4th International Workshop on Embedded Systems

Katholieke Hogeschool Kempen, Belgium

September 29 – 30, 2005

Ubiquitous Computing

Content:

- Introduction
- Technology Trends, Visions
- Networking in UbiComp: CAN, PLC, Wireless, Infrared, Ad Hoc Networks
- Embedded Systems, Sensors and Actuators
- Sensors for Location Tracking, Location Sensing
- Multi-Sensor Systems, Sensor Networks
- Context Awareness
- Wearable, distributed and context-aware computing

Content II:

- Wearable Computing
- Augmented Reality
- Telepresence
- Tangible Bits
- Roomware
- Cooperative Buildings
- Information Appliances
- Proactive Computing
- Amorphous Computing
- Digital City
- User Experience Design
- Pervasive Computing

Enabling Technologies

- Handheld/ Wearable Device
- Display Technology
- Automatic Identification
- Networked Sensors
- Biometrics
- Distributed Computing
- MEMS (Microelectromechanical Systems)
- Voice Recognition/ Sound
- Wireless networking
- Motion Tracking
- Vision System
- Pen Computing

Language Issues:

English
ubiquitous
Ubiquitous Computing
Similar meaning:
Pervasive
Nomadic Computing
Nomads

Mobile Computing and related expressions:

- Ubiquitous Computing
- Pervasive Computing
- Nomadic Computing
- Wireless Networks (Wireless LANs)
- Wireless Application Protocol (WAP)
- Bluetooth
- Mobile IP
- mobile Agents

New scientific area covering many diverse subjects in Computer Science and Telecommunications.

New area in teaching and research, covered by several international initiatives:

- "Ubiquitous Computing"
- EU-Program "Disappearing Computer"
- U.S. Program "IT Expeditions into the 21st Century"

Ubicomp

The idea of ubiquitous computing as invisible computation was first articulated by Mark Weiser in 1988 at the Computer Science Lab at Xerox PARC.

Mark Weiser
July 23, 1952 - April 27, 1999

Xerox PARC:
"*Palo Alto Research Center*"
(now "*Palo Alto Research Center Incorporated*")
http://www.parc.xerox.com/

parc® Palo Alto Research Center

Ref.:
`http://www.ubiq.com/hypertext/weiser/weiser.html`

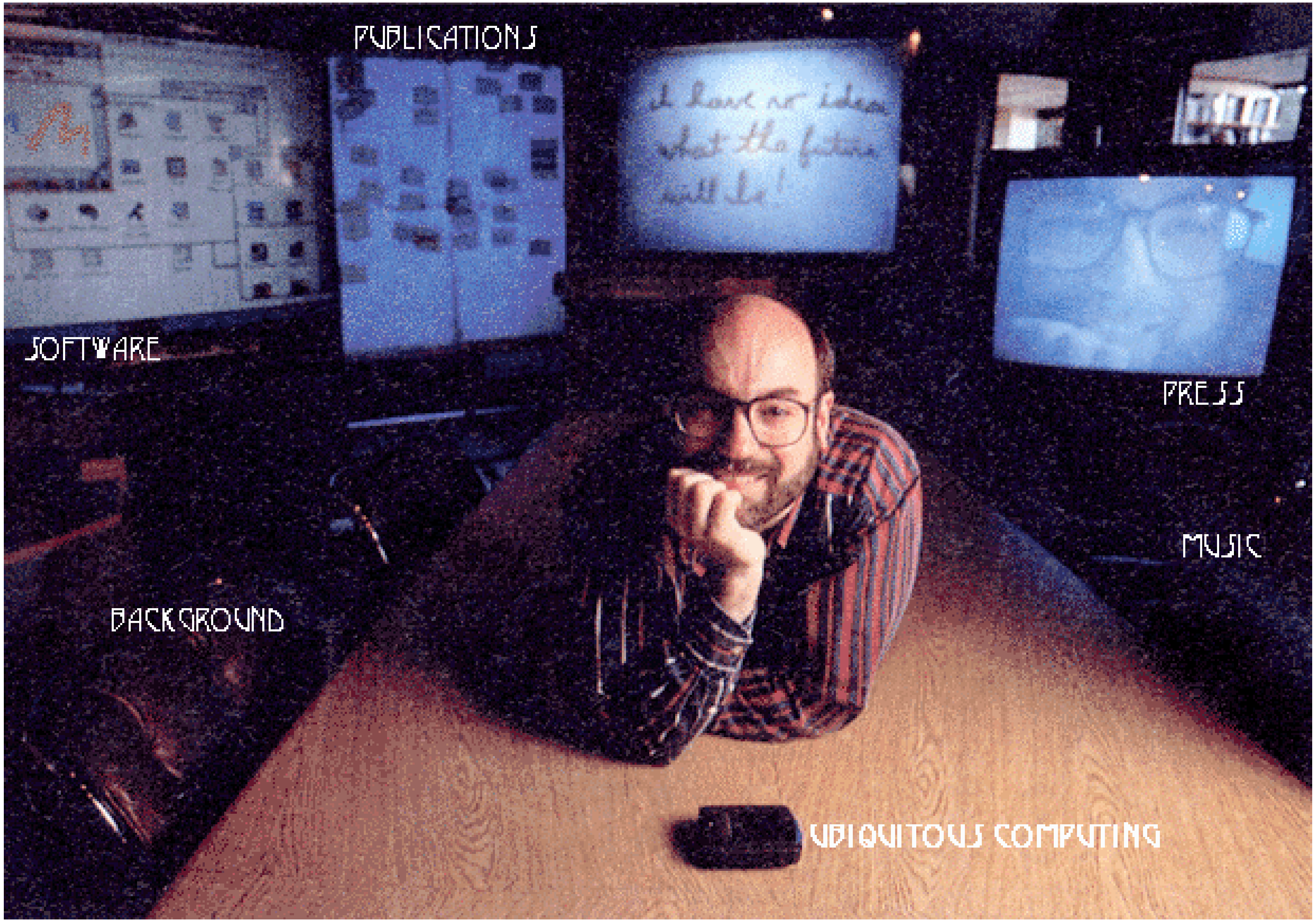
Mark Weiser:

"Ubiquitous computing names the third wave in computing, just now beginning. First were mainframes, each shared by lots of people. Now we are in the personal computing era, person and machine staring uneasily at each other across the desktop. Next comes ubiquitous computing, or the age of calm technology, when technology recedes into the background of our lives."

Calm Technology

Reader

Mark Weiser


PUBLICATIONS
SOFTWARE
PRESS
MUSIC
BACKGROUND
UBIQUITOUS COMPUTING

Some Computer Science Issues in Ubiquitous Computing

Mark Weiser
March 23, 1993

"Ubiquitous computing is the method of enhancing computer use by making many computers available throughout the physical environment, but making them effectively invisible to the user."

Scientific American Ubicomp Paper

SCIENTIFIC AMERICAN.COM

Mark Weiser:
The Computer for the 21st Century,
Sci. Amer., 265 (3), 94-104, September 1991

"The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it."

Reader

Ubiquitous Computing

Computers everywhere.

"Making many computers available throughout the physical environment, while making them effectively invisible to the user".

"Ubiquitous Computing is fundamentally characterized by the connection of things in the world with computation".

Ubiquitous computing is considered the Third Wave of computing.

- **The First Wave was many people per computer.**
- **The Second Wave was one person per computer.**
- **The Third Wave will be many computers per person.**

Three key technical issues are: power consumption, user interface, and wireless connectivity.

Current Ubiquitous Computing

In its broadest sense, ubiquitous computing is currently seen to comprise any number of
mobile, wearable, distributed and context-aware computing applications.

In this way, Ubicomp may consist of research into
'*how information technology can be diffused into everyday objects and settings, and to see how this can lead to new ways of supporting and enhancing people's lives.*'

Ref.:
The Disappearing Computer Initiative
(http://www.disappearing-computer.net)

Current Ubiquitous Computing

‘Integration of physical and digital interaction.’

In addition to research in engineering, computer and hard sciences, continuing investigations in human-computer interaction and computer supported cooperative work draw on psychology, anthropology and sociology

Ref.:
EQUATOR Interdisciplinary Research Collaboration (http://www.equator.ac.uk).

Pervasive Computing:

The trend towards using computers in everyday life, not only including personal computers, but very tiny - even invisible - devices, either mobile or embedded - in almost any type of object imaginable, including cars, tools, appliances, clothing and various consumer goods - all communicating through increasingly interconnected networks.

What is Pervasive?

- Computation that is freely available everywhere.
- A scenario where all devices are networked, human-centric, communicate and interact with each other.

The 6As model of pervasive computing:

- The "authorized access to anytime-anywhere-any device-any network-any data".

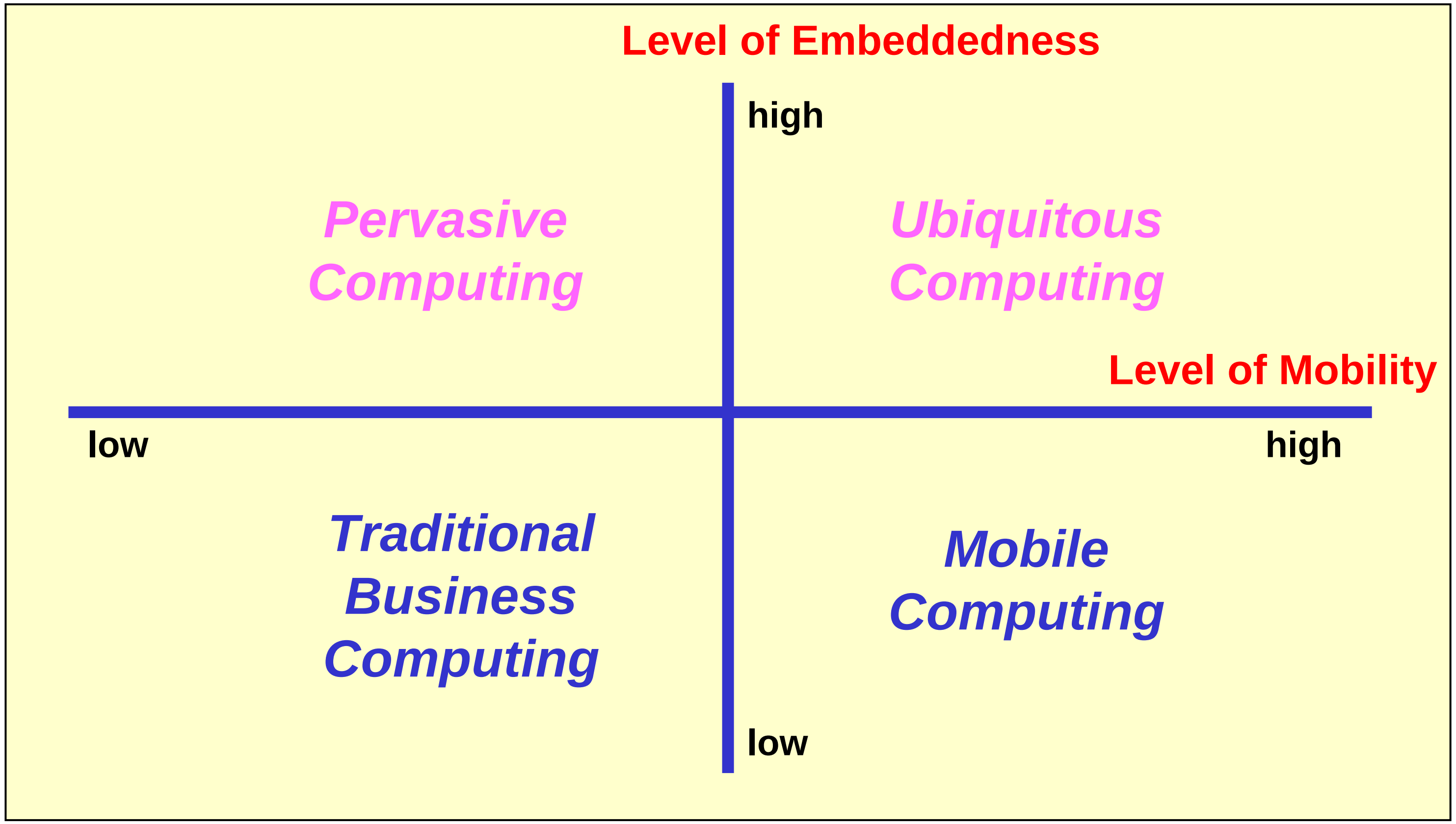
What makes a System ubiquitous:

- Embedded
- Networked
- Available Everywhere
- Context-Awareness
- New Devices

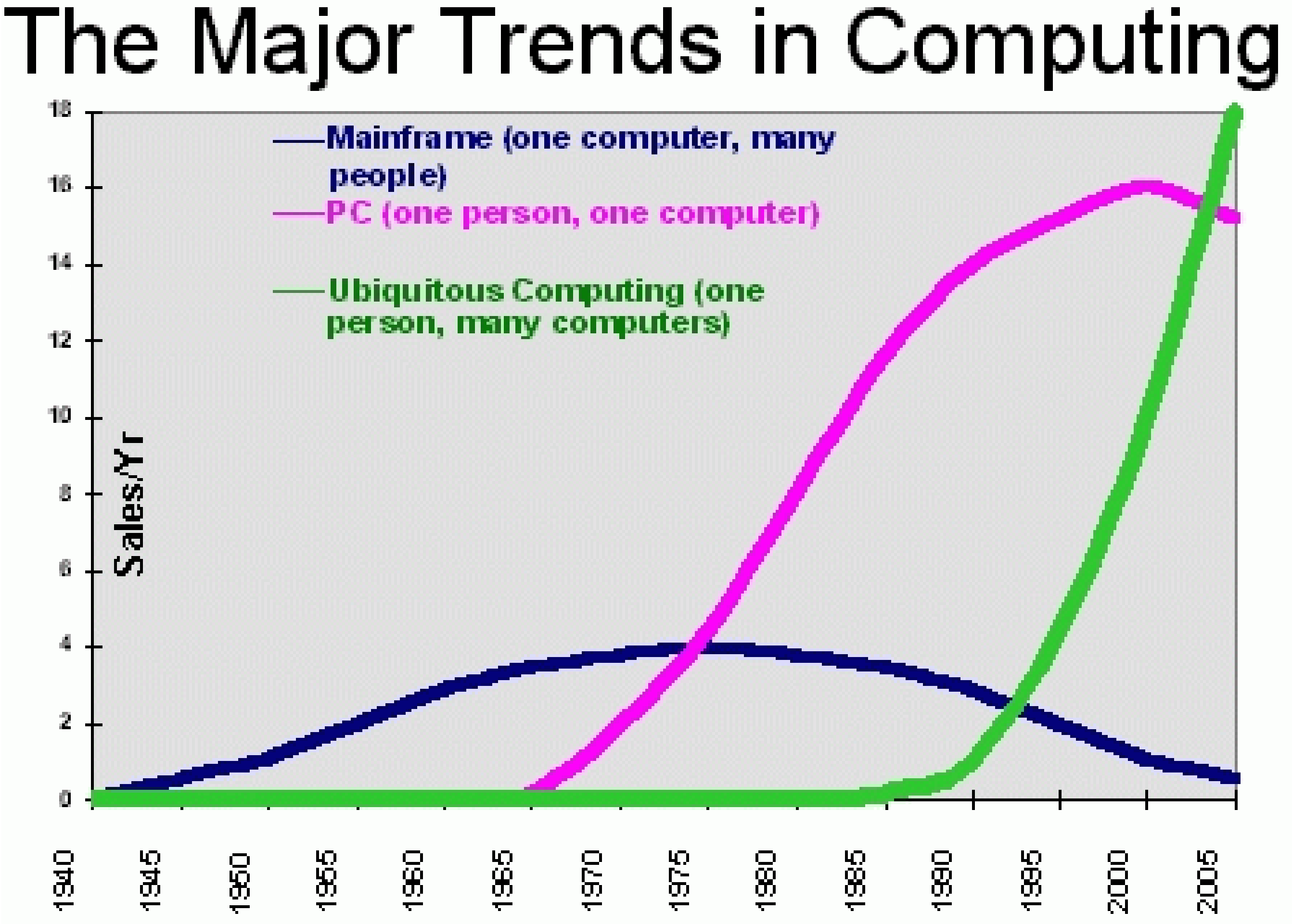
Nomadic computing:

What pervasive devices do is to connect nomadic users.
They can access different locations, URLs that point to specific content through barcodes, electronic tags, optical recognition methods and infrared and radio frequency transceivers available on PDAs (personal digital assistants) and laptops through direct or indirect sensing methods.

Pervasive Computing and modern Technologies:



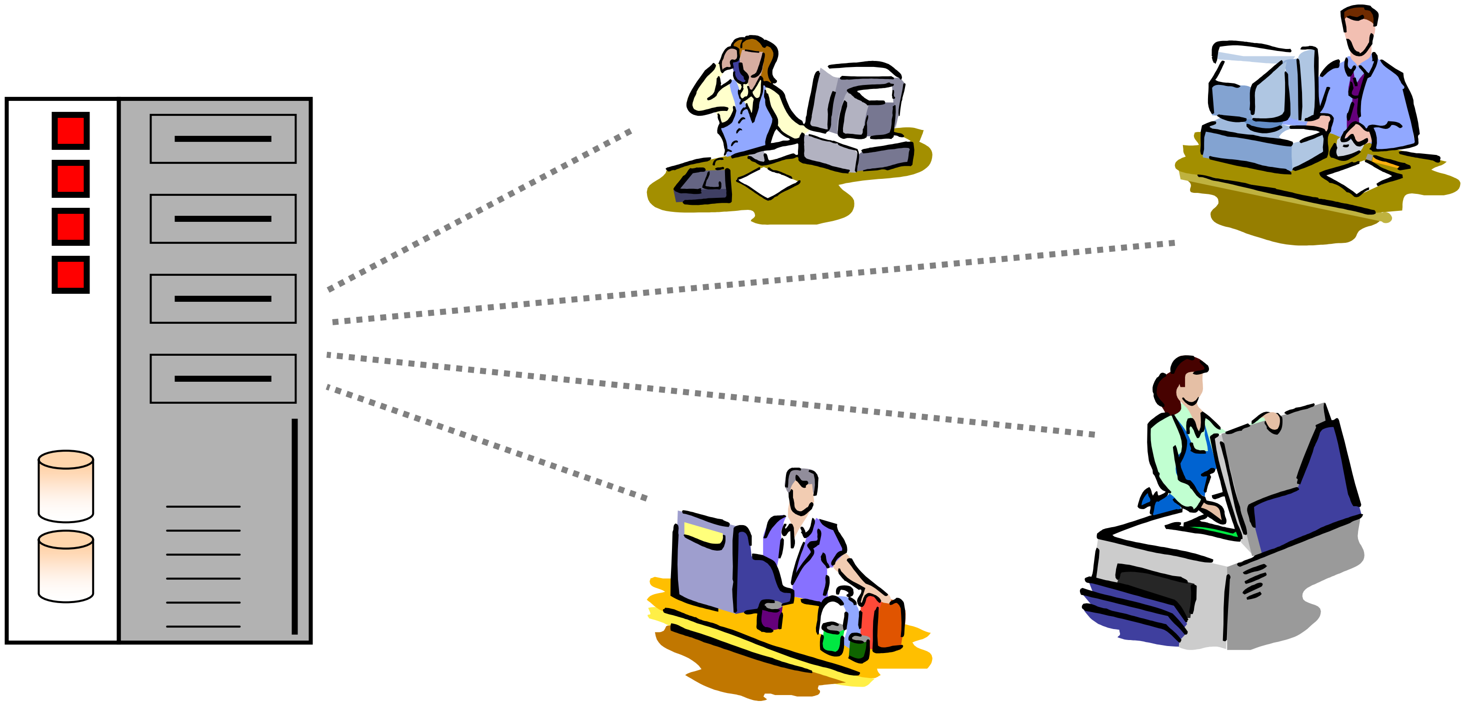
Trends in Computing



Trends

Mainframe Era:

- Many people share one computer



Trends

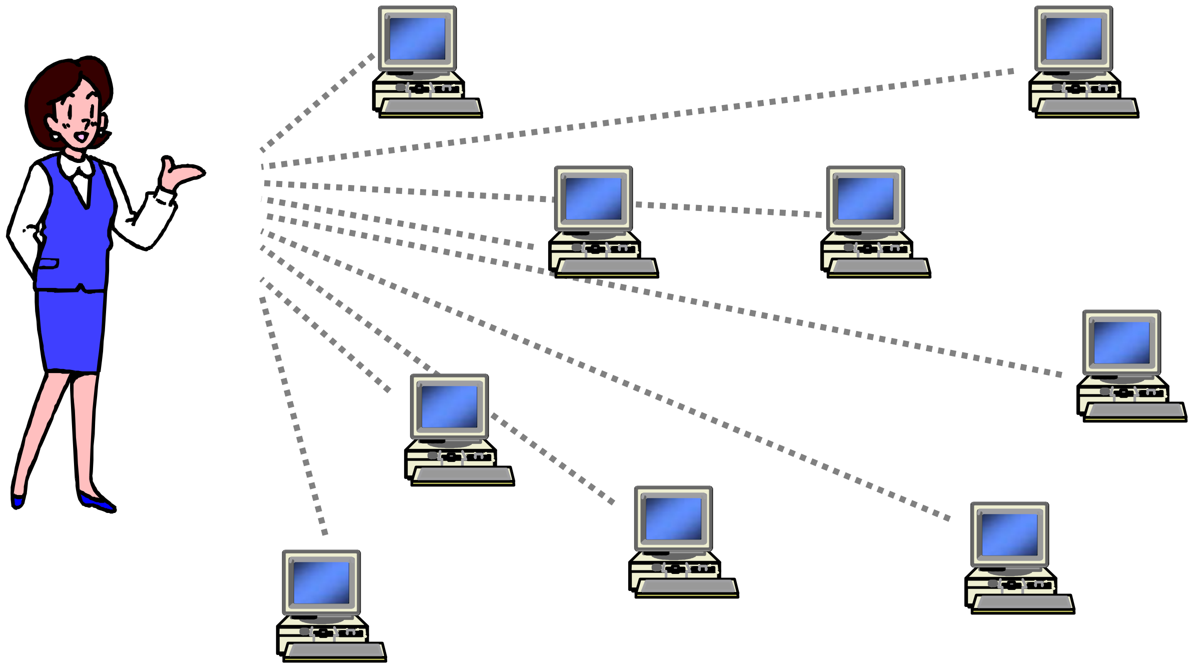
Personal Computer Era:

- One person with one computer

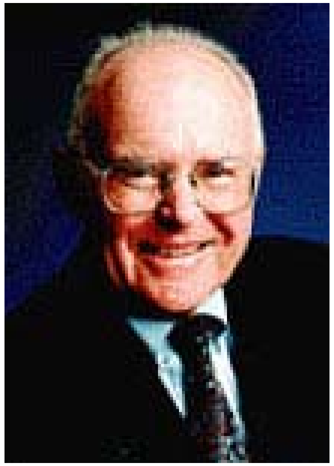
Trends

Ubiquitous Computing Era:

- Many computers serve each person



Moore's Law

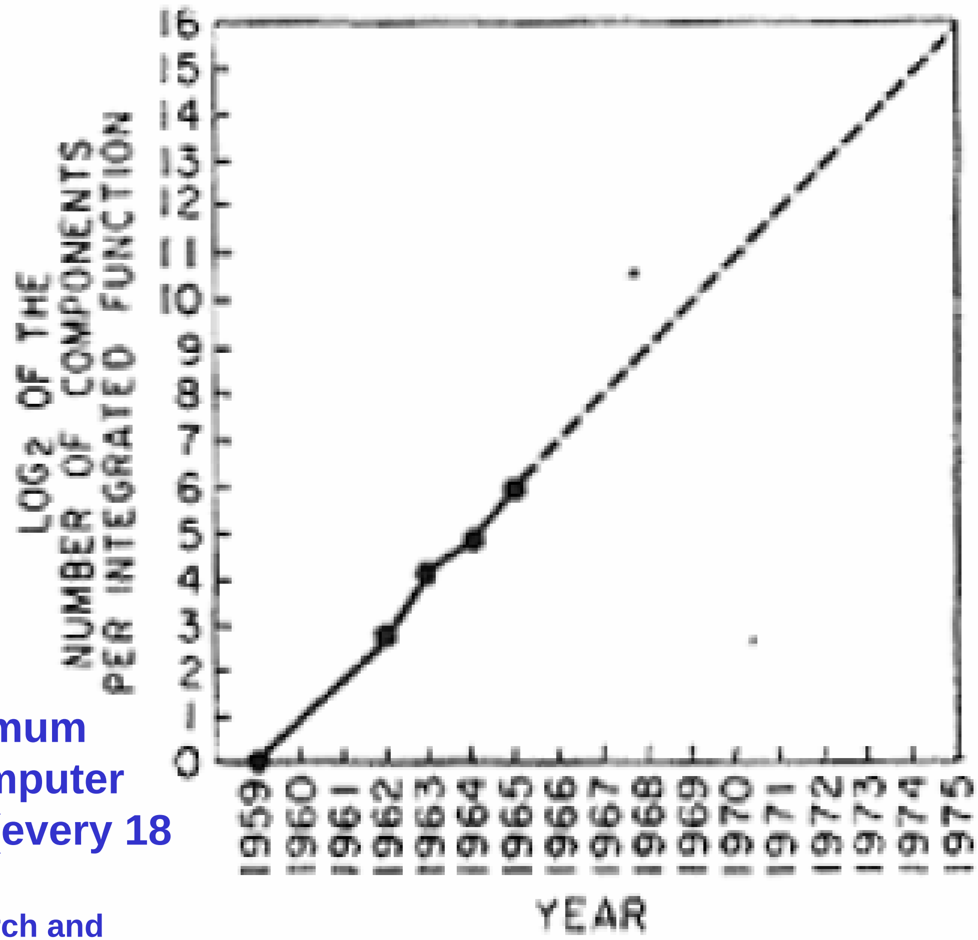


Gordon Moore

Co-founder of Intel in 1968.

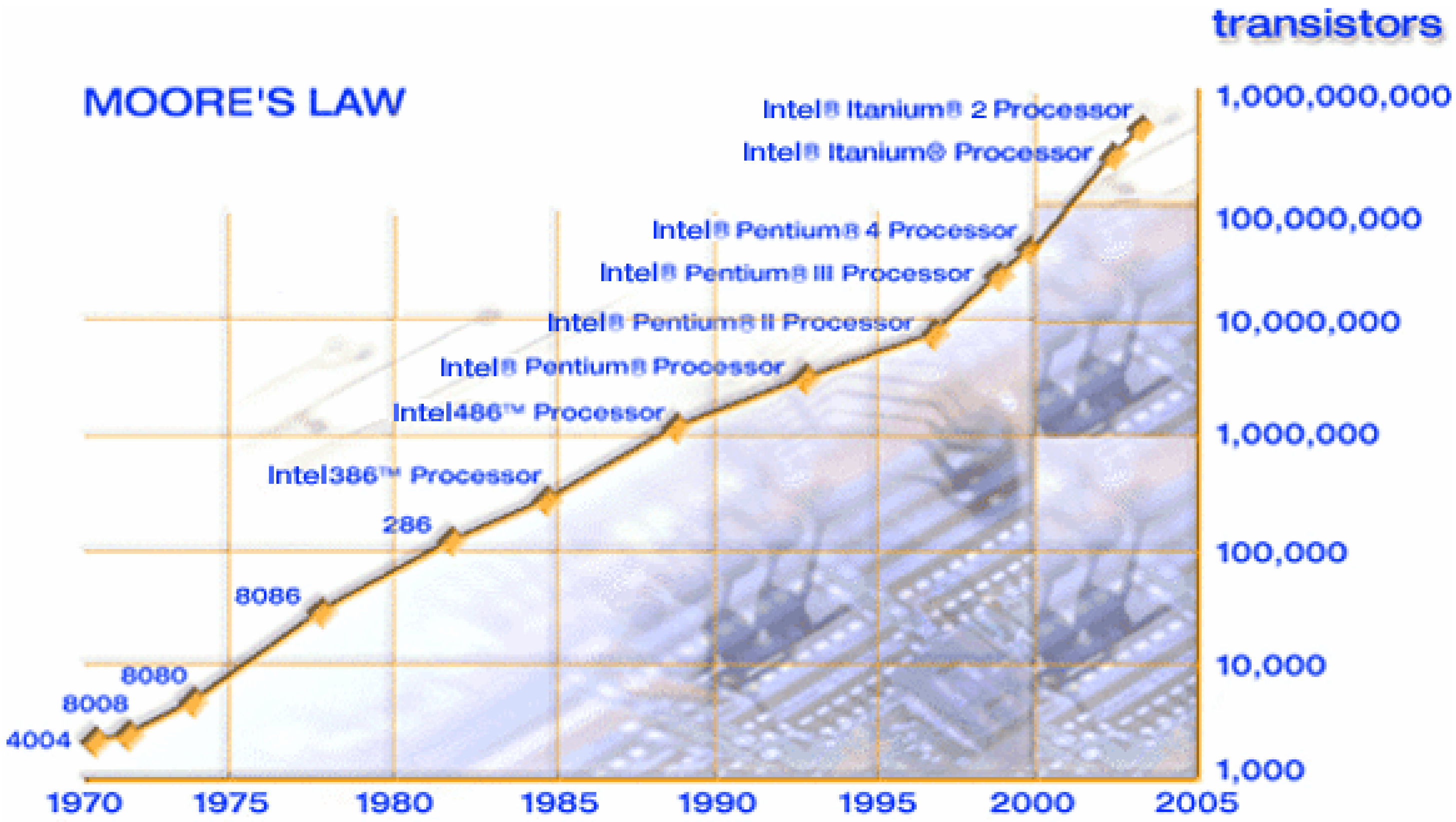
Moore predicted that the maximum number of transistors on a computer chip would double every year (every 18 months).

In 1965 Moore was Director at the Research and Development Laboratories, Fairchild Semiconductor division of Fairchild Camera and Instrument Corp.

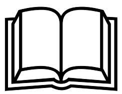


Ref.: http://www.intel.com/research/silicon/mooreslaw.htm

Moore's Law



This trend may continue another 10 years
(using current technology)

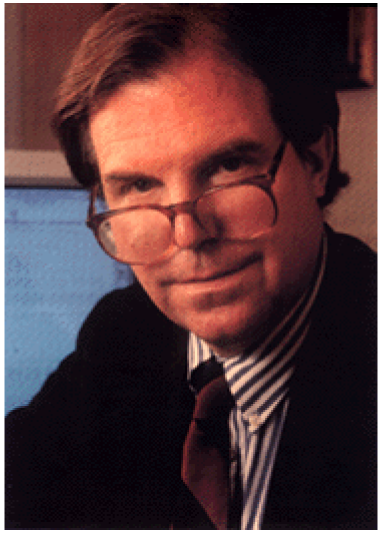


Reader

New Eras

"New eras of computing start when the previous era is so strong it is hard to imagine that things could be different"

David Culler, 1999
University of California Berkeley
Dept. of Electrical Engineering and Computer Sciences



Nicholas Negraponte - MIT Media Labs
"Things that think want to link".

This is the doctrine on which pervasive computing is based!

"I think there is a world market for maybe five computers"

Thomas Watson, CEO IBM, 1943

"Picture a day when a billion people will interact with a million e-businesses via a trillion interconnected, intelligent devices"

Louis V. Gerstner Jr., CEO IBM, 2005

Nomadics

Some implications of Nomadicity:

- **Each persons uses many devices:**
  - Total number of nomadic devices >> number of people
- **Large number of fixed devices:**
  - Many computers embedded in environment
  - Nomadic devices must interact with fixed infrastructure
- **Many nomadic devices are essentially PC-peripherals.**

Smart Devices

Hardware-architecture definition of “Smart Devices”
BILL of Things' rights (Things have right to):

- **Have an identity**
- **Access other objects**
- **Detect the nature of their environment.**

*Neil Gershenfeld. "**When things start to think**." 1999*

Neil Gershenfeld
Director of the Physics and Media Group at MIT's Media Lab.
Co-Director of the ***Things That Think*** consortium.

Smart Devices

Neil Gershenfeld:

Smart devices cover a continuum from passive electronic tags or minimal data-providing smart cards through networked sensors and actuators to intelligent devices and their networked services. The word "smart" does not in this context indicate a breakthrough in artificial intelligence or autonomousness of the devices in any strong sense

Project Results

P946 Smart Devices "When Things Start to Think"

Strategic Study

Overview:

The essential message of this strategic study is an inconvenient one:
The upcoming paradigm shift towards Ubiquitous Computing is highly likely to change the IT and Telecommunications business considerably, probably more than the Internet changed Telecommunications a few years ago.

Ref.:
http://www.eurescom.de/public/projectresults/P900-series/946d1.asp

Smart Devices

Minimal definition of a smart device:

A physical object with an ***embedded processor***, ***memory***, ***sensors*** and/or ***actuators***, and a ***network connection***.

Features:

- Ability to interact with its environment (i.e. as sensor and/or actuator) and/or a user. This is merely the ‘device’ requirement.
- Some portion of its interactive functionality observable and/or controllable over a network.
- Ability to, with the input from other networked devices if necessary, be able to change its state and its outputs to provide a service.

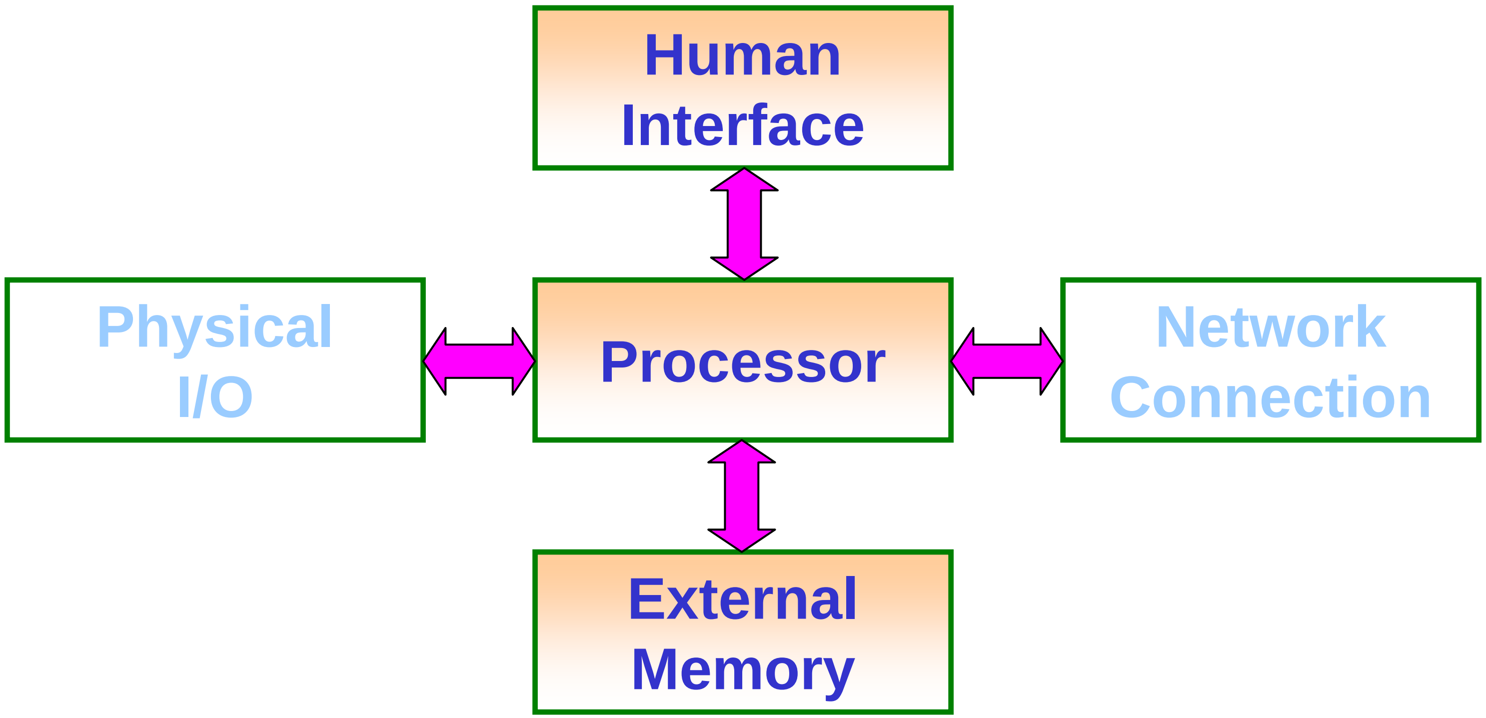
Differences between

- a general purpose computer,
- a communication terminal and
- a smart device by the different text sizes

Project P946-GI,
Smart Devices “When Things Start to Think”, 2000

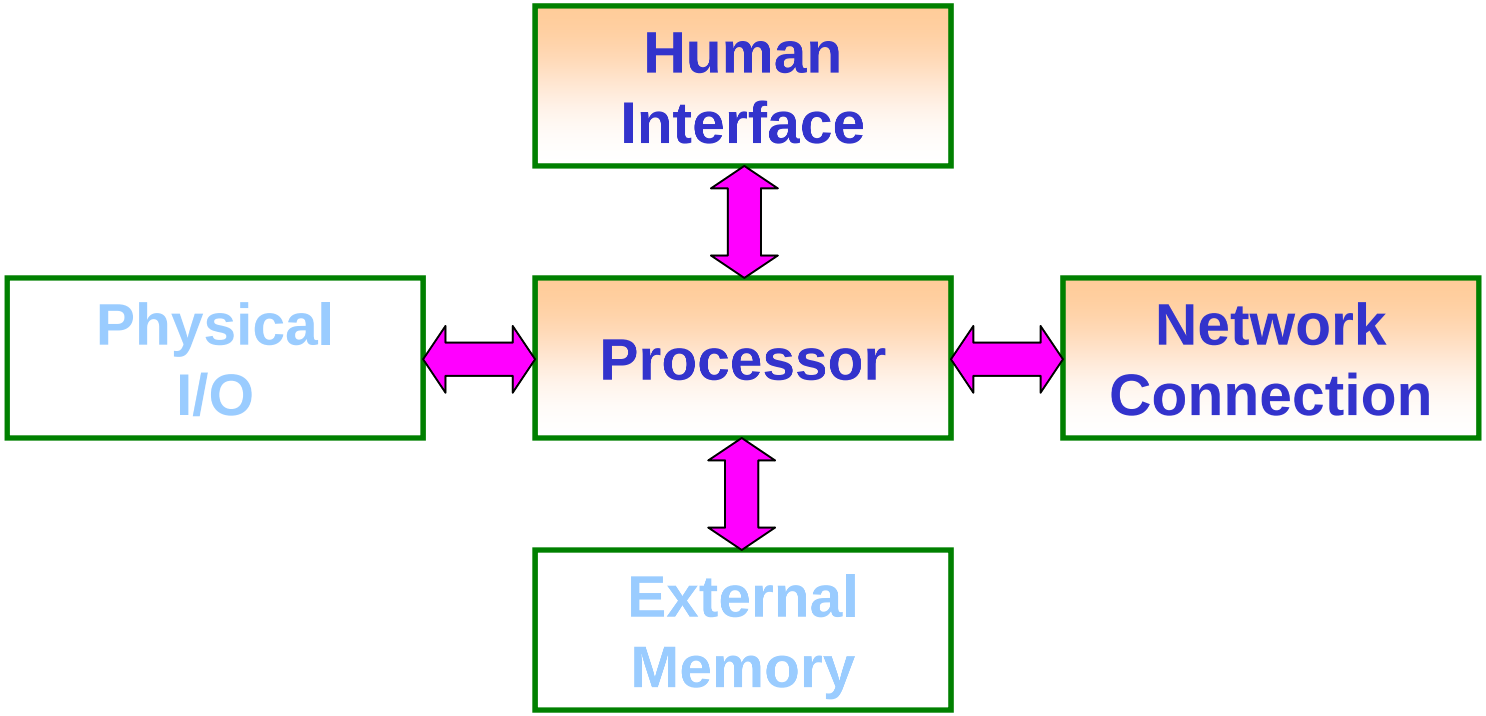
Smart Devices

General-purpose computer:



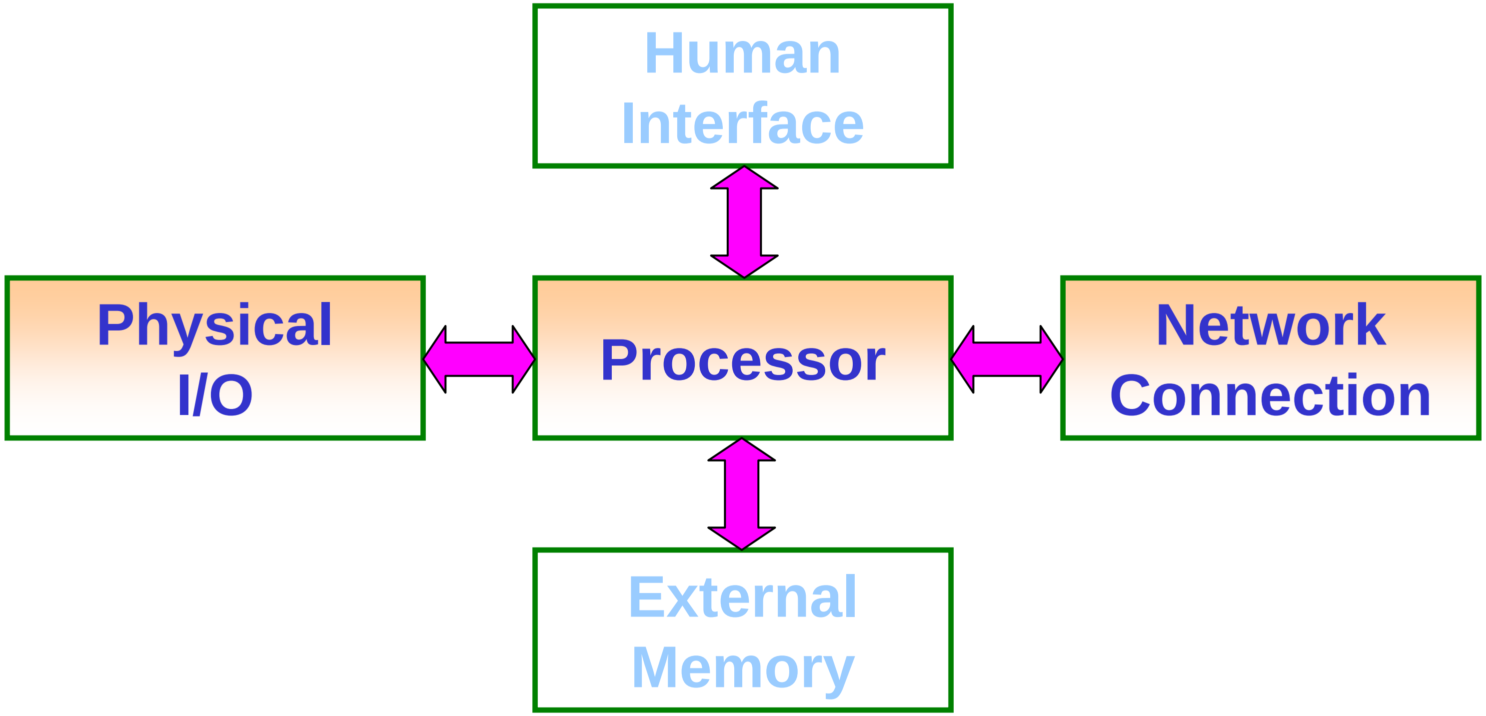
Project P946-GI,
Smart Devices "When Things Start to Think", 2000

Communication terminal:



