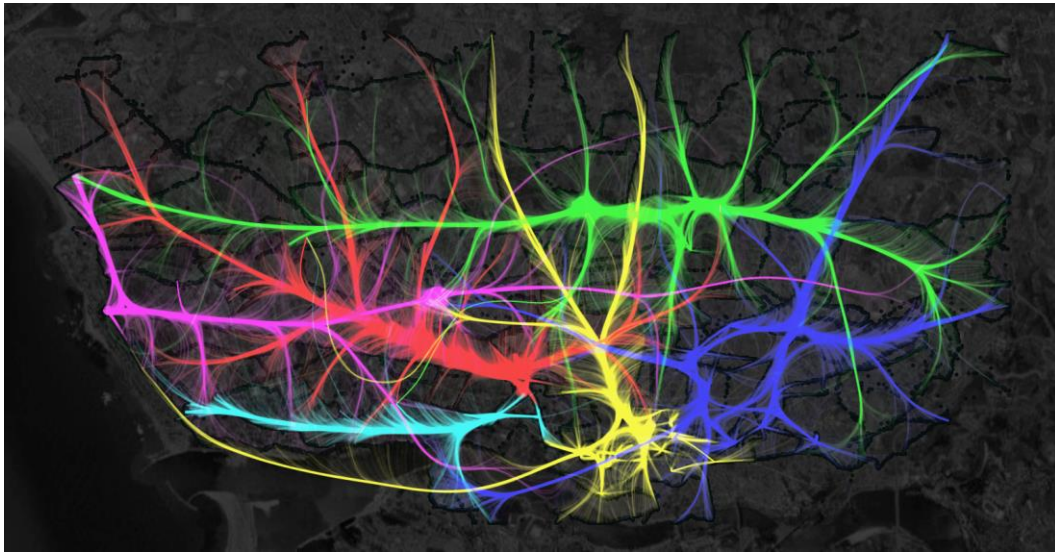
Acquire real-time data from WiFi sensors (e.g. traffic, pollution, waste collection, etc.)

600+ vehicles





City Pilot: results (1 year)

