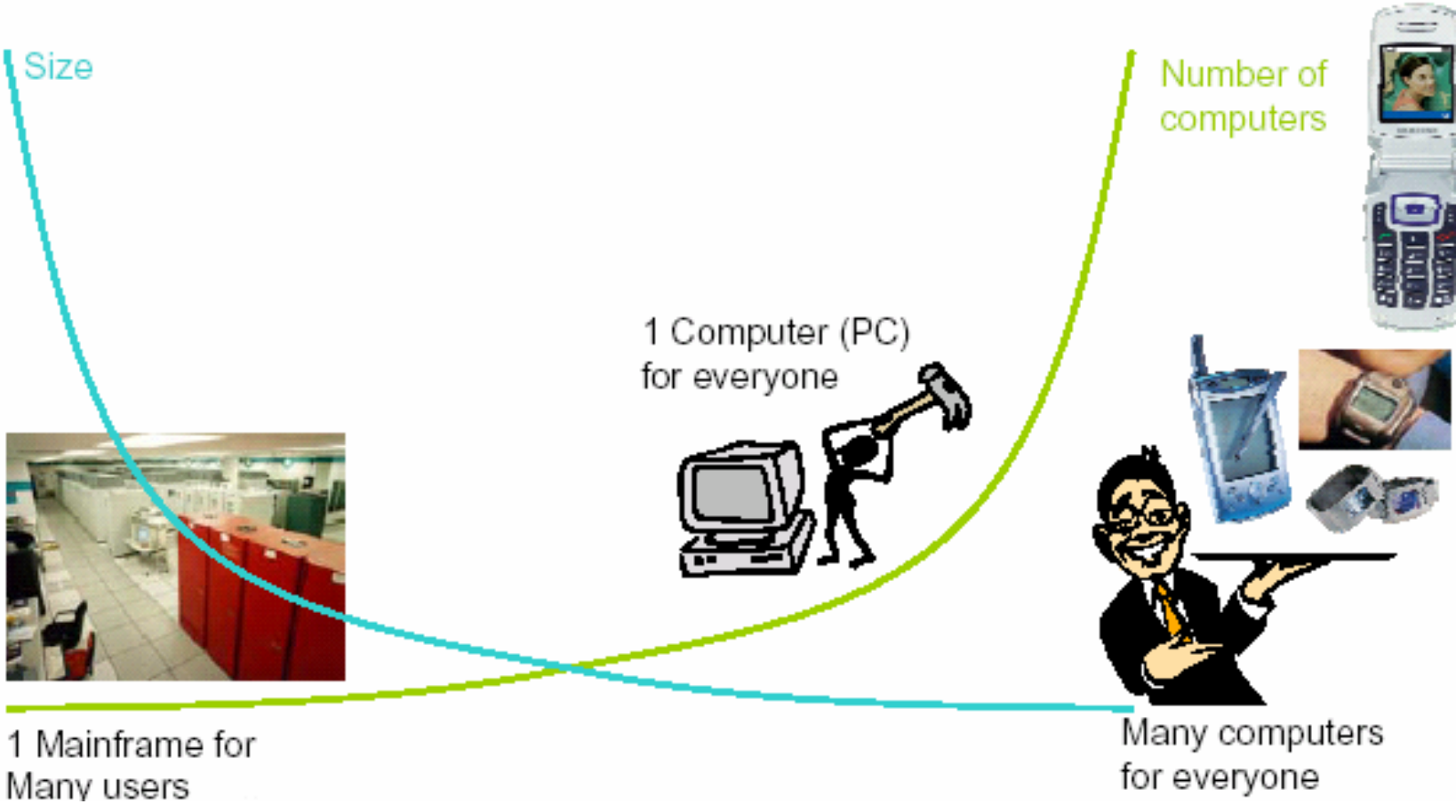
Pervasive Computing and Context-aware Technologies

Meaning

- **Pervasive computing** is a term describing the concept of integrating computation into the environment, rather than having computers which are distinct objects. Promoters of this idea hope that embedding computation into the environment would enable people to move around and interact with computers more naturally than they currently do.

