IoT for Smart Cities
Part A: services

DIPARTIMENTO
DI INGEGNERIA
DELL'INFORMAZIONE

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Outline

- **Part A: introduction**
  - Who am I?
  - Smart City Services
  - Technical requirements
- **Part B: technologies**
  - Cellular
  - Short range
  - Long-range low power
- **Part C: pilots and trials**
  - Padova Smart City
  - Smart Santander

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Let's start with… my self-introduction!

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SIGNET people

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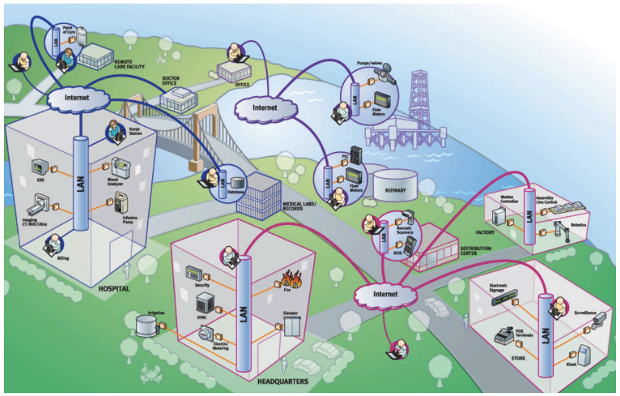
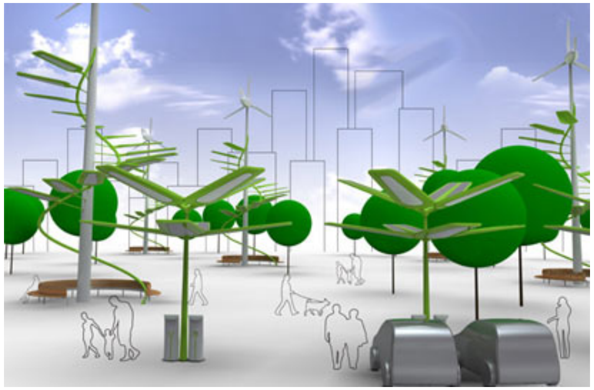
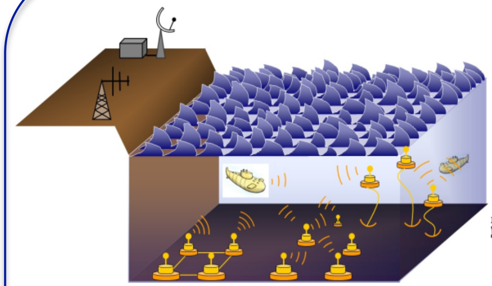
Main research areas...

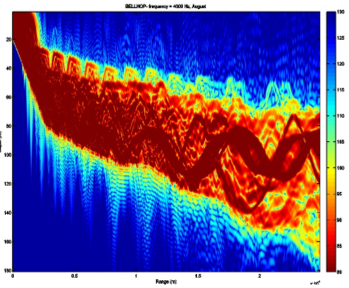


Next generation mobile & IoT

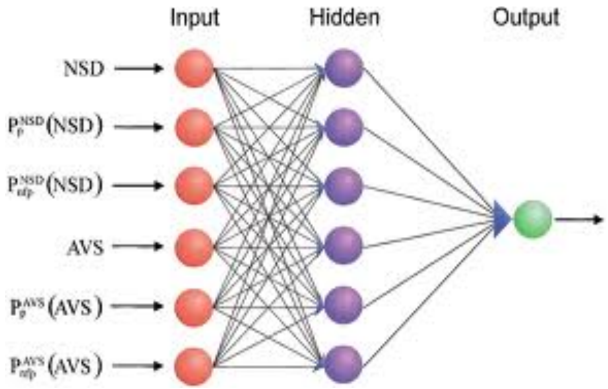


Energy harvesting



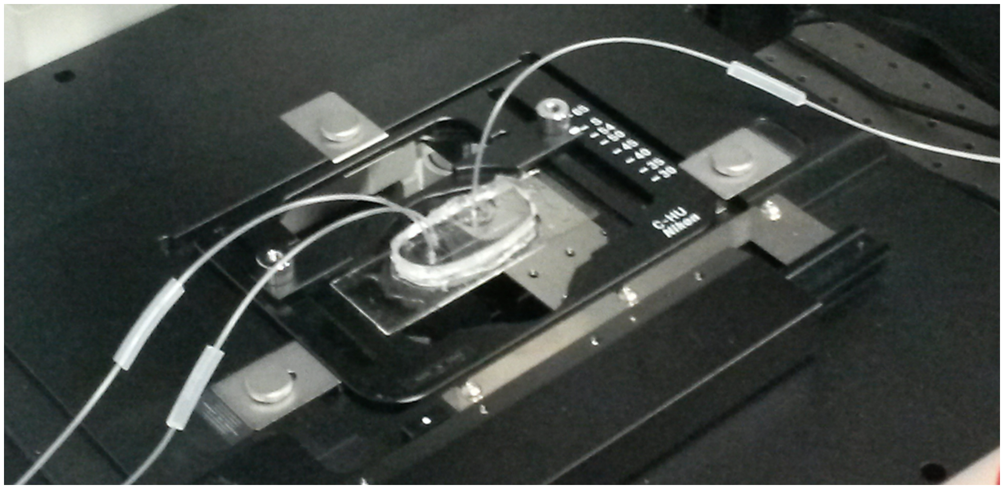


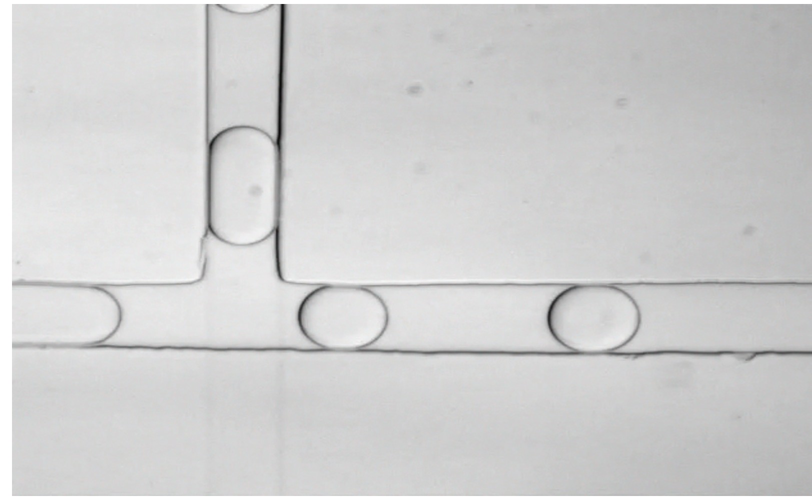
Underwater communications

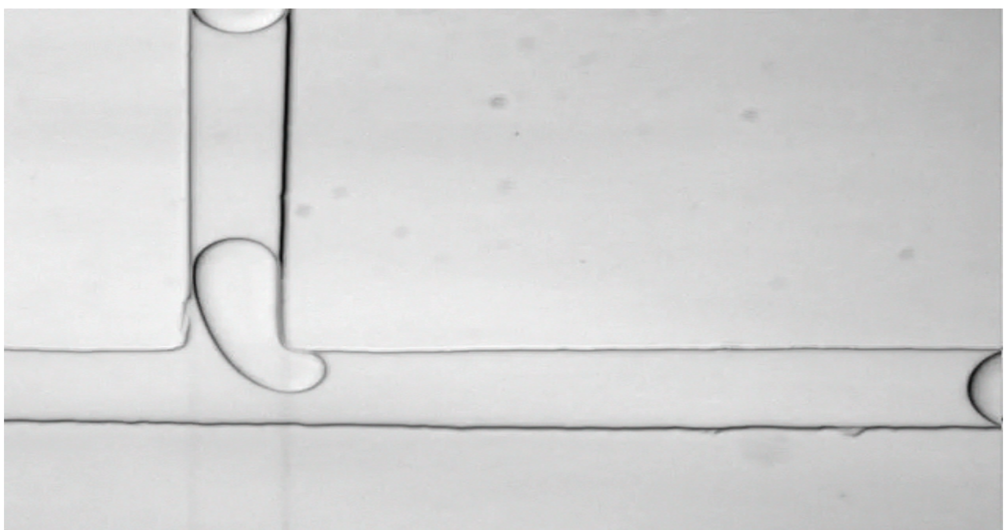


Cognitive Networks

Plus more exotic stuff...







