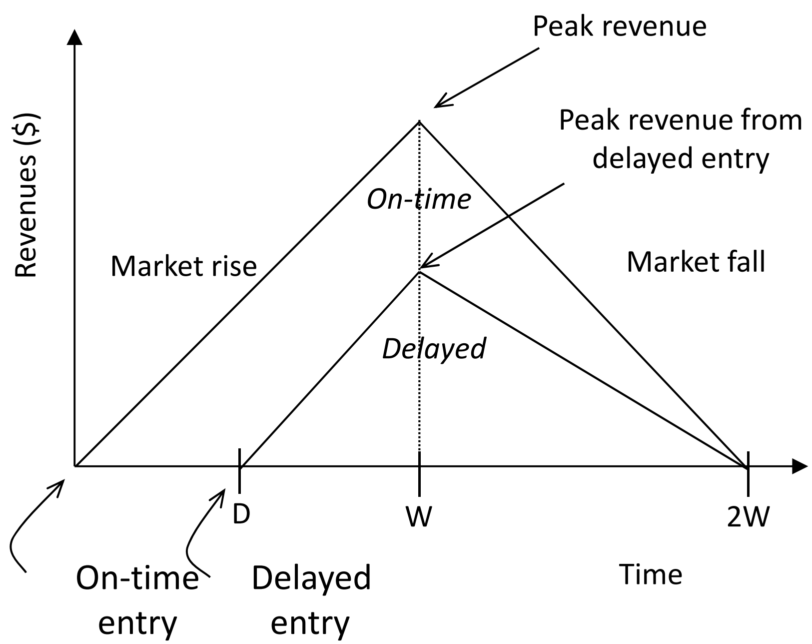
Losses due to delayed market entry



- **Simplified revenue model**
  - Product life = 2W, peak at W
  - Time of market entry defines a triangle, representing market penetration
  - Triangle area equals revenue
- **Loss**
  - The difference between the on-time and delayed triangle areas

–Lifetime 2W=52 wks, delay D=4 wks

–(4*(3*26 –4)/2*26^2) = 22%

–Lifetime 2W=52 wks, delay D=10 wks

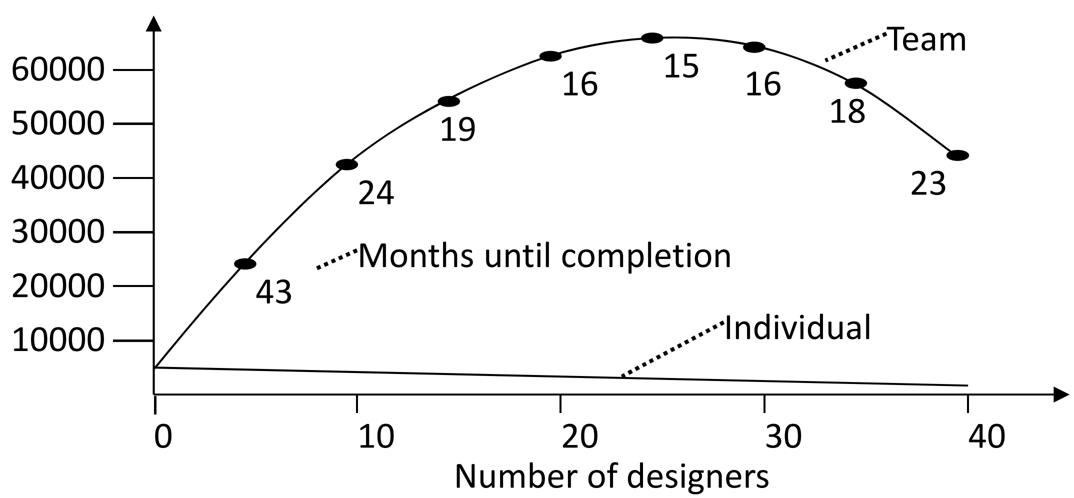
–(10*(3*26 –10)/2*26^2) = 50%

–Delays are costly!

The mythical man-month

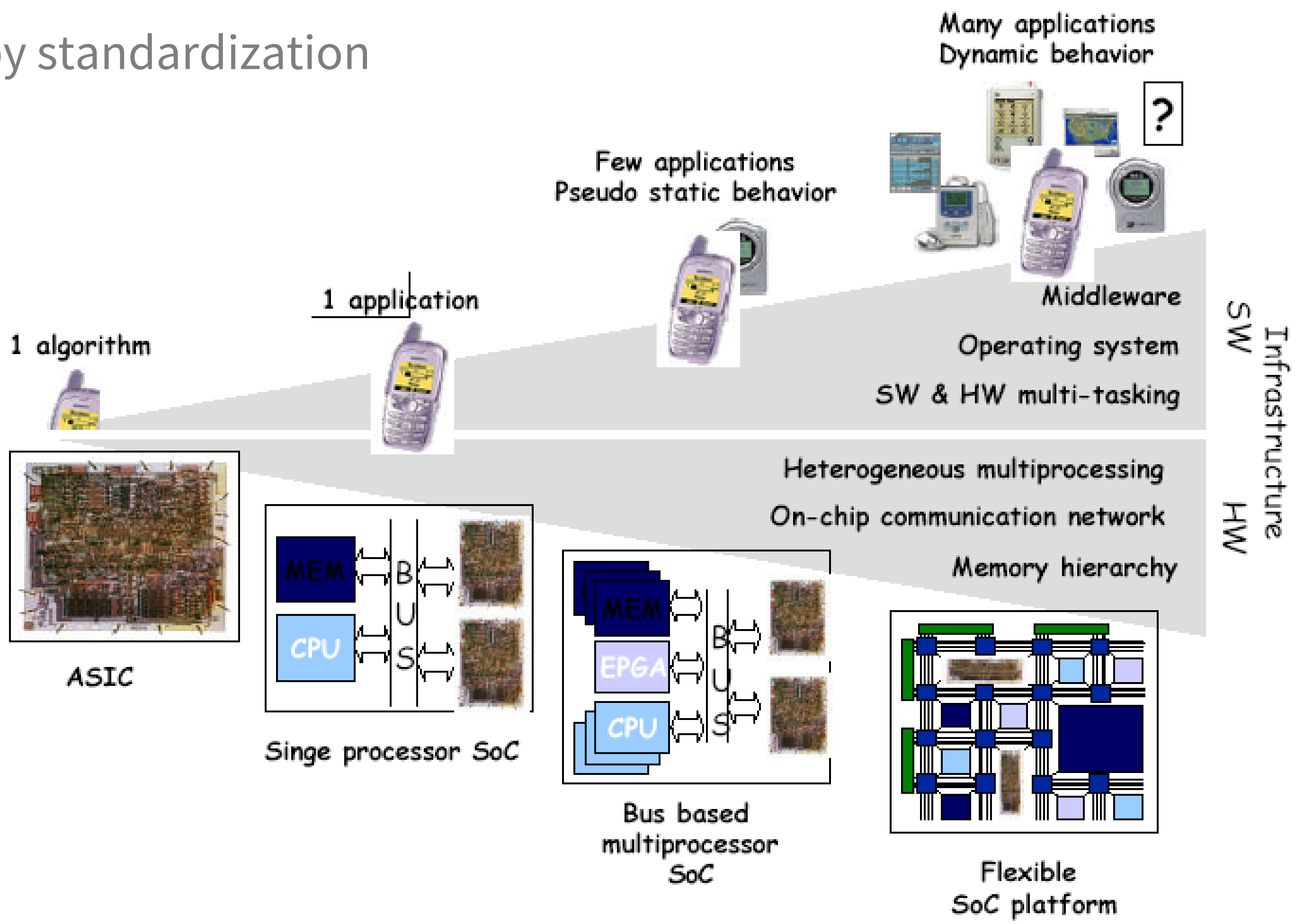
- **The situation is even worse than the productivity gap indicates**
- **In theory, adding designers to team reduces project completion time**
- **In reality, productivity per designer decreases due to complexities of team management and communication**
- **In the software community, known as “the mythical man-month” (Brooks 1975)**
- **At some point, can actually lengthen project completion time! (“Too many cooks”)**

