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Positioning, tracking and smart mobility

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Applications for positioning and tracking

- E-commerce (optimize shipping and withdrawals)
- Logistics (optimizing routes, fleet management, goods,)
- Driving and navigation (especially for visually impaired individuals)
- GPS-free localization techniques for accurate road safety applications
- Electric mobility (optimizing EV charges, battery lifetime, savings)
- Smart mobility (improve performance for car sharing and pooling, transportation with dynamic paths)
- Targeted advertising (geo-aware advertisements,)
- E-health and monitoring
- Augmented indoor reality
- Locality based social networks and gaming

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Technologies

- Indoor
  - Wi-Fi
  - iBeacon
  - NFC
  - RFID
  - Bluetooth low energy
  - Ultra wide band
  - Computer vision
  - Laser-based

- Outdoor
  - GPS (US)
  - GLONASS (RU)
  - Compass (CN)
  - Galileo (EU)

•GPS signals cannot always meet the requirements of crucial position-based applications in dense urban environment.

5G wireless technologies, togheter with **Software Defined Radios** and **Software Defined Networks** enable new indoor and outdoor scenarios. 5G-based positioning and tracking fosters Smart Mobility and Intelligent Transport Systems

Significant heterogeneity in:

- Devices
- Topologies
- Crowding factors (over spaces and channels)
- Propagation conditions
- Operational contexts
- Algorithms
- Performance Requirements
- Applications

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Algorithms and methods

Methodologies

- Proximity
  - the device falls within the coverage of low-range radio beacons
- angle-based 1
  - Triangulation
  - Pattern matching
- range based
  - trilateration
  - multi-lateration
- fingerprinting and scene recognition
  - Offline phase for mapping observations
  - Online phase for estimating position using pattern matching.
- history-based solutions
  - Use past positions, the mobility model and topological constraints
  - HMM, particle filter, Kalman filter, …

Requirements

- Good accuracy and precision depending on the LBS
- Low CAPEX and OPEX costs
- Availability with/without fine-grained synchronization
- Immunity to noisy and lossy channels affected by multipath, fading, shadowing
- Position + heading

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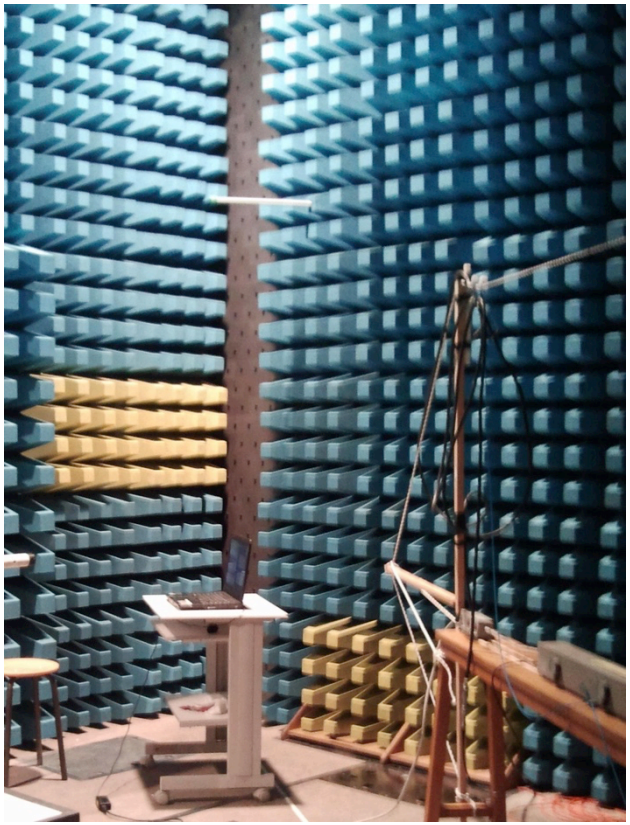
Propagation, channel and observations

- attenuation
- multipath
- shadowing
- interference
- Doppler
- Signal strength
- LoS
- NLoS
- latency
- delay
- power



- RSSI
- ToA
- AoA
- DToA
- fingerprinting
- range
- anchor id

Logistics

Objectives

- Make the logistics chain safer, cheaper, and more efficient.