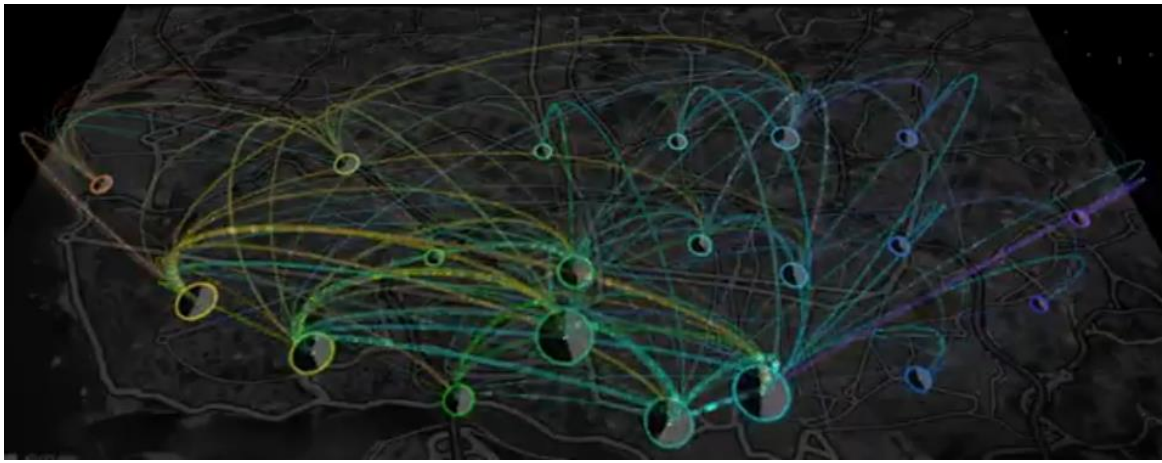


608 vehicles

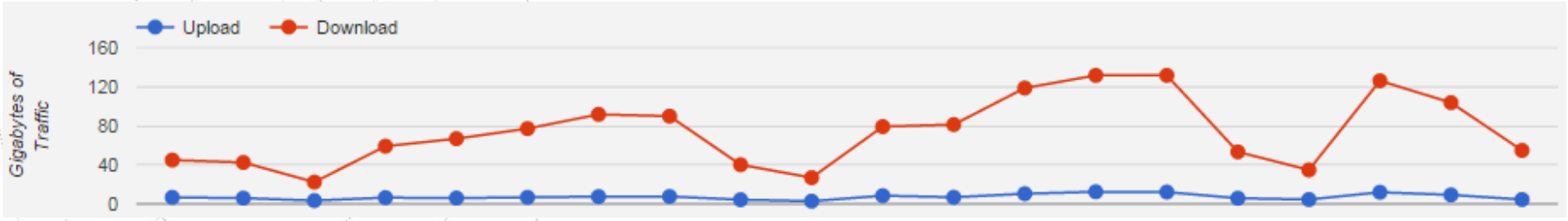
57 road side access points

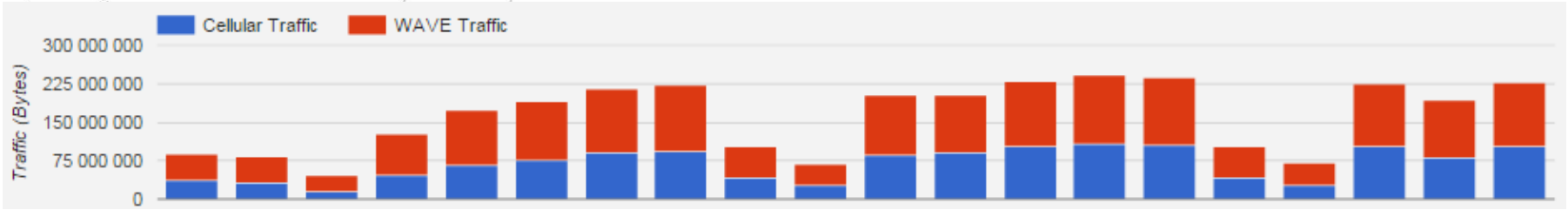
26.7 TB of Internet Traffic
2.35 million Internet Sessions
261 108 unique users

451,000 hours of Internet traffic (equivalent to 51 YEARS)



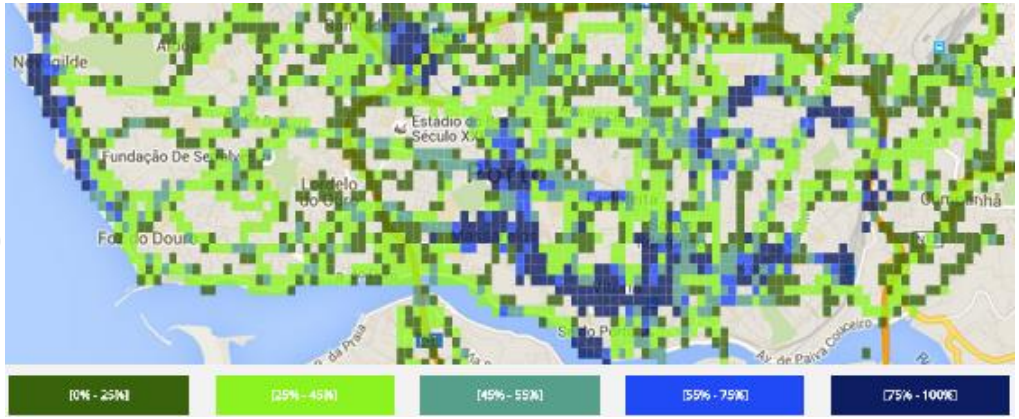
City Pilot: Internet and network results