Recent Research Projects

European

- 2010-2013: "IoTa" (sensor networks)
- 2010-2014: "SWAP" (sensor networks)
- 2010-2013: "Medieval" (cellular networks)
- 2010-2012: "SaPHYre" (cellular networks)
- 2010-2013: "CLAM" (underwater networks)
- 2010-2013: IIT – NAUTILUS (underwater networks)
- 2008-2010: "Aragorn" (cognitive networks)
- 2009-2010: "NEWCOM++" (ad hoc networks)
- 2007-2010: "SENSEI" (sensor networks)

Others

- 2010-2014: EDA – RACUN (underwater networks)
- 2010-2012: ONR (underwater channel modeling)
- 2010-2011: JHU/APL (underwater MAC protocols)
- 2010-2011: VideoTec (wireless sensor networks)
- 2011-2012: Patavina Technologies (wireless sensor networks)
- 2009-2011: ARO@UCSD (cognitive networking)
- 2010-2013: NSF@UCSD (underwater localization and networking)

Collaborations

Industrial

- Qualcomm
- NTT DoCoMo
- Lucent Bell Labs
- ST Microelectronics
- NATO Undersea Research Centre
- IBM Zurich research Lab
- Ericsson Research
- Telecom Italia Labs
- Alcatel CIT
- European Space Agency

Academic

- Massachusetts Institute of Technology (MIT)
- Stanford University
- Univ. of South California (USC)
- University of Illinois – Urbana Champaign
- Univ. of California San Diego (UCSD)
- Univ. of California Los Angeles (UCLA)
- Inria – Sophia Antipolis (Francia)
- Pennsylvania State University
- New Jersey Institute of Technology
- Centre Tecnològic de Telecomunicacions de Catalunya (CTTC – Barcellona)
- German Airospace Center (DLR)
- Scripps Institution of Oceanography (at UCSD)
- Woods Hole Oceanographic Institution (Massachusetts)
- National University of Singapore

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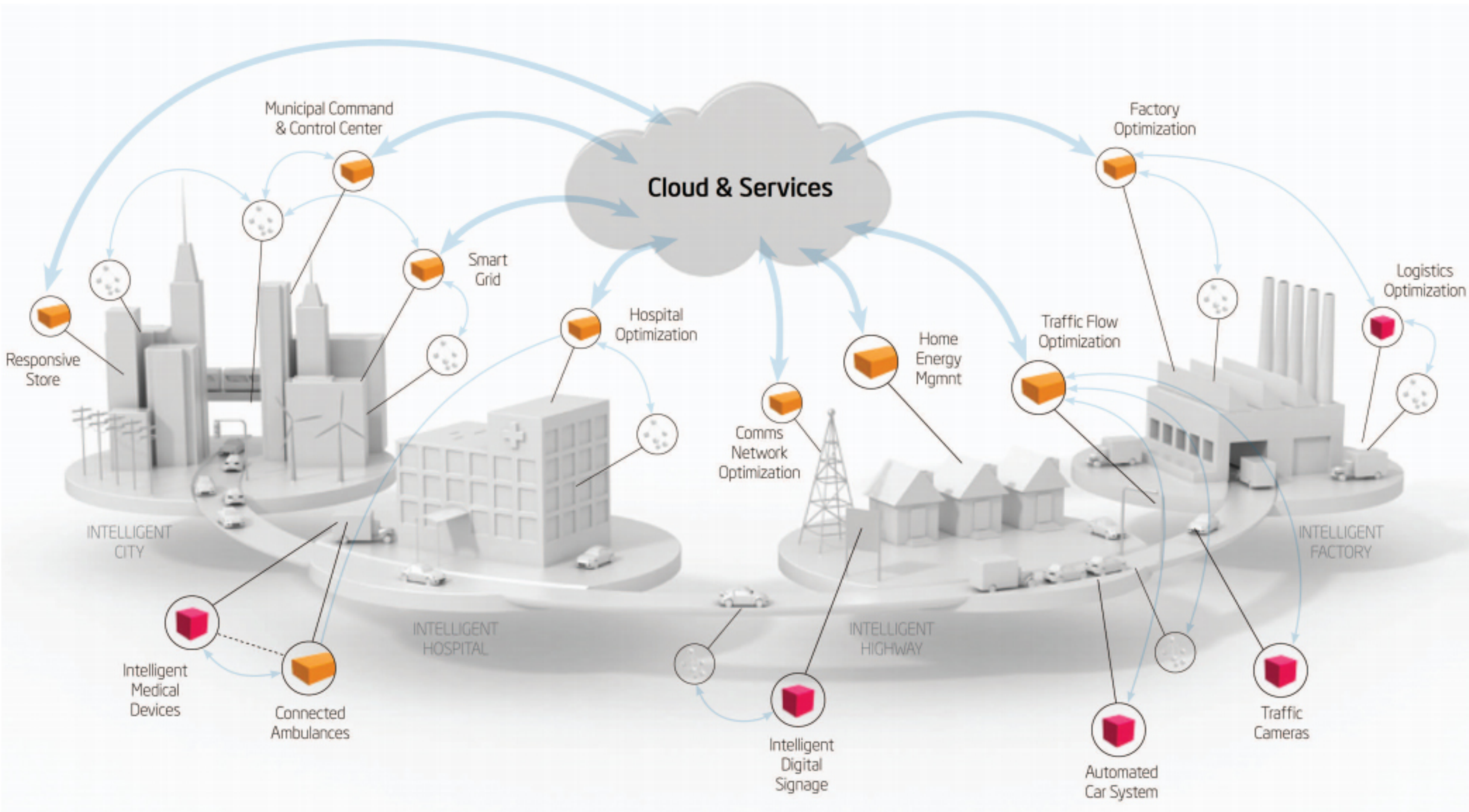
Internet of Things



The Internet (of Things)

