

UBiQUITOUS cOMPUTiNG

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EXAMPLES

Timeline of Ubiquitous Computing Projects

Responsive Environments, Krueger, 1974

UbiComp, XeroxParc, 1988

ActiveBadge, ORL Cambridge, 1988

XeroxParc ParcTab etc. 1991

Things That Think, MIT MediaLab, 1991

Wearable, Augmented Reality z.B. KARMA (CMU), 1993

Adaptive Home, Boulder, 1993

Newton, Apple, 1993

PocketWeb, TecO, 1994

Buxton: Reactive Environment, 1995

Classroom2000, FCE, GeorgiaTech, 1997

MediaCup, TecO, 1998

Portolano, Washington, 1999

Cooltown, HP Labs, 1999

Oxygen, MIT, 1999

Smart Dust, Berkeley, 2000

Smart-Its, TecO, 2000

EXAMPLES

☐ Active Badges (Olivetti Research Lab, Cambridge, since 1988)

- ☐ Developed 1988-92 in Cambridge in the Olivetti & Oracle Research Laboratory
- ☐ Worn by users to locate them on the campus
- ☐ Mobile IR Sender for persons and equipment
- ☐ More than 1500 badges and 2000 senders have been produced

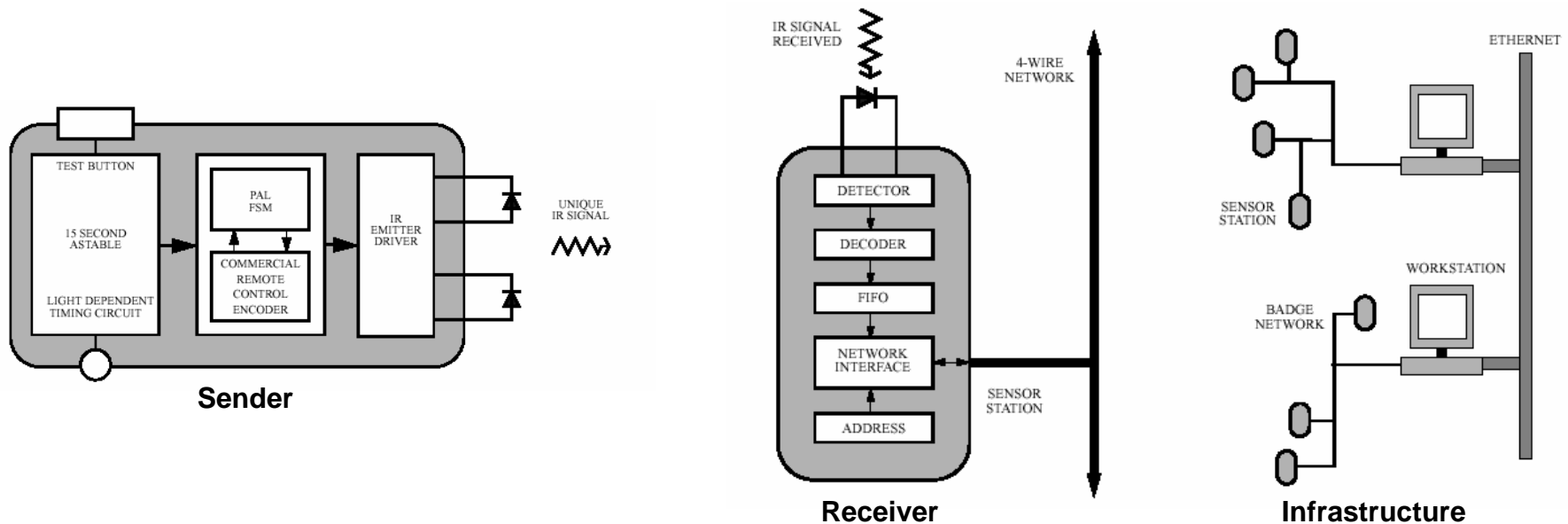


Source: <http://www.uk.research.att.com/ab.html>

EXAMPLES

Active Badges (Olivetti Research Lab, Cambridge, since 1988)

- ❑ Based on infrared receivers and senders
- ❑ Originally intended to aid the telephone receptionist in locating callees
- ❑ Program allowed calls like FIND(name), NOTIFY(name), etc.



- ❑ R. Want, A. Hopper, V. Falcao, and J. Gibbons, "The active badge location system," ACM Transactions on Information Systems, vol. 10, pp. 91--102, Jan. 1992. <http://citeseer.nj.nec.com/want92active.html>

EXAMPLES

▣ Active Badges (Olivetti Research Lab, Cambridge, since 1988)



EXAMPLES

Xerox PARC – ParcTab system (1992)

- ☐ UbiComp technology has been developed at Xerox PARC since 1988
- ☐ ParcTab has been under development since 1992
- ☐ The environment was created to realize the **research method** of Ubiquitous Computing:

„Construction of working prototypes of the necessary infrastructure in sufficient quantity to debug the viability of the system in everyday use; ourselves and a few colleagues serving as guinea pigs.“ [Weiser]

- ☐ Key issues in ParcTab: Location and Scale
- ☐ Location is used to establish context information
- ☐ Scaling must be achieved to map the device design to the requirements of the real world environment and user expectations (e.g. carryable)
- ☐ Focus: devices, power consumption, networks, displays / Interactions.
- ☐ Different devices for different purposes

But:

„The real power of the concept comes not from any of these devices; it emerges from the interaction of all of them“ [Weiser]

EXAMPLES

Xerox PARC

□ Main components are three classes of devices which are used in offices:



▪ Tabs

Tiny computer, analogous to tiny individual notes or Post-it notes, also similar to the tiny little displays of words found on book spines, light switches, and hallways.



▪ Pads

Laptop size, analogous to scrap paper to be grapped and used easily, with many beeing used by a person at the same time



▪ Liveboards

Wall-sized interactive surface, analogous to the office whiteboard or the home magnet-covered refridgerator or bulletin board.

EXAMPLES

Xerox PARC

☐ Devices

- Development of example mobile devices
- Devices are not personal objects, but can be used by everybody
- For each person there should be hundreds of tabs, tens of pads and one or more lifeboards.

☐ Networks

- Network support for a large number of devices
- Small energy consumption

☐ Information and Infrastructure

- Ubiquitous access to information and services

☐ Context

- Improving the functions of devices, networks, interactions and applications using context

☐ Interaction

- Design of non-explicit interaction patterns
- Interaction with mobile devices

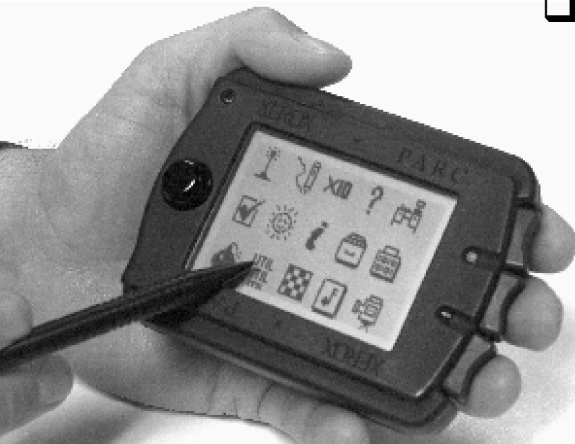
☐ Applications

- Exploiting location and context information
- Enabling computer supported collaborative working (CSCW)

