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SMART SYSTEMS INTEGRATION 2008
European Conference & Exhibition on integration issues of miniaturized systems
MEMS, MOEMS, ICs and electronic components
9-10 April 2008, Barcelona, Spain

Wireless Smart Systems Beyond RFID

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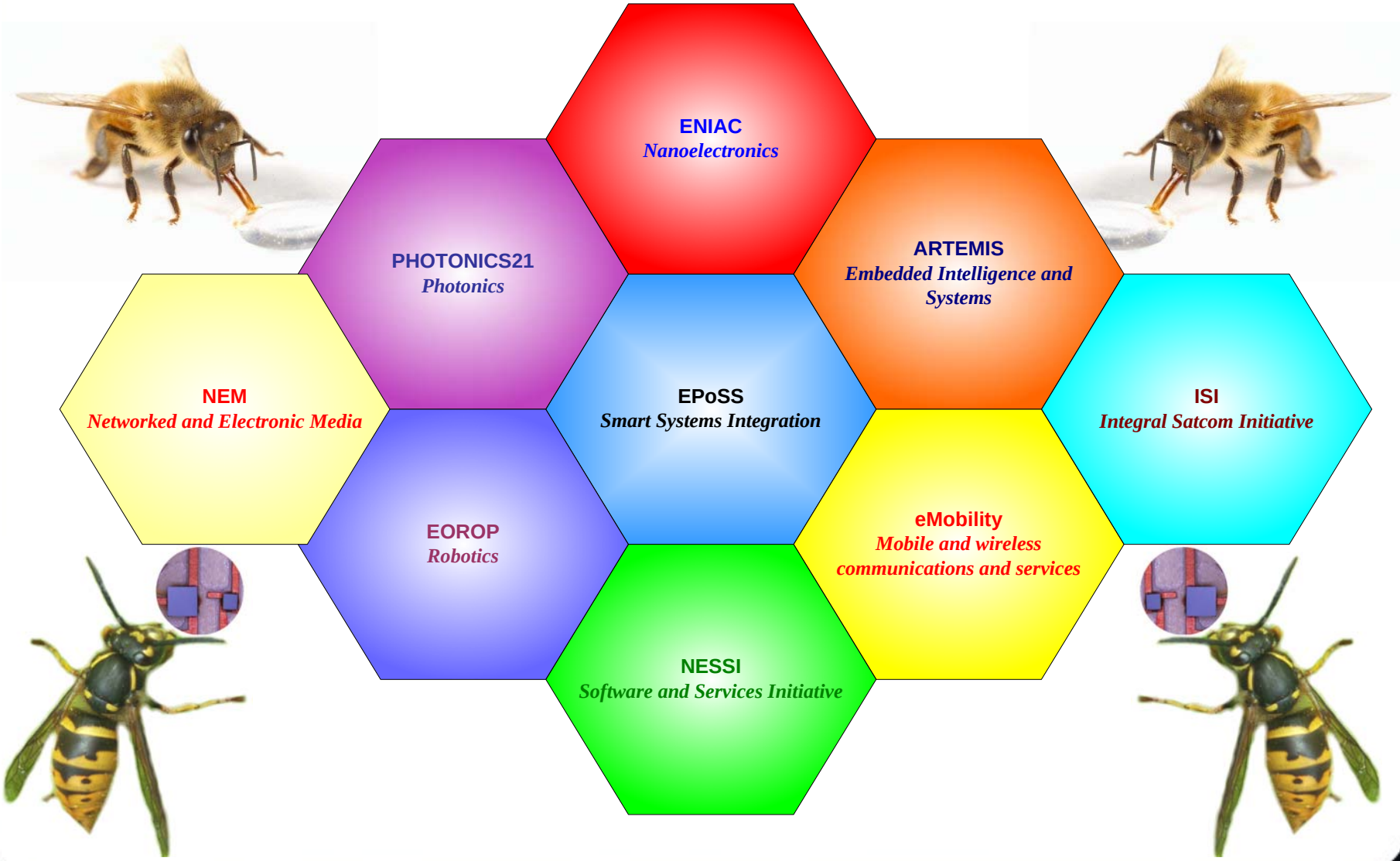
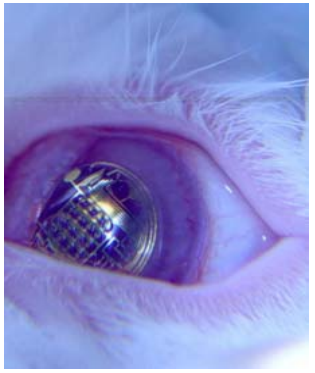
European Technology Platforms



Wireless Smart System Applications

- Automotives
- Aeronautics
- Information and Telecommunication (ITC)
- Medical Technologies
- Logistics and object mobility and management