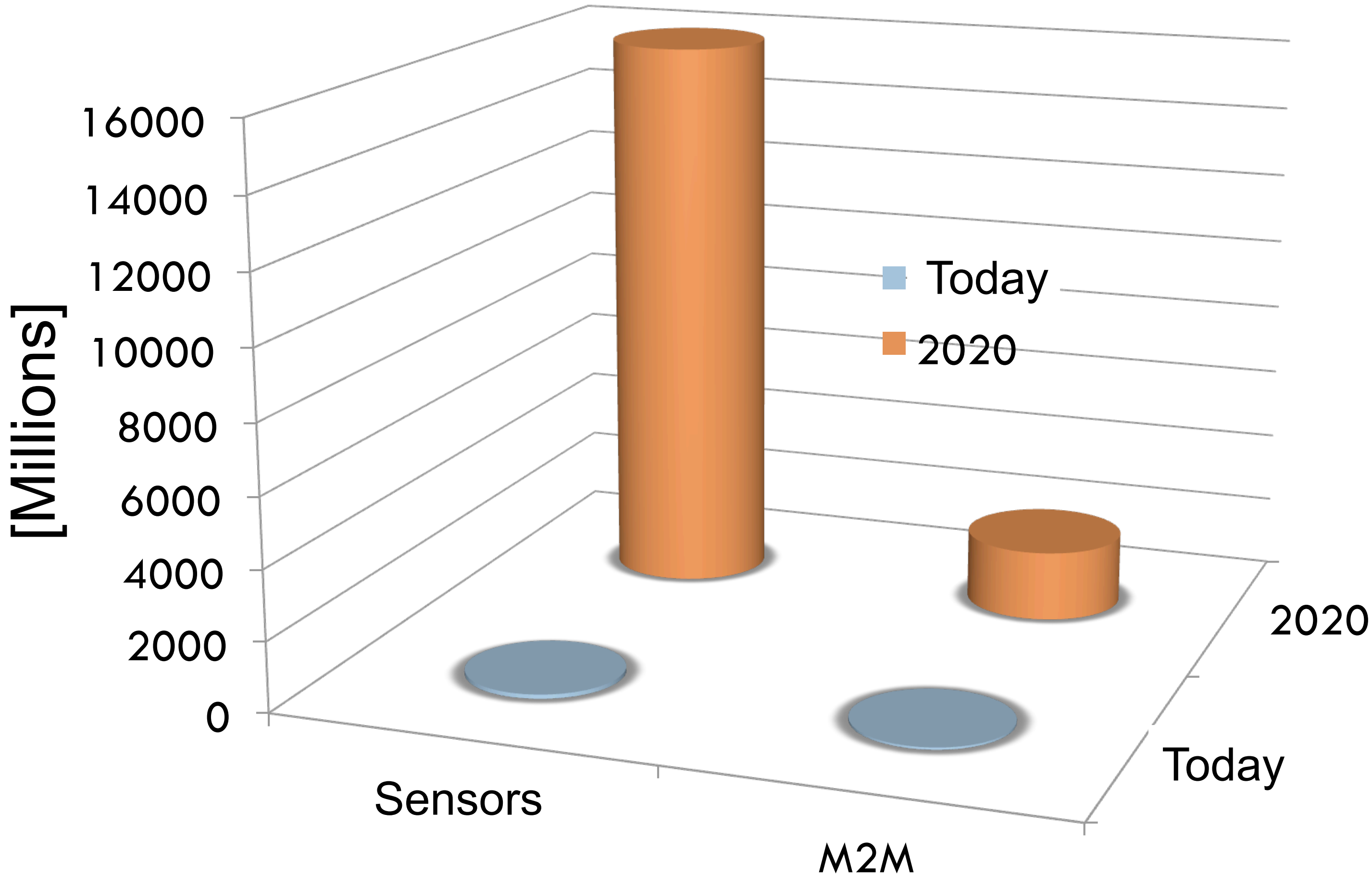
… is already made of things. (If that's not the case then we have a serious case of mass hysteria:-) For this reason, we prefer not to refer to a so-called "Internet of Things," nor to use the IoT acronym. Where it is necessary to distinguish our imperfect expectation of the future from the current Internet, we instead speak about the Internet with many more things but otherwise we just talk about the Internet."

Kutscher and Farrel, "Towards an Information-Centric Internet with more Things", Informational Internet-Draft draft-kutcscher-icn-wmt-00, February 2011.

Motivation

- **What**
  - Providing Internet connection to potentially ANYTHING
- **When**
  - ~1995 → WSN
  - ~2000 → IoT
  - ~2020 → hundred of BILLIONS of devices connected
- **Why**
  - A (still largely unforeseen) plethora of new services
    - Smart Cities, Smart Grids, Smart everything!
  - huge, Huge, HUGE market (again… potentially)

Number of interconnected objects



•Jim Morrish, Principal Analyst at Analysys Mason
http://www.analysysmason.com/About-Us/News/Press-releases/Internet-of-Things-will-grow-to-16-billion-connectable-consumer-devices-by-2020-says-Analysys-Mason/
Steve Hilton, Principal Analyst at Analysys Mason
http://www.analysysmason.com/Research/Content/Reports/RRE02_M2M_devices_forecast/

What's a machine

- Any device (or software) that can perform automated tasks, e.g., smartphones, refrigerator, sensors, etc.
- Devices that can
  - **take autonomous decisions** based on information received from other devices
  - in a mostly **unsupervised** manner
  - act much **smarter than traditional devices**

The Business Perspective

- **Cisco**
  - The estimated market of $**14.4 Trillion** up for grabs in the coming decade
- **Intel**
  - IoT brought about $**2 billion** of the company's $12.8 billion in revenue in 2013, which equated to 32% growth year over year
- **IBM**
  - Since 2003 IBM spent over $**50 billion** on acquisitions and R&D in preparation for a radical shift in IBM's business

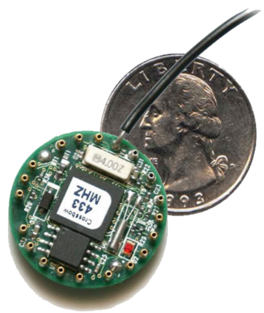

“A year from now basically every new phone that's sold will have [Near Field Communication]. It's a two-way, bio-directional RFID communication link that makes this device work as a tag or as a reader.Ó
Sony Ericsson's VP of systems architecture
Håkan Djuphammar,
Sony Ericsson

Enabling technologies: wireless

Wireless Short Range

- RFID

- Low power
  - (ZigBee, Bluetooth)