- Actors
  - public institutions, regulators, freight forwarders, stevedores, haulers;

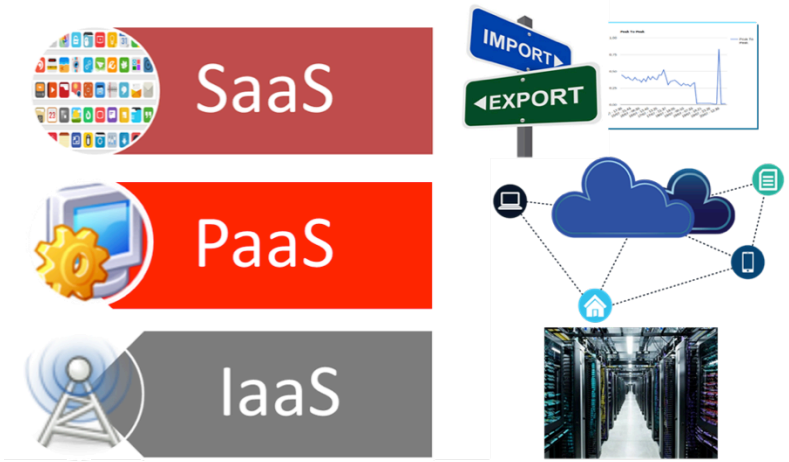
- Infrastructures:
  - terminals, highways, railways, motorways of the sea;

- Requirements
  - shift from "Transport Industries" to "Integrated Transport”

- Applications

Shipment consolidation and optimization pick-up points, navigation, access and authorization, testbed in big harbors

Logistics Node ICT architecture



SaaS:

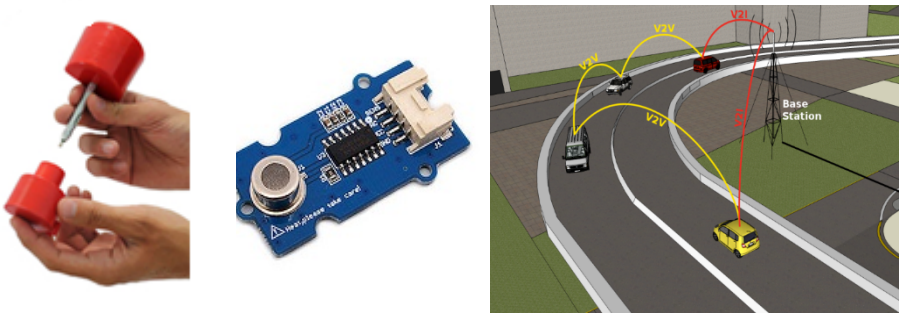
- Monitoring of sensing, operations, and events:
  - in real-time, allowing for On-Line Analytical Processing allowing for off-line studies and knowledge extraction.
- Providing the users with:
  - tracking services of heavy vehicles;
  - risk assessment per zone, per worker, per process.

PaaS:

- Custodial, aggregation, indexing of information coming from the field and from interoperable third parties:
  - considering all these functions as components of a standard solution (e.g. OneM2M coordinated by ETSI) [1, 2]

IaaS:

- Smart tags (RFID), vehicular networks (VANET), distributed sensors (IoT devices):



V2I communications and AOA estimation [3]

EU Project carriers

Ended (Nov. 2016)

ETSI C-ITS Plugtests™

Testing event for co-operative transport systems focusing on vehicle-to-vehicle and vehicle-to-infrastructure communications (hosted by CNIT) [3, 4].

Ongoing H2020

WiSHFUL

Wireless Software and Hardware platforms for Flexible and Unified radio and network controL

WiSHFUL open calls

Funded (H2020)

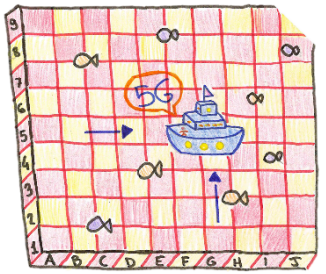
AUTOPILOT

4G+ network on the highway and landside.

IoT-01-2016: Large Scale Pilots

SLICES

Submitted (H2020)



5G (W/ satellite) network prototype to connect landside and waterfront.

