“Systèmes Intégrés Sans Fils”

Roberto Rivoir
Atmel Rousset
Zone Industrielle 13106 Rousset Cedex
Tel. 0033.442536343 email: roberto.rivoir@rfo.atmel.com

Forum OCOVA Objets COmmunicants sécurisées et VAlorisation
Château de Charance, Gap, 22 September 2005

Outline

- Wireless Panorama: an Introduction
- Wireless Sensor Networks (SPIN)
  - Application Scenarios
  - Network and HW Configuration
  - Some Practical Cases
- Wireless Micro-devices:
  from the RFID to the Smart Communicative Components (SC^2)
- Cellular Networks
  - 4G Paradigm, Silicon Platforms
  - Secured Radiocommunications
- Challenges
  - Design: Re-configurable Systems
  - Technology: Microsystem Integration
- Conclusion

Part I:

Introduction

What is the future of Wireless* ?

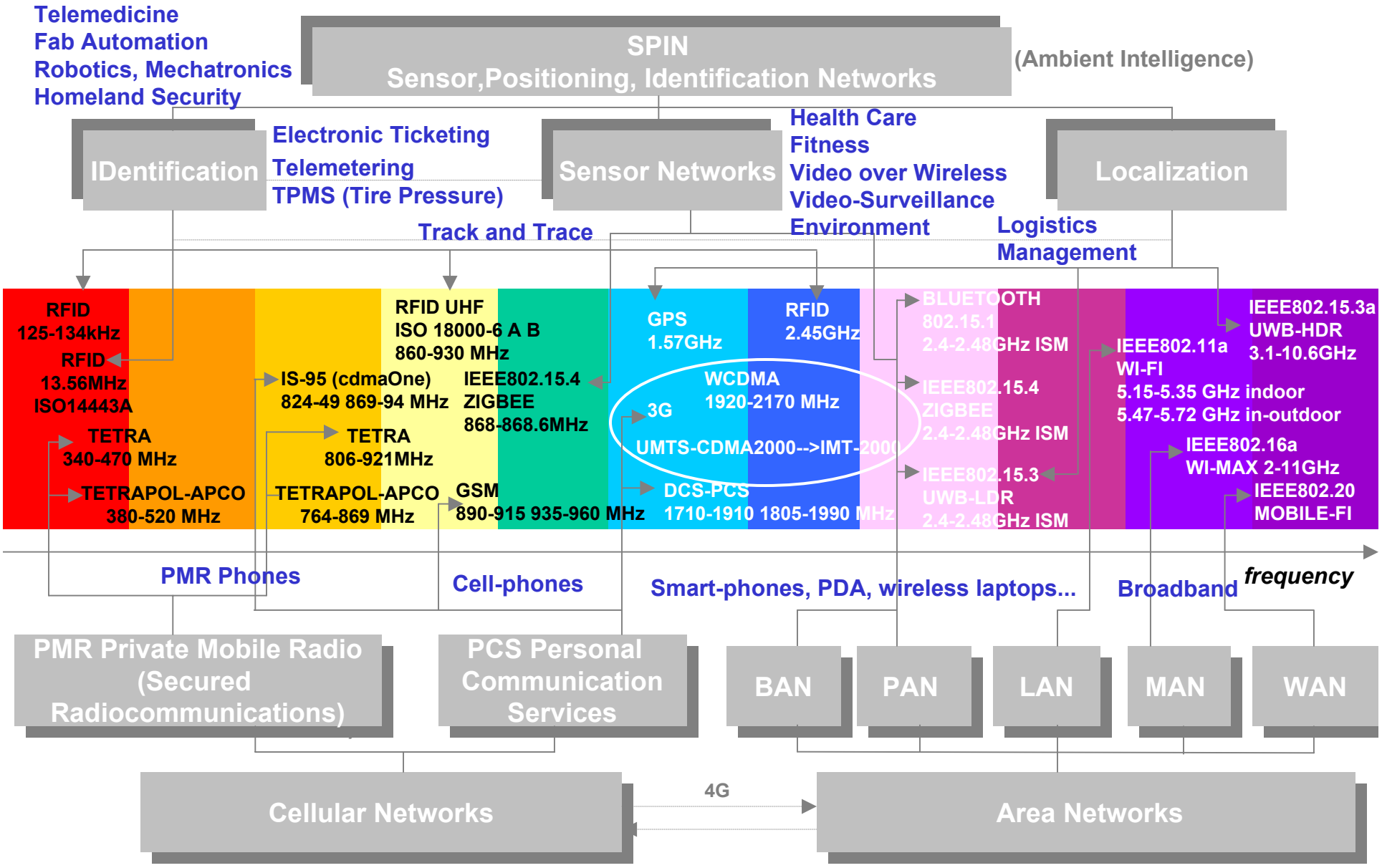
- Craig R. Barret, CEO, Intel Corp — Most important Technology for the coming decade: **"Wireless"**
- William A. Wulf, President N. Ac. of Eng. — Most important technology for the coming decade: **"Smart intercommunicating everything"**
- John T. Chambers, CEO, Cisco Systems — Most important technology for the coming decade: **"Affordable Broadband Internet access in every home"**
- Kazuo Murano, President Fujitsu Ltd. — Technology that has evolved in a surprising way: **"The cellphone"**
- Judy Estrin, Chairman, Packed Design — Technology that has evolved in a surprising way: **"The cellphone… also surprising is the quality still poor, and how we tolerate it"**
- C.Gordon Bell, Senior Researcher, Microsoft — Most important Technology for the coming decade: **"Wireless"**
- F.D. Berman, Director, Un. Of S.Diego — Technology that has evolved in a surprising way: **"Cellphones and personal technology. I don't think A.G. Bell thought about this when invented the phone"**
- Priscilla Nelson, National Science Foundation — Most important Technology for the coming decade: **"Distributed sensing, which goes hand in hand with computation capability"**
- Wendy Hall, Prof. of Computer Science — Most important technology for the coming decade: **"Wireless embedded computing"**

* "40 Tech Gurus tell us what's next", IEEE Spectrum, November 2004

Wireless Generations & Milestones

Generation	Milestone	Features
1G	Voice Telephony, Paging	Analog Modulation (AMPS, TACS)
2G	Voice Telephony and supplementary service (SMS,..)	Digital Modulation (GSM, IS95, IS136)
3G	Multi-media services: audio, video, video-phoning Internet, Web browsing	Digital Packet Network transmission (UMTS, WCDMA, CDMA2000)
4G	ABC = Always Best Connected Integration of UMTS and Wi-Fi in the Cellphone	Seamless roaming among multiple kinds of networks Convergence, interoperability of wireless standards and networks
AmI	Seamless Wireless Networked Environments: human body, home, office, factory, car, …	People and objects bi-directionally connected and communicating

Wireless Panorama



Part II:

Wireless Sensor Networks

(SPIN)

Wireless Sensor Networks: Application Scenarios

AVIONICS

- Chassis structural analysis

AUTOMOTIVE

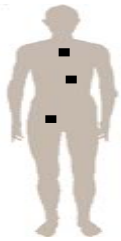
- Tire Pressure Monitoring Systems (TPMS)
- Keyless-Entry-Keyless-Go (KEKG)
- Car maintenance, Sensor Interfaces (SI)
- Pre-crash sensors
- Infotainment (video + radio + GPS + GSM)

