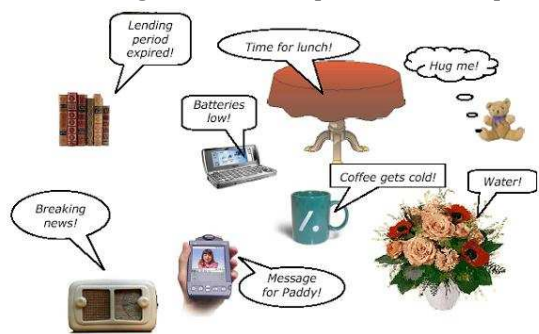Sensor network
Embedded system

Slices area adapted from Prof. Chung-Ta King

Why embedded systems?

▸ **People want everything to be smarter, not just computers.**
 ▸ See "when things start to think" [當鞋子開始思考]

▸

What does that mean?

(1) Smart Object:
 Embedded processor and possibly sensors in everyday objects, remember pertinent events
 ▸ Responsive and proactive
 ▸ "Smart": additional functions to their normal function
▸ **Communicate with environment and each other**
 ▸ Interface to the user (e.g., speech, gesture)
 ▸ Networked with environment or other smart devices

▸

Making things smart

image source: IBM

▸

Wearable computers

Smart glasses

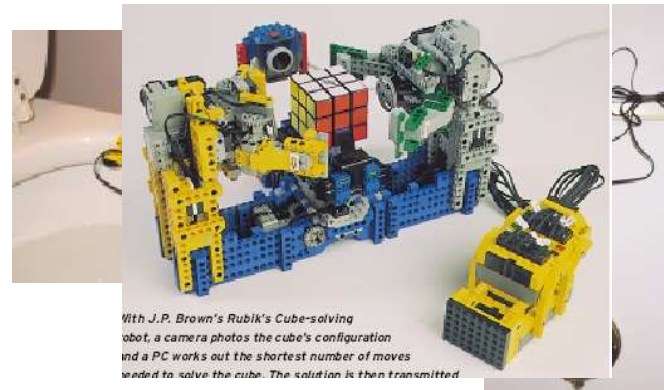external view

the user's
virtual image

Making things smart: Lego

Making Lego Smart:
**Robot command Explorer (Hitachi H8 CPU, 32KB RAM, IR)**

Lego mindstorms

With J.P. Brown's Rubik's Cube-solving
robot, a camera photos the cube's configuration
and a PC works out the shortest number of moves
needed to solve the cube. The solution is then transmitted

What does that mean?

(2) Ubiquitous Networking
- Fiber optics: from Gbits/s to Tbits/s
- Powerline
  - coffee maker "automatically" connected to the Internet
- Wireless
  - mobile phone: GSM, GPRS, 3G
  - wireless LAN (> 10 Mb/s)
  - Bluetooth
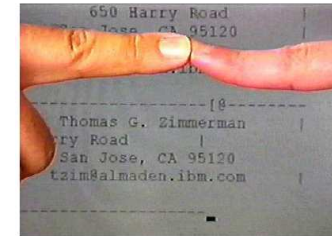- Room network, body area network, personal area network (PAN)
- Internet-on-a-chip
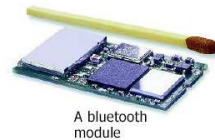
A bluetooth module

Body area networks

- Very low current (some nA), some kb/s through the human body
- Possible applications:
  - Car recognize driver
  - Pay when touching the door of a bus
  - Phone configures itself when it is touched

business card exchange (IBM)

What does that mean?

(3) New materials:
- Semiconductors, fibers
  - information and communication technologies
- Organic semiconductors
  - change the external appearance of computers
- "Plastic" laser
  - Opto-electronics, flexible displays,…
- …

Plastic displays

- OLED
- Organic semiconductors
- Plastic displays (~ 1 mm thick) for flexible displays

Smart paper, electronic ink

▸ Electronic ink
  ▸ micro capsules, white on one side and black on the other
  ▸ oriented by electrical field
  ▸ substrate could be an array of plastic transistors
▸ Potentially high contrast, low energy, flexible
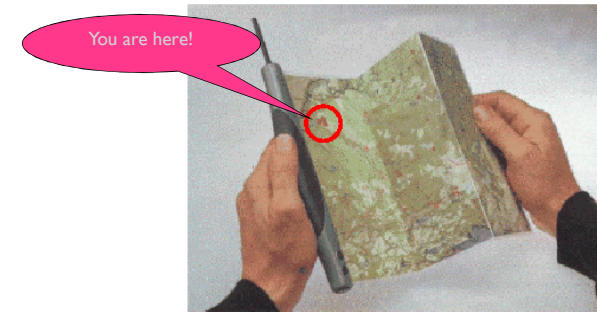▸ Interactive: writable with magnetic pen
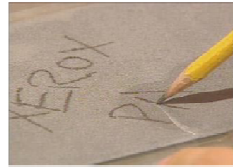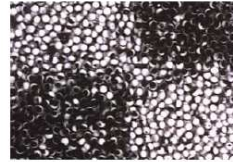
An electronically charged pencil rotates the "pixels"

Interactive map

▸ Foldable and rollable

You are here!