ICT-08-2017: 5G PPP Convergent Technologies

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Car sharing with EVs

The car by reading the CAN-bus (Controller Area Network)

Car battery status (EV SoC State of Charge)

Position and tracking of vehicles

- GPS when available,
- dead reckoning,
- inertial or radio-based
- Exploiting vehicle-to-infrastructure and vehicle-to-vehicle communication

- Status and location of EV charging stations
- Selection of the optimal charging station

Demetra project

PON project

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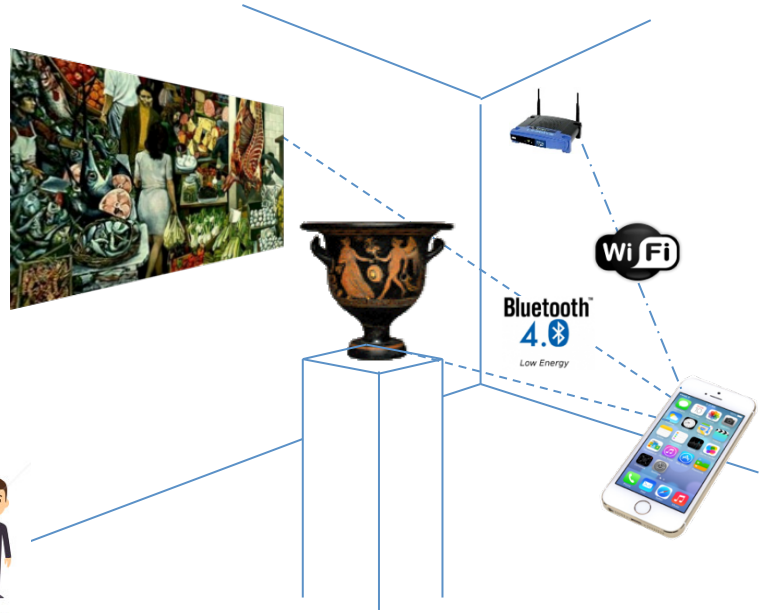
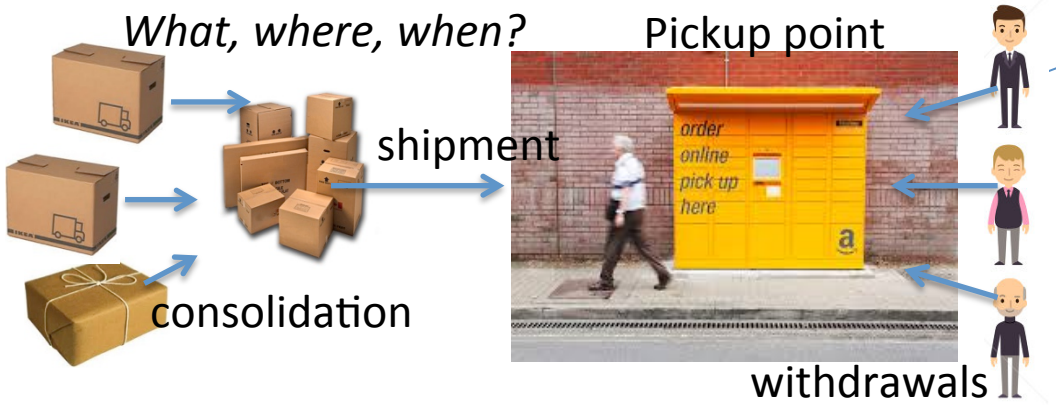
Touristic and e-commerce applications

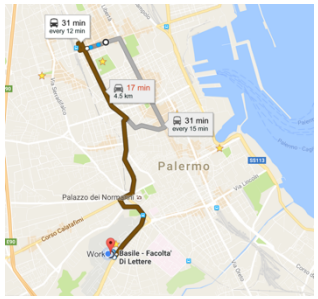
- Analysis of periodical paths
- Autonomous navigation for visually impaired
- Spatial and temporal analysis of activities, tracking position and heading
- Route optimization
- User profiling (buyers, tourists, …)





Regional NEPTIS project for augmented experience of the Cultural Heritage – integration of indoor and outdoor technologies