- 1M transistors, 1 designer=5000 trans/month
- Each additional designer reduces for 100 trans/month
- So 2 designers produce 4900 trans/month each



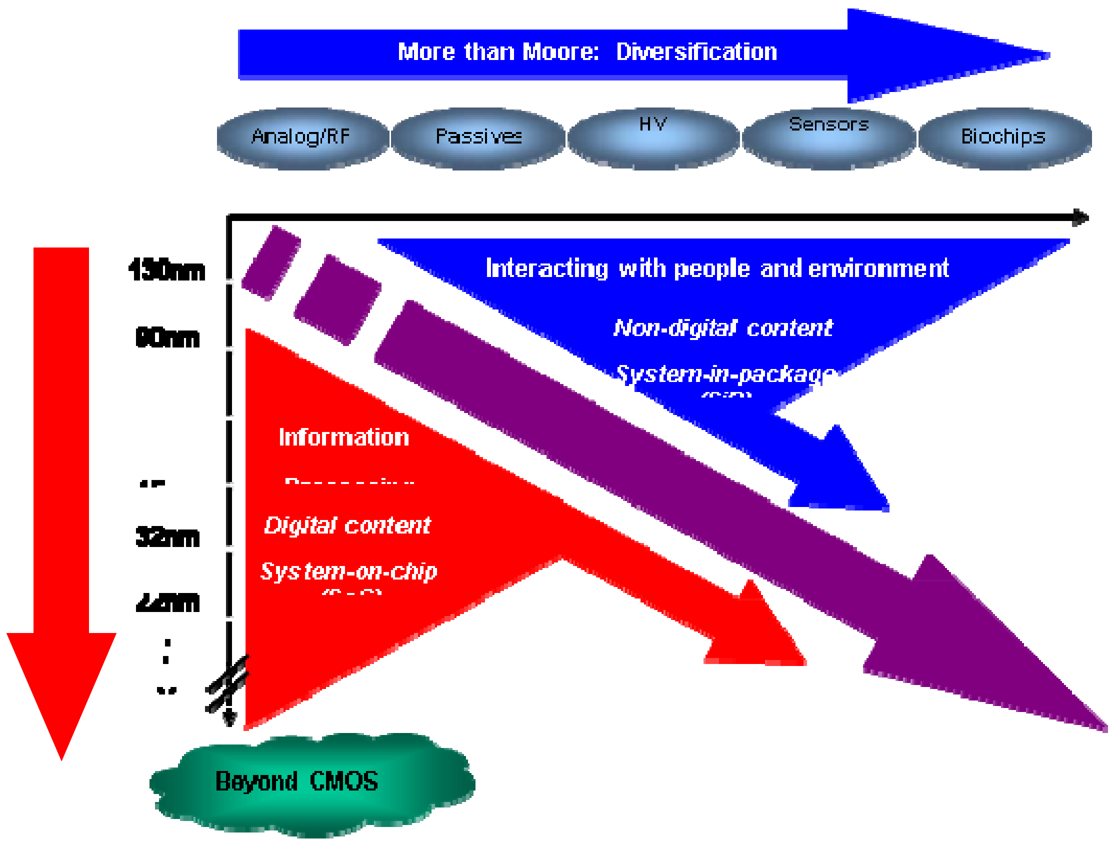
Platform based design

- **Design methodology must support re-use**
  - at high abstraction levels
  - supported by standardization