- **Ubiquitous Computing** "The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it." So began Mark Weiser's seminal 1991 paper that described his vision of ubiquitous computing now also called pervasive computing. Pervasive computing represents a major evolutionary step in a line of work dating back to the mid 1970s. Two distinct earlier steps in this evolution are distributed systems and mobile computing. Some of the technical problems in pervasive ...

A Clear Trend



Weiser' vision

- Mark Weiser (1952–1999) chief technology officer at Xerox's Palo Alto Research Center (Parc)
- The computer for the 21st Century, Scientific American, 1991
- 1991
  - No Pentium processor, no Windows
  - Mainframes in companies
  - UNIX are the major OS in universities

Ubiquitous: Writing VS. Computing

Writing

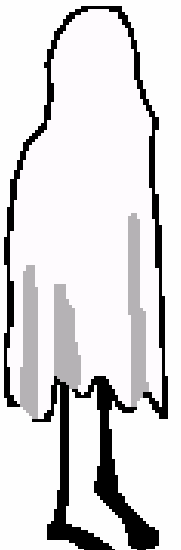
- Freeing from the limit of individual memory
- Past
  - Few people can read
  - Monks copy individual books
  - Each book was unique
- Today
  - Writing is ubiquitous
  - Constant background presence

Computing

- Freeing from the limits of many things
- Today
  - Few people use computers
  - Developers write applications
  - Each computer is unique
- Future
  - ????

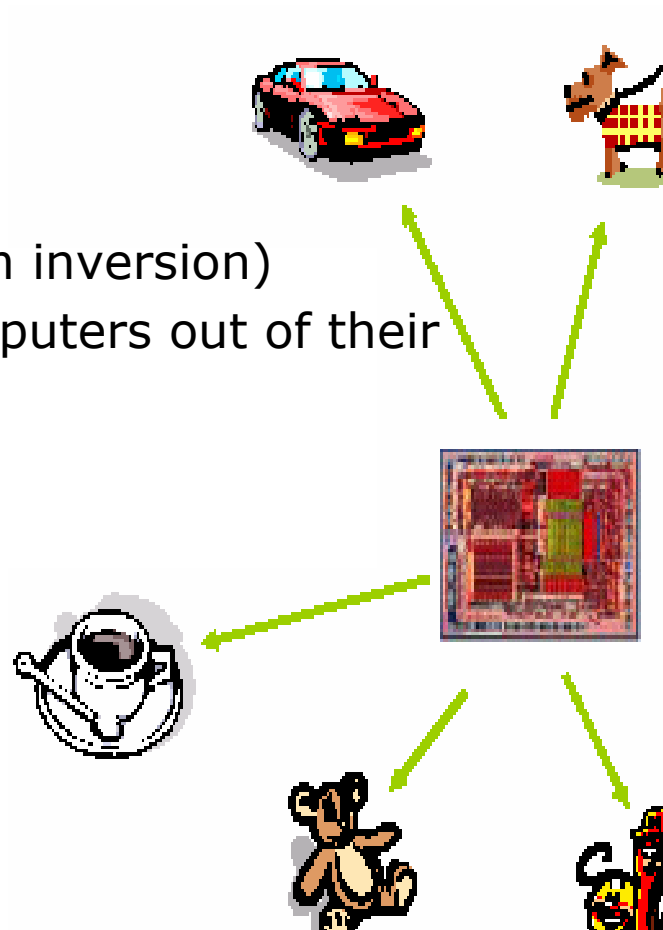
Disappearance

- Fundamental consequence of human psychology
  - Whenever people learn something sufficiently well, they cease to be aware of it
  - Only when things disappear, we are freed to use them without thinking and so to focus beyond them on new goals
  - Writing, reading, calculating, driving,…



Pervasive Computing and Virtual Reality

- Diametrically opposed
- Virtual Reality
  - World in the computer
- Pervasive Computing
  - Computers in the world (paradigm inversion)
  - Embodied virtuality (drawing computers out of their electronic shells)
- Augmenting Reality
  - AR Quake