SUMO – Simulation of Urban MObility



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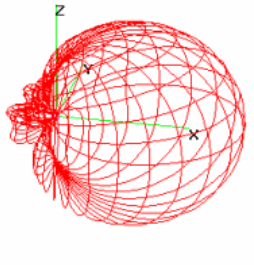
Key Enabling Technnologies: radio

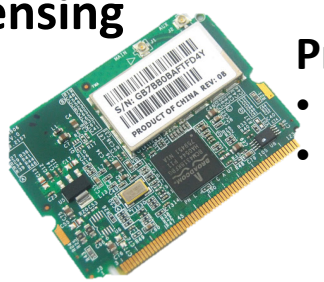
Advanced, holistic and distributed sensing

- Accelerometer
- Magnetometer
- Giroscope
- Barometer
- proximity
- Light
- (Front, rear, multiple) camera(s)
- GPS
- NFC
- Wi-Fi
- Bluetooth
- GSM/CDMA/4G

5G wireless technologies



- high performance (low latency and high bit rates)
- Use of smart antennas and MIMO

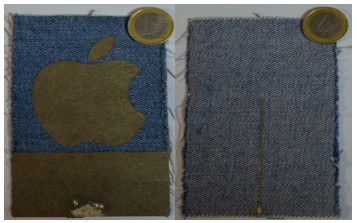


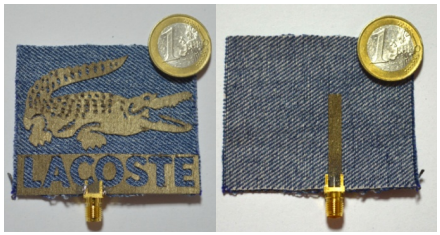
Programmable wireless platforms

- WMP Wireless MAC processor [6]
- Dedicated MAC protocols [7]
  - Accurate ToF, advanced FP, …

Portable / wearable devices

- Wearable and embeddable antennas/ rectennas/sensors
- Wearable rectennas (rectifying antennas), combined with wireless power transmission, can play a major role so to turn sensors into energy autonomous systems
- Wearable antennas as effective devices for localization and tracking

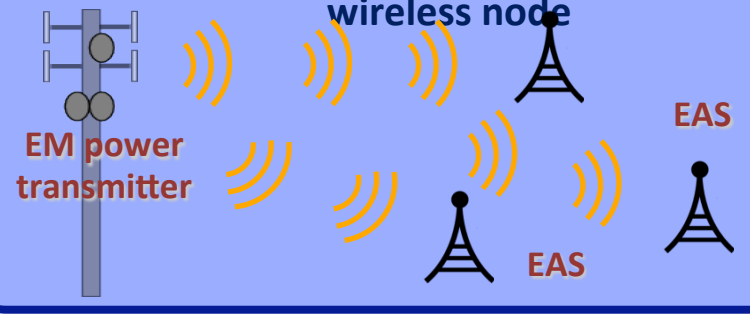




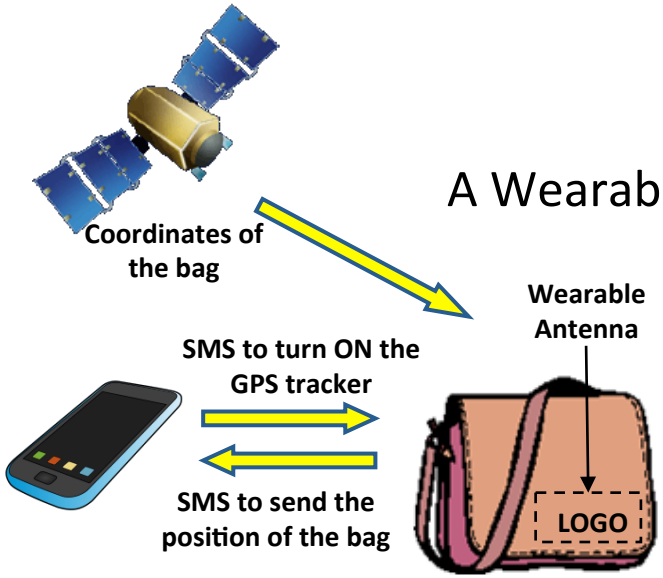
Key enabling technologies: wearable

Wearable antennas

WPT (Wireless Power Transmission)
***ad hoc generated EM radiation is* used to power a wireless node**

