Internet des Objets
Internet of Things (IoT)

LAAS-CNRS

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Université
de Toulouse

Outline

- Introduction
- NTT-Japan vision of IoT
- Current international projects
- Technology enablers
- Challenges of IoT
- Conclusion

Internet of Things (IoT)

Definitions:

- *“Things having identities and virtual personalities operating in smart spaces using intelligent interfaces to connect and communicate within social, environmental, and user contexts.”*
- *“Interconnected objects having an active role in what might be called the Future Internet.”*
- *Wikipedia: In computing, the Internet of Things refers to a, usually wireless and self-configuring, network between objects, such as household appliances*

Semantically:

- *“A world-wide network of interconnected objects uniquely addressable, based on standard communication protocols.”*

Convergence of telecommunication, informatics and electronics

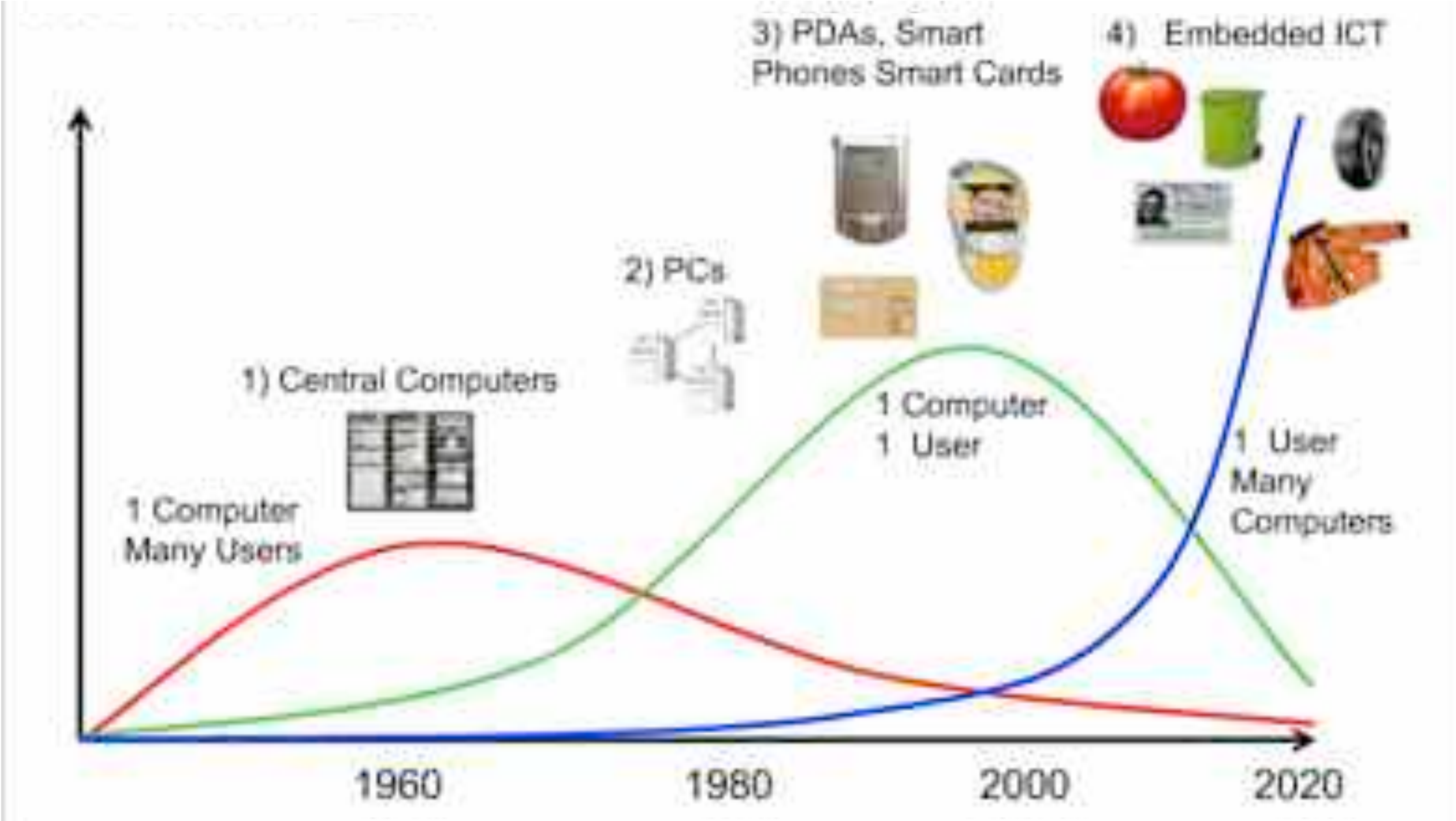
Other terminologies

- Ambient Intelligence
- Ubiquitous computing
- Machine-To-Machine
- Pervasive computing
- Everyware
- ADUN: Appliance Defined Ubiquitous Network

Next Internet Revolution:

- *From networking of human beings to networking of things*

Towards the Internet of Things: the Post PC-era



The Internet Front-Tier

Why “Real” Information is so Important?