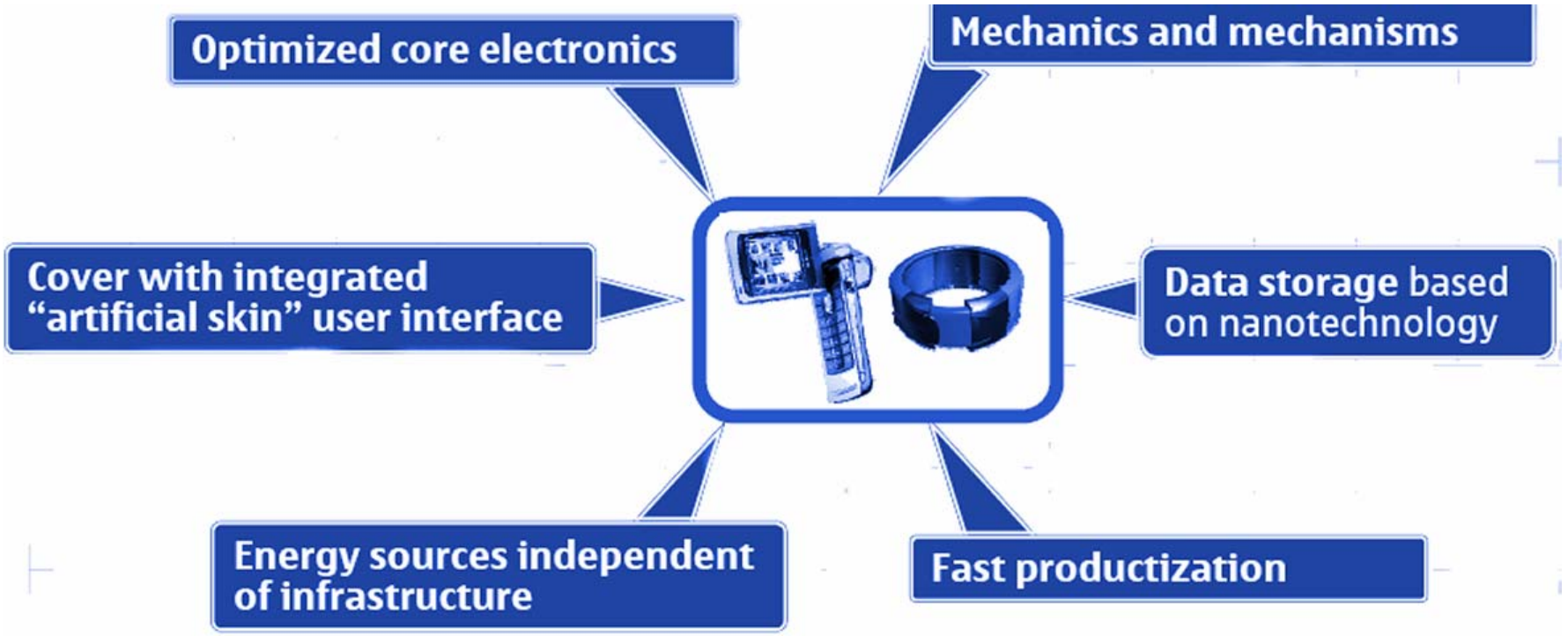
Wireless Smart System Applications

- Mobile robots with different sensing capabilities combined with wireless sensor networks and RFID ubiquitous networks.
- Robust and versatile hybrid/heterogeneous networked systems that can be deployed in automotive, aeronautics applications and placed in inaccessible, or remote spaces (oil platforms, mines, forest for fire protection, tunnels, pipes, etc.) or in cases of emergencies or hazardous situations (earthquakes, fire, floods, radiation areas, etc.,).
- Ultra low power consumption tags
  - Increased reading range - passive/semi passive RFID tags
  - Longer operating life - active RFID tags
- Harsh environment RFID smart systems working at -40 to 200°C, with vibration and shocks conditions and in contact with different chemical substances