Small Computers

- Portable computer, well…
  - General purpose
- Notebooks
- Sub notebooks
- Personal Digital Assistants (PDA)
- Appliances
  - Single purpose + communication
  - Smart phone
- Smart Dust

Connecting Computers

- Not by wire
- Not by infrared either
- Wireless communication via radio waves
  - WLAN
  - Bluetooth
  - ZigBee
- Connecting computers and services increases applications exponentially

Vision of the Future 1/2

From the paper “How and Why you will talk with your tomatoes”

Somewhere in Germany there is a factory that produces the little cans that canned food goes into. This factory makes cans that appear perfectly normal it's just that each **can contains a tiny computer, a small amount of memory, and a short-range radio transceiver**. It's a smart can and the factory that makes them charges eight pennies more for each one. As part of their production, the cans get embedded with a small amount of data such as the date of manufacture, the batch and can number, the alloy details etc.

Once produced these cans travel all over Europe. One batch of these cans is sent to Italy where they go to a tomato-canning factory and are filled with tomatoes. At this factory, as part of the canning process, the can gathers a **little more data: it is full of diced Roma tomatoes, it was filled on a certain date as part of a particular batch, and it has a particular use-by date.**

One of these cans of tomatoes gets exported to the USA. As it moves off the wharf it is processed and **its data content is translated from Italian to English**. After a brief stint in a warehouse it ends up on a supermarket shelf. **At the supermarket it inherits a little more information such as the retail price and date of being placed on the shelf. At some point a customer's pantry knows to order the can and one is sent to your house in the next delivery. Before the can leaves the store, the supermarket extracts the information it needs for stocktaking.**

Some weeks later you're at your desk at work thinking about dinner, and decide that tonight you're going to cook a romantic meal for two. You look up your recipes, select one, and check your pantry for the necessary ingredients. **Your tomatoes have cheerfully registered themselves to the pantry upon arrival, so it is able to report that all you need is some fresh basil that you can pick up on the way home**. **At the supermarket, you find the basil and drop it into the trolley, which updates the cumulative price of your selections. Noticing the screen's flicker, you glance down and see an advertisement for a special on oregano. You cancel it and disable further advertising. Finally done, you push the trolley through the checkout, where your account is debited for the total, and your home address attached to your items.**

Vision of the Future 2/2

From the paper “How and Why you will talk with your tomatoes”

You push the trolley onto the track for delivery before heading to the cafe for a coffee on the way home as the store delivers the shopping for you.

At home you begin to cook, placing the opened can of tomatoes from the pantry onto the table. **The can reports that it has been opened (after detecting the pressure differential).** You've been meaning to get the auto-light on your gas stove fixed for weeks now and seemingly every time you want to light it you can't find the matches. **You ask the kitchen to locate the nearest box for you: there's one in the cutlery drawer.**

You've had enough though, so you direct the kitchen to factor the stove repair into your budget. Your stove knows not to hassle you again. Having enjoyed your meal, you turn on the television but during the first ad break a scrolling message from the kitchen appears at the bottom the screen **telling you that there's an open can of tomatoes that's been getting warm for over two hours**. **You swear briefly, but are at least glad the house didn't interrupt while you were busy. It knows you're not watching an important show and it did have the decency to wait for an ad break.**

You go to the kitchen and put the can into the fridge, pausing briefly to put the matches back on the fridge where you expect them. Three days later you wake up and struggle to the kitchen for a cup of coffee. As you grab the milk, you see the fridge's display panel has a number of messages for you. You'll deal with the emails later but notice that the fridge is complaining that there is a can of tomatoes that is getting beyond its prime.