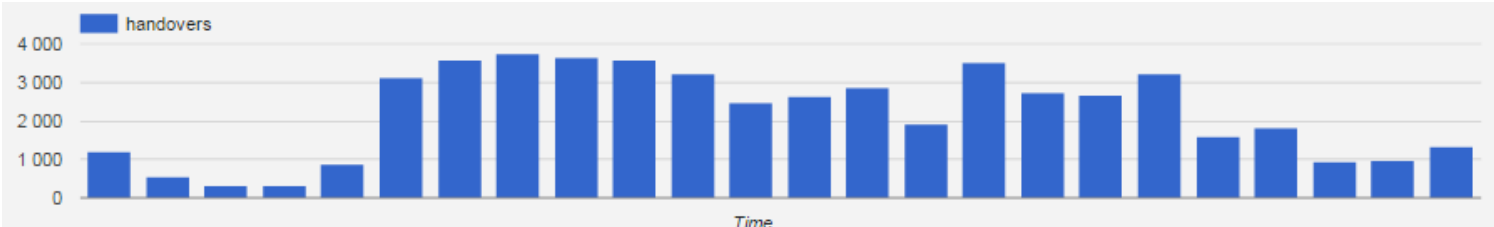




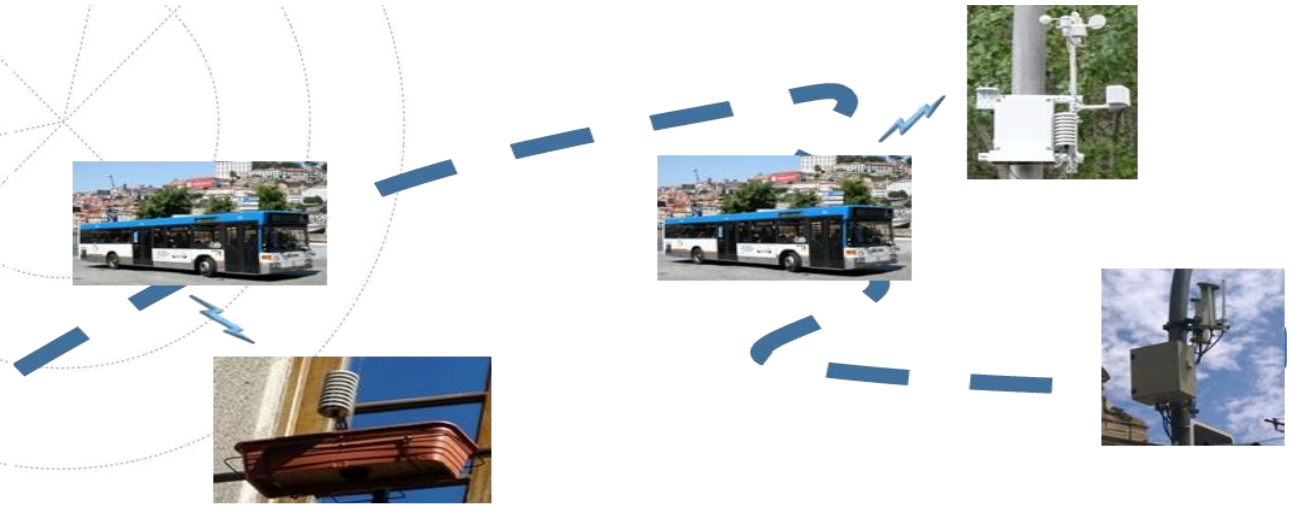
38.71% average offload

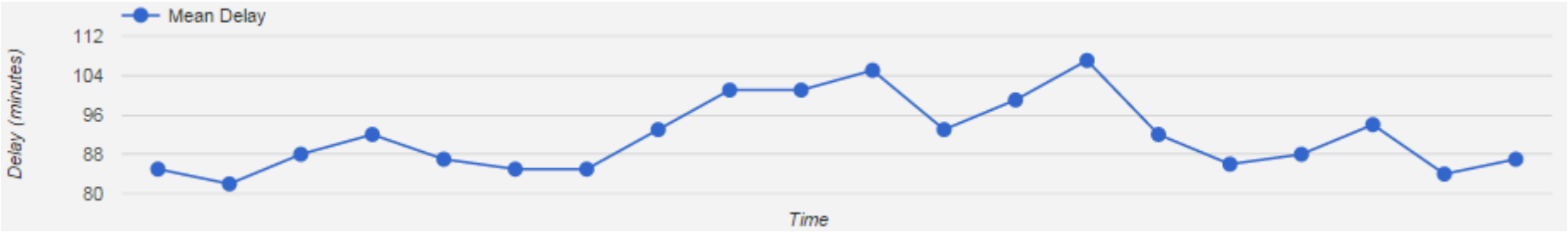
City center with more than 70% traffic offload