Applications and Drivers

Source: NOKIA

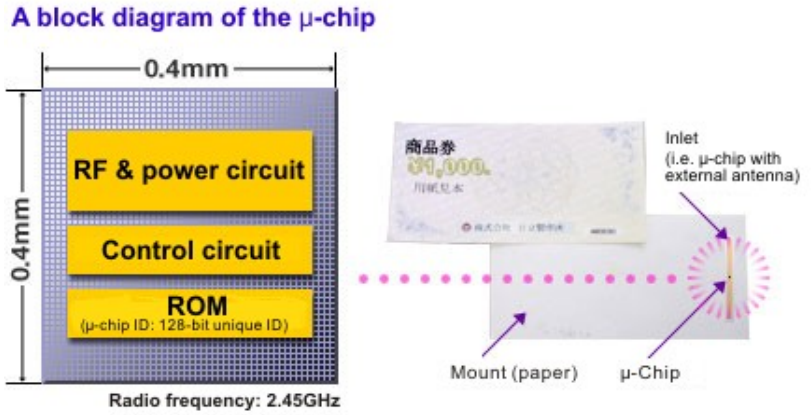
Miniaturized communication device



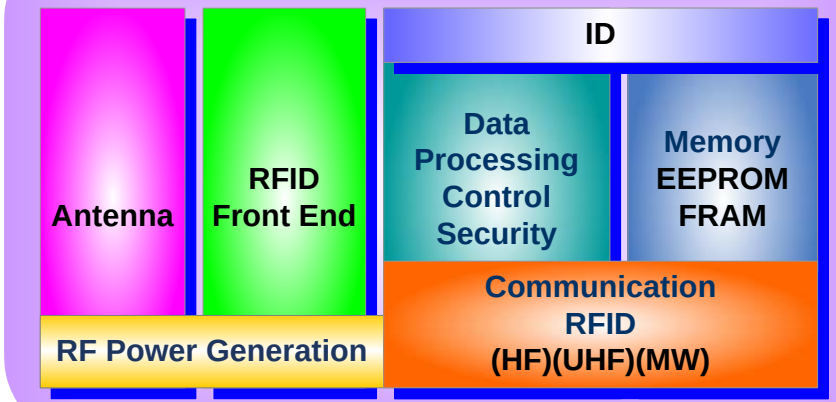
Source: NOKIA

Wireless Systems RFID

- RF ID
  - Antenna
  - Integrated Circuit Micro/Nanoelectronics
    - RF Front End
    - Memory
    - ID - 96 bits
    - RFID Communication Protocol
    - Digital Processing
    - Security
  - Assembly
  - RF Power Generation
  - Low Cost