At first you can't find them, but the fridge locates them behind the last of the beer, and you grab the can and blend them. Enjoying your tomato juice with your coffee, **you begin a casual cleanup and throw the empty can into the recycling unit. The recycling unit strips any personal information from the can, and noticing the alloy content ensures it gets picked up for recycling. Some time later the can is shipped to Germany for recycling.**

Features: Computer Size

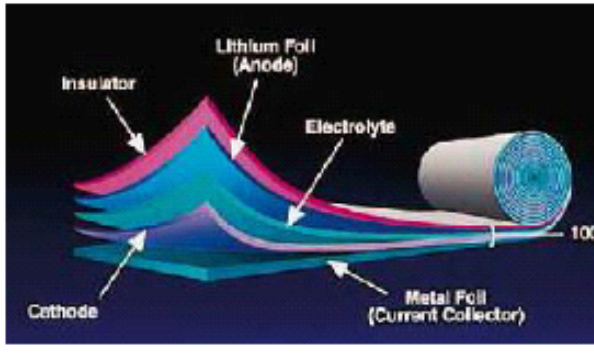
- Hardware is getting smaller and smaller
  - What is the smallest computer you own?
  - What is the smallest computer you know?
- Smart Dust
- Nanotechnology
  - Micheal Crichton, Prey, Harper Collins, 2002
- Limitations
  - Computational resources
  - Physical interconnection
  - User interface
  - Power consumption

Features: Resources (CPU, Memory)

- No 2-3 GHz CPUs for embedded devices available
  - Trade-off between performance and power consumption
- No 1 GByte main memory
- No hard disk; flash memory instead
  - GBytes available but expensive
- What performance have today (your) mobile devices?
  - Processor speed
  - Transient and persistent memory
  - Hours of operation?

Features: Power Consumption

- Battery technology does not keep pace with increase in computer technology
- Known technologies
  - Lithium ion or lithium polymer
- Future Technologies
  - Fuel Cell (notebook runs for 1 day)
  - Star Trek technology should be discovered fast…
- Always on VS. Wake on wireless?
  - Power-aware computing and communication
  - New attacks: Sleep Deprivation

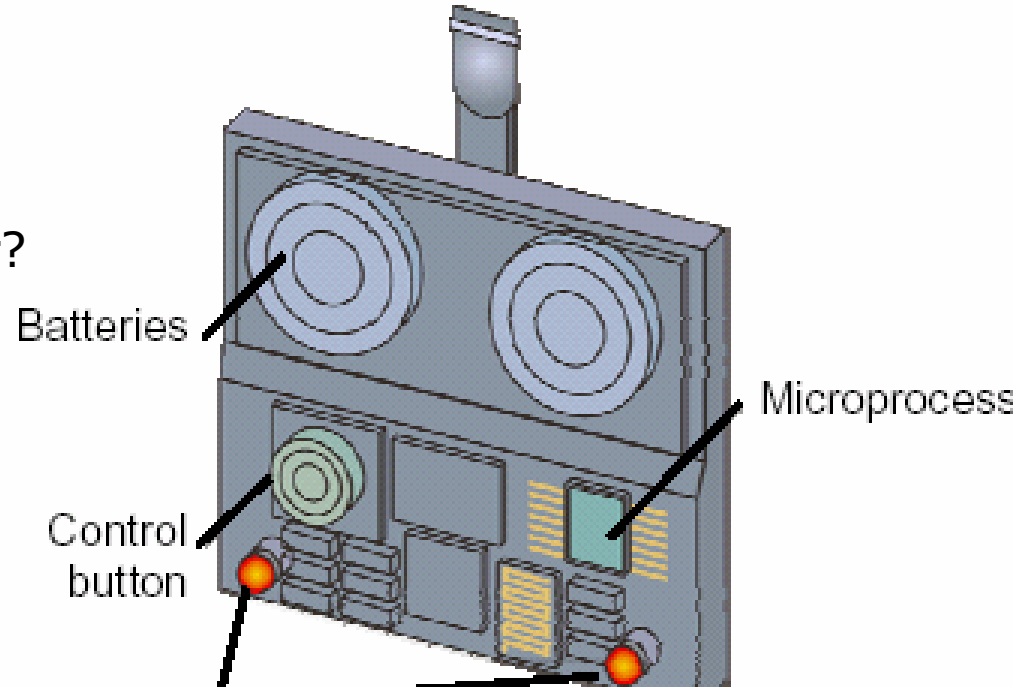


Examples: Tabs (centimeter-scale)

- Smallest components
- Interconnected
- Examples
  - Active badges
  - Tabs with display
  - …

Examples: Active badges

- First developed by Olivetti Cambridge Research
- Identify person or object to devices
- Keeping track
- Location
- Extras
  - Camera
  - Voice recording
  - Did i close the door?