City Pilot: IoT network results





City Applications: CMU-PT S²MovingCity Project

City Pilots

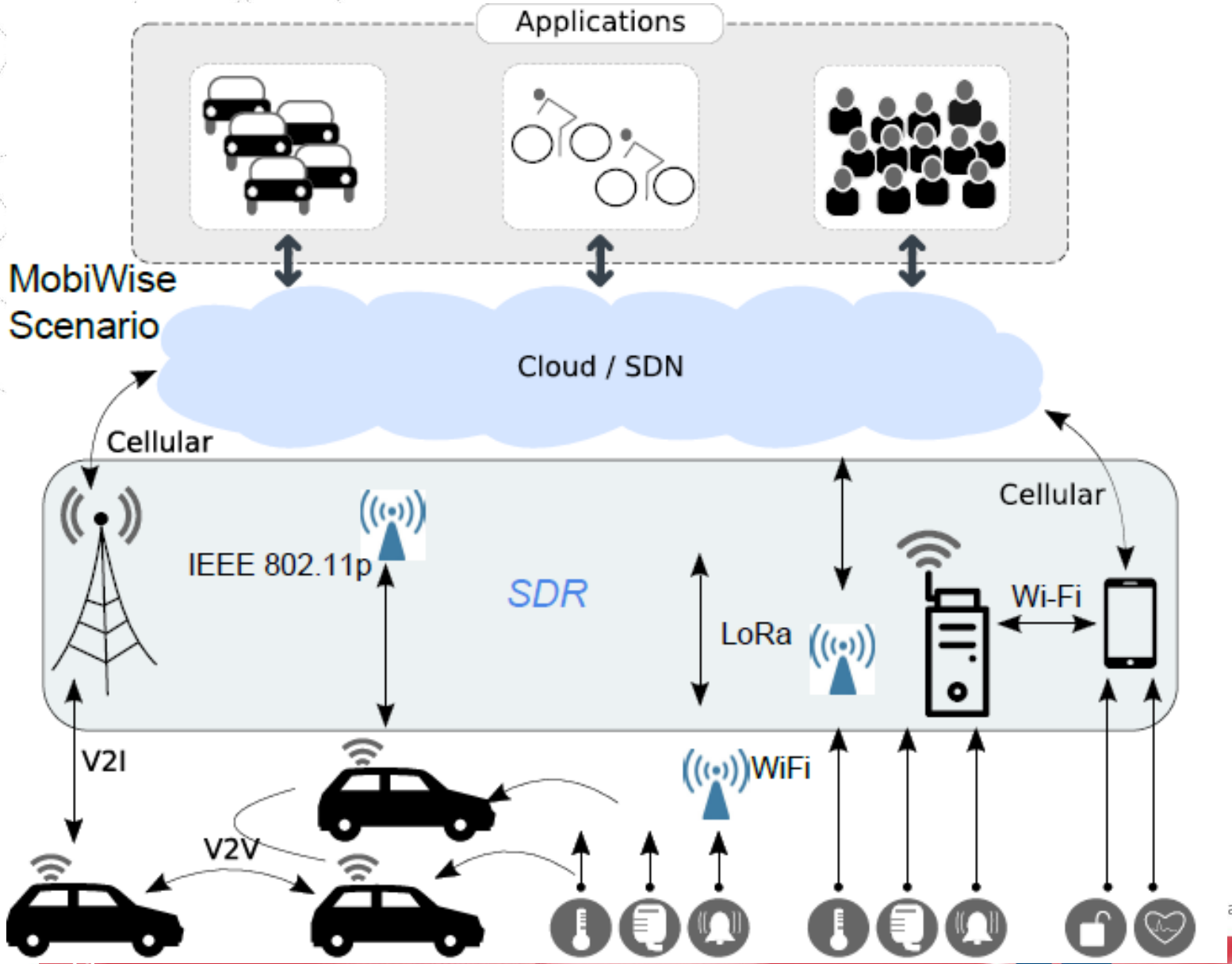
Effective mobility:
City interventions in public spaces:
Impact of big events in public spaces:

city flows and impact in the environment
measuring city comfort (persons, commerce, city)
cost effective scalable option to cellular technologies

OBJECTIVES
Better infrastructure (T1)
Better sensing (T2)
Better understanding (T3)
Better services (T4)
Better City (Comfort) (T5)

Disaster management and relief

5G Architecture



What's Next?

Thanks!

susana@ua.pt

http://nap.av.it.pt

http://www.av.it.pt/ssargento

Credits to: Carlos Ameixieira, Filipe Neves, André Cardote, Rui Meireles, Luís Coelho, João Afonso, Bruno Areias, Eduardo Mota, Rui Costa, Ricardo Matos João Barros, Diogo Lopes, Diogo Carreira, Maria João Souto, Raquel Rodrigues, Paulo Calçada, Tânia Calçada, Daniel Moura, Ana Aguiar, JM Fernandes, André Zúquete, Leandro Ricardo, Rui Pedro, Nelson Capela, André Martins, Marco Oliveira, Bojan Magusic, Gonçalo Gomes, Gonçalo Pessoa, Jorge Pereira, Junior Luis, Diogo Magalhães, Pedro Santos …