- High power
  - WiFi

Wireless Long Range

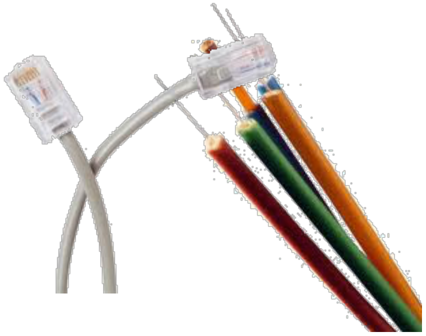
- Cellular
  - GSM
  - LTE
  - 5G

- Low power
  - LoRa
  - SigFox
  - …

Enabling technologies: wired

- Powerline Communication

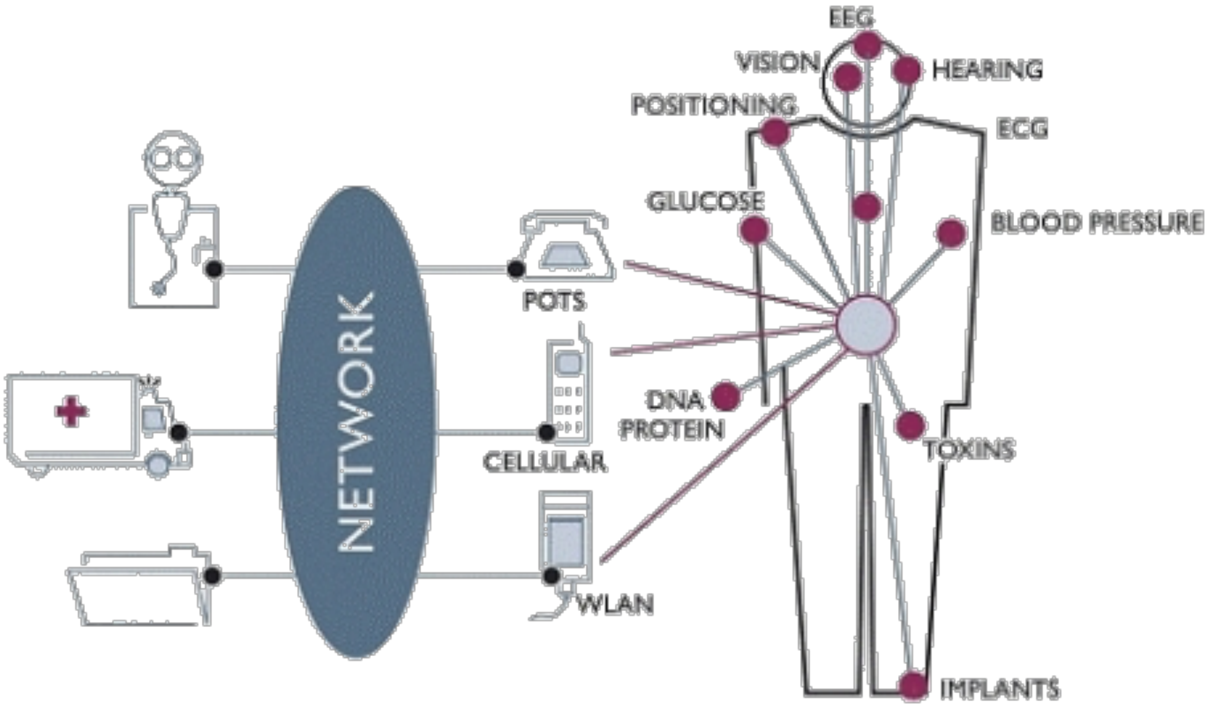
- Wired connections



EXAMPLE OF APPLICATIONS

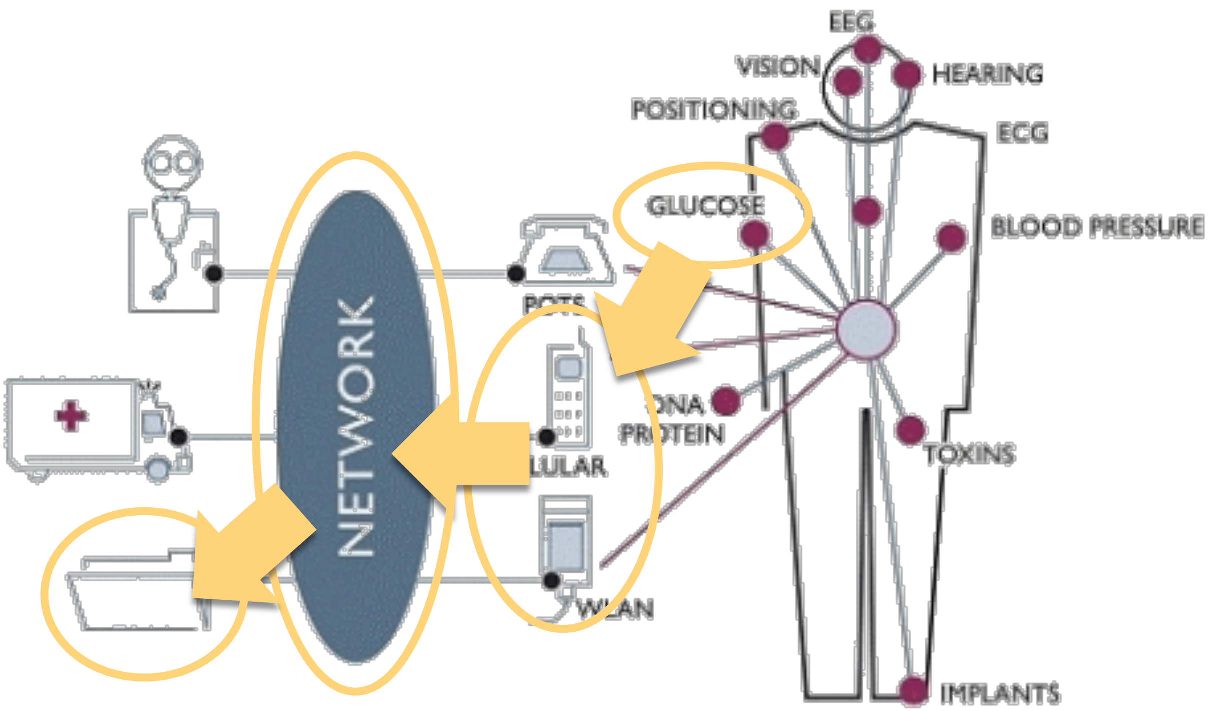
Example: assisted living

- Remote monitoring of health status



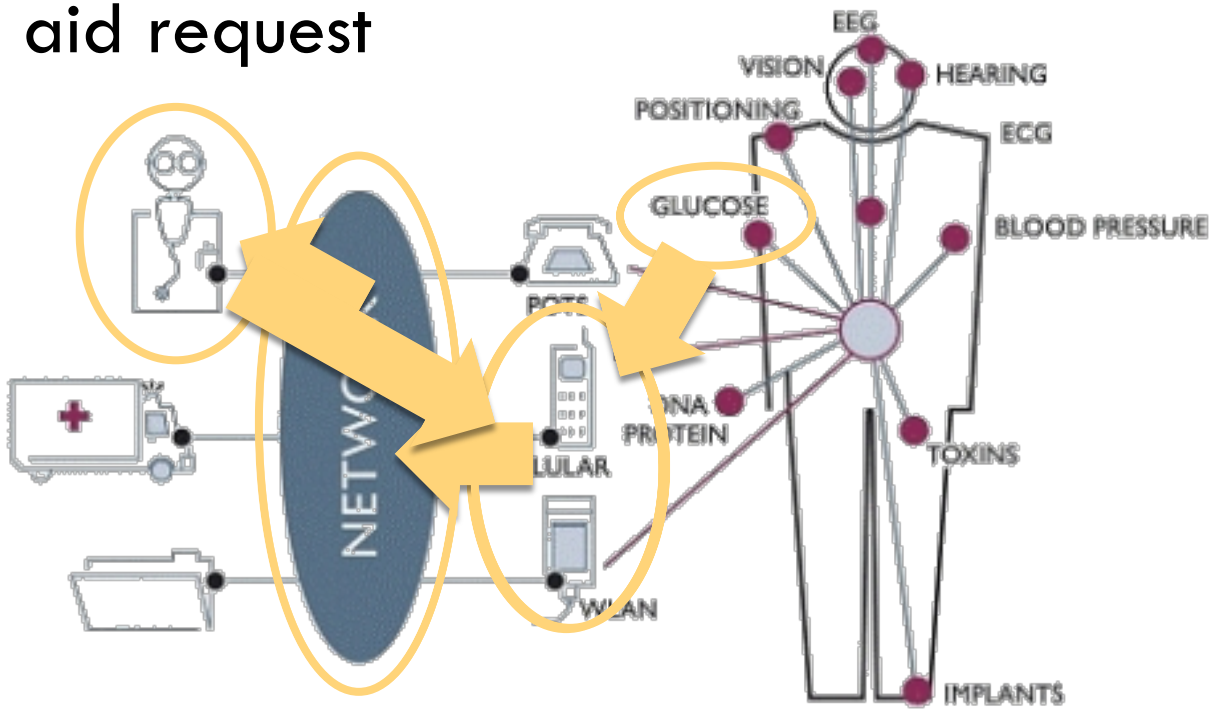
Example: assisted living

- Remote monitoring of health status
- Remote assistance



Example: assisted living

- Remote monitoring of health status
- Remote assistance
- Automatic first aid request