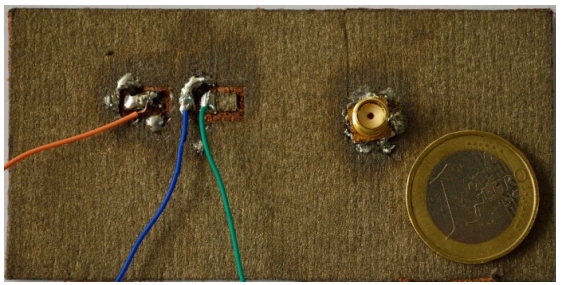


Wearable rectennas for energy autonomous wearable sensors



A Wearable Logo Antenna for GPS-GSM Based Tracking Systems

Front view


Back view

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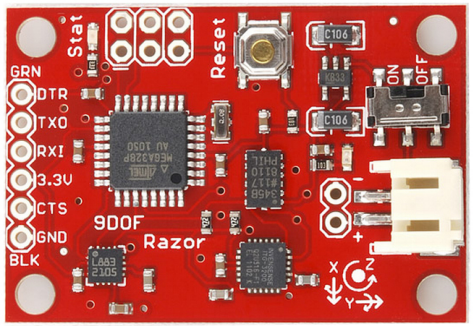
KET: cost inertial measurement unit (IMU)

Inertial navigation system based on a low cost inertial measurement unit (IMU)

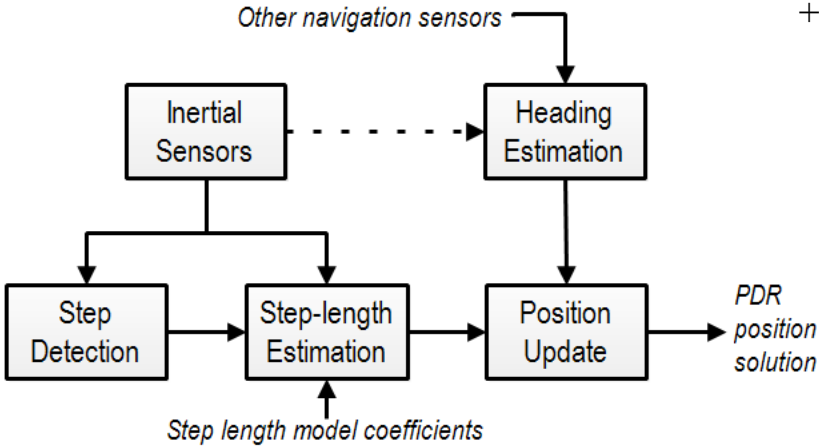
- The designed system achieves a **good accuracy** in tracking a mobile agent
- It does not employ **magnetometers**.

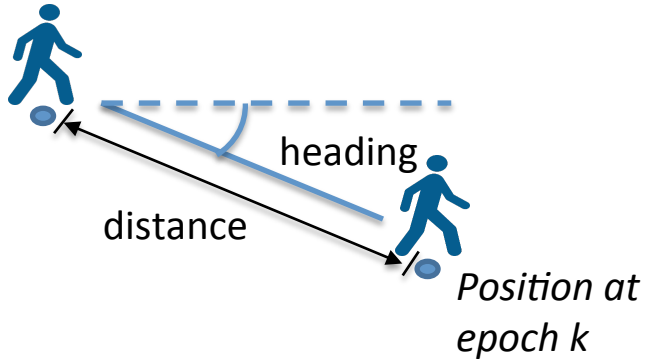
A video is available [8]



IMU board
(ITG3200, ADXL345 sensors
+ ATmega328)