EXAMPLES

Xerox PARC - **PARCTAB**

- ☐ Post-it like device (many per user)
- ☐ Unistroke input using stylus
- ☐ Dimensions: 10.2 x 7.8 x 2.4 cm
- ☐ Weight: 215g (7oz)
- ☐ Screen: 6.2 x 4.2 cm, 128 x 64 monochrome pixels, 21 chars x 7 lines
- ☐ Touch input: passive pressure sensing, Button Input: three finger switches
- ☐ Sound: Piezo electronic tone generator
- ☐ Wireless Interface: IR at 850nm, DEC/Olivetti active badge compatible
 - 6 Emitters, 2 Detectors, Datarate: 19.2 baud
- ☐ Processor: Intel 8051-type (Signetics 87C524/528, 12 MHz)
 - ☐ Memory: 8K (v1) 128K (v2) RAM
 - ☐ Ports: I2C external bus, recharge port
 - ☐ Battery: 12 hours continuous or estimated 2 weeks normal use, rechargeable
- ☐ Case: Plastic with a removable belt clip
- ☐ Supports left and right handed use by flipping display automatically



Source: <http://www.ubiq.com>

EXAMPLES

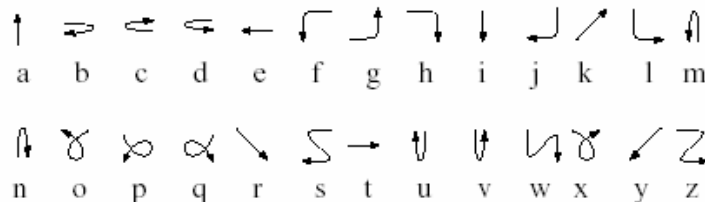
Xerox PARC - **PARCTAB**

❑ Problem:

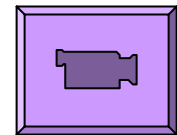
- ❑ Small display makes input interactions difficult

❑ Solution:

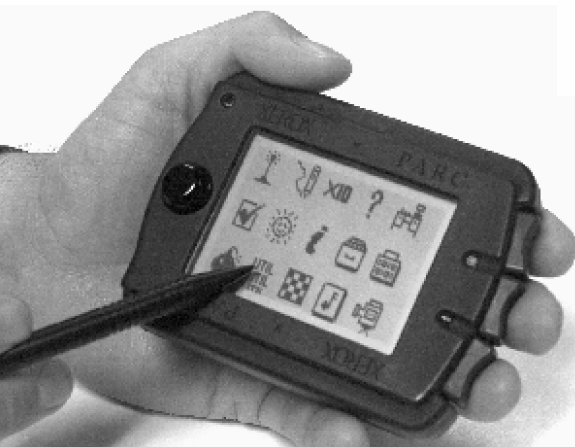
- ❑ 3-Button approach (up/down/select)
- ❑ Stylus for touch screen actions (on-screen keyboard, icons)
- ❑ Unistroke system allows for fast typing of letters but people have to learn the language



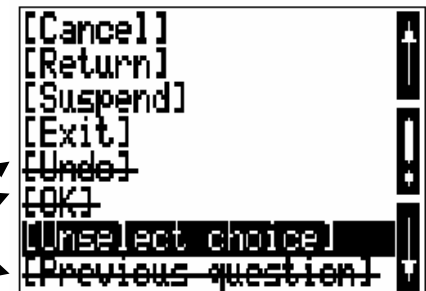
The Unistroke alphabet



Tab



Unavailable options, that do not make sense in the location context are crossed out.



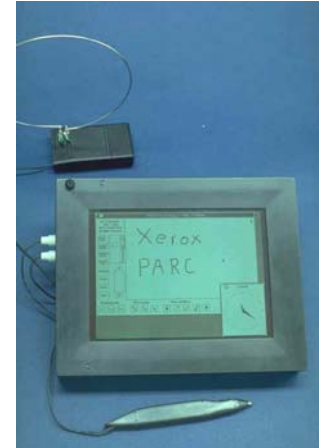
A scroll list

Source: <http://www.ubiq.com>

EXAMPLES

Xerox PARC - PARCPAD

- ☐ Paper-Size device (some per user)
- ☐ Dimensions: 22.2 x 28 x 3.8 cm
- ☐ Weight: 51lbs 4oz
- ☐ Screen: 640 x 480 LCD Display (3 levels of grey)
- ☐ Pen: tethered electromagnetic sensing
 - ☐ Sound: Built-in microphone, speaker, piezo beeper
 - ☐ Wireless Interface: 250kbps radio, 19.2kbps IR
 - ☐ Processor: Motorola 68302, about 4 MB
 - ☐ External Ports: Stylus/micropone, PCMCIA, IMB Serial, RS232, I2C bus, keyboard
 - ☐ Internal Ports: second audio channel, ISDN, Expansion port
 - ☐ Battery: 3 hours (rechargeable)
- ☐ Used mainly as display and interaction means
- ☐ Computation is mainly performed at the server



EXAMPLES

Xerox PARC - Liveboard

- ☐ Wall-size device (one or two per user)
- ☐ Dimensions: 83 x 52 x 30 inch
- ☐ Weight: 560lb (250kg)
- ☐ Screen: very bright 45 x 65 inch, 1024 x 768 monochrome pixels, 640 x 480 color pixels, NTSC video
- ☐ Pen: IR wireless
- ☐ Sound: stereo
- ☐ Networking, processor, and ports determined by choice of embedded workstation, either PC or Sun
- ☐ Power: 12 amps at 115 volts

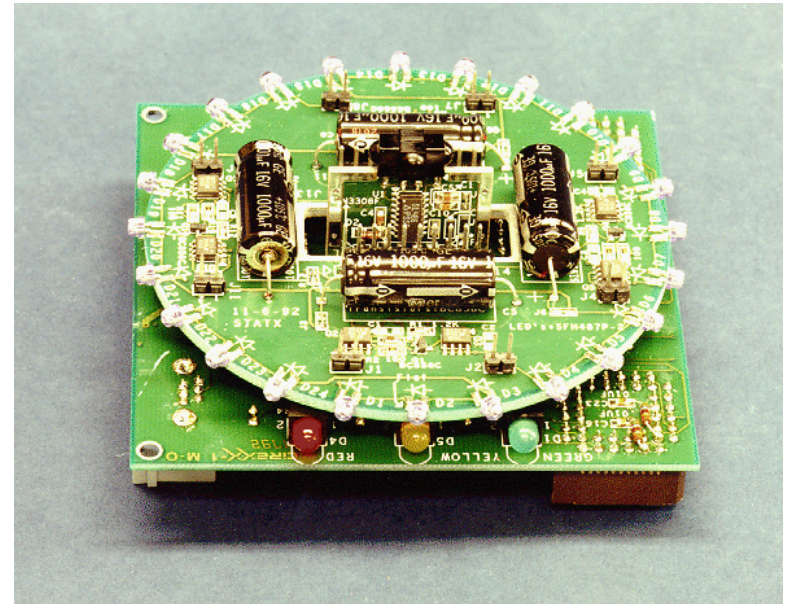
- ☐ Allows distance collaboration applications
- ☐ Distance-aware (knows who is close)
- ☐ Touch-sensitive surface
- ☐ Actually sold as a product