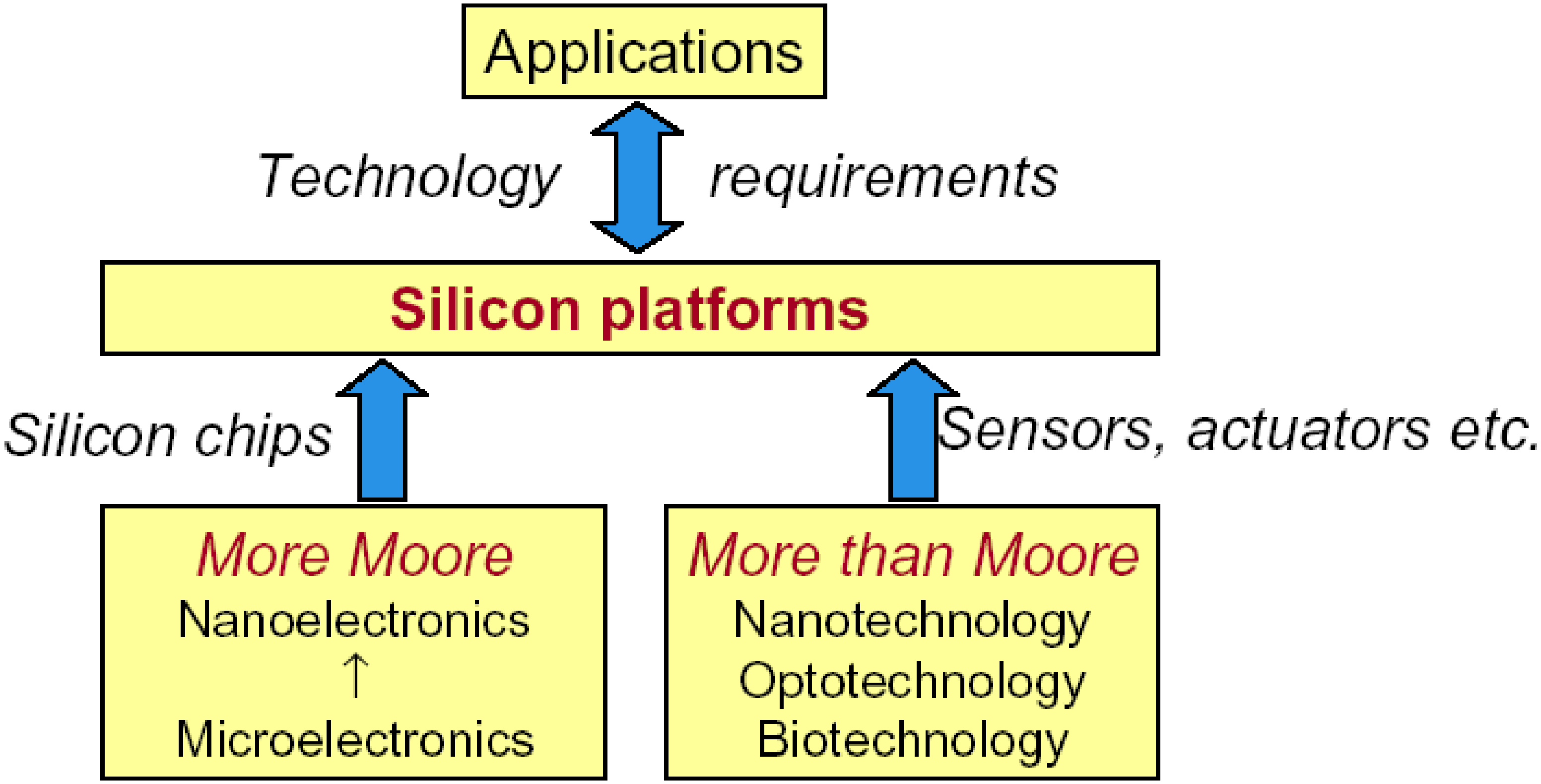


More – than - Moore

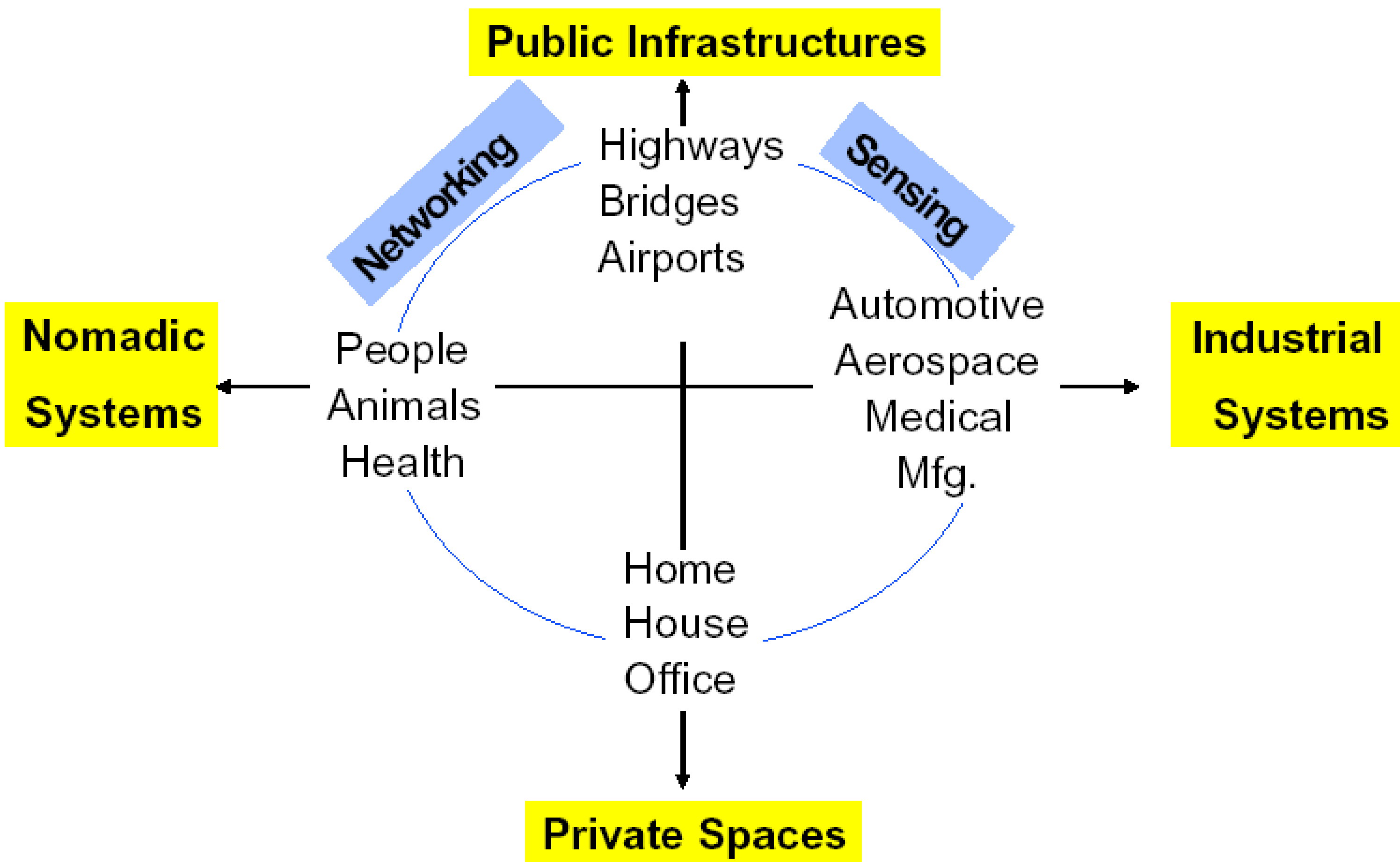
- The combined need for **digital and non-digital** functionalities in an integrated system is translated as a dual trend in the International Technology Roadmap for Semiconductors: **miniaturization** of the digital functions ("More Moore") **and functional diversification** ("More-than-Moore")



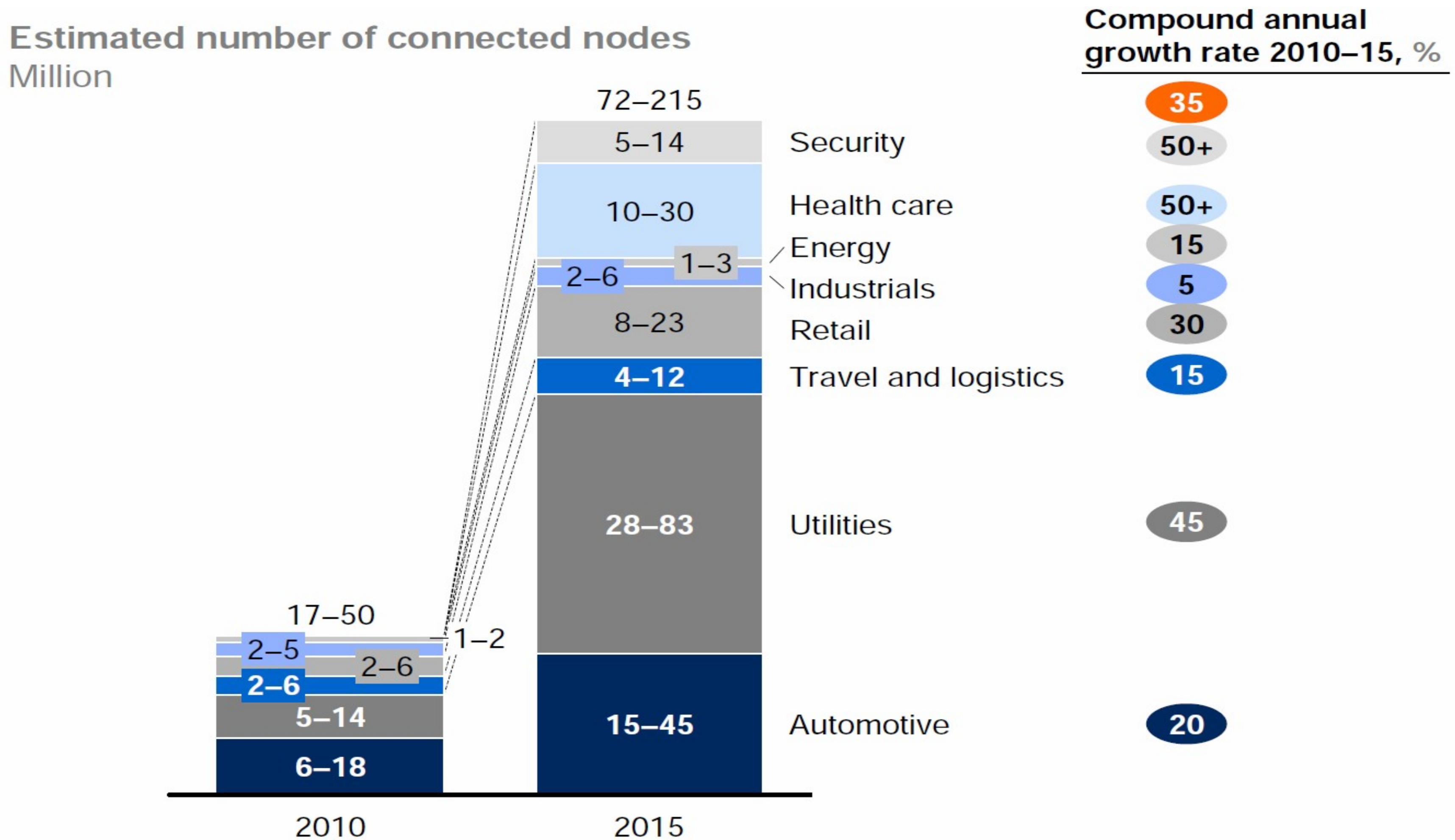
Applications in 2020: Technology requirements