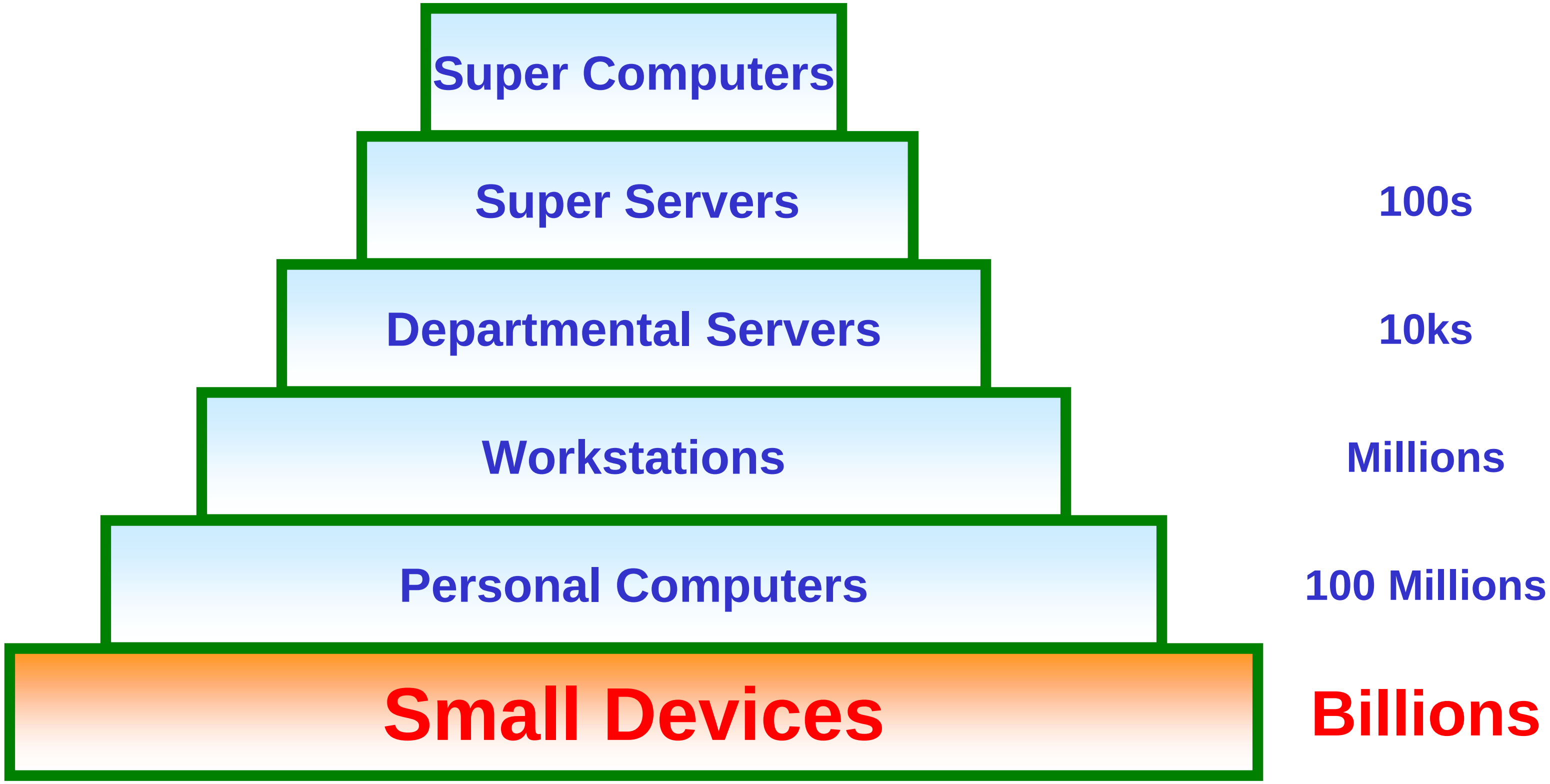
Project P946-GI,
Smart Devices “When Things Start to Think”, 2000

Smart Device:



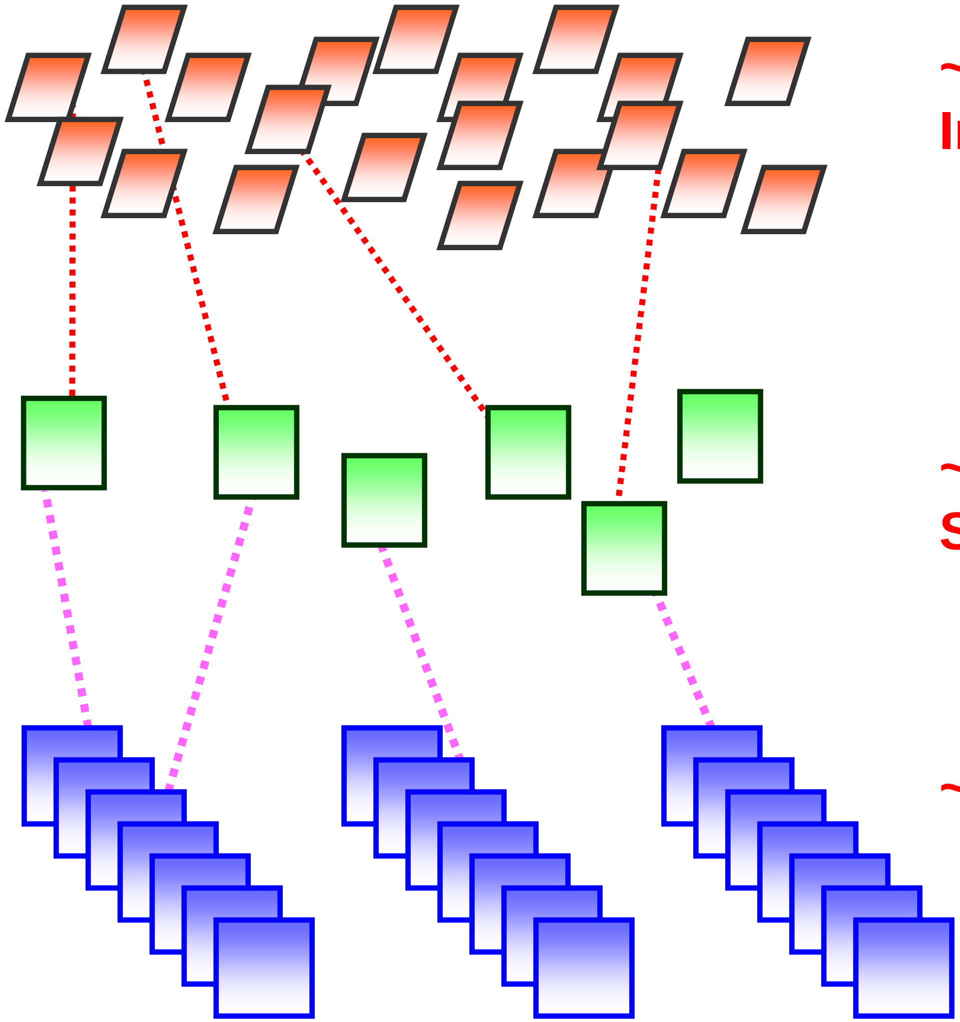
Project P946-GI,
Smart Devices "When Things Start to Think", 2000

Emerging Platform Pyramid



David Culler, U.C. Berkeley
ISRG Retreat

Future Internet Systems



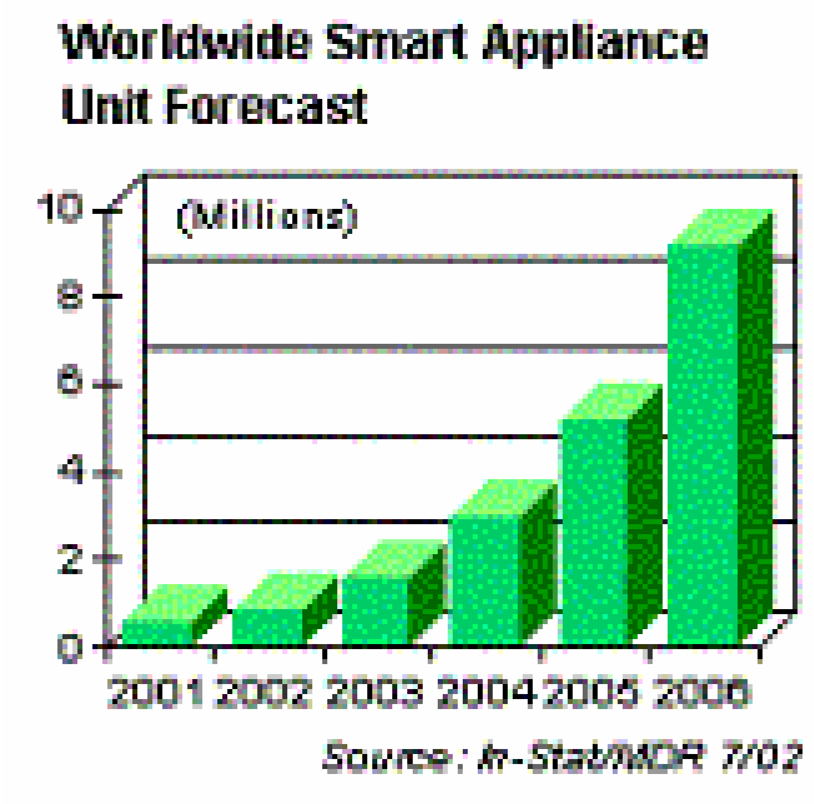
~10 Billion of Information Appliances

~100 Million of Stationary Computers

~Million Scalable Servers

David Culler, U.C. Berkeley
ISRG Retreat

Smart Appliances

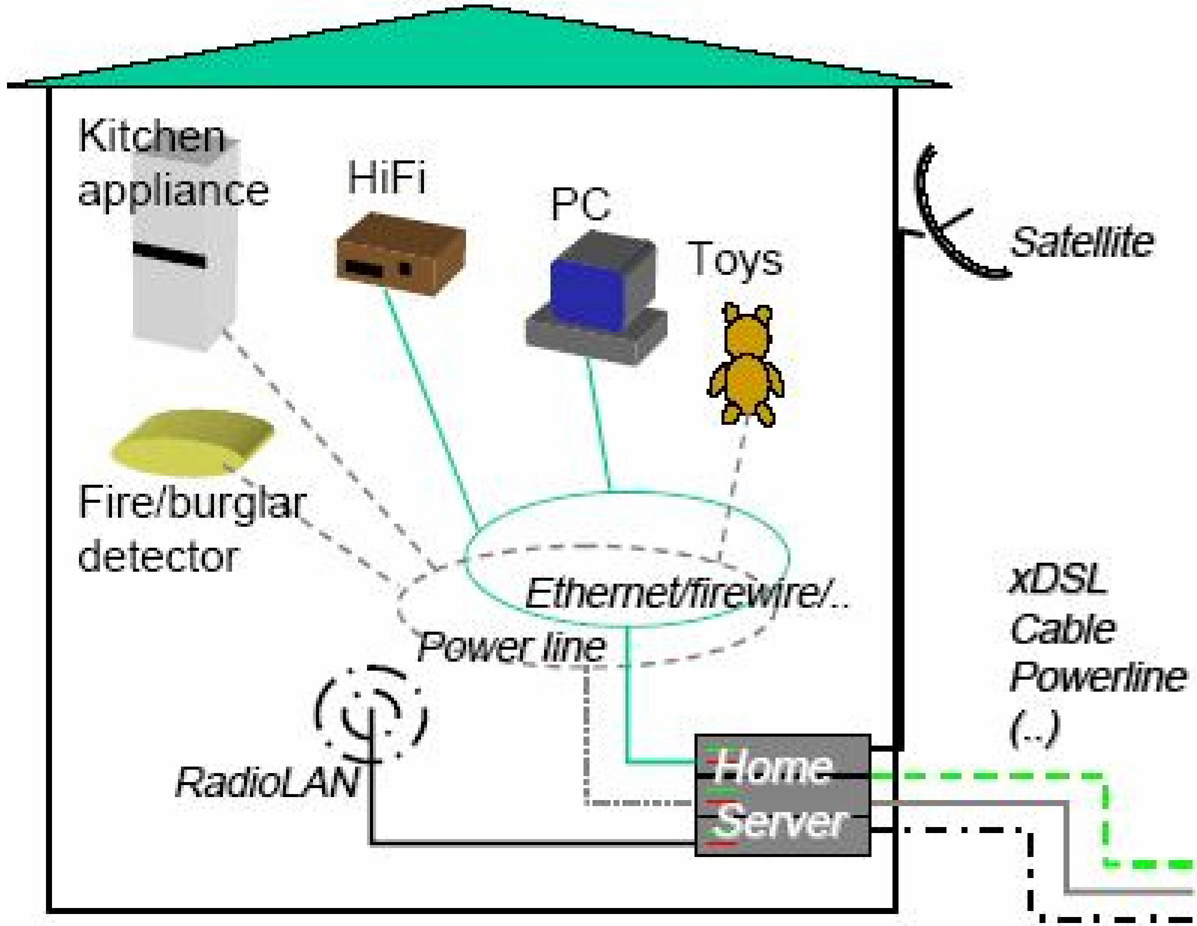


2000:
~5 billion microprocessors sold, only 120 million of them (roughly 2.5%) used in PCs.

Estimate:
Until 2005 the number of processors in the average home will grow from 40 to 280 and the number of embedded chips sold to support increasingly intelligent devices will grow to over 9 billion.
Intelligence and connectivity will be designed into almost every electronic device.

Ref.:
http://www.dcs.napier.ac.uk/~mm/socbytes/feb2004/4d.htm
"Web Enabled Internet Appliances? Are they a Reality?"

Smart Appliances



The Home Server in the basement

Ubiquitous Computing

Motes and Smart Dust

Content:

Introduction

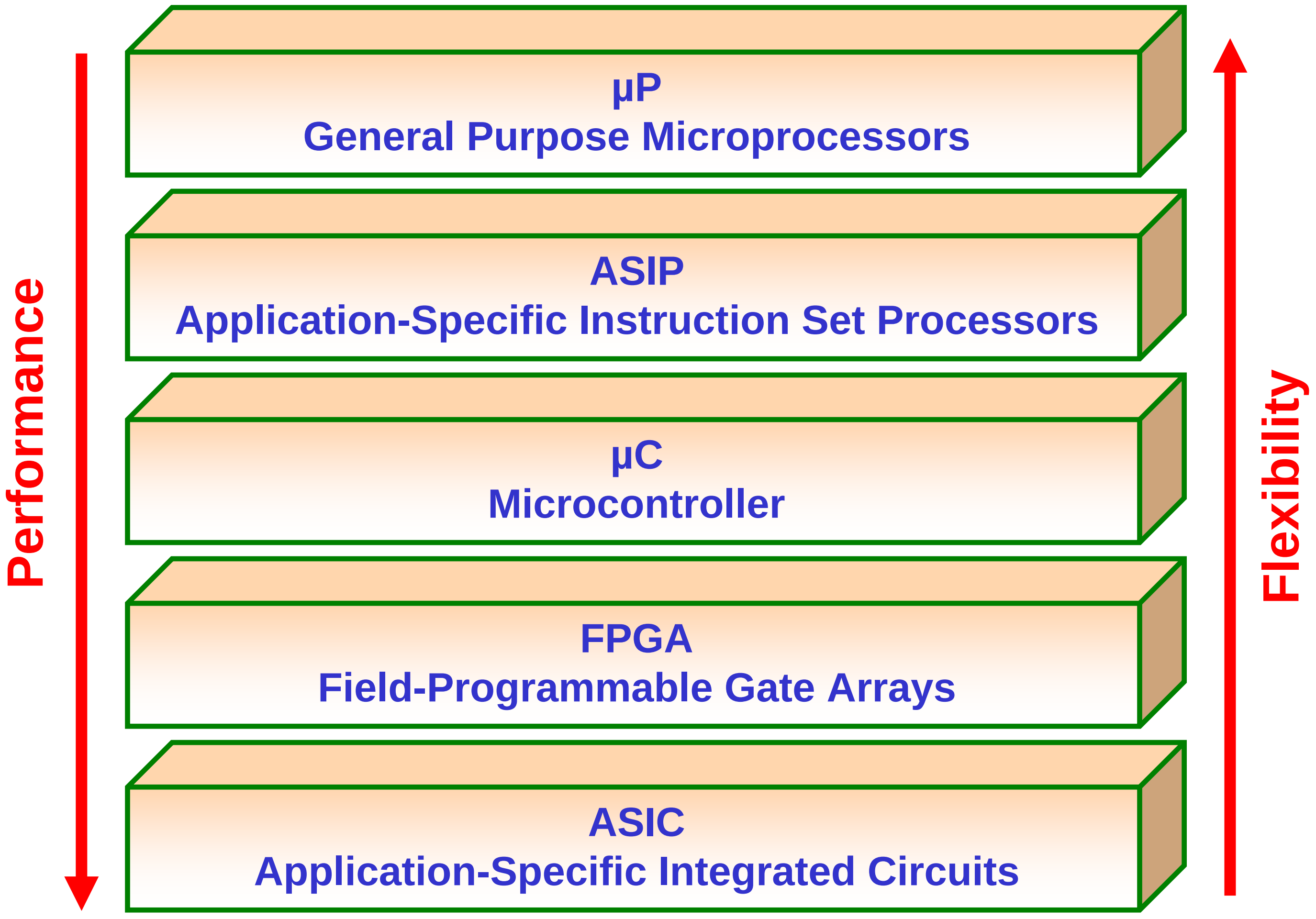
- **Hardware:**
  - UCLA-WINS: Wireless Integrated Network Sensors
  - Rockwell WSN,
  - MIT µAMPS,
  - UCLA Medusa,
  - Berkeley Motes
  - Smart-Its Platform
  - Smart Dust
  - BASIC Stamp, JStamp
- **Software:**
  - TinyOS

Hardware for Ubicomp

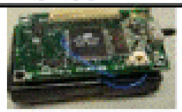
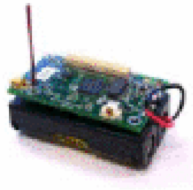
Available Architectures:

- General Purpose Microprocessors
- ASIP – Application-Specific Instruction Set Processors
- Microcontroller
- FPGA – Field-Programmable Gate Arrays
- ASIC – Application-Specific Integrated Circuits

Ubicomp Hardware II



Motes

Mote Type	WeC	Renee	Mica	Mica2	Mica2Dot
					
Microcontroller					
Type	AT90LS8535	Atmega163	Atmega128	Atmega128	Atmega128
CPU Clock (Mhz)	4	4	4	7.3827	4
Program Memory (KB)	8	16	128	128	128
Ram (KB)	0.5	1	4	4	4
UARTs	1	1	2 (only 1 used)	2	2
SPI	1	1	1	1	1
I2C	Software	Software	Software	Hardware	Hardware
Nonvolatile storage					
Chip	24LC256		AT45DB041B		
Size (KB)	32		512		
Radio Communication					
Radio	RFM TR1000			Chipcon CC1000	
Frequency	916 (single freq)			916/433 (multiple channels)	
Radio speed (kbps)	OOK		ASK	FSK	
Transmit Power Control	Programmable resistor potentiometer			Programmable via CC1000 registers	
Encoding	SecDed (software)			Manchester (hardware)	

Ref.:
http://ttdp.org/tpg/html/book/x416.htm

Motes:

- a new computing concept.

Other names for motes:

- smart dust
- wireless sensing networks.

The Basic Mote Idea:

New way of thinking about computers:

- The core of a mote is a small, low-cost, low-power computer.
- The computer (optionally) monitors one or more sensors (e.g. for temperature, pressure, humidity, acceleration, position, light, weight, sound, vibration, stress, etc.).
- The computer communicates with the outside world through a radio link.
  Typical distances for radio communication are 3 to 50m.
  Limiting factors: Power consumption, size and cost.

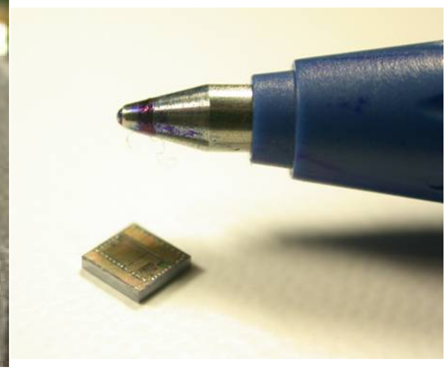
A Mote Computer:
Small Form Factor, Built in Sensors, Communication Link

Mica2 and Mica2Dot

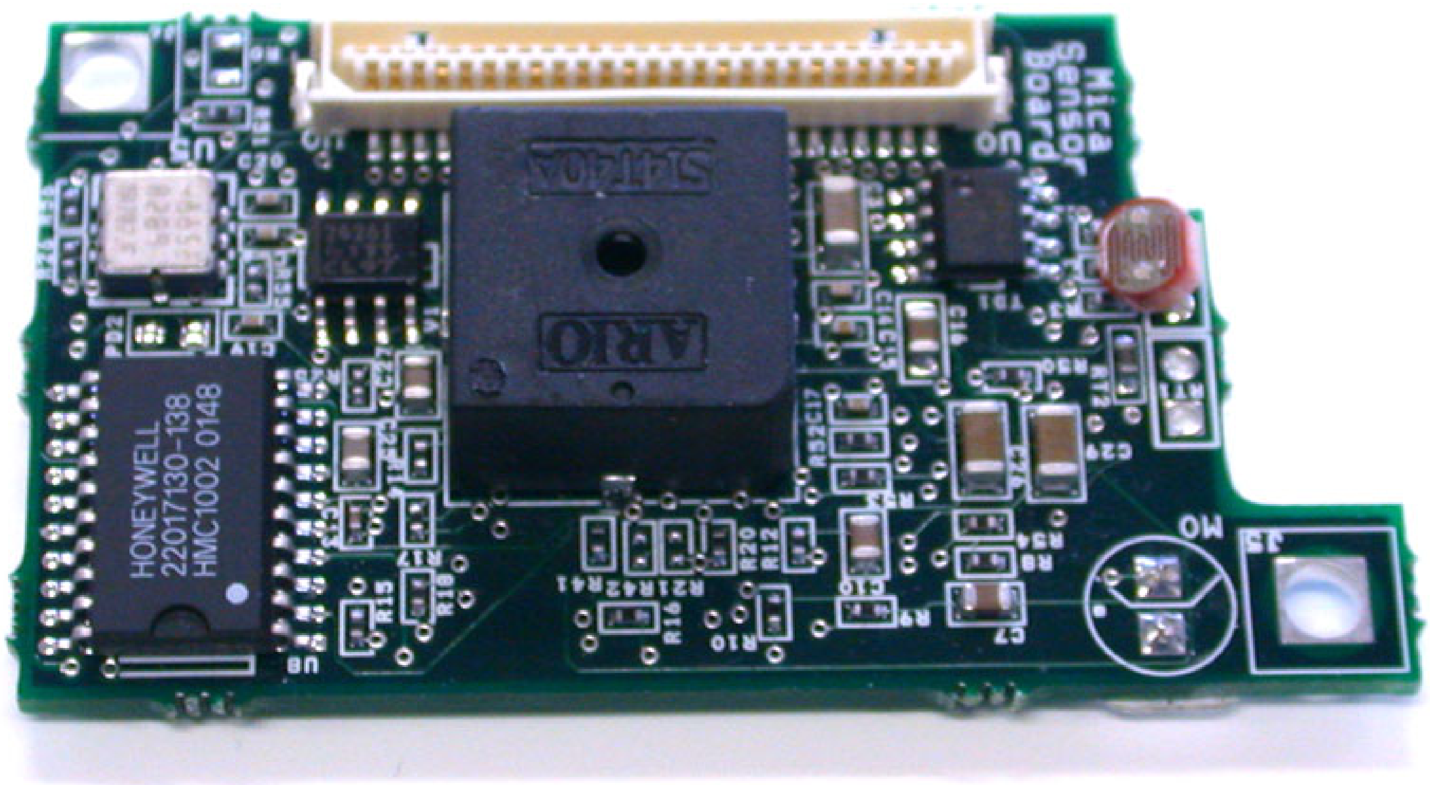
- ATMega 128L 8-bit, 8MHz, 4KB EEPROM, 4KB RAM, 128KB flash
- Chipcon CC100 multichannel radio (Manchester encoding, FSK). Up to 500-1000ft.

Spec Mote (2003)

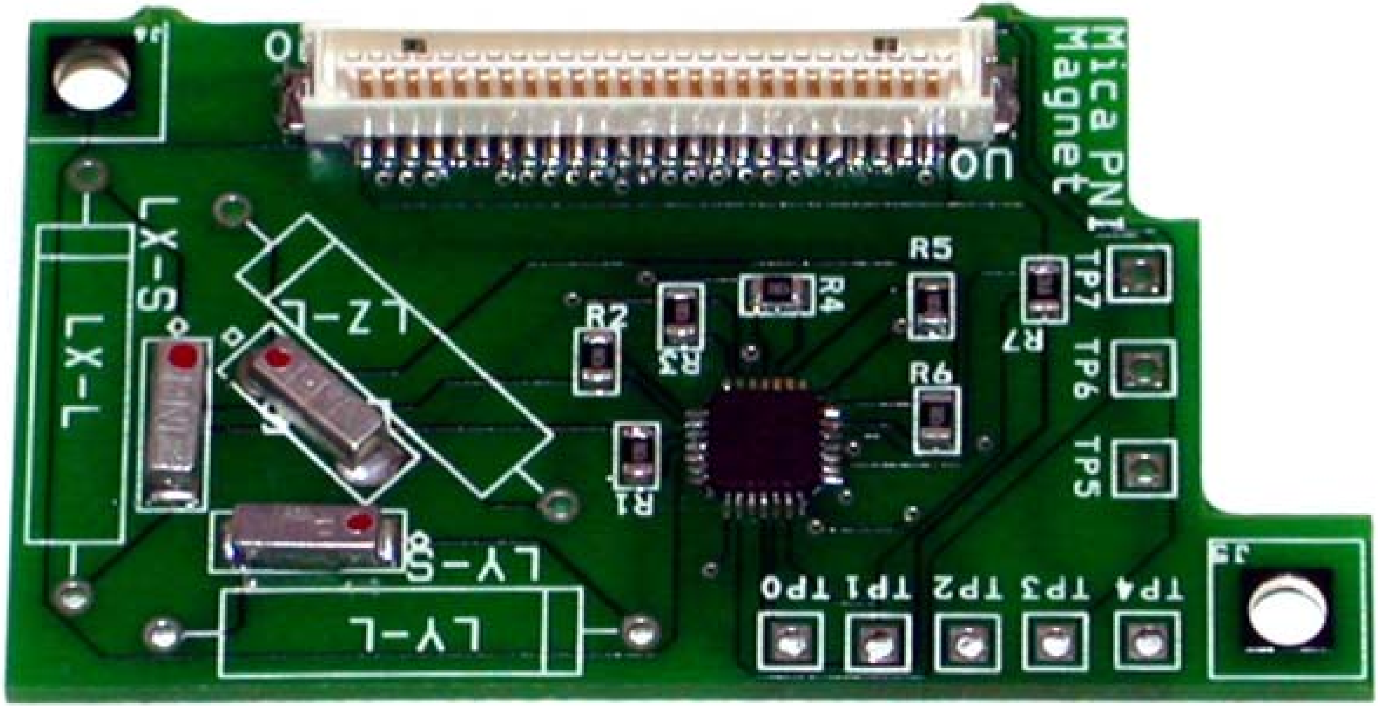
- size: 2x2.5mm, AVR RISC core, 3KB memory, FSK radio (CC1000), encrypted communication hardware support, memory-mapped active messages



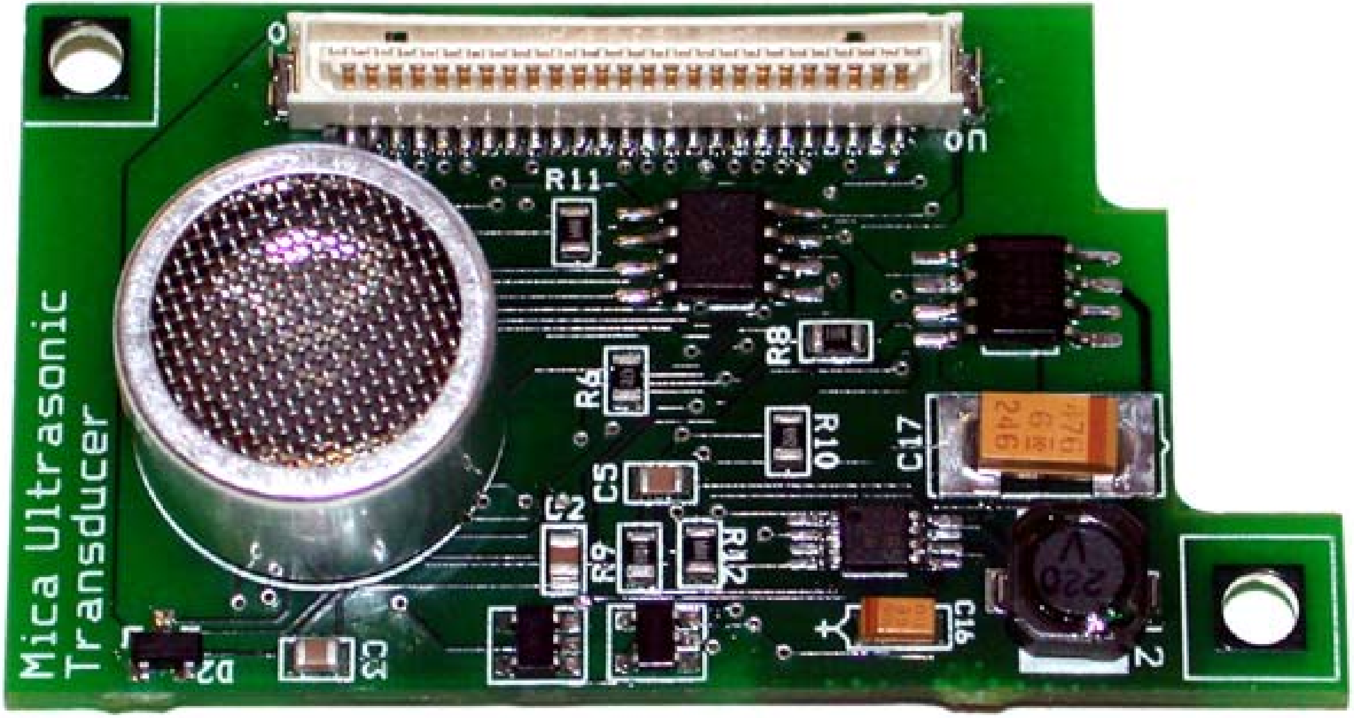
Sensor Board



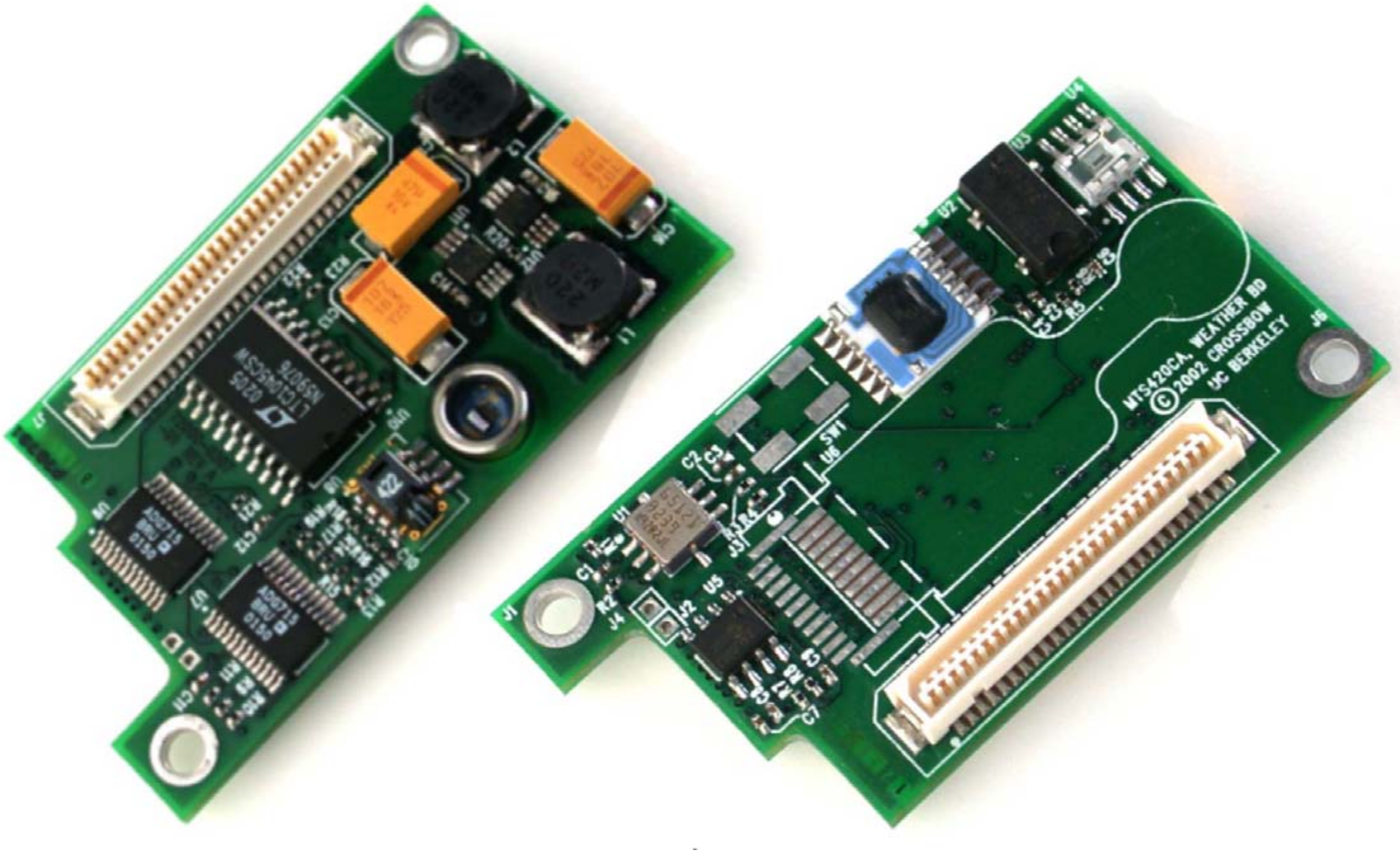
PNI Magnetometer-Compass



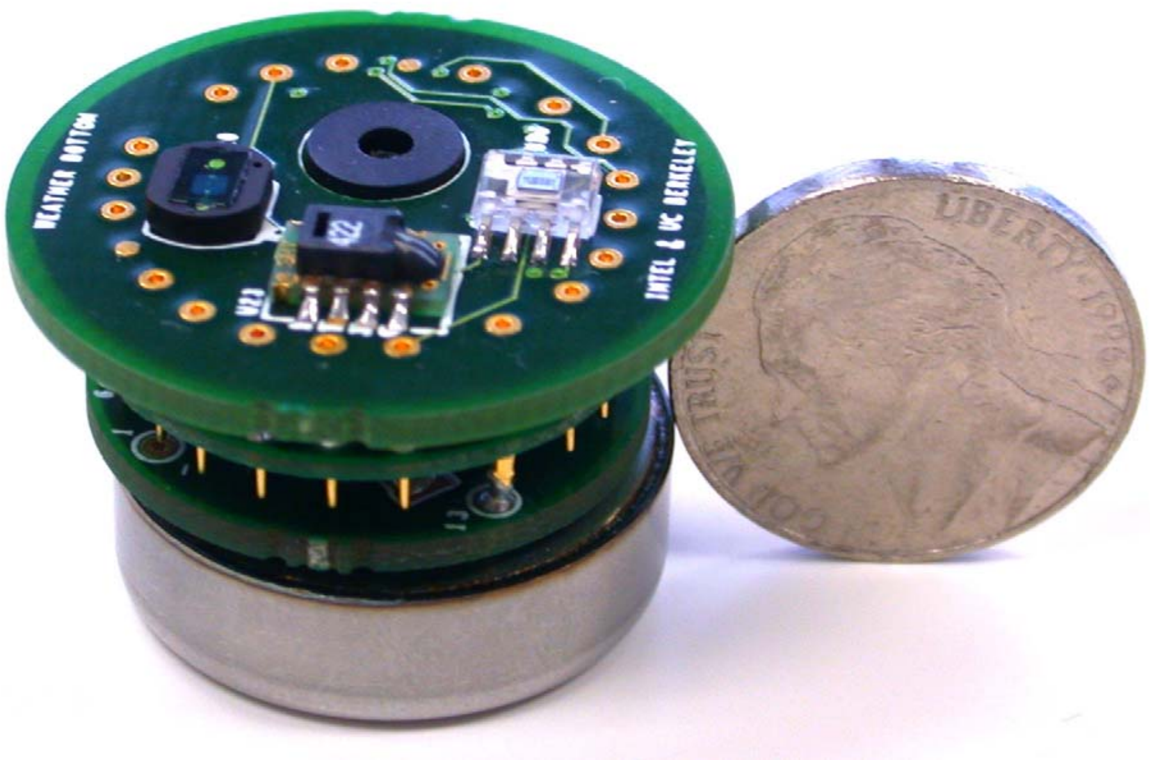
Ultrasonic Transceiver



Mica Weather Board



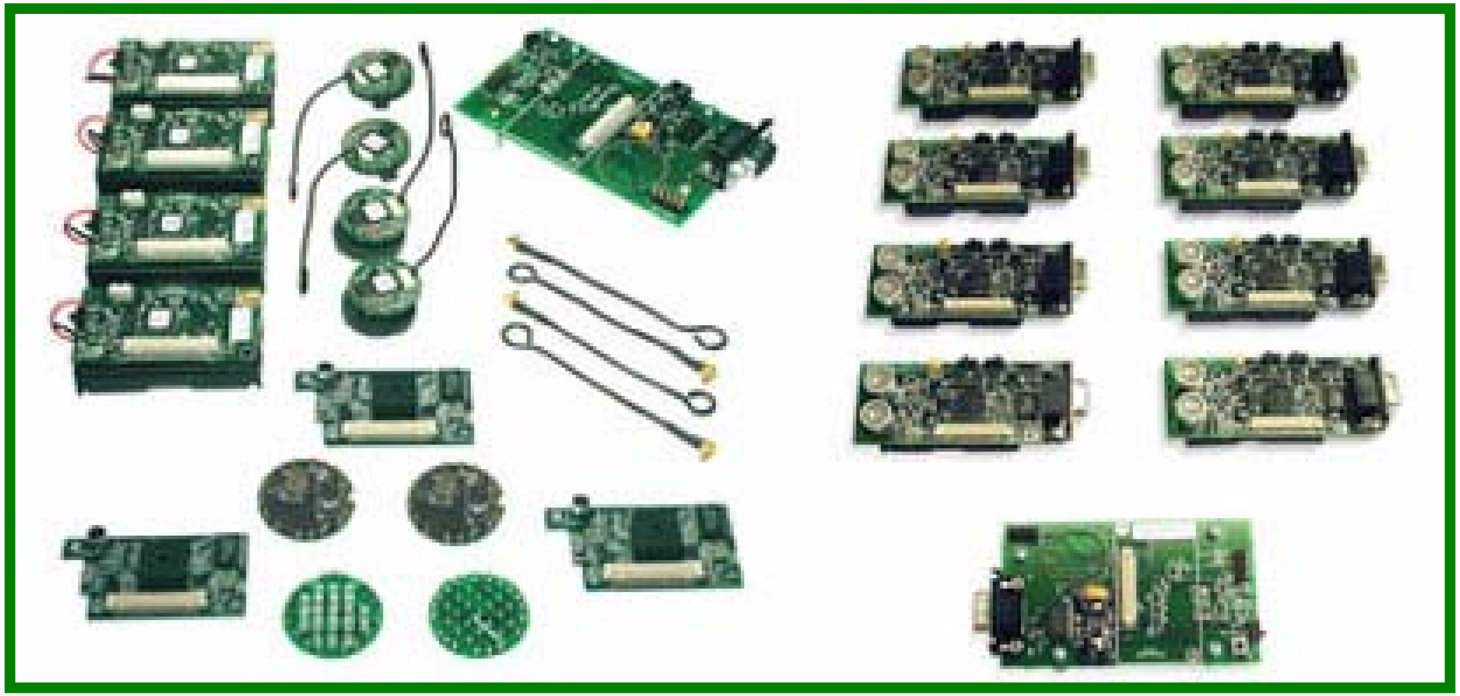
MicaDot Sensor Boards



Mote Kits

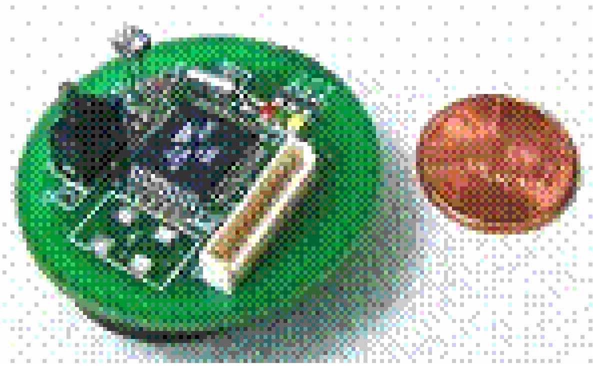
Crossbow Technology Inc.

Global Leader in Sensory Systems



Ref.:
http://www.xbow.com

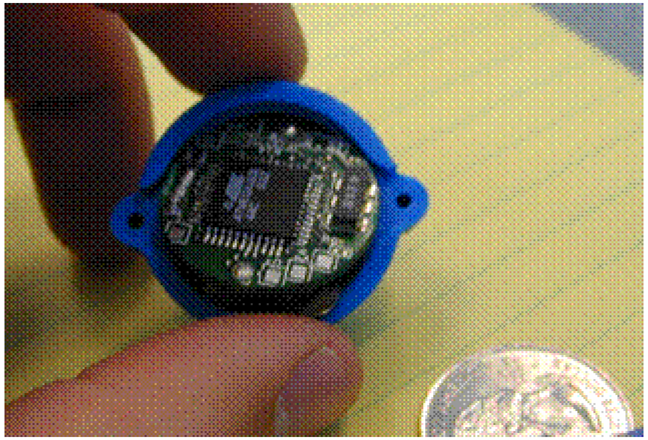
Mote Kits



Wireless Micro-networking:

- Ultra-low Power
- Short-range RF wireless
- Low-cost
- Self-healing ad-hoc networking
- Multi-hop, peer-to-peer topology
- Multi-year operation

Mica2dot:
Wireless sensor network device designed to be the approximate size of a quarter.



Ref.:
http://www.jlhlabs.com/

Mote Kits

Typical Application:

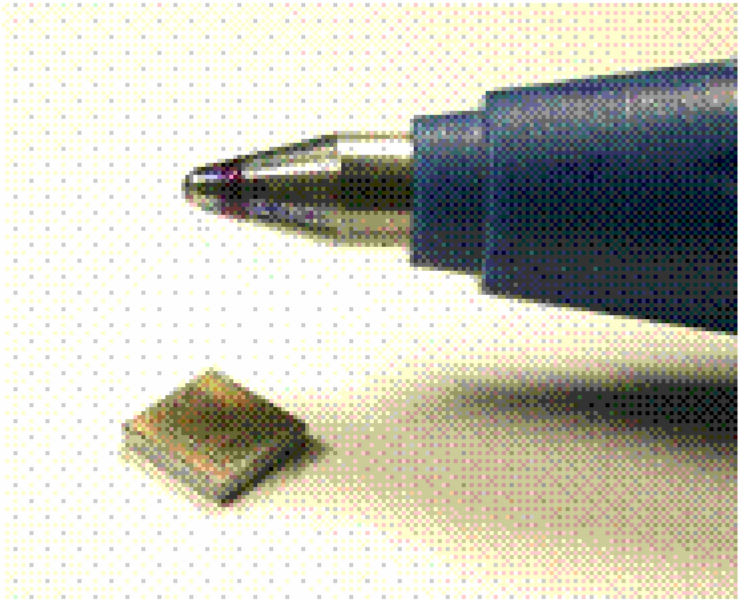
- **Ad-hoc wireless embedded network for precision agriculture. Sensors detect temperature, light levels and soil moisture at hundreds of points across a field and communicate their data over a multi-hop network for analysis.**

Ref.:
http://www.jlhlabs.com/

The Spec Node

Spec was designed in the fall of 2002 by Jason Hill to be a highly integrated, single-chip wireless node.
The CPU, memory, and RF transceiver are all integrated into a single 2.5x2.5mm piece of silicon. Fabricated by National Semiconductor, it was successfully demonstrated in March of 2003.

Spec contains specialized hardware accelerators designed to improve the efficiency of multi-hop mesh networking protocols. Additionally, in includes an ultra-low power transmitter that drastically reduces overall power consumption. Spec represents the future of embedded wireless networking.