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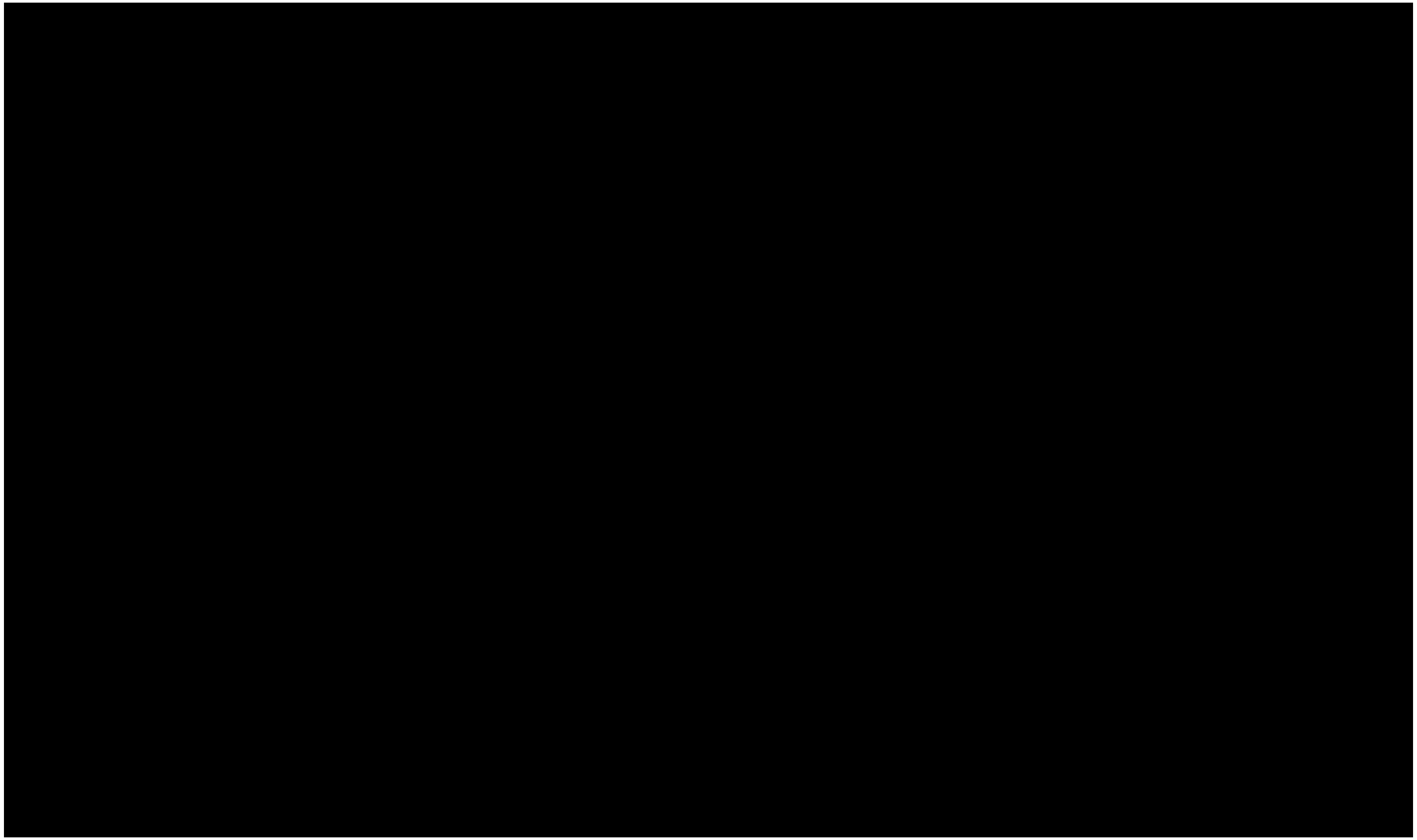
Internet Of Things: NTT Vision



S-room: http://www.kecl.ntt.co.jp/csl/sirg/Eindex.html

Blogject

Internet of Things

More than RFID tags + networked sensors

- *« "Things" in the pervasive Internet, will become 1st-class citizens with which we will interact and communicate »*
- Blogjects are objects that blog
- Pigeonblog: www.pigeonblog.mapyourcity.net/blog/index.php

Julian Bleecker, Assistant Professor at University of Southern California
Head of the Mobile and Pervasive Lab

