POLITECNICO MILANO 1863

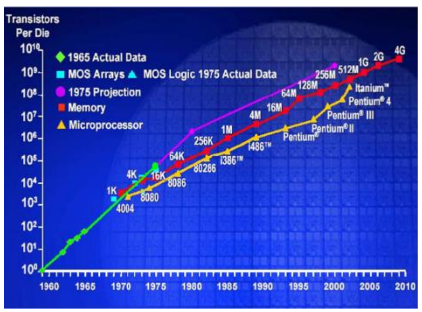
# Computing Systems

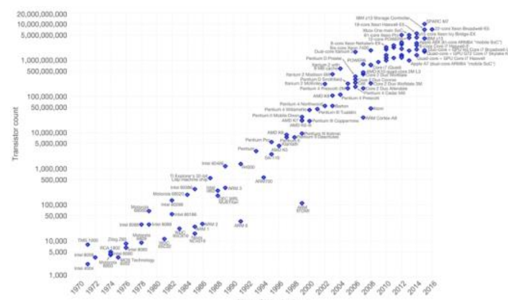
## Introduction

*Ver. 2.1 - 2021*
*Ver. 2.0 - 2020*
*Ver 1.6 – 2017 Aug/Sep*

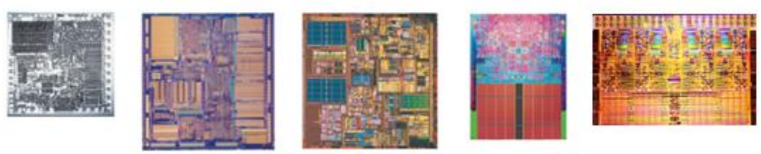
Introduction

- Moore’s law (first course-grain observation)
  - Silicon availability doubles every 18 months




  - Implications: more functionalities/less area, less power, less costs…



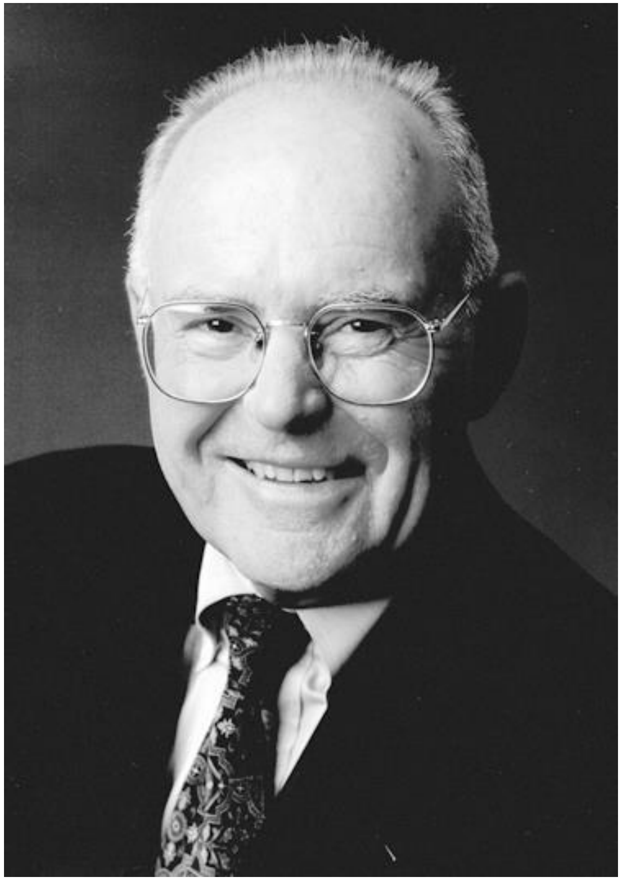
8086 3um | 386 1.5um | Pentium 4 0.18um | Core2 Duo 65nm | Nehalem 45nm