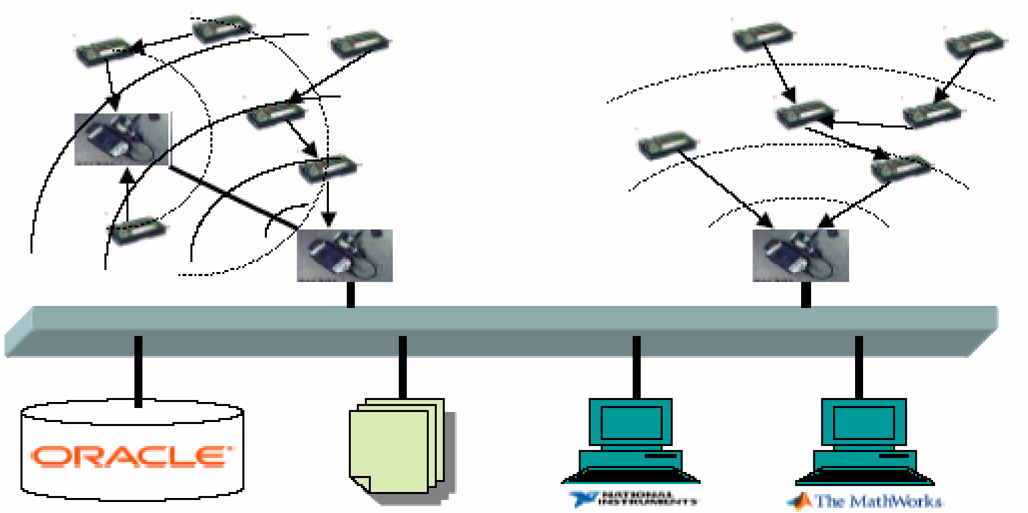


Ref.:
http://www.jlhlabs.com/

Mote Applications

Tiered architecture to support taskable, scalable monitoring

- Mica2 motes (8 bit microcontrollers w/TOS) with Sensor Interface Board hosting in situ sensors
- Tasking and multihop transport among motes
- Microservers are solar powered, 32-bit processors, linux OS
- Pub/sub bus over 802.11 to Databases, visualization and analysis tools, GUI/Web interfaces

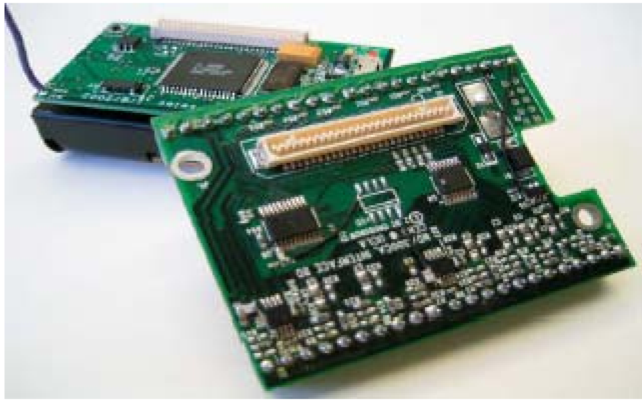


System Support for Dense Monitoring

UCLA USC UCR CALTECH CSU UC MERCED

Mote Applications

Sensor Interface Board:
Mote DAQ system (Rahimi, Wimbrow)

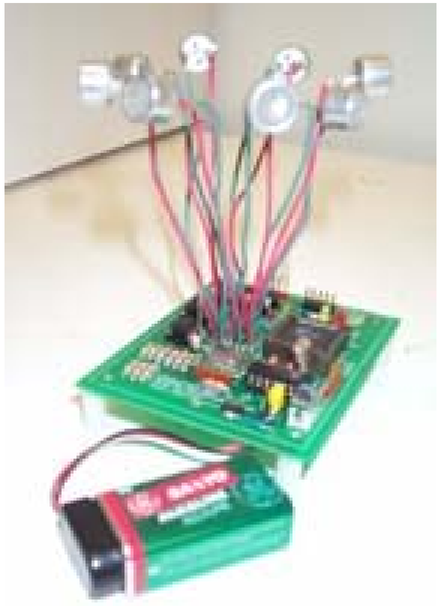


- **A general framework for attaching multiple instances and different types of sensors**
    - ADC true 12bit
    - High gain differential channels
    - Digital Input (Interrupt driven)
    - Digital Outputs
    - Counter, frequency
    - Relay output
    - On board voltage, temperature and humidity
- ***Flexible sampling* rate**
- **Configurable for different translation functions per channel based on the sensors that has been attached**
- **Tested with different sensor types.**
    - http://www.cens.ucla.edu/~mhr/daq/
    - Now sold by Crossbow

UCLA Medusa

UCLA Medusa

NESL Networked & Embedded Systems Laboratory



First generation
Medusa node prototype

Ref.:
www.cens.ucla.edu

UCLA Medusa

Overview:

Due to the diversity of their applications, it is unlikely that a single sensor node platform would be able to span the energy, cost, functionality, form factor and other requirements of all the applications. In fact, even within a single system one might expect to see multiple tiers of nodes with different capabilities, such as a sensor field for tracking that consists of a large number of trip wire nodes and a small number of tracker nodes. Sensor nodes that are currently available fall at two extremes in the node architecture space.

On the one hand there are the Motes from UC Berkeley that provide very small form factors and long lifetimes, but provide spartan processing and memory, thus limiting their use to sensor modalities that require simple processing.
On the other hand are the big sensor nodes, such as the ones from Rockwell and Sensoria, which are essentially embedded versions of PCs or PDAs in their computing memory capabilities, but have limited lifetimes and large size.

Ref.:
http://deerhound.ats.ucla.edu

UCLA Medusa

UCLA Medusa MK-2:

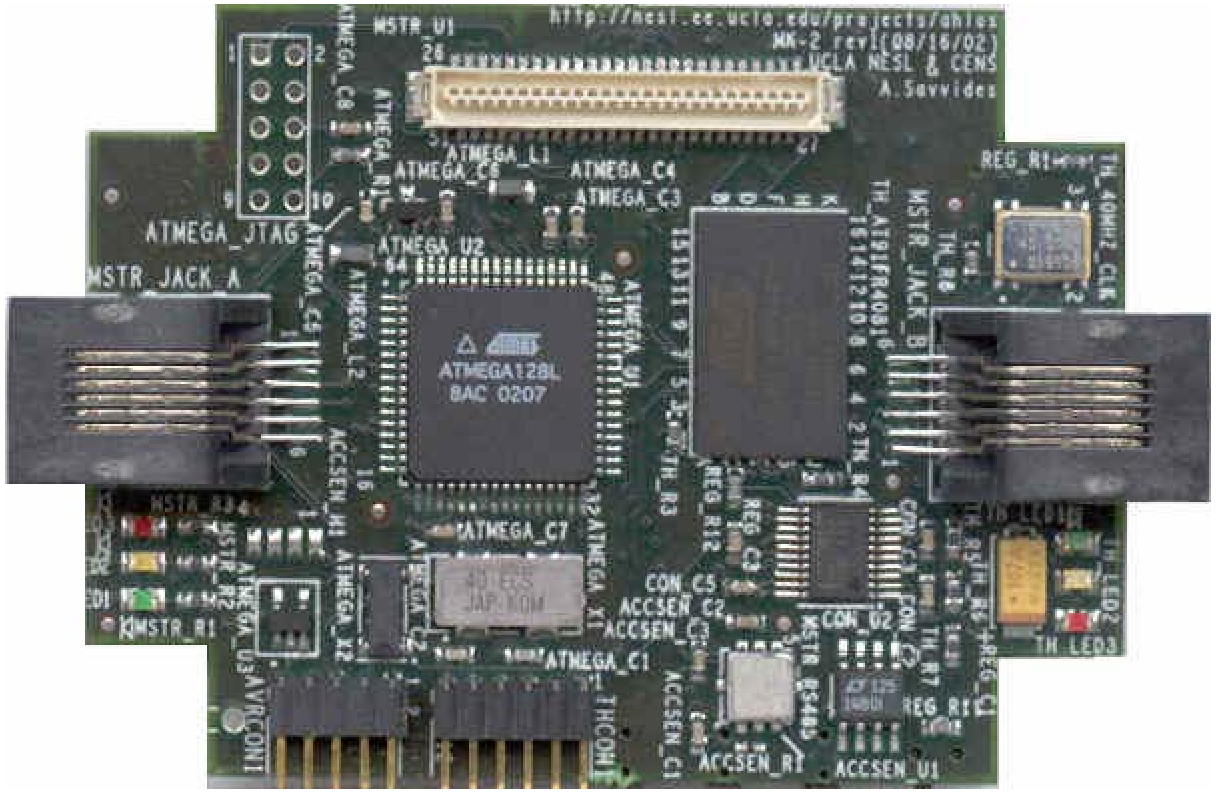
There exists a need for sensor nodes that are situated in the middle that are more capable than the Motes, so as to be able to handle some of the common collaborative signal processing functions, and are smaller and lower power than the big iron nodes.
One application than would benefit from such a node would be a network of nodes for habitat monitoring that have enough processing and memory to locally perform signal-processing functions such as multilateration, Kalman filter, and beam forming for node and source localization.

The Medusa MK-2 sensor node helps bridge this gap in the range of sensor nodes.

Ref.:
http://deerhound.ats.ucla.edu

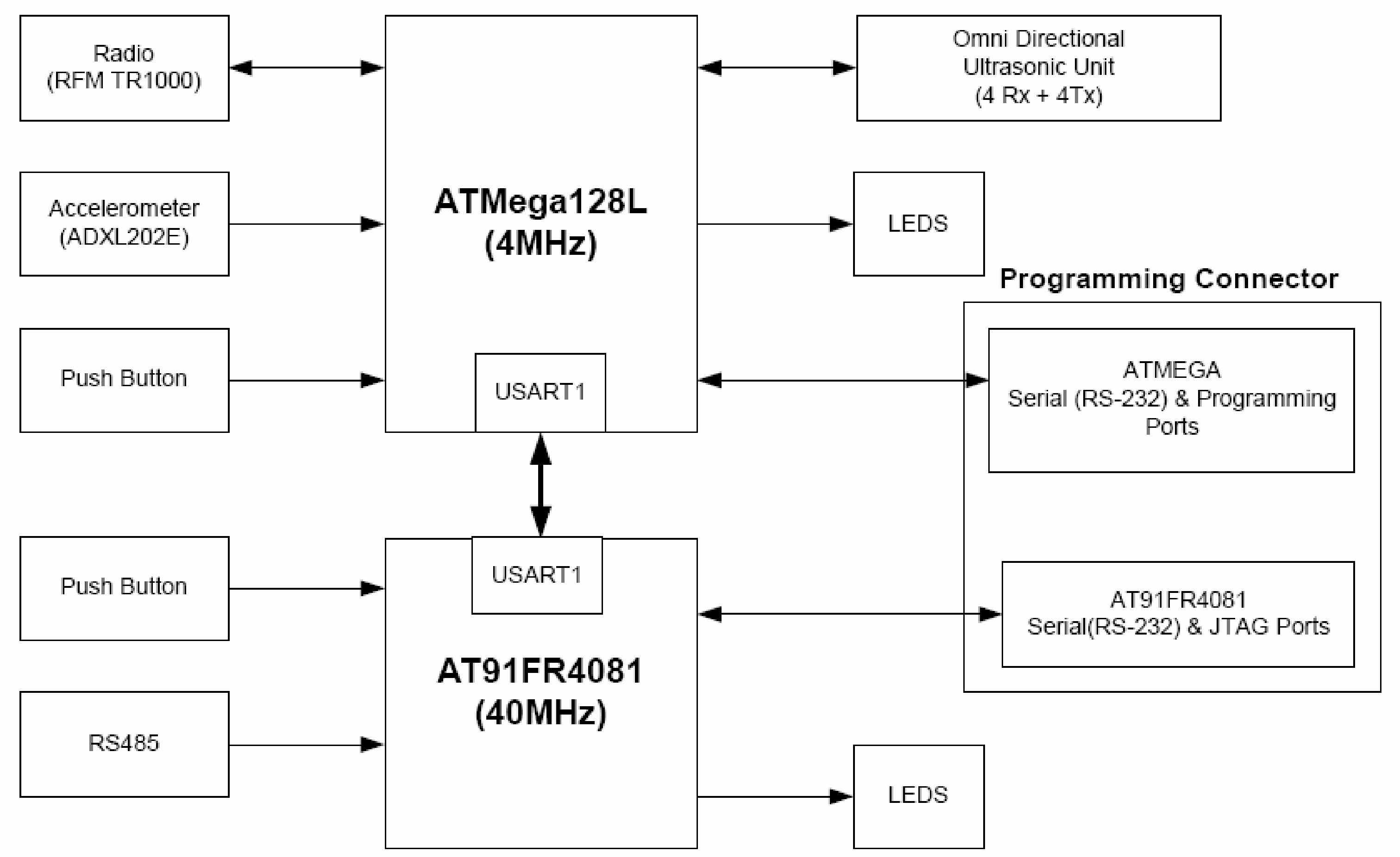
UCLA Medusa

Medusa MK-2 Node (2002)



Ref.:
www.cens.ucla.edu

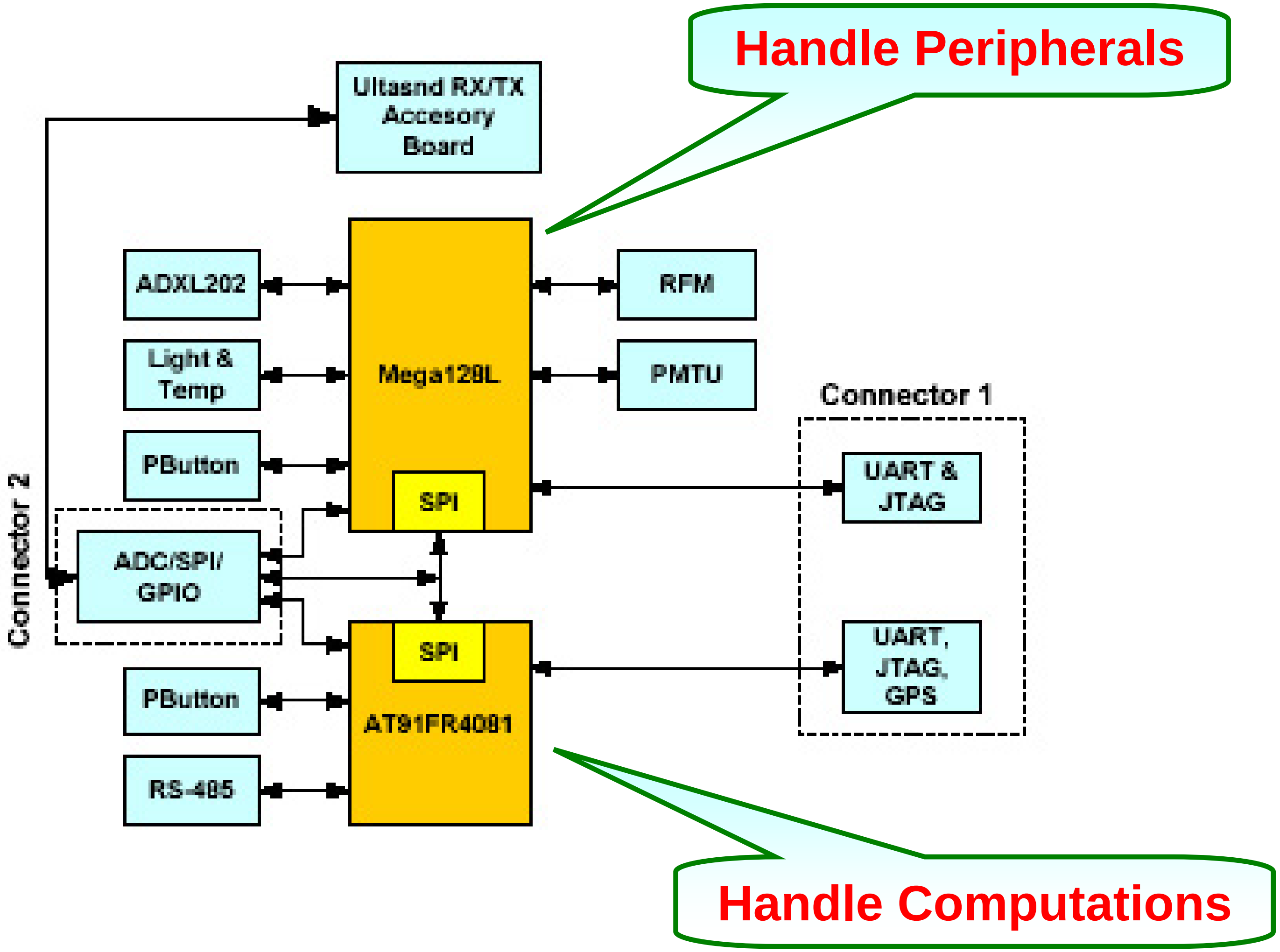
UCLA Medusa


Radio
(RFM TR1000)
Accelerometer
(ADXL202E)
Push Button
ATMega128L
(4MHz)
USART1
Omni Directional
Ultrasonic Unit
(4 Rx + 4Tx)
LEDS
Programming Connector
ATMEGA
Serial (RS-232) & Programming
Ports
Push Button
RS485
USART1
AT91FR4081
(40MHz)
AT91FR4081
Serial(RS-232) & JTAG Ports
LEDS

UCLA Medusa

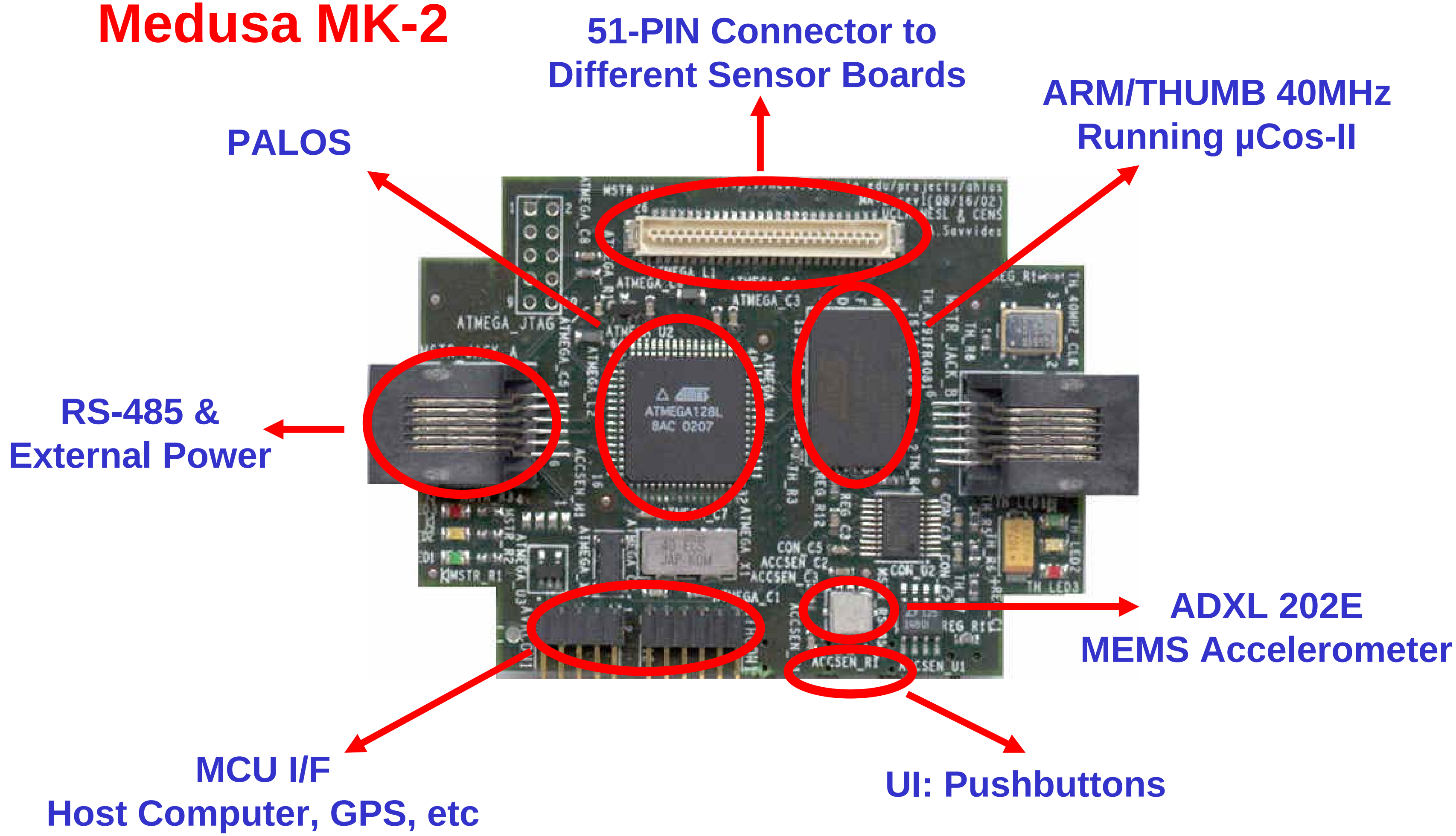
- **Ample computation power**
- **M2 Node**
  - AVR Mega103L
  - TR1000 RFM Radio
  - 40MHz ARM THUMB
    - 1MB FLASH, 136KB RAM
  - 1 Accelerometer
  - 2.5Mbps RS-485 bus
  - 3 current monitors (Radio, Thumb, rest of the system)
  - THUMB processor can run eCos
  - Power Consumption 30 - 115mW
    - Depends on mode of operation
  - 540mAh Rechargeable Li-Ion battery
- **Ultrasound accessory board**
  - 6 40KHz transducers
  - More sensors….

UCLA Medusa


Handle Peripherals
Ultasnd RX/TX Accesory Board
ADXL202
Light & Temp
PButton
Mega128L
SPI
RFM
PMTU
Connector 1
UART & JTAG
Connector 2
ADC/SPI/ GPIO
SPI
PButton
AT91FR4081
RS-485
UART, JTAG, GPS
Handle Computations

UCLA Medusa

Medusa MK-2



UCLA Medusa – Operating Systems

On the Medusa MK-2 nodes two operating systems are used:

PALOS:

The **PALOS** (Power Aware Lightweight Operating System or Park And Locher OS) project is an OS development effort initiated by UCLA Networked and Embedded Systems Lab.
PALOS is a cross-platform lightweight operating system used on embedded processes.

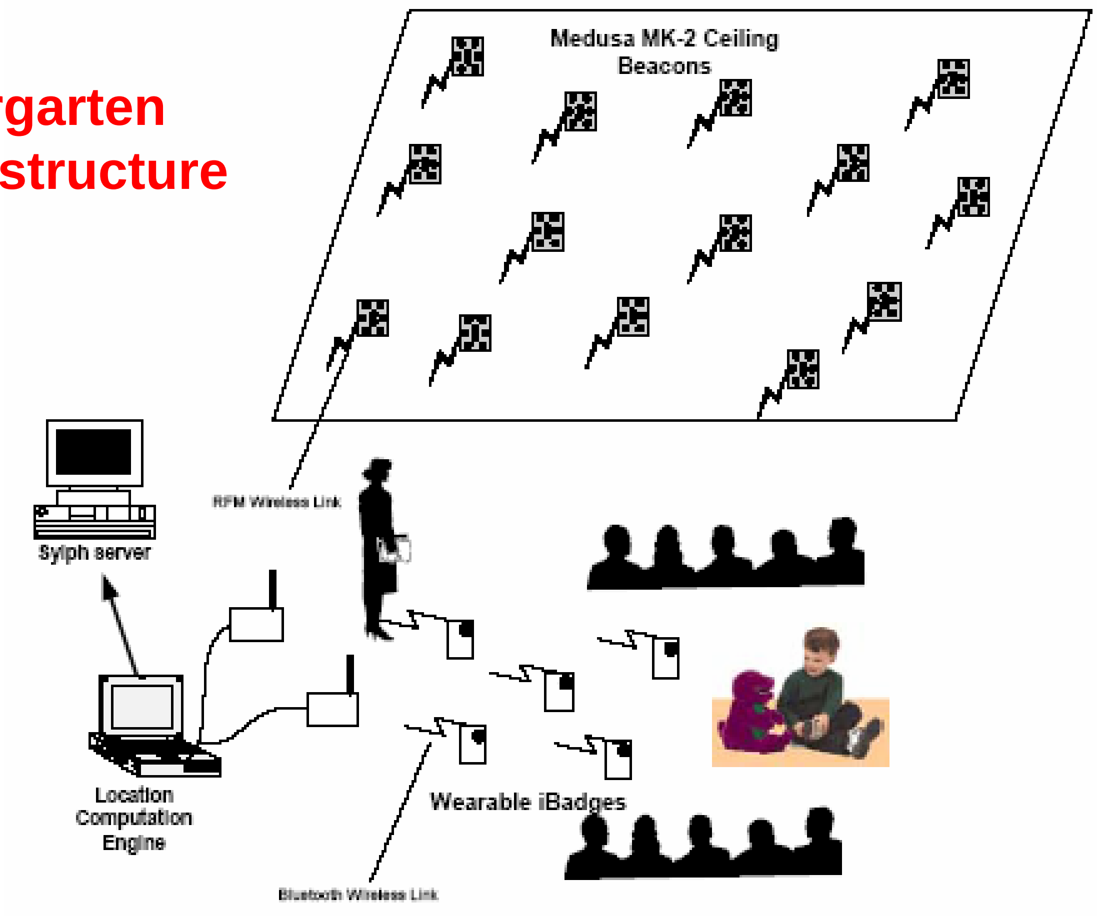
µ COS-II:

µ COS-II is a small, powerful real-time operating system (Real-Time Kernel) developed by Jean J. Labrosse.
µC/OS-II is a highly portable, ROMable, very scalable, preemptive real-time, multitasking kernel (RTOS) for microprocessors and microcontrollers. µC/OS-II can manage up to 63 application tasks. Over 100 microprocessor ports are available.

Ref.:
http://sourceforge.net/projects/palos/
http://www.ucos-ii.com/

UCLA Medusa - Application

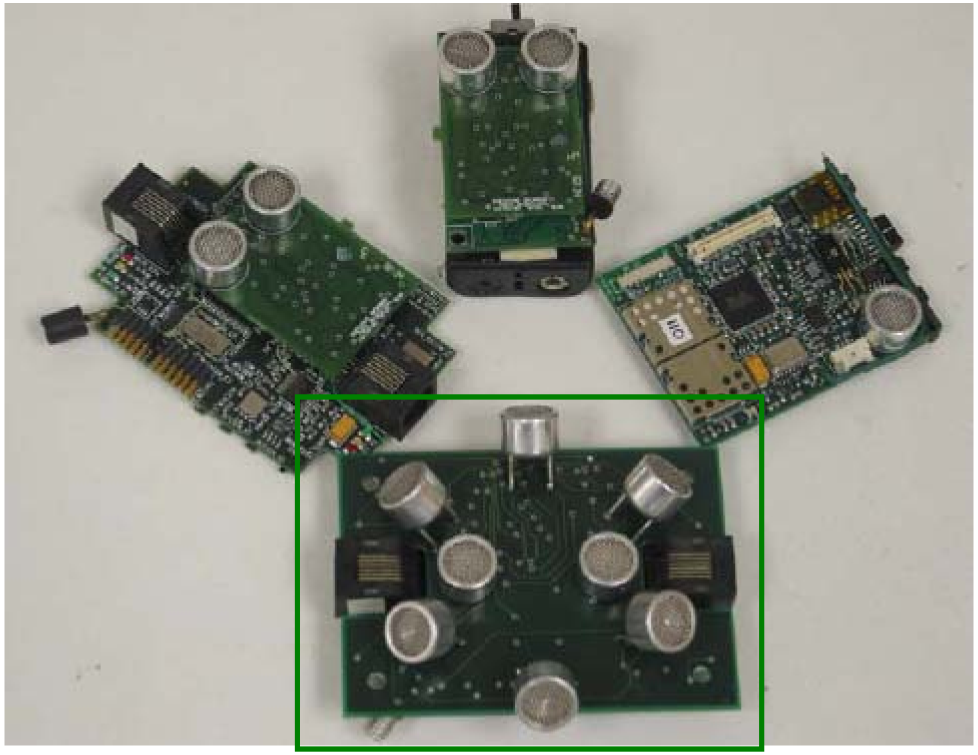
The Smart Kindergarten Localization Infrastructure



A SELF-CONFIGURING LOCATION DISCOVERY SYSTEM FOR SMART ENVIRONMENTS,
Andreas Savvides, Electrical Engineering Department, Yale University
Mani Srivastava, Electrical Engineering Department, University of California, Los Angeles

UCLA Medusa - Application

The Smart Kindergarten Localization Platforms



Omni directional ultrasound board

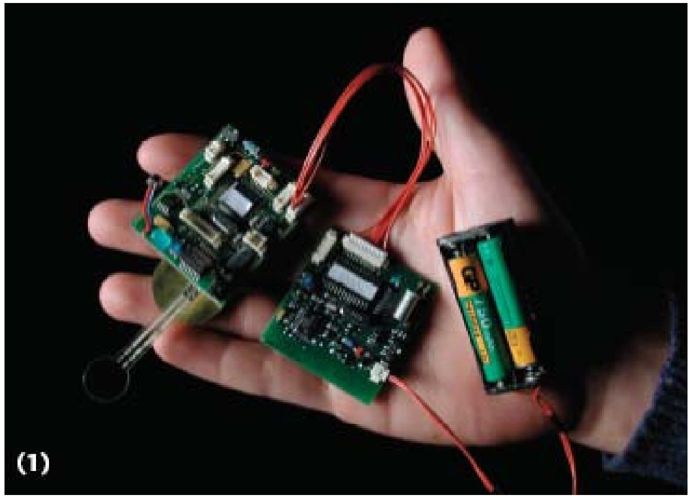
Smart-Its Platform

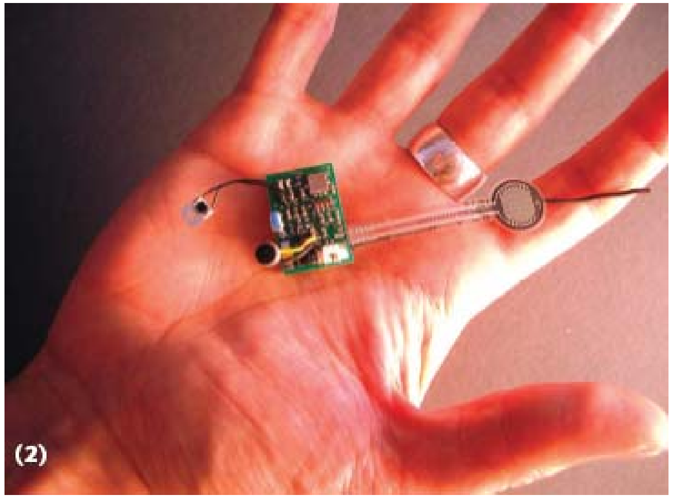
The **Smart-Its project** is interested in a far-reaching vision of computation embedded in the world. In this vision, mundane everyday artefacts become augmented as soft media, able to enter into dynamic digital relationships. In our project, we approach this vision with development of "Smart-Its" - small-scale embedded devices that can be attached to everyday objects to augment them with sensing, perception, computation, and communication. We think of these "Smart-Its" as enabling technology for building and testing ubiquitous computing scenarios, and we will use them to study emerging functionality and collective context-awareness of information artefacts.
Smart-Its is a collaboration of **Lancaster University, ETH Zurich, University of Karlsruhe, Interactive Institute and VTT**. The project is part of the European initiative **The Disappearing Computer**, and funded in part by the Commission of the European Union, and by the Swiss Federal Office for Education and Science.

Ref.:
http://www.smart-its.org/

Smart-Its Platform

"You can think of a Smart-Its as a small, self-contained, stick-on computer that users can attach to objects much like a 3M Post-It note."

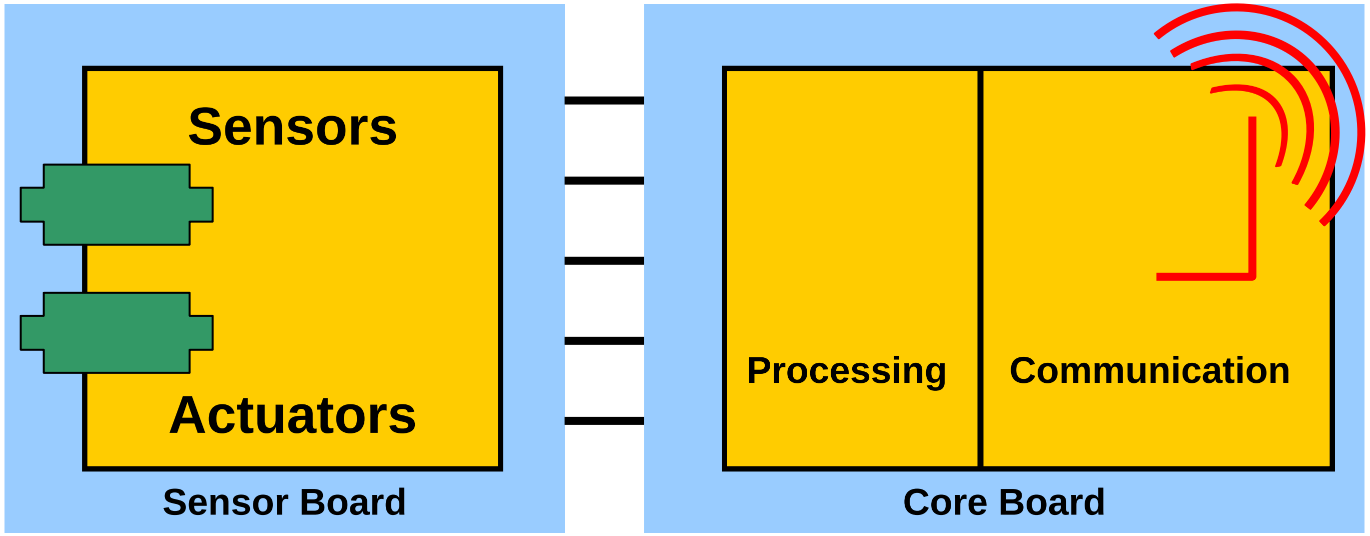




Smart-Its hardware development from (1) larger hardware to (2) smaller hardware.

Ref.:
http://www.smart-its.org/

Smart-Its Platform



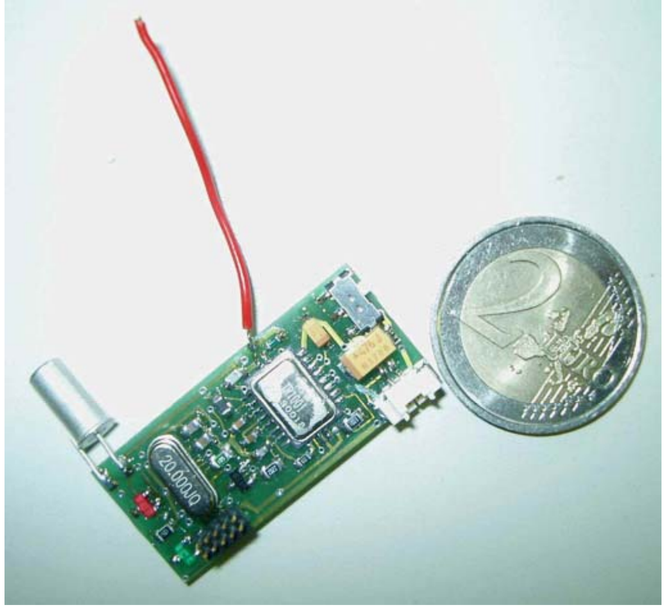
Smart-Its hardware consists of two separate components: a core board and a sensor board.

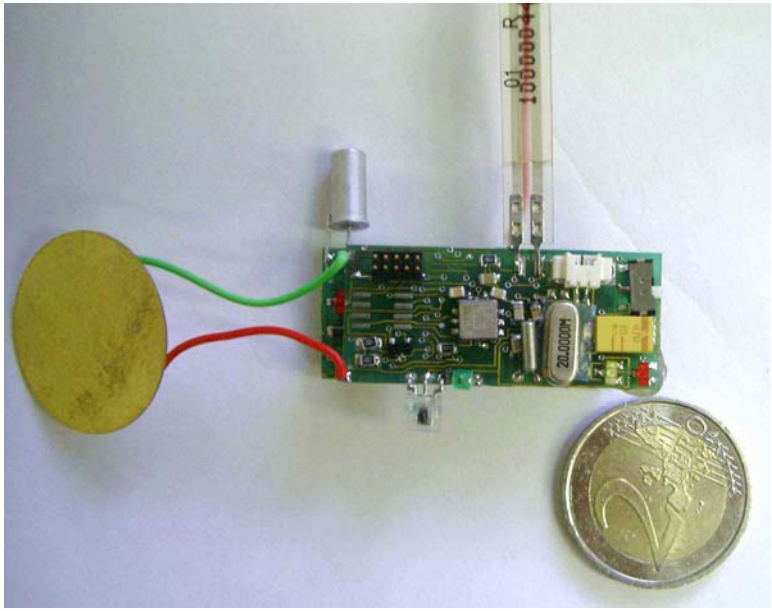
The Smart-Its features efficient short-range communication through a wireless ad hoc network. Hardware requirements and constraints for the radio link design were size, energy consumption, full control on the physical layer, and midspeed transmission bandwidth (125 kilobits per second). Up to 1,024 nodes can request to be sent at the same time.

Ref.:
http://www.smart-its.org/

TECO Particle

2002:
Device shrinkage: 15x40 mm:
left: Smart-Its, right: Smart-Its with Sensor board stack on top

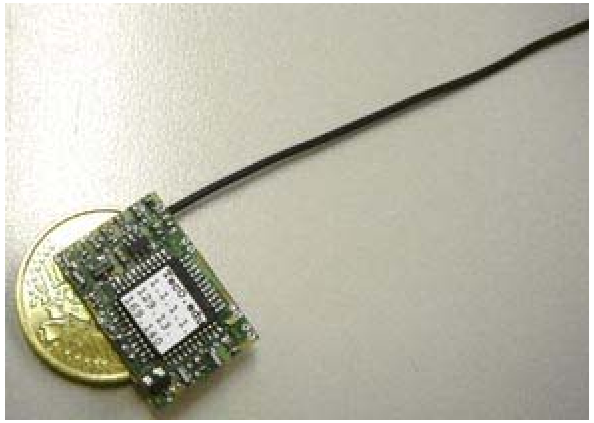


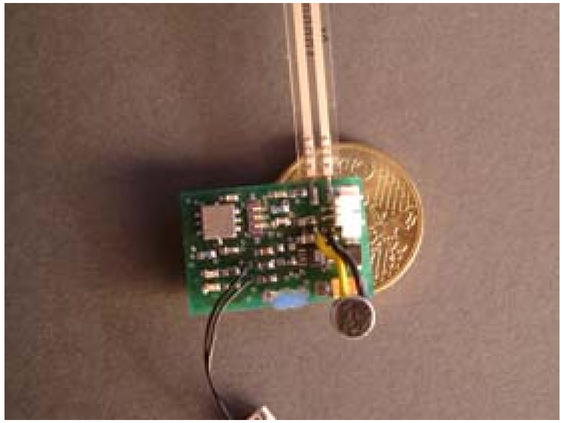


Ref.:
http://particle.teco.edu/

TECO Particle

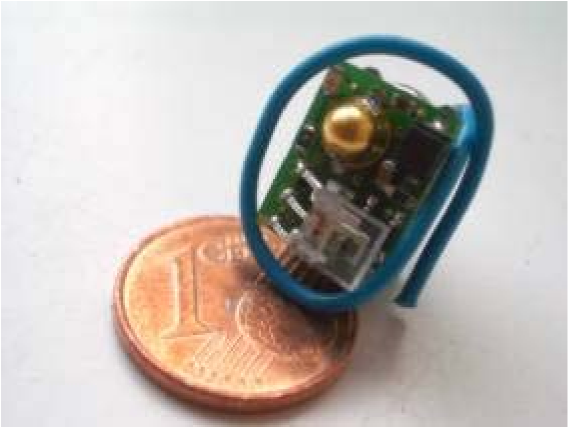
2003:
New Smart-Its Versions (1/81,1/84):
15x25 mm, left: Communication Board,
17x30 mm, right: Sensor Board.