Pigeonblog – An alternative way to participate in environmental air pollution data gathering

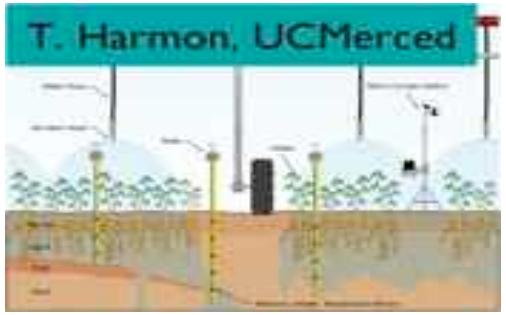
- Urban homing pigeons equipped with GPS enabled electronic air pollution sensing devices capable of sending real-time location based air pollution and image data to an online mapping/blogging environment.

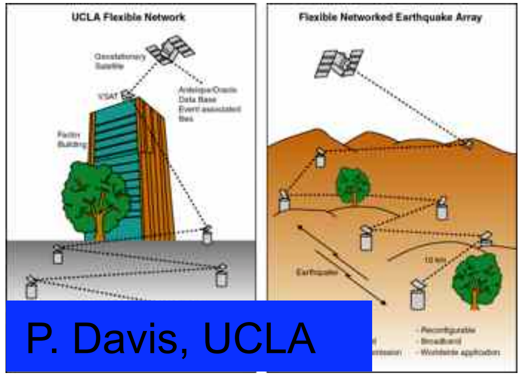
http://www.beatrizdacosta.net/

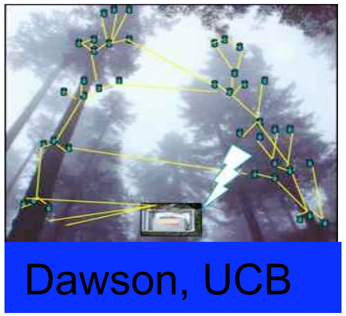
Pigeonblog Social Impact

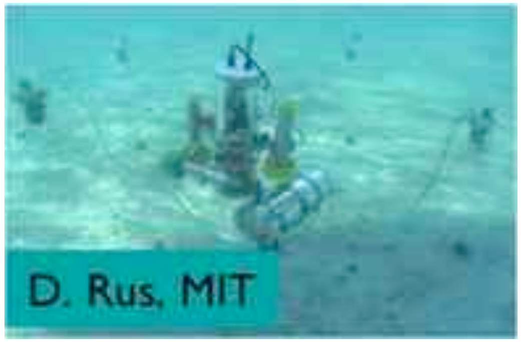
- Pigeons tell about quality of air we breath
- Importance of pigeons shifts from a common nuisance to a participant in life and death discussions about the state of the micro-local environment
- Pigeons= Web2.0 progeny of the Canary in the coal mine

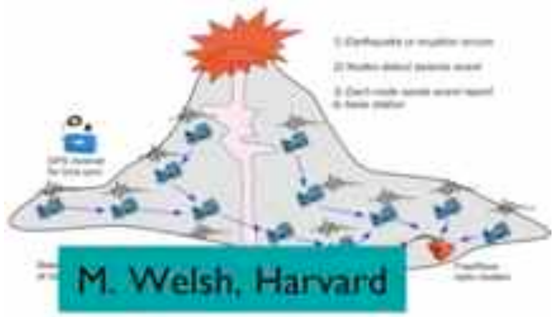
Science application drivers explore complex spatial variation and heterogeneity