From Intel

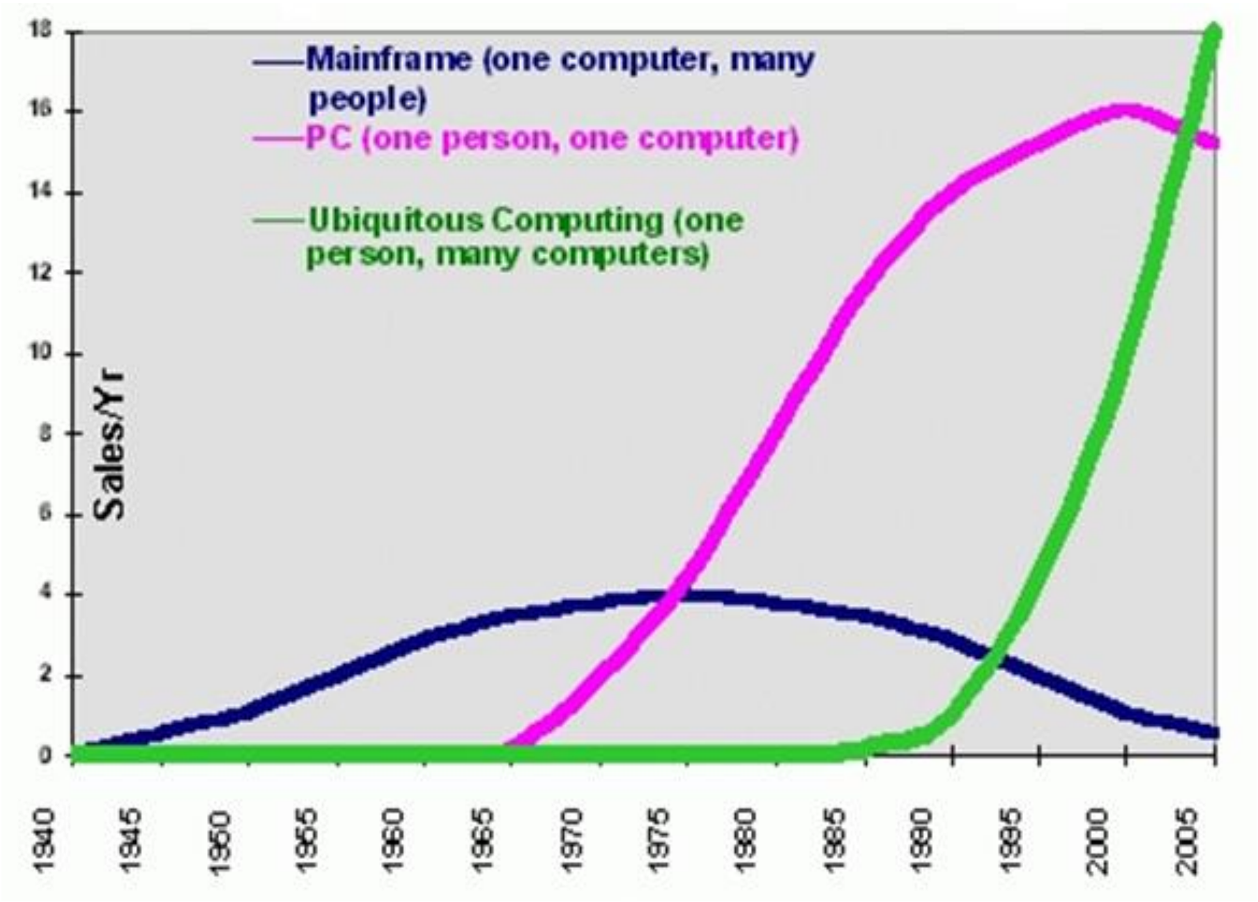
  - Technology processes more reliable

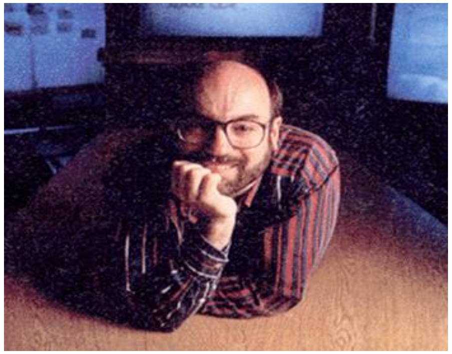
# Gordon Moore

- Cofounded Intel in 1968 with Robert Noyce.
- Moore's Law:
  - number of transistors on a computer chip doubles every year
    - observed in 1965
- Since 1975, transistor counts have doubled every two years.



# Introduction



July 1952 – April 1999

*Ubiquitous computing*, *pervasive computing*, *ambient intelligence, calm technology* or *everywhere* are different name for the same paradigm

# Introduction

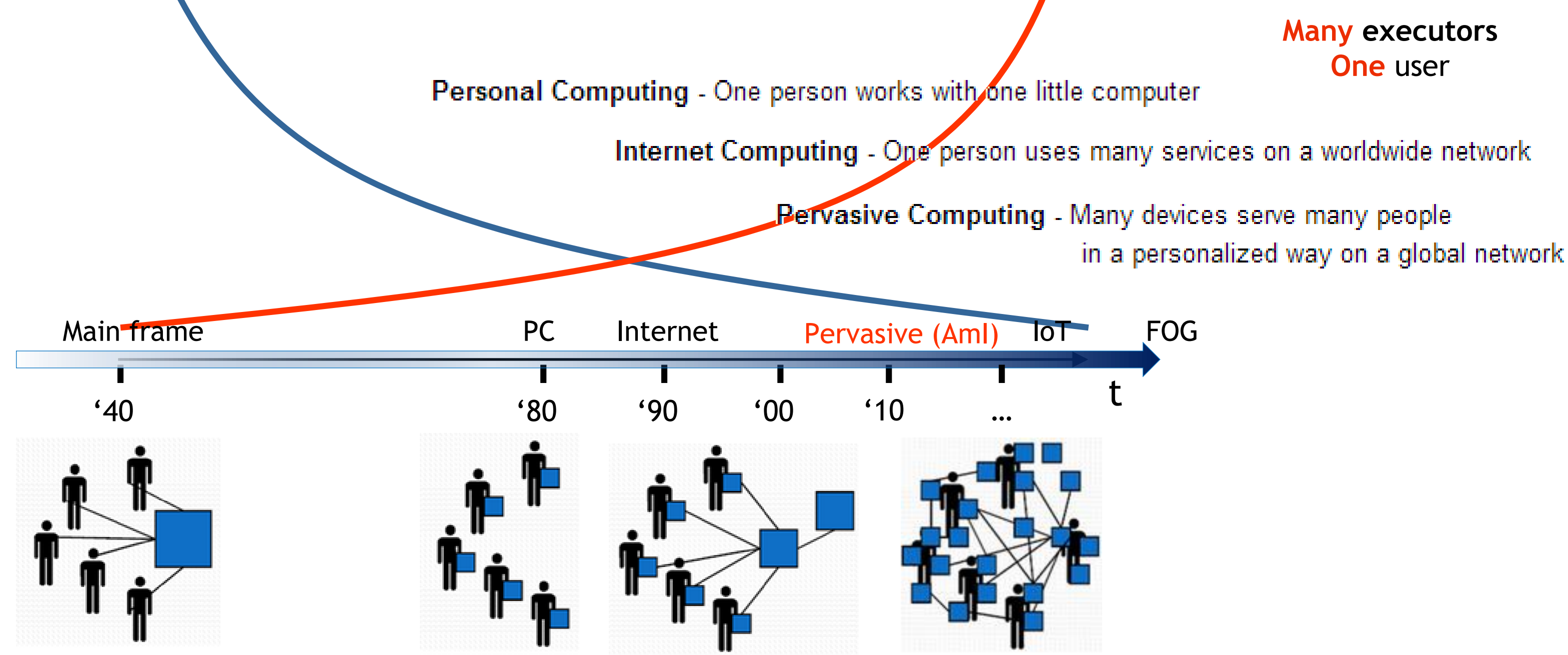
Today: IoT, Cyber physical systems… other names with some small differences…