DEFENSE, SECURITY

-Homeland Security
-Video Surveillance
- Alarms

« Smart Intercom-munication Everything »

HEALTH FITNESS



- Health monitoring & care:
Hearth disease, Alzheimer, Diabetes (pacemaker, defibrillators, glucosemeter)
- Telemedicine:
Patient monitoring,
Elderly surveillance at home
- Fitness: Athletes-Referees performance

ENVIRONMENT

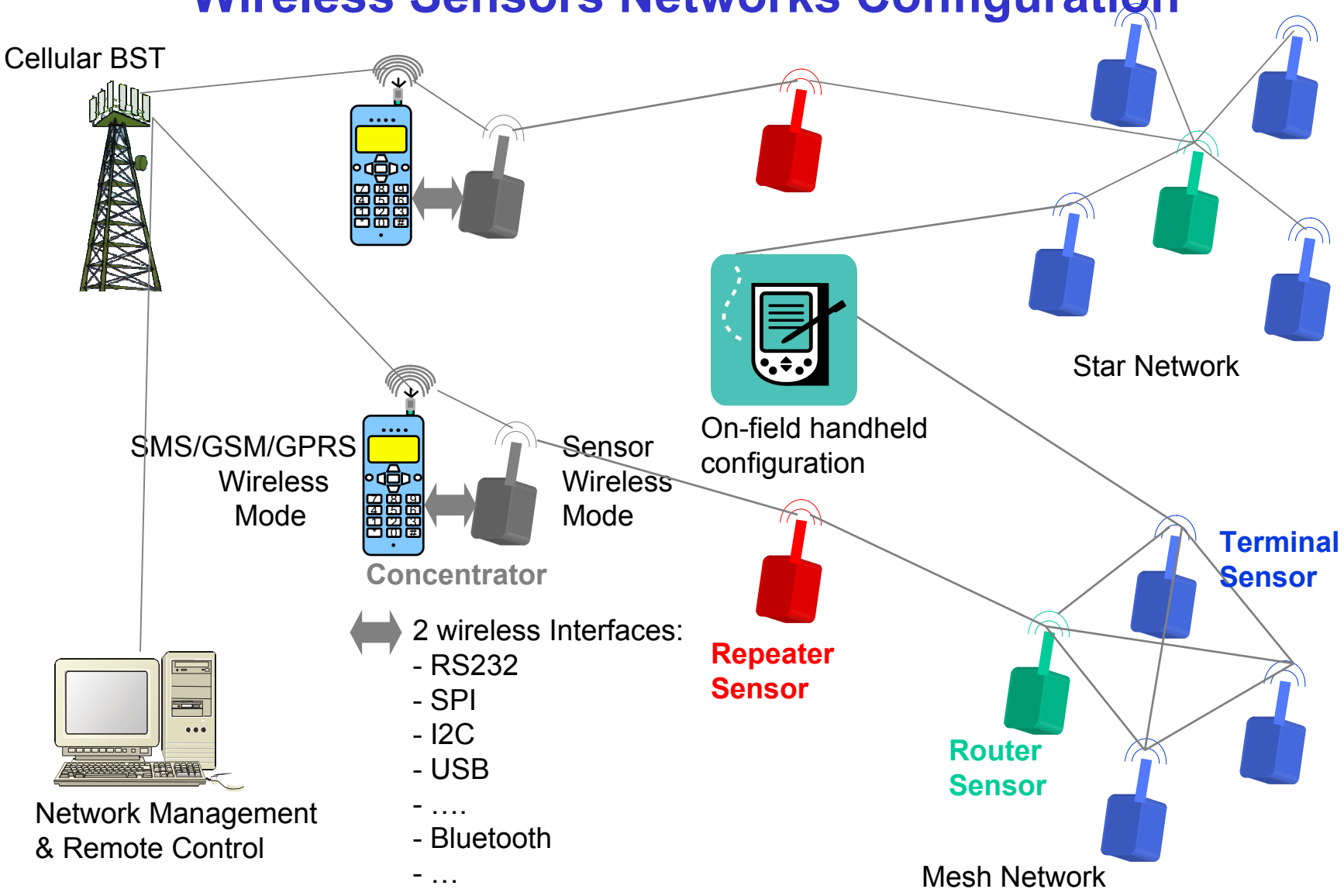
- Wildfire detection
- Telemetering (water, gas,…)
- Pollution control
- Pest control in wooden frameworks

SMART FAB

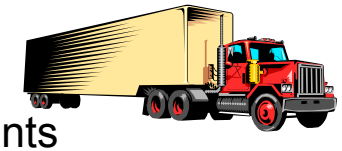
- “Plug & Produce”, “Is everything OK?”
- Smart, Flexible, & Reconfigurable manufacturing process
- Accelerated Products Customization
- Model based Diagnostic, Prognostic,
- E-maintenance

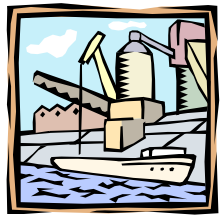
Wireless Sensor Networks + Pervasive Computing + Artificial Intelligence =
= High Potential Technology for addressing many societal problems