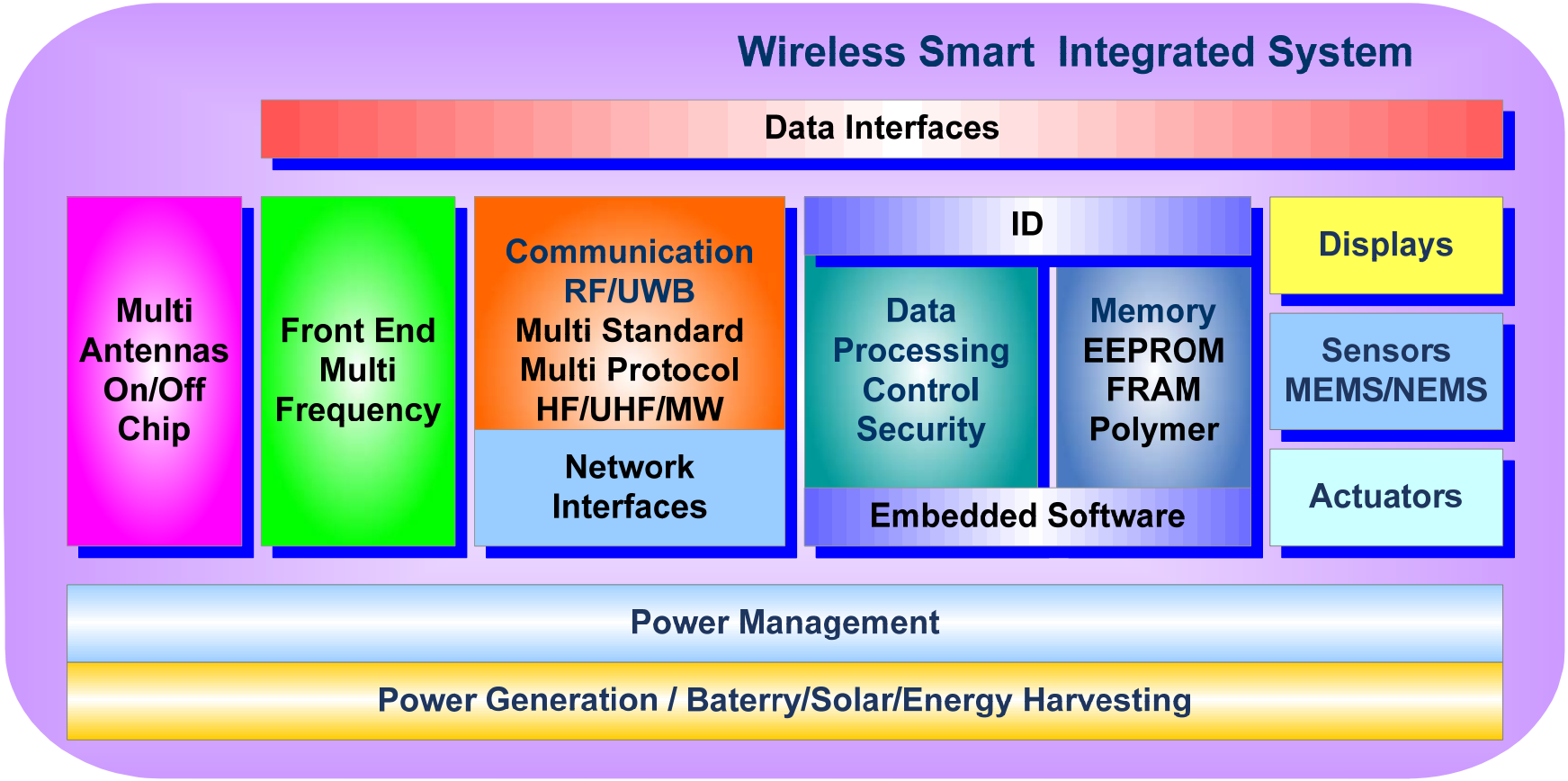
Source: Hitachi



Source: SINTEF

Smart Wireless Systems

- Beyond RF ID



Source: SINTEF

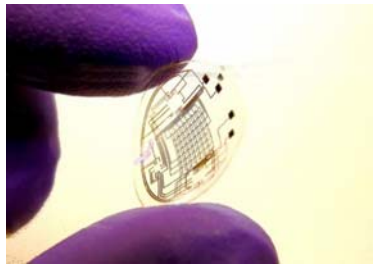
Smart Wireless Systems

- Beyond RF ID - Functionality
  - Multi Antennas
    - On Chip Antenna –OCA
    - Coil on Chip (HF)
    - Printed antennas
    - Embedded antennas
    - Multiple antenna substrates
    - 3D structures
  - Integrated Circuit Micro/Nanoelectronics/Polymer
    - Multi RF Front Ends
      - HF/UHF/MW/Radar
    - Memory – EEPROM/FRAM/Polymer
    - ID 128 bits + other type ID
    - Multi Communication Protocols
    - UWB
    - Digital Processing
    - Security

Source: Toshiba

- Displays
  - Bi-stable
  - Flexible
  - Transparent

Combined flexible contact lens with an imprinted electronic circuit



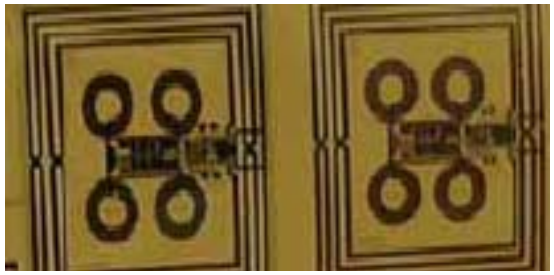
Source: University of Washington

Source: Siemens

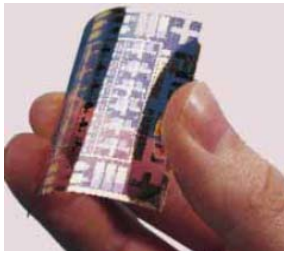
- Sensors/Actuators
  - MEMS/NEMS
  - Sensors on Chip
  - Molecular sensors
- Assembly
- Power Generation
  - RF
  - Solar
  - Harvesting (vibration, temp, etc.)
  - Batteries printed/polymer
  - Fuel cells

Smart Wireless Systems

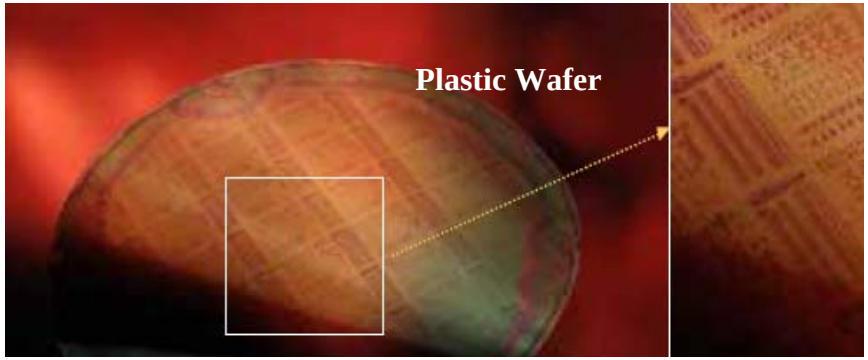
- Beyond RF ID - Cost
  - Antenna
    - Printed antennas
    - On Chip Antenna
  - Polymer electronics
    - RF Front End
      - HF/UHF
    - Memory –Polymer
    - ID 128 bits or less
    - Communication Protocol
    - Digital Processing
    - Security
  - RF Power Generation
  - Ultra Low Cost



Source: Philips



Plastic chips

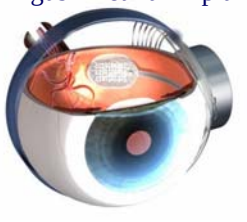


Source: PolyIC

Smart Integration and Nanosizing

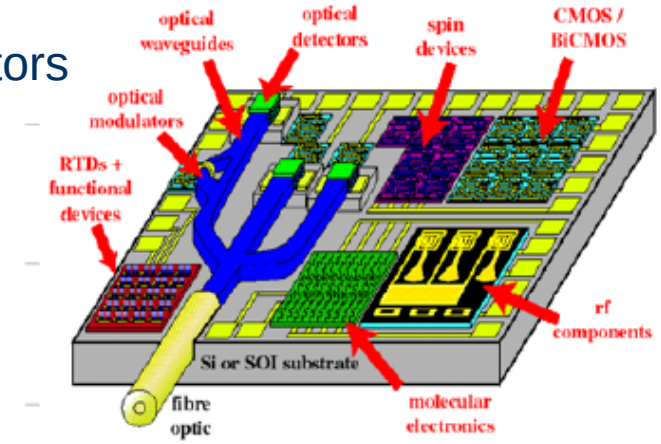
- Targets for the technology development
  - Low cost materials and fast processes
  - Improvement of performance
  - Miniaturization
- Trends
  - Communication devices integrated with other electronic products,
  - Communication devices are small devices dedicated only for some specific functions and for short-distance communication
- Miniaturization and Nanosizing
  - Optical waveguides, detectors and modulators
  - NanoRF components
  - Molecular electronics