Application contexts of embedded systems



Growth of connected nodes

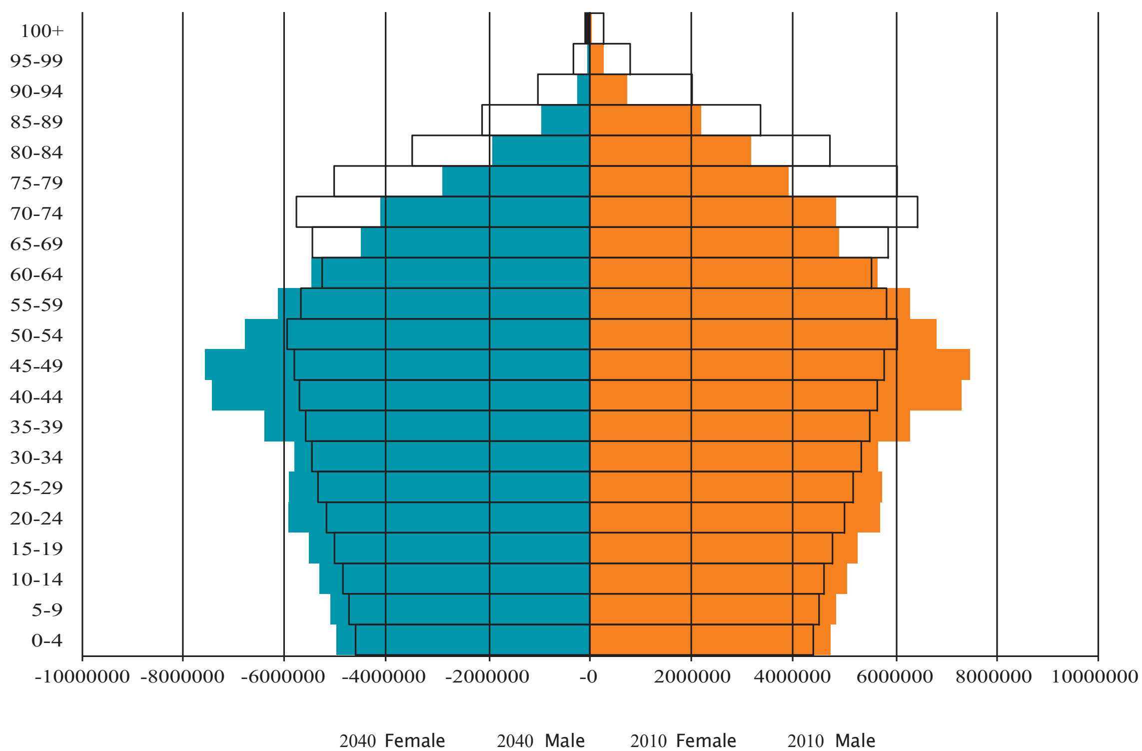


NOTE: Numbers may not sum due to rounding.
SOURCE: Analyst interviews; McKinsey Global Institute analysis

Ambient Assisten Living (AAL)

- **Ageing at home vs working forever?**

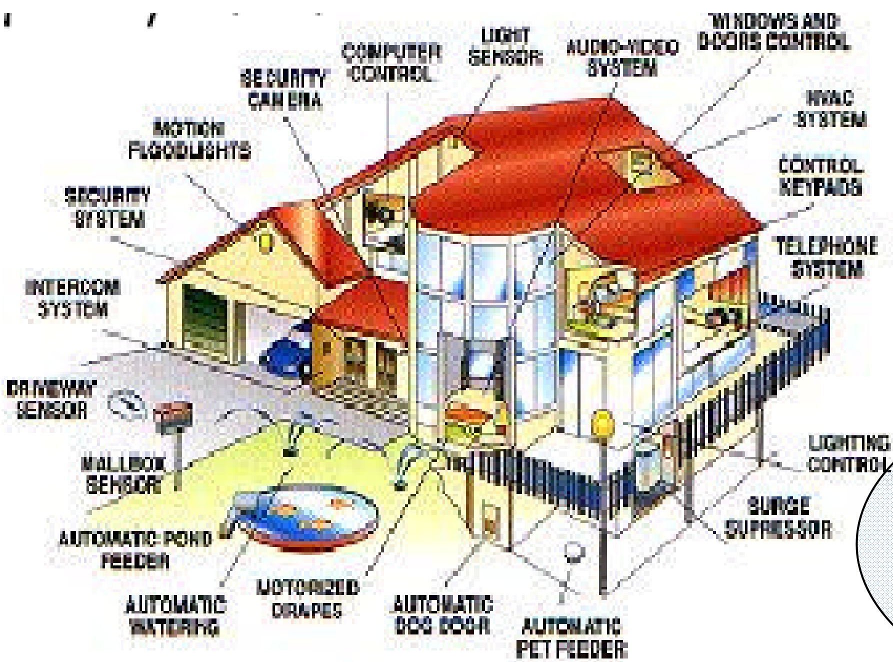
Population Structure: Western Europe, 2010 vs 2040 (projected)

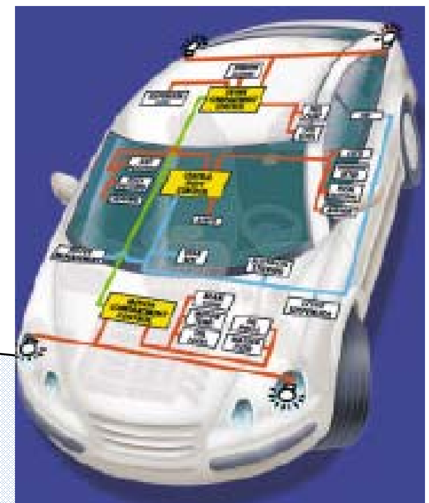


Note: "Western Europe" here defined as EU-15 plus UK, CH, NO and smal adjacent islands and territories.
Source: US CENSUS IDB, available at http://www.census.gov/population/international/data/idb/informationGateway.php

Networked Embedded Intelligence

- Enabling transportation, infrastructure industries
- Leading to revolutions like the digital home
- Turning ambient dreams into reality
- Enabling sensor networks improving our quality of life

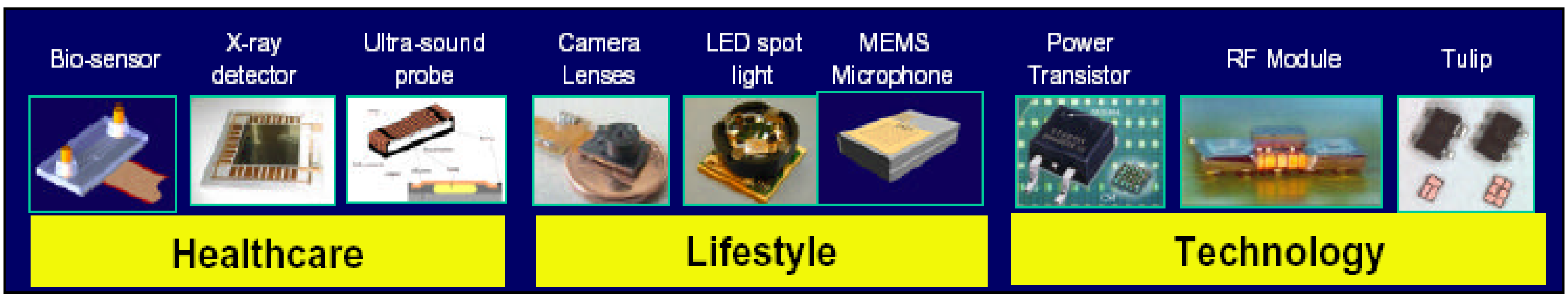




Ubiquitous
Low Power
High performance
Interconnected

Long term technology trends

- **System-on-Chip (SoC)**
  – Focus on full integration and lowest cost per transistor
- **System-in-Package (SiP)**
  – Focus on lowest cost per function and for total system
- **Complementing, not competing architectures**
- **Each requiring a different industrial approach**
  – Advanced R&D / knowledge needed
  – Different manufacturing competences