EXAMPLES

📐 Xerox PARC – Deathstar Basestations

- ❑ Serves as a **communication hub** for any device in its cell.
- ❑ Radius is about 20 feet – limited also by the walls of an office.
- ❑ Functions include coding/decoding of infrared packets, buffering data, executing link-level protocol checks (e.g. format or checksum), serial interface provision, visually indication of its communication status.
- ❑ Master/Client Network infrastructure
9600/19200 baud
- ❑ Diffuse communication (not irDA)
allows for using reflection
- ❑ Small power consumption,
but low datarate



EXAMPLES

📷 Xerox PARC – Deathstar Basestations

❑ Infrared Communication

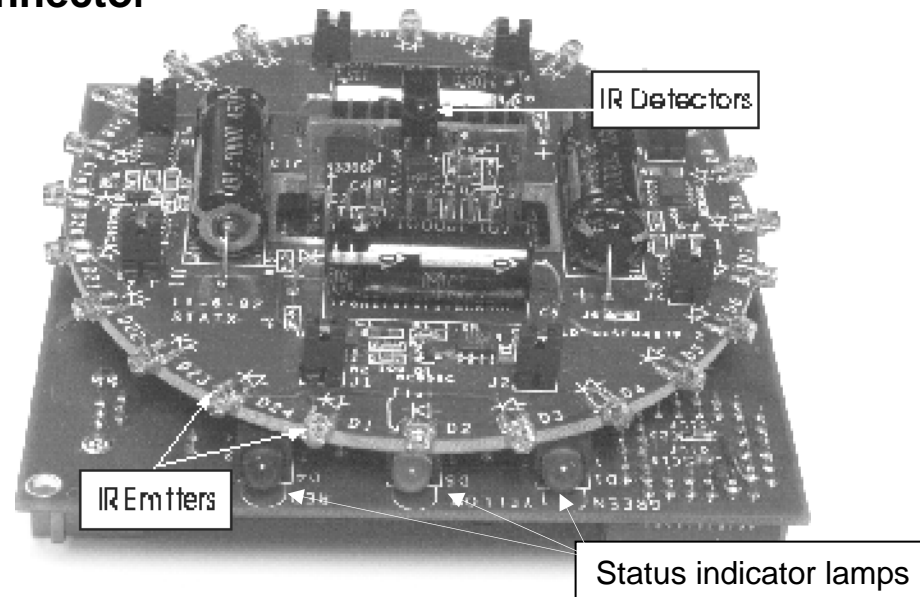
- Wavelength: 880nm
- Data rate: variable 9.6k, 19.2k, 38.4k pulse-position modulation
- Protocol: CSMA

❑ Interface

- 38.4k baud serial connection up to 30m in length (2-pair telecom cable)
- Serial line daisy chain capability for 10 units (RJ11 4/6 jacks)
- External 20-pin peripheral connector

❑ Input electrical requirements

- 12 volt direct, or
- Optional power through the serial cable

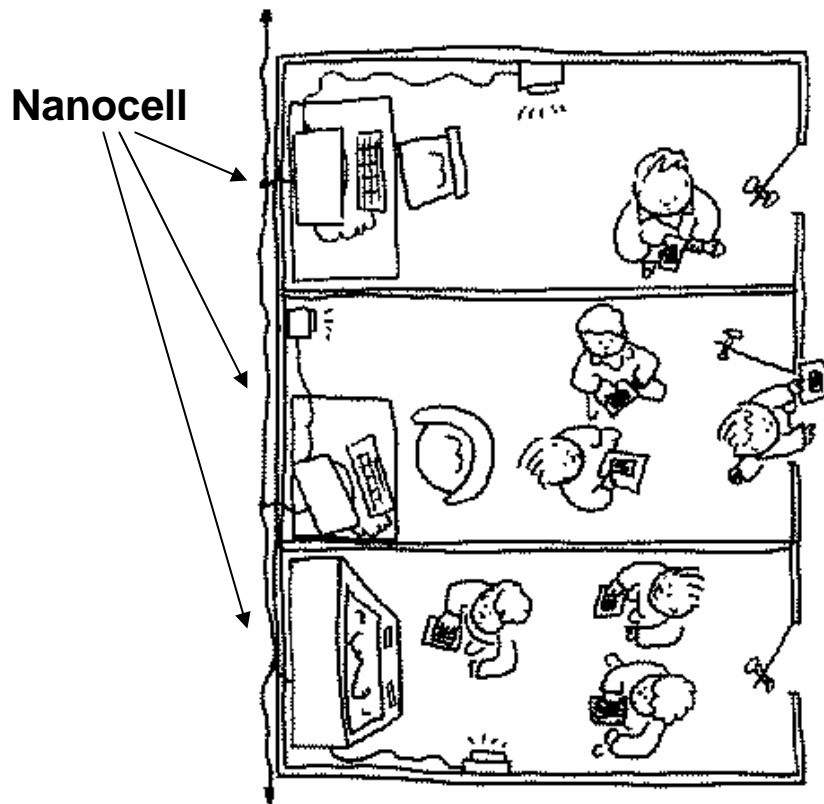


Source: <http://www.ubiq.com>

EXAMPLES

▣ Xerox PARC – System Architecture

- Tabs (and there users) are located in rooms (,nanocells‘)

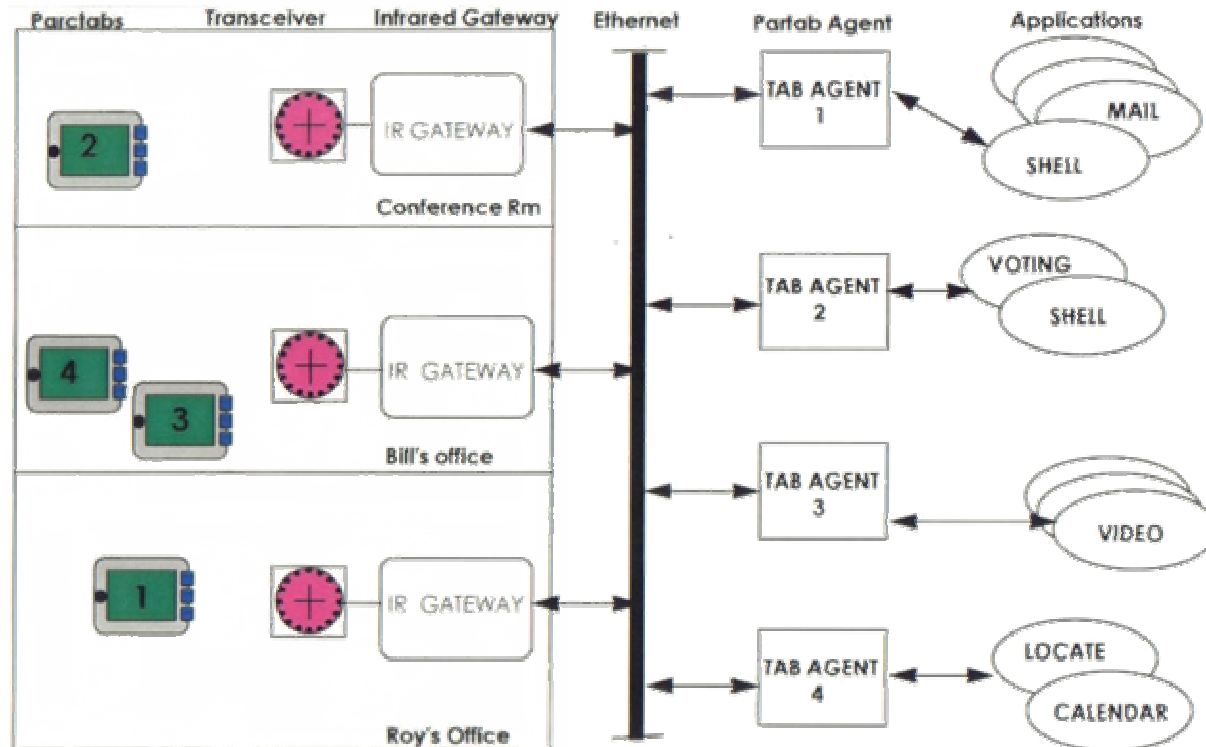


Source: <http://www.ubiq.com>

EXAMPLES

▣ Xerox PARC – System Architecture

- ❑ Tabs (and there users) are located in rooms (,nanocells‘)
- ❑ Deathstar Transceivers are connected with the LAN via gateways
- ❑ Each tab has its own Tab Agent who controls the respective applications