Ref.:
http://particle.teco.edu/

TECO Particle



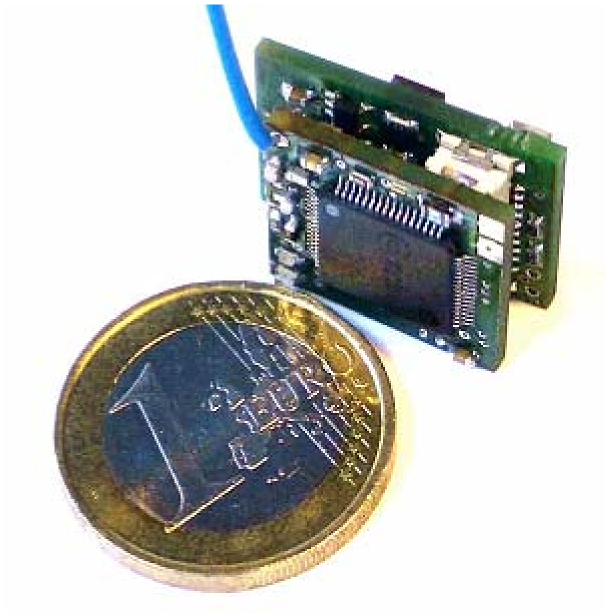
Particle in 1cm³ includes Battery,
Sensors, CPU & Memory,
RF communication

µPart

- 1cm³ including Battery, Sensors, CPU&Memory, RF communication
- 2 Board approach: RF&CPU and Sensors. Batteries stacked between boards
- RF&CPU Unit:
  - Transmitter in 868, 914 MHz Band Communication or 433, 310/315 MHz Band
  - 8 Bit PIC12F675 processor, 4 MHz
  - Field strength regulation
  - Range: 1-30 meters in house
  - Predicted price range: 15 Euro in single quantity
  - available Q1/2005
  - Compatible with all PC based Particle tools
- 6 PIN, 4 I/O Port µParticle bus
  - 2 A/D channels
  - SPI, I2C, serial communication
  - Multi-purpose I/O
  - Interrupt lines
- Sensor Units
  - example: Movement (ball switch), light sensor (see picture), 1 LED, power regulation for unit

Ref.:
http://particle.teco.edu/

TECO Particle



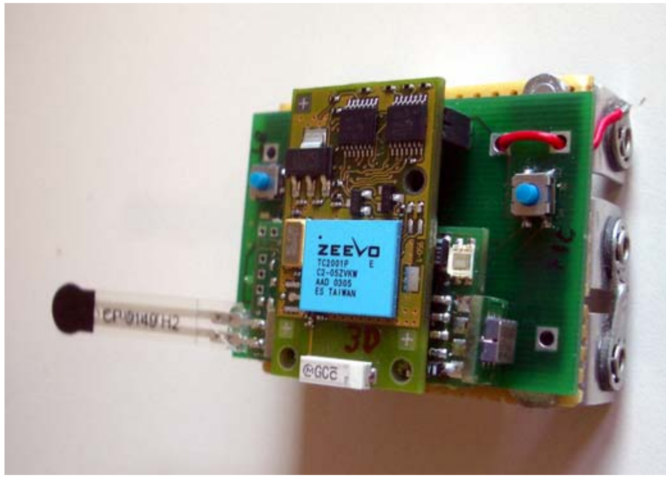
Particle-C (part-c, in front) stacked to a sensor board (back)

Ref.:
http://particle.teco.edu/

Part-C

- 18x18mm Particle including Processor (8051), RAM (4kbyte), Program Flash (32kbyte) and Data Flash (512 kByte)
- 868, 914 MHz Band Communication (software selectable channels) or 433, 310 MHz Band
- Field strength measurement (RSSI) and field strength regulation
- Range: 1-30 meters in house
- Fully compatible Particle BUS for all sensor and add-on boards boards (e.g. see picture) including:
  - 4 A/D channels
  - SPI, I2C, serial communication
  - Parallel I/O, Multi-purpose I/O
  - Interrupt lines
- Real-time clock and automatic time syncronization via network protocol (max. deviation 10 us)
- 2 LED output
- 1 Ball Switch Input
- 3.6 V input voltage (protected) for e.g. lithium cell type batteries
- In circuit programming and debugging
- Fully compatible with all Particle tools (e.g. Analyser etc.)
- Free Compiler available (SDCC)
- Predicted price range 50-60 Euro

TECO Particle



A Blueticle stacked with sensor board

Bluetooth Particle (blueticle)

- 45x50mm
- Bluetooth Master/Slave
- Supports RFCOMM (RS232 emulation over bluetooth) for easy access
- Fully Particle compatible, Tools (e.g. Analyser) can be used
- Particle Sensor Boards can be used (see picture)
- Power regulation for use with batteries >=3.6V
- Uses 3xAAA rechargables for convenient runtime

Ref.:
http://particle.teco.edu/

TECO Particle Computer

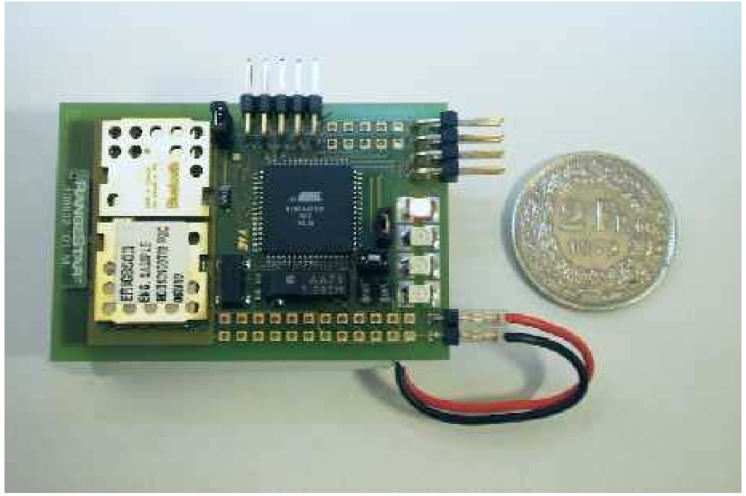
The aim of Particle Computers is to allow development of Ubicomp artefacts, embedded wireless sensor nodes etc. for developers not familiar with embedded systems, hardware, low-level or network programming.
Particle Computer results are published open source.
In the current status Particle Computers provides a integrated environment that provide access to functionality both by embedded systems experts and by non-computer experts

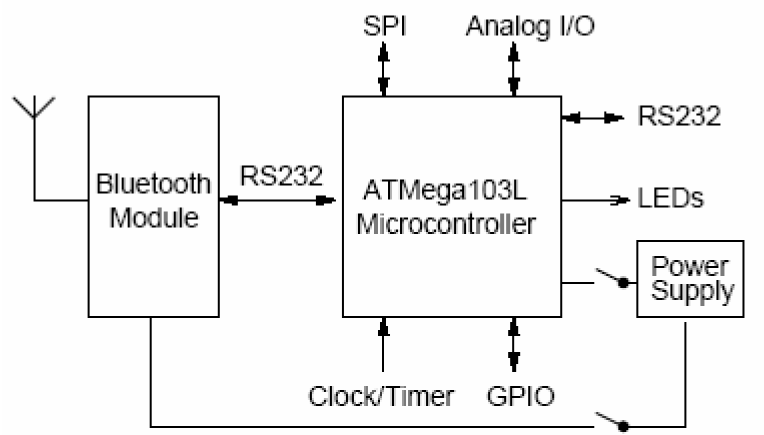
- ready-to-run set of hardware components coming with embedded software that can be used without any knowledge of hardware or low-level software
- modular hardware design that still enables the developers to change configuration by changing hardware
- Integration hardware that allows you to access embedded devices from the Internet, from your PDA etc.
- Additional hardware modules that can be used for further custom hardware development
- Software that allows writing Particle Computer programs for the embedded devices or for PC based services in various languages (C, Java, Delphi)
- Tools to control supervise and configure the Particle hardware
- Tools to support development
- Services for simplest access to Particle Computer output as sensor and context information through querying a database or using the data in programs as Excel or Matlab

Ref.:
http://particle.teco.edu/

Smart-Its

Smart-Its Artefacts



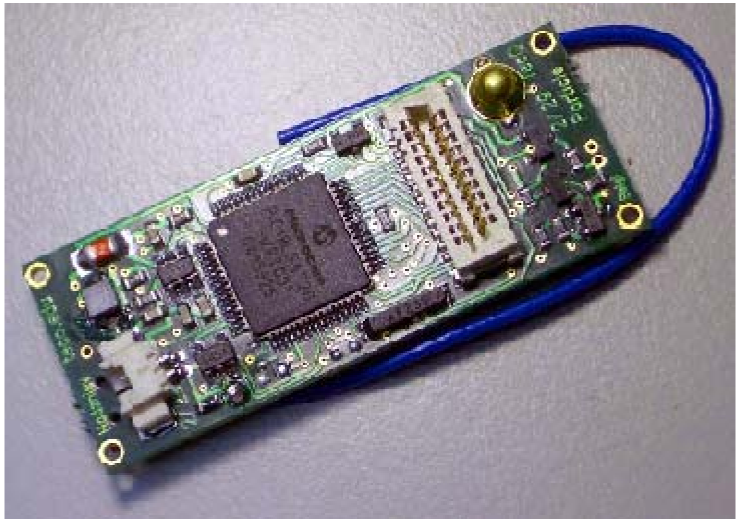


System Overview

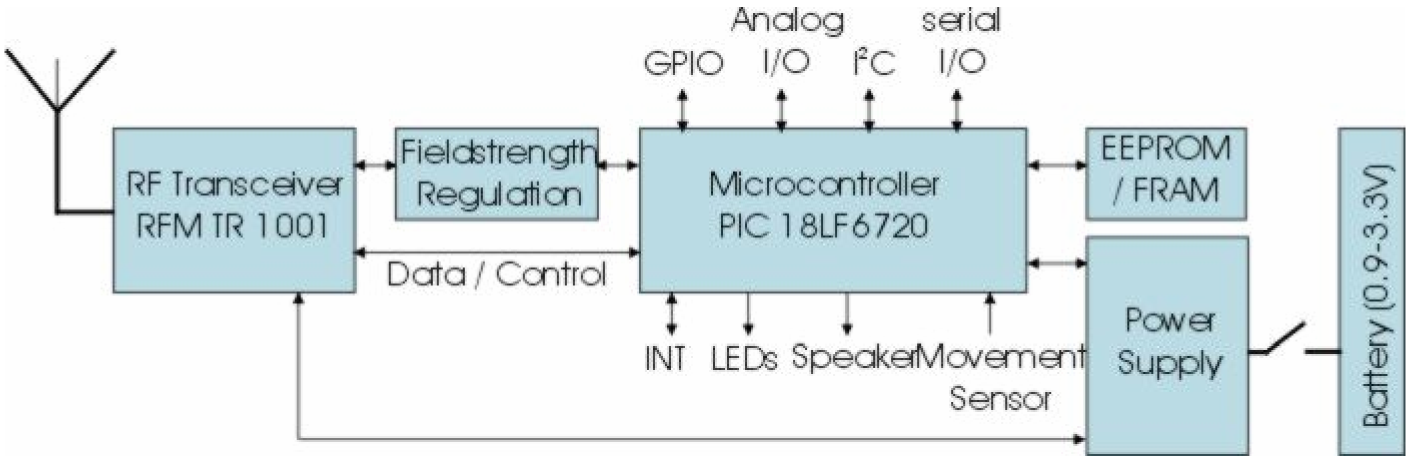
Smart-It based on Atmel's ATmega103L microcontroller with 128 kB of in-system programmable flash memory and only 4 kB of SRAM.
Ericsson's Bluetooth modules allow communication between different devices.

Ref.:
http://www.smart-its.org/artefacts/artefacts.html
First Experiences with Bluetooth in the *Smart-Its* Distributed Sensor Network,
Oliver Kasten, Marc Langheinrich, Swiss Federal Institute of Technology Distributed Systems Group

TECO Particle Computer



Processor:
PIC 18F6720 at 20 MHz,
Internal Memory: 128kbyte program Flash, 4kbyte RAM, 1kbyte EEPROM



Ref.:
http://particle.teco.edu/

Smart Dust

Smart Dust

The goal of the Smart Dust project is to build a self-contained, millimeter-scale sensing and communication platform for a massively distributed sensor network. This device will be around the size of a grain of sand and will contain sensors, computational ability, bi-directional wireless communications, and a power supply, while being inexpensive enough to deploy by the hundreds. The science and engineering goal of the project is to build a complete, complex system in a tiny volume using state-of-the art technologies (as opposed to futuristic technologies), which will require evolutionary and revolutionary advances in integration, miniaturization, and energy management. We forsee many applications for this technology:

Weather/seismological monitoring on Mars
Internal spacecraft monitoring
Land/space comm. networks
Chemical/biological sensors
Weapons stockpile monitoring
Defense-related sensor networks
Inventory Control
Product quality monitoring
Smart office spaces
Sports - sailing, balls

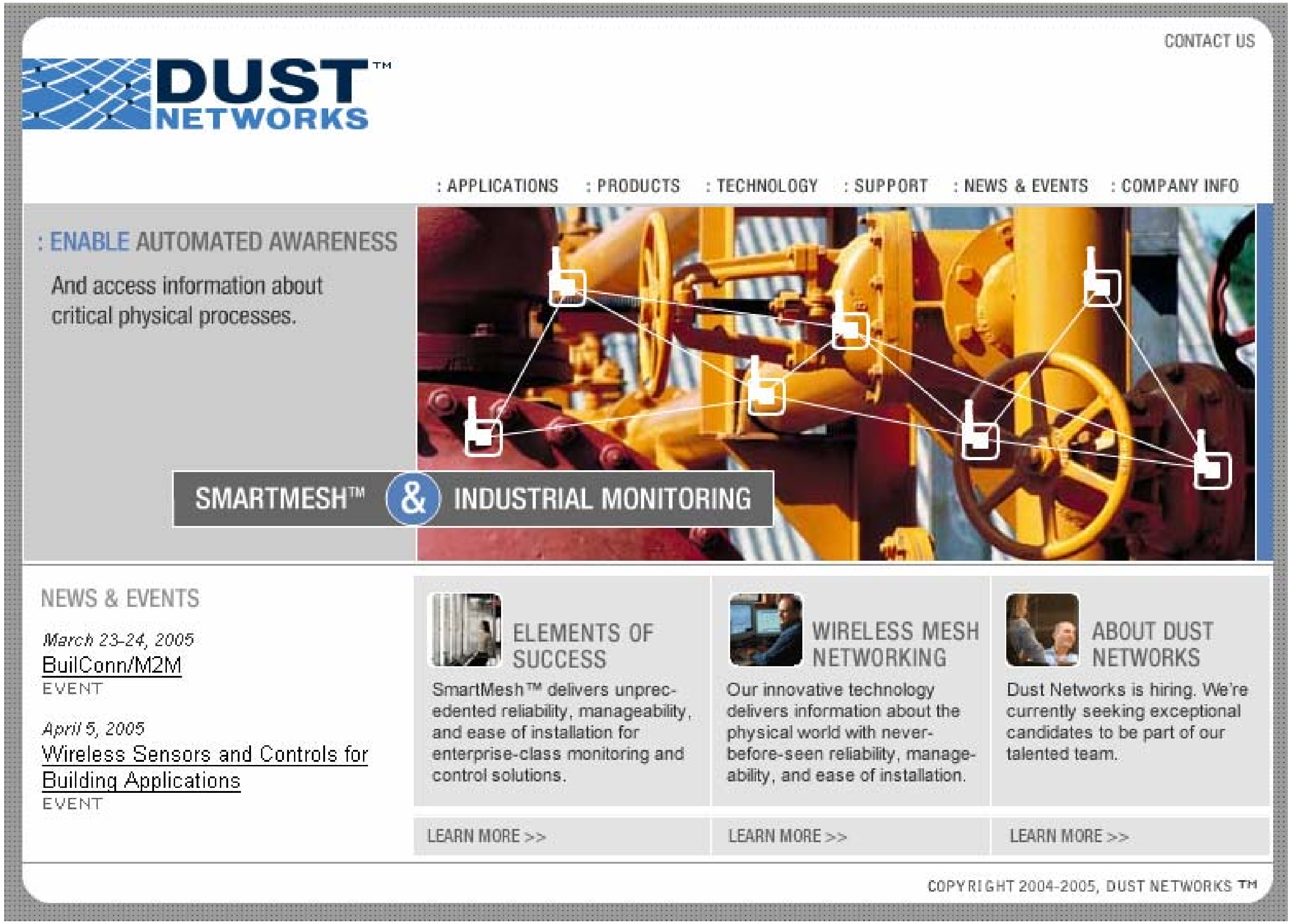
SMART DUST

Autonomous sensing and communication in a cubic millimeter

Supported by the DARPA/MTO MEMS program

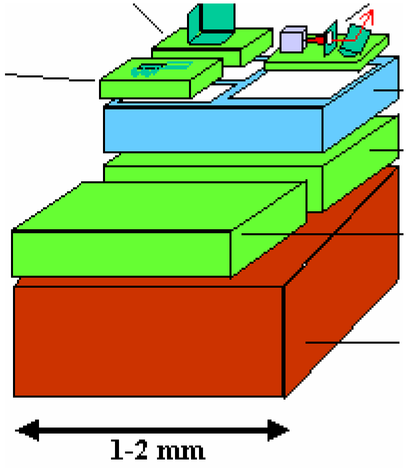
http://robotics.eecs.berkeley.edu/~pister/SmartDust/

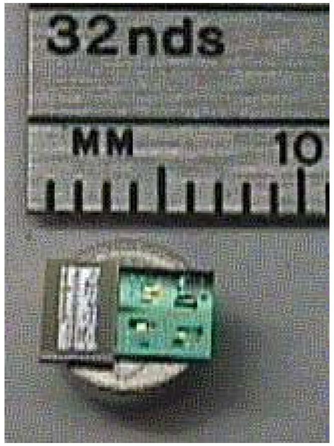
Smart Dust



Ref.:
http://www.dust-inc.com

Smart Dust





The two figures above represent where we are and where we'd like to be.
On the left is where we hope to be in July of '01 - a cubic millimeter device with a sensor, power supply, analog circuitry, bidirectional optical communication, and a programmable microprocessor. Click on the figure to get more detail.
On the right is where we are now (July '99) - a (currently) non-functional mote with a volume of about 100 cubic millimeters. There are two silicon chips sitting on a type-5 hearing aid battery. The right chip is a MEMS corner cube optical transmitter array - it works. On the right is a CMOS ASIC with an optical receiver, charge pump, and simple digital controller - it doesn't work (we violated some of the design rules in the 0.25 micron process, but the next one should work).

http://robotics.eecs.berkeley.edu/~pister/SmartDust/

Smart Dust

Properties of Smart Dust:

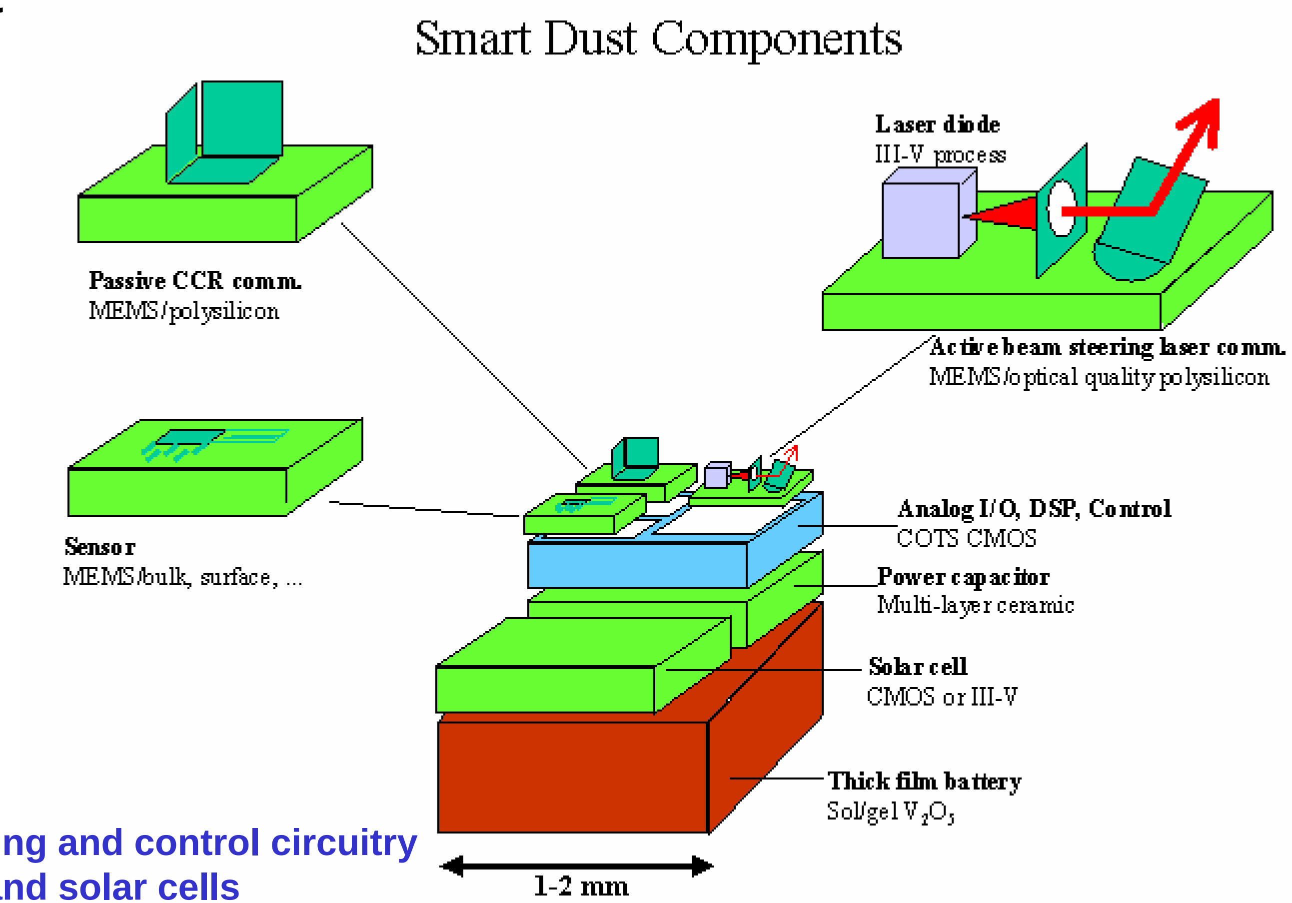
- Remain Suspended in air
- Buoyed by air currents
- Can sense and communicate for many hours/days

Integrated into Smart Dust Motes:

- MEMS sensors
- Signal processing and control circuitry
- Power source and solar cells
- Laser diode and MEMS mirror for active optical communication
- Retroreflector and optical receiver for passive optical communication

http://robotics.eecs.berkeley.edu/~pister/SmartDust/

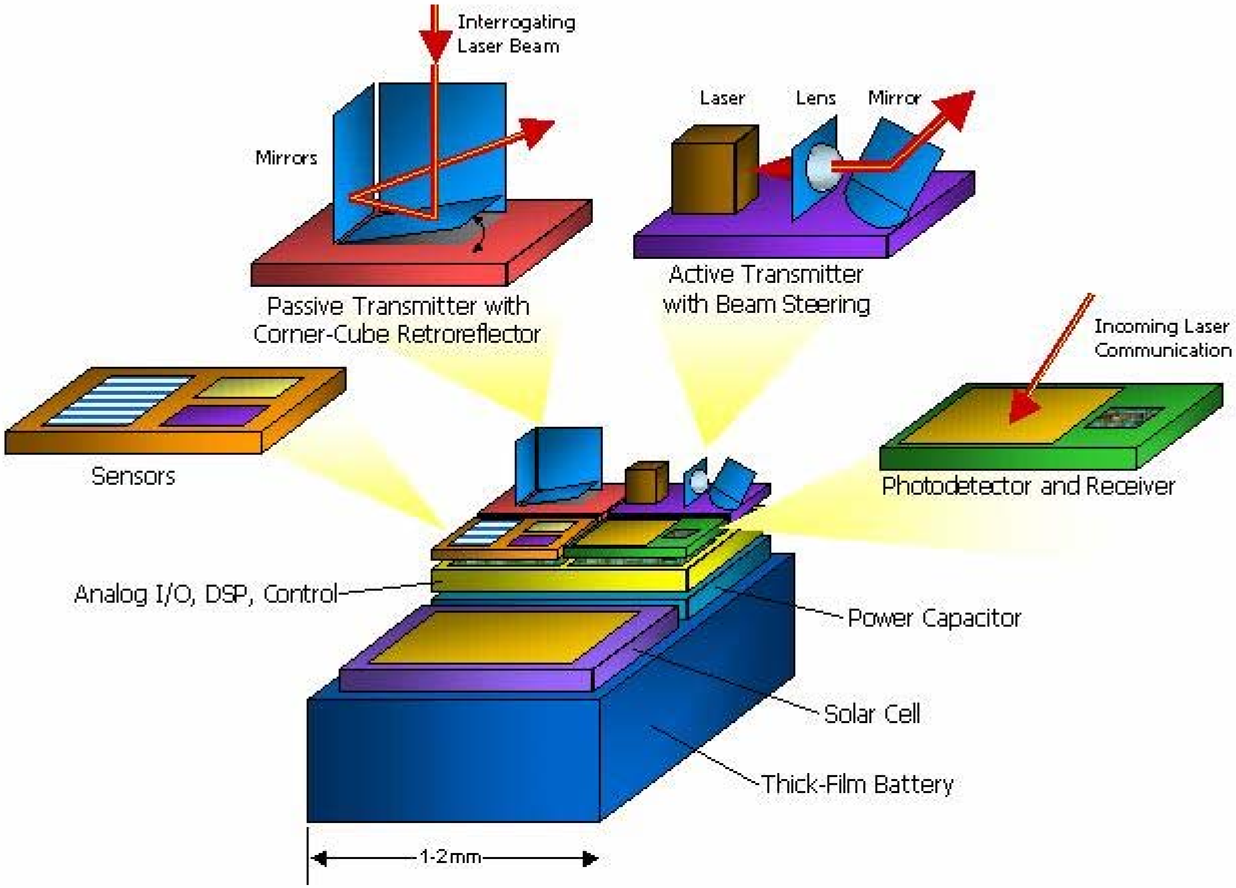
Smart Dust



Components:

- MEMS sensors
- Signal processing and control circuitry
- Power source and solar cells
- Laser diode and MEMS mirror for active optical communication
- Retroreflector and optical receiver for passive communication

Smart Dust



Ref.:
http://www-bsac.eecs.berkeley.edu/archive/users/warneke-brett/SmartDust/index.html

Smart Dust

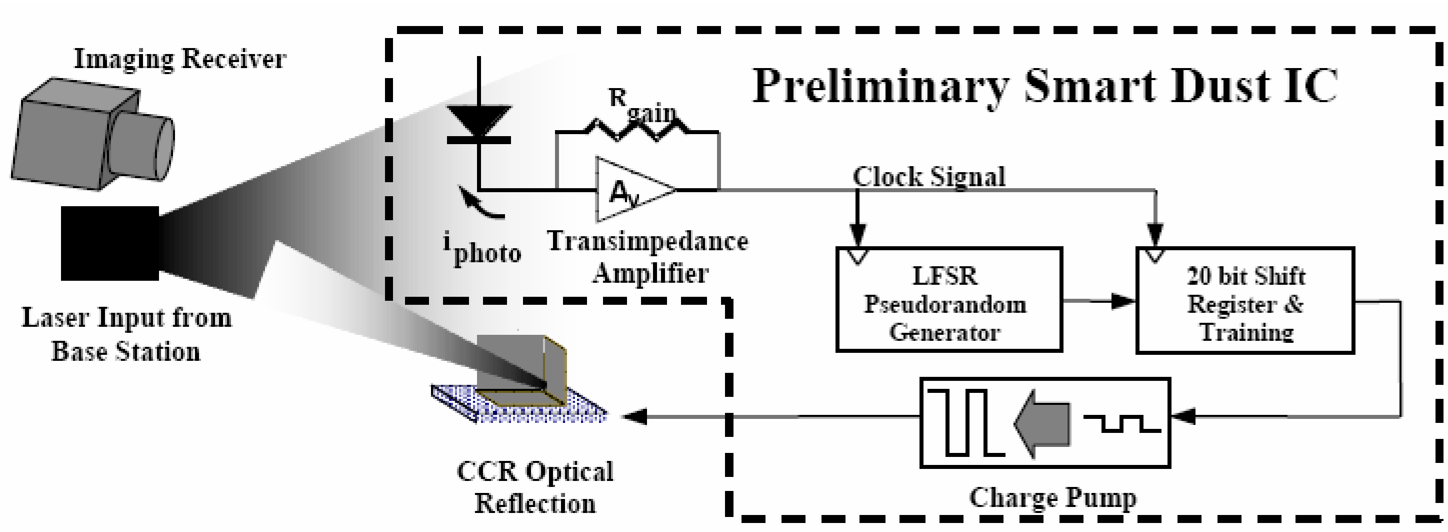
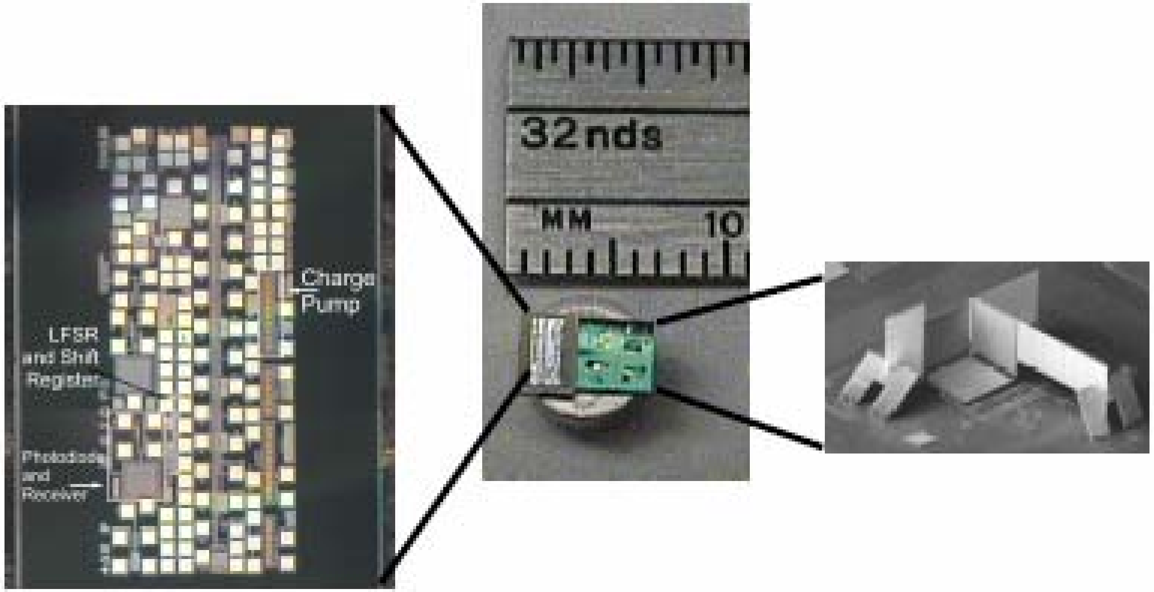


Diagram of a CMOS ASIC circuit.
Optical input from the base station is used as the system clock to generate pseudorandom data.

Ref.:
PRELIMINARY CIRCUITS FOR SMART DUST
Bryan Atwood, Brett Warneke, and Kristofer S. J. Pister
Berkeley Sensor and Actuator Center, Dept. Of Electrical Engineering and Computer Sciences
University of California, Berkeley

Smart Dust

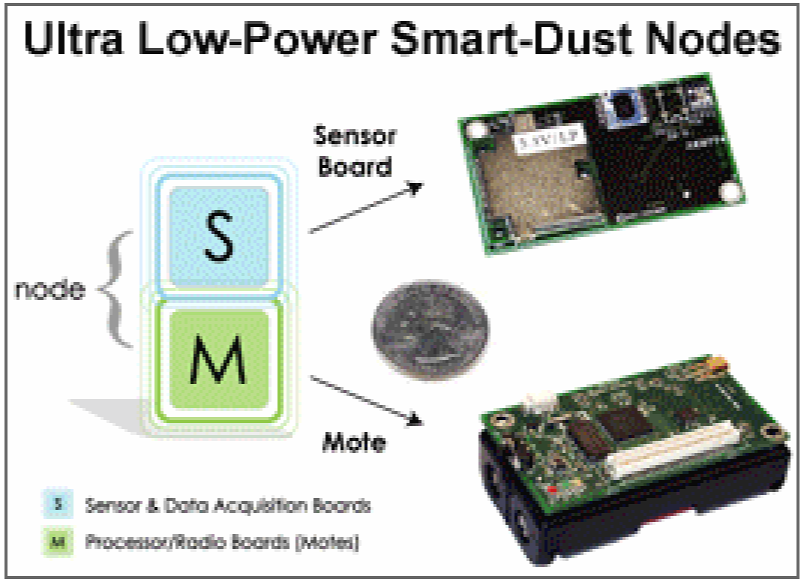


First MicroMote Attempt:

The photo shows the three components of the initial, nonfunctional attempt: a MUMPS chip containing four corner cube reflectors, shown on the right, for communication; a CMOS ASIC (left) for control; and a hearing aid battery for power.

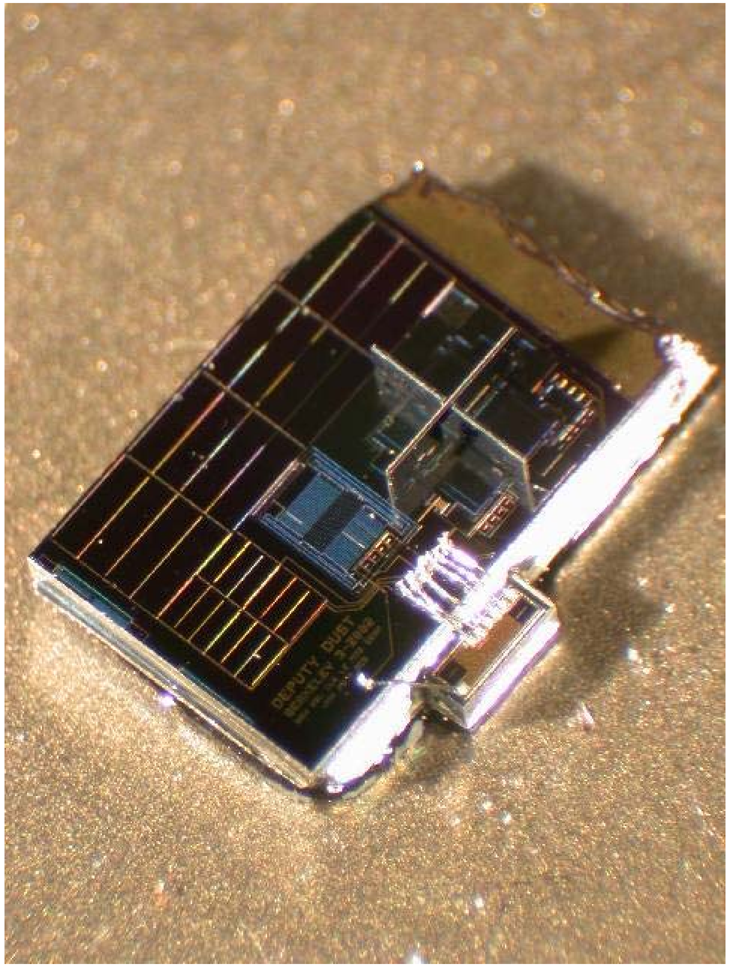
The total volume of the mote is under 100 mm2.

Smart-Dust Nodes

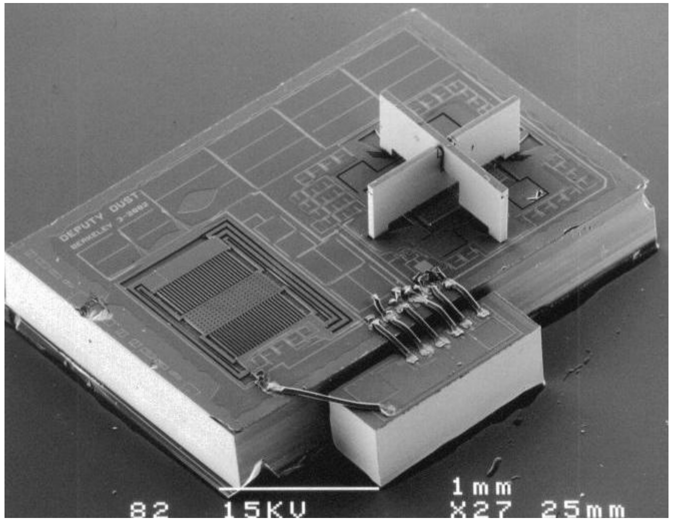


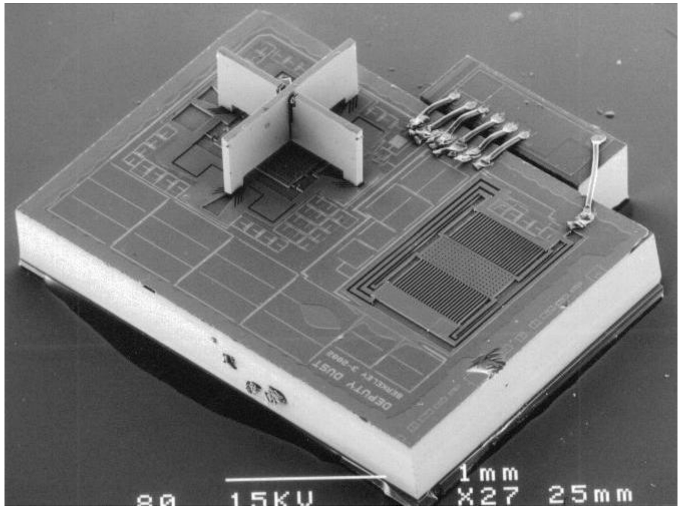
Mote

Solar powered mote with bi-directional communications and sensing (acceleration and ambient light) -- same CMOS ASIC as Golem Dust with with a custom process to integrate solar cells, CCR, accelerometer, and high voltage FETs
6.6 mm^3 total circumscribed volume



Golem Dust





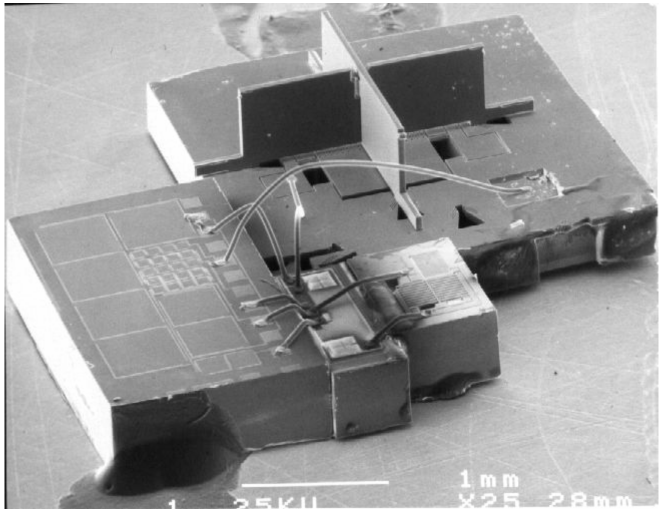
Golem Dust

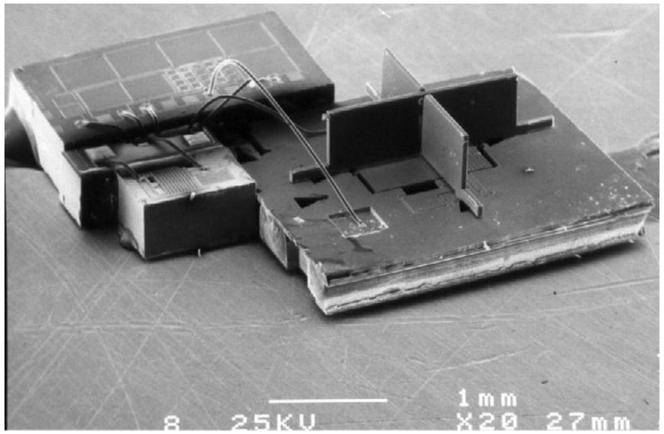
solar powered mote with bi-directional communications and sensing (acceleration and ambient light)

11.7 mm^3 total circumscribed volume

~4.8 mm^3 total displaced volume

Golem Dust

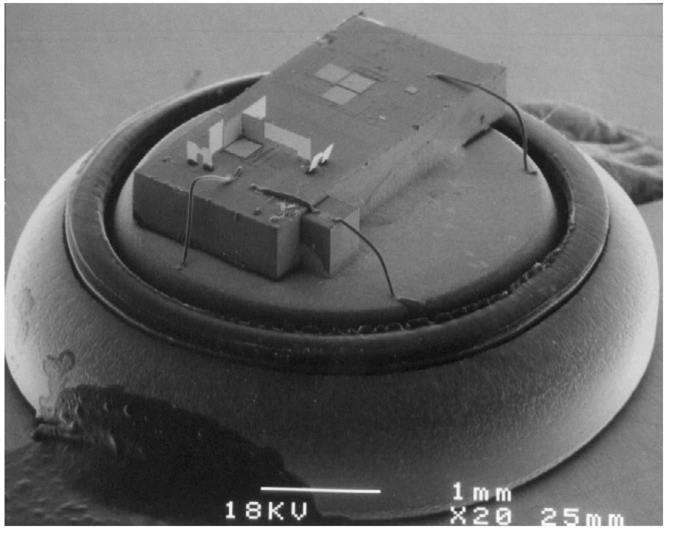


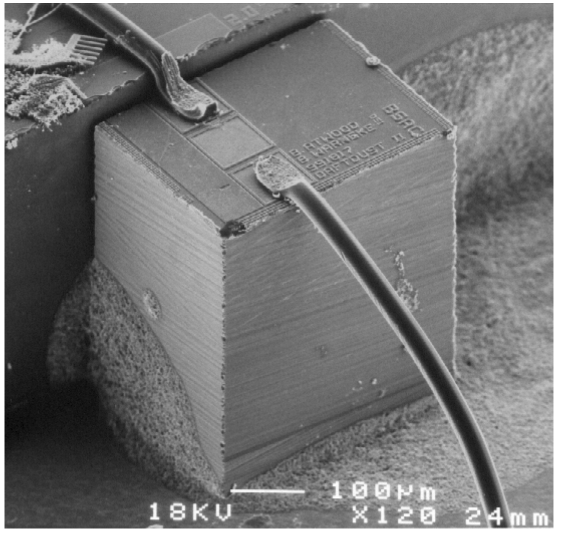


Daft Dust

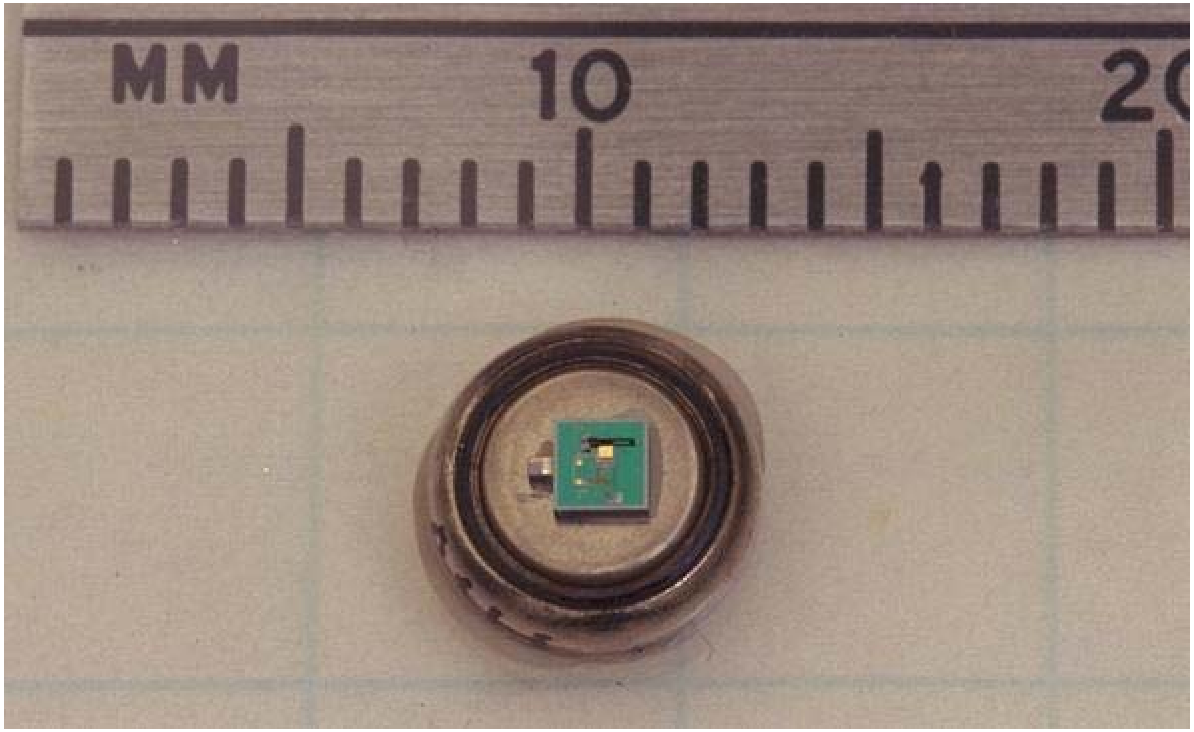
Daft Dust

63 mm³ bi-directional communication mote



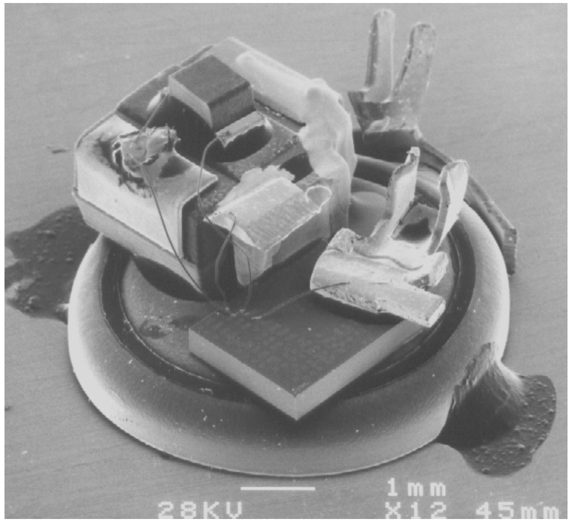


Daft Dust

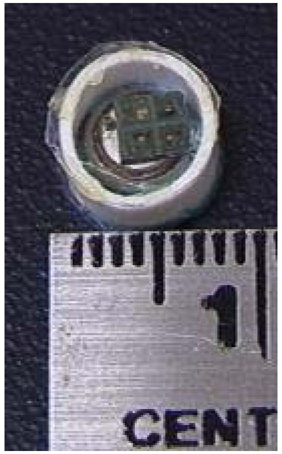


Flashy Dust

Flashy Dust
138 mm^3 uni-directional communication and sensing (ambient light) mote



Daft Dust



this mote has four CCR's facing towards each quadrant for better hemispherical coverage

AFILE Systems

JStamp Microcontroller Boards

(introduced 2004)

Jstamp (2004)

JStamp shatters preconceptions about what embedded Java is:

Common Misconceptions	JRealTime Reality
Java is slow because it must be interpreted. There are no general-purpose native Java processors (maybe someday there will be).	Today is that day! The aJile processors used in JStamp execute Java as their native instruction set. This brings Java performance on a par with assembly code or C running on comparable processors. There is no longer any siginficant performance penalty for programming in Java.
Embedded Java is expensive.	JStamp includes a native Java processor, 512 KBytes SRAM, 512 KByte to 2 MBytes flash, and other supporting circuitry starting under $100 in moderate quantities. Development kits start at $300.
Embedded Java is power hungry.	Stamp internally is a 3.3V system. Its on-board power converter accepts 5-14 VDC and even provides 100 mA at 3.3V for your use off-module. At 7 MHz, JStamp draws only 30 mA with a 5V supply, and even less current at higher voltages. A common 9V alkaline battery will power JStamp for over 24 hours.

continued

Ref.:
http://www.jstamp.com/reality.htm

FACHHOCHSCHULE KIEL University of Applied Sciences

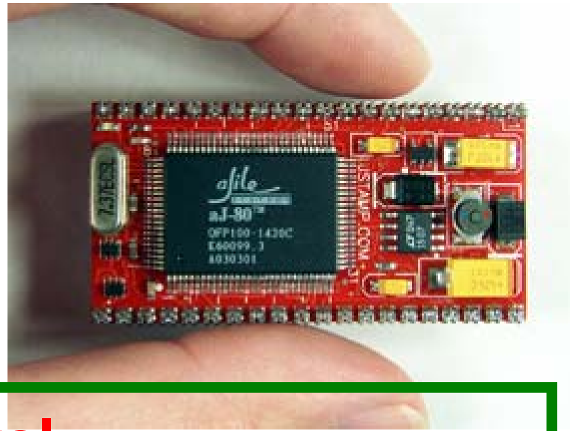
JStamp

Common Misconceptions	JRealTime Reality
I need deterministic performance and good real-time response. There's no way Java can deliver that.	JStamp can and does. The aJile aJ-80 controller includes RTSJ (Real Time Specification for Java) support and provides absolutely deterministic behaviour. Learn more at www.rtj.org.
Embedded systems are hard to program, and expensive to maintain. Development takes a long time.	Java is not a panacea for all embedded problems. A bad programmer can still write bad firmware in Java. However, Java, appropriately applied, has been well-documented to reduce development time and expense and ease maintenance.
We've always used C and assembly code. What's wrong with that?	Nothing, The developers of JStamp have written C and assembly code for years. (We also drew schematics with pencil and paper a long time ago, and laid out circuit boards on mylar film -- we don't miss those days at all.) C has been around a long time. Take advantage of current software technology and use the language of the new millenium - Java.
If native execution is really such a great idea why isn't some big company like Intel or IBM developing Java controllers?	Good question. Here's another: Why did it take two guys in a garage to start the personal computer revolution (Apple) instead of one of the mainframe companies of the day? Hewlett-Packard was also started by two guys in a garage. Recent history shows that revolutionary technology comes from small upstarts, not the old guard. They simply have too much invested in the old way of doing things.