- Weiser's 3 waves of computing:
  - *"**First** wave in computing: mainframes, each shared by lots of people.*
  - ***Second** wave in computing: personal computing, person and machine staring at each other across the desktop.*
  - ***Third** wave in computing: **ubiquitous computing (UbiCom), pervasive computing**, or the age of **calm technology**, when **technology go backwards into the background of our lives**."*
- ***"Deepest technologies are those that disappear*.** They interweave in the daily life weave until they are undistinguishable of it". (*Weiser*, 1991)

- **History of Computing Systems**

**One executor**
**Many Users**

**Many executors**
**One user**



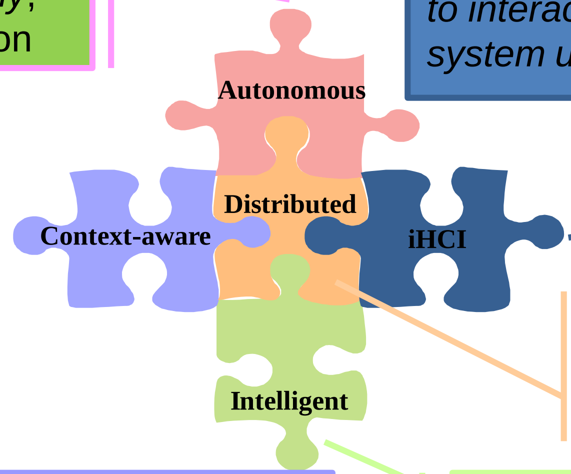
# Introduction

- Three main properties for **pervasive systems** (Weiser in 1991):
  - **Computers need to be networked, distributed and transparently accessible**
    - In1991, little wireless computing, Internet far less pervasive
  - **Computer Interaction with Humans needs to be more hidden**
    - In 1991, much HCI was overly intrusive
  - **Computers need to be aware of environment context**
    - In 1991, computers were mostly “disconnected” from the environment. They were just computing platforms.
      - Optimization of computers systems needs to operate in contact with physical and human environments

# Properties of a Cyber Physical System

**Autonomous**: Computers can operate *autonomously*, without human intervention

**Implicit Human Computer Interface (iHCI)**: "*an action, performed by the user that is not primarily aimed to interact with a computerized system but which such a system understands as input*" Schmidt (2000).




**Distributed:** Computers need to be networked, distributed and transparently accessible

**Context-Aware**: A context represents the state or situation in the environment of a system that affects that system's behaviour. It is a key property of **smart environments**

**Intelligent**: Computers can handle a multiplicity of dynamic actions and interactions, governed by intelligent decision-making and intelligent organisational interaction. This require some form of *artificial intelligence*

Original Weiser definition

Two properties added successively

# Cyber Physical System

- Cyber Physical Systems
  - The term cyber-physical systems refers to the tight conjoining of and coordination between **computational** and **physical** resources.
  - In cyber-physical systems, *physical and software components are deeply intertwined, each operating on different spatial and temporal scales, exhibiting multiple and distinct behavioral modalities, and interacting with each other in a myriad of ways that change with context*.
    - [US National Science Foundation, Cyber-Physical Systems - https://www.nsf.gov/pubs/2010/nsf10515/nsf10515.htm]

# Phygital System

- Phygital Systems
  - The term phygital systems describes blending digital experiences with physical one.  Phygital reduce the divide between the **physical** and **digital** worlds.
    - COLLINS: a blend of the physical and the digital. Largely used in marketing for an experience that blends the two (new definition: 07/05/2020)
    - [https://www.urbandictionary.com/](https://www.urbandictionary.com/): Phygital is a concept of blending digital experiences with physical experiences taking the best aspects from each space to create the optimal customer experience.
  - *… Phygital is governed by the three "I's:" **Immediacy**, **Immersion**, and **Interaction**. The first two, immediacy and immersion, come from the digital world, while interaction, comes from the physical world. A successful Phygital strategy must combine all three of these elements.*

# Pervasive Systems

- Research progresses in Pervasive systems field
  - Quick respond
    - e.g., autonomous collision avoidance
  - More precision
    - e.g., robotic surgery and nano-tolerance manufacturing
  - Work in dangerous or inaccessible environments
  - Large-scale and distributed coordination
    - e.g., automated traffic control
  - High efficiency
  - Augment human capabilities
  - Enhance societal wellbeing
    - e.g., assistive tech. and ubiquitous healthcare monitoring and delivery.

# Cyber Physical & Phygital Systems

- Cyber Physical System products and byproducts
  - Smart Mobile
    - Smart card, smart mobile
  - Human Computer Interface
  - **Smart Environment**
    - **Annotating the physical world**
    - **Sensors and Sensor Networks**
    - **Micro Actuation and Sensing: MEMS**
    - **Embedded Systems**
  - Context-Aware systems
    - Spatial awareness (e.g. GIS), mobile awareness

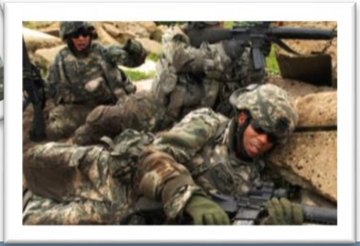
- **Smart Environments**
  - Definition1: *a small world where different types of smart devices are continuously working to make inhabitants' lives more comfortable*
    - *Cook, Diane; Das, Sajal (2004). Smart Environments: Technology, Protocols and Applications. Wiley-Interscience*
  - Definition2: *a physical world that is richly and invisibly interwoven with sensors, actuators, displays, and computational elements, embedded seamlessly in the everyday objects of our lives, and connected through a continuous network*
    - *Mark Weiser*

# Smart Environment

- **Smart Environments**
  - Industrial and research topics
    - **Embedded systems**: a special-purpose device designed to perform one or a few dedicated functions. It is *embedded* as part of a complete system including hardware, mechanical parts…
    - **Intelligent clothing**: an articles of clothing, footwear or accessories that feature micro-electronic sensors which gather, communicate and output usage and performance data.
    - **Wearable computing**: a computer accompanying  us in our every day life and offer help as we need it.