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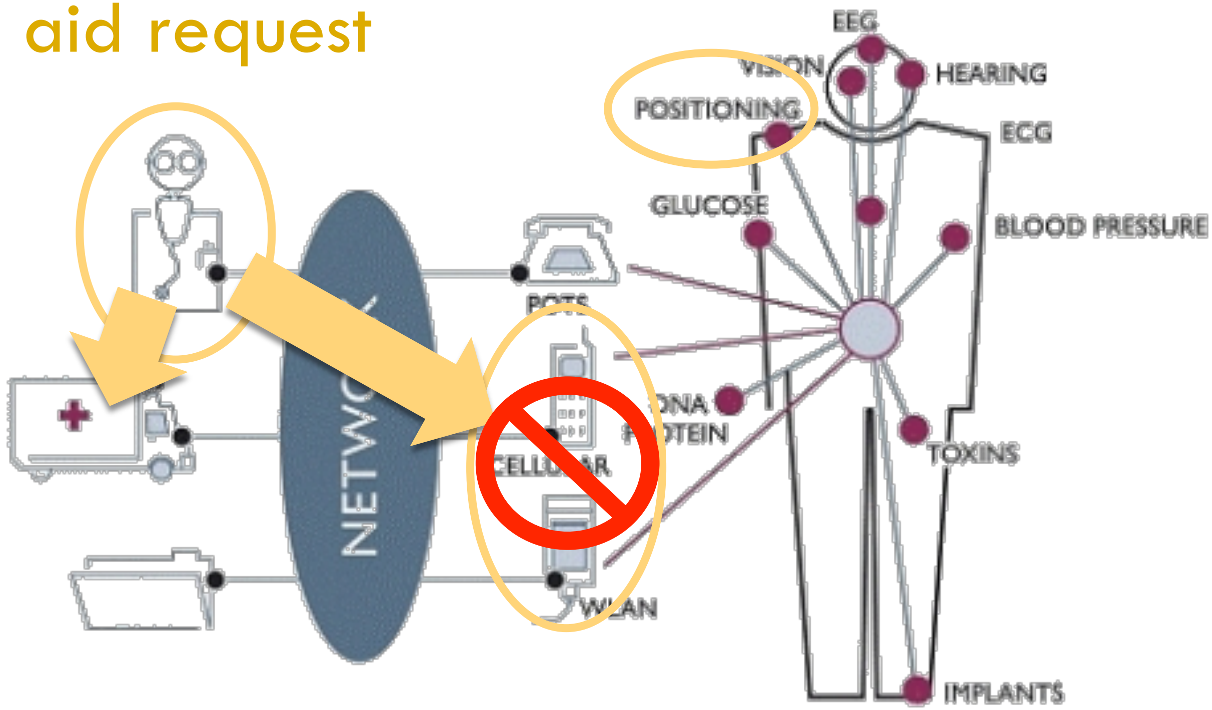

Indoor navigation

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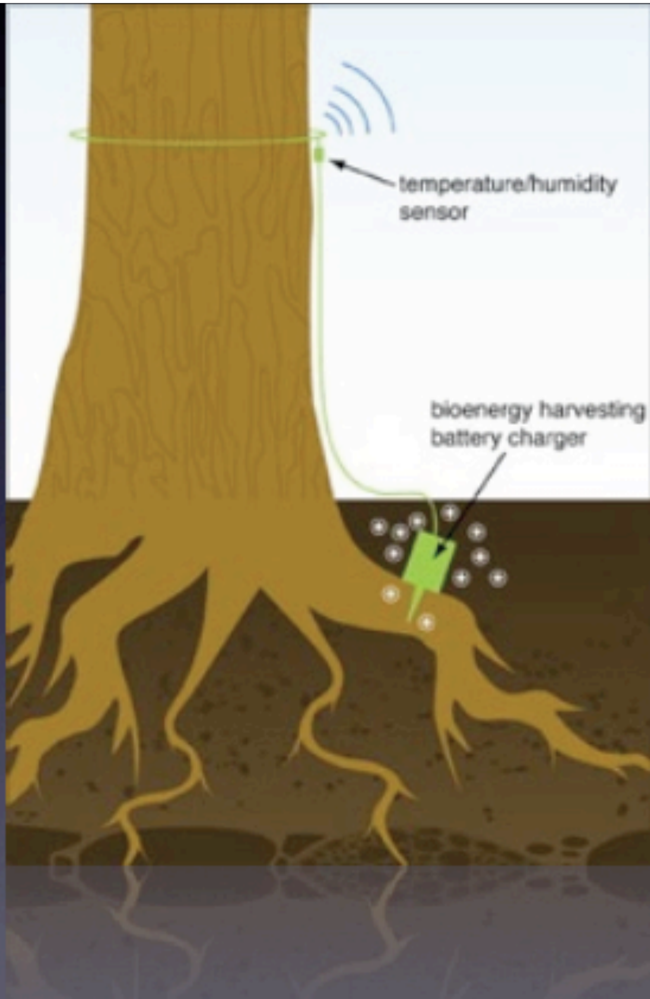
Self-sustainable forest fire detection system



Sensors powered by trees

Posted by David Pescovitz, October 7, 2008 10:02 AM
MIT researchers are developing a novel power scavenging systes for small wireless sensors that monitor for forest fires. The sensors are powered by the trees themselves. Each sensor's battery is trickle charged with the electricity generated by the imbalance in pH between the tree and the soil.