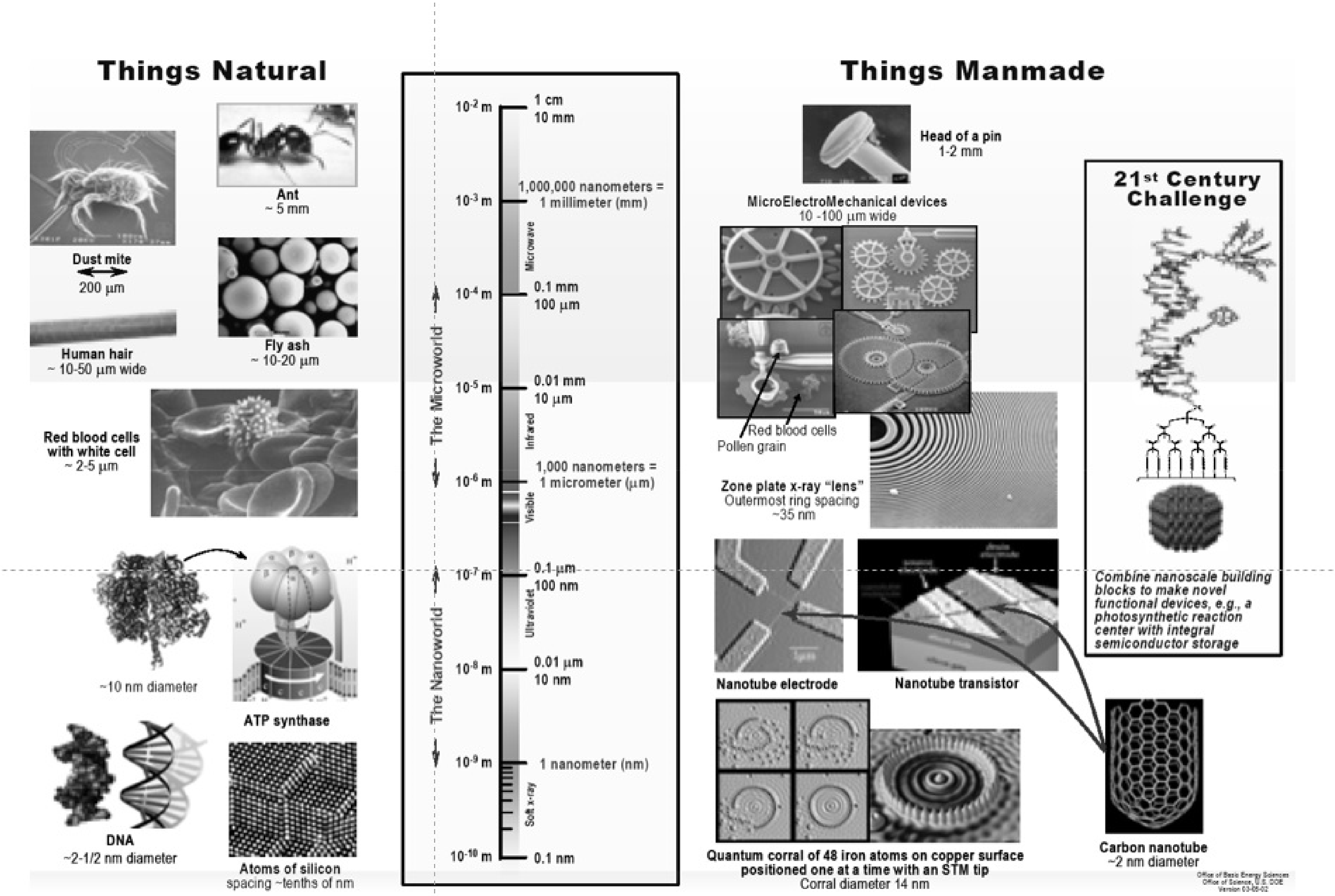
Embedded Systems 10 years from now

- **Networked: from working in isolation towards communicating, networked, distributed solutions**
- **Secure: threatened by enormous security issues, challenging its technical and economical viability**
- **Complex:**
  - Giga-complexity enabled by nano-technology
  - Complex through heterogeneity
  - Transducer devices
    - Sensors: Biosensors, MEMS, NEMS
    - Actuators/Interactive Screens/Displays
    - Speech input device/Handwriting input devices
  - Computing devices: more software than hardware, application domain specific, reconfigurable
  - Communication: protocols, standards, RF
- **Low power: scavenging power**

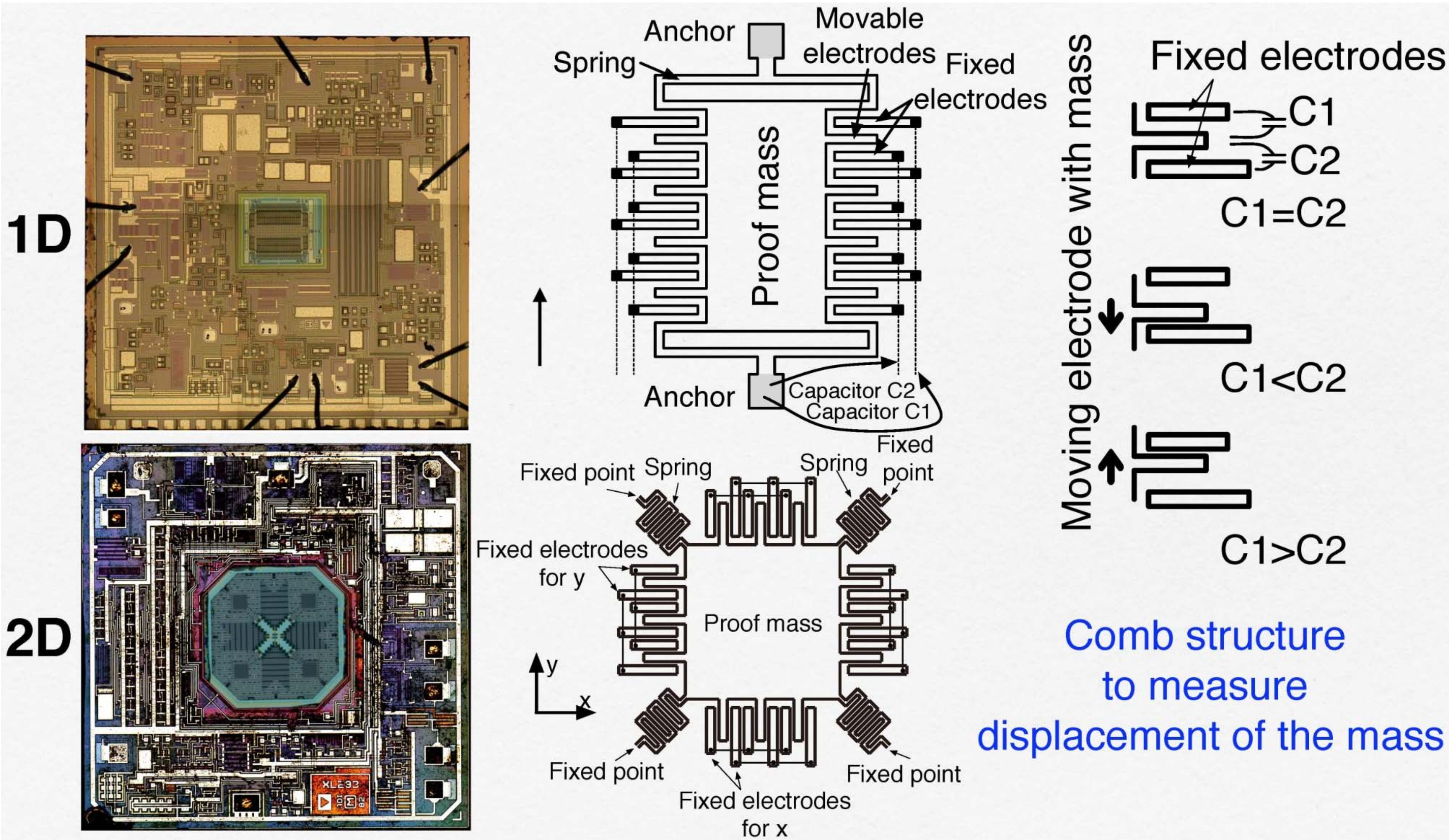
What is a MEM?

- **MEMS = Micro-Electo-Mechanical Systems**
  - creation of 3-dimensional structures using integrated circuits fabrication technologies and special micromachining processes
  - typically done on silicon or glass (SiO2) wafers
- **MEMS Devices and Structures**
  - transducers
  - microsensors and microactuators
    - mechanically functional microstructures
  - microfluidics: valves, pumps, flow channels
    - microengines: gears, turbines, combustion engines
- **Integrated Microsystems**
  - integrated circuitry and transducers combined to perform a task autonomously or with the aid of host computer
  - MEMS components provide interface to non-electrical world
    - sensors provide inputs from non-electronic events
    - actuators provide outputs to non-electronic events

What is the size we are talking about?