Ref.:
http://www.jstamp.com/reality.htm

JStamp

Systronix JStamp Modules



On JStamp, Java is the native level

Welcome to the Native Level
The fact that Java is the native level makes the JStamp very fast; there is no Java interpreter layer between your Java code and the silicon. It allows JStamp to be very small; there is no need for extra memory to store a Java interpreter. It means that JStamp runs real Java; the JStamp runs actual Java byte codes. There is no compile-time, build-time, runtime, or at-any-other-time translation of Java byte codes into proprietary opcodes. This leads to the slogan that JStamp is real fast, real small, real Java.

Ref.:
http://www.rawbw.com

Jstamp-CPU

The CPU on JStamp is the aJ-80 from aJile Systems. The aJ-80 is programmed entirely in Java. The standard Java Virtual Machine byte codes are its native instruction set. The aJ-80 is rated for a maximum operating frequency of 80 MHz. It is possible to configure JStamp to run at many clock speeds; as slow as 7.372 MHz or far faster than the aJ-80's maximum rated frequency of 80 MHz. Due to the 7.372 MHz crystal used on JStamp, the highest in-spec clock frequency is 73.72 MHz. JStamp's power use is proportional to its speed; the slower you run it, the less power is uses. This is very useful for battery powered systems.

The aJ-80 contains a number of built-in I/O peripherals. These include two UARTs, a serial peripheral interface (SPI) controller, three very versatile 16-bit timer/counters, as well as general-purpose I/O ports.

Ref.:
http://www.rawbw.com

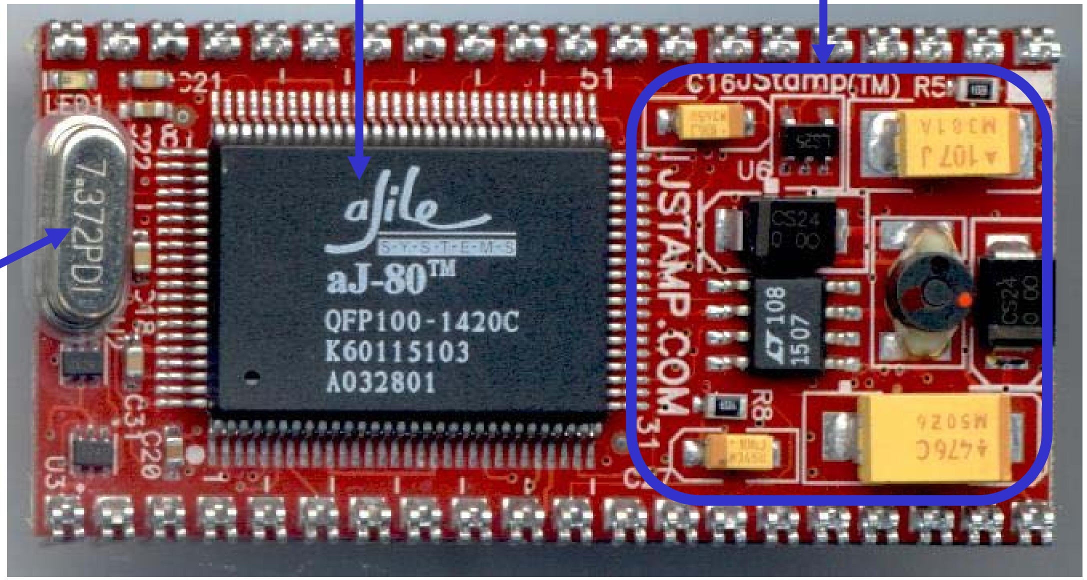
JStamp

Top Side

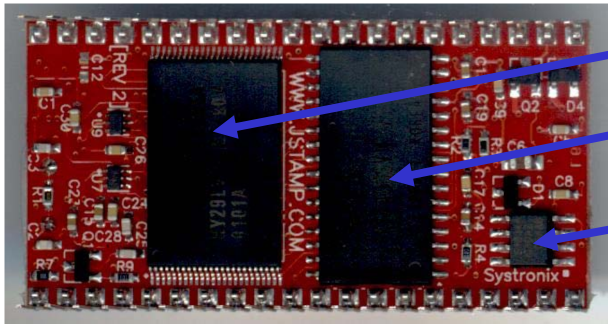
CPU

Voltage Regulator

Crystal



Bottom Side



Flash ROM (512kB)

Static RAM (512 kB)

Reset

Ref.:
http://www.rawbw.com

AFILE

Real-time Low-power Processor aJ-100™

The world's first Real-Time direct execution Processor for Java.

The aJ-100 is the second generation of the JEM™ processors, which was first developed at Rockwell Collins. With an embedded real-time kernel, the aJ-100 is designed for real-time embedded applications that require high-performance and low-power consumption.
The aJ-100 includes all the I/O functions required for embedded applications such as PLCs, sensors, handheld devices and mobile Internet applications.

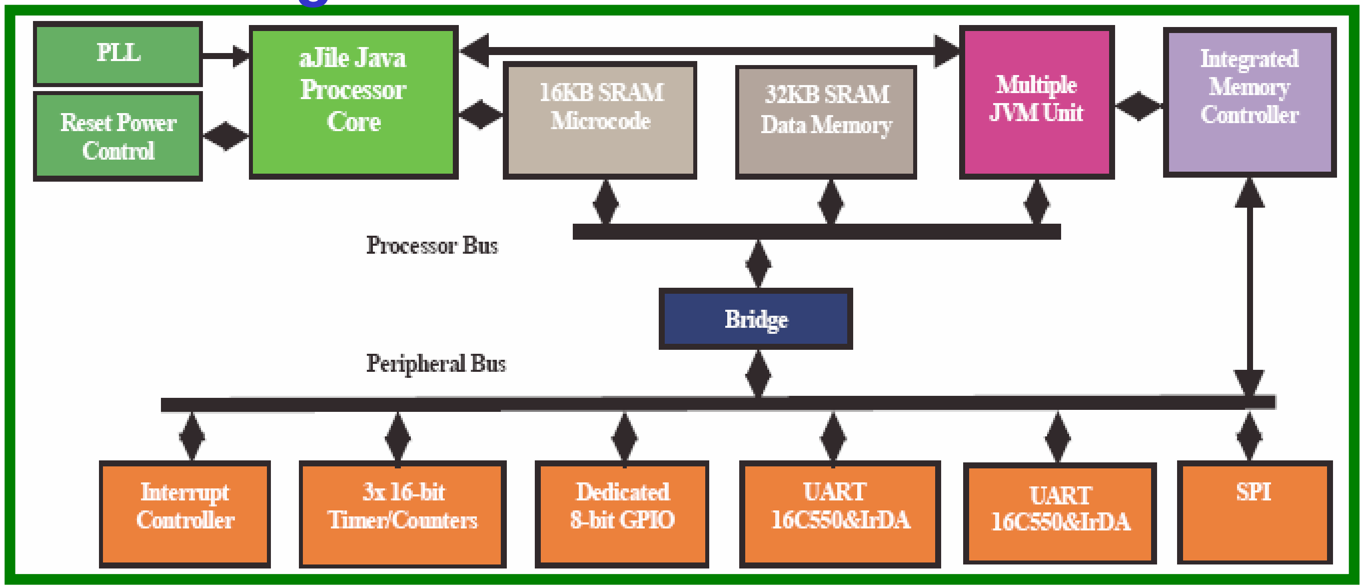
aJile Systems, Inc.:
aJile Systems, Inc. was founded in 1999 by four senior technologists from Rockwell Collins, Sun Microsystems, Integrated Device Technology and Centaur Technologies. aJile Systems is headquartered in San Jose, California, with research and development centers in Cedar Rapids, Iowa and Austin, Texas.

Ref.:
http://www.ajile.com/

Java Processor aJ-100

Real-time Low-power Java Processor aJ-100

Block Diagram for aJ-100



Ref.:
http://www.rikei.co.jp

AFILE

aJ-100TM Real-time Low Power JavaTM Processor

The aJile Systems aJ-100 is the first device in a family of single-chip Java microcontrollers that directly execute Java Virtual MachineTM (JVM) bytecodes, real-time Java threading primitives and a number of extended bytecodes for embedded operations. Java threading primitives (wait, yield, notify, monitor enter/exit) are implemented as extended bytecodes eliminating the need for a the traditional RTOS.
The result is extremely low executive overhead with thread to thread context switch times of less than 1µsec. The aJ-100 features on-chip memory and all the I/O functions required for use in many real-time networked embedded applications. Bundling the aJ-100 microcontroller with a J2ME-based Java run-time system, optimizing application build tools, debugger, third-party IDE's and an evaluation board provides a complete solution for implementing real-time embedded Java applications. The powerful combination of direct JVM bytecode execution, direct multithreading support, and fully protected multiple JVM environments is ideal for efficient, safe, and robust Java execution. The aJ-100 is ideally suited for real-time networked embedded products such as industrial controllers, smart mobile devices, consumer appliances and automotive communications devices.

Ref.:
http://www.ajile.com/

AFILE

Features

JEM2 32-bit Direct Execution Java Processor Core

- Native JVM bytecode
- Extended bytecodes for I/O and threading support
- IEEE-754 floating-point arithmetic
- Writeable control store supports custom extended bytecodes

Native Java Threading Support

- Hard real-time, multi-threading kernel in hardware
- Threading operations are atomic including true Java synchronization
- Built-in deterministic scheduling queues
- Directly supports the Real Time Specification for Java (RTSJ)
- Thread to thread yield in less than 1µsec
- Eliminates traditional RTOS layer

Multiple JVM Manager (MJMTM)

- Support two independent JVM's
- Brick wall time and space protection
- Support external memory protection

Ref.:
http://www.ajile.com/

AFILE

Internal 48KB RAM

- 32KB dedicated data memory
- 16KB microcode memory

Memory Controller

- 8-bit, 16-bit or 32-bit interface
- Eight chip selects to support ROM, Flash, SRAM, and peripheral devices

Dual 16550 compatible UARTs

- 128-byte FIFO on Rx and Tx
- Support IrDA physical layer protocol

Three 16-bit Timers/Counters

- Flexible count control and counter I/O
- Pulse Width Modulation (PWM)
- Waveform measurement

Serial Peripheral Interface (SPI)

- Master/Slave operation
- Four external chip selects
- Programmable transfer length

Ref.:
http://www.ajile.com/

AFILE

Five 8-bit General Purpose I/O Ports

- I/O programmable on a per-bit basis
- Flexible interrupt generation

Phase Locked Loop (PLL) and Power Management

- Transparent CPU power down when the “run queue” is empty
- Individual peripherals can be deactivated when not in use
- Global clock disable with external wake-up pin

IEEE 1149.1 (JTAG) Interface

- Boundary scan
- Low-level debugger interface
- JPDA Java Debugger Interface

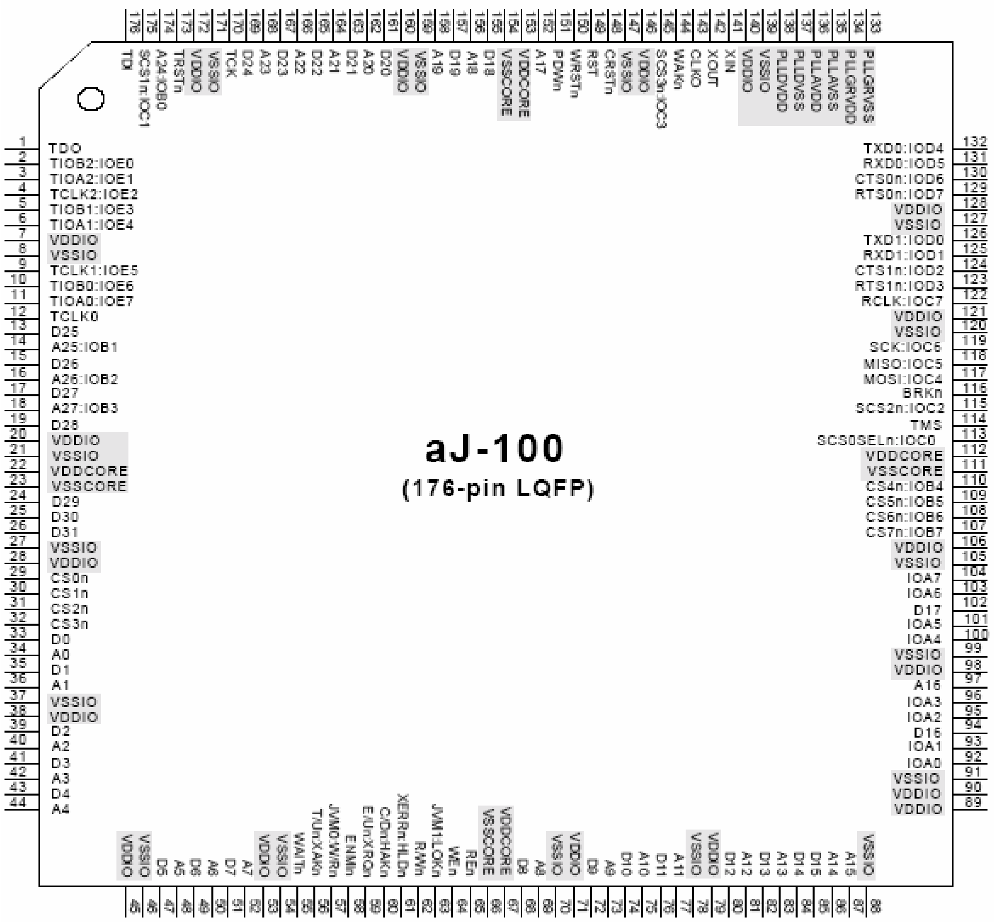
Designed for ultra-low-power operation

- Less than 1mW/MHz power consumption
- Fully static operation up to 100 MHz
- Implemented in 3.3V and 0.25µm CMOS process
- Core operates at 2.5V

Ref.:
http://www.ajile.com/

AFILE

aJ-100 Pin Assigment

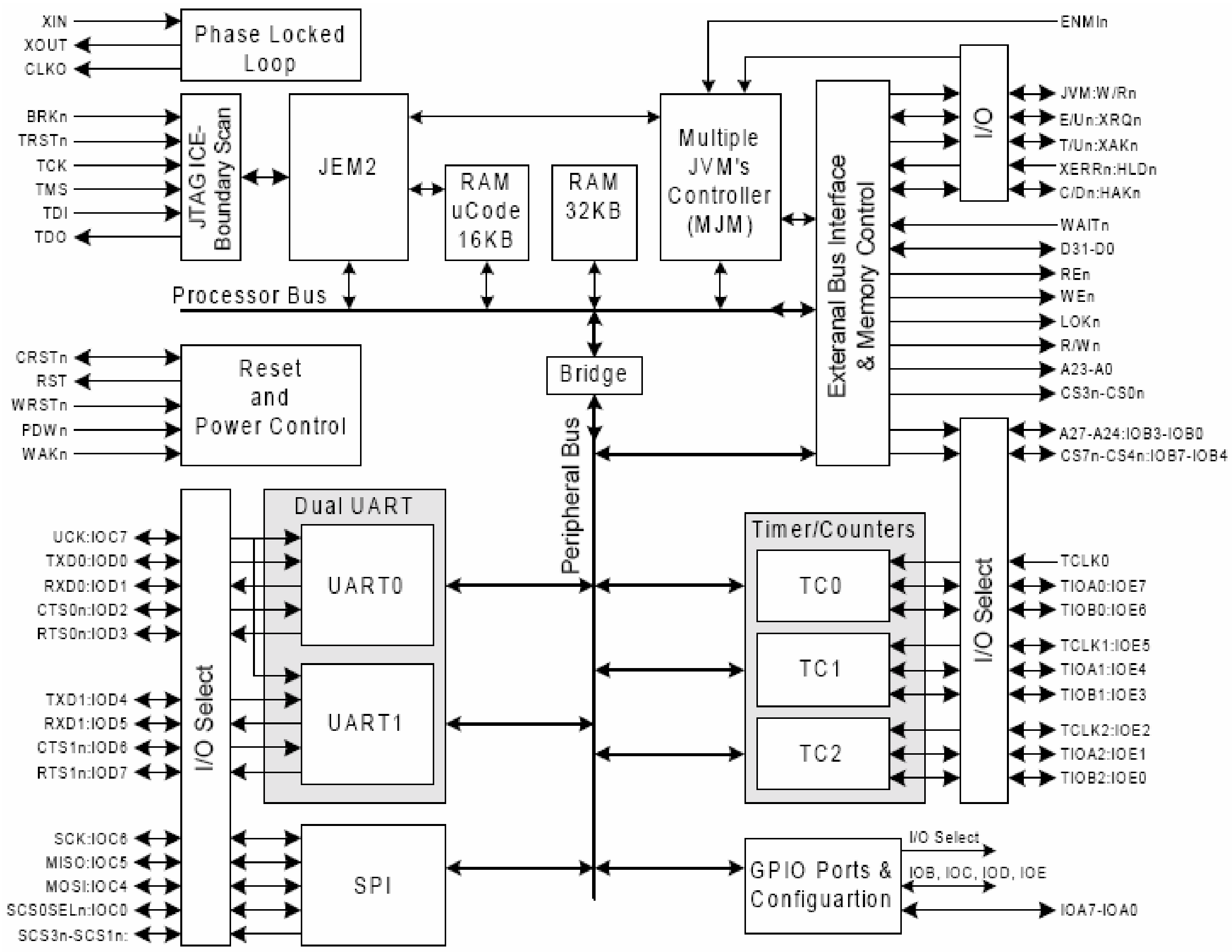


Housed in a 176-lead LQFP package

Ref.:
http://www.ajile.com/

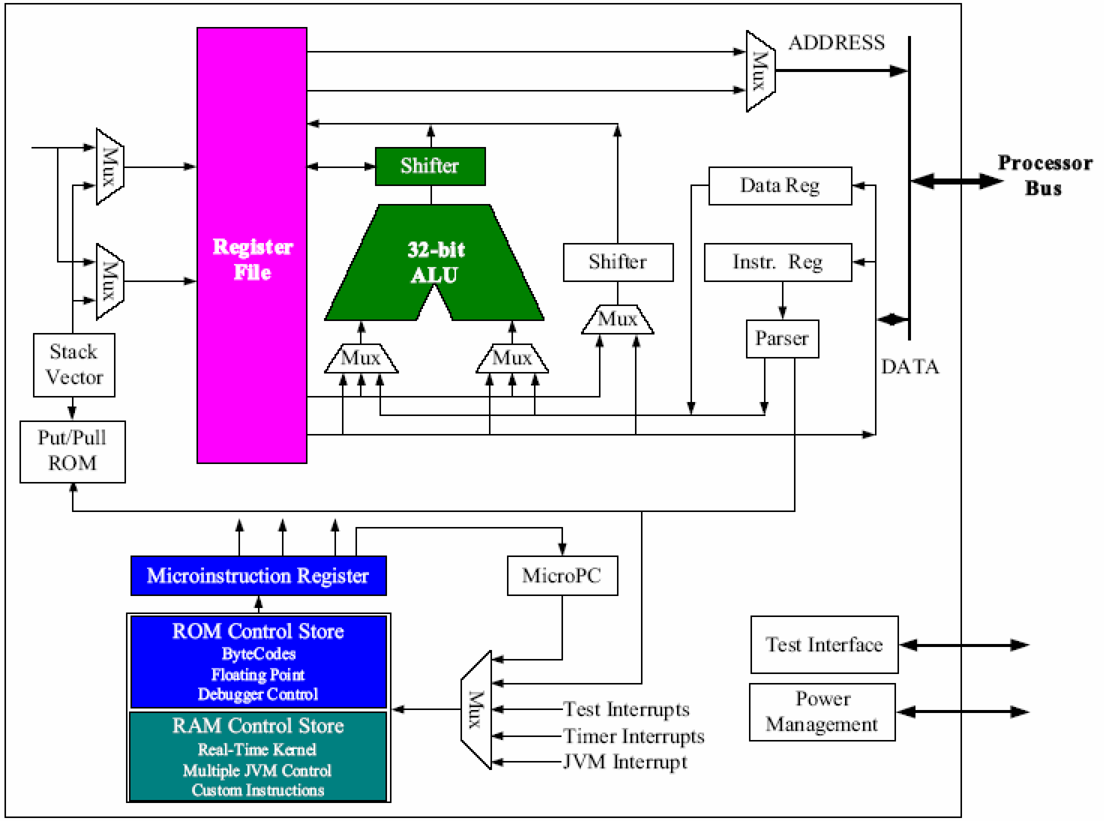
AFILE

aJ-100 Architecture



Ref.:
http://www.ajile.com/

aJile - JEM



JEM2 core architecture.

The JEM2 core implements the entire JVM instruction set in silicon; the only two bytecodes that trap immediately to software are *multianewarray* and *athrow*. Obviously, operations like class loading are handled in software, but once resolution has occurred, execution of bytecodes like *invokevirtual* are done as single JEM instructions, including lock detection.

Ref.: http://www.ajile.com/

AFILE

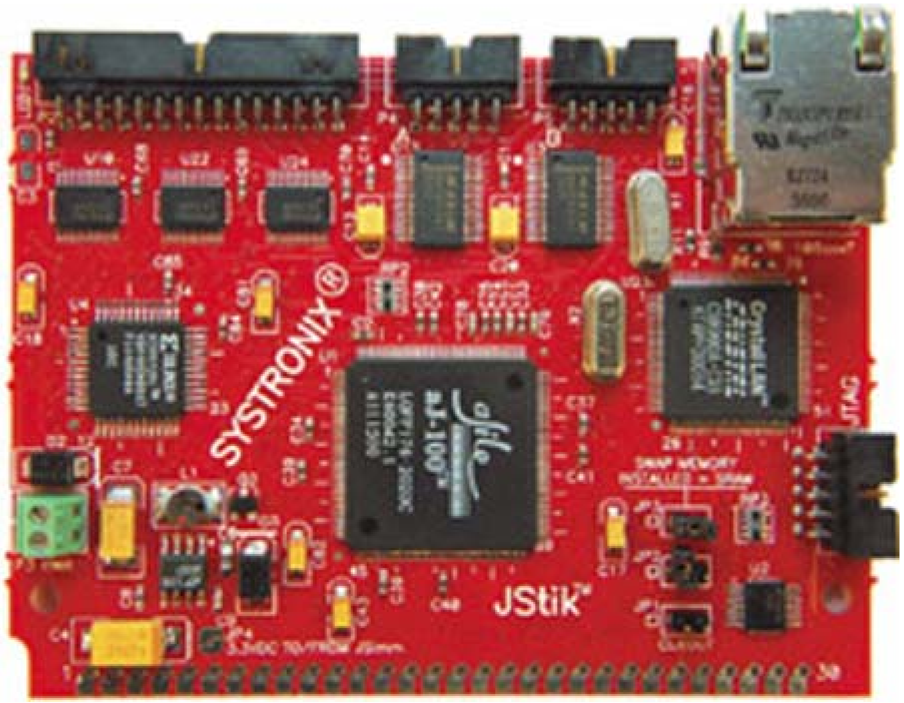
aJile Systems (2004)

develops, manufactures and markets a family of low-power, direct execution processors for Java Technology and Mobile Java OS (MJOS)

RTSJ The Real Time Specification for Java

Ref.:
http://www.ajile.com/
https://rtsj.dev.java.net/

JStick

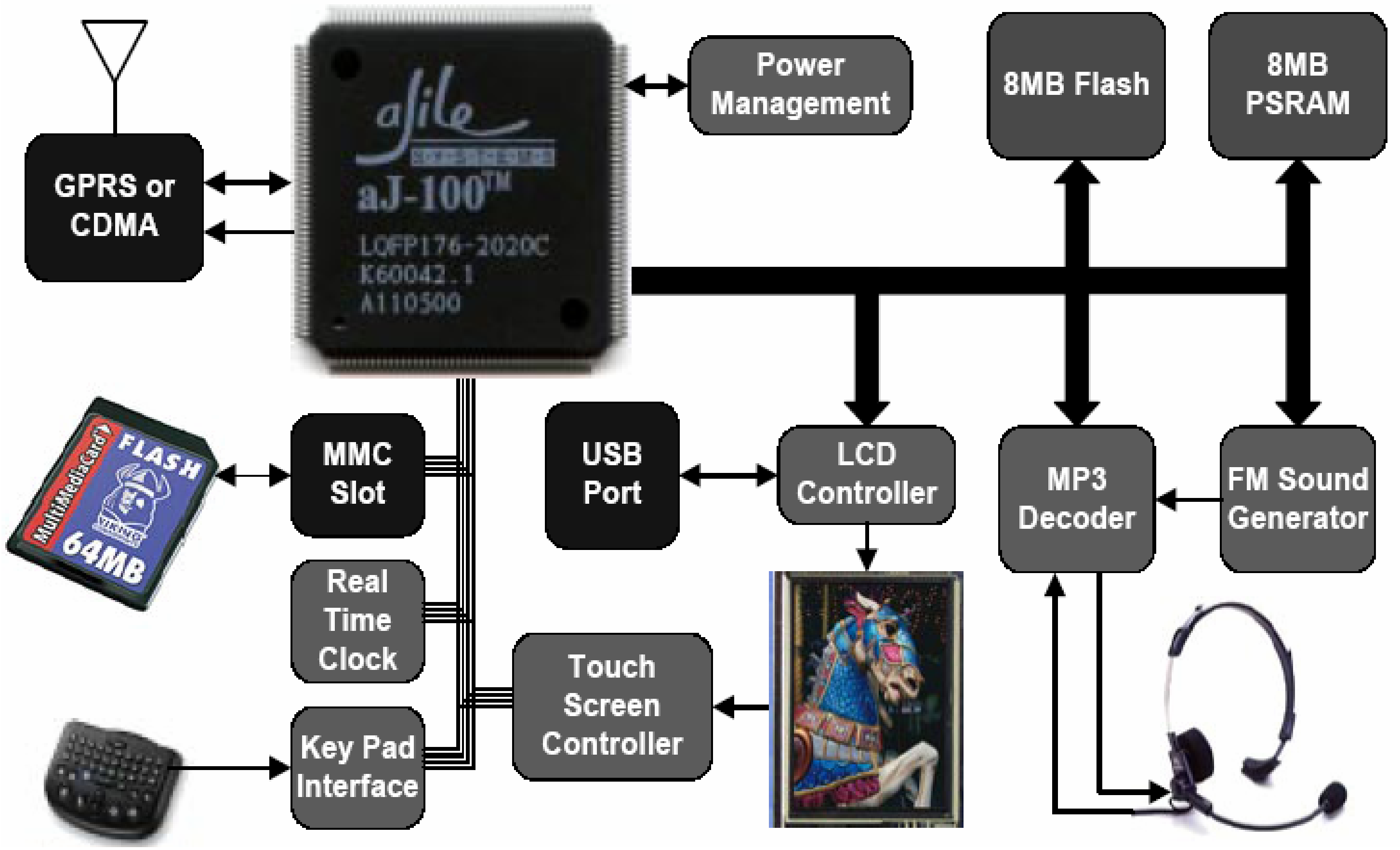


The Jstik

is a true SBC running embedded Java.

Ref.:
http://www.ajile.com/
https://rtsj.dev.java.net/

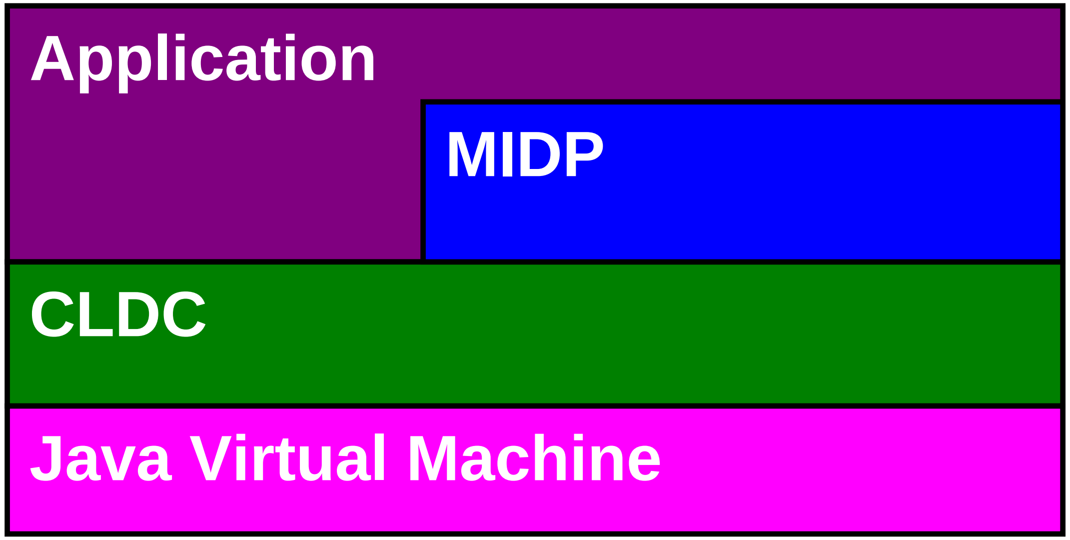
aJile Wireless Reference Platform



Block Diagram of the aJile Wireless Reference Platform (aJ-100WRP)

Ref.:
http://www.rikei.co.jp

Java Solution



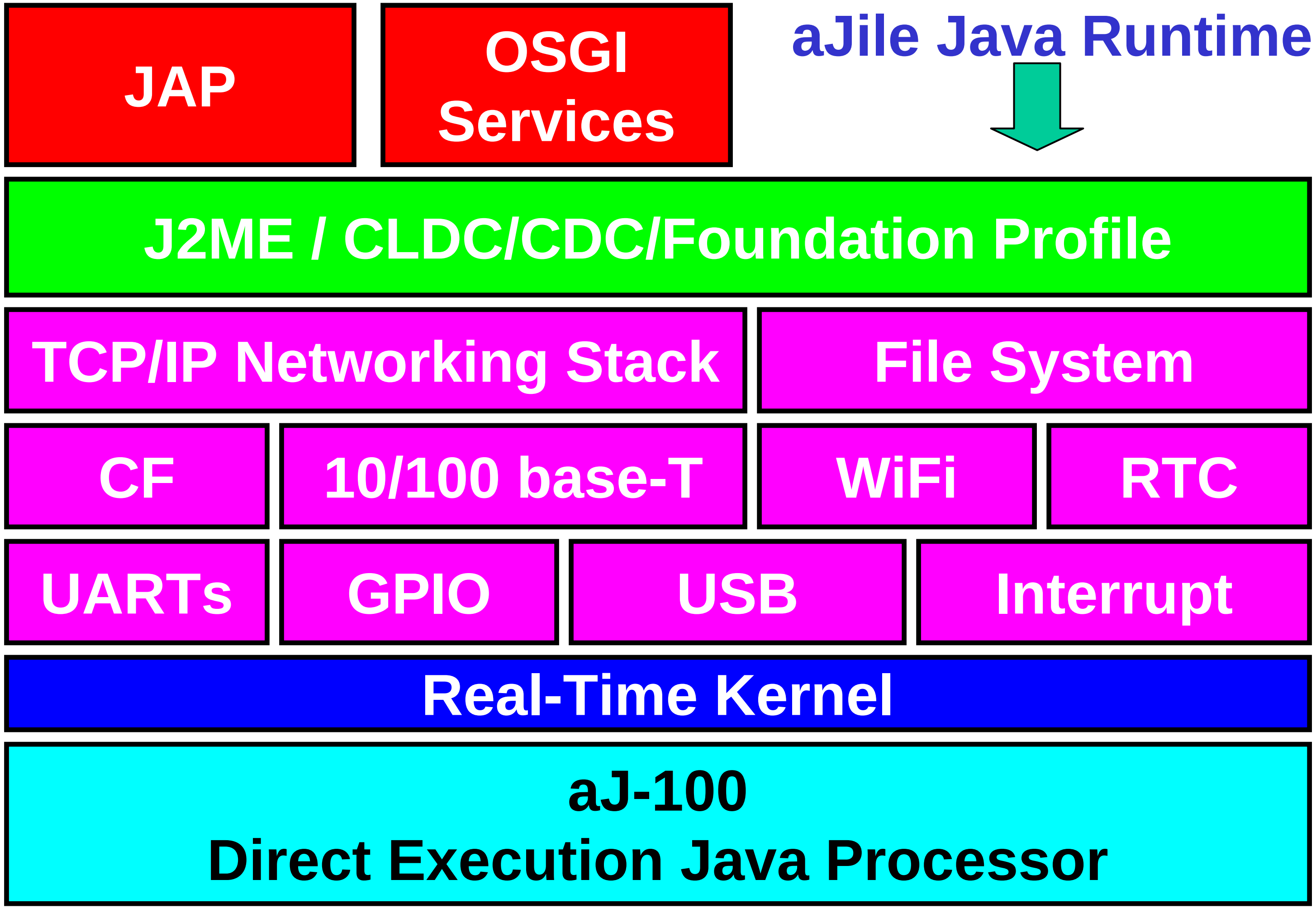
J2ME:
software architecture for a typical application

The J2ME **Connected, Limited Device Configuration** (**CLDC**) specifies a Java 2 subset for memory constrained (less than 512 KB available for the Java environment) devices with lower-speed and potentially intermittent network connectivity, such as mobile phones and Personal Digital Assistants. The **Connected Device Configuration** (**CDC**) is targeted at somewhat lessconstrained devices, such as set-top boxes and other "plug-in-the-wall" network appliances.

In addition to these standard configurations, a number of vertical market profiles can be defined for J2ME devices. One particularly important J2ME profile is the **Mobile Information Device Profile (MIDP)**, which, amongst other features, defines a minimal set of graphical API's for information appliances such as mobile phones, Personal Digital Assistants, etc.

Ref.:
http://www.ajile.com/

Complete Java Solution based on aJile

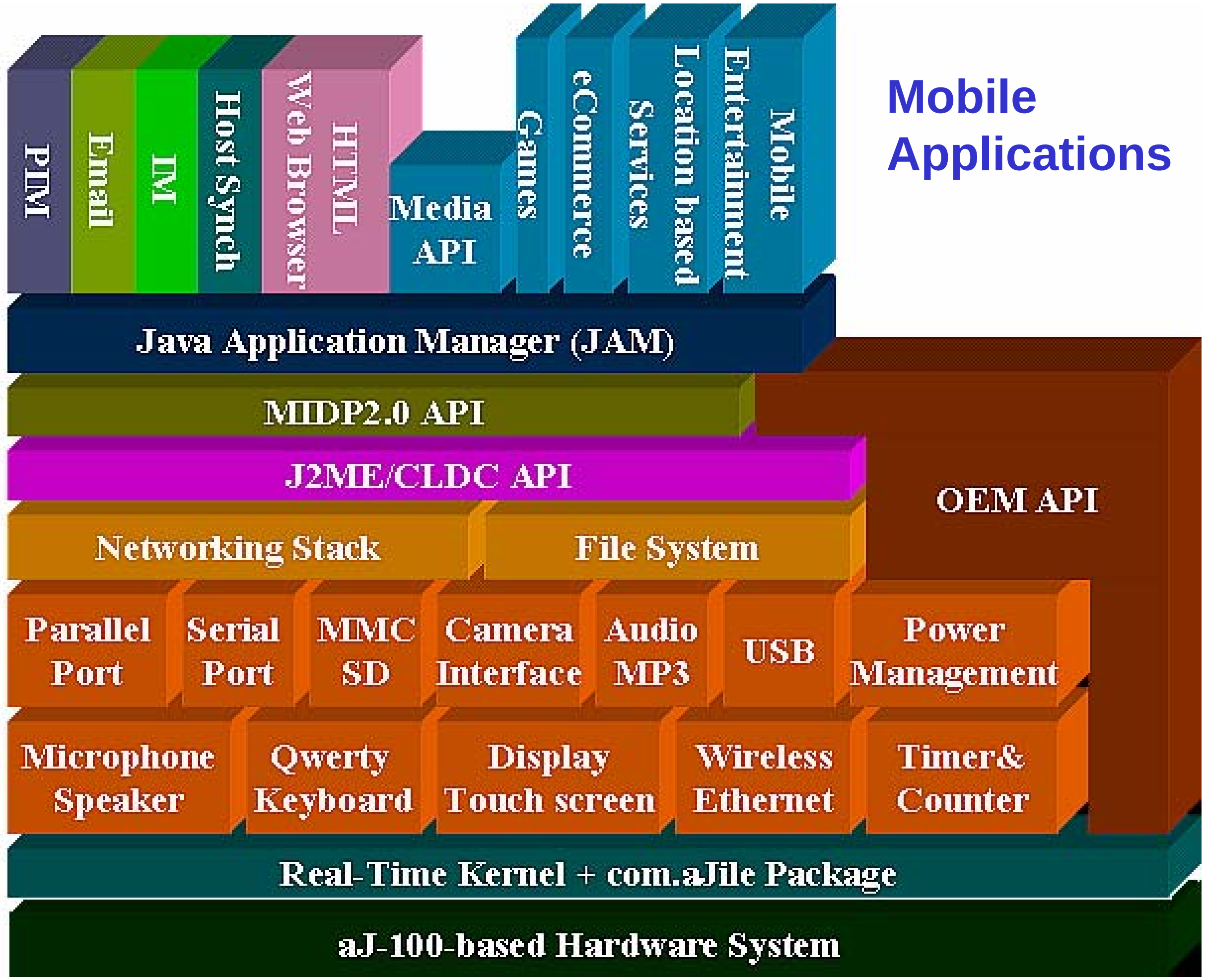


Ref.: http://www.ajile.com/

Java Solution

Middleware

aJile Mobile Java OS (MJOS)



Mobile Applications

Complete Java solution based on the aJile family of processors.

Ref.: http://www.ajile.com/

Ubiquitous Computing

Sensor Technology
Location technology (indoor, outdoor)

Content:

- Introduction
- Technology Trends, Visions
- Networking in UbiComp: CAN, PLC, Wireless, Infrared, Ad Hoc Networks
- Embedded Systems, Sensors and Actuators
- **Sensors for Location Tracking, Location Sensing**
- Multi-Sensor Systems, Sensor Networks
- Context Awareness
- Wearable, distributed and context-aware computing

Motivation

Motivation for usage of sensors in Ubiquitous Computing:

Human-Centered Application of Computers:

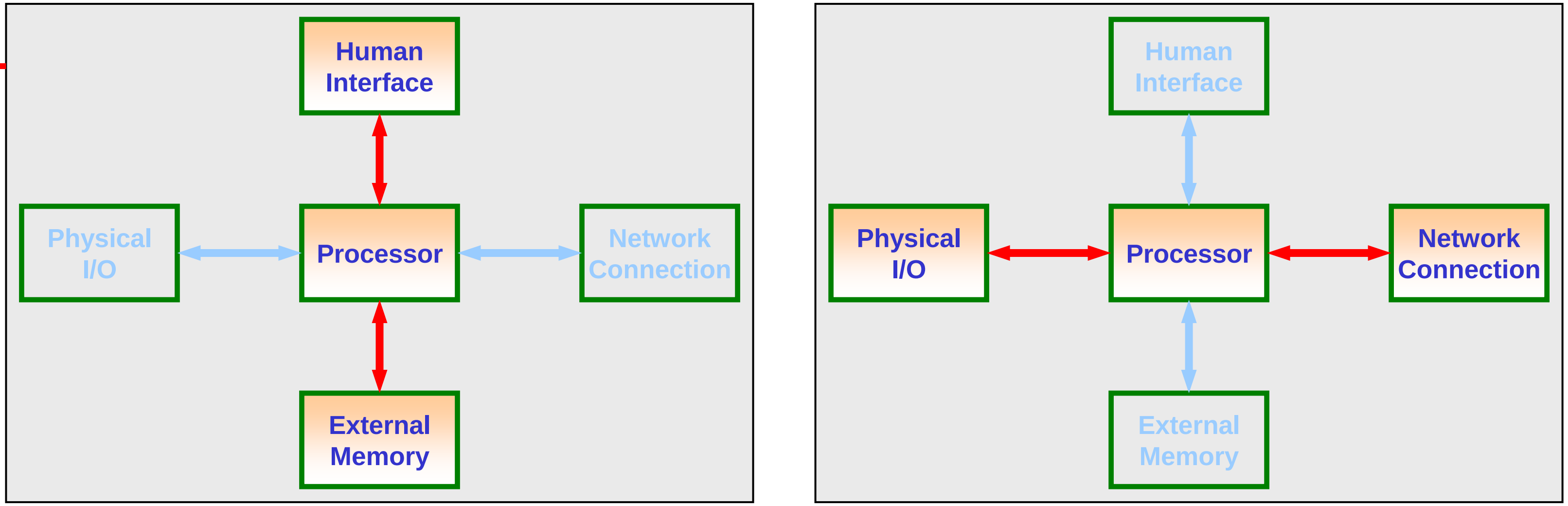
- **Then**: People had to adapt to Systems
- **Now**: Systems should adapt to people
  - **Reactive to what people do**
  - **Proactive, anticipating what people want to do**
  - **Situated, sharing context with human user**
- We are going from explicit (**computer-directed**) to implicit (**activity-driven**) interaction between people and systems

Required: Observation of Human Activity

Ref.:
Hans-W. Gellersen, Lancaster University

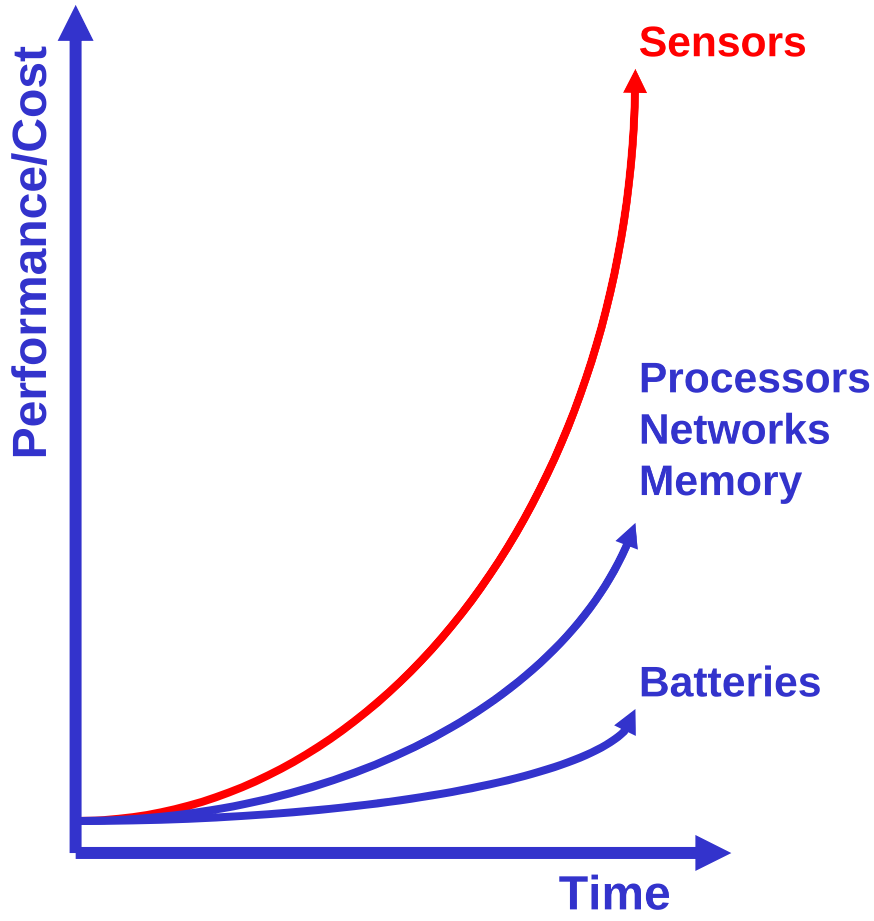
Device Development:

- from general-purpose to applied computer
- low power CPUs
- user interfaces
- extended networking to allow for interaction
- increased physical Input/Output (I/O)



Ref.:
Hans-W. Gellersen, Lancaster University

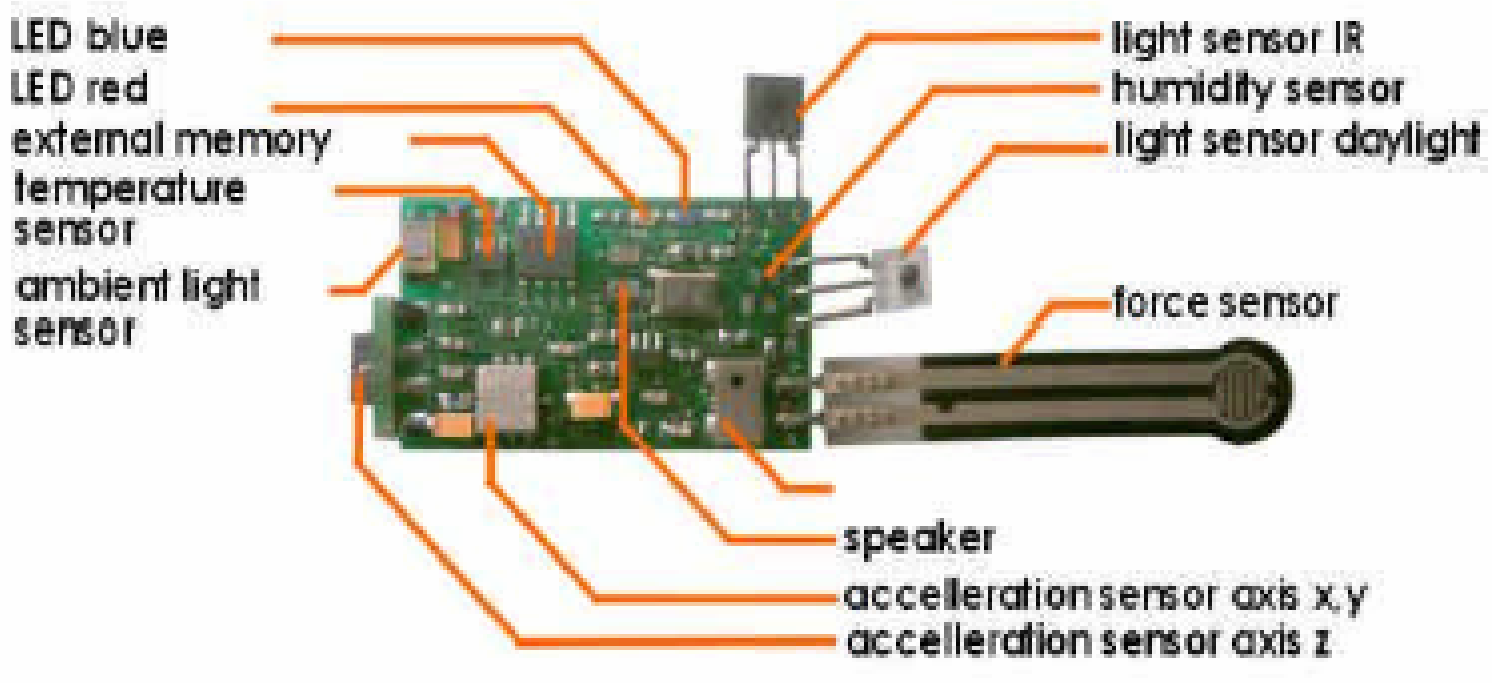
Enabling Technology



Moore's Law:

- fast development of sensors
- miniaturization:
  MEMS
  piezo-materials
- lowering cost

General Sensor Board (Teco)



Location Sensitivity

Examples:

- **GPS (Global Positioning System):**
  Supplies geographical coordinate information.
- **MPS (Mobile Positioning System):**
  Ericsson's Location Based Services (LBS) solution. MPS consists of a server-based Gateway Mobile Positioning Centre (GMPC), a server-based Serving Mobile Positioning Centre (SMPC) and software extensions for the operator's mobile network.
- **Active Badge System:**
  Provides a means of locating individuals within a building by determining the location of their active badge.