IMU
foot-mounted





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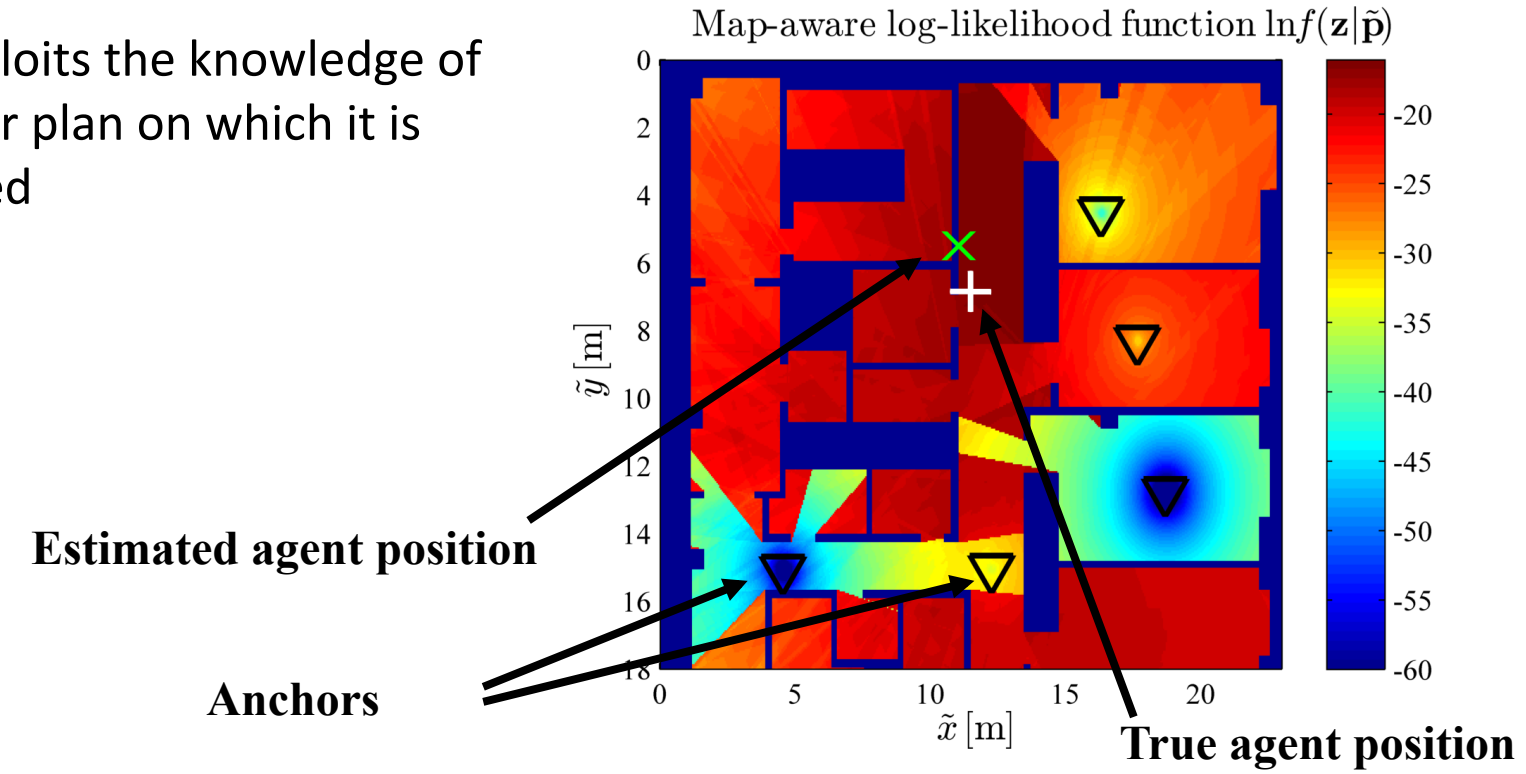
Map-aided 169 MHz indoor localization

- Localization system achieving **good accuracy (1-3 m)** in indoor enviroments.

- Based on low cost commercial transceivers (anchors) operating at 169 MHz.