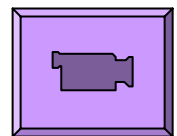
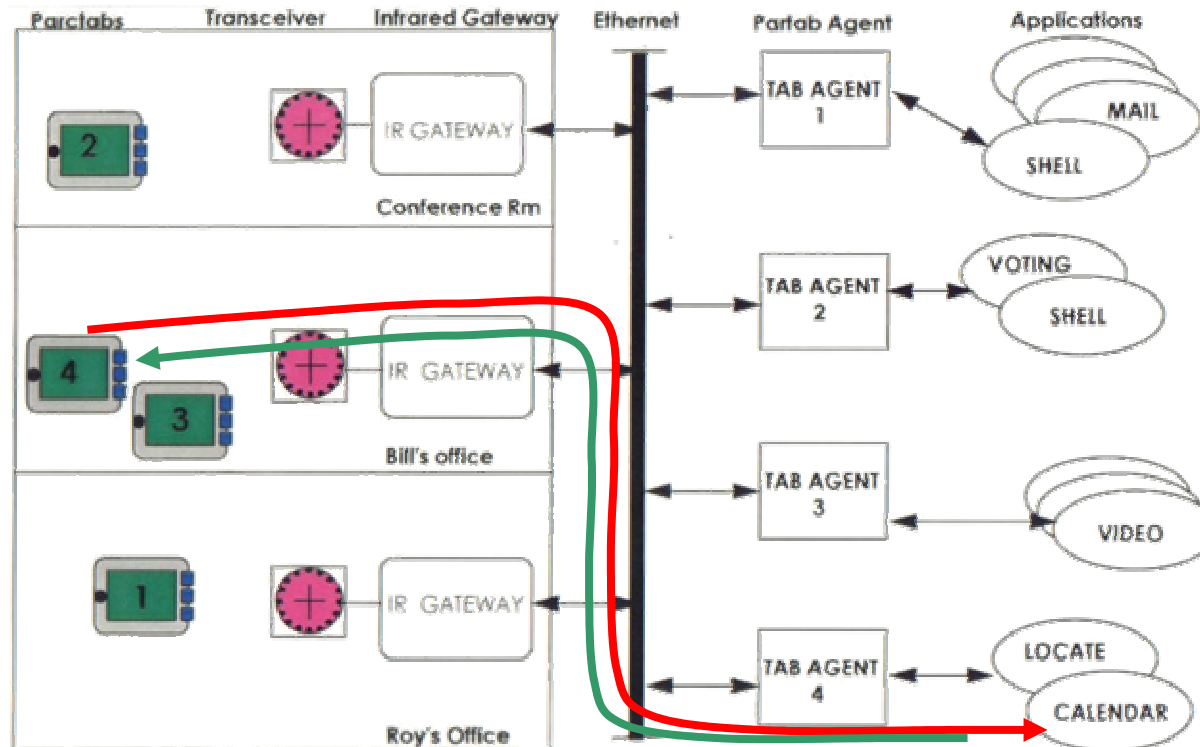


Source: <http://www.ubiq.com>

EXAMPLES

📱 Xerox PARC – System Architecture

- ❑ The nanocell transceiver adds location information to requests
- ❑ The gateway forwards the request to the appropriate tab agent
- ❑ The response of the application is then send back to the tab

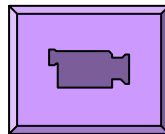


Pad

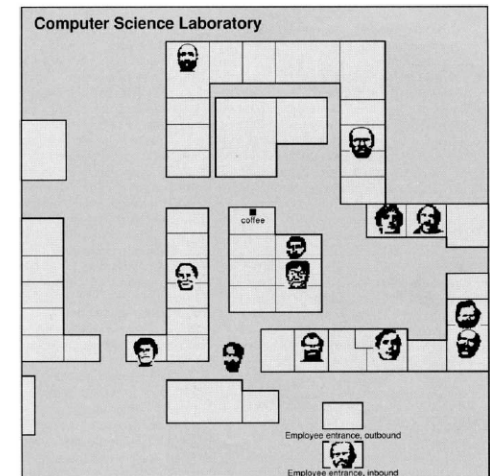
EXAMPLES

Xerox PARC - Applications

- ☐ Information Access
 - Calendar, weather service, user locations, etc.
- ☐ Communication
 - Email, phone, video conferencing, etc.
- ☐ Remote Control
- ☐ Computer Supported Collaborative Working (CSCW)
 - Remote voting, shared documents, etc.



CSCW



Symbolic presentation
of user location

EXAMPLES

Xerox PARC - Context

- ❑ **Basic Context** Information is available as
 - Location of users tracked by Olivetti Badges
 - Locations of devices identified through deathstar location
 - Identity and status of nearby devices
(like printer, Liveboards, coffee machines, etc.)
 - Physical parameters (time, temperature, light, weather, etc.)
- ❑ **Higher-level contexts** can be created through
 - Combination/Association (who is nearby)
 - Aggregation (statistical record of location information)
 - Augmentation (near devices, information available in context)

EXAMPLES



Example: RFID Chef

- ☐ Developed by ETH Zurich
(<http://www.inf.ethz.ch/vs/res/proj/rfidchef/>)
- ☐ RFID Chef is a prototype household application
- ☐ It uses radio frequency identification (RFID)
- ☐ Kitchen items and ingredients, equipped with remotely accessible electronic tags, drive an interactive context-aware recipe finder through the use of an event-based infrastructure.
- ☐ Document:
Marc Leinheinrich, Friedemann Mattern, Kay Römer, Heinrich Vogt:
First Steps towards an Event-based Infrastructure for Smart Things.