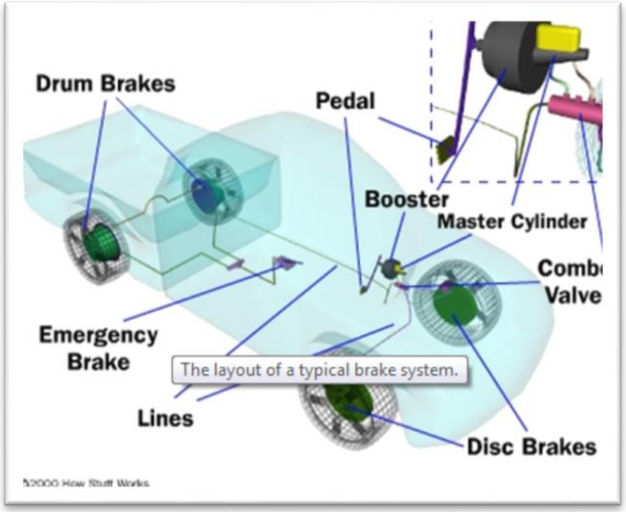

# Smart Environment

- **Smart Environments**
  - Industrial and research topics
    - **Sensor network**: a network consisting of spatially distributed autonomous devices using sensors to cooperatively monitor physical or environmental conditions, such as temperature, vibration, pressure, motion, at different locations
    - **Tagging, Tracking and Locating**: Use of active or passive RFID to locate items, for security, for tracking, for automated routing of physical objects, for automated physical Access…

# Smart Environment

- The design of devices for Smart Environment should include:
  - **Transform intrinsic functionalities into programmed functionalities**
    - Embedded systems
  - **Enhance existing apparatus and systems**
    - Intelligent Clothing, Wearable systems and Ambient monitoring
  - **Allowing systems to communicate each other**
  - **Simplify, reducing or eliminate the user interface**
    - iHCI : implicit Human Computer Interface

- Intrinsic functionality and programmed functionality
  - Example 1: **ABS** – the action on the disk break is mediated by a device that transforms the braking apparatus (from the braking pedal to the disk) for a direct working into a mediated action.
    - Motivation: safety

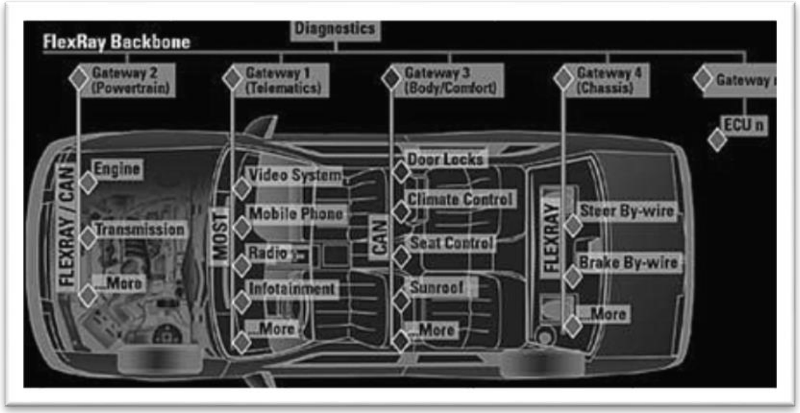



(from www.HowStuffWorks.com)

# Smart Environment: preliminary examples

- Intrinsic functionality and programmed functionality
  - Example 2: **drive-by-wire** – in a drive-by-wire system, most or all of hydraulic and mechanical parts are replaced by electrical wires, sensors, actuators and a device transforms the data from sensors into actions of actuators (Accelerate-by-wire, Brake-by-wire, Steer-by-wire)
    - Motivations: flexibility, less weight in the car, more space in the car

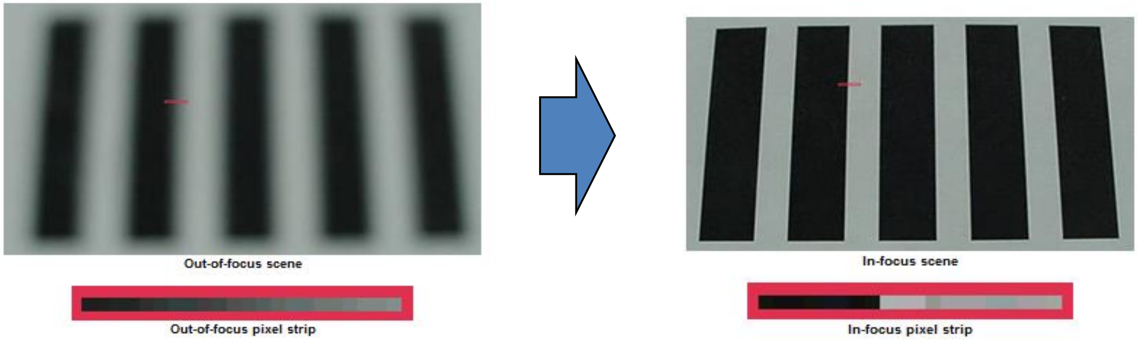
MOST Bus: synchronous data communication to transport audio, video, voice and data signals via plastic optical fiber.




http://www.cvel.clemson.edu/auto/auto_buses01.html

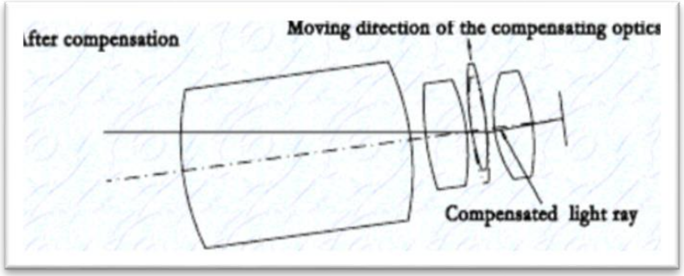
# Smart Environment: preliminary examples

- Intrinsic functionality and programmed functionality
  - Example 3: **Passive Autofocus** - determine the distance to the subject by an analysis of the image.
    - By moving the lens, the difference in intensity between adjacent pixels improved or got worse; the system then searches for the point where there is maximum intensity difference between adjacent pixels. That's the point of best focus.
    - Motivation: market expansion