Advantages:

- **Information can be filtered using details about location and time.**
- **Useful for calm computing.**

Context Sensing

- Systems and technologies that automatically locate people, equipment, and other tangibles.
- Develop a taxonomy to help developers of location-aware applications better evaluate their options when choosing a location-sensing system

“Location Systems for Ubiquitous Computing,” Jeffrey Hightower, Gaetano Borriello, University of Washington, *IEEE Computer Magazine*, August 2001

ScatterWeb

Embedded Sensor Board
ESB 430/1

- 1 Mhz MSP430 Processor
- Low power
- 2kb RAM, 60kb Flash
- 433/869 MHz radio: 19,2 kbit/s, 100m range
- Can be programmed using a modified Gnu-C-Compilers
- www.scatterweb.de

Ref.:
ScatterWeb GmbH Berlin
http://www.scatterweb.de/

ScatterWeb

Typical Usage Scenarios

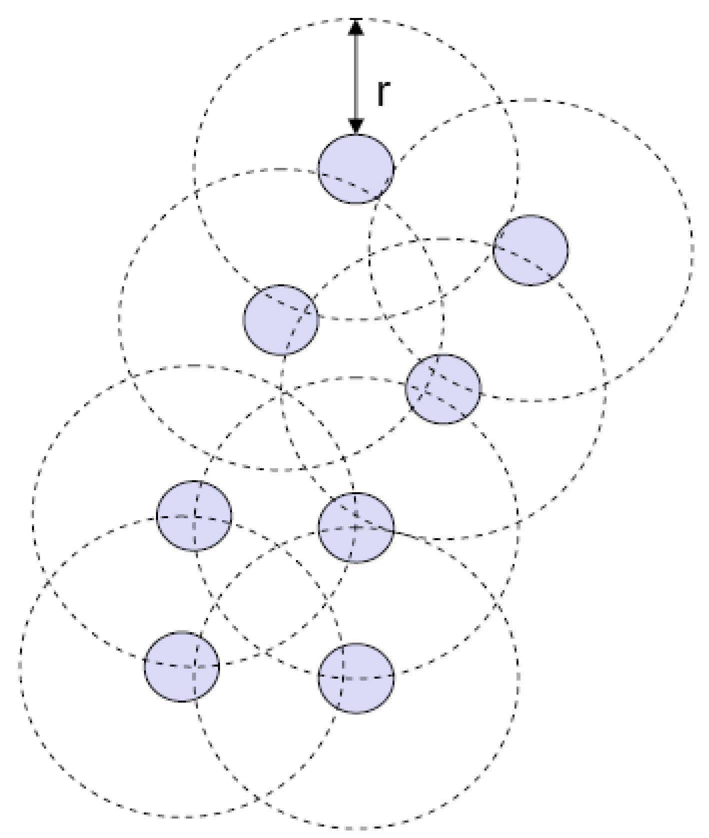
ScatterWeb's independence from infrastructures, capabilities for autoconfiguration, low-power design, and flexibility opens up a wide range of usage scenarios:

- Environmental monitoring
- Enhanced mobile entertainment
- Intelligent buildings
- Disaster recovery
- Ad-hoc process control

The system serves as a test-bed for ad-hoc networking, peer-to-peer networks, power and resource constrained communication devices, and sensor networks.

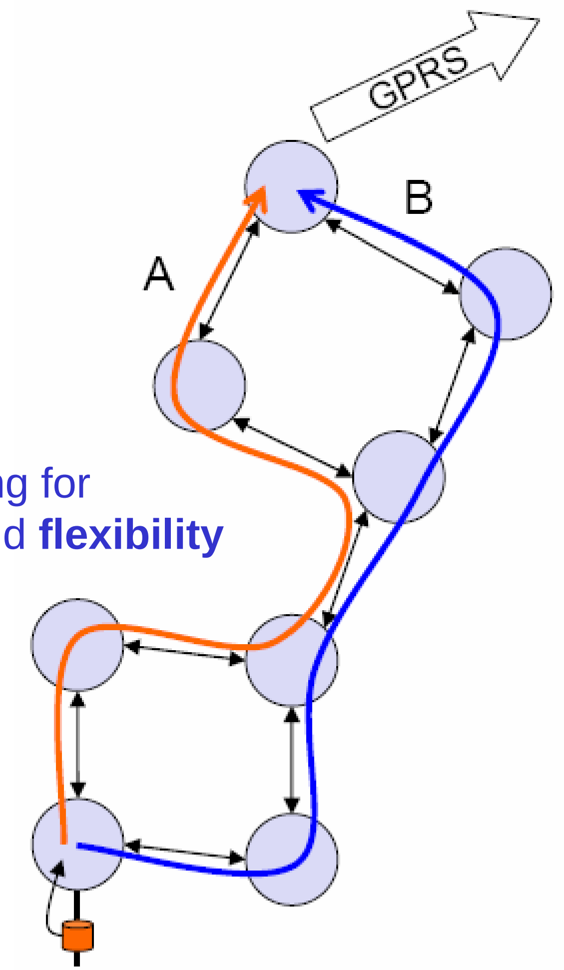
Ref.:
ScatterWeb GmbH Berlin
http://www.scatterweb.de/

General Sensor Board (Teco)



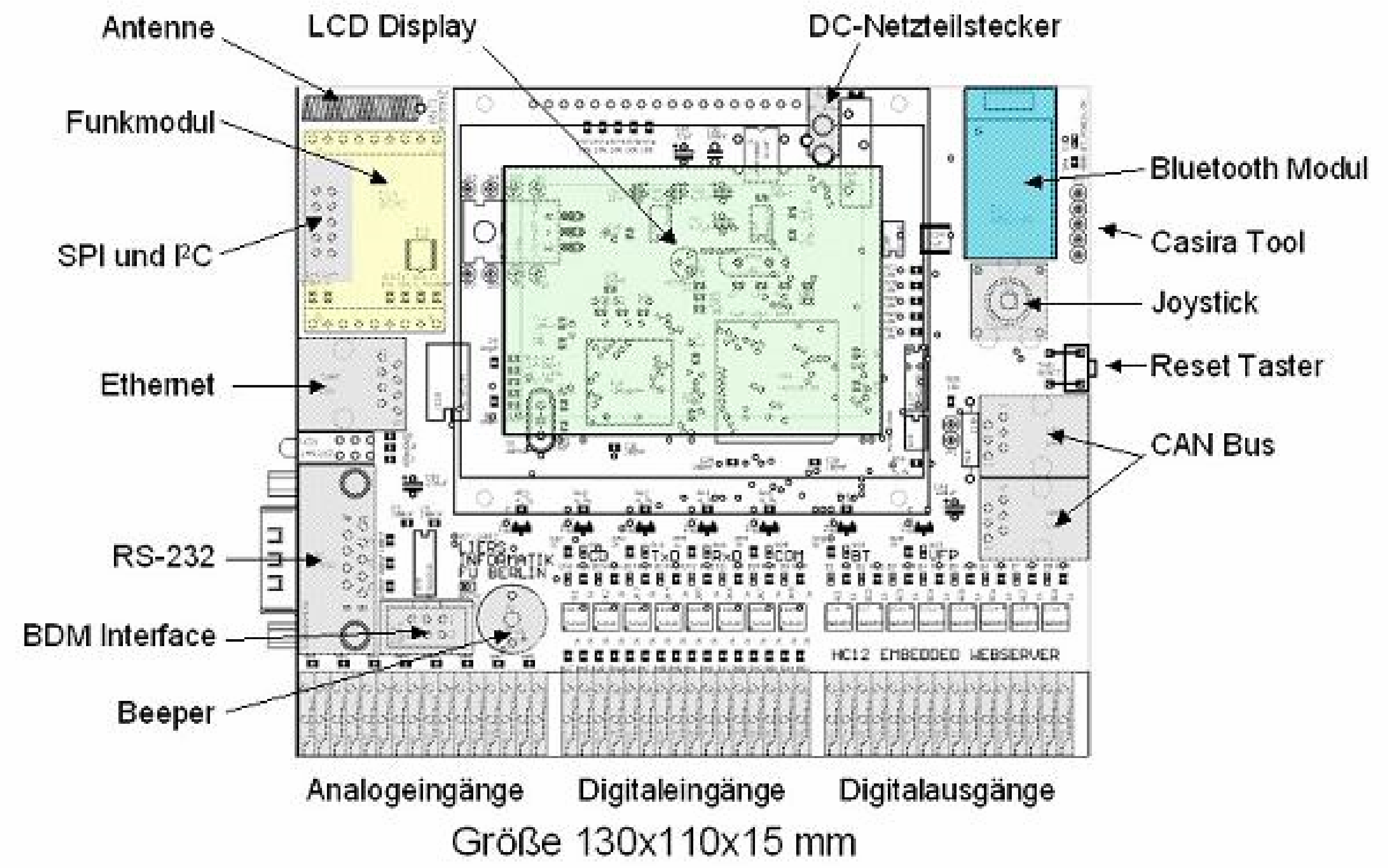
short- distance communication
minimizes energy consumption

multipath routing for
robustness and **flexibility**



Ref.:
ScatterWeb GmbH Berlin
http://www.scatterweb.de/

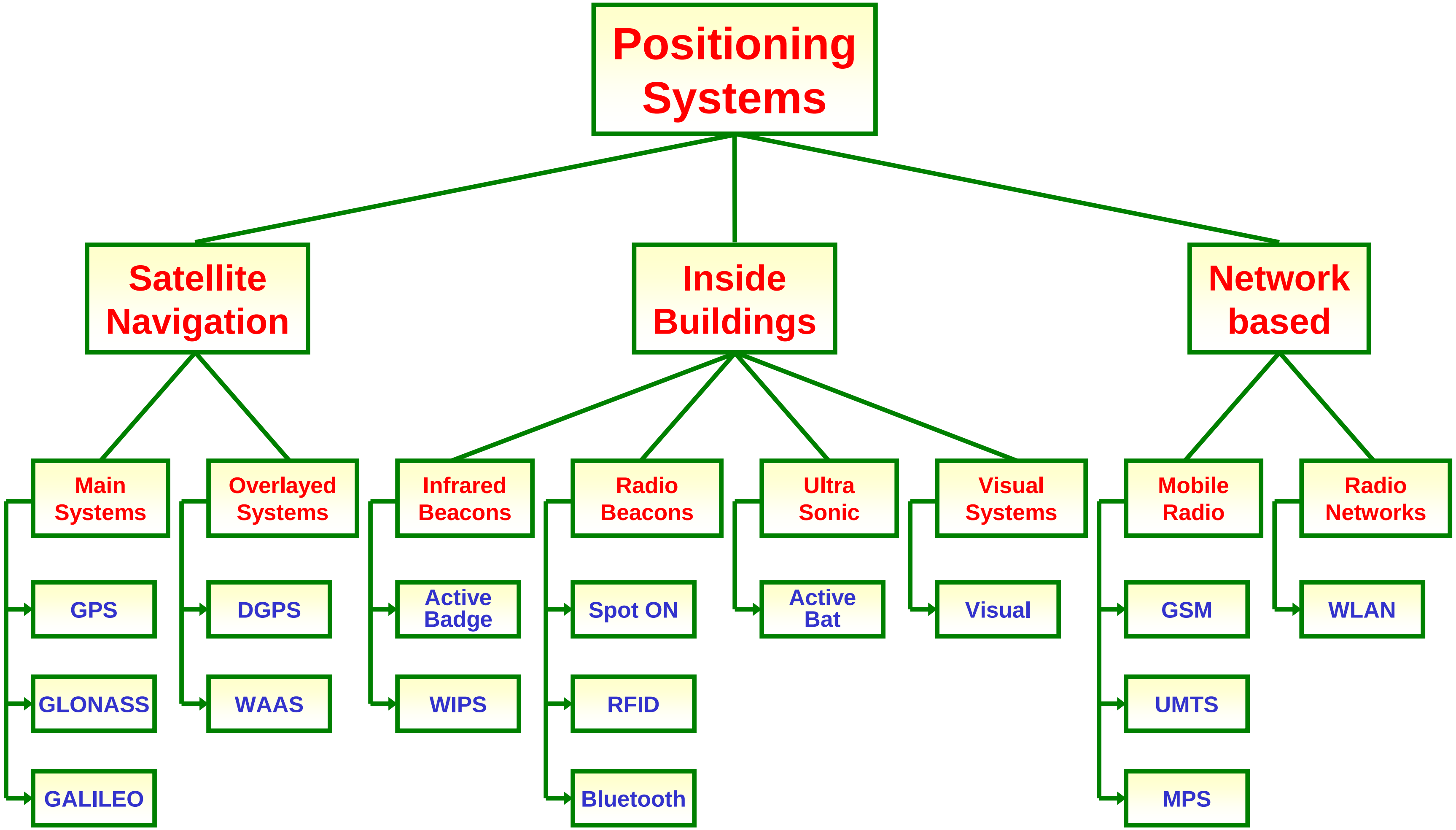
Scatterweb



Ref.:
ScatterWeb GmbH Berlin
http://www.scatterweb.de
http://www.inf.fu-berlin.de/inst/ag-tech/scatterweb_net/home/documents.htm

Location Based Services - LBS

Positioning



Ref.:
Jörg Roth: Mobile Computing, dpunkt Verlag, Heidelberg, 2002

SAPOS

SA*POS*® - Satellitenpositionierungsdienst der deutschen Landesvermessung
Satellite *Positioning Service* of the German State Survey

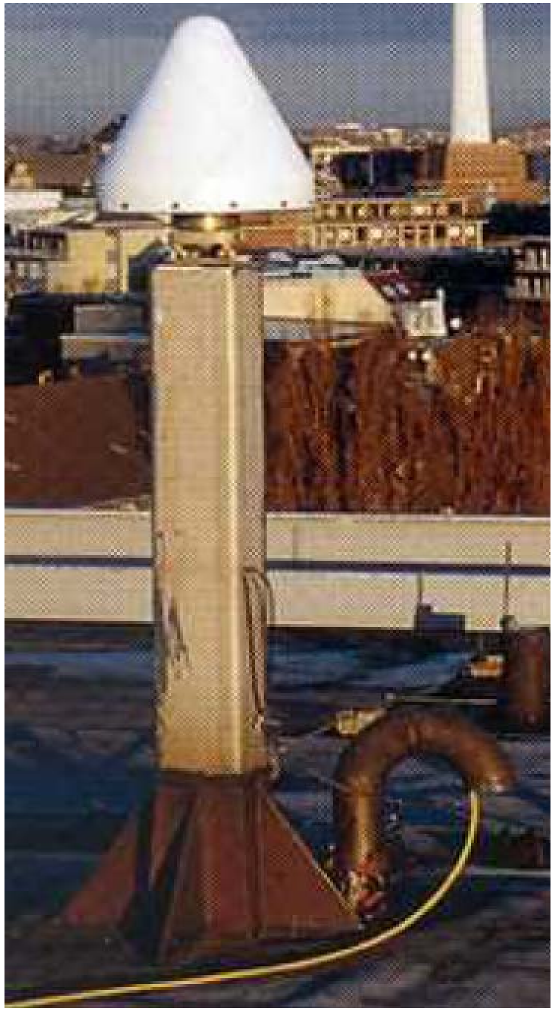
The Satellite Positioning Service **SA*POS*®** . a joint project of the Working Committee of the Surveying Authorities of the States of the Federal Republic of Germany (AdV). It ensures you the current accurate spatial reference by a network of permanently registering reference stations based on the Europe-wide standardized reference system ETRS89.

SA*POS*® is based on the Global Positioning System (GPS) and provides data for your positioning and navigation purposes, with whose assistance you can increase your positioning accuracy into the millimeter range. With **SA*POS*®** you need only one receiver for your differential GPS measurements.

Throughout Germany a network of more than 250 GPS reference stations is available.

Ref.:
www.sapos.de

SAPOS - Applications



Reference Station

SA*POS* Reference Stations

Ref.:
www.sapos.de

SAPOS

SAPOS
German National Survey Satellite Positioning Service

Service	Time to result	Transmission	Data Format	Accuracy
EPS Real Time Positioning Service	Real time	Radio Data System (RDS) of FM radio stations, 87-108 MHz	RTCM 2.0	1-3 m
HEPS Precise Real Time Positioning Service	Real time	5 separate radio frequencies at ~160 MHz, exclusively used	RTCM 2.1	1- 5 cm
GPPS Geodetic Positioning Service	Postprocessing Within ~15 min.	Telephone, GSM	RINEX	1 cm
GHPS Precise Geodetic Positioning Service	Postprocessing	Mail etc.	RINEX	< 1 cm (mm)

EPS	Echtzeitpositionierungsservice
HEPS	Hochpräziser Echtzeitpositionierungsservice
GPPS	Geodätischer Postprocessing Positionierungsservice
GHPS	Geodätischer Hochpräziser Positionierungsservice

Ref.:
www.sapos.de

SAPOS – Precision Positioning

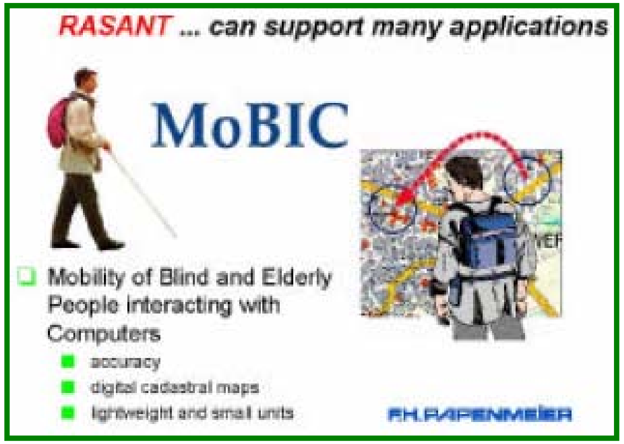
SAPOS GPPS and GHPS

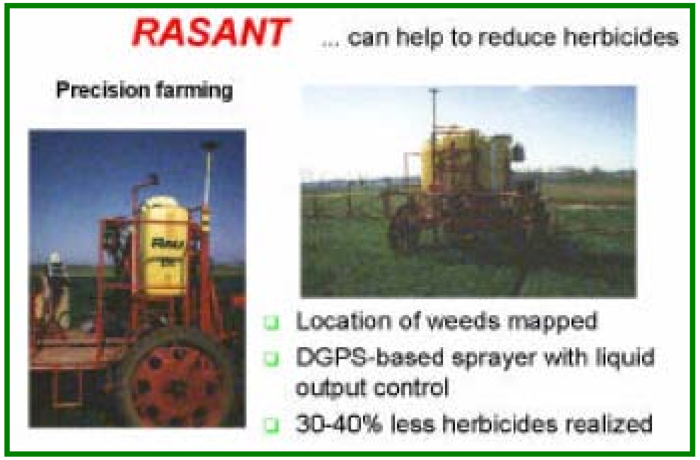
Geodetic Precise Positioning Service (GPPS) with an accuracy of 1 cm is not available in real-time but in postprocessing (after your surveying outside). The GPS satellite signals which are registered permanently by the base stations can be used in the receiver independent data format RINEX.

By using Geodetic High Precision Positioning Service you can reach accuracies up to 1 mm (with corresponding long ovservation time). To get even increasing accuracies you should use precise satellite ephemerides from Internation GPS-Service for Geodynamics (IGS). The evaluation of your measurements is made with corresponding calculation software in postprocessing.

Ref.:
www.sapos.de

SAPOS - Applications





Ref.:
www.sapos.de

Directional Virtual Fencing (DVF)

Directional Virtual Fencing™ is:

- A novel **methodology** for controlling the location and direction of movement of free-ranging animals without conventional fencing.
- A combination of **Global Positioning System (GPS)** technology and **animal conditioning**.
- A way to produce directional movement of animals on a landscape using **bilateral cues** ramped from least to most irritating. Cues applied to the animal's left side move the animal to the right and vice versa.

Dean M. Anderson, Purushotham Nayak, Barbara Nolen,Ed L. Fredrickso, Rick E. Estell, Craig S. Hale and Kris M. Havstad:
DIRECTIONAL VIRTUAL FENCING (DVF™) & FLERDS,
USDA-ARS Jornada Experimental Range, Las Cruces, NM;
Future Segue, Las Cruces, NM

Directional Virtual Fencing (DVF)

Current situation:

Global challenge for many of the world's

- **4 x 10^9 domestic animals**

that forage on some of the world's

- **13 x 10^9 hectares**.

Ref.:
Dean M. Anderson, USDA-ARS Jornada Experimental Range, Las Cruces, NM;
Future Segue, Las Cruces, NM

Directional Virtual Fencing (DVF)

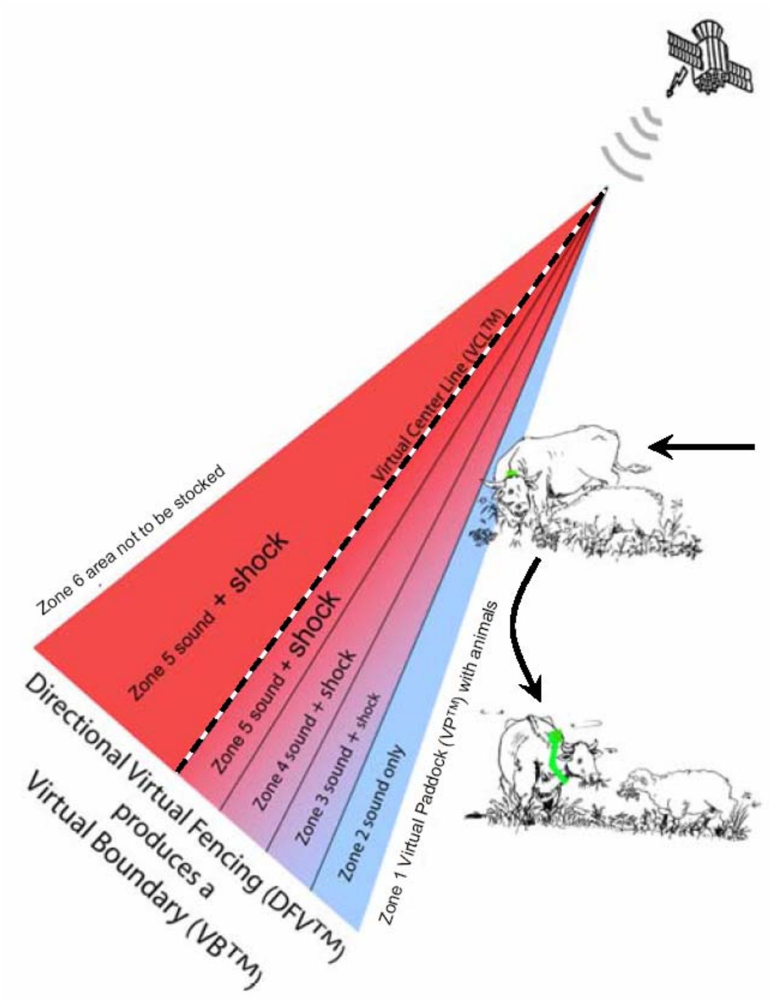
Directional Virtual Fencing (DVF™) defines a novel, new methodology for the control of animals. It involves the control of animal location and direction of movement through the application of ramped audio and or electric shock cues applied to either the animal's right or left side to initiate directional movement.

DVF™ combines physics, electronics, biology and ecology to first determine the animal's location on the landscape using Global Positioning System (GPS) technology, and second using Geographic Information System (GIS) data to direct the animal to the proper location, when necessary.

DVF™ capitalizes on animal behavior to accomplish a change in the animal's location through instrumental animal conditioning using programmable cues that are applied autonomously in a manner consistent with low-stress animal handling procedures in static, as well as moving Virtual Paddocks (VP™).

Ref.:
Zack Butler, Peter Corke, Ron Peterson and Daniela Rus:
Virtual Fences for Controlling Cows,
Dartmouth College, Department of Computer Science, Hanover, NH, USA;
CSIRO, Manufacturing & Infrastructure Technology, Brisbane, QLD, Australia;
MIT Computer Science and Artificial Intelligence Laboratory, Cambridge, MA, USA;

Directional Virtual Fencing (DVF)



A schematic representation of how Directional Virtual Fencing (DVF™) operates with a programmable Virtual Boundary (VB™) that activates a series of cues ramped from least severe (audio sound only) at the VB™ perimeter that defines a Virtual Paddock (VP™) to most severe (audio sound + electric shock) on either side of the Virtual Center Line (VCL™).

Cues are applied to either the animal’s right or left side depending on the angle of the animal’s head with respect to the VCL™ once the VB™ is penetrated.

The animal’s movement that results from these cues should put the greatest distance between the animal and the VCL™ in the shortest amount of travel, and with the least amount of stress.

Directional Virtual Fencing (DVF)

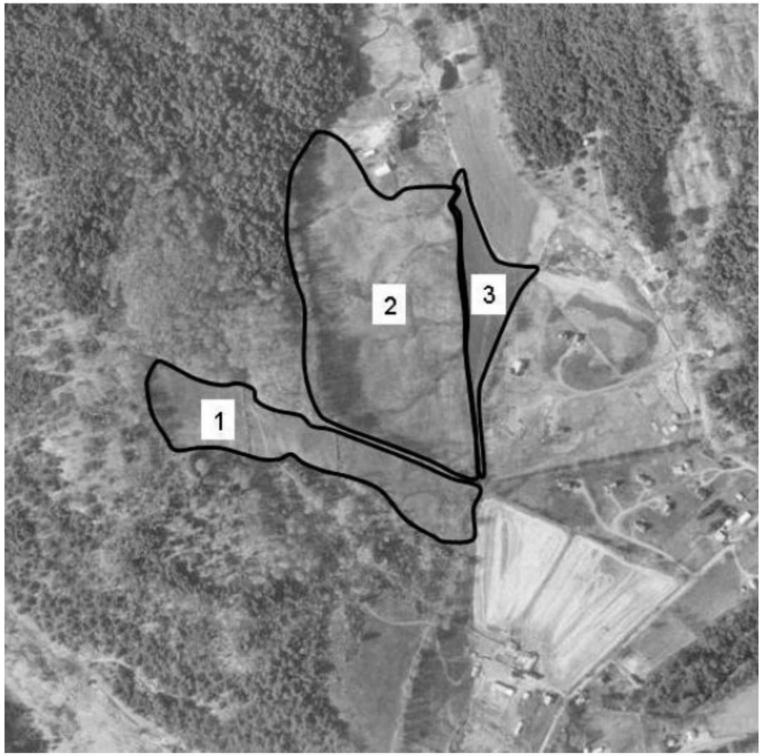
The Cyber Cow Whisperer and His Virtual Fence

Some call Dean M. Anderson Sky Rider, but he's really a Cyber Cow Whisperer.
His colleagues call him Sky Rider because he rounds up cattle with the help of Global Positioning System (GPS) signals coming from satellites.
But his prototype locator/controller cow collar also whispers electronic versions of the cowboy's "gee" (go right) and "haw" (go left) into the cow's ears. By controlling movement, the whispered commands act as a virtual fence.

The prototype virtual fence device as a neck saddle.

Ref.:
http://www.ars.usda.gov/is/AR/archive/nov00/cow1100.htm

Directional Virtual Fencing (DVF)



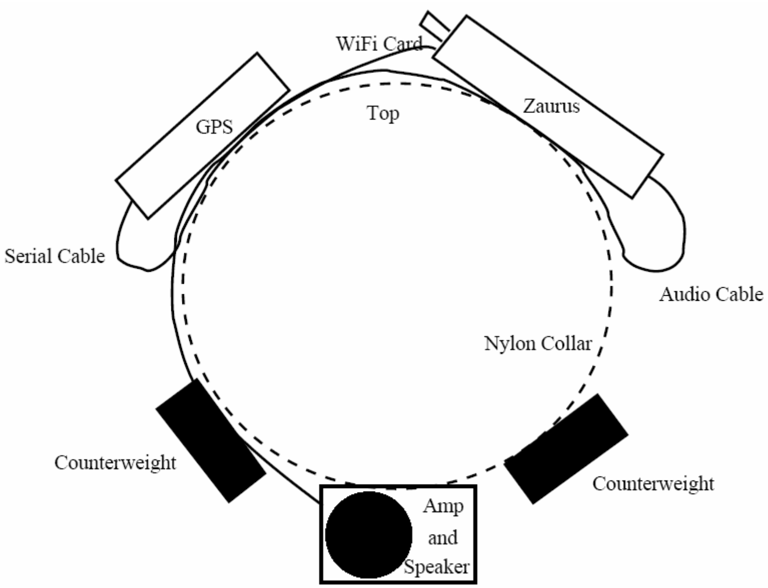
A cow wearing a DVF-collar

Ref.:
Zack Butler, Peter Corke, Ron Peterson and Daniela Rus:
Virtual Fences for Controlling Cows,
Dartmouth College, Department of Computer Science, Hanover, NH, USA;
CSIRO, Manufacturing & Infrastructure Technology, Brisbane, QLD, Australia;
MIT Computer Science and Artificial Intelligence Laboratory, Cambridge, MA, USA;

Directional Virtual Fencing (DVF)

The Smart Collar Hardware

The collar-computer is a Zaurus PDA with a 206MHz Intel StrongArm processor, 64MB of RAM, with an additional 128MB SD memory card.
It runs Embedix Linux with the Qtopia window manager. The Zaurus has a serial port and stereo sound port. A Socket brand 802.11 compact flash card provides a wireless network connection. An eTrex GPS unit is connected to the serial port of the Zaurus. A small Smokey brand guitar amplifier is used to reproduce sounds from the Zaurus audio port.



A fully assembled collar.

Directional Virtual Fencing (DVF)

Virtual Fences Control Cattle

Virtual Fence Data

Locations of cow 4132 in JER Paddock 10B (466 ha; 1,103 ac) while wearing a virtual fencing device to control its location and direction of movement. Each dot represents uncorrected Global Positioning System (GPS) fixes. Note the effectiveness of the programmable bilateral auditory/tactal cues in controlling the animal's location (Fig. B).

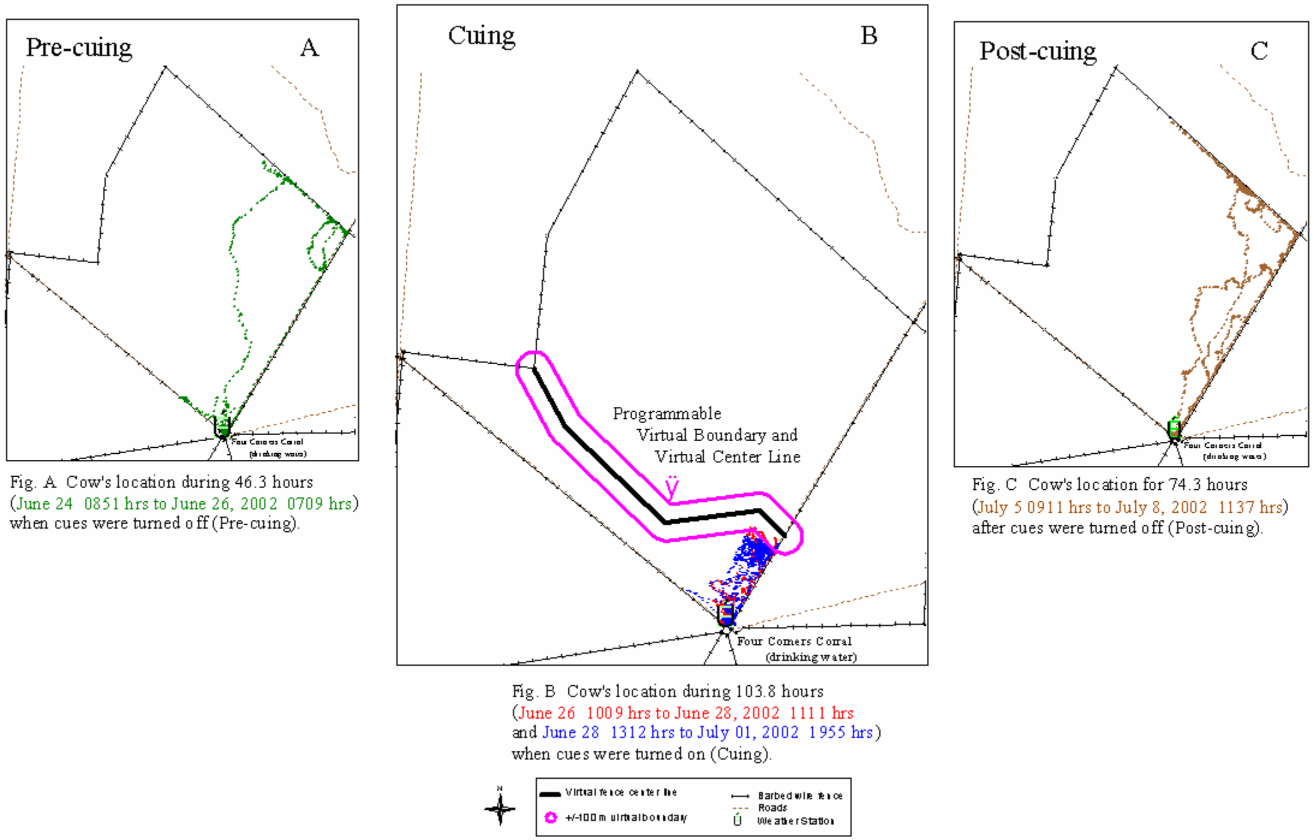


Fig. A Cow's location during 46.3 hours (June 24 0851 hrs to June 26, 2002 0709 hrs) when cues were turned off (Pre-cuing).

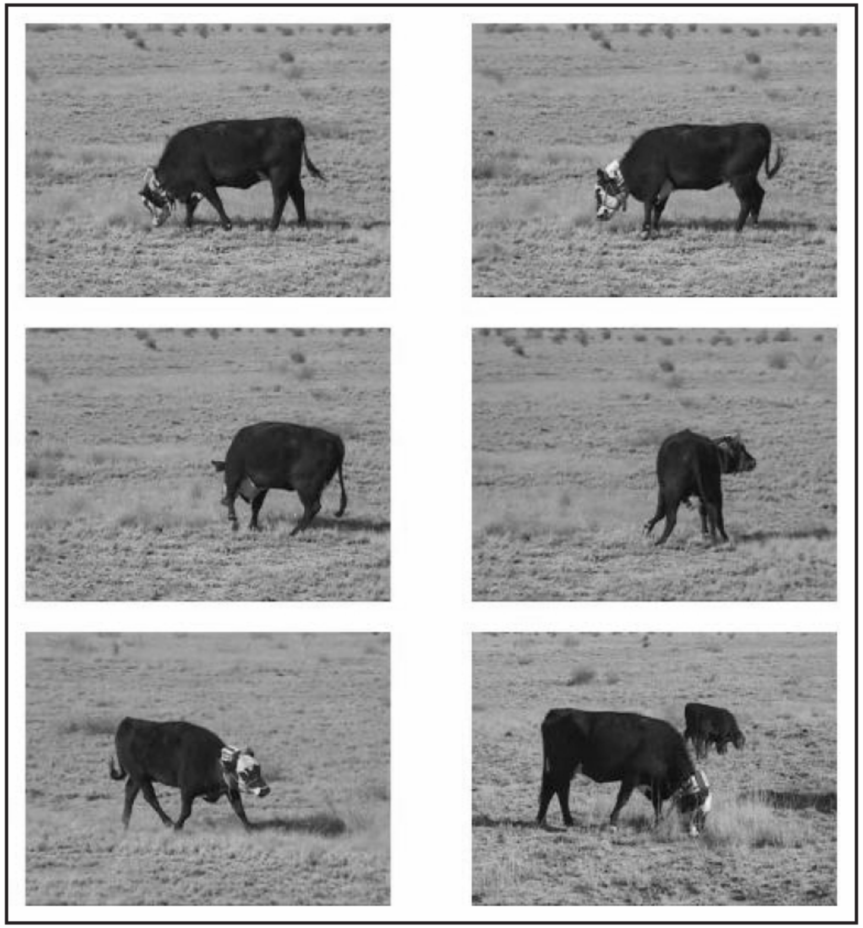
Fig. B Cow's location during 103.8 hours (June 26 1009 hrs to June 28, 2002 1111 hrs and June 28 1312 hrs to July 01, 2002 1955 hrs) when cues were turned on (Cuing).

Fig. C Cow's location for 74.3 hours (July 5 0911 hrs to July 8, 2002 1137 hrs) after cues were turned off (Post-cuing).

http://www.ars.usda.gov/Main/docs.htm?docid=5564&pf=1&cg_id=0

Directional Virtual Fencing (DVF)

Sequential photos documenting the response of a foraging cow to bilateral cuing from a virtual fence device housed in the neck-saddle. The cow initially grazing south is stimulated on its left side, it turns north (right) and walks away from the cue and subsequently re-establishes grazing in a northerly direction in the presence of two calves.



VIRTUAL FENCING - A PRESCRIPTION RANGE ANIMAL MANAGEMENT TOOL FOR THE 21ST CENTURY
D. M. Anderson, USDA, Agricultural Research Service, Jornada Experimental Range; NMSU; Las Cruces, NM, U.S.A.

Directional Virtual Fencing (DVF)

TECHNICAL DESCRIPTION

The main part of the GPS Plus collars is a powerful RISC CPU. 32 MBit non-volatile flash memory is used to store up to 100.0000 complete data sets (time, latitude, longitude, height, navigation status, number of satellites used, etc.). Additionally the signal of a two-axis tilt sensor and the temperature of the collar are sampled continuously and the cumulative value is stored at five minutes intervals, during the lifetime of the collar, in the flash memory (for a maximum of 3.5 years).

The flexible Hard- and Software design allows the use of 8 / 12 or 16-channel GPS receiver. Due to the in-circuit programming capability of the CPU, software changes can be made easily. Numerous serial communication and analogue/digital interfaces can be used to connect different types of external sensors or additional communication devices.