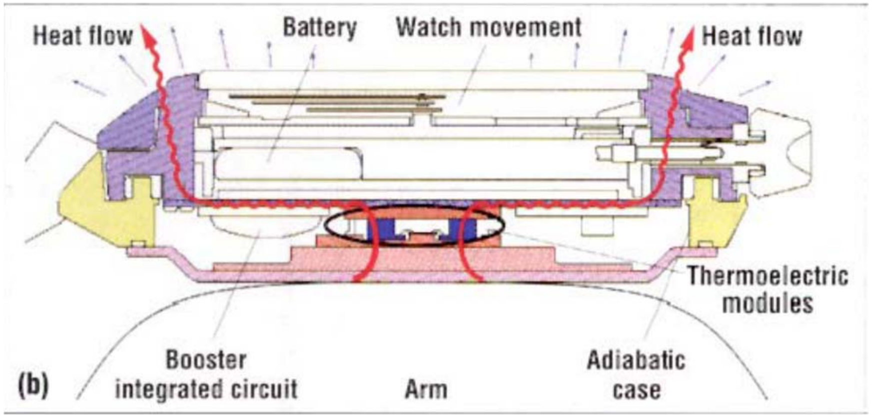


Inside an accelerometer

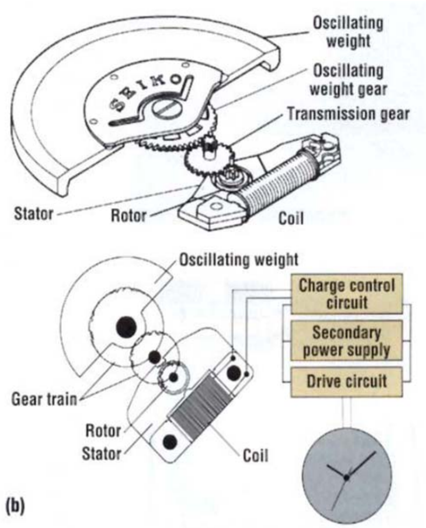


Crazy ideas on energy scavenging

- **Objects with temperature gradients create energy**
  - –ATMOS clock
  - –Seiko watch
  - –Driving motes at Alcoa

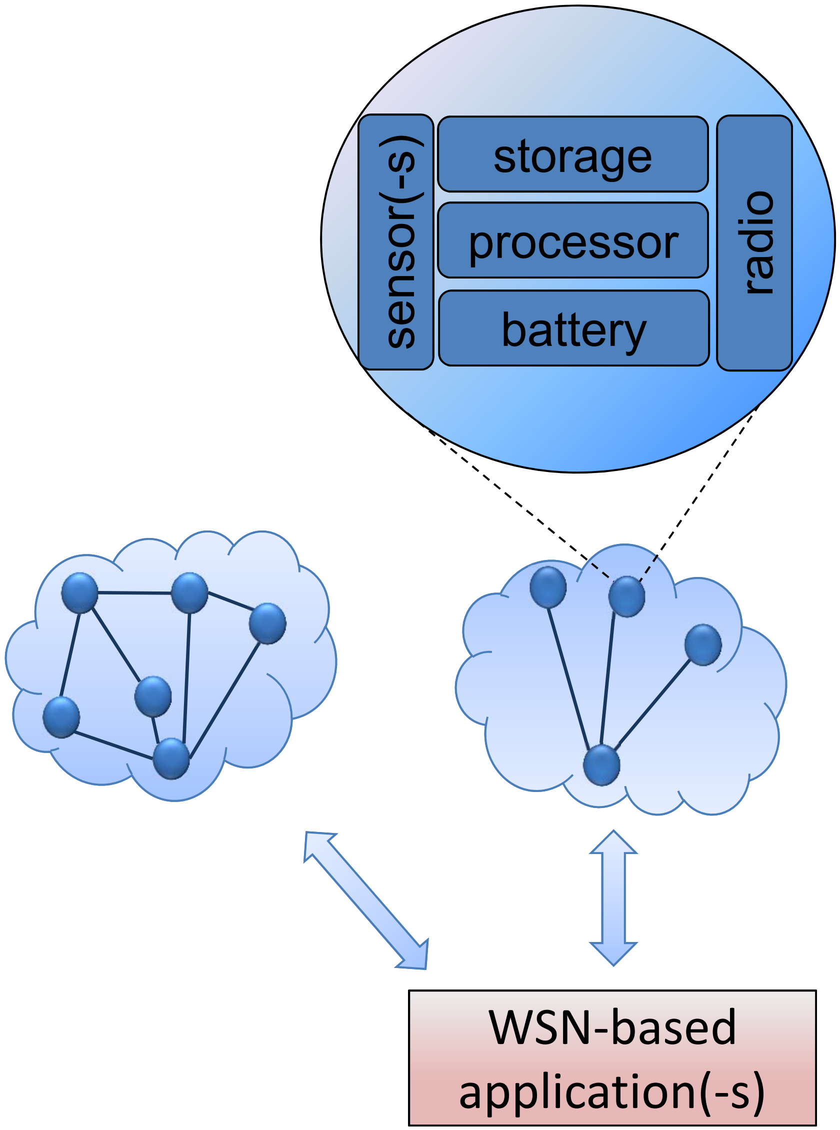


- **Vibrations**
  - –Self winding watches
  - –Produces 5microwatts on average when worn 1milliwatt when forcibly shaken



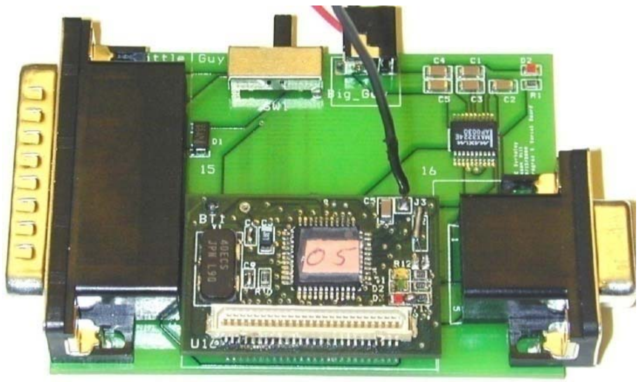
Wireless sensor node

- **small (battery-powered) devices**
  - – sensing local conditions
  - – typically with limited resources
- **forming "nodes" within a wireless network**
  - – covering region / object of interest
- **enabling (new) applications**
  - – based on sensor data collection, fusion, reasoning, and response