# Smart Environment: preliminary examples

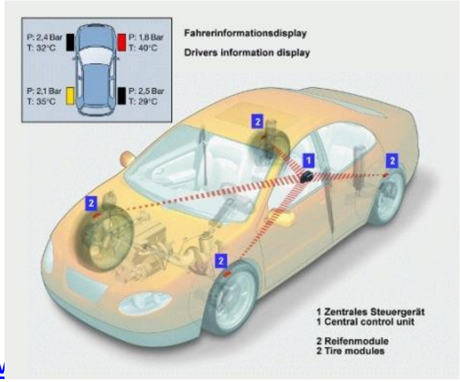
- Intrinsic functionality and programmed functionality
  - Example 4: **Image Stabilizers And Anti-Shake Systems** – compensate user vibration to make razor-sharp images.
    - By moving the lens or CCDs to compensate vibration.
      - In a lens with a stabilizer, shake-detecting **gyro sensors** measure the angle and speed of lens movement; such a movement is compensated by motor, actuator, shifting a group of lens elements in the appropriate direction to counteract the effect of lens shake.
    - Motivation: market expansion

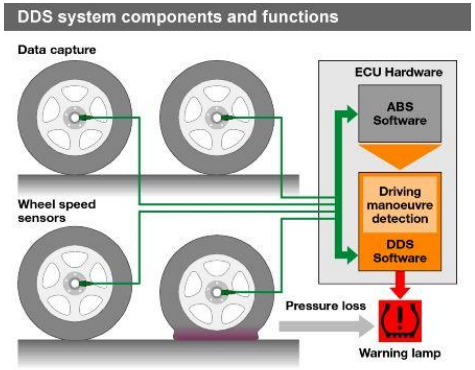



(from http://www.fujinon.co.jp/en/news/001002.htm )

# Smart Environment: preliminary examples

- Intrinsic functionality and programmed functionality
  - Example 5: **Tire-pressure monitoring system (TPMS) - to monitor the air pressure inside the pneumatic tires on various types of vehicles.**
    - Information to the driver of the vehicle, either via a gauge, a pictogram display, or a simple low-pressure warning light.
    - Motivation: safety

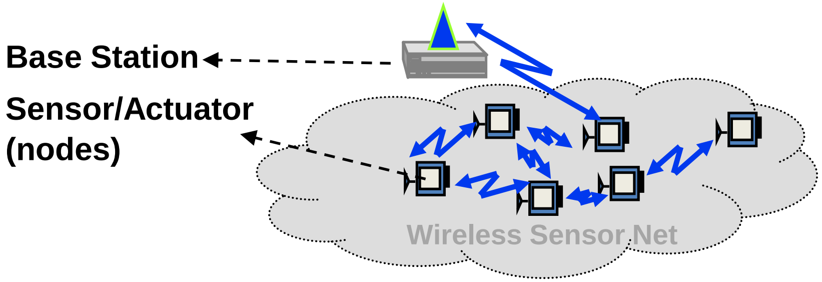



(from http://v

# Smart Environment

- Embedded system
  - **Goal**: to improve system characteristics by making programmable intrinsic aspects
  - **Applications**: building automation, automotive, white and brown goods, transportation…
  - **Examples**:
    - X-By-Wire
    - Autofocus both passive and active
    - Washing machine
      - The systems identifies automatically the degree of dirtiness, scales the detergent, identify the temperature of the water its quantity  and, finally, determines the best wash cycle.



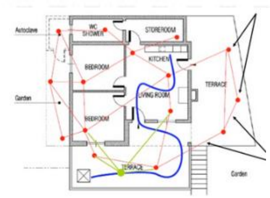

# Smart Environment

WSN: "*Special distributed autonomous sensors to monitor physical or environmental conditions.*"

WSN: "*It is a deployment of several devices equipped with sensors that performed a collaborative measurement process.*"

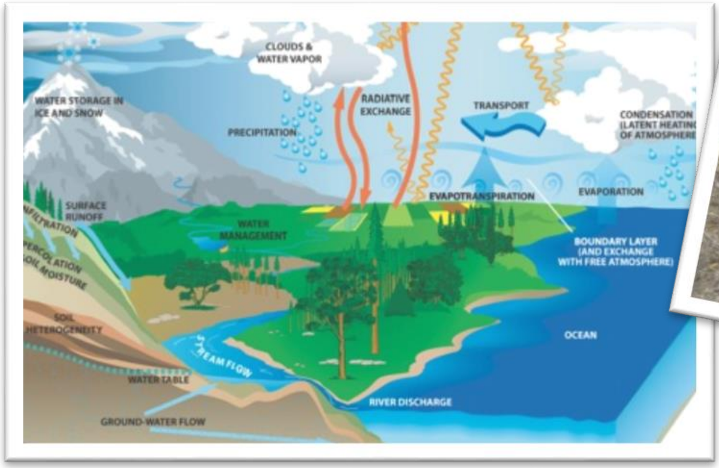
- Wireless Sensor Network
  - **Goal**: to supervised and to monitor environments
  - **Application**: surveillance, ambient and eco-systems monitoring…


  - **Examples**: RF Target Tracking using Wireless Sensor Networks



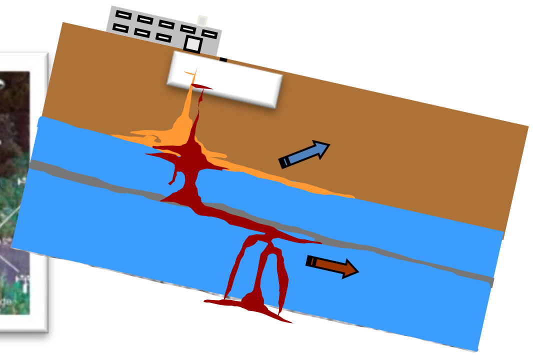
# Smart Environment

- Other examples for WSN application :
    - Agricultural WSN
    - Ocean Environmental Sensing
    - Hydro watching