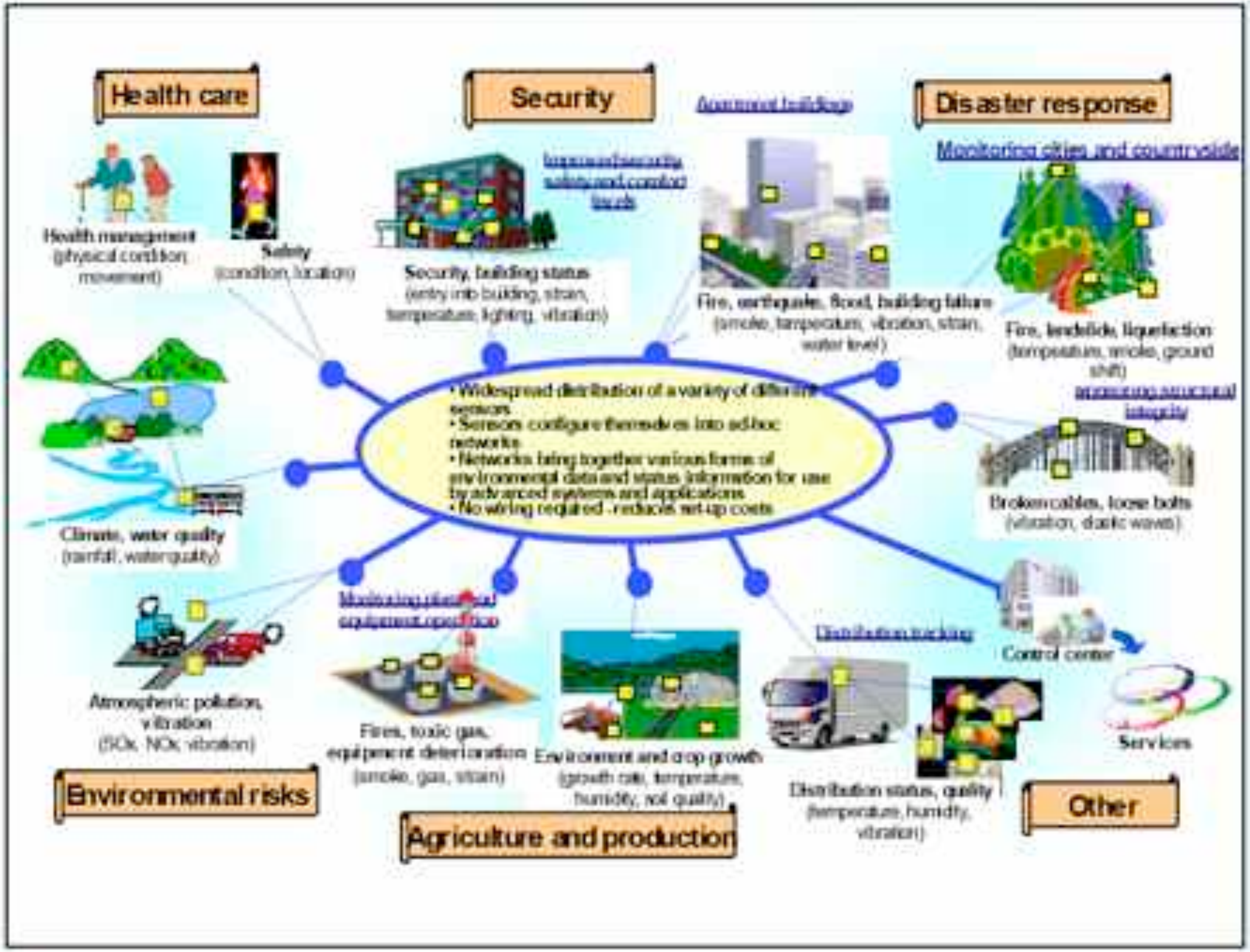






FRANCE : SensLab ANR Project - http://www.senslab.info

Japanese vision of ubiquitous sensor networks



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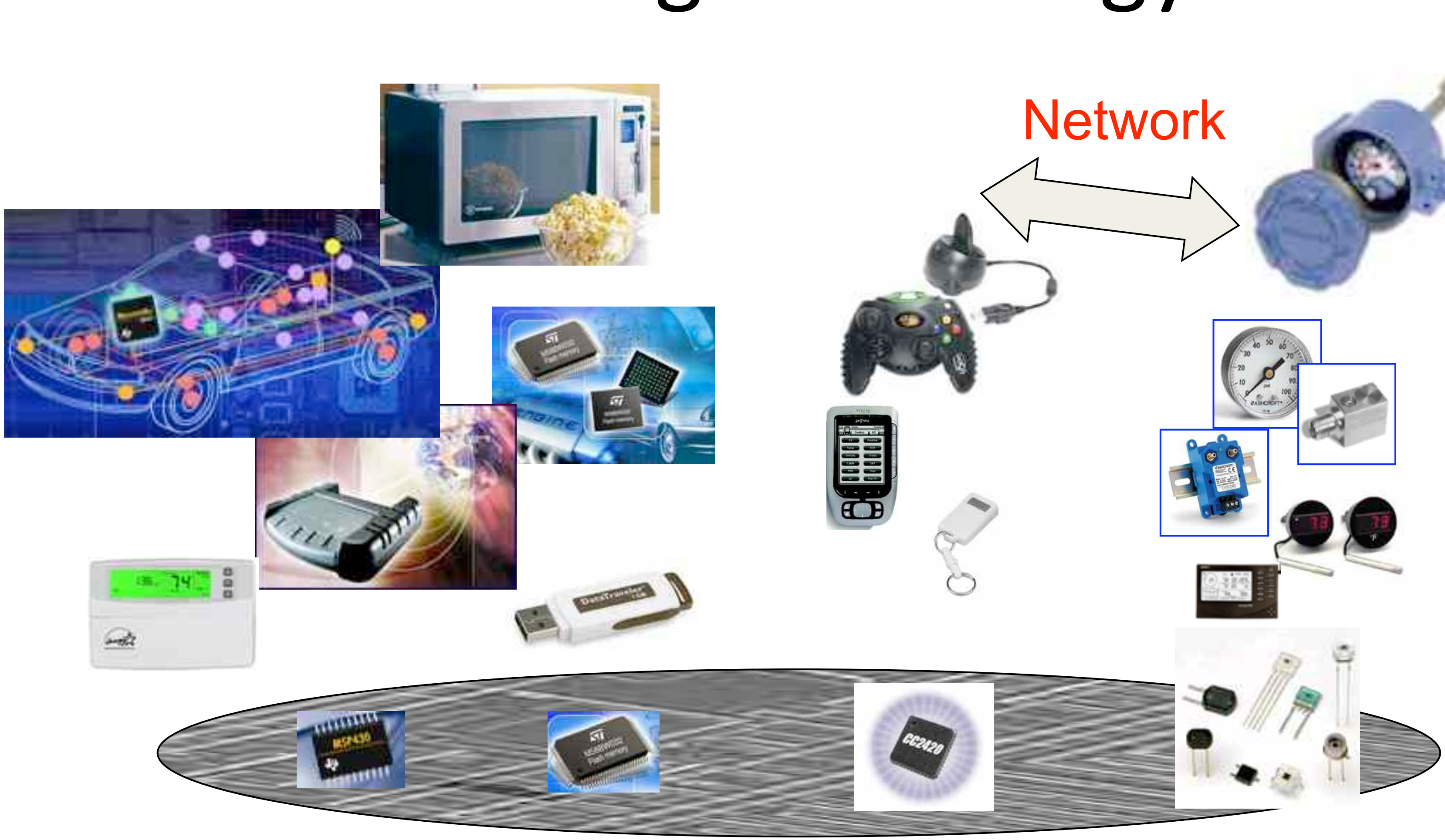
Enabling Technology



Microcontroller | Flash Storage | Radio Communication | Sensors

IEEE 802.15.4

Four important technological enablers

- **RFID**: a simple, unobtrusive and cost-effective system of identification and communication