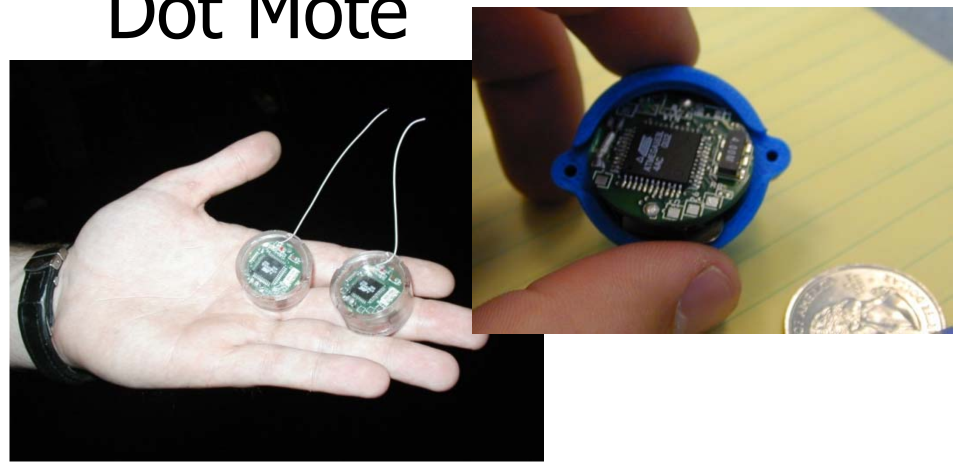


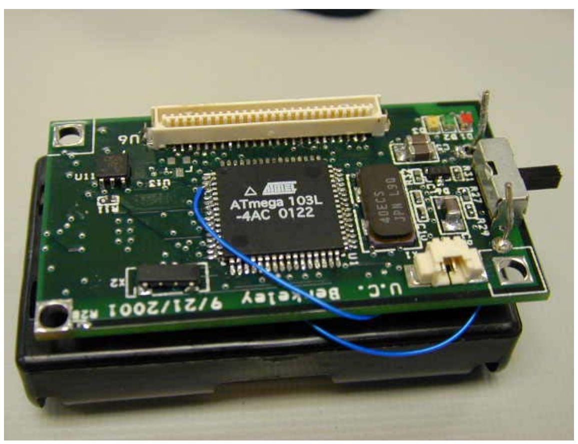
Examples of Wireless Sensor Nodes

Rene Mote



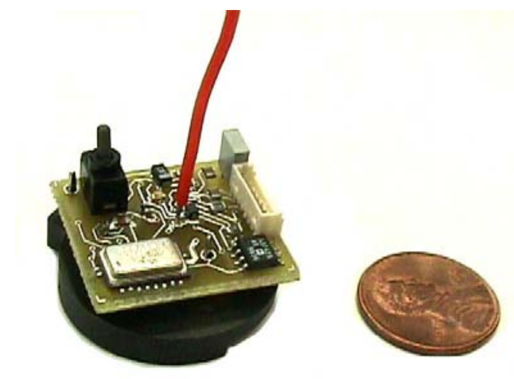
Dot Mote





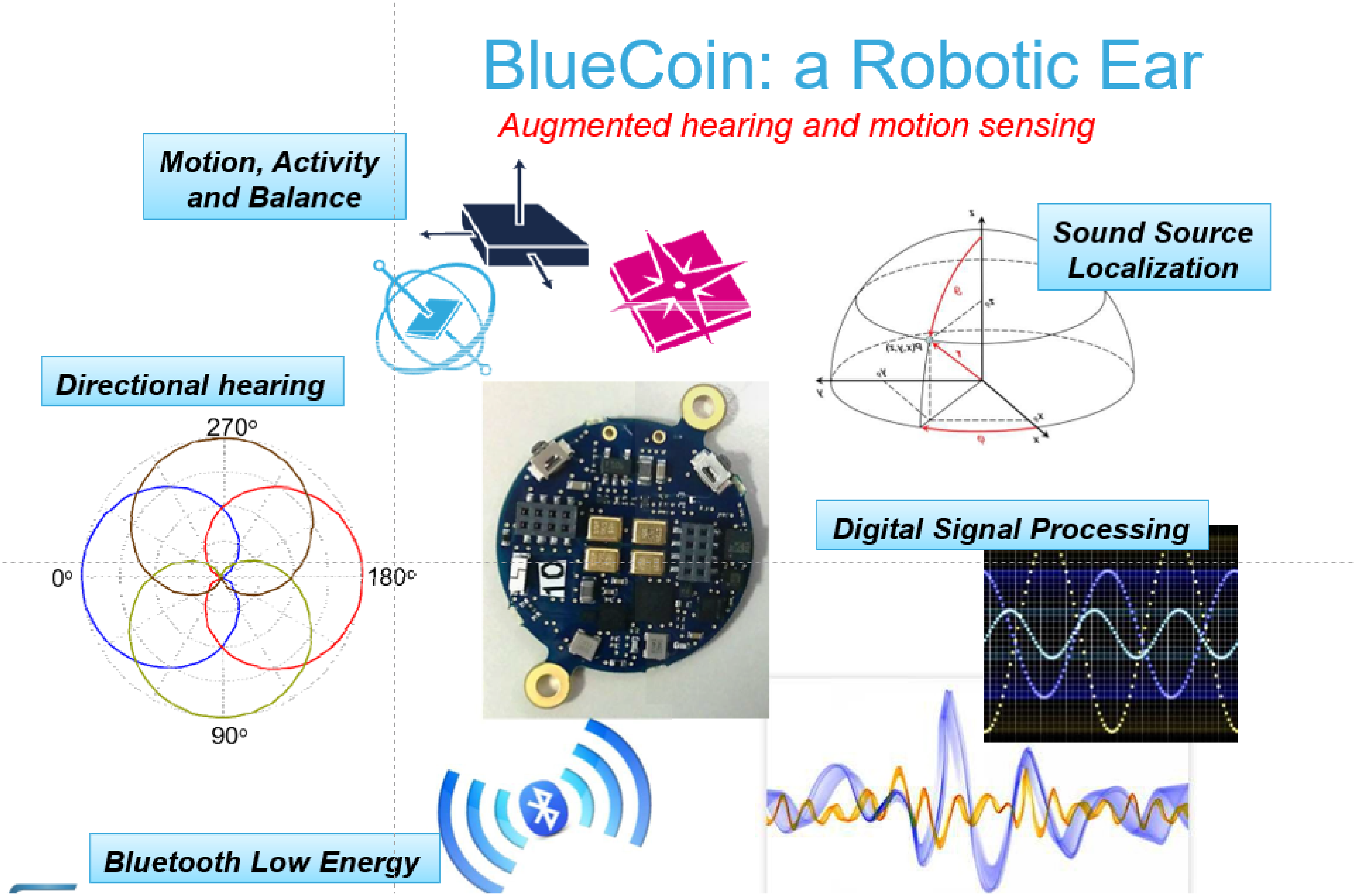
MICA Mote

BSN Mote



weC Mote

Example of platform: bluecoin by STM

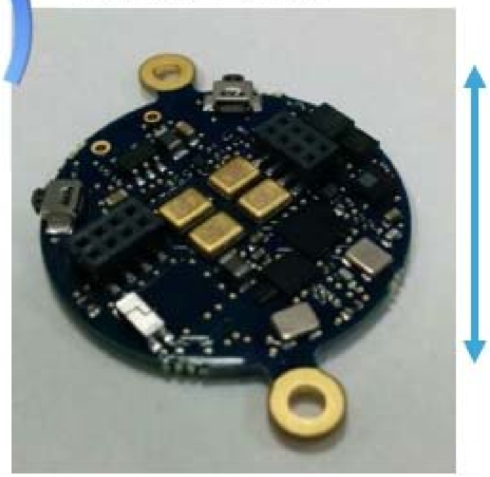


Example of platform: bluecoin by STM

- Features
  - Advanced audio processing
    - Sound Source Localization
    - Beamforming
  - Wide band audio over BLE (BlueVoice)
  - Sensor fusion
    - Inertial, environmental, acoustic.
  - Complete development kit
    - Battery holder
    - CoinStation
- Main components
  - STM32F446
    - ARM Cortex-M4F@180MHz - 128KB RAM
  - u4 Microphone Array (4x MP23DB01MM)
  - Bluetooth-Low-Energy radio (BlueNRG-MS)
    - Bluetooth 4.1, multiple role simultaneously
  - 6+3 axis inertial module (LSM6DS3+LIS3MDL)
  - Absolute pressure sensor (LPS25HB)