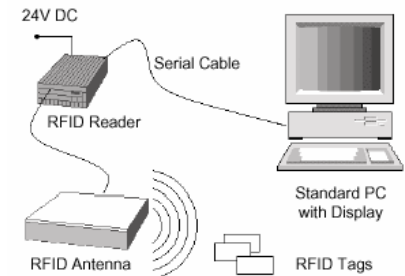
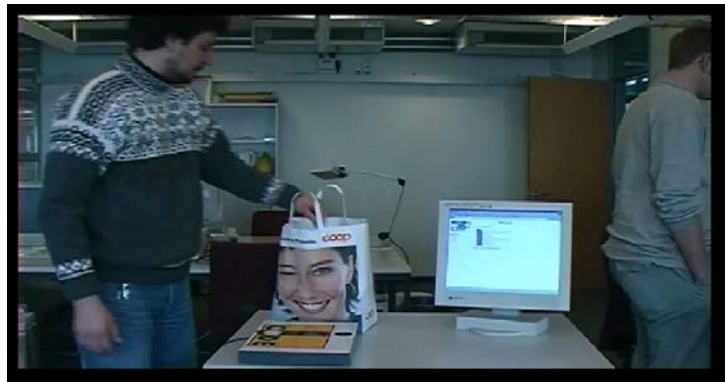
RFID types

EXAMPLES

Example: RFID Chef



Video



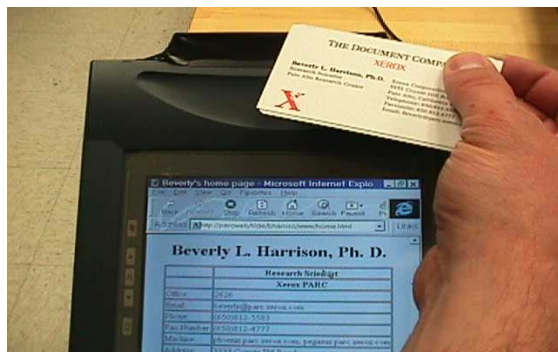
Setup

Source: <http://www.inf.ethz.ch/vs/res/proj/rfidchef/>

THE ViSiON

Example: The Portolano project (University of Washington)

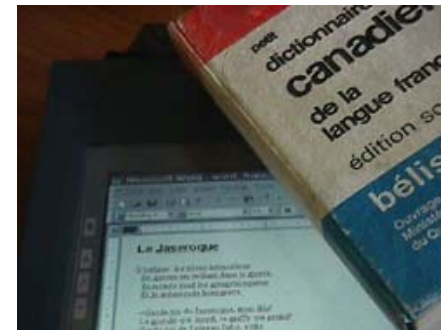
- Data shadows could be attached to daily life objects



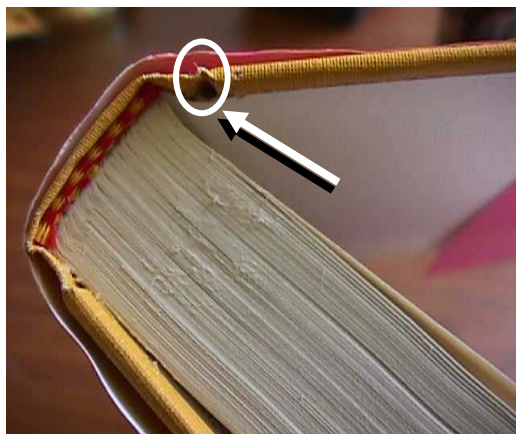
Business Cards deliver Homepages



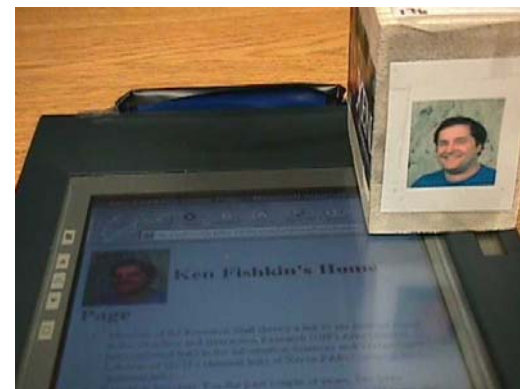
Watch for identification and query of meeting agenda



Moving dictionary issues automatic Web page translation



RFIDs find authors and references

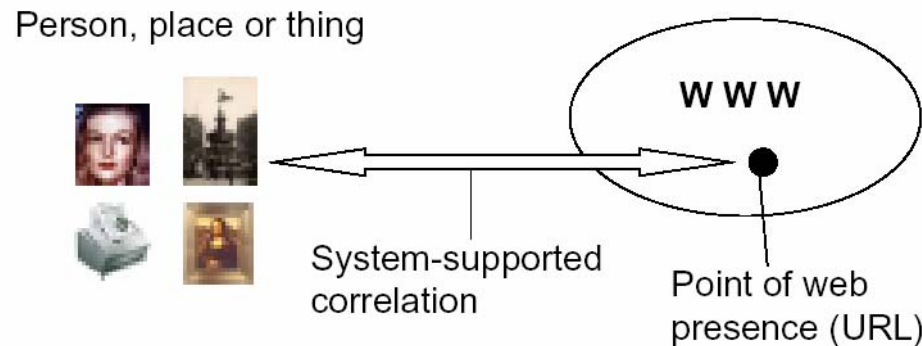


Source: <http://portolano.cs.washington.edu/>

EXAMPLES

Example: Cooltown (HP Labs Palo Alto, since 2001)

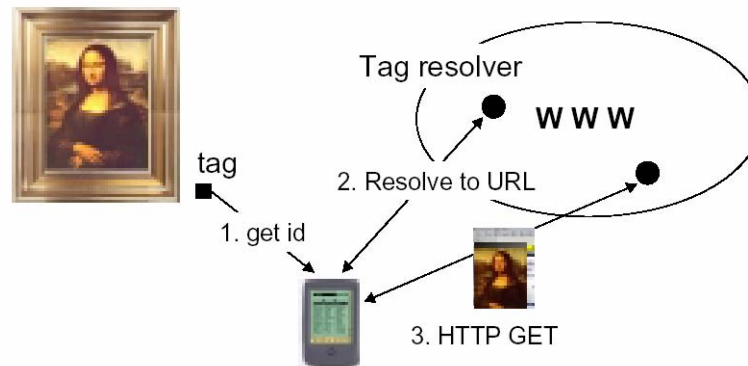
- Demo Center in Singapore
- Kindberg T. et.al.: *People, Places and Things: Web presence for the Real World*. HP Laboratories Technical Report HPL-2000-16.
- Goal:
 - Create ,**web presence**‘ for people, places and things
 - Linking of physical and virtual world
 - Accessing computing power (smart objects) without interfaces



EXAMPLES

Example: Cooltown

- ❑ Based on **HTTP**, which makes it available on large range of devices
- ❑ The definition of **physical presence** (,within sight or call' or ,at hand') is matched to **virtual presence** (location-dependent view of services)
- ❑ Each physical entity has a URL or an embedded web server



- ❑ Virtual presences can be automatically adapted to the user's need, e.g. by modifying the semantics of certain functions on the page
- ❑ People can control and interrogate with devices, e.g. sending a page to a printer, or switching off the light at home from remote
- ❑ Smart devices can interact with other physical points via their virtual point of presence

EXAMPLES

Example: Cooltown

- ❑ The infrastructure is prototyped in layers
- ❑ The lowest layer allows for sensing the object idea by different means
 - **direct sensing**: infra-red beacons deliver the URL of the object
 - **indirect sensing**: values must be looked up at a resolve server to obtain a URL (e.g. GPS locations)
 - Problems:
 - How to create new points of presence?
 - How to resolve tags, where the resolver is not known?