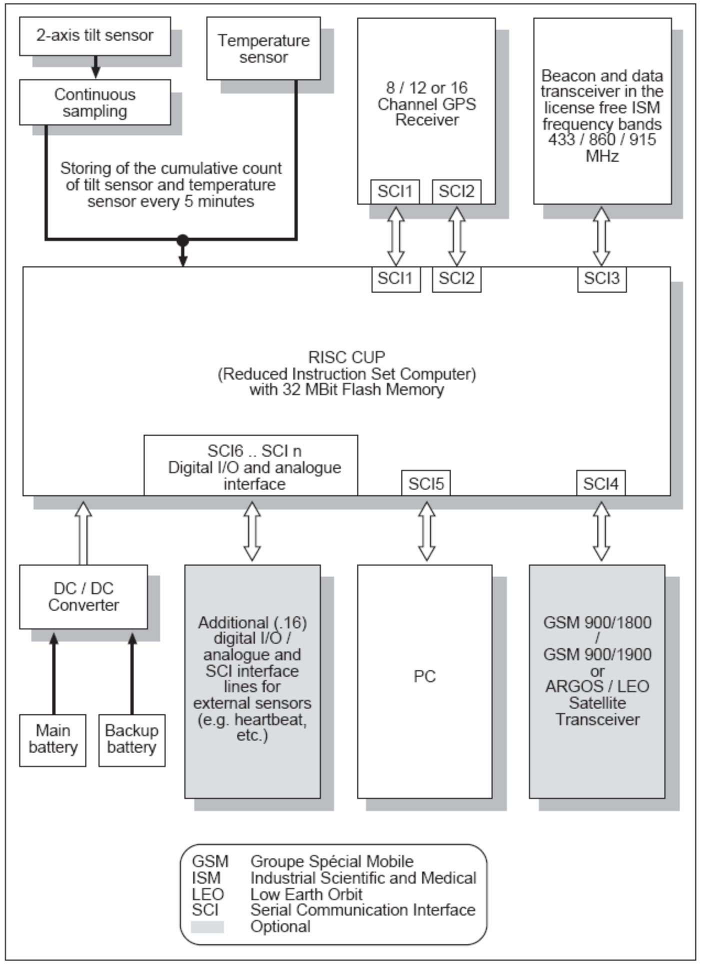


Diagram of the GPS Plus Collar

HIGH PERFORMANCE GPS COLLARS, USE OF THE LATEST AVAILABLE TECHNOLOGY

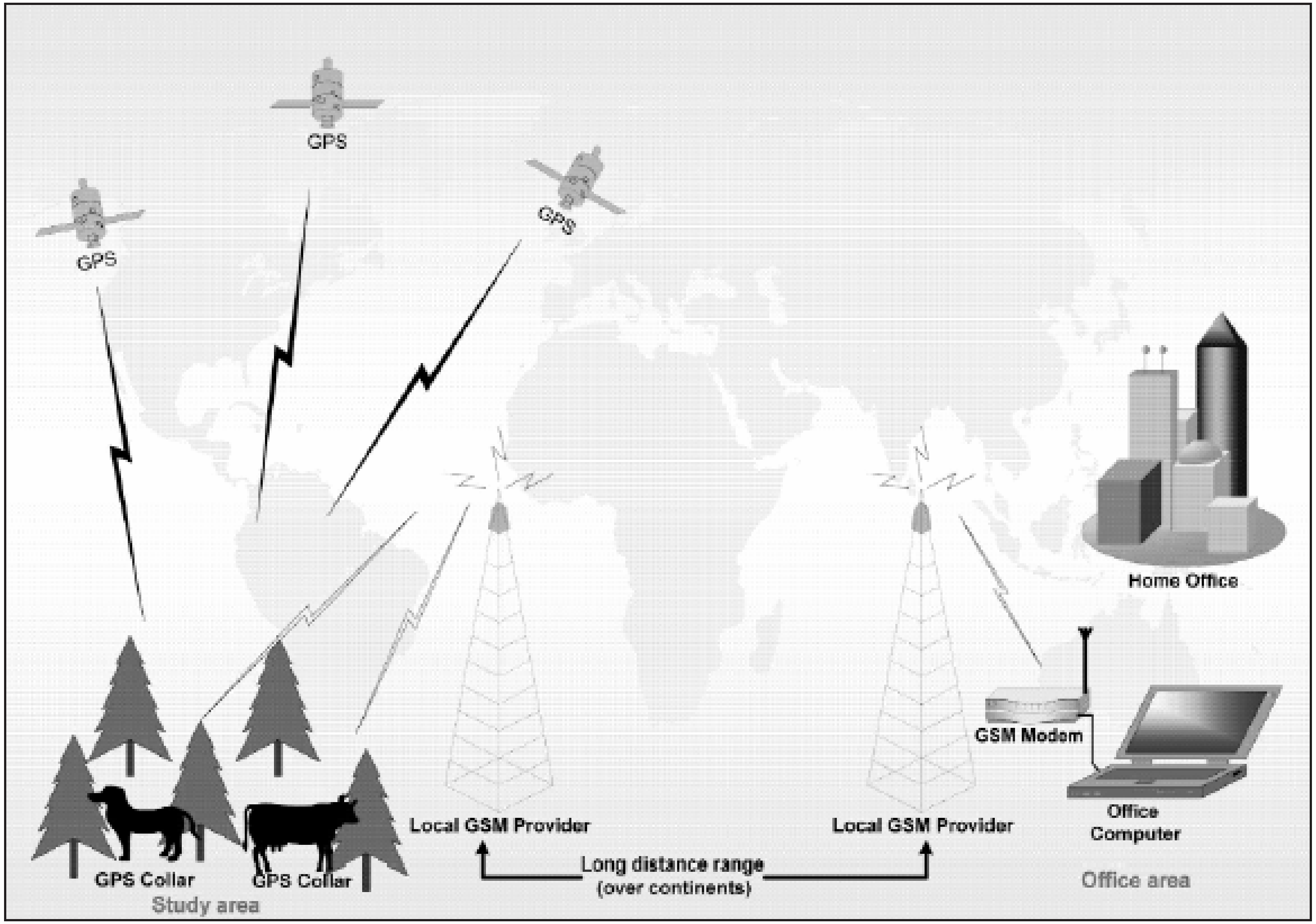
Robert Schulte[1] and Ulrich Fielitz[2]
[1] VECTRONIC Aerospace GmbH, Carl-Scheele-Str. 12, D-12489 Berlin, Germany
[2] Environmental Studies, Am Herberhäuser Weinberge 23, D-37075 Göttingen, Germany

Directional Virtual Fencing (DVF)

The collars have the following features:

- Temperature and activity sensors as standard.
- Powerful combined beacon and data transmitter, with a range of more than 10 km (ground to ground).
- Fast data transmission to the ground station.
- Positions can be programmed by the input of the time and date, with no need to use timetables.
- Continuous logging and storing of temperature and activity information, at regular intervals of five minutes
- during the lifetime of the collar.
- More than 100,000 complete datasets, without DGPS information, can be stored in the onboard memory.
- Interface to GSM and satellite transceiver/transmitter.
- Low Weight: less than 500 g. for more than 3,700 positions (with an average Time to First Fix of 1 minute).
- Several different battery packs available.
- Battery pack replaceable by the user.

Directional Virtual Fencing (DVF)

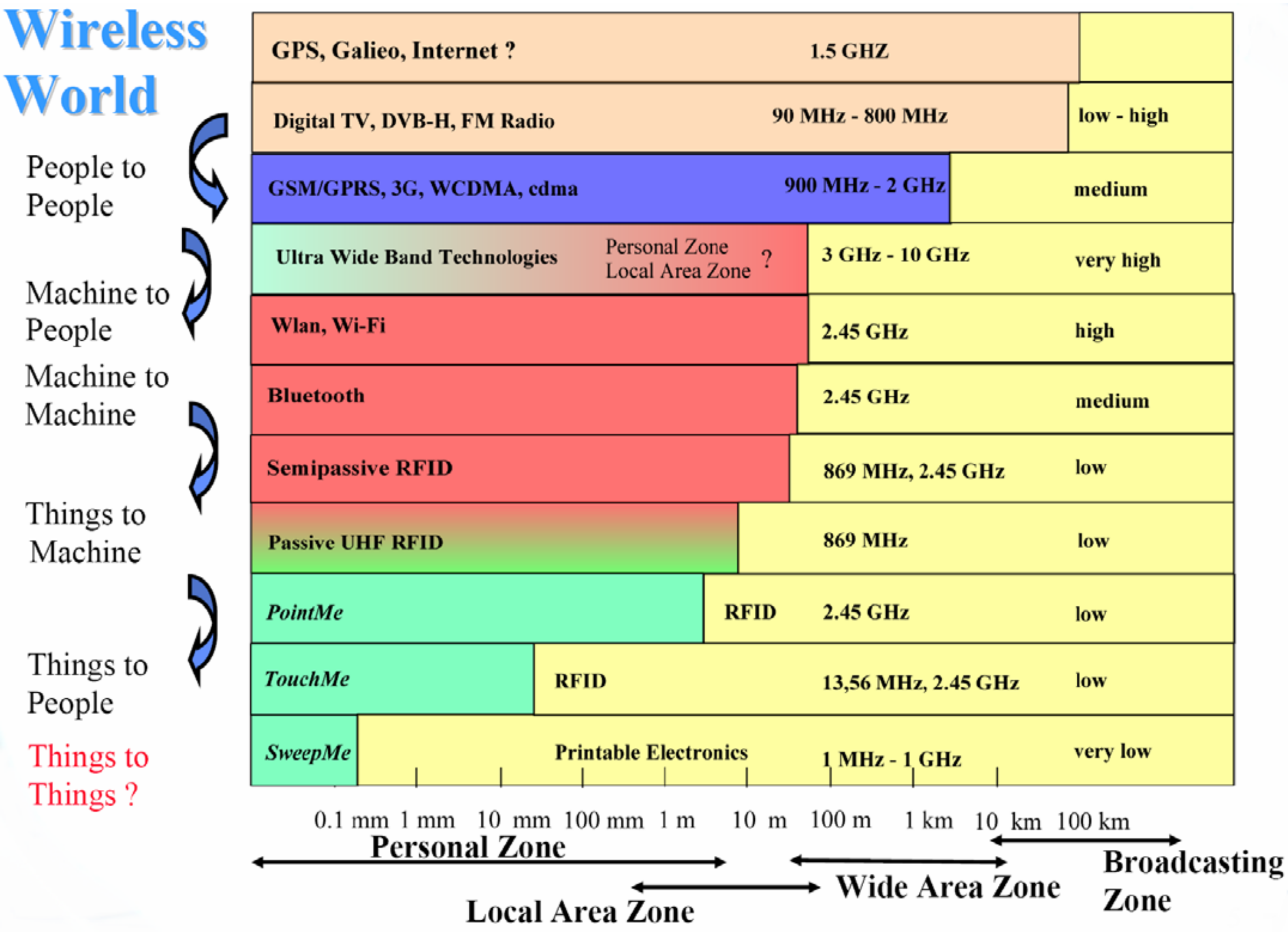


Transmission of GPS Data via GSM

RFID

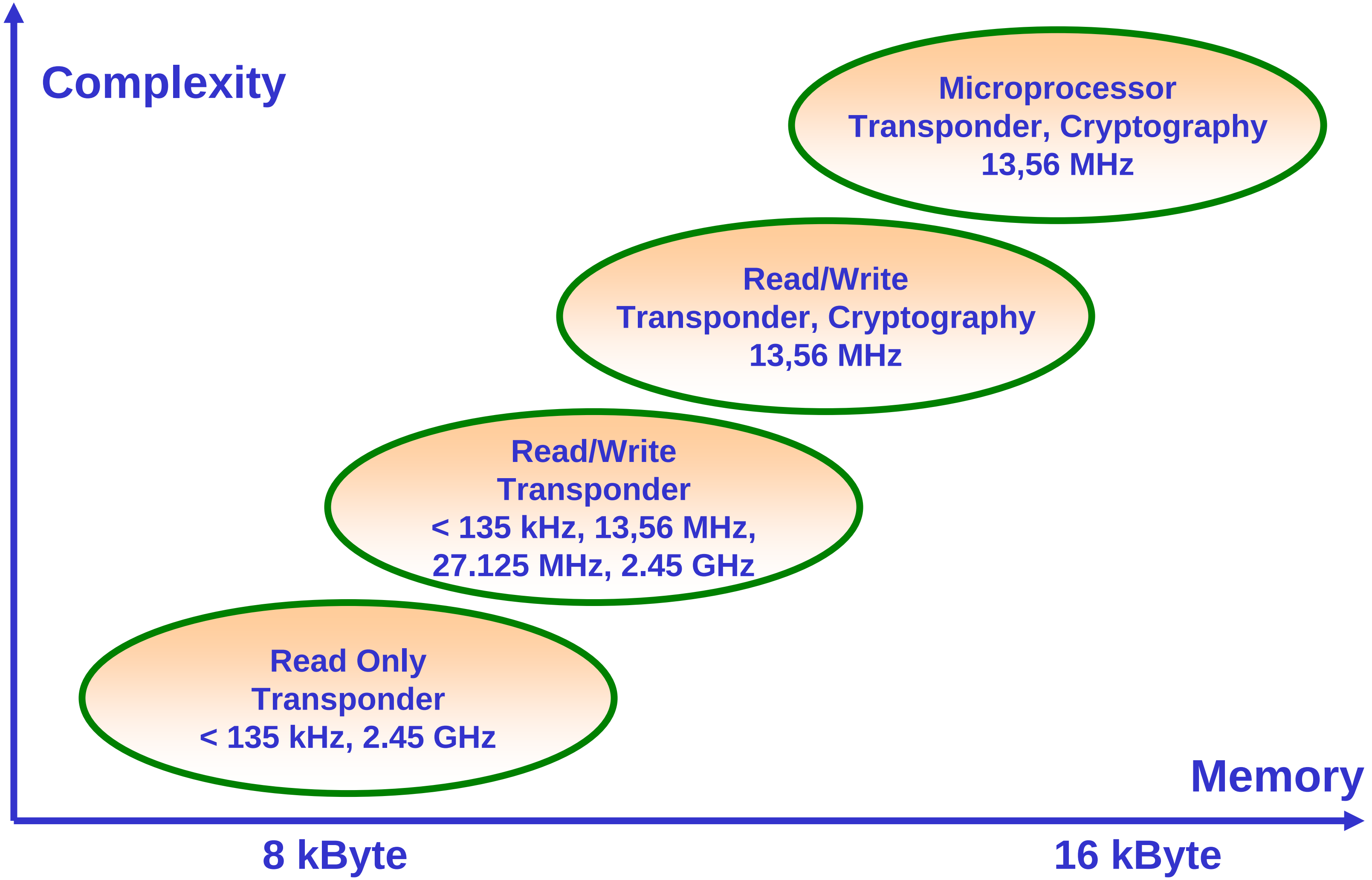
Radio Frequency Identification

RFID



Ref.:
Heikki Seppä, VTT Tietotekniikka:
Mikro Mikro- ja nanotekniikan ja nanotekniikan mahdollisuudet mahdollisuudet elektroniikassa elektroniikassa

RFID

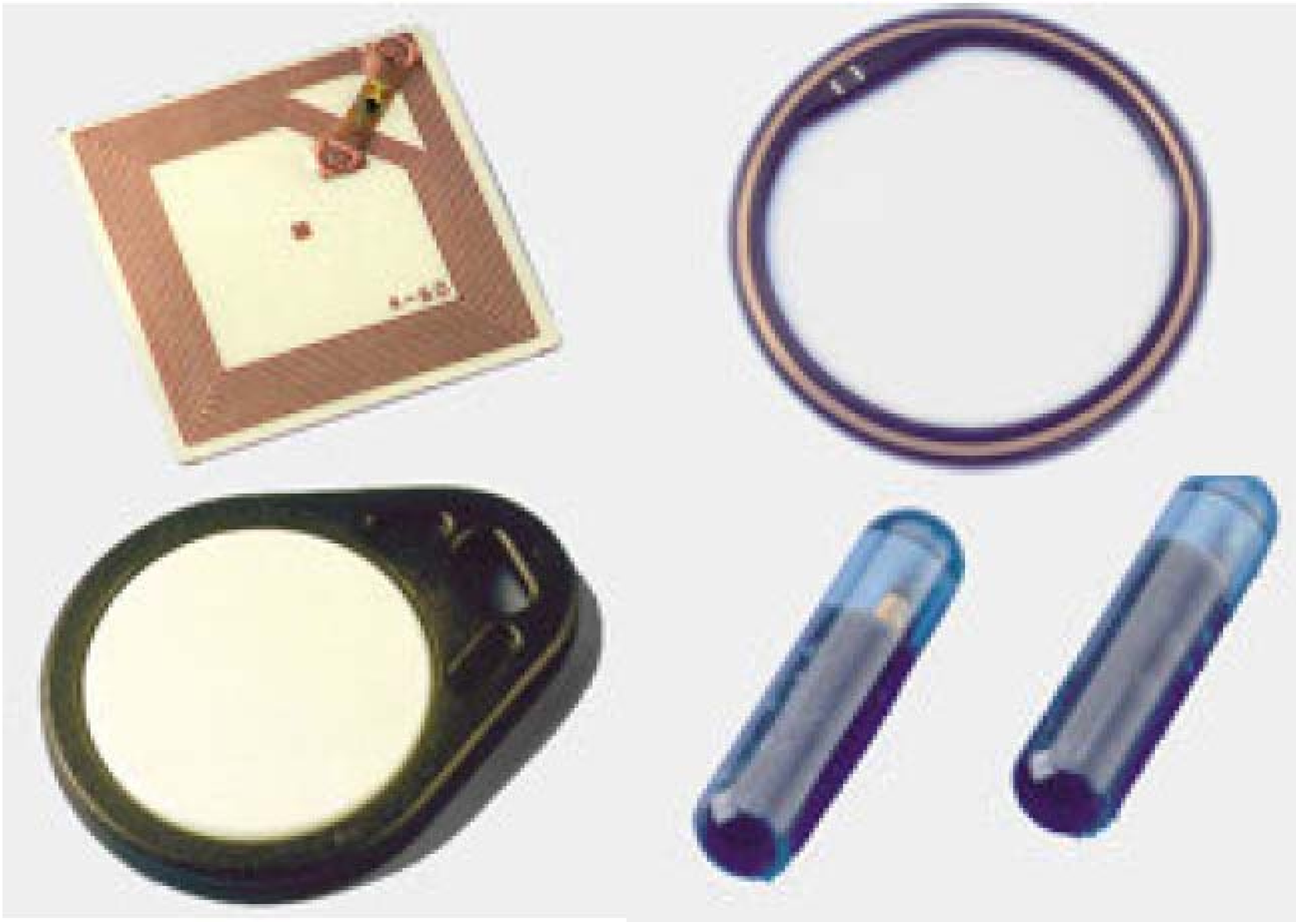

Complexity
Microprocessor
Transponder, Cryptography
13,56 MHz
Read/Write
Transponder, Cryptography
13,56 MHz
Read/Write
Transponder
< 135 kHz, 13,56 MHz,
27.125 MHz, 2.45 GHz
Read Only
Transponder
< 135 kHz, 2.45 GHz
Memory
8 kByte
16 kByte

RFID Models

Mfgr.	Type	Frequency	Read Range	Comments
Transponder Technologies Intellitag 500	Passive	915 MHz	**11 feet**	“Read range up to 3.5m (11.48 ft) using unlicensed 915 MHz reader with one antenna; read range up to 7m (22.96 ft) with two antennas"
Telenexus	Passive	915 MHz	**15 feet**	“Telenexus has developed a reader and antenna for the 915 MHz long-range RFID system...with a read range of over 15 feet. The tag is a low-cost passive transponder.”
Alien	Passive	915 MHz	**17 feet**	“The maximum freespace read range of these emulator tags is 5 meters, consistent with the performance of other known UHF passive tags.”
iPico	Passive	915 MHz	**66 feet USA licensed** **20-26 feet USA unlicensed** **3 – 7 feet EU**	Read range “depends on reader configuration and tag enclosure.30 W EIRP (USA site licensed):> 20m4 W EIRP (USA unlicensed): 6-8m500 mW ERP (Europe): 1-2m”
Matrics/Savi	Passive	unspecified	**33 feet**	“The first product to come from the collaboration will be a handheld device that reads Matrics' passive EPC tags…The unit will be able to read passive tags from up to 33 feet (10 meters) away”

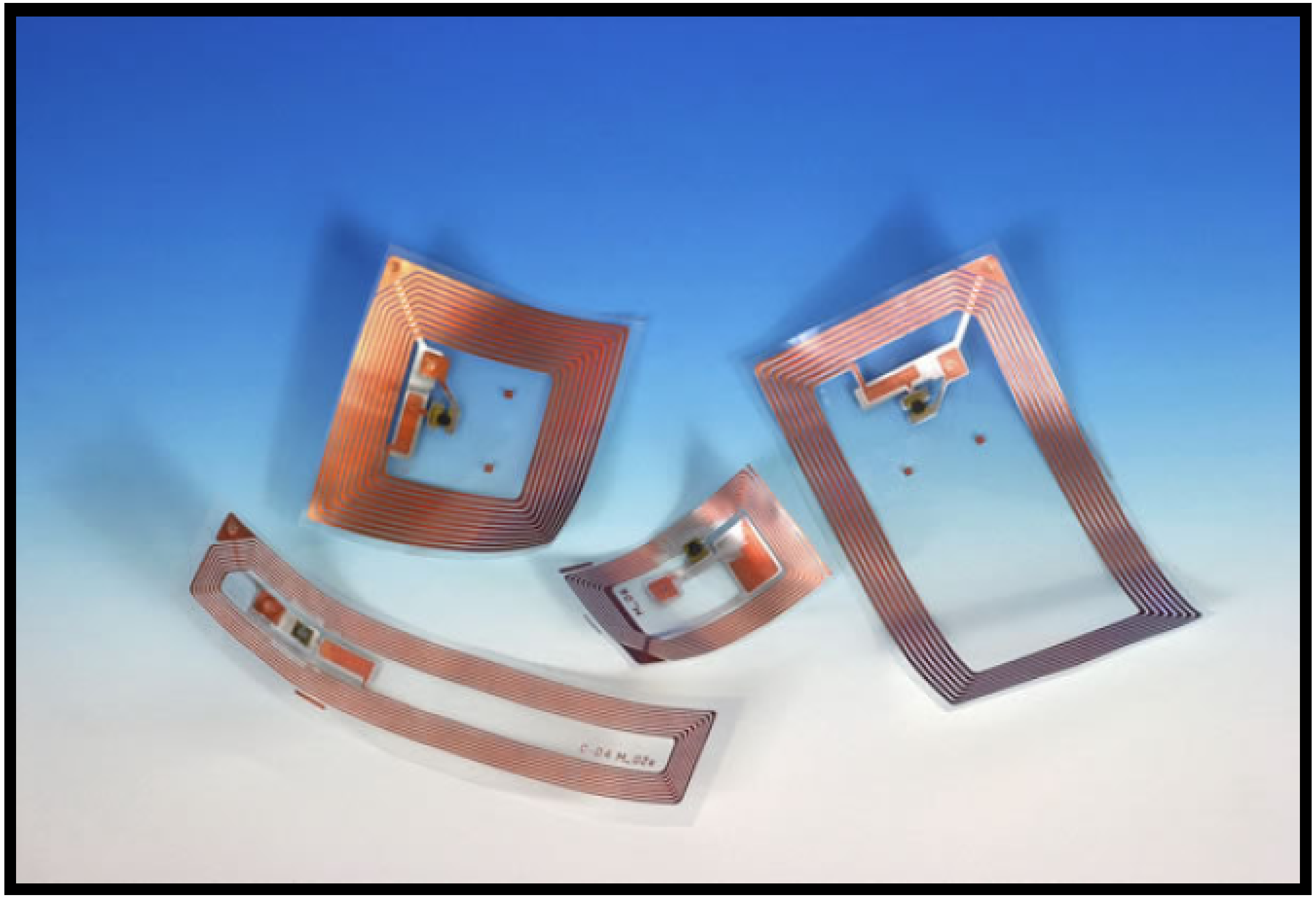
Ref.:
Michael Koch, FB Informatik, Universität Dortmund

RFID Construction



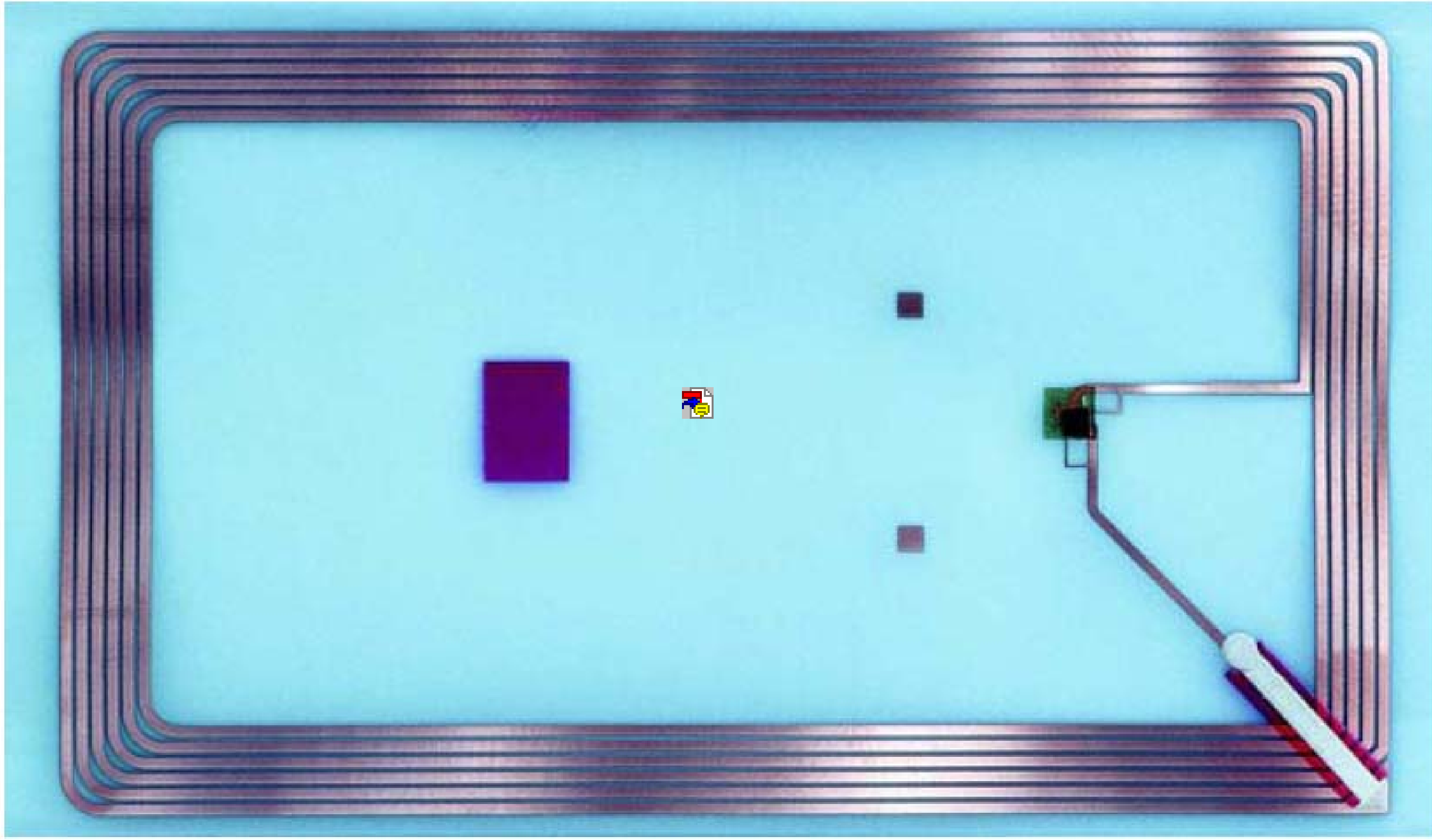
Ref.:
Joachim Klein, Technische Universität Kaiserslautern

RFID Construction



Ref.:
Scooter Willis, Sumi Helal - University of Florida
A Passive RFID Information Grid for Location and Proximity Sensing for the Blind User

RFID Construction

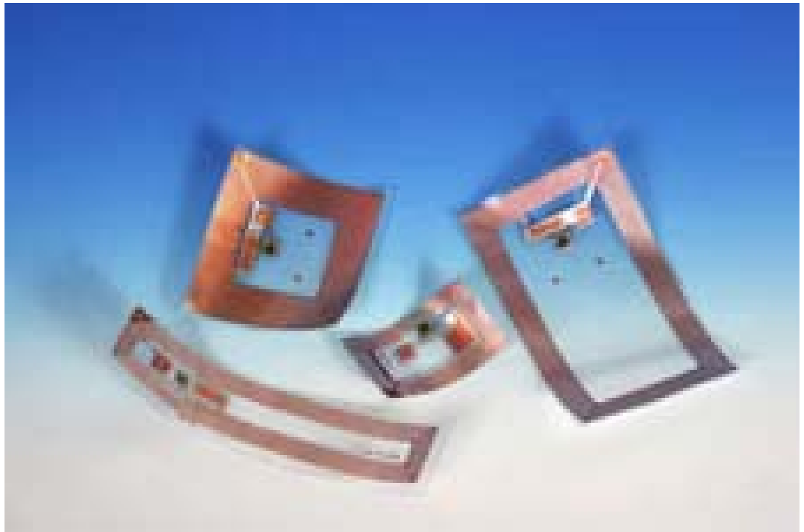


Inductive 13.46 MHz (Rafsec)

Ref.:
UPM Rafsec
http://www.rafsec.com

RFID – Transponder

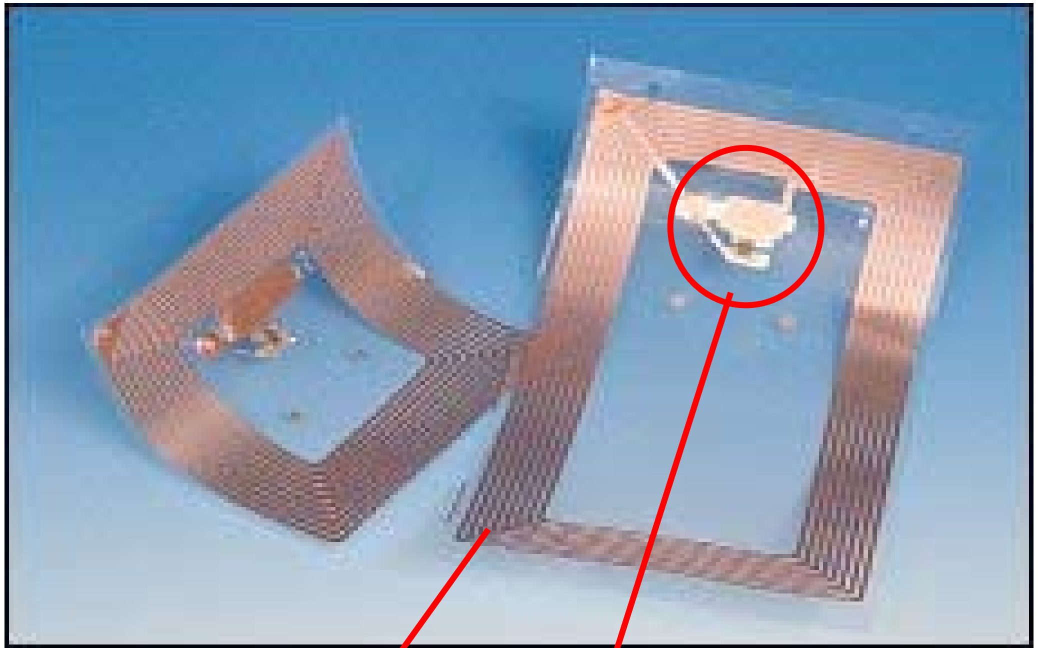
RI-I16-112A
Tag-it™ HF-I Inlay:
24mm Circular



RI-I02-112A, RI-I02-112B
Tag-it™ HF-I Inlays:
rectangle-large

Ref.:
http://www.rf-id.com/rfidtech.htm

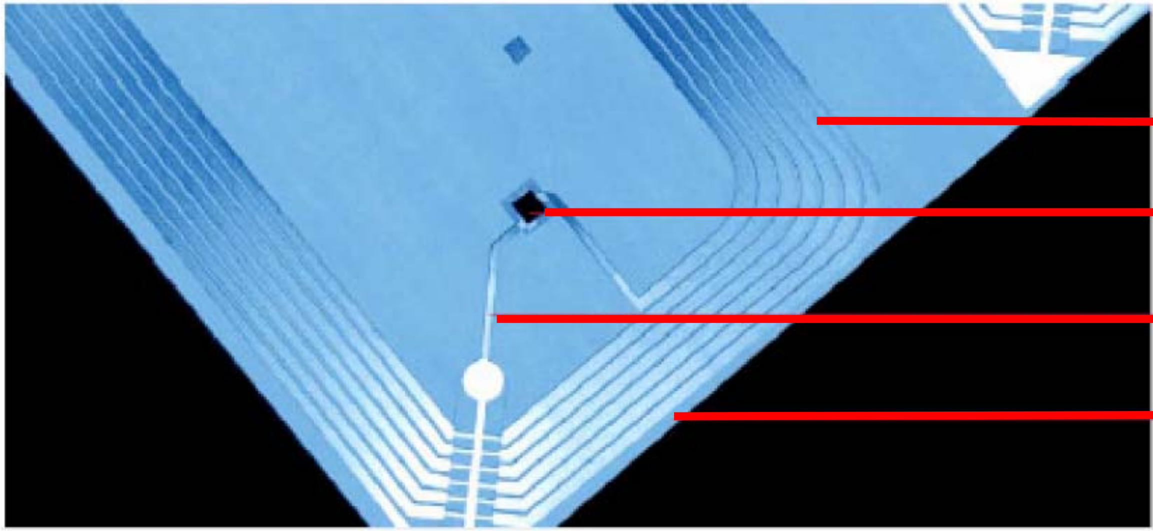
RFID – Transponder



Antenne   IC chip

Ref.:
Michael Koch, FB Informatik, Universität Dortmund

RFID – Transponder



Ref.:
Yann-Rudolf Michel, RFID-Technologie

VeriChip

Technology gets under clubbers' skin

(CNN) -- Queuing to get into one nightclub in Spain could soon be a thing of the past for regular customers thanks to a tiny computer chip implanted under their skin.

The technology, known as a VeriChip, also means nightclubbers can leave their cash and cards at home and buy drinks using a scanner. The bill can then be paid later.

The system is also designed to curb identity theft and prevent fraudulent access to credit card accounts that is increasingly common in crowded restaurants and clubs.

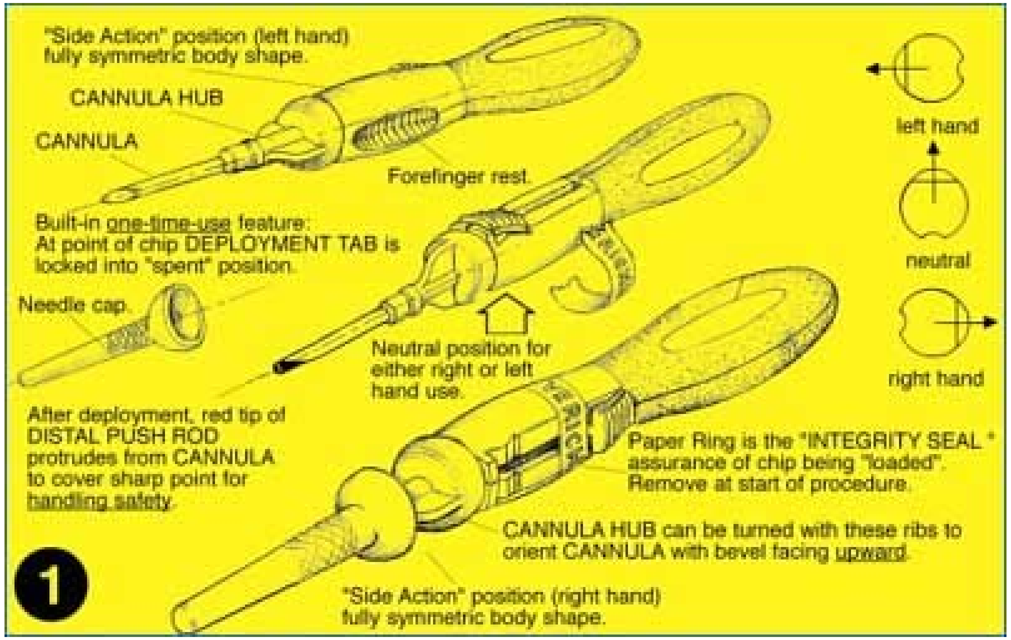
Clubbers who want to join the scheme at Baja Beach Club in Barcelona pay 125 euros for the VeriChip -- about the size of a grain of rice -- to be implanted in their body.

http://edition.cnn.com/2004/WORLD/europe/06/09/spain.club/

VeriChip

VERICHIP™

Insertion Procedure



http://edition.cnn.com/2004/WORLD/europe/06/09/spain.club/

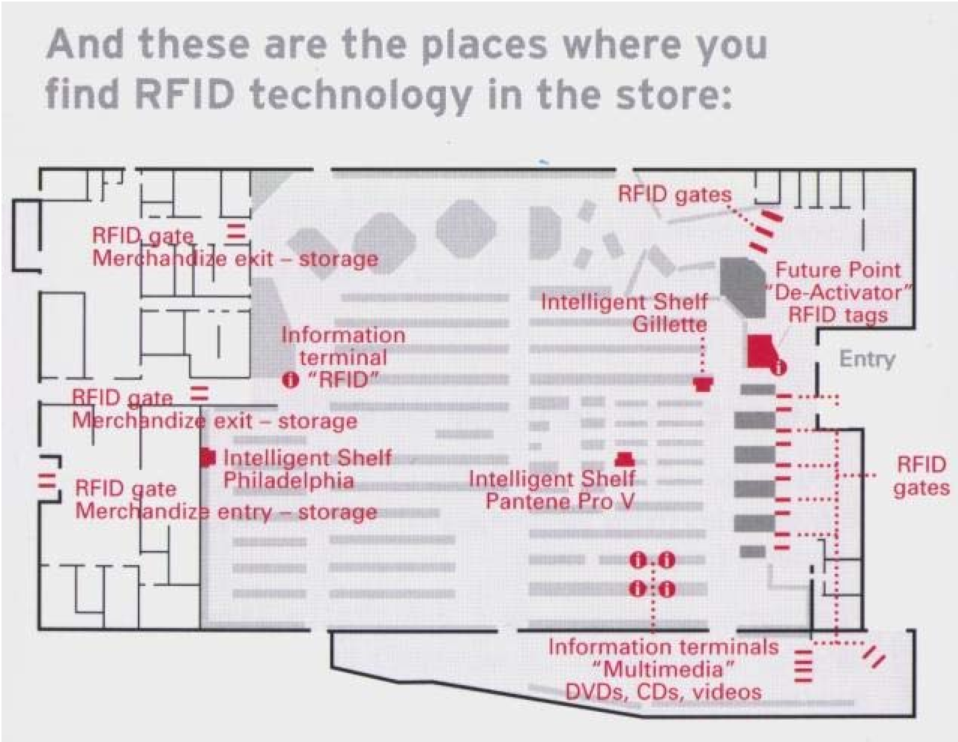
VeriChip

FDA approves computer chip for humans. Devices could help doctors with stored medical information.
The VeriChip, the size of a grain of rice, is inserted under the skin with a needle in a procedure that takes less than 20 minutes to complete.

http://slate.msn.com/id/2109477/

http://msnbc.msn.com/id/6237364/

RFID Applications in the Store:
The METRO "Future Store"



Ref.:
http://www.spychips.com/metro/albrecht-tour-4.html

Problem:
Privacy Invasion and Numbering

Reaction

peRFIDe:
perfidy

RSA SECURITY

Killer app or privacy poison?

Depending on your perspective, Radio-Frequency Identification (RFID) technology is either a dream come true or your worst nightmare.

Ref.:
http://www.rsasecurity.com

Ref.:
http://www.spychips.com/metro/albrecht-tour-4.html

RFID Applications

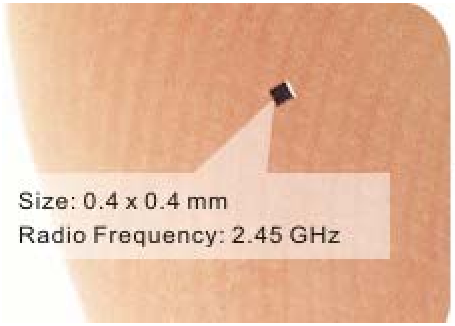
RFID operates in multiple frequency ranges, including low (125 KHz), high (13.56 MHz) and UHF (868 MHz to 954 MHz). The second-generation UHF standard is getting a lot of attention because UHF is considered most suitable for warehouse environments, where many early adopters of RFID in the supply chain are focusing their efforts.

RFID Mu-Chip

Hitachi

μ-Chip

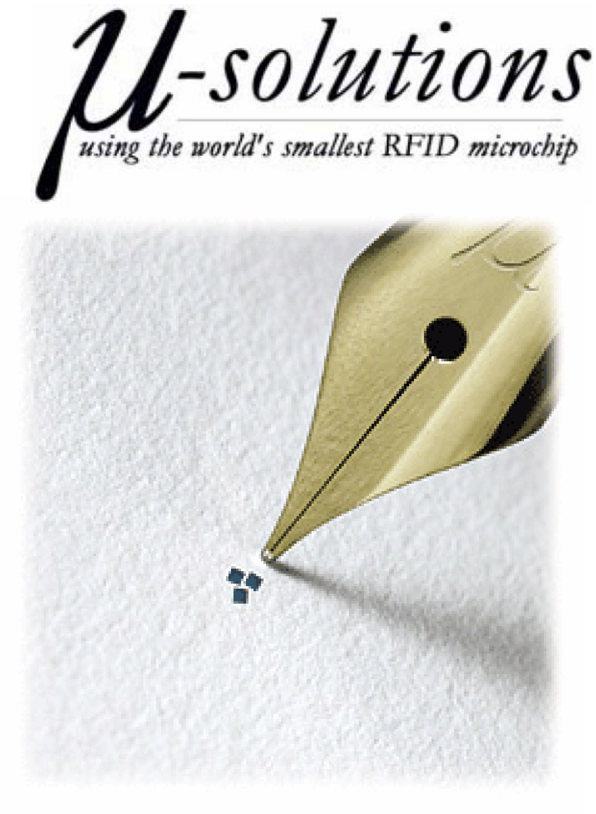
The World's Smallest RFID IC
(Radio Frequency Identification Integrated Circuit)
μ-chip



The μ-chip is Hitachi's response to resolving some of the issues associated with conventional RFID technology. The μ-chip uses the frequency of 2.45GHz. It has a 128-bit ROM for storing the ID with no write-read and no anti-collision capabilities. Its unique ID numbers can be used to individually identify trillions of trillions of objects with no duplication. Moreover with a size of 0.4mm square, the μ-chip is small enough to be attached to a variety of minute objects including embedding in paper.