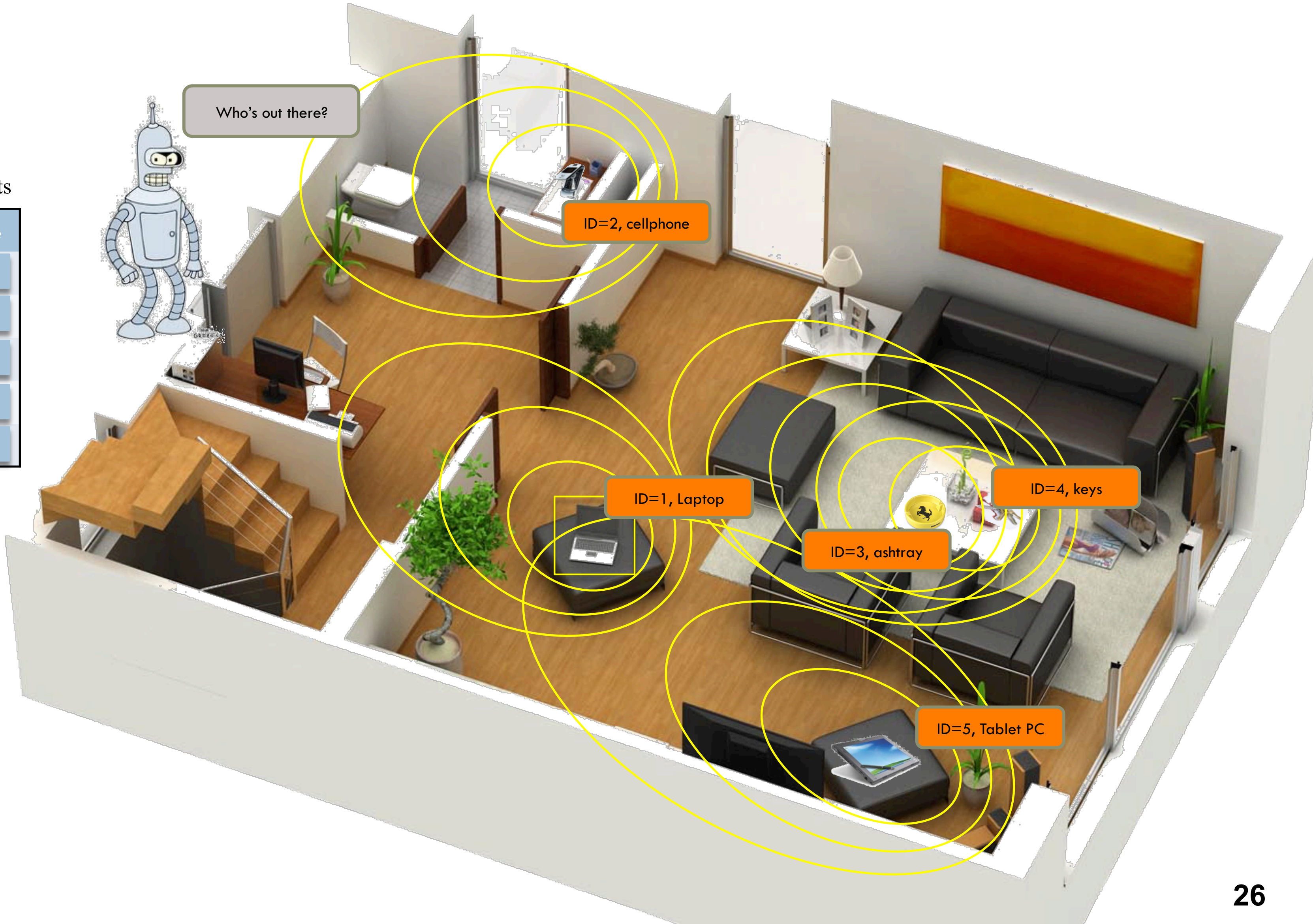
From the MIT News Office:
The system produces enough electricity to allow the temperature and humidity sensors to wirelessly transmit signals four times a day, or immediately if there's a fire. Each signal hops from one sensor to another, until it reaches an existing weather station that beams the data by satellite to a forestry command center in Boise, Idaho.

Shuguang Zhang, one of the researchers on the project and the associate director of MIT's Center for Biomedical Engineering (CBE).

Smart ambient

Smart Objects Lists

ID	Object type



Workplace comfort & health

- Indoor environments
  - CO_2 < 600 ppm
  - CO_2 >1000 ppm
  - CO_2 >2500 ppm

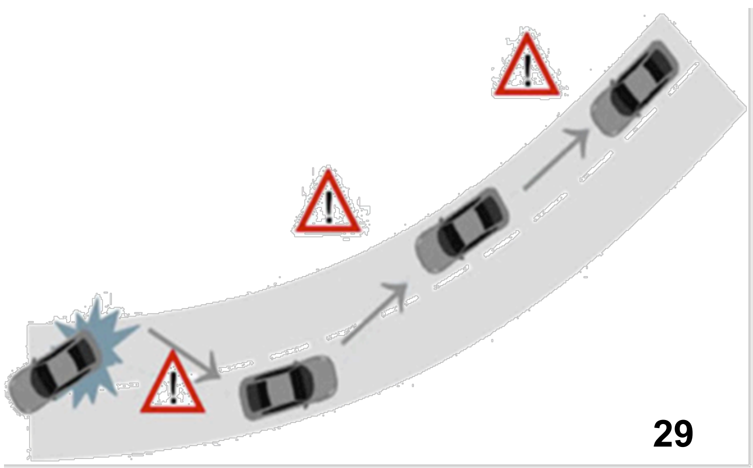
- Experimental study: scuola media Coletti Feb/2009
  - CO_2 level
    - after 30 min → 1950 ppm
    - opening the window for 5 min → 800 ppm
    - outdoor → 600 ppm

VANET: Vehicular networks

- Vehicles Transformed into "**Computers on the Wheels**" or "**Networks on the Wheel**"
- Vehicular Communication System (VCS):
  - Vehicle to Vehicle (V2V) Communication
  - Vehicle to Infrastructure (V2I) communication
- Advantage and Usage of VCS:
  - Information sharing
  - Co-operative driving
  - Other value added services like Navigation, internet access etc.

VANET services

- Propagation of emergency and alert messages
  - Uses multi-hop/multi-cast technique
  - Intelligent broadcasting
- High bandwidth link with vehicle and roadside equipment
  - Entertainment
  - Internet access
- Multi hop unicast, Geocasting, Mobicasting
  - Gaming
  - Messaging
  - Platooning
  - …



http://www.horizon2020news.it/argomenti/smart-city

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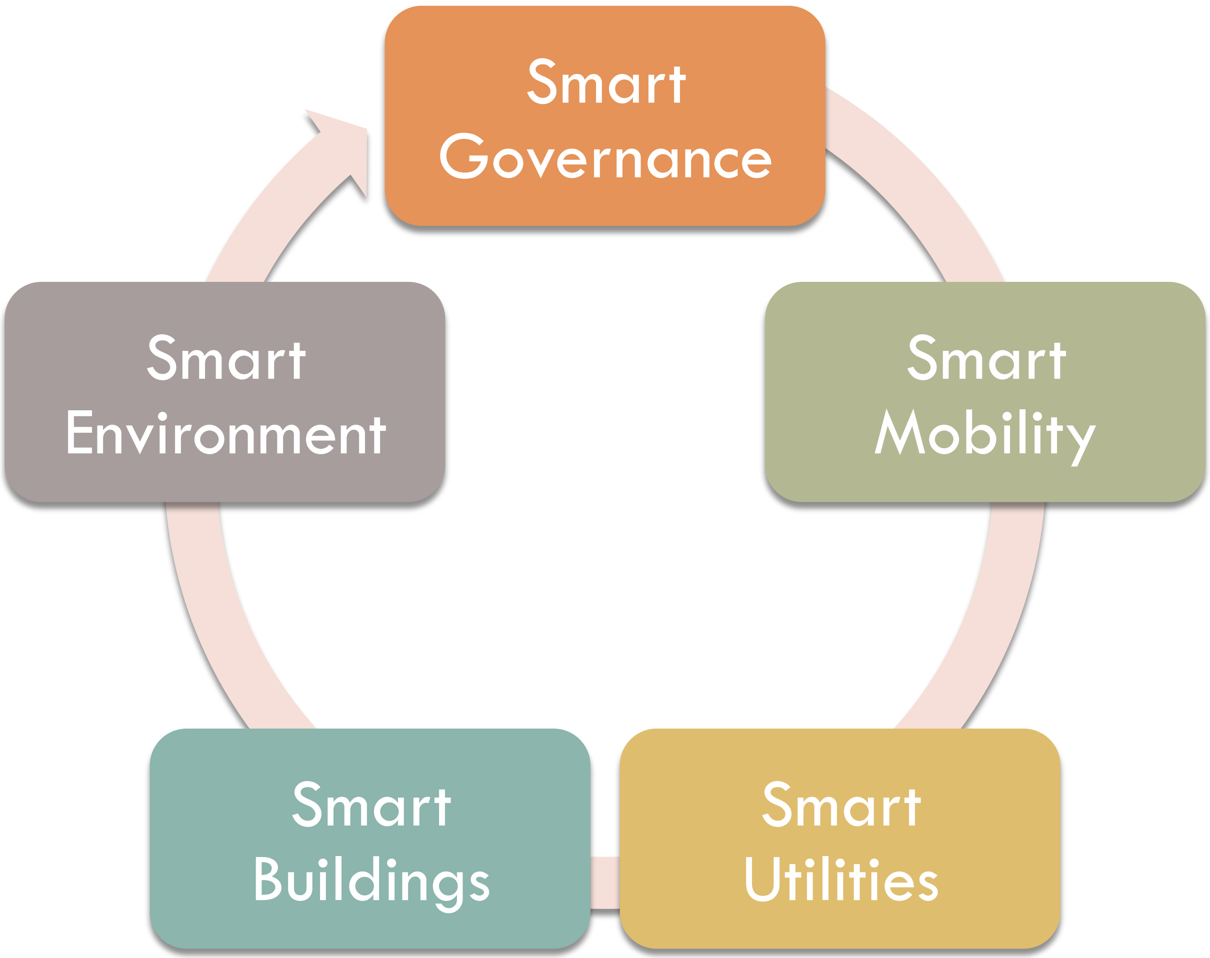
Smart Cities