Wireless Sensors Networks Configuration

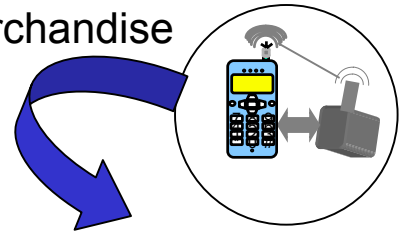


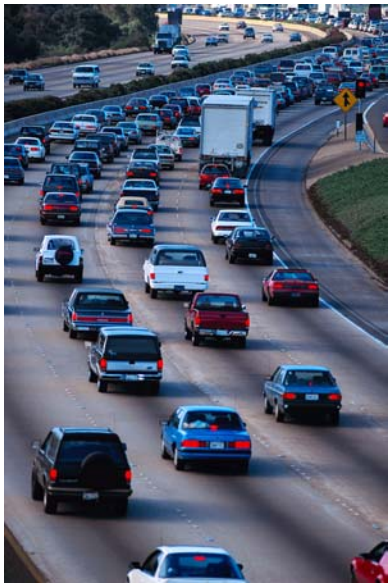
Wireless Sensor HW Configuration

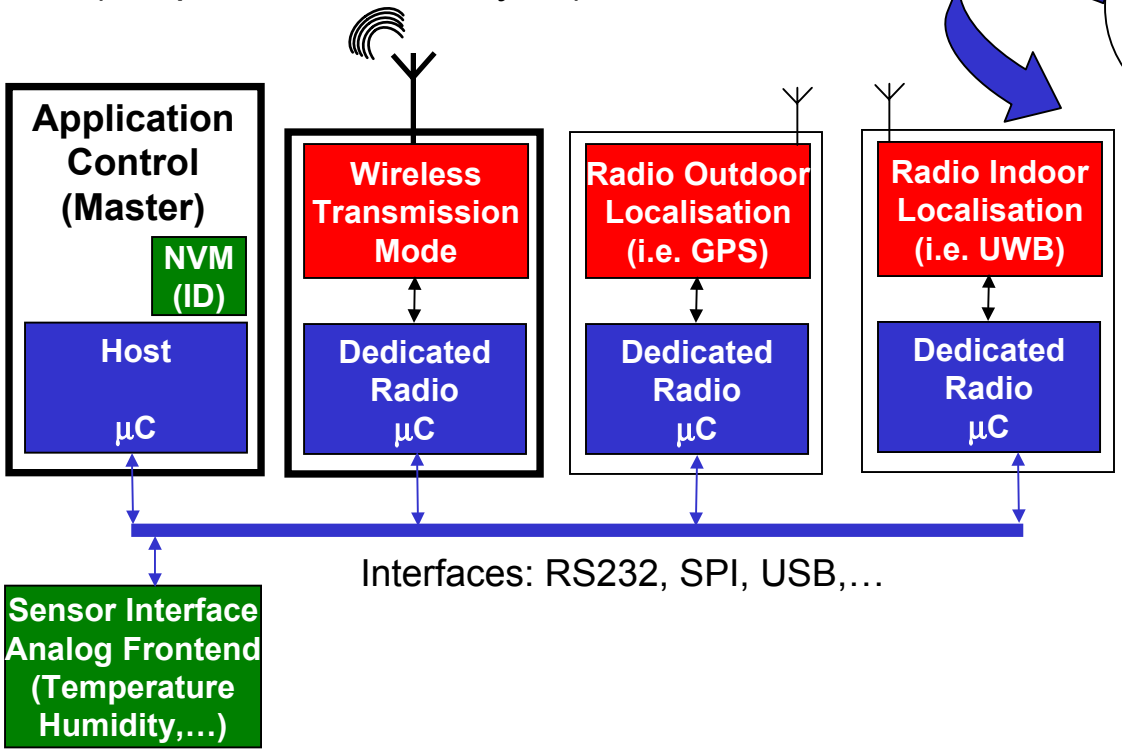




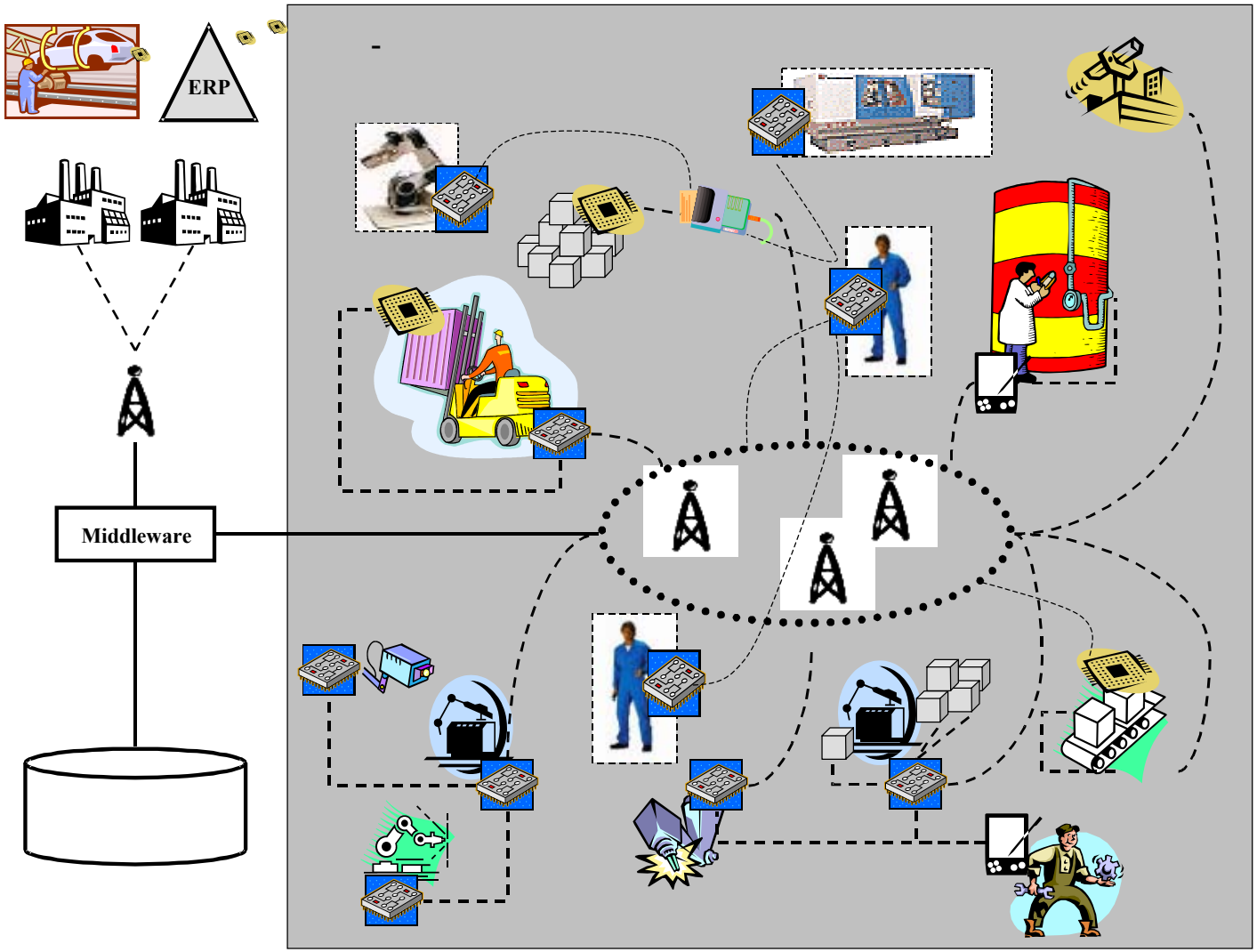
- Complex Application Example:
  - Tracking of a truck moving from-into-to different environments (indoor, outdoor)
    Parameter monitoring of the transported merchandise (temperature, humidity,…)







SPIN Networks Example → The Smart Factory Concept



RFID

Reader

Smart Sensor

The “Smart Fab” Concept - 2

- Machine tools today are quite sophisticated by themselves, but they are isolated and interact only with the operator
- It would be highly desirable:
  - to ask at any moment to the production chain: “is everything OK?”
  - to “Plug & Produce”
  - Have flexible and re-configurable manufacturing processes (customization)
  - Linking in-plant with out-of-plant processes (e-maintenance, “fab opening”, track-and-trace)
- The best way to imagine how a Smart Fab should behave, is to compare the manufacturing process chain to a football match:
  - From his previous match experiences (auto-learning process),
  - From the analysis of the position of the ball, of his position and all other players positions in the floor,
  - From the Coach suggestions, →
- **each football player knows what is the next best decision to take**
  - **The ball is the good under production**
  - **The Players are the machine tools / robots**
  - **The Coach is the ERP (Enterprise Resource Planning)**