Ref.:
http://www.hitachi.co.jp/Prod/mu-chip/

RFID Mu-Chip



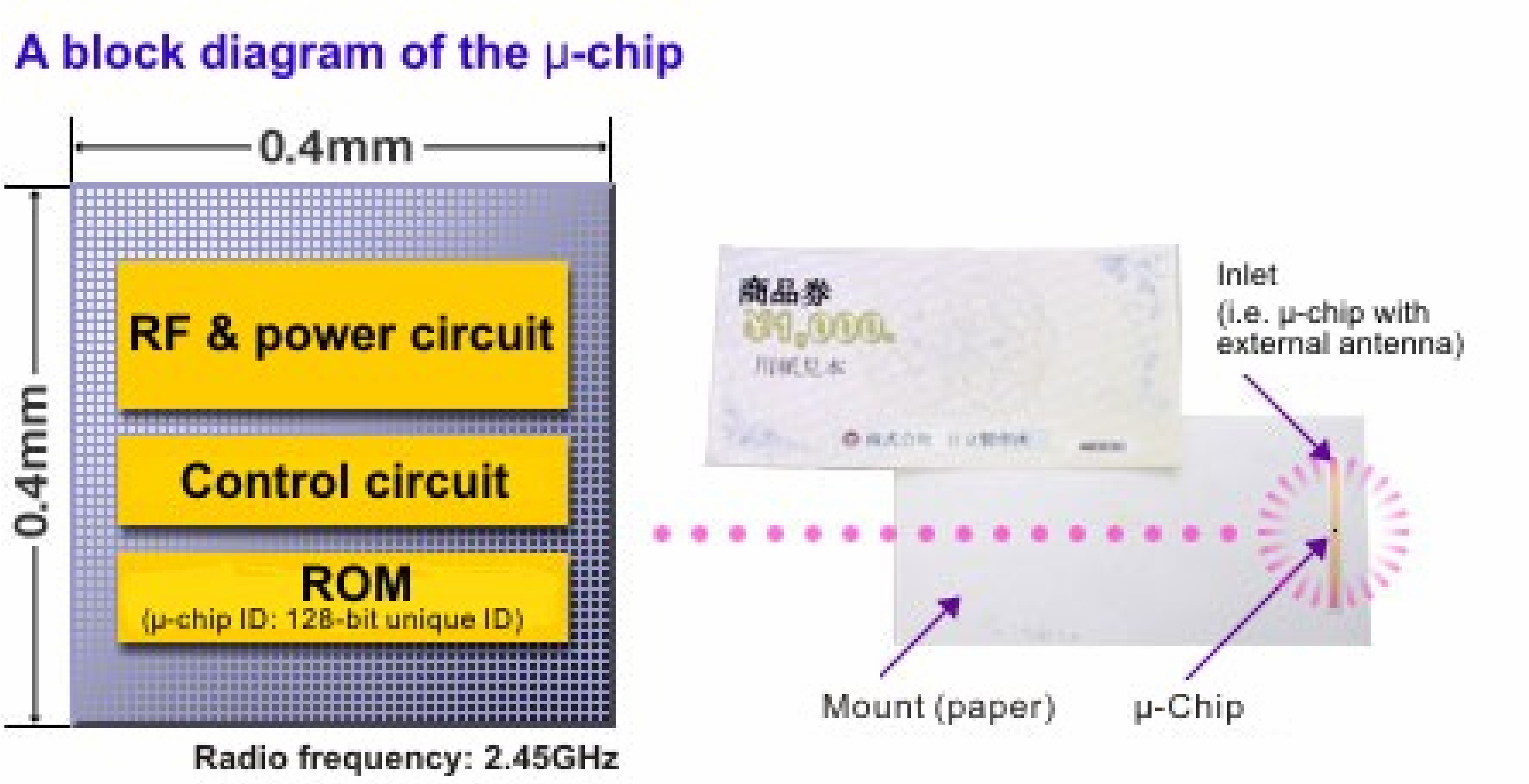
Ref.:
http://www.rfidjournal.com/article/view/337

RFID Mu-Chip

Parameter	Value
Carrier Frequency	2.45 GHz
Frequency Bandwidth	2.400 – 2.4835
Chip Size	0.4mm x 0.4mm
Chip Thickness	0.06mm – 0.15mm
Chip Technology	0.18 µm CMOS
Metallization	3 layer aluminium
Memory Capacity	128 bit
Data transfer rate	12.5 kbps
Minimum Operating Voltage	0.5V
Antenna Connection	Anisotropic Conductive film
Power Supply Method	Rectified Electromagnetic Energy
Clock Signal	100 KHz
Reading Distance	Up to 400mm according to reader power
ROM ID number format	• Header: 1 – 6 bits • Service id: 10 – 36 bits (according to class A – d) • Application Data: 62 – 88 bits (according to service id) • EDC Code: 24 bits
Modulation Style	ASK

Ref.:
http://www.hitachi.co.jp/Prod/mu-chip/

RFID Mu-Chip



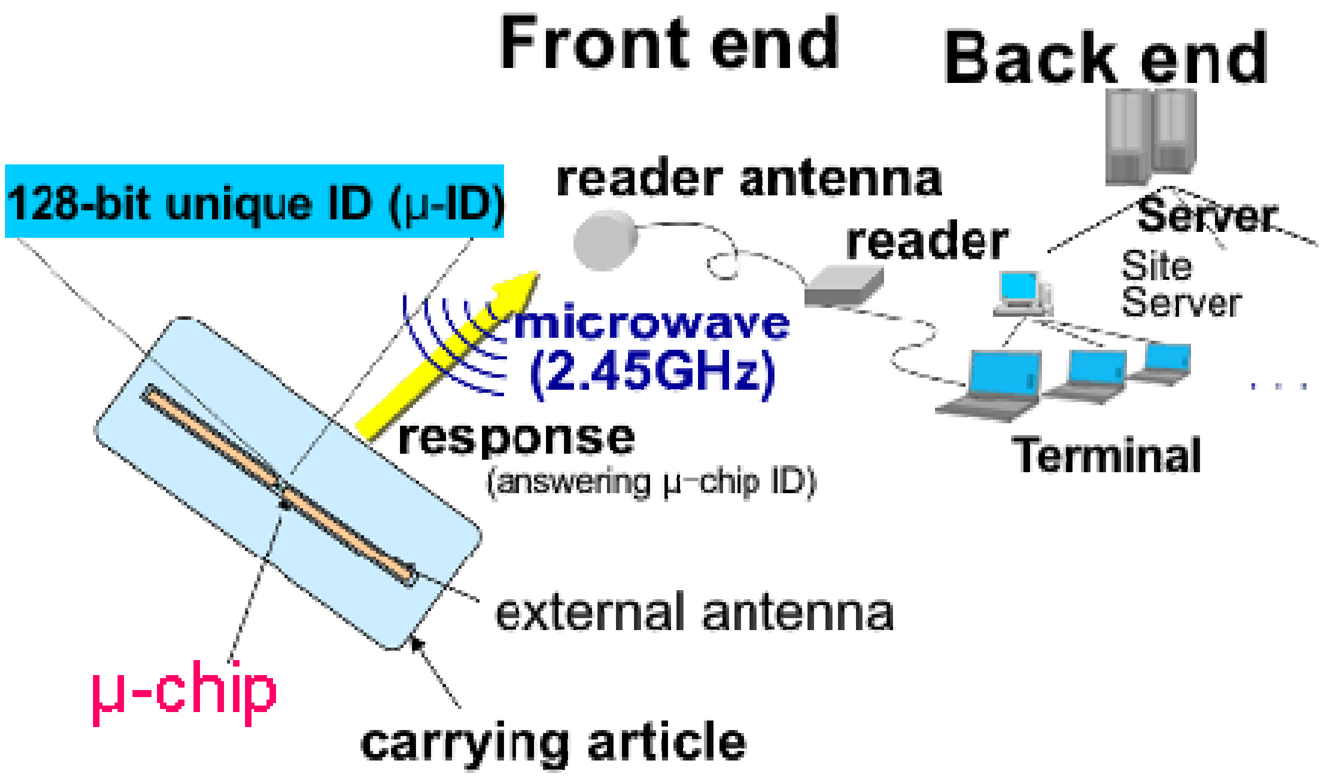
Ref.:
http://www.hitachi.co.jp/Prod/mu-chip/

Technical Description
Specifications of the μ-chip

- **Simple Mechanism: 128-bit read only memory, no anti-collision control**
- **Super-micro Chip: 0.4 mm x 0.4mm**
- **Battery Less: The μ-chip a passive IC, that receives the microwave from the reader, generates electric power from the microwave, decodes its μ-chip ID and transmits it back to the reader.**
- **Unique ID (μ-chip ID): Each μ-chip stores unique 128-bit data in its ROM as its ID, to distinguish it from the others.**
- **Radio Frequency: 2.45 GHz**
- **Maxmum Communication Length: about 25 cm (with an external antenna) (Reader: 300mW, 4 Pach Antenna, Circular Polarization)**
- **Response Time: 20msec**

Ref.:
http://www.hitachi.co.jp/Prod/mu-chip/

RFID Mu-Chip



Ref.:
http://www.hitachi.co.jp/Prod/mu-chip/

RFID Mu-Chip

Operations:

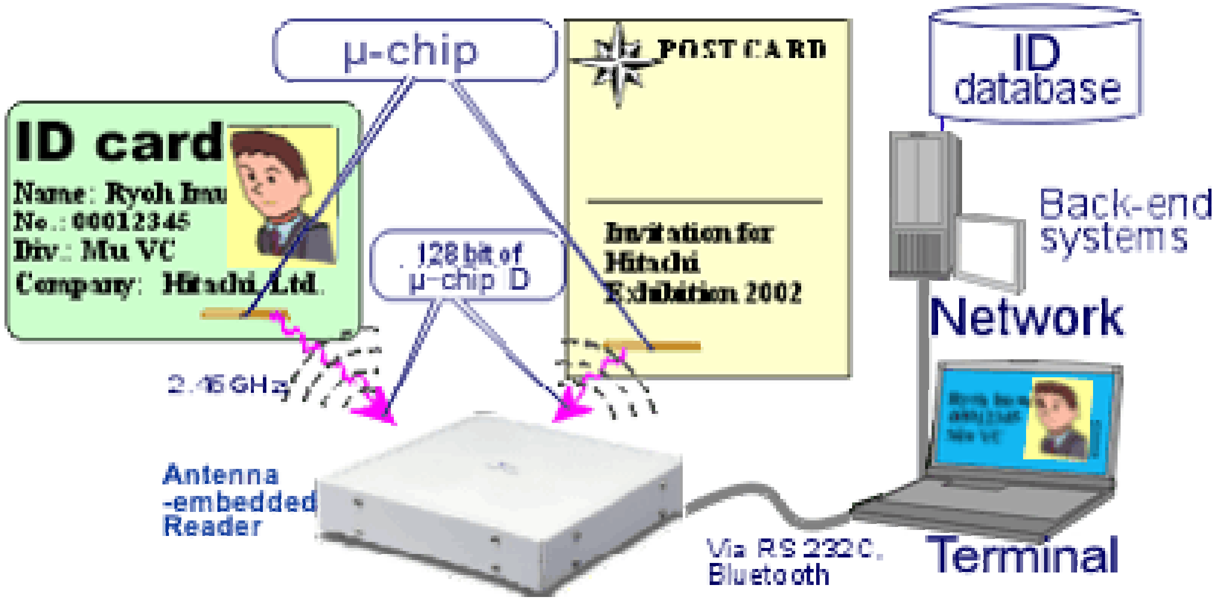
- **Interrogation: When the reader is activated by a terminal device (PC), it radiates microwave on to the µ-chip attached to a carrying article and the µ-chip returns its µ-chip ID to the reader. The carrying article may be a tag, a label or a customers products.**
- **Database Query: The terminal device authenticates the µ-chip ID and uses it to retrieve information from the database about the article carrying the µ-chip. The result of the query can be displayed on the terminal device or used by a software application.**
- **Database Construction: The database may be located at the site server or at the central server and stores attributes of the µ-chip carrying article. Information associated with the event of readout may be used to update the database.**
- **Linking: Linking each µ-chip ID to the carrying article is performed upon application of the µ-chip to it.**
  The attributes of the article at this point comprise the basic entry to the database. For efficient, automated linking process, consultation and engineering services are available.

Ref.:
http://www.hitachi.co.jp/Prod/mu-chip/

RFID Mu-Chip

Possible Applications: ID Management

- Secure access-permission card embedded with a µ-chip
- µ-chip embedded entrance ticket (invitation card) for an exhibit/event

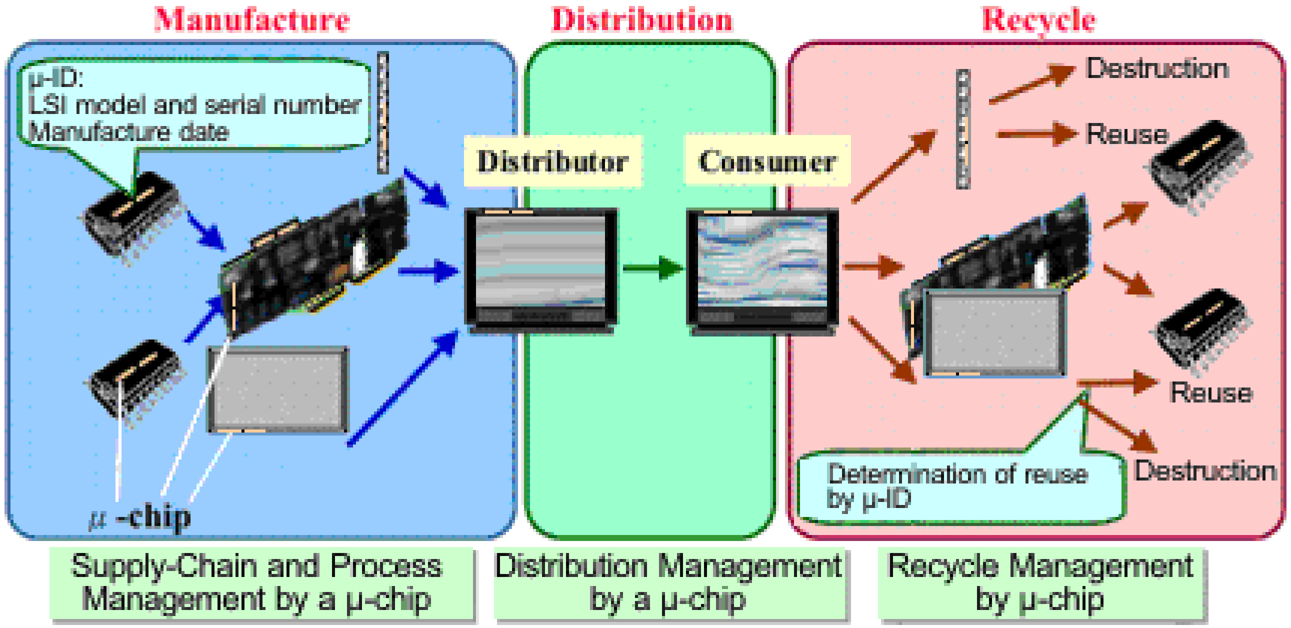


Ref.:
http://www.hitachi.co.jp/Prod/mu-chip/

RFID Mu-Chip

Possible Applications: Life Cycle

- Assigning unique µ-chip ID's to individual parts or products
- Using a database containing information about product stages from manufacturing and distribution to the recycling process
- Helping manage product lifecycle information



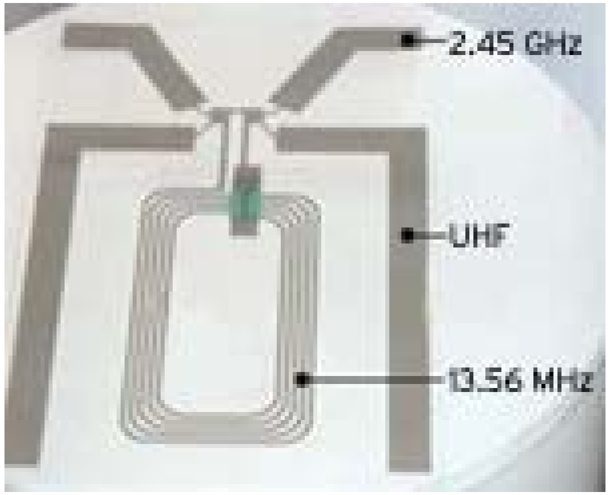
Ref.:
http://www.hitachi.co.jp/Prod/mu-chip/

RFID Toppan Forms

First Multifrequency Chip:

RFID microchip that can operate at all frequencies from 13.56 MHz to 2.45 GHz.

MM chip with three antennas



Toppan's MM chips

Ref.:
http://www.rfidjournal.com/article/articleview/831/1/1/
http://www.toppan-forms.com/

Personnel and Article Tagging

Ref.:
http://www.copytag.com/2001/active/apps-articles-1.html

Hidden Tags

Concern: Item-level tagging

Ref.:
SPYCHIPS: Laying the groundwork for pervasive consumer surveillance
www.spychips.com

Hidden Tags

Ubiquitous readers

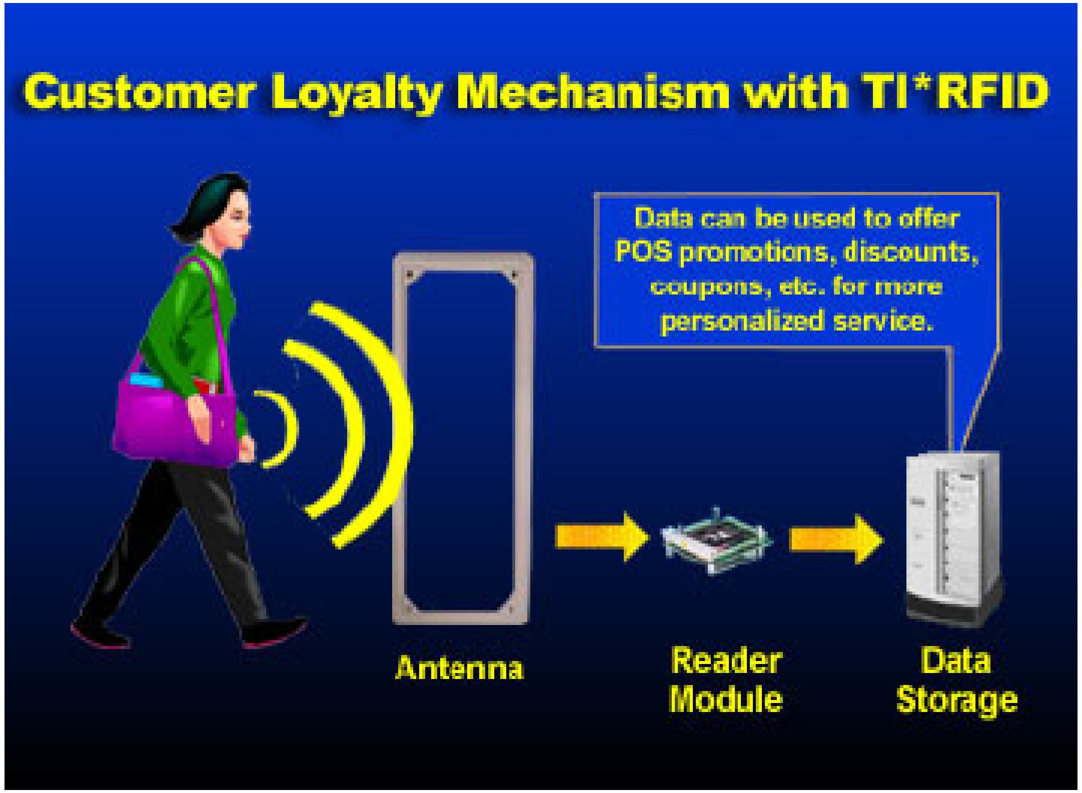
Reader devices can be invisibly embedded in:

- Walls
- Doorways
- Floor tiles
- Carpeting
- Floor mats
- Vehicles
- Roads
- Sidewalks
- Counters
- Shelving
- Furniture
- Consumer products
  - Printers
  - Copiers
  - Vacuum cleaner
- Handheld devices, e.g., cellphones, PDA's

Ref.:
SPYCHIPS: Laying the groundwork for pervasive consumer surveillance
www.spychips.com

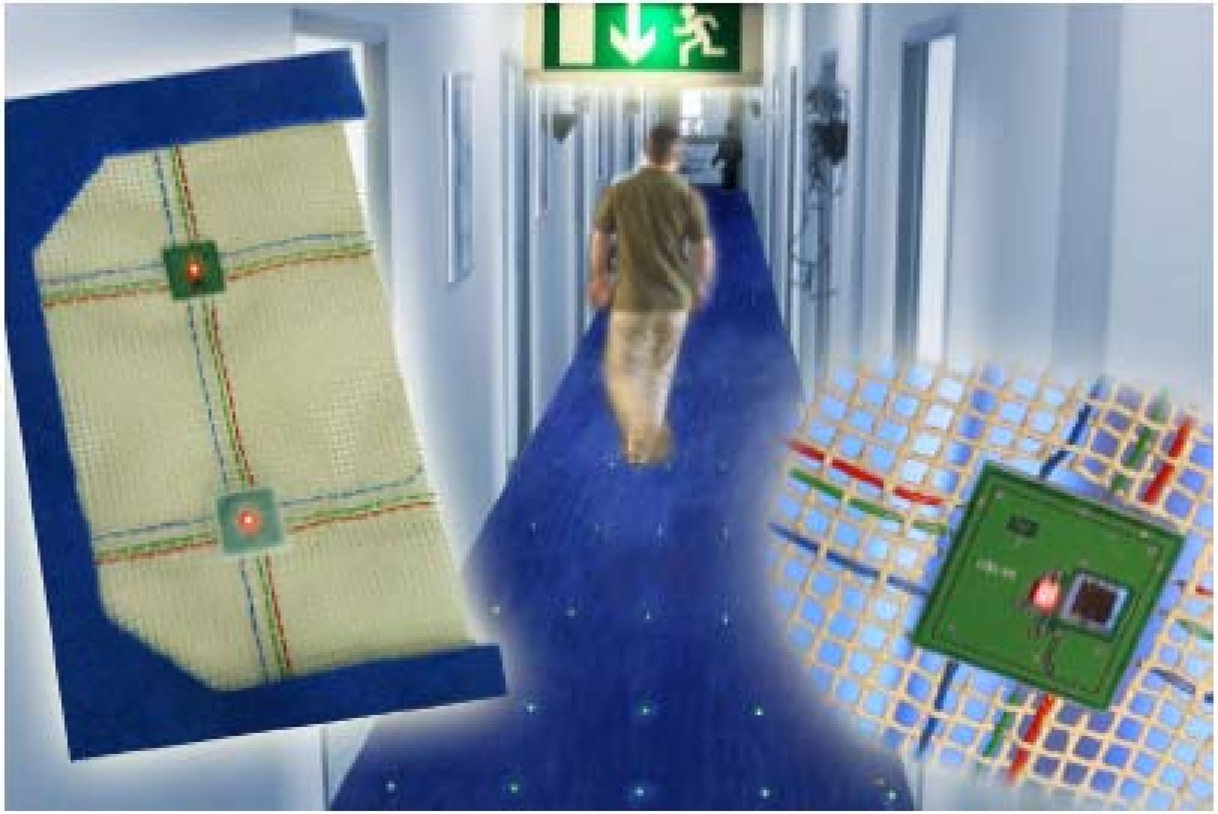
Hidden Tags

Ubiquitous readers



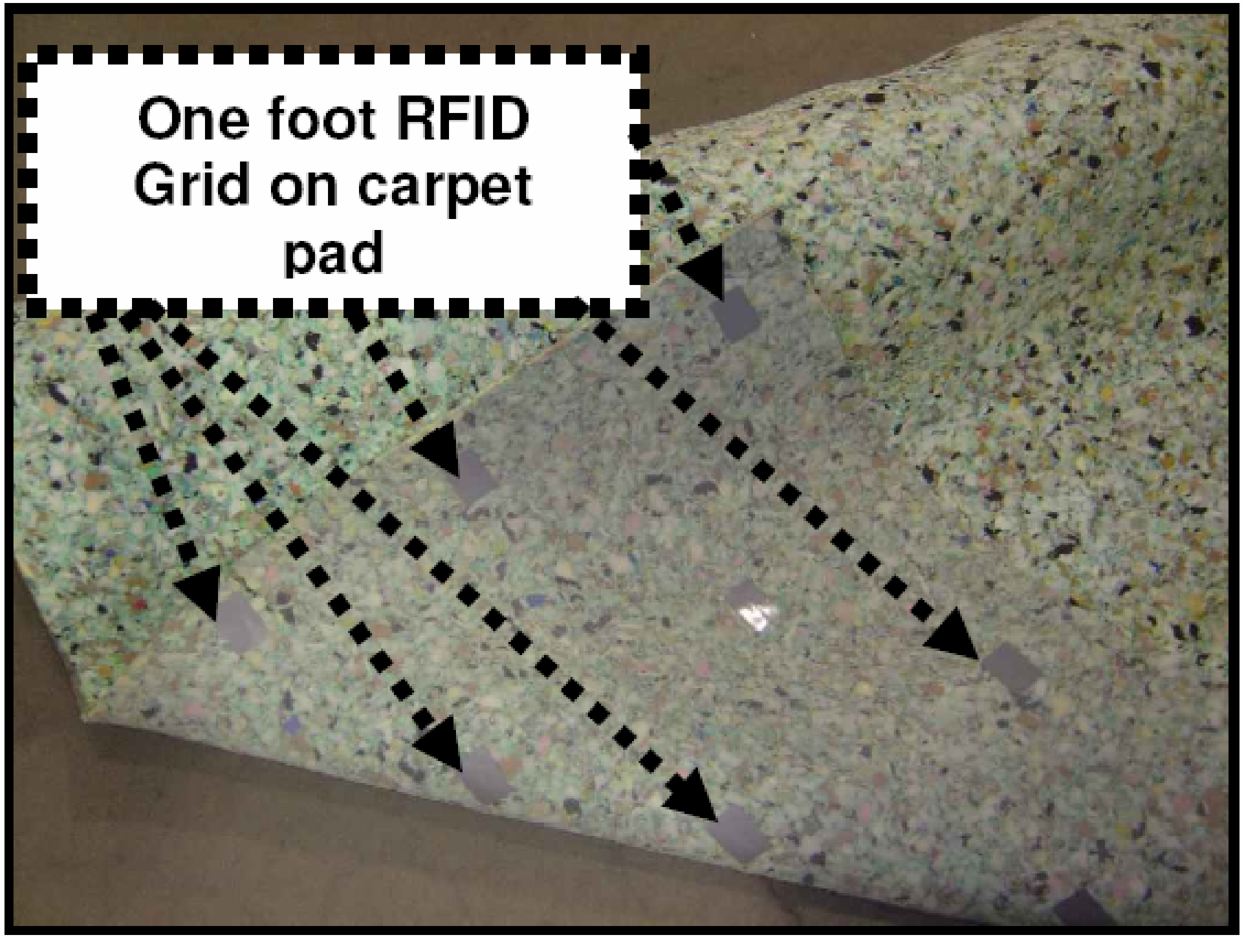
Ref.:
SPYCHIPS: Laying the groundwork for pervasive consumer surveillance
www.spychips.com

Ubiquitous readers – In Flooring



Ref.:
SPYCHIPS: Laying the groundwork for pervasive consumer surveillance
www.spychips.com

RFID Carpet

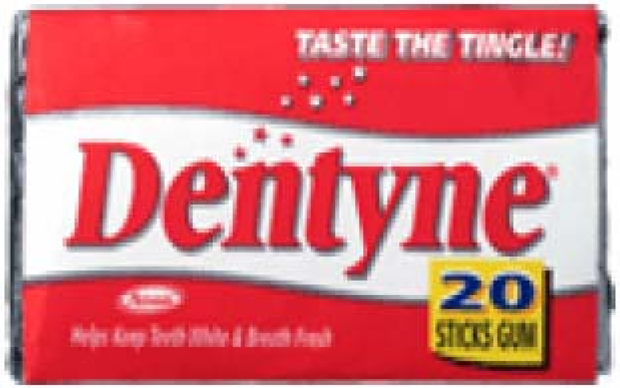


Ref.:
Scooter Willis, Sumi Helal - University of Florida
A Passive RFID Information Grid for Location and Proximity Sensing for the Blind User

Hidden Tags

"With these things you could literally tag a pack of chewing gum."

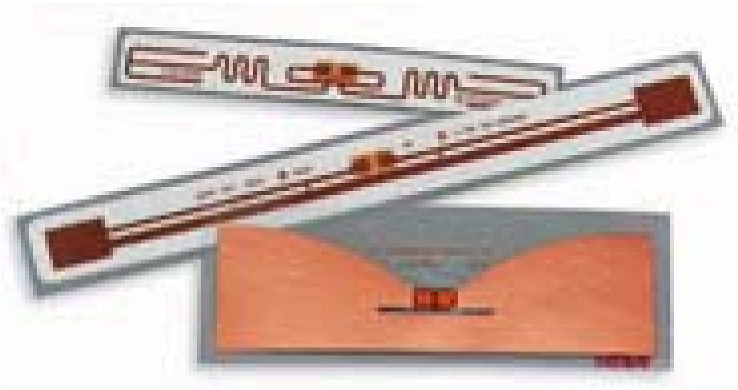
Jeff Jacobsen, Alien Technology



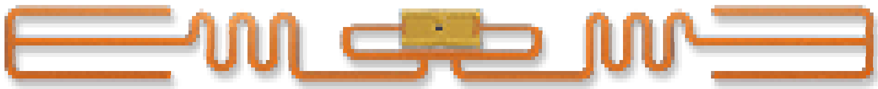
"Alien envisions [conductive] ink being mixed with regular packaging ink to create antennas on boxes of cereal and other disposable packaging."

Ref.:
SPYCHIPS: Laying the groundwork for pervasive consumer surveillance
www.spychips.com

Alien Technology



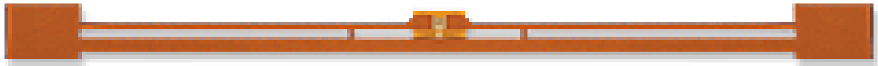
Alien Technology produces ultra-high frequency (UHF) tags as well as 2450 MHz (microwave) frequency tags (EPC - Electronic product code Class 1 hardware).



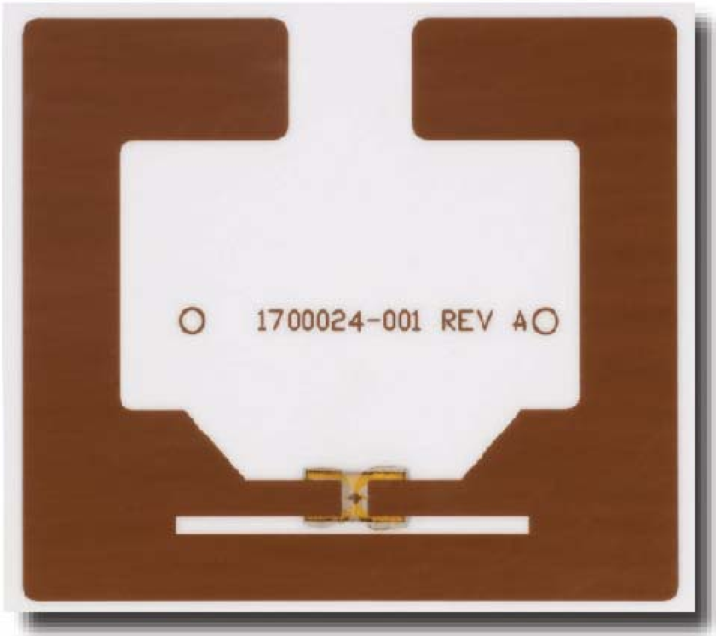
"Squiggle"™ antenna design Approximate Size: 95mm x 10mm Small UHF form factor Very low cost UHF tag Low-cost 4x6 label solution

Ref.:
http://www.alientechnology.com

Alien Technology



"I2" antenna design Approximate Size: 134mm x 13mm High gain in a controlled orientation Excellent tag for controlled environment



Alien "2 x 2" tag Small form factor for labels as small as 2 inches x 2 inches Low cost "RFID Label" solution for DSD & airline baggage tags 96-bits

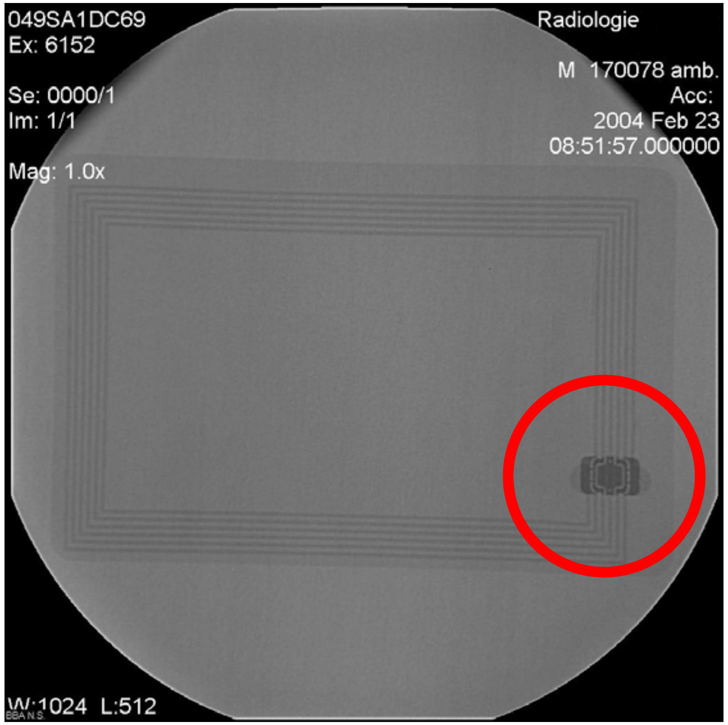
Ref.:
http://www.alientechnology.com

Hidden Tags

Tags hidden in loyalty card:

METRO's Payback loyalty card

FoeBuD
"Verein zur Förderung des öffentlichen bewegten und unbewegten Datenverkehrs e.V."



X-ray shows hidden RFDI-chip

Ref.:
SPYCHIPS: Laying the groundwork for pervasive consumer surveillance
www.spychips.com

Future Store

METRO Group

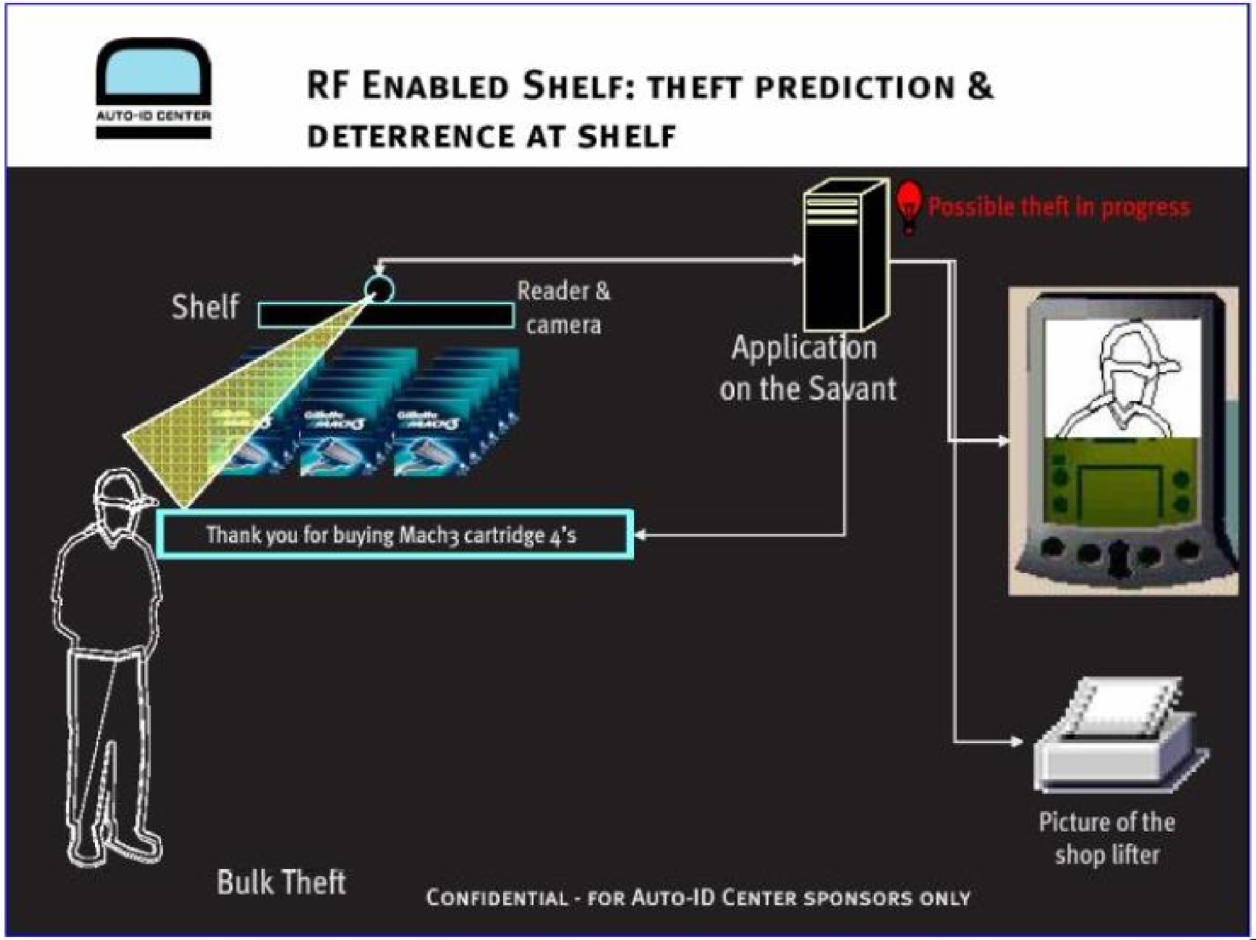
The Spirit of Commerce

Like they did at the "Future Store"

The RFID industry's flagship "Future" store had hidden RFID tags in its loyalty cards. For details of how CASPIAN uncovered the scandal and rocked Germany, see: http://www.spychips.com/metro/scandal-payback.html

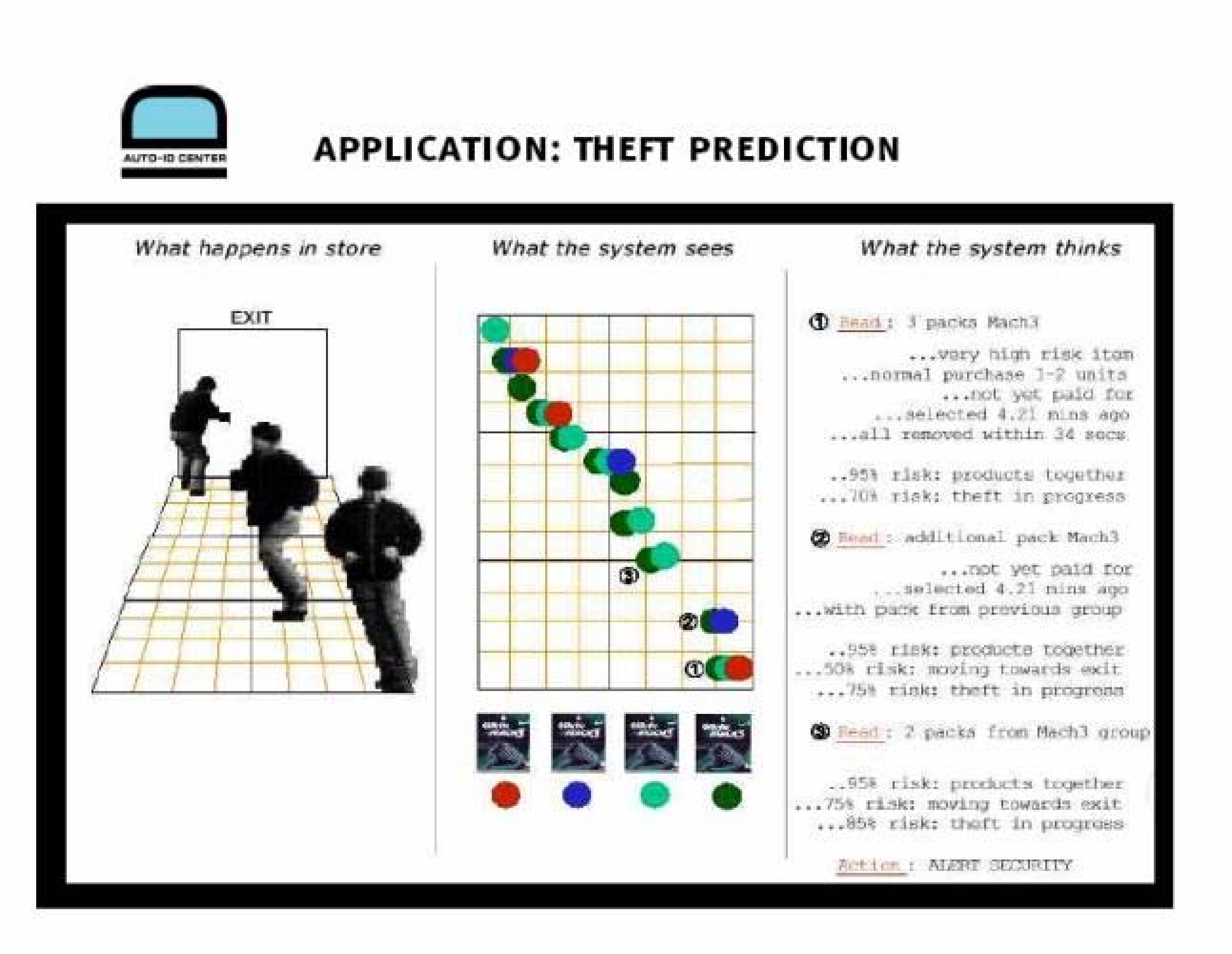
Ref.:
SPYCHIPS: Laying the groundwork for pervasive consumer surveillance
www.spychips.com

Theft Prediction



Ref.:
SPYCHIPS: Laying the groundwork for pervasive consumer surveillance
www.spychips.com

Theft Prediction



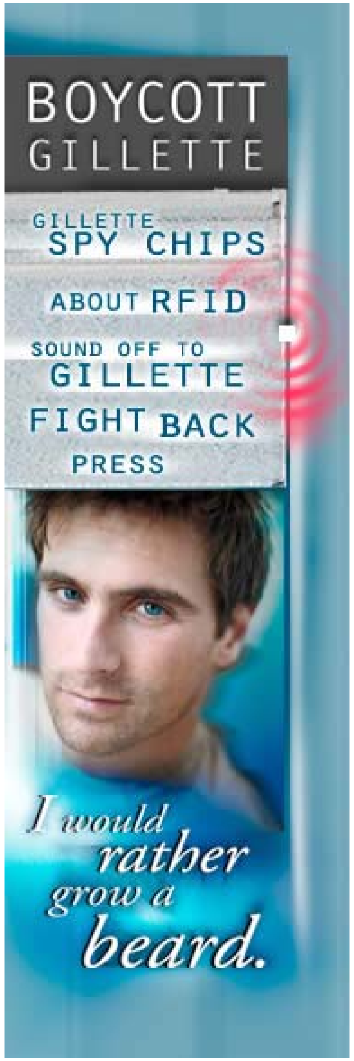
Ref.:
http://www.boycottgillette.com/evidence/evidence2.html

Tesco tests spy chip technology

Tesco Stores: Gillette Smart Shelf
A tracking system uses sensors hidden under Gillette shelves to detect when products are picked up.
Whenever a shopper picks up a packet of razor blades from a spy shelf, SNAP! A hidden camera secretly takes a closeup photo of the shopper's face. (And a second photo is snapped at the cash register to make sure the product is paid for!)

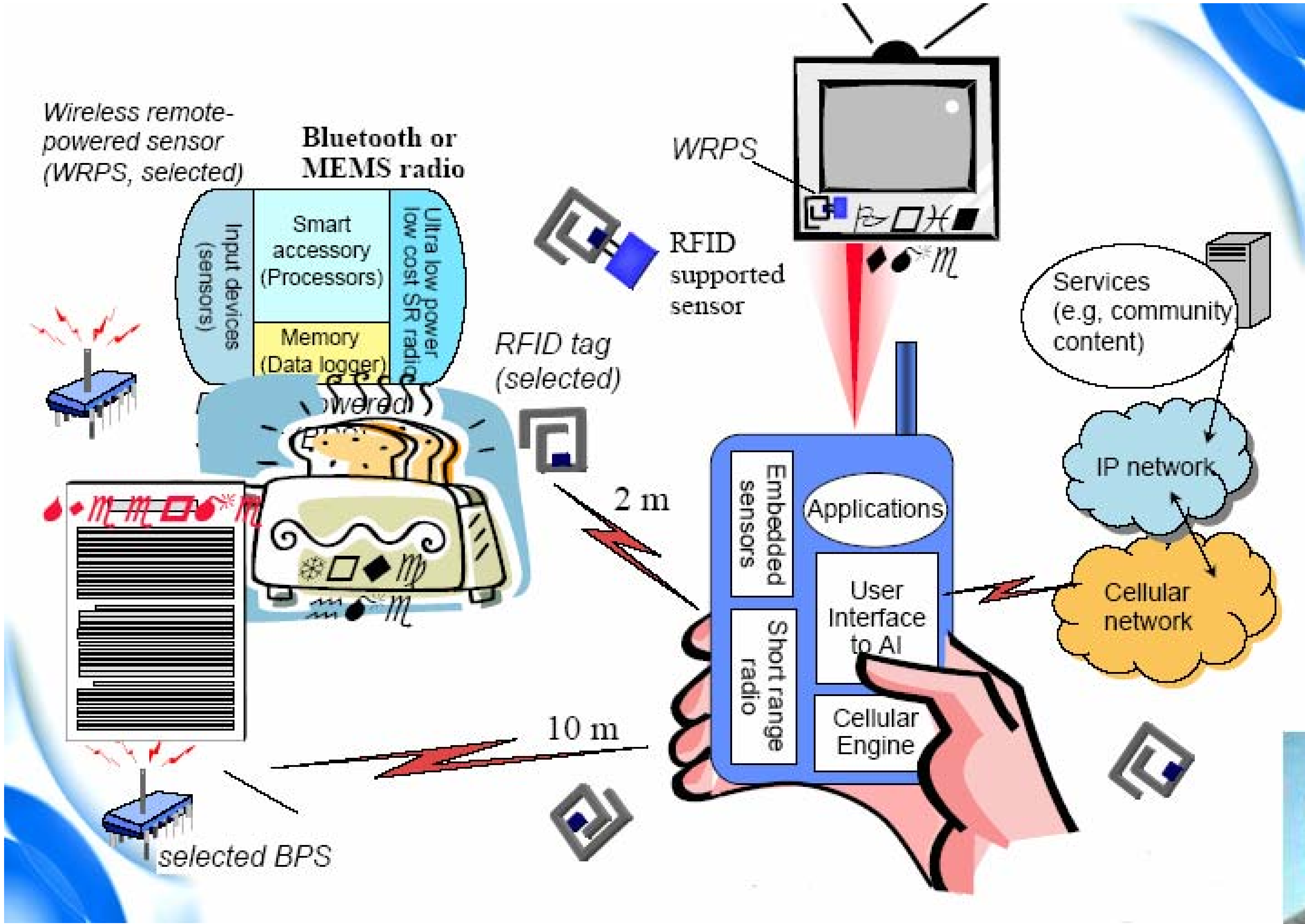
Ref.:
http://www.boycottgillette.com/spychips.html

Tesco tests spy chip technology



Ref.:
http://www.boycottgillette.com/spychips.html

Functional Environment



Ref.:
Heikki Seppä, VTT Information Technology

Final Words

Mark Weiser:
The Computer for the 21st Century

"Most important, ubiquitous computers will help overcome the problem of information overload.

There is more information available at our fingertips during a walk in the woods than in any computer system, yet people find a walk among trees relaxing and computers frustrating. Machines that fit the human environment, instead of forcing humans to enter theirs, will make using a computer as refreshing as taking a walk in the woods."

The end

Thank you!

FACHHOCHSCHULE KIEL
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The End

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