# Smart Environment

- Other Examples for WSN application
  - Detection of the structure response to seismic perturbation
  - Control to avoid water contamination
  - Monitoring of eco-systems

  - Surveillance and emergency
    - Traffic and Emergency: [Example]
    - Information Environments: [Example]
  - WSN and health care

# Smart Environment

- Other Examples for WSN application
  - Z-wave & Smart Home

# Smart Environment

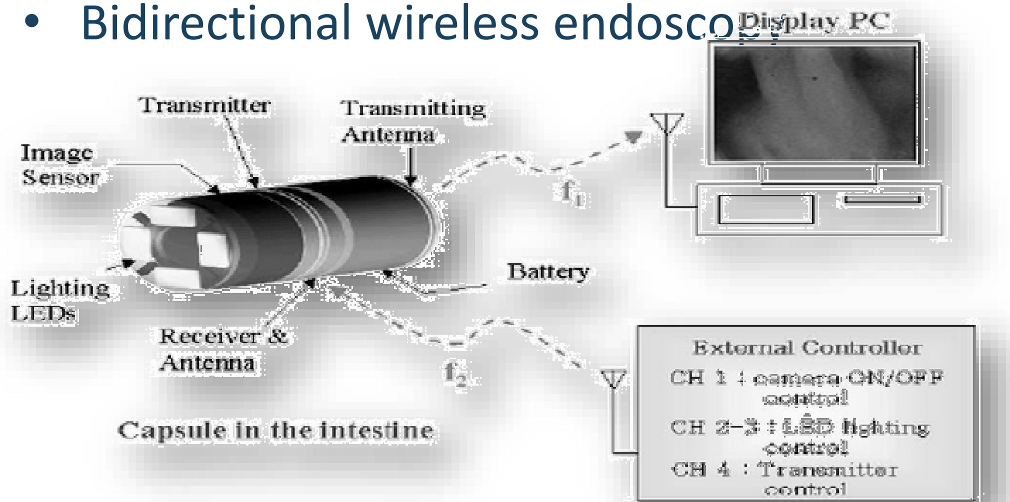
- Examples for SN and RFID application
  - Localization and product identification


From METRO Group - http://www.future-store.org

  - [Transferring data with a touch (Panasonic 2016)](#) @ CEATEC 2016

# Smart Environment

- Examples for Wireless and Camera for medical applications
  - Bidirectional wireless endoscopy

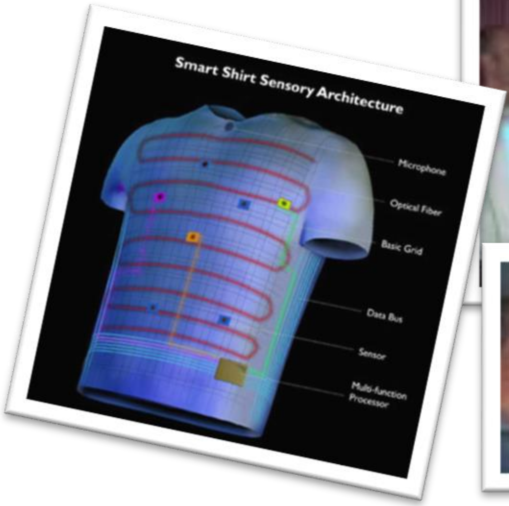



From Microsemi

  - [An example]()

## Smart Environment

- Smart Clothing
  - **goal**: amplify and mediate the reality surrounding a person and detect biological parameter
  - **Application**: management of complex systems, assistance to the disabled, safety, health care
  - **Examples**:
    - Medical Monitoring
    - Disease Monitoring
    - Infant Monitoring
    - Obstetrics Monitoring
    - Clinical Trials Monitoring
    - Athletics
    - Biofeedback
    - Military Uses




http://ldt.stanford.edu/~jeepark/jeepark+portfolio/cs147hw8jeepark.html

# Smart Environment

- Wearable Computing
  - **goal**: to enhance the user experience through the worn product
  - **Application**: any application that require computational support while the user's hands, voice, eyes, arms or attention are actively engaged with the physical environment.
  - Examples:
    - **Google Glasses**

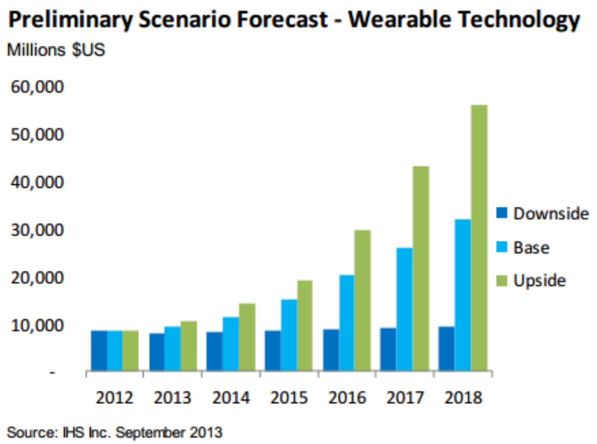
    - **E3 Wristband (https://www.empatica.com/)**



http://en.wikipedia.org/wiki/Wearable_computing
Mann's experiments with wearable computers started in late 1970s