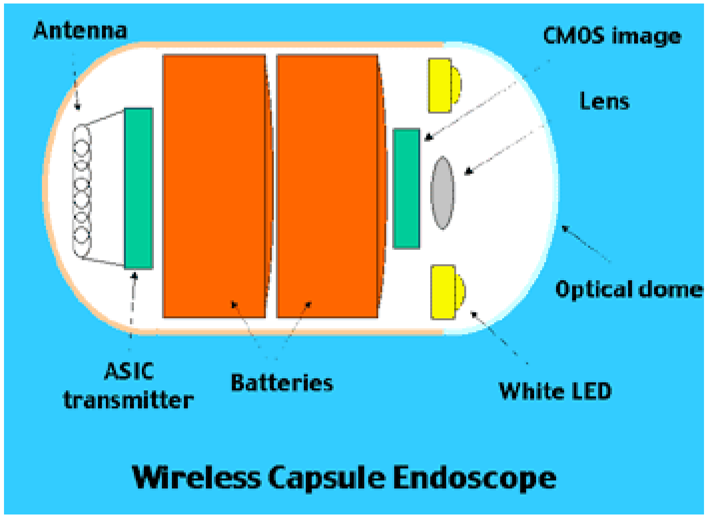
BlueCoin+

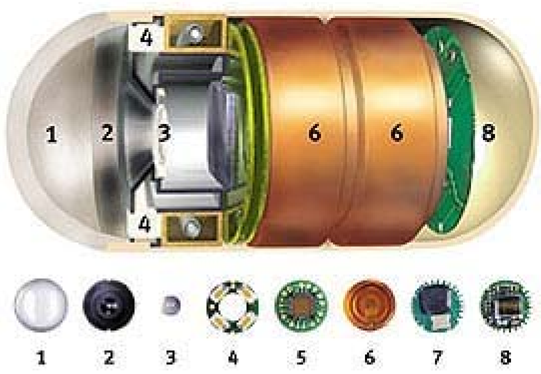
Bottom view



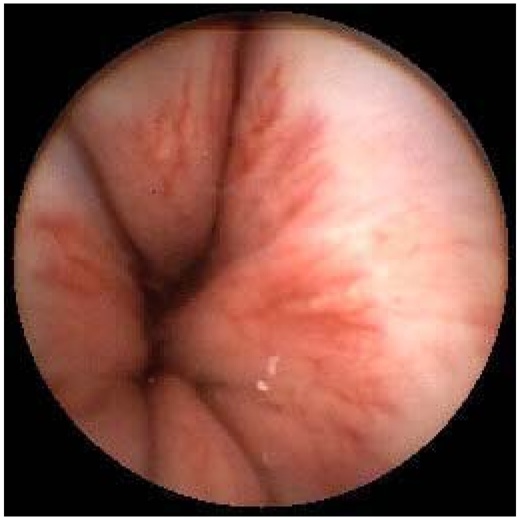
Top view + Coin battery holder + battery

Example: Pill camera

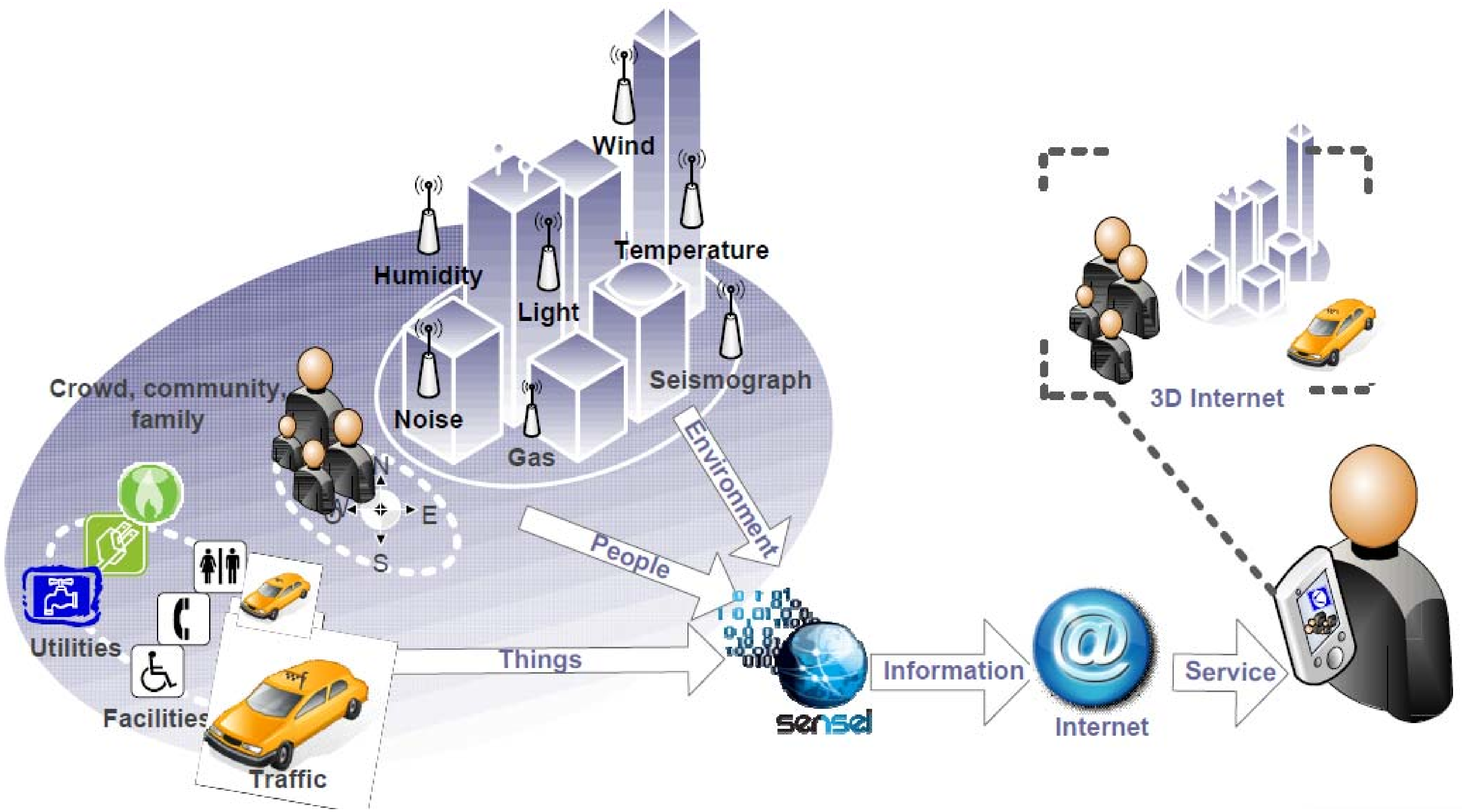




Distal esophagus with edema and erythema. Geographic ulceration suggestive of Barret's Esophagus.



Example of use: intelligent cities (SoS)



Examples: Social network adapted to elders

- **Aging population**
  - Healthcare cost could double among EU member states by 2060
- **eHealth Action Plan 2012-2020**
  - ICT solutions should be applied to health and healthcare systems to increase their efficiency, improve quality of life and unlock innovation in health markets
- **People are willing to actively participate in decisions that concern their medical condition**
  - From 2007. to 2013. percentage of individuals who used Internet for health-related information increased from 24% to 44%
  - Active participation leads to better health outcomes.

Challenge

- **Access to medical data provided through patient portals**
  - Useful for some patients
  - Require substantial technical knowledge
- **Devices used for accessing patient portals**
  - Smartphone, tablets, PCs
  - Modern small screen mobile devices are too complex and/or too small for most of them to use
- **Bringing ICT solutions closer to elder population**
  - it is necessary to address barriers to technology adoption and consequently develop well-designed system that can be used even if the end user is technically illiterate (Independent Age, 2015)

About the speaker

William Fornaciari is Professor at Politecnico di Milano – Dipartimento di Elettronica Informazione e Bioingegneria. He published six books and over 200 papers, collecting 5 best paper awards, one certification of appreciation from IEEE and holds 3 international patents on low power design. Since 1997 he has been involved in 19 EU-funded international projects. In FP7 he has been WP leader for the COMPLEX and CONTREX IP projects, Project Technical Manager of 2PARMA (ranked as success story by the EU) and currently he is Project Coordinator of the RECIPE project and in FP7 of the HARPA project. In H2020 he is contributing to the following projects: MANGO, SafeCop, M2DC and RECIPE. He cooperated for around 20 years with the Technology Transfer Center of POLIMI and in 2013 he created a startup company (IBT Solutions srl) candidate to receive the EIT award in 2016. His main research interests cover multi-many core architectures, NoCs, HPC, low power design, software power estimation, run time resource management, wireless sensor networks, thermal management, and EDA-based design methodologies. He is member of the HiPEAC NoE.

THANKS FOR YOUR ATTENTION

ANY QUESTION ?