- **Sensor technologies**: detection of changes in the physical status of things
- **Smart technologies**: embedded intelligence in the things themselves
- **Nanotechnology**: smaller and smaller things having the ability to interact and connect

1. RFID

Three components:

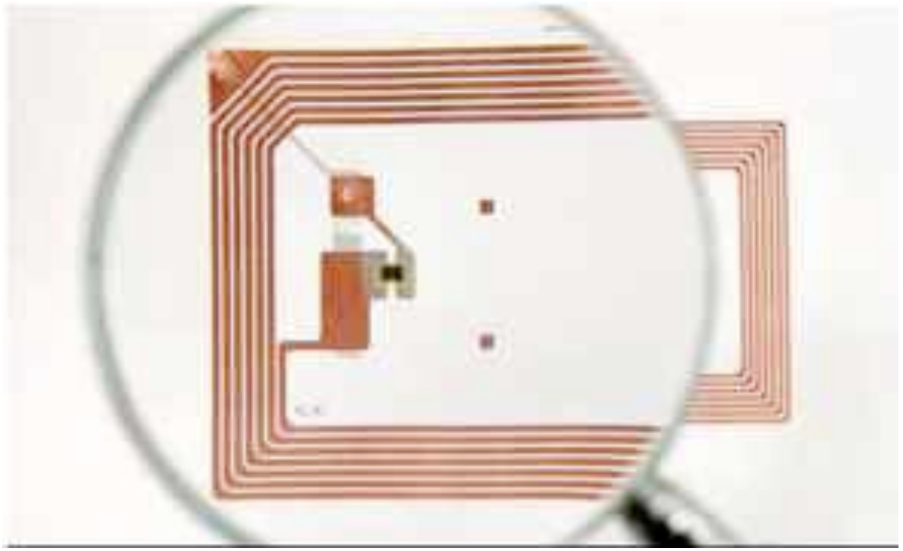
•Transponder or tag consisting of a coupling element (coil or antenna) and an electronic chip. No need of power source since the tag take the energy from the EM field emitted by the readers.