# Smart Environment

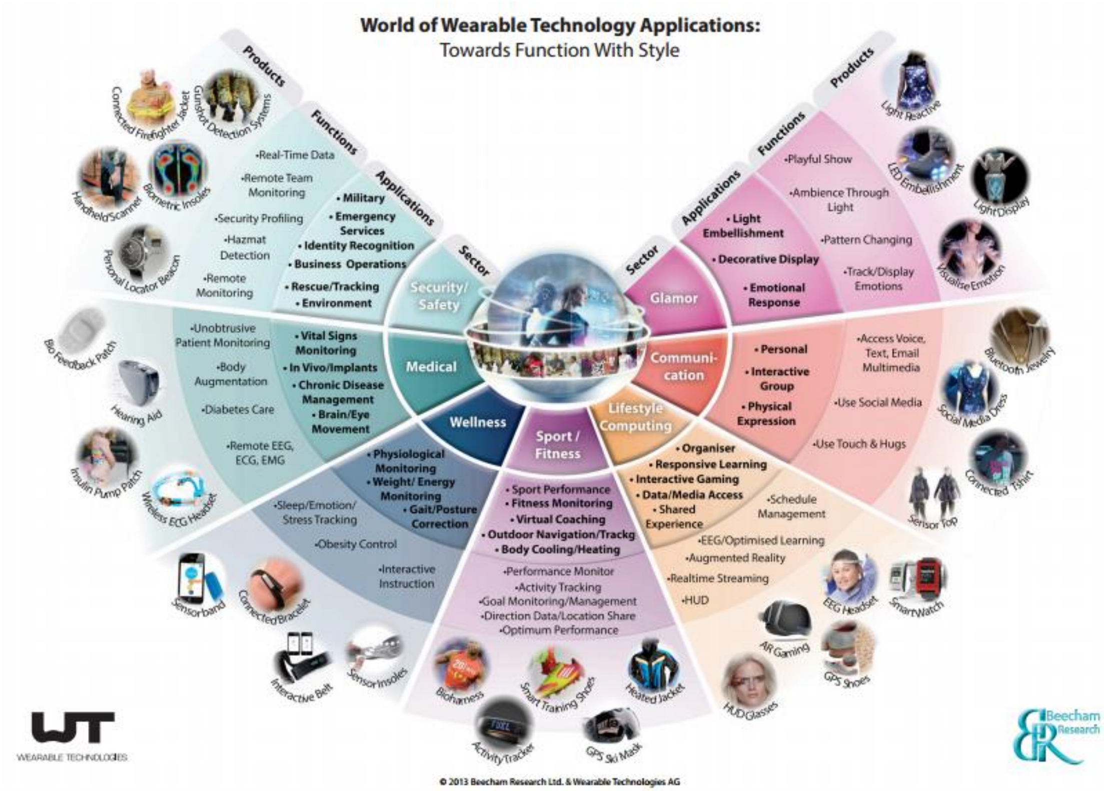
- Wearable device test:
  - Wearable …
    - being worn for an extended period of time, with the user experience significantly enhanced as a result.
  - And Smart
    - having advanced circuitry, wireless connectivity and independent processing capability.




Base: reasonable adoption rate for wearable technology

# Smart Environment

- http://www.beechamresearch.com/files/BRL%20Wearable%20Tech%20Report%20Outline.pdf



## Smart Environment

Source: http://www.ihs.com/pdfs/Wearable-Technology-sep-2013.pdf

# Wearable Tech: Key Enabling Technology

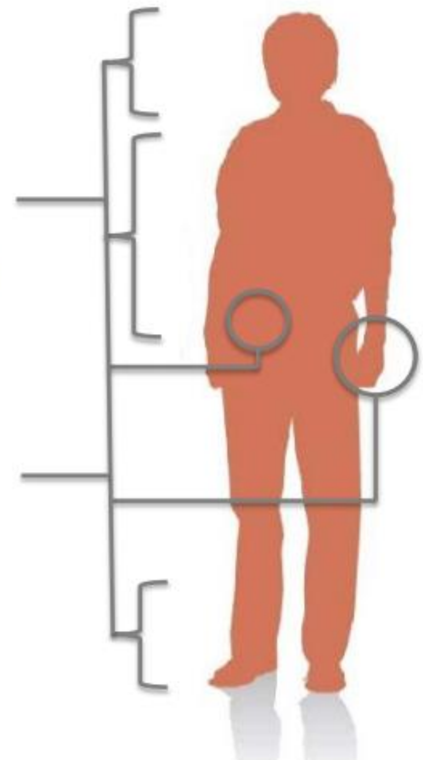
**MEMS:** Multisensor combo packages, easy to implement 9-axis inertial measurement units (IMUs), with the requisite sensor fusion software algorithms, made it simple to use the sensors in a wide range of wearable.

**Bluetooth Low Energy (Smart):** Optimized for low-power operation and naturally supports the power requirements of sensor accessories.

**Long-term evolution:** Energy harvesting

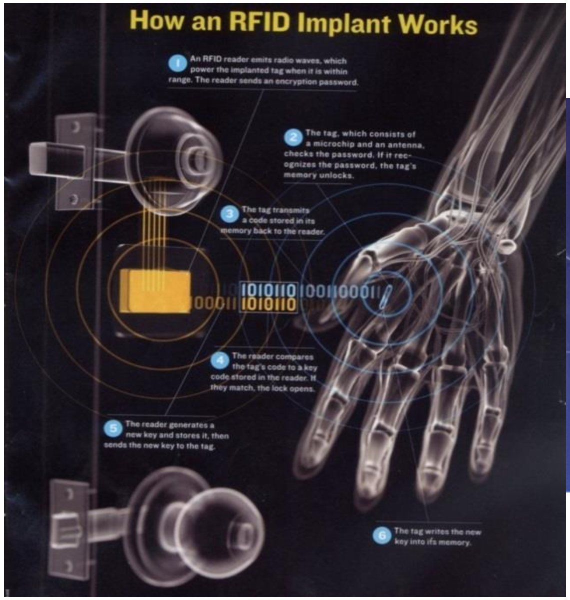
**Telehealth:** 75% POTS, steady transition to cellular gateways and mobile phone. By 2020, cellular will be dominant transmission method

**All Other Wearable:** Other than pedometers, rapidly approaching 100% wireless connectivity, smartphone is hub, stresses importance of apps