Smart Cities concept

- Make a better use of public resources
  - Increase quality of services offered to citizens
  - Reduce the operational costs of public administration
  - Improve transparency and reduce the gap between citizens and administrations
    - Stimulate active participation of citizens to management of public affairs
      - E.g: http://www.decorourbano.org
    - Stimulate creation of new services

Smart city ecosystem



Roadblocks

- Political issues
  - Attribution of decision-making power to different stakeholders
- Financial aspects
  - Lack of clear business model
- Technical impairments
  - Non-interoperability of many heterogeneous enabling technologies

SMART CITY SERVICES

Structural Health of buildings

- Monitoring of conditions of historical building
  - Polluting levels
  - Humidity/temperature
  - Vibrations
  - Tension sensors in the structure
    - Also to check impact of earthquakes

Waste management

- Intelligent waste containers
  - Detect level of load
  - Check quality of garbage
  - Communicate with Internet
- Optimize collector trucks route
  - Reduce costs
  - Improve efficiency
  - Reduce pollution

Air quality monitoring

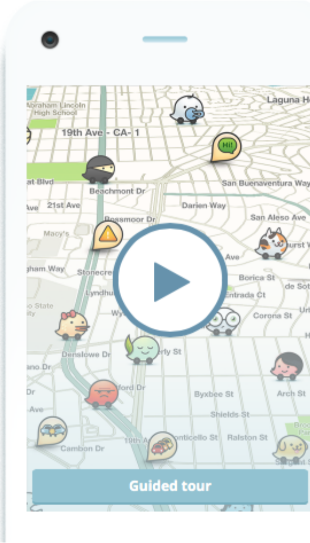
- The 20-20-20 European Union directive targets:
  - 20% reduction of greenhouse gas emissions by 2020
  - 20% cut of energy consumption
  - 20% increase of use of renewable energy sources
- Air quality sensors can be use to
  - Check the quality of the air and trigger prompt intervention when needed
  - Provide feedback to citizens about quality of air
    - eg, suggesting healthier paths for running or strolling

Noise monitoring

- Noise is a form of pollution that is quite annoying for citizens
  - Hospitals, residential areas, …
- Noise sensors can be used to
  - Map the acoustic pollution over the city
  - Improve public security by recognizing alarming sounds
    - House/cars alarms, glass crashes, brawls,…

Traffic monitoring

- Many cities already use traffic monitoring cameras in critical points
- This system may be further empowered by exploiting sensing and localizing capabilities of modern vehicles
  - https://www.waze.com
- Real time accurate traffic monitoring can
  - Help citizens better planning their trip to office
  - Help administration to discipline traffic