Argus II retinal implant



Source: Second Sight Medical Products Inc

Source: Samsung



Source: NOKIA

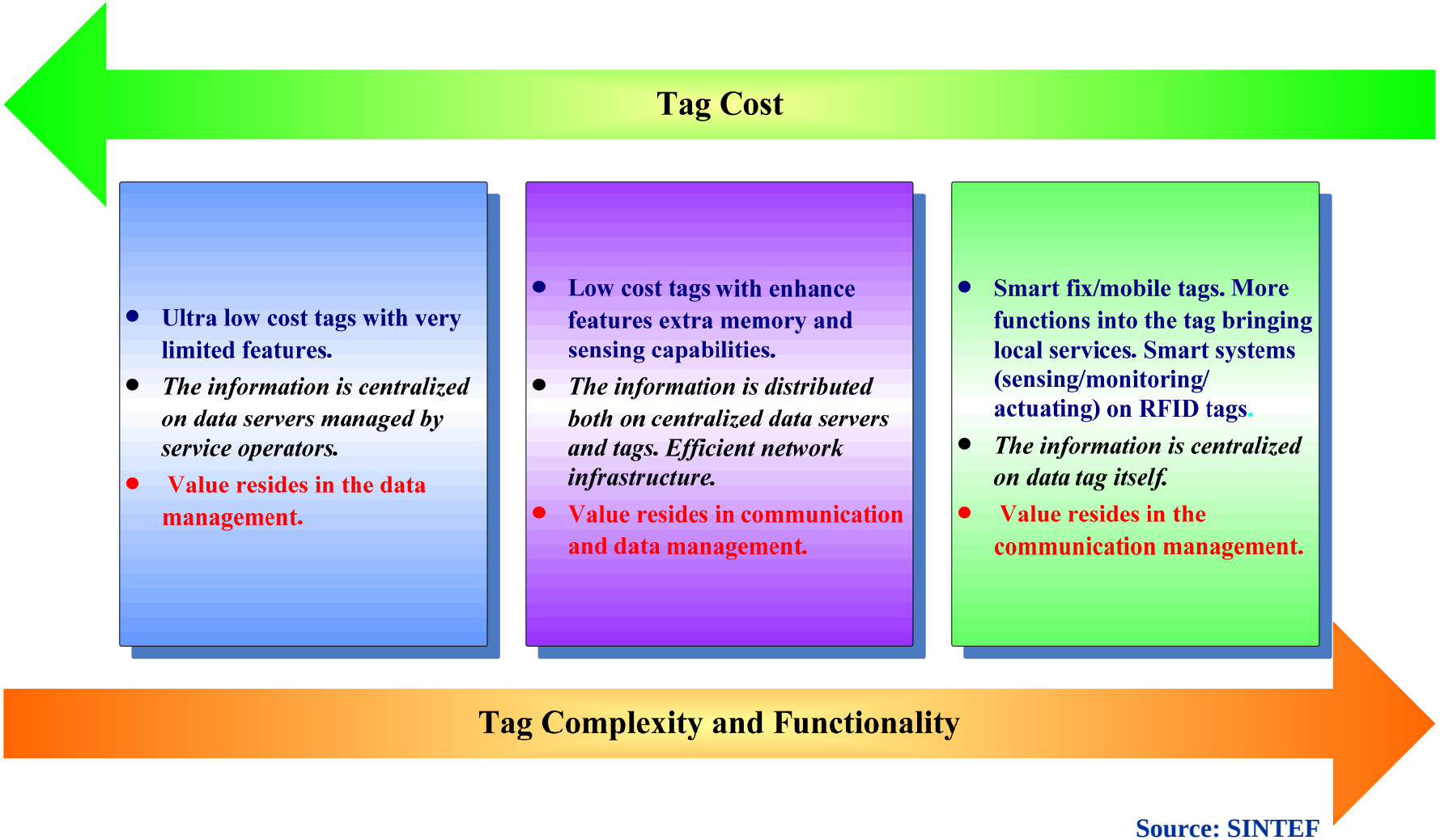
Wireless Systems Characteristics

- Wireless
  - Limited bandwidth, high latency
  - Variable link quality and link asymmetry due to noise, interference, disconnections
  - Easier snooping
    - Signal and protocol processing
- Mobility
  - Determine variability in system design parameters:
  - Connectivity, bandwidth, security domains, location awareness
    - Protocol processing
- Portability
  - Limited capacities (battery, CPU, I/O, storage, dimensions)
    - Energy efficient signal and protocol processing

Source: Momenta

Source: Momenta neck-worn PC

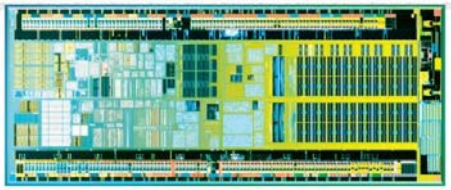
Smart Wireless Systems



Source: SINTEF

Smart Wireless System on Chip

- Two trends:
  - Increasing use of “embedded intelligence”
  - Networking of embedded intelligence
- Future directions:
  - Complex: Network on chip
    - Terabit optical core, gigabit wireless
  - Smart: Smart on chip
    - Pervasive self-powered autonomous sensor “nodes”
  - Low cost: One cent on chip
    - Low cost RFID/Radios
    - Short-range (10-100m), low power (10nJ/bit), low bit rate (1-100kbps)
    - CMOS/Polymer technologies
- The consequence:
  - Smart spaces, intelligent interfaces, ad hoc hybrid networks