- Other examples of Wearable computing
  - Body RFID

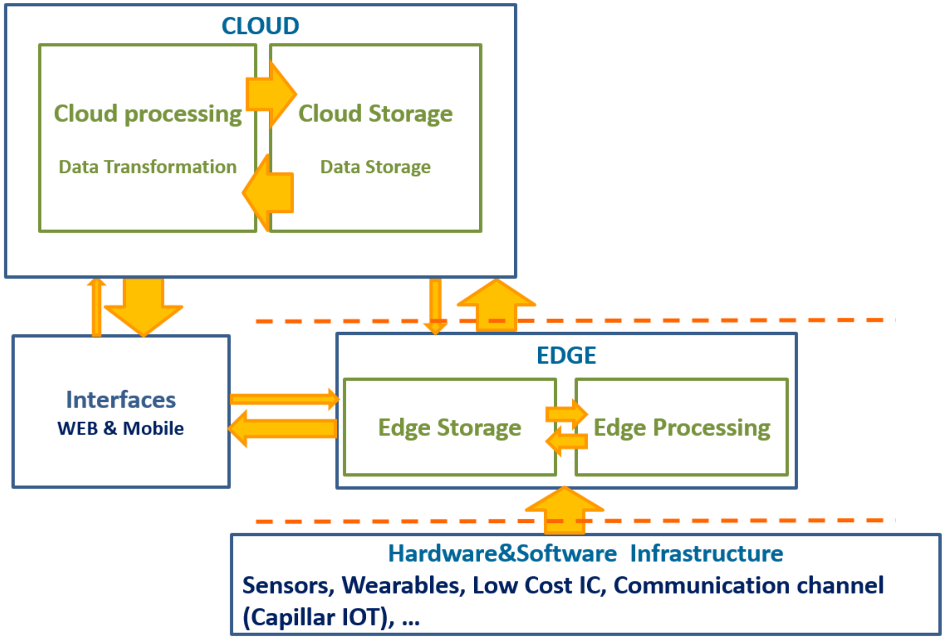




*Source: IEEE Spectrum, 2007*

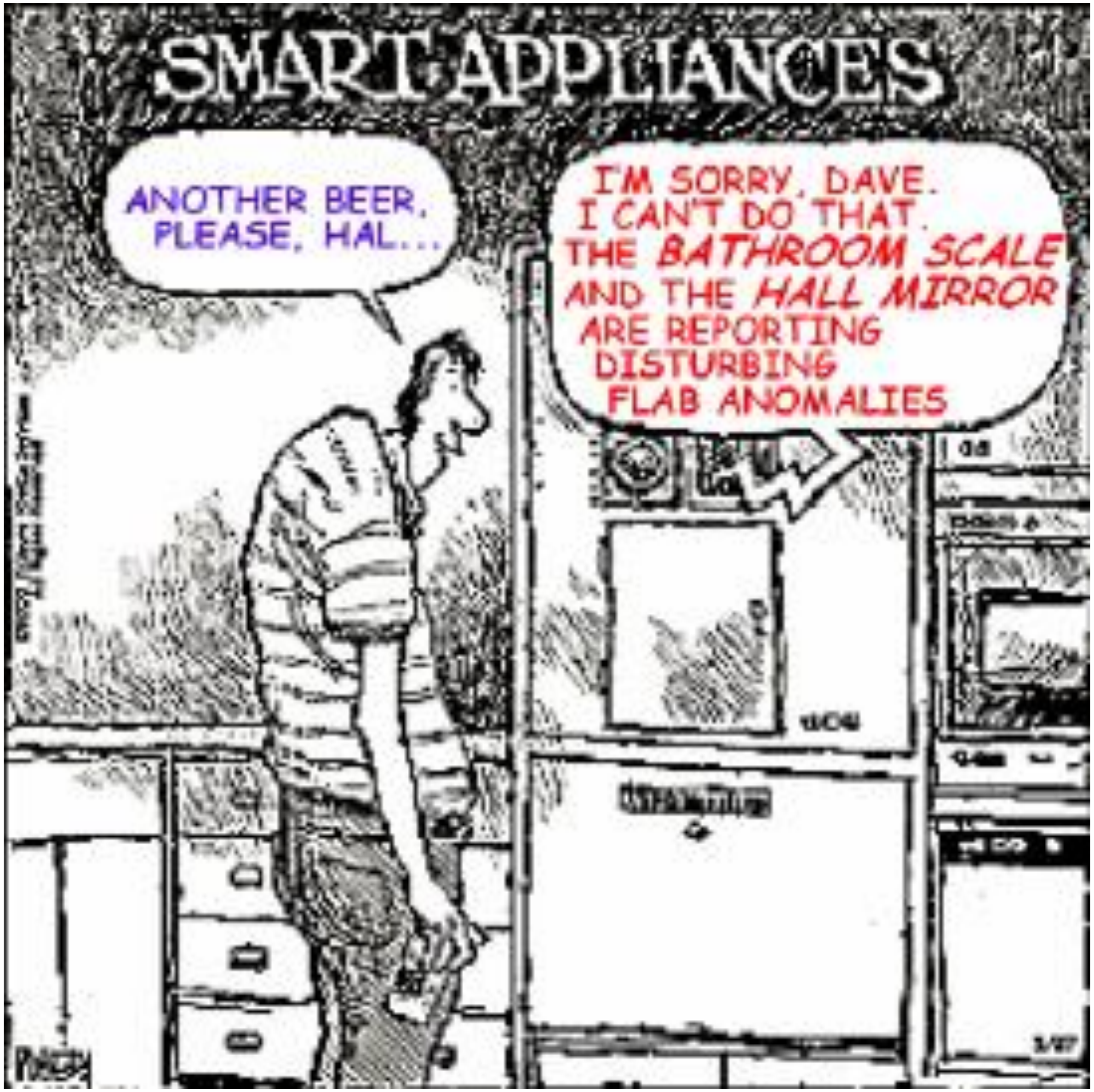
# Final considerations

- Cyber Physical Systems applications is a complex interaction among relative simple set of pervasive devices.



# Some conclusions

- Pervasiveness means “computers in the world”
- Some social impacts and drawbacks could limit the application fields
  - Privacy and security
  - Introduction of new barriers for fragile people
    - Problem of *digital inclusion*
- From now... to future (DoCoMo)
- HoloLens (Microsoft)
- Prototypes (example of projects)


SMART APPLIANCES
ANOTHER BEER, PLEASE, HAL...
I'M SORRY, DAVE. I CAN'T DO THAT. THE BATHROOM SCALE AND THE HALL MIRROR ARE REPORTING DISTURBING FLAB ANOMALIES