- ❑ The middle layer is the web itself

- ❑ The upper layer provides services related to places and nomadic users (PlaceManager)

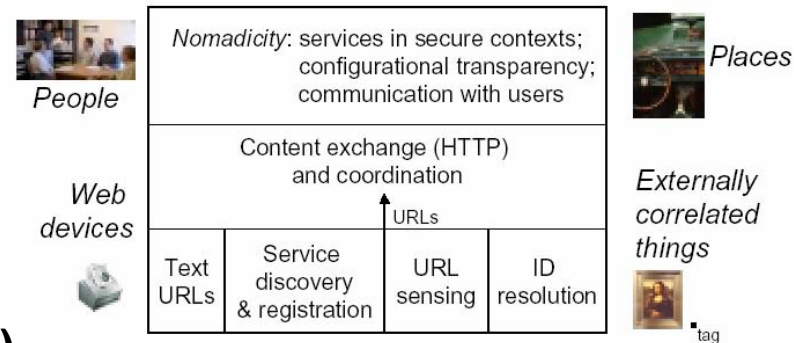
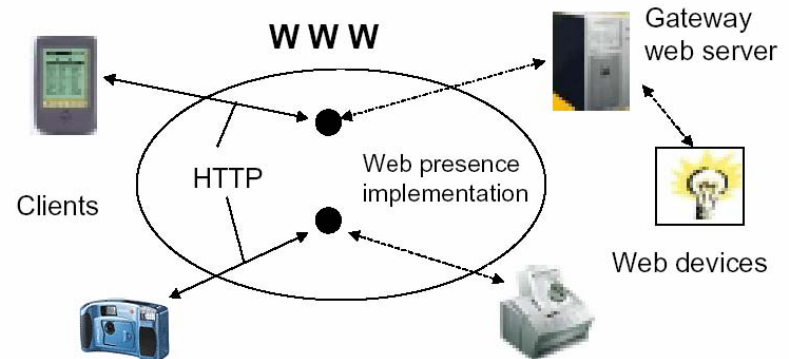


Figure 3. Infrastructure layers



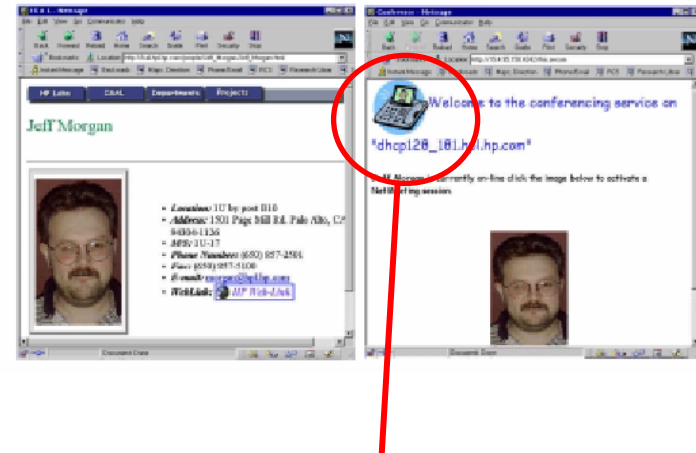
EXAMPLES

Example: Cooltown

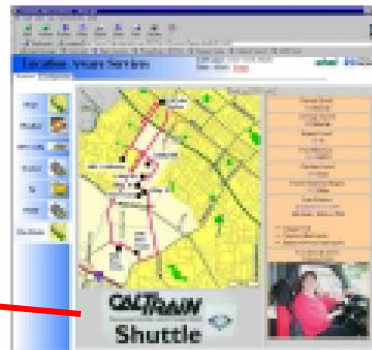
Example Services



Museum visitor's PDA screen
New links pop up automatically,
if the user is near interesting items



If the page owner is near a communication device,
a new link (e.g. NetMeeting) is included



A web-present bus,
equipped with a
GPS receiver

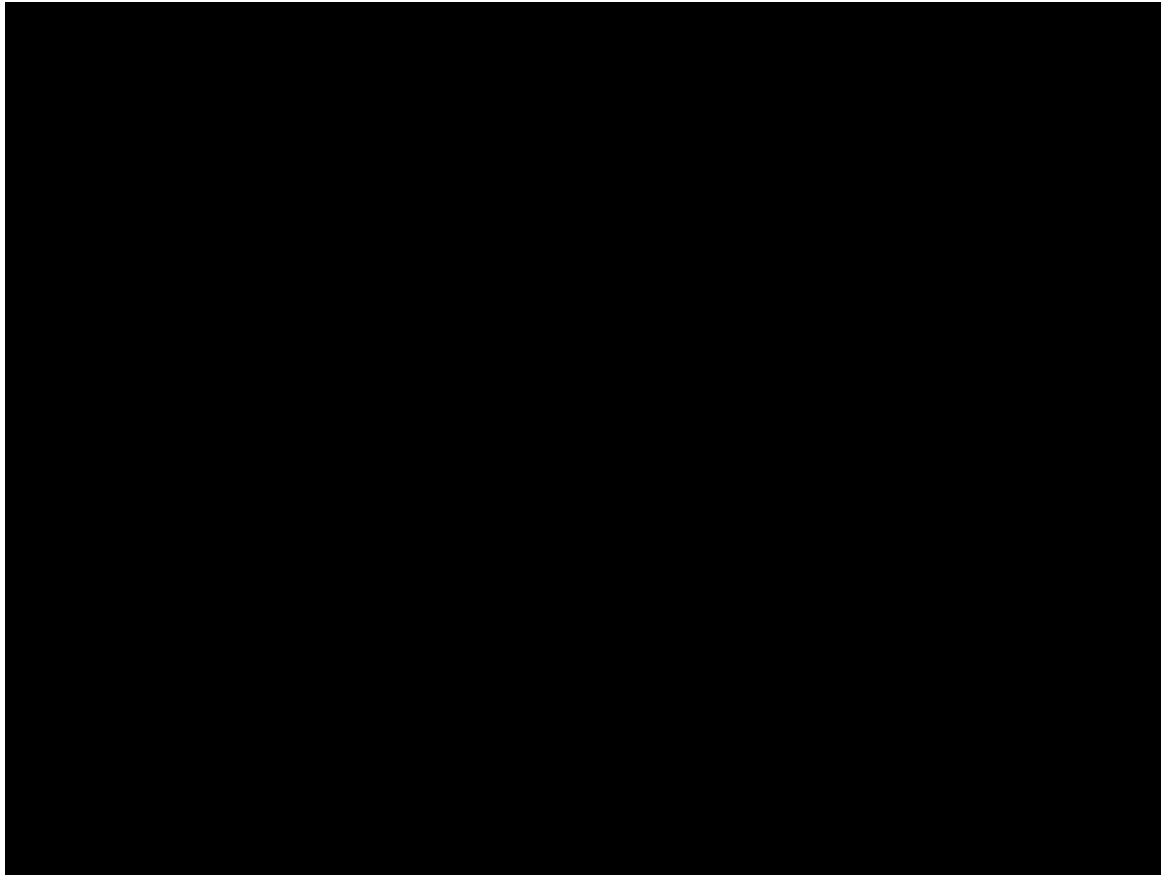
Source: <http://www.cooltown.com>

EXAMPLES



Example: Cooltown

☐ Demo Video



Source: <http://www.cooltown.com>

EXAMPLES



Example: Smart MediaCup

- ❑ Developed at Tecu (University of Karlsruhe)
- ❑ MediaCup is an ordinary coffee cup augmented with sensing, processing and communication capabilities (integrated in the cup's bottom), to collect and communicate general context information in a given environment.
- ❑ Demonstrator is used since September 1999
- ❑ What can I do with my MediaCup?
 - Detect Meetings
 - Send a beep to the watch, when coffee is too hot
 - Request ‚brew new coffee‘ from coffee machine
 - Automatically switch to de-coffeinated, if you have too much caffeine already.
 - Drink coffee or tea out of it ... ;-)



Source: <http://mediacup.tecu.edu>

EXAMPLES

Example: Smart MediaCup

- Possible usage scenarios:
 - Status of cups in offices are available online:
 - <http://mediacup.teco.edu/cups/>
 - Smart watch queries temperature