Source: Intel

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Reconfigurable Wireless Systems

- Wireless sensor networks - hundreds of nodes used in applications like ambient monitoring in buildings, environmental monitoring, home automation, personalization, localisation, positioning, etc. This needs to:
  - Identify methods of effectively managing power consumption at different levels of the network design, from network routing down to the architecture of individual nodes.
  - Use efficient methods of networking a large number of energy constrained nodes
  - Design and verify these highly complex devices
  - Increase the flexibility, programmability and debug support of these devices without sacrificing speed and power performance.
  - Increase the robustness and coverage of individual nodes

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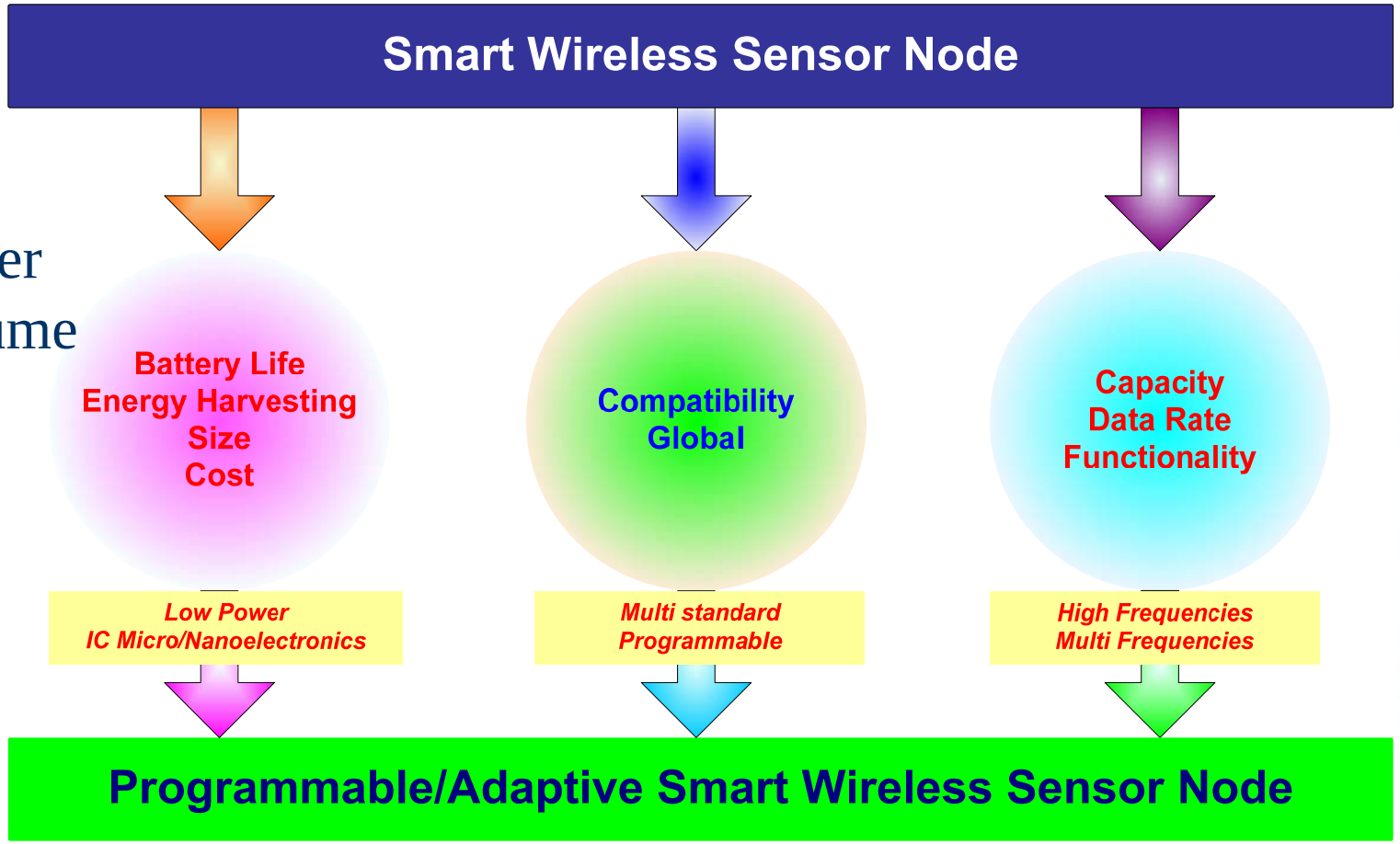
Smart Wireless Systems

- Low Cost
- Low Power
- High volume



- Multi-mode/Multi-band operation
- Service Integration

Source: SINTEF

Reconfigurable Wireless Systems

- Need for reconfigurability by using the same hardware platform to adapt to different conditions since the network nodes will be used in a wide range of applications, and they will need to adapt to their environment (communication standard, frequency, power consumption, data rate).