Examples: Xerox Parc Tab

MIT Media Lab - Shoes

- Energy scavenging
- Broadcast ID every 3 to 5 steps

Examples: MIT Media Lab - MediaCup

- Sensing, processing and communication capabilities
- Periodically broadcasting state of cup
- Applications
  - Visualizing the state of the cup
  - Inferring and indicate meetings through aggregations of cups
  - Wrist computer warns if I am getting close to a hot cup.

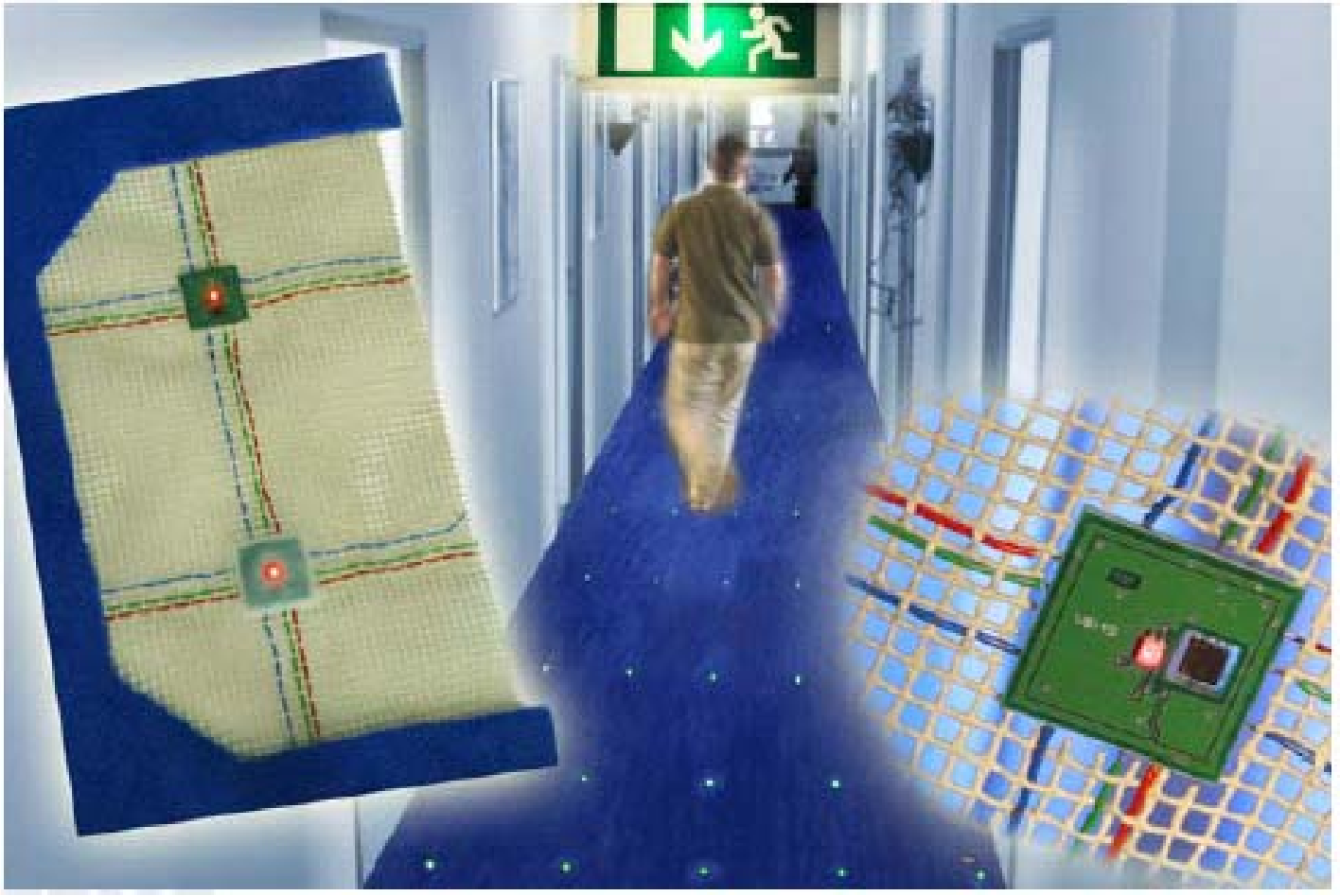
Examples: Pads (A4-A3 scale)