Smart clothing

▸ Conductive textiles that are soft and warm to touch
  ▸ Integrate conductive fibers into woven materials
  ▸ Move audio, data, and power around a garment
▸ Conductive inks:
  ▸ Print electronically active patterns directly onto fabrics

e.g., textiles that change conductivity when streched

What does that mean?

(4) Smart Sensors:
▸ Autonomous perception of and interacting with the user's environment
  ▸ Establish contextual relationship
  ▸ Recognizing objects
▸ Examples:
  ▸ Miniaturized cameras, microphones,…
    ▸ Context detection: users in a meeting
    ▸ Speech controlled devices
  ▸ Location sensors
    ▸ GPS, GSM, radio signals
  ▸ Fingerprint sensor, radio sensors, RFID, Infrared, …

POSITION
N 047°
23'17"
E 008°
34'26"

RFIDs ("Smart Labels")

- Identify objects from distance
  - small IC with RF-transponder
- Wireless energy supply
  - magnetic field (induction) ~1m
- ROM or EEPROM (writeable)
  - ~100 Byte
- Cost ~$0.1 ... $1
  - consumable and disposable
- Flexible tags
  - laminated with paper

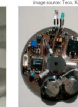## Consequences of ubiquity

1. Possible to link physical world with virtual world
   - Note that the ubiquitous Internet has already made it possible to access information/resources/services *anytime* and *anywhere*
   - But, they remain in the cyberspace
   - Need to access information/resources/services in the surrounding physical world

Smart mug

Smart lego

Smart speakers

Application: Exhibition guide

My Exploratorium
Where I visited:

Viewed at home or school

RFID

URL over infrared

Content server

802.11

Internet

Pi-station: beacon (infrared), barcode
RFID plus processing, I/O, and networking
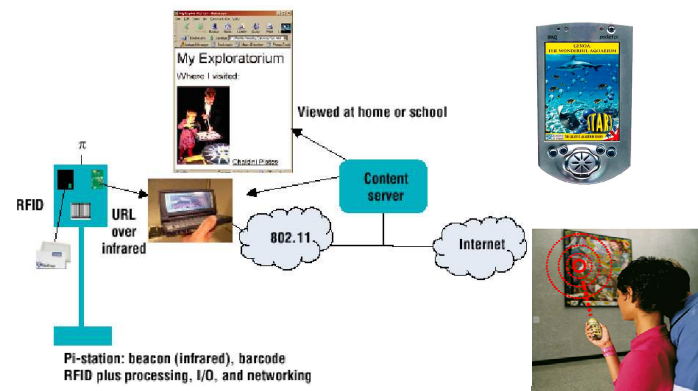
Application: Augmenting buzi cards

- When the card is brought close to a computer, the corresponding homepage is displayed

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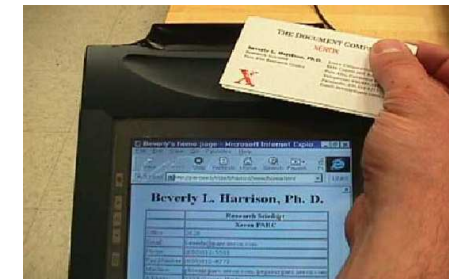
Consequences of ubiquity

2. *Human attention* becomes the scarcest resource
- Be invisible and non-intrusive
  => smart, proactive, and autonomous
  => context-aware and adaptive
- Human out of the loop

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Context-aware for invisibility

- Let computer systems aware of and/or deduce the situation automatically by remembering history and sensing contexts
  - Reduced explicit interaction, more responsive, adapting to changing situations
- Contexts:
  - Identity
  - Spatial: location, orientation, speed
  - Temporal: date, time of day, season
  - Environmental: temperature, light, noise
  - Social: people nearby, activity, calendar
  - Physiological: blood pressure, heart rate, tone of voice

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Context-aware applications

- Triggers: On X do Y
  - "Notify doctor and nearby ambulances if serious health problem detected"
  - "Remind me to talk to Chris about user studies next time I see him"
- Metadata tagging:
  - "Where was this picture taken?"
  - "Find all notes taken while Mae was talking"
  - Stick-e notes: University of Kent
    - Attaching notes to a context, later trigger the note when context occurs again

Context-aware applications

- Reconfiguration and streamlining:
  - Telephone forwarding, turn off cell phone in theaters
  - Automatically adjust brightness / volume
  - Select modes in multimodal interaction
  - Multimedia / Bandwidth adaptation
- Input specification
  - Send mail only to people in building now
  - Print to nearest printer
  - "Find gas stations nearest me"
- Presentation of contexts
  - Current location, idle?, currently in?

Consequences of ubiquity

3. Very complex and unpredictable systems and operating environments
   - Push to runtime, late binding, adaptive
   - Complexity management and self-management (self-configuring, -healing, -optimizing, -projecting)
     => *autonomic computing*

Summary

- Ubiquity in computation and communication
- Consequences and principles
  - Linking physical world and virtual world
  - Context-awareness
  - Self-management
  - ……
- Keep the vision of pervasive computing and apply the principles to computing systems for value-added features and services, and for innovative applications