• Interrogator or reader

• Middleware which forwards the data to another system such as a database, a PC or robot control system

Frequencies:

• LF: 125kHz
• HF: 13.56MHz
• UHF: 800-600MHz



•Lack of established international standard, except EPC

Verichip: Implantable RFID

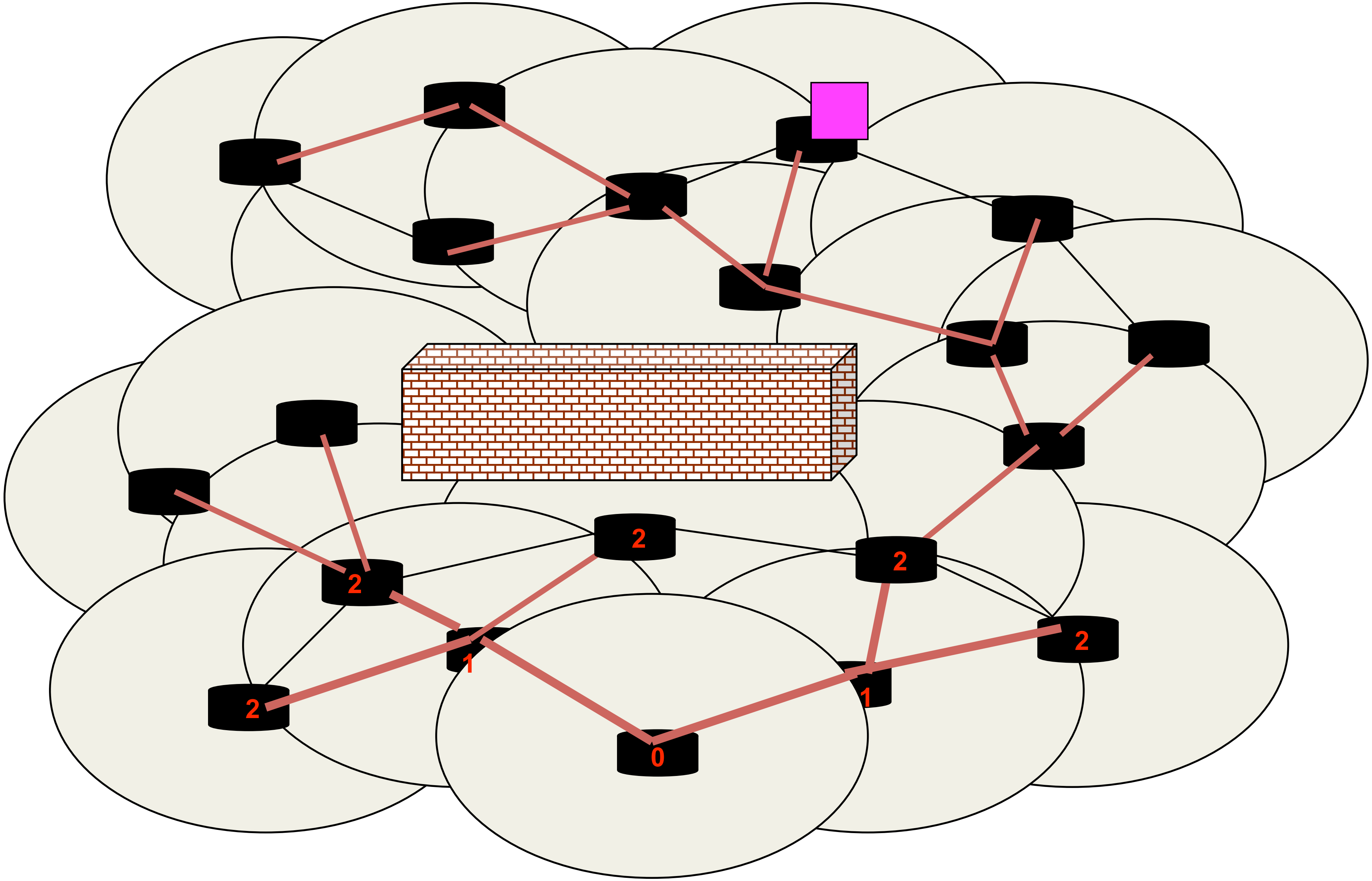
RFID: More than barcode

- Unique identification of individual items, allowing databases of specific item/location information to be generated, giving each item its own identity for real-time identification and tracking.
- Data capture without the need for line of sight or physical manipulation.
- Tags can be passive, semi-passive or active, and also read-only, read/write or read/write/re-write.
- Privacy-Enhancing Technologies can be used to kill or block tags. Ex: biometric passport

2. Sensor technologies

- Bridge between physical and virtual worlds
  - **Sensors**: Collect data from the environment
  - **Actuators**: implement decisions
- *« Two heads are better than one »*: Intelligence of a single sensor increases exponentially when used in a network
- Wireless Sensor Networks (WSN): low cost, flexibility
  - **Sensor node**: small, low-power, includes sensor, power-supply, data storage, µP, low-power radio, ADCs, data transceivers and controllers
  - **RFID sensor tag**: combining RFID and sensor