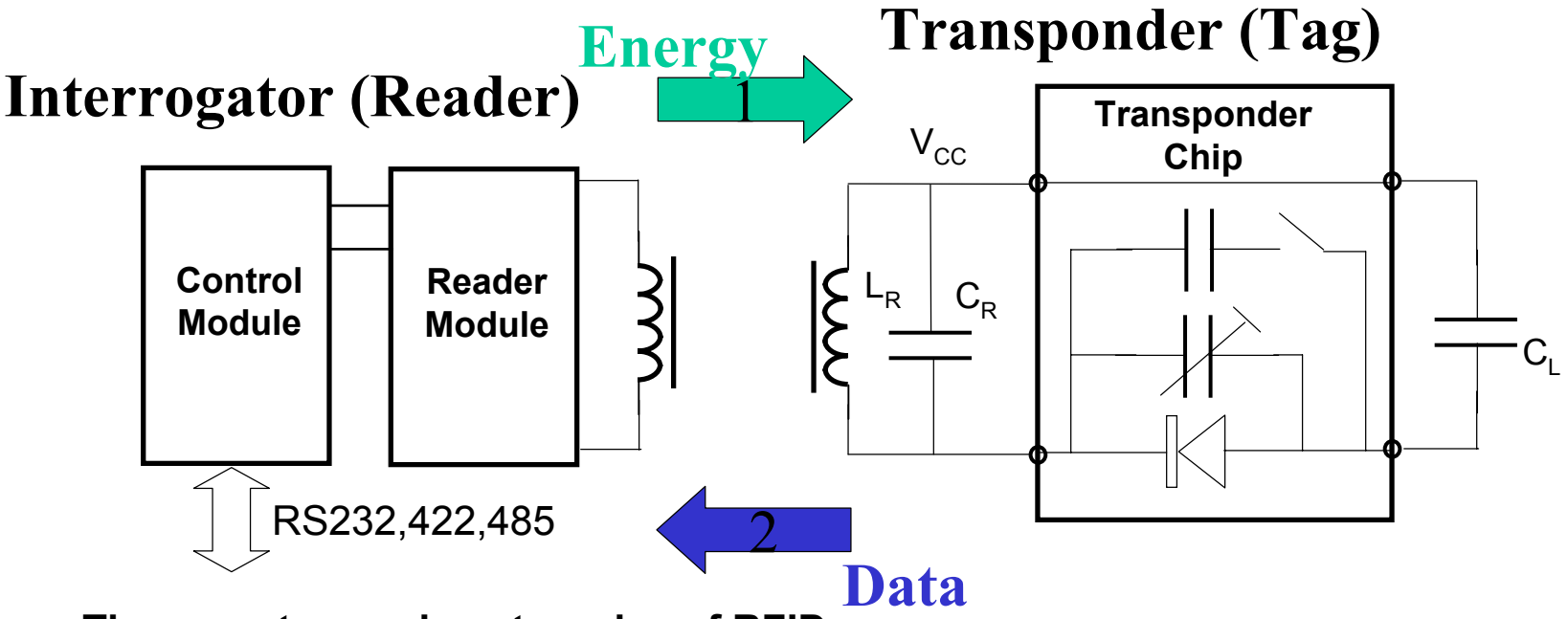
Part III:

Wireless Micro-Devices:

from the RFID to the Smart Communicative Components

RFID Tags

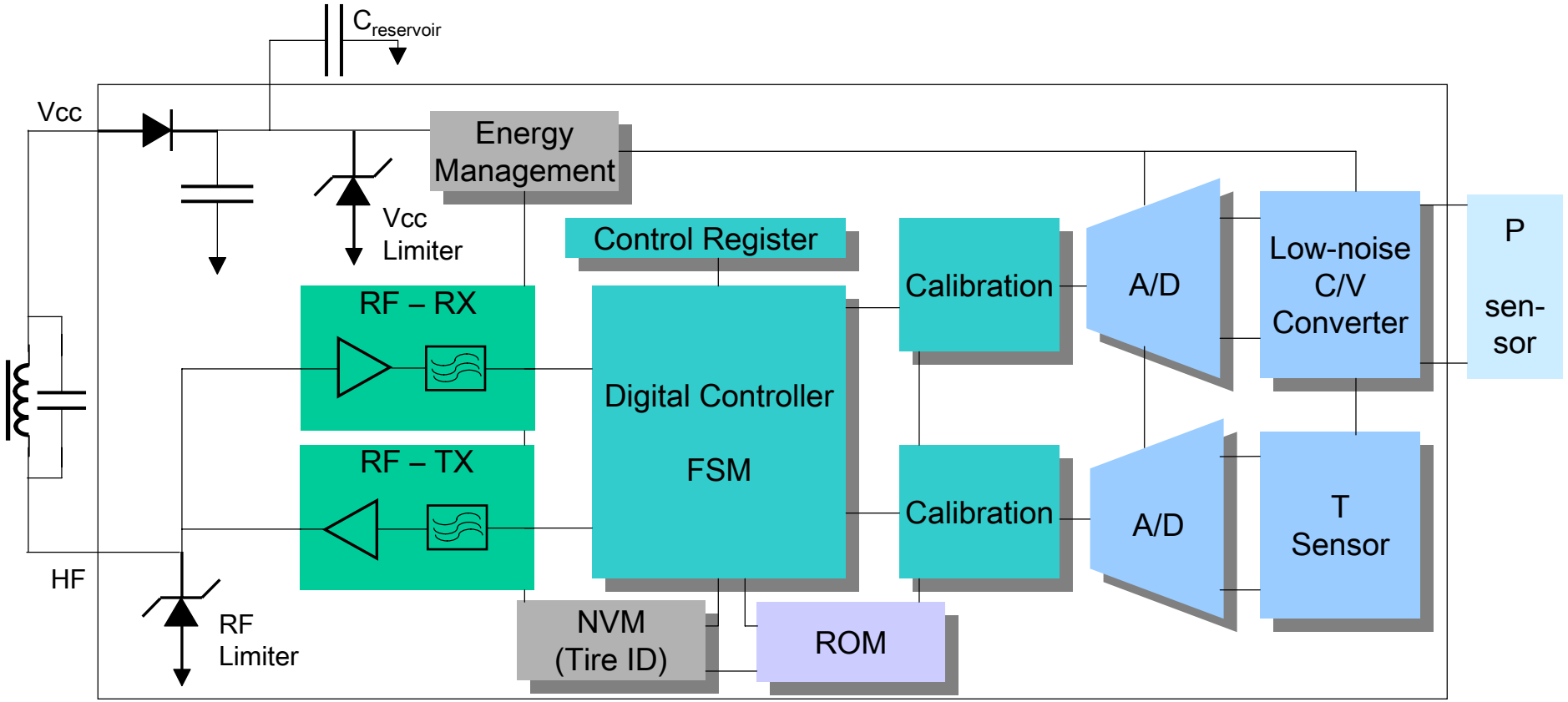
- **RFID = Radio Frequency Identification**
- **Applications:** lifestock management, security systems, access control, telepass, payments&billing, factory automation, smart buildings,...