- It exploits the knowledge of the floor plan on which it is deployed



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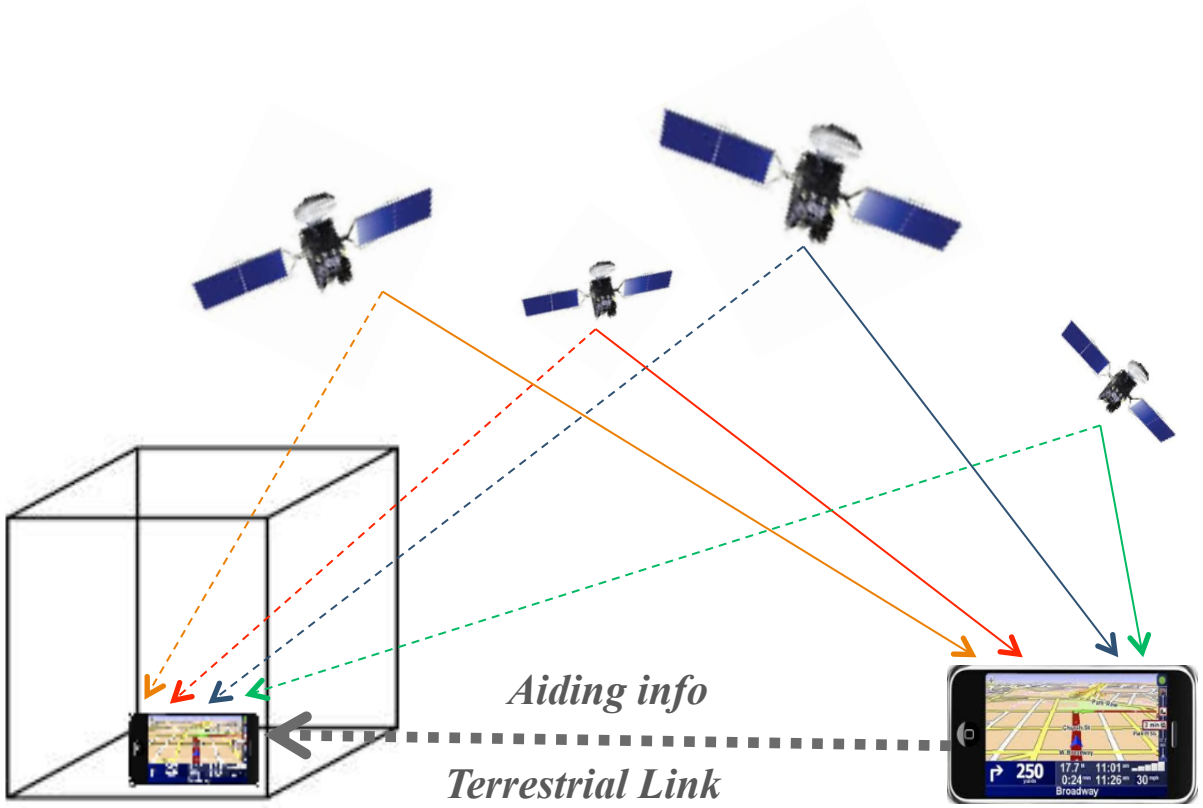
P2P Cooperative Positioning
Multi-constellation

- **GPS**
- **GLONASS**
- **BEIDOU**
- **GALILEO**

Hybrid solution
Multi-technology
Multi-constellation
Multi-node



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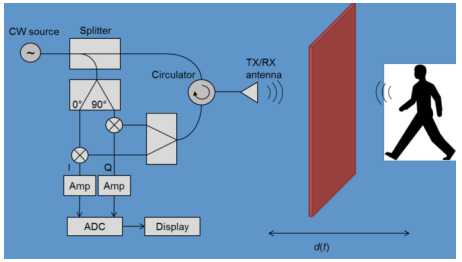
Radar-like and radar-based technologies

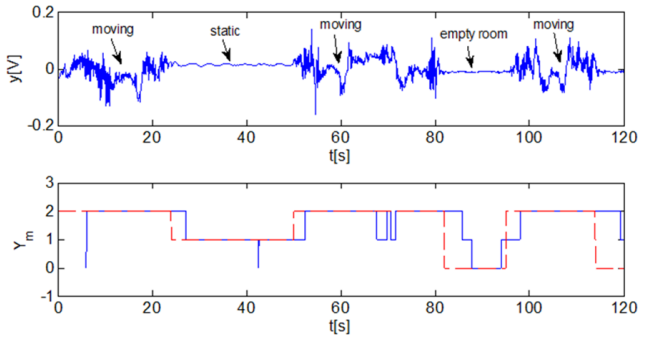
- **localization and tracking of non-cooperative people**