Self-Organized Mesh Routing



Sensor technologies

- Major challenges:
  - Possibility for nodes to self-organize themselves into a network
  - Power constraint
  - Size reduction
  - WSN Assembly/Packaging
  - Memory and storage capacity
  - Limited processing speed and communication bandwith

3. Smart technologies/systems

- Any conventional material or thing that can react to external stimuli may be called « smart thing »
  - Smart materials: passive, active and autonomous
  - Smart clothing and wearable computing
  - Smart homes
  - Smart vehicles
  - Robotics

BNAIC 2008

Future Cars as Mobile Computers, Mobile Sensors and Mobile Internet Nodes: Car2X as part of the Internet of Things

1. More Safety
2. Less Pollution
3. More Efficiency
4. Better Connectivity
5. More Fun

Prof. Wolfgang Wahlster, German Research Center for AI, DFKI GmbH

4. Nanotechnologies

Challenges

- Gap between basic and applied research : *Valley of Death*
- Push back the limits of semiconductor performance and density:
  - Size reduction
  - Increased speed
  - Increased memory capacity
  - Decrease in energy consumption

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IoT Challenges

- **Energy**: Harvesting, conservation & consumption
  - New and more efficient and compact energy storage: batteries, fuel cells, and printed/polymer batteries, supercapacitors…
  - New energy generation devices coupling energy transmission methods or energy harvesting/scavenging using energy conversion.

2 AA => 1.5 A.h (~4 W.h)
Cell => 1 A.h (3.5 W.h)

Cell: 500 -1000 mW => few hours active
WiFi: 300 - 500 mW => several hours
GPS: 50 – 100 mW => couple days

$$\text{Average Power} = \boldsymbol{f}_{act} * P_{act} + \boldsymbol{f}_{sleep} * P_{sleep} + \boldsymbol{f}_{waking} * P_{waking}$$

WSN: 50 mW active, 20 µW passive
450 µW => one year
45 µW => ~10 years

IoT Challenges

- **Intelligence**:
  - Capabilities of context awareness and inter-machine communication: sensing, localization & actuation
  - Communication capabilities: multi-standard & multi-protocol compatibility
  - Integration of memory and processing power
  - Ultra low power design: from processors/microcontrollers cores, signal processing & sensors to base stations
  - Capacity of resisting harsh environments
  - Affordable security
  - New class of simple and affordable IoT-centric smart systems
  - Intelligence vs Size & cost trade-off

IoT Challenges

- **Communication**: Physical wave transmission & Protocols
  - New, smart multi frequency band, reconfigurable antennas, integrated on-chip and made of new materials
  - Modulation schemes and transmission speed allowing multi-frequency energy efficient communication protocols and transmission rates.
  - New methods of power consumption management: from network routing down to the architecture of individual devices.
- **Integration** of smart devices into non-standard substrates
  - Into textiles and paper, even metal laminate: printed electronics
  - Into the products themselves: physically integrate RFID structure with the material of the object (ultra-thin structures < 10μm)
  - Development of new substrates with conducting paths and bonding materials adequate for harsh environments and for ecologically sound disposal.

IoT Challenges

- **Interoperability**: Future tags must integrate different communication standards and protocols that operate at different frequencies and allow different architectures, centralized or distributed, and be able to communicate with other networks unless global, well defined standards emerge. Ex: TinyOS de Berkeley http://www.tinyos.net/
- **Standards**: Without clear and recognized standards such as the TCP5/IP6 in the Internet world, the expansion of the Internet of Things beyond RFID solutions cannot reach a global scale. Sustainable fully global, energy efficient communication standards that are security and privacy centered and are using compatible or identical protocols at different frequencies are therefore needed.
- **Manufacturability**: Costs must be lowered to less than one cent per tag, and production must reach extremely high volumes, while the whole production process must have a very limited impact on the environment.

IoT Challenges

- Niche Applications / No single killer application enabling the network infrastructure
  - Almost impossible to standardize the wireless interfaces between objects and the network.
  - Ubiquitous use of applications at low cost for construction and operation
- Security and Privacy Control: *Big Brother?*
  - Widespread adoption of any object identification system: need for special long-term security protection installed.
- Network Infrastructure Creation and Evolution
  - Efficient migration from the Internet / Efficient use of the existing infrastructures
  - Accommodate functionally-improved objects and technologies in the future