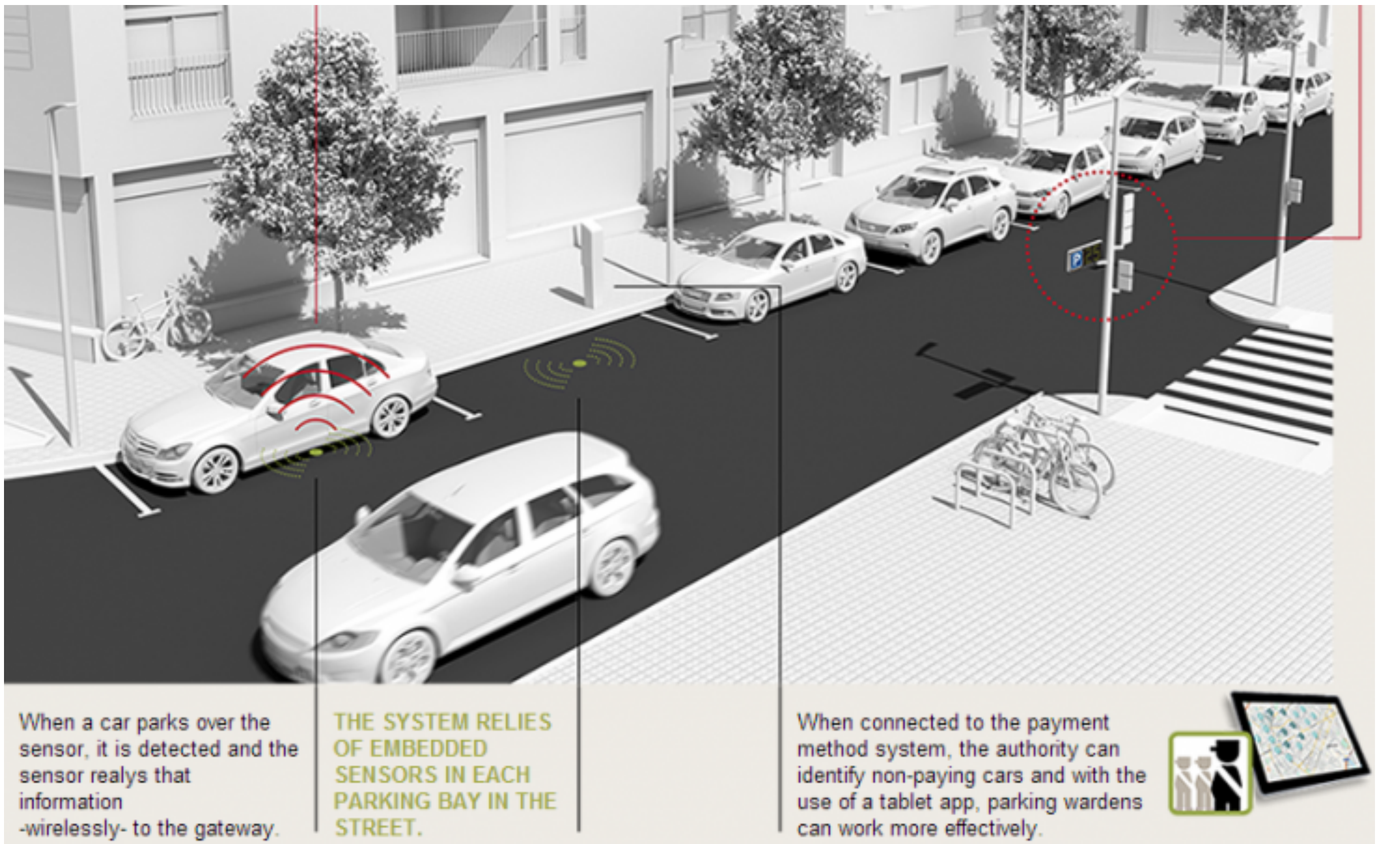


Smart Parking

- Finding a parking place: a modern nightmare!
  - Waste of time → economic loss
  - Source of frustration → health impact
  - Pollution → health/environmental impact

Smart Parking

- Smart parking (e.g., worldsensing.com)
  - Place sensors on each parking lot

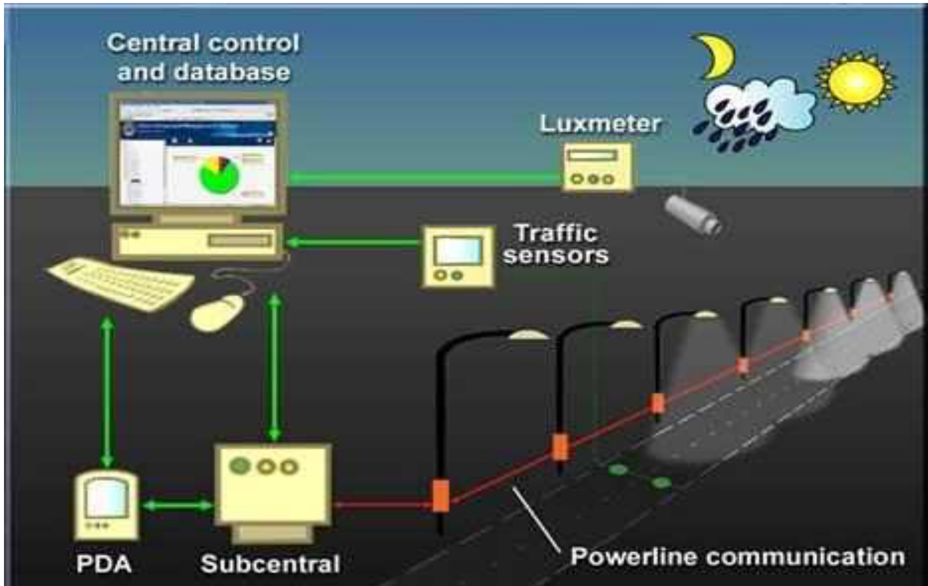


Smart Parking

- Smart parking
  - Place sensors on each parking lot
  - Place intelligent boards along the streets
  - Provide app for smartphones

Smart lighting

- Place sensors on street lamps along the road
- Optimize the light intensity according to
  - Time of the day
  - weather conditions
  - presence of people
- Automatically find burned bulbs
  - Reduce replacement time
  - Reduce costs
- Provide WiFi access



http://powertuningegypt.com/Smart%20Street%20Lighting

Smart Grid

- Household energy usage accounts for ~50% electric & ~33% energy usage in Italy
  - Extremely important to improve building energy efficiency

- In 2005 ENEL starts deploying the first SMART GRID
  - Cost: 2.1 billion euros
  - Saving: 500 milions per year!

- USA: Energy Dep. forsee up to 117 billions of dollars saving by 2030
- Smart grid can also decrease CO_2 emission of 12% in USA & 15% in India

Fonti: *Ministero dello Sviluppo Economico, 2005
•National Energy Technology Laboratory (2007-08) (PDF). NETL Modern Grid Initiative — Powering Our 21st-Century Economy. United States Department of Energy Office of Electricity Delivery and Energy Reliability. p. 17. Retrieved 2008-12-0
•R.G. Pratt, M.C.W. Kintner-Meyer, P.J. Balducci, T.F. Sanquist, C. Gerkensmeyer, K.P. Schneider, S. Katipamula, T.J. Secrest. The Smart Grid: An Estimation of the Energy and CO2 Benefits. Pacific Northwest National Laboratory Prepared for the U.S. Department of Energy under Contract DE-AC05-76RL01830
•Molly Webb, McKinsey & Company. SMART 2020: Enabling the low carbon economy in the information age. A report by The Climate Group on behalf of the Global eSustainability Initiative (GeSI)

Service specifications

Service	Network type(s)	Traffic rate	Tolerable delay	Energy source	Feasibility
Structural health	802.15.4; WiFi; Ethernet	1 pkt every 10 min per device	30 min for data; 10 seconds for alarms.	Mostly battery powered.	1: easy to realize, but seismograph may be difficult to integrate
Waste Management	WiFi; 3G; 4G	1 pkt every hour per device	30 min for data	Battery powered or energy harvesters.	2: possible to realize, but requires smart garbage containers
Air quality monitoring	802.15.4; Bluetooth; WiFi	1 pkt every 30 min per device	5 min for data	Photovoltaic panels for each device	1: easy to realize, but greenhouse gas sensors may not be cost effective
Noise monitoring	802.15.4; Ethernet	1 pkt every 10 min per device	5 min for data; 10 seconds for alarms	Battery powered or energy harvesters.	2: the sound pattern detection scheme may be difficult to implement on constrained devices
Traffic congestion	802.15.4; Bluetooth; WiFi; Ethernet	1 pkt every 10 min per device	5 min for data	Battery powered or energy harvesters.	3: requires the realization of both Air Quality and Noise Monitoring
City energy consumption	PLC; Ethernet	1 pkt every 10 min per device	5 min for data; tighter requirements for control	Mains powered	2: simple to realize, but requires authorization from energy operators
Smart parking	802.15.4; Ethernet	On demand	1 minute	Energy harvester	1: Smart parking systems are already available on the market and their integration should be simple.
Smart lighting	802.15.4; WiFi; Ethernet	On demand	1 minute	Mains powered	2: does not present major difficulties, but requires intervention on existing infrastructures.
Automation and salubrity of public buildings	802.15.4; WiFi; Ethernet	1 pkt every 10 minutes for remote monitoring; 1 pck every 30" for in-loco control	5 minutes for remote monitoring, few seconds for in-loco control	Mains powered and battery powered	2: does not present major difficulties, but requires intervention on existing infrastructures.

References

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  Top-100 most downloaded papers in IEEEXplore from May 2014 to December 2014
- A. Laya, V. I. Bratu, and J. Markendahl, "Who is investing in machine-to-machine communications?" in Proc. 24th Eur. Reg. ITS Conf., Florence, Italy, Oct. 2013, pp. 20–23
- M. Dohler, I. Vilajosana, X. Vilajosana, and J. Llosa, "Smart Cities: An action plan," in Proc. Barcelona Smart Cities Congress, Barcelona, Spain, Dec. 2011, pp. 1–6.

Questions?

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First Break

We deserve it!

http://www.keepcalmstudio.com/gallery/poster/L90JKS