TecO - MediaCup-Net

Michaels Office						Meeting
Martins Office						
HWGs Office						
Meeting Room						

Explanation: Colors: red=hot cup; blue=cold cup



Someone plays with cup

Someone drinks

Cup is not used



EXAMPLES



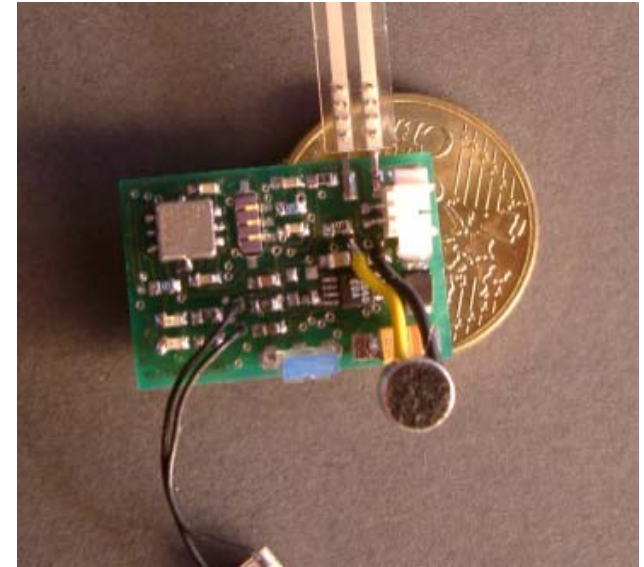
Example: Smart-Its

- ❑ Smart-Its is a collaboration of Lancaster University, ETH Zurich, University of Karlsruhe (Teco), Interactive Institute and VTT. The project is part of the European initiative **The Disappearing Computer** (<http://www.disappearing-computer.net>)
- ❑ Goal: Developing small-scale embedded devices, that **can be attached to everyday objects** (like Post-Its) **to augment them with sensing, perception, computation, memory, and communication.**
- ❑ Using Smart-Its to build and test ubiquitous computing scenarios, especially context-awareness of information artefacts
- ❑ Teco's development system consists of RF Communication and Sensor boards, APIs and OS for application development of Smart-Its and PC-based services, and a bridge for backend (Ethernet /IP) communication
- ❑ Smart-Its can be considered as the next generation of smart labels

EXAMPLES

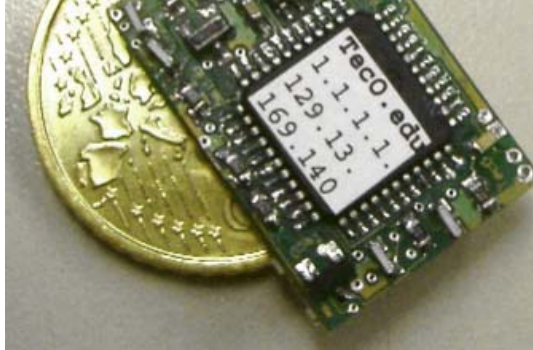
Example: Smart-Its Sensor Board

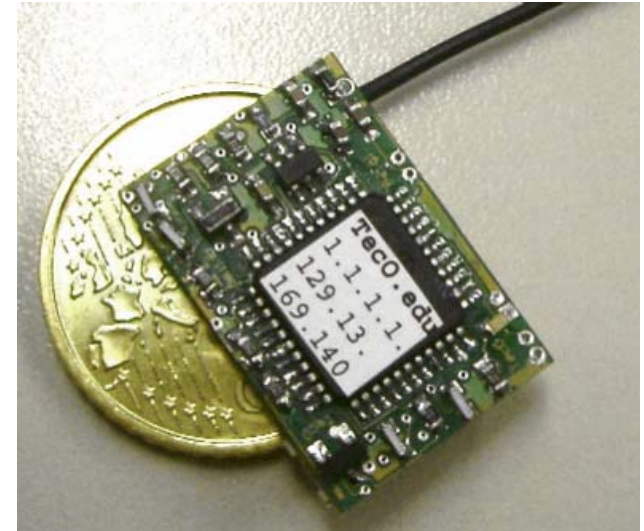
- ☐ Sensor Board 1/84
- ☐ Size: 17x30 mm
- ☐ 8 kByte FRAM
- ☐ Power supply through main board (e.g. Smart-It) or separate, from 1-3.3V; internal generation of 5V
- ☐ **Interfaces** to Smart-Its RF:
 - extended I2C (I2C & interrupt control line, 300 kHz), serial or parallel
- ☐ **Temperature Sensor** highprec. via AD7417
- ☐ **Humidity Sensor** SHSA3
- ☐ **Acceleration Sensor** (3 axis, 2xADXL202 or ADXL210), mid prec.
- ☐ **Pressure Sensor**, low prec. (from 20 g - several kilogram), IEE FSR152
- ☐ **Light Sensor** (daylight or IR as replacement), mid prec., e.g. TSL250 for daylight
- ☐ **Microphone** (capacitive microphone, MAX4040) high precision, high linear
- ☐ Piezo **Speaker** Output, 2 LED (can be replaced by e.g. vibration motor)
- ☐ Additional feature connector for more sensors etc, incl. A/D, Interrupt lines, digital I/O, serial, I2C, SPI, software selectable
- ☐ hardware supported I2C and serial line (TTL) interfaces



EXAMPLES

Example: Smart-Its Communication Board

- ❑ P 1/81
 - ❑ Size: 17x30 mm
 - ❑ **Communication**: RFM 868.35 MHz, 125kbit/s, encoding adopted to application / low power consumption, slotted TDMA/CS&CA, strict sync
 - ❑ **Processing**: PIC 18F452 20 MHz, 32kByte Program memory, 1.5k RAM
 - ❑ **Sensors**: 1/2 sensors & 2/3 actuator on board (2/3 LED, 0/1 Piezo, 1 digital/analog sensor, 1 digital sensor with interrupt, 1 feature interface for additional sensors, sensor boards, actuators, Ethernet bridges, additional RAM: serial (TTL level), I2C, general I/O)
 - ❑ Power supply: 0.9-3.3V: lithium coin cell, AAA, AA, A batteries, rechargables, NC cells, NiMH cells ...
 - ❑ in circuit programming and debugging with off-the-shelf programmers, over-the-air programming
 - ❑ RTC
 - ❑ Size: 15x25mm
- 
- A photograph showing a small, green printed circuit board (PCB) module. The module has a white label with the text 'Teco.edu' and the IP address '129.13.169.140'. It is placed next to a gold coin for scale. The coin is a 1 Euro coin, which is 23.25 mm in diameter. The PCB module is approximately 15 mm by 25 mm.



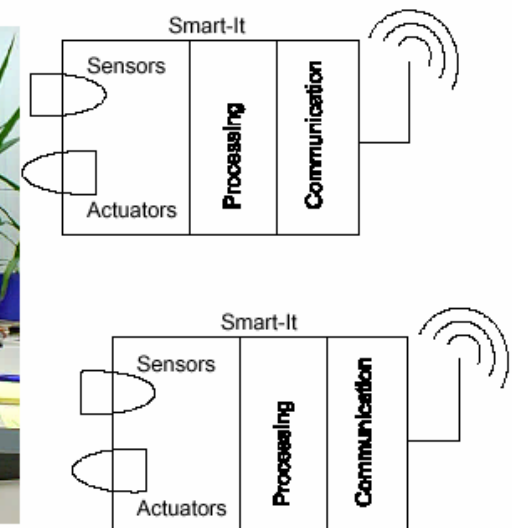
Source: Teco Karlsruhe (<http://smart-its.teco.edu>)



EXAMPLES

Example: Smart-Its Artifacts

- ❑ Friends are generic stand-alone computing devices, but always attached as secondary objects to a physical object of primary interest.
- ❑ This can be done at any stage of the lifetime of an object.
- ❑ Friends are active and contextual aware nodes in digital networks.
- ❑ Goal: every real object can be made smart by attaching a Smart-It to it, which is programmed in an appropriate way to support the objects purpose.
- ❑ Example: Location finder for documents.