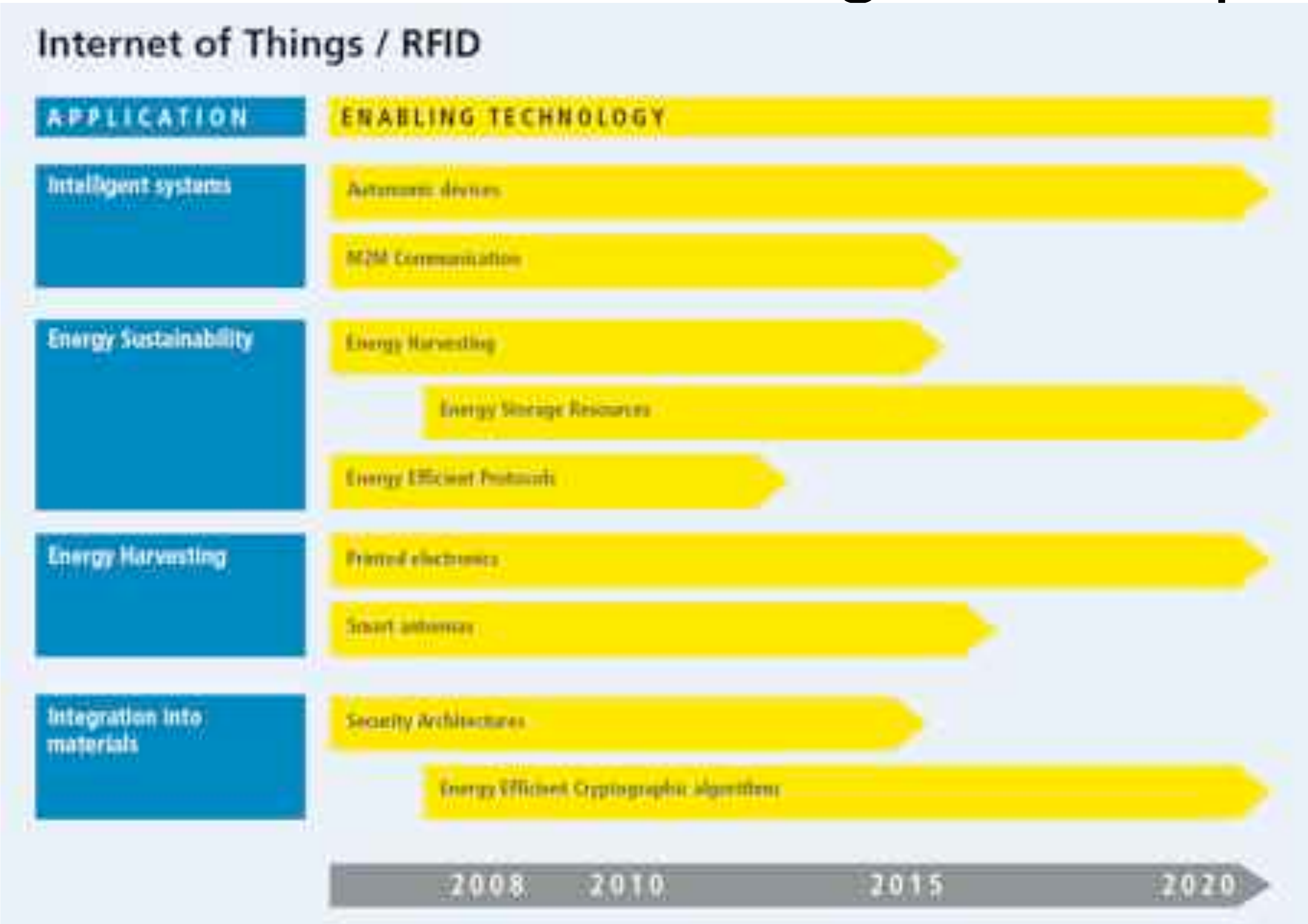
Other Challenges

- Application driven:
  - lifetime (> 25yrs in aeronautics, ≈ 100 yrs for SHM in buildings), harsh environment, biocompatibility
- Robustness and reliability, both at hard and soft levels
- Security/Malware: resilience
- Build realistic models for simulation, emulation, prototyping, etc: scale issues
- Mobility

Wide technological trends

- **"Exaflood" or "Data deluge"**: explosion of the amount of collected and exchanged data. 2015: more than 220 Exabytes of data will be stored. ***Imperative to find novel ways and mechanisms to find, fetch, and transmit data.***
- **Energy** for WSN node operation needs to dramatically decrease: ***search for a zero level of entropy where the device or system will have to harvest its own energy.***
- ***Miniaturization of devices is also taking place amazingly fast***.
- **Autonomic resources**: To cope with complexity and heterogeneity, systems will have to show self-properties, such as ***self-management, self-healing and self-configuration***.

EPOSS Internet Of Things Roadmap



Conclusion

- **Internet Of Things** : fusion of the real, virtual and digital worlds, creating a map of the physical world within the virtual space
- Innovative technologies and approaches will be required to make IoT a reality
- Innovation will come from convergence of sciences and technologies

1+1 > 2

IoT: opportunity for LAAS interdisciplinarity

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