- hostile and not accessible environments
- Imaging of static scenarios in trough-wall configurations
- Detection and movement tracking of people in not accessible environments
- Classification of persons' activities beyond the obstacle
- Systems for localization and tracking based on opportunistic sources (Wi-Fi,..)
- Motion Detection based on Ubiquitous Wi-Fi Devices
- Earth monitoring, detection and tracking of clouds

Classification of human activities beyond obstacles

- short-range radar in CW modality at 2.45 GHz
- Real-time detection (no person, static person, moving person)





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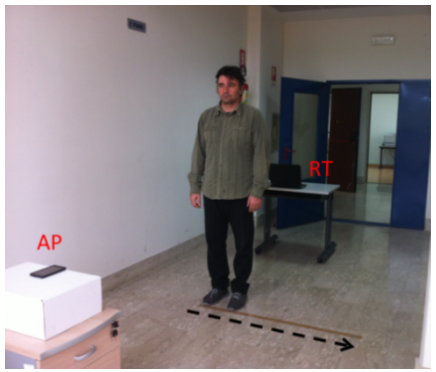
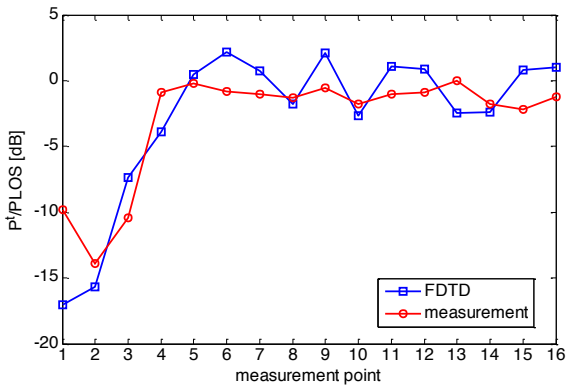
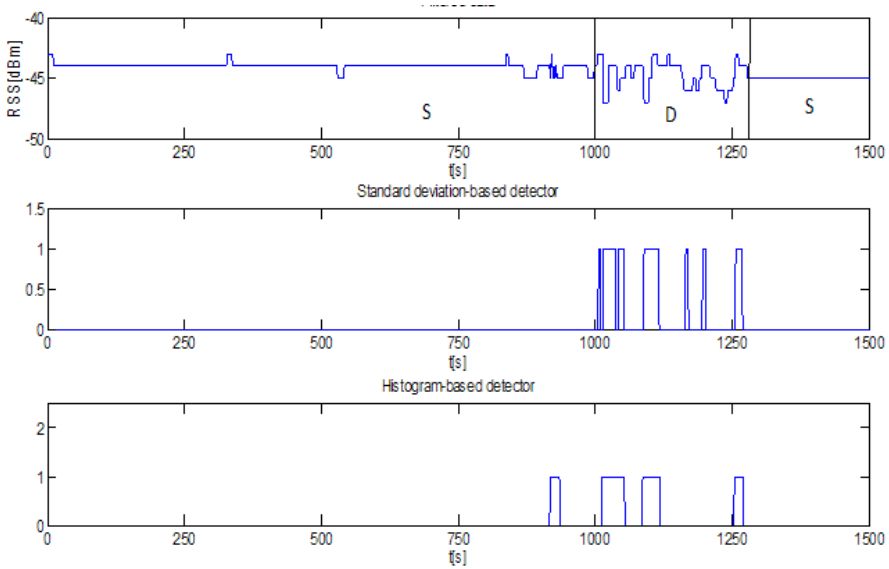
Motion Detection

- based on Ubiquitous Wi-Fi Devices
- Real-time detection of human movements in indoor scenarios based RSSI variations
- Exploitation of commercial devices, e.g. a smartphone as a Wi-Fi access point and a laptop with dedicated software as a receiver
- Simple and effective data processing algorithms (standard deviation, histogram analysis)





Experimental characterization of the system



RSSI data (top panel) and output of motion detection algorithms (middle and bottom panels)

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