Source: Teco Karlsruhe (<http://smart-its.teco.edu>)

EXAMPLES



Example: Smart-Its

Interacting with Disappearing Computers?

- Hold two artifacts (with attached **Smart-Its**) together – and *shake!*



image: TecO

Source: Friedemann Mattern (ETH Zurich)

EXAMPLES



Example: Smart-Its

Shaking Two Objects Together Establishes a "Friendship"

- The **shaking** motion establishes a **shared context** (i.e., acceleration pattern) that no other devices will have



- After the shared context has been established, the two devices can open a direct **communication link**

Source: Friedemann Mattern (ETH Zurich)

EXAMPLES



Example: Smart-Its

A Possible Application: Child Watch

- If the two objects are **too far apart** (e.g., radio communication breaks down), the user is notified with an audible **"beep"**



EXAMPLES

Example: Smart-Its

Or Think of a Credit Card and
a Wrist Watch...



- Shake together before first use (establish friendship)
- Credit card will only work when in proximity of watch

EXAMPLES

Inpromptu (TeCo)

- Michael Beigl, Tobias Zimmer, Albert Krohn, Christian Decker, Philip Robinson:
CREATING AD-HOC PERVASIVE COMPUTING ENVIRONMENTS,
Proceedings of PERVASIVE'2004, Vienna, April 2004.



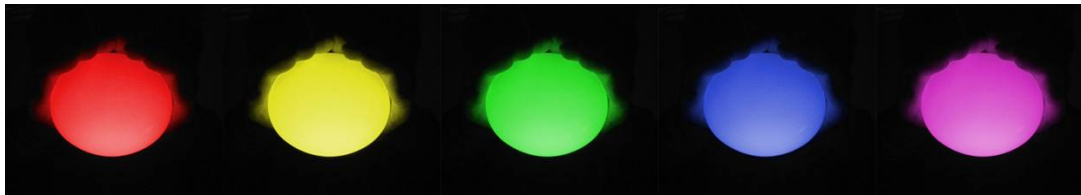
EXAMPLES

Ambient Devices – The Ambient ORB

- ❑ Frosted glass Orb slowly transitions between thousands of colors to show changes in the weather, the health of your stock portfolio, or if your boss or kid is on instant messenger.
- ❑ It can be customized to a set of free channels, such as market indices or weather in major cities and can also be customized to personal info.



150 US\$

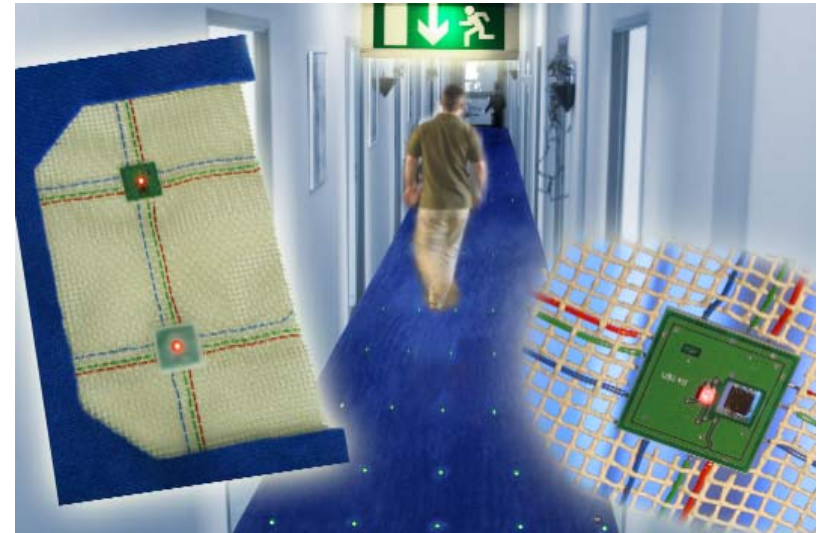


Source: <http://www.ambientdevices.com/>, Shop online at <http://www.brookstone.com/>

EXAMPLES

Examples: SmartCarpet (Infineon, Munich, Germany)

- ☐ The textile contains a weave of conductive fibre studded with sensor chips and LEDs (light emitting diodes).
- ☐ Can make floors, walls and even building columns part of a building's security, maintenance or climate-control system.
- ☐ After being fitted to a floor and hooked up to a power source and a computer, the electronic carpet becomes "aware" of the position of each sensor chip
- ☐ Each chip communicates via a self-learning and self-organising network with its immediate neighbour and uses a software algorithm to ascertain its own position.
- ☐ Among its uses:
 - Visitors can be guided by following a breadcrumb trail of LEDs;
 - Pressure sensors can detect intruders;
 - Temperature sensors can detect a fire while the LEDs mark out an escape route.



Source: http://zdnet.com.com/2100-1105_2-1000468.html

EXAMPLES

Examples: SmartBrick (University of Illinois, Urbana, USA)

- ☐ Liu Chang, Jon Engel (Center for Nanoscale Science and Technology)
- ☐ Combination of sensor fusion, signal processing, wireless technology and basic construction material into a multi-modal sensor package that can report building conditions to a remote operator
- ☐ The prototype has a thermistor, two-axis accelerometer, multiplexer, transmitter, antenna and battery hidden inside a brick.
- ☐ Built into a wall, the brick could monitor a building's temperature, vibration and movement.
- ☐ Such information could be vital to firefighters battling a blazing skyscraper, or to rescue workers ascertaining the soundness of an earthquake-damaged structure.

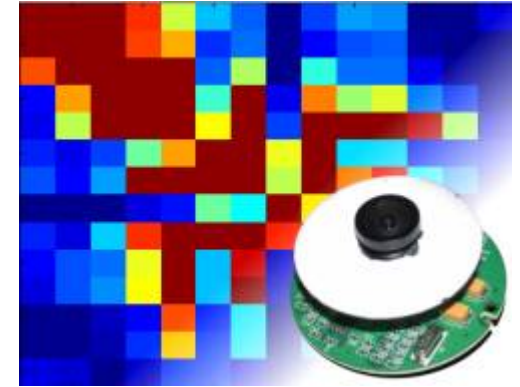


Source: <http://www.news.uiuc.edu/scitips/03/0612smartbricks.html>, <http://www.micro.uiuc.edu/>

EXAMPLES

Examples: Pedestrian Flow (MERL - Mitsubishi Electric Research Lab, MA, USA)

- ☐ Christopher R. Wren
- ☐ Capturing and exploiting the macroscopic patterns of behavior exhibited by the occupants of a building
- ☐ Very cheap motion sensors are scattered over the entirety of a building
- ☐ Self-configuration of network
- ☐ Probabilistic descriptions of the relative positions by analyzing temporal relationships of motion
- ☐ Goal: to improve many building systems: elevators, heating and cooling systems, lighting, information networks, safety systems, and security systems.



Source: <http://www.merl.com/projects/PedestrianFlow/>