Source: NOKIA

Advantages

- High level of adaptivity
  - Different layers and between layers
  - Adaptive applications
  - Self organizing and self healing architectures
  - Adaptive radios
- Reconfigurable air interfaces - multi mode/multi standard/multi frequency nodes/terminals - SW radio implementations
- Improved physical layer design
  - SoC/SiP
  - Spatial domain processing multiple input multiple output (MIMO) with smart antennas
  - Integrated space time receiver design (integrated multi user detector decoder)
- System design that will allow high mobility and broadband transmission
- Signal system level simulations

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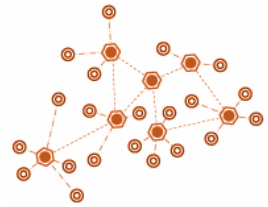
Pervasive Embedded Intelligence



Devices as Appliances

Ad-hoc Sensor

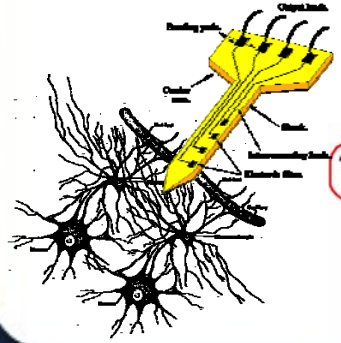
RFID Node

Sensor Node

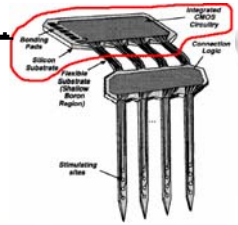
Adaptive Wireless

On-Body

In-body

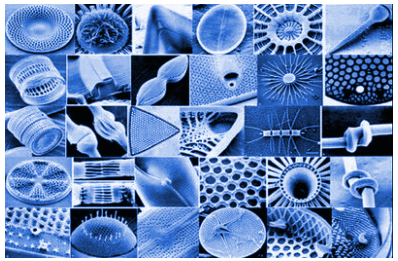


Neuro-stimulators



DynamicArm

MEMS Sensors



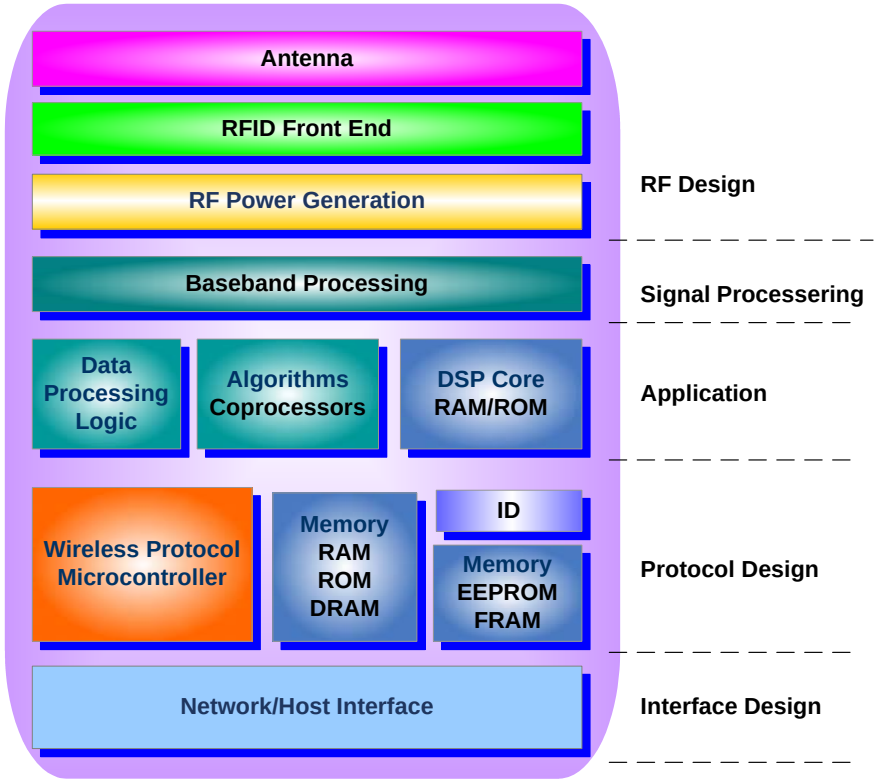
In-Home

Challenges and Constraints

- Semiconductor technology scaling gives rise to three key challenges:
  - Challenge of scalability
    - the need to extend communications and processing to large data, over heterogeneous channels
  - Challenge of adaptation
    - the need to reuse and retarget both hardware and software
  - Challenge of integration
    - the need to more optimally exploit heterogeneous component technologies with respect to cost, performance, energy tradeoffs
- Fundamental technology *constraints*:
  - Energy (limitations of batteries, sensors)
  - Bandwidth (limited speed of semiconductor devices)
  - Non-scalability of analog circuits
  - Scaling of on- and off-chip interconnects