- Antidote to Windows
- Like paper

Examples: Boards (wall-scale)

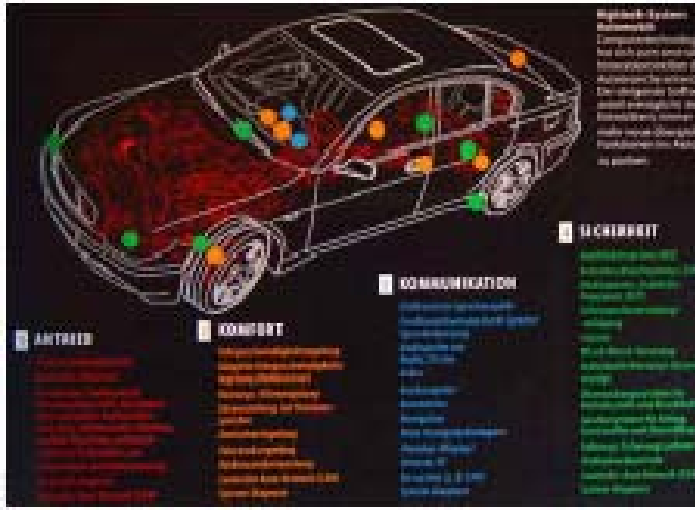
- Video and image screens
- Bulleting boards
- White boards
- Flip charts
- Interactive paintings

Examples: Smart Carpets



Examples: Not Only Small - Cars

- They are big enough
- They have their own power supply
- They are expensive enough
- At least for Germany, they are the primary commercial
- force and the most precious toy
- They are a major source of pollution
- …
- Telematics
  - Telecommunication and Automation
  - For some it is about computers and mobility



Examples: Early Applications

- Early Applications
  - Mobile communication
  - Dynamic Route Planning
    - Traffic information
  - GM, On Star System
    - Simple to use button to connect to a human operator
      - Emergency call
      - Info
  - Experiment with Voice Scripting
- Advanced Applications
  - Passenger-oriented services
    - Information services (Emergency, traffic)
    - Productivity (mobile office)
    - Entertainment (TV, Hi-Fi, Games)
  - Vehicle-oriented services
    - Maintenance (on site inspection)
    - Security (ABS, air-bags,…)
    - Anti-theft
    - Comfort (heating, air-conditioning)
  - Trip-oriented services
    - Navigation

…..Oh great, but

- In addition to showing some of the ways that computers can enter invisibly into people's lives, this scenario points up some of the social issues that embodied virtuality will engender. Perhaps key among them is privacy: hundreds of computers in every room, all capable of sensing people near them and linked by high-speed networks, have the potential to make totalitarianism up to now seem like sheerest anarchy. Just as a workstation on a local area network can be programmed to intercept messages meant for others, a single rogue tab in a room could potentially record everything that happened there."

HCI – Human Computer Interaction

Exploiting All Senses

- Vision
- Hearing
- Sense of touch
- Not yet
  - Smell
  - Taste

- Calm computing
  - Attention threshold
  - Autonomic Computing

Some Examples

Conclusions 1

- Small, lightweight, cheap