- **There are two main categories of RFID:**
  - ***near field*****,** employing inductive coupling, the reader and the tag are closed like in a “space transformer”
  - ***far field*****,** the two units communicate like two wireless units through electromagnetic waves

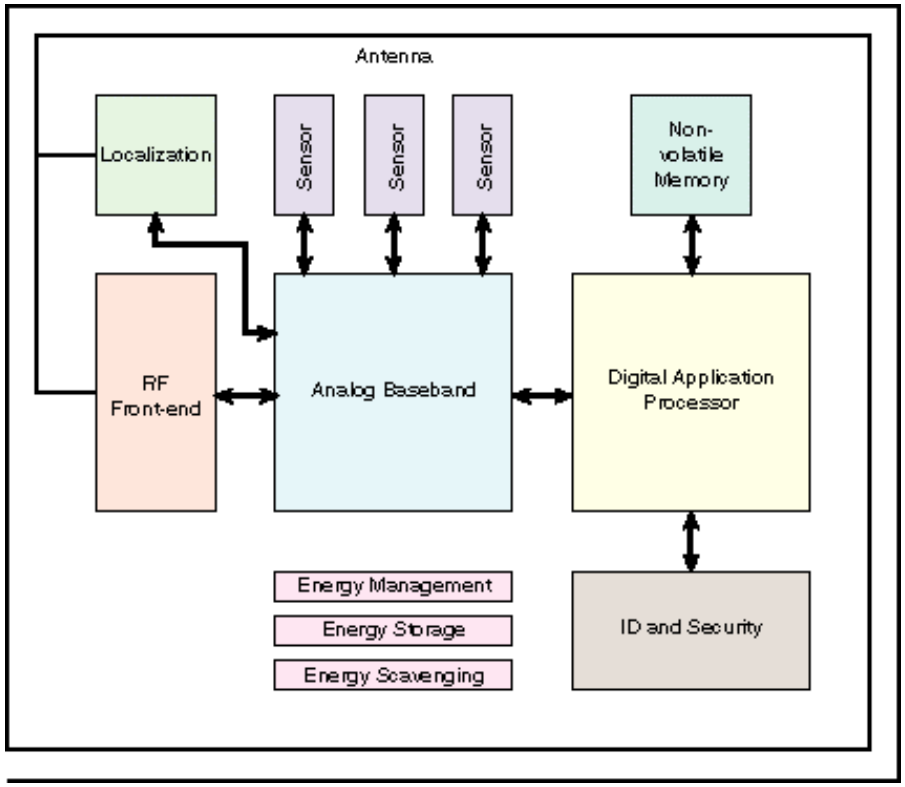
TPMS: Tire Pressure Monitoring Systems

- Sensing: temperature measurement (internal), pressure measurement (external)
- ID: unique identification number (i.e. 24-bit or 48-bit)
- Batteryless (wireless supplied, or energy scavenged, wheel rotation)
- Different transmission modes, ASK modulation, Manchester coding, Anticollision

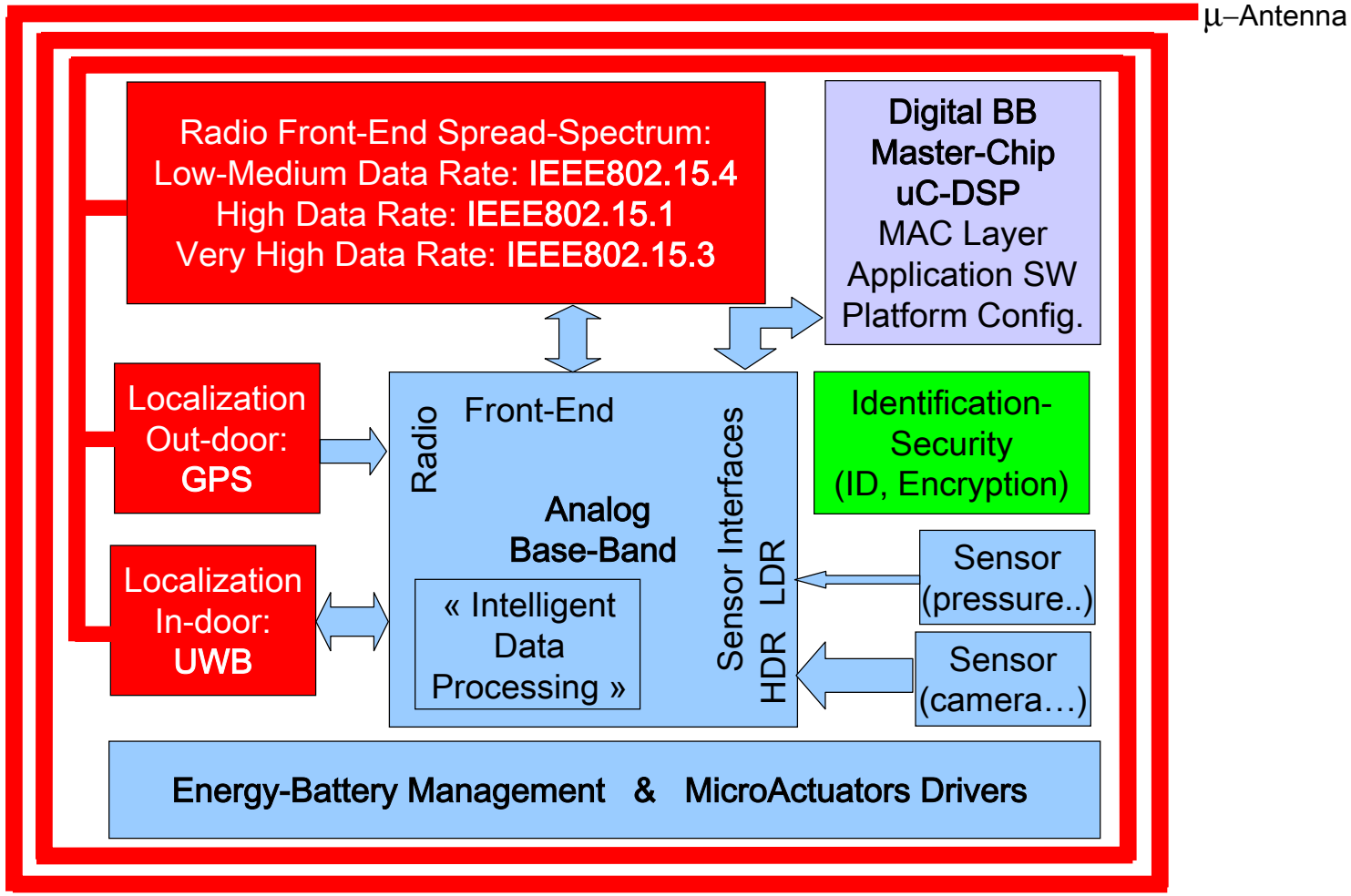


Smart Communicative Components (SC^2)

- **Capabilities:**
  - SPIN = Sensing, Positioning (Indoor, Outdoor), Identification
  - Autolearning, Intelligent Data Processing, capability to locally store, elaborate before send information
  - Security Management
  - Trasmission through different wireless modes, depending on requirements/conditions



Smart Communicative Components: platform example



SPIN Networks: Winning Standards

Characteristics	IEEE802.15.4 ZigBee	IEEE802.15.1 Bluetooth	GPS	IEEE802.15.3a (UWB-HDR)
Max. Data Rate	250 kbit/s	1-3 Mbit/s (V12 → V2 EDR)	50 bit/s	100 Mbit/s @ 10m 200 Mbit/s @ 4m
Max. Distance	30 meters	10 meters	-	10 meters
Frequency Allocation	2.4-2.4835 GHz (ISM)	2.4 GHz (ISM)	1.57542 GHz	3.1 – 10.6 GHz
Channel Bandwidth	0.3-0.6-2 MHz	1 MHz	2.046 MHz	Min. 500MHz Max. 7.5 GHz
No. RF Channels	1-10-16	79	-	1-15
Modulation	BPSK-OQPSK	GFSK	BPSK	BPSK, QPSK
Spreading	DS-SS	DS-FH	DS-SS	(Multiband)
Max. TX Power	~25mW,max in EU	20dBm	- (only RX)	-41.3 dBm/Hz
Sensitivity	-85dBm	-70 dBm	-140 dBm	-

- **Hot topics:**
  - **Localisation** technologies (GPS → Galileo, UWB, Wi-Fi,...)
  - ULP (Ultra Low Power) long range data transmissions

Part IV:

Cellular Networks

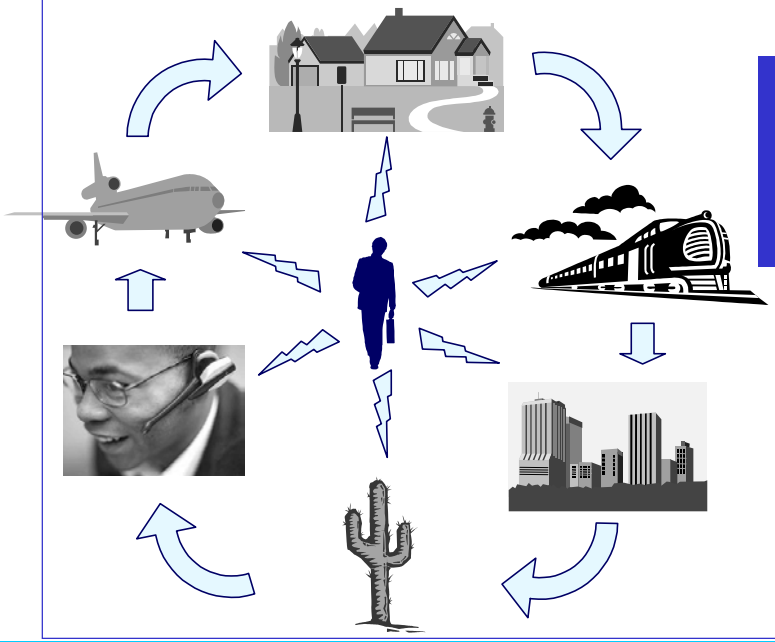
4G = Fourth Generation

- **ABC = Always Best Connected**
- **WWW.CON = Wireless Wireline Worldwide CONvergence**

Moving towards the mobility paradigm

Network-centric /device specific

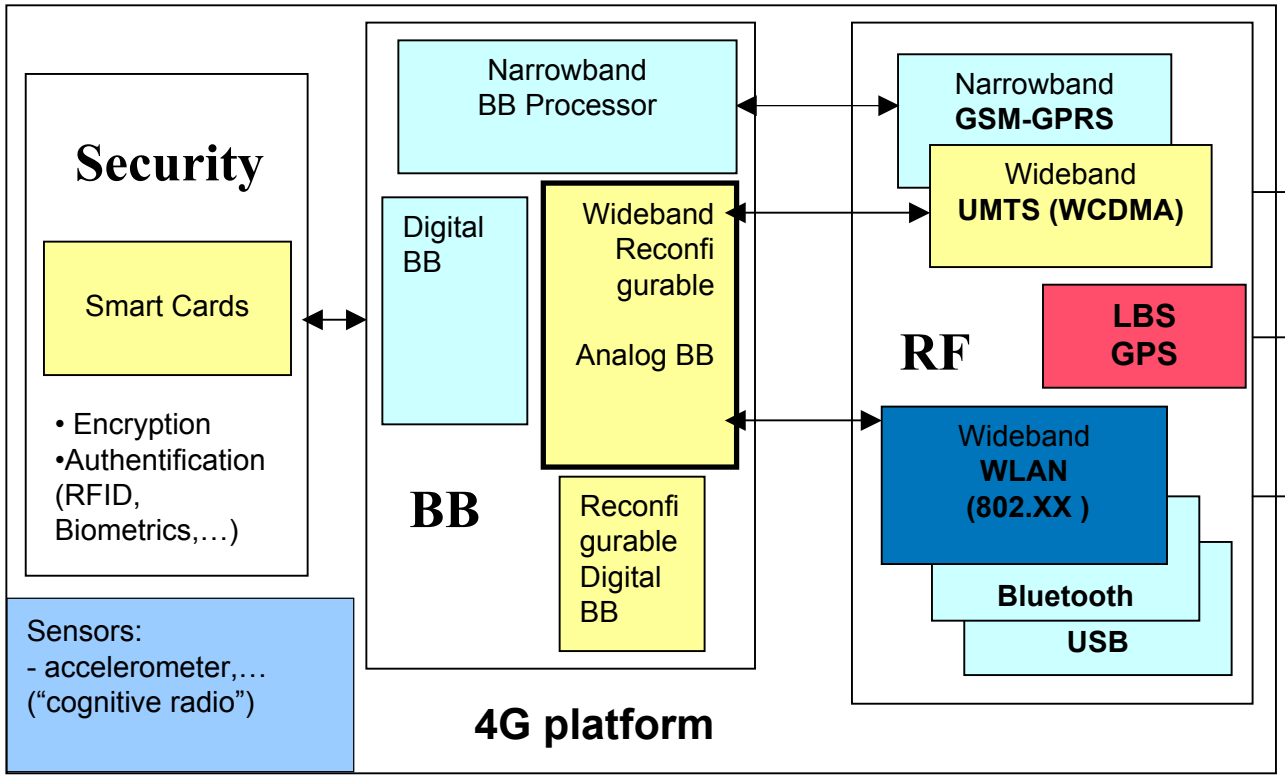
User-centric/device agnostic



4G = User-Centric Technology

Optimum connectivity and seamless mobility anytime, anywhere

Overview of a 4G smarTerminal



- **Cellular modes**
  - GSM, GPRS
  - UMTS
- **WLAN modes**
  - (WI-FI,…)
- **PAN modes**
  - Bluetooth
  - DECT…
  - USB Wireless
- **LBS**
  - GPS (Galileo)
- **Authentication**
  - SIM, Fingerprint,
  - RFID
- **Security**
  - Ciphering,
  - Encryption
- **Sensors**
  - Context Aware
  - Cognitive Radio

Secured Radiocommunications (PMR)

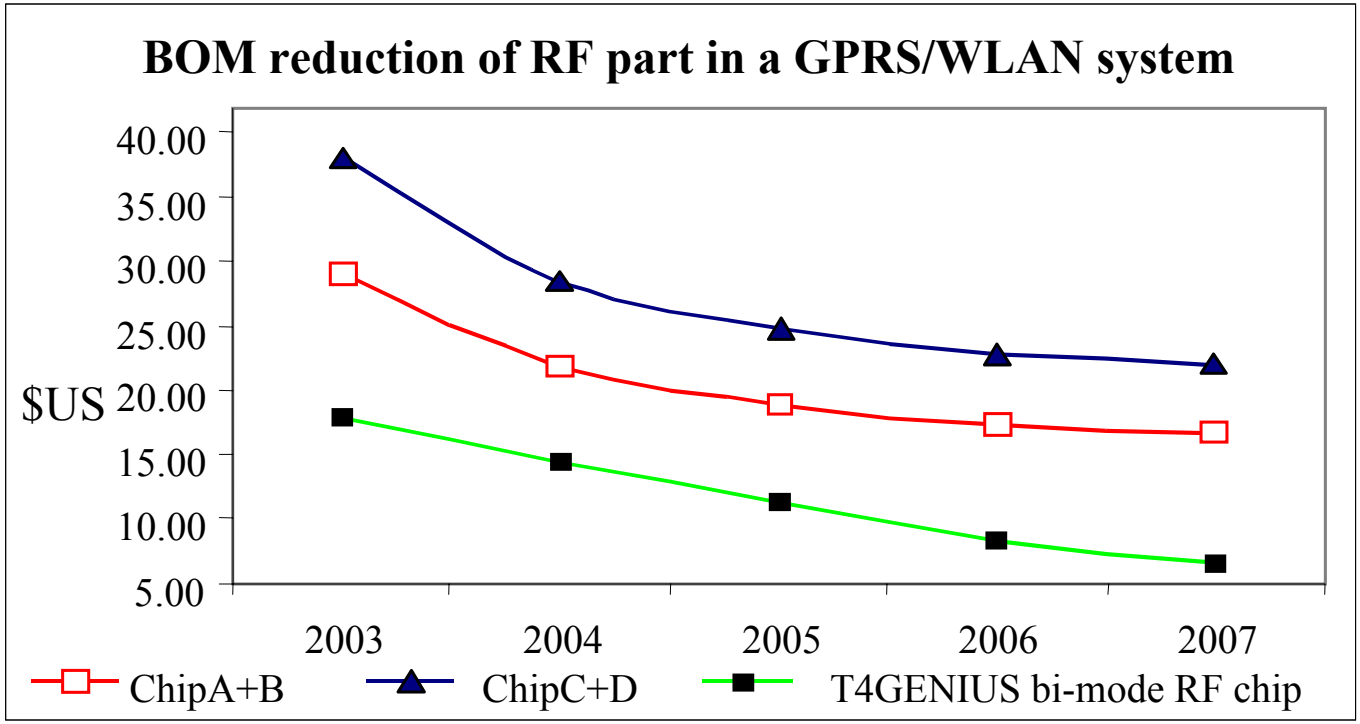
- A **specific, dedicated** wireless mode:
  - Guarantee of access to the network
  - Security, confidentiality of exchanges
  - Specific features:
    - Group call,
    - Priority call,
    - Emergency mode
- Priority users : **emergency services, police, firefighters, hospitals…**
- Most important **standards** over the world:
  - TETRA (400 & 800MHz)
  - TETRAPOL (400 & 800MHz)
  - APCO25 (700 & 900MHz)

Part V:

Challenges

Design Challenges : Multi-mode Reconfigurable Architectures

- **There is a huge market for multi-mode reconfigurable systems:**
  - Cellphones: GSM-DCS-PCS multi-band radio, GSM/GPRS/WCDMA/WLAN
  - Bluetooth V2: GFSK for 1Mbit/s, pi/4DQPSK for 2Mbit/s, 8DPSK for 3Mbit/s
  - PMR interoperable terminals: Tetra-Tetrapol-Apco25
  - Adaptive-Multi-Rate (AMR) 8/16 ksample/sec voice-wideband codecs



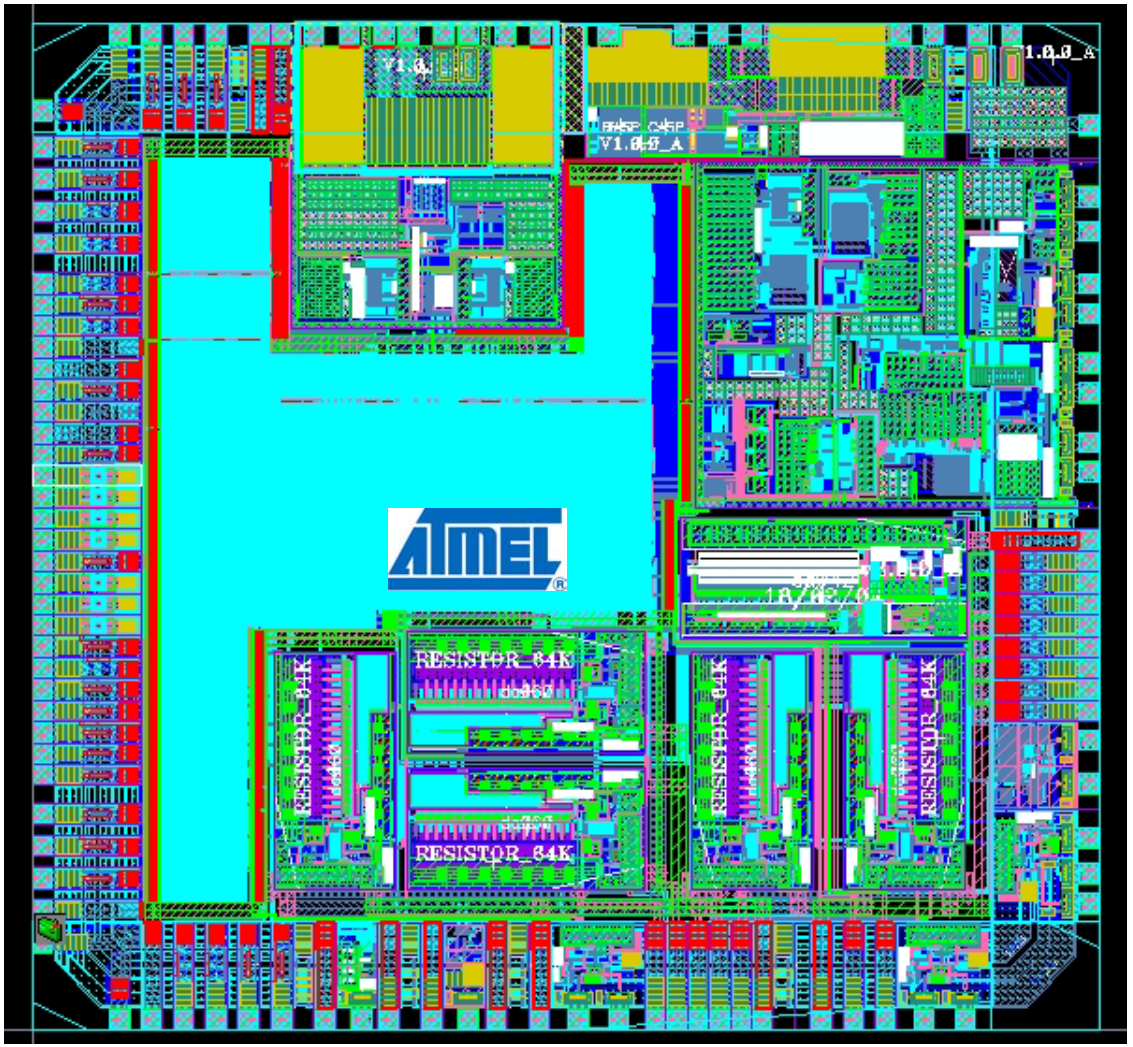
Simulation showing the cost reduction for an integrated GPRS-WLAN RF chip versus separate ASSP's

Example: 3G PMR Reconfigurable Analog Base-Band

- **PMR multi-mode operability:**
  - Tetrapol
  - Tetra
  - Apco25

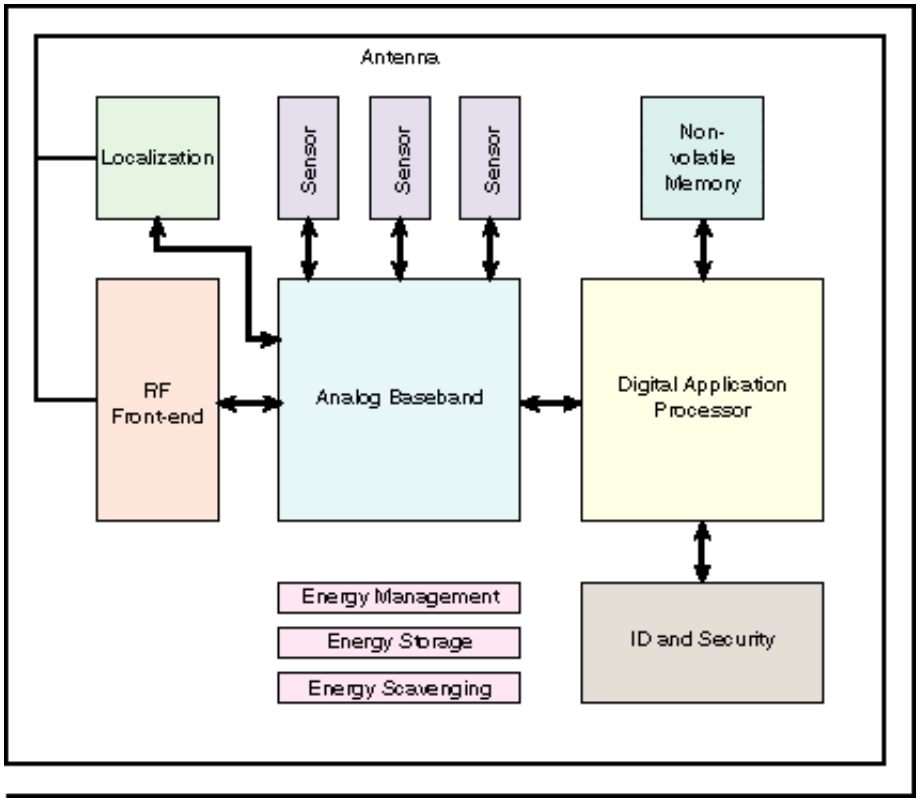
  - Analog MAC mode
  (Mutual Aided Channel)

- **Features**
  - Programmable master clocks
  - Reconfigurable digital filtering

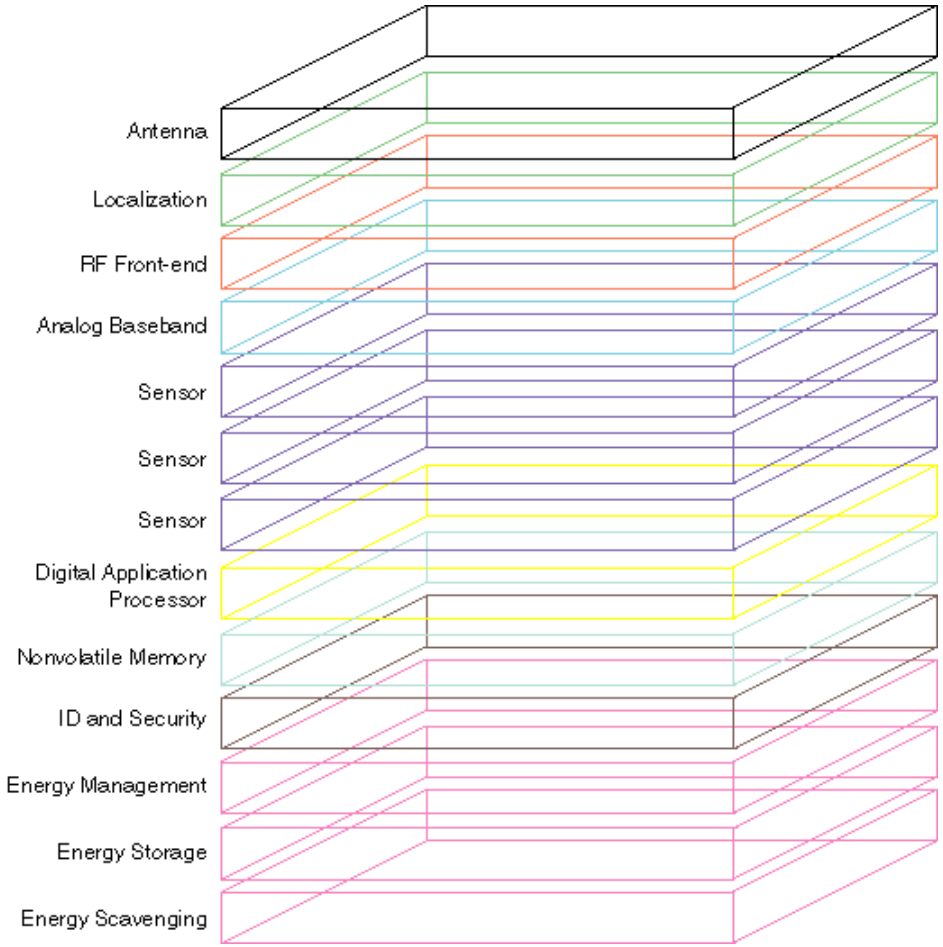


Technology Challenges: Smart Sensors Integration

Horizontal Integration: Chip-Set



Vertical Integration: Microsystem



Conclusion

- **Wireless market is currently subdivided into three big categories:**
  - **SPIN Networks** ☛ They enable the AMI (Ambient Intelligence)
  - **Cellular Networks** ☛ consumer and PMR modes converging into secure communications
  - **Area Networks** ☛ converging with cellular into 4G systems

- **Challenges:**
  - System costs reductions, miniaturization
  - Micro-system horizontal and vertical integration
  - Multi-mode multi-standard reconfigurable systems
  - Only CMOS technology
  - Face the challenges of following up the CMOS deep submicron scaling trend (0.13um, 90nm, 65nm,..):
    - Decrease of power supply, degradation of some electrical parameters
    - Signal integrity (clock speed increases, jitter, crosstalk, substrate noise,…)

- **However, wireless is seen as high-potential technology for solving or alleviating many societal problems. Strong research efforts will continue, and with them new outstanding achievements will arrive.**