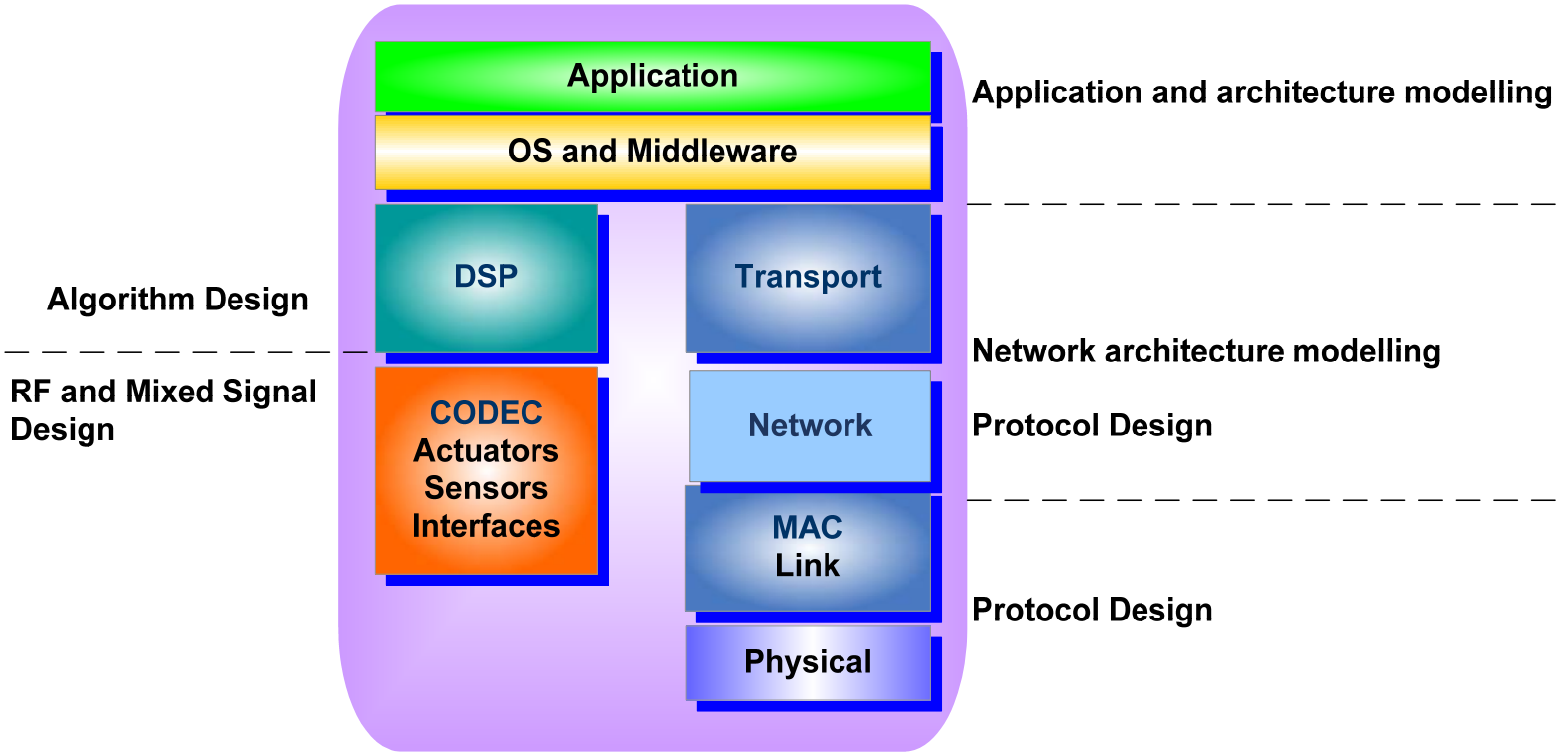
On Chip View

- Integrated heterogeneous systems
  - Hardware/software
  - Mixed analog/digital (RF/BB)
- Circuits with minimal analog processing
- Maximize digital computation
- Reuse communication, multimedia modules
- Energy efficient software
- Flexible, low power protocol processing



Network view

- On chip application computing
- On chip communication and networking
- Indeed, complete integration of all layers of a networked node on a single chip



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Beyond RF IDentification

- Ambient Intelligence and ubiquitous computing
- Hybrid wireless sensor networks that are characterised by modularity, reliability, flexibility, robustness and scalability.
- Different communication protocols
  - RFID
  - ZigBee
  - Ultra low power Bluetooth
  - WiFi
  - WirelessHART
  - ISA100.11a
- Wireless monitoring of different ambient parameters (video, audio, temperature, light, humidity, smoke, air quality, radiation, energy, etc)
- Mobile robotic sensor networks.

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Beyond RF IDentification

- **Hybrid wireless sensor networks** that enable context and situation based personalised applications and services:
- User context identification
  - Biometrics
  - Privacy mood
  - Attention
  - Gesture
  - Posture
- Social context
  - Surrounding people and/or objects/things
  - Type of group
  - Link to people and/or objects/things
  - Net link - Internet of Things
- Environmental context
  - Location, position
  - Time
  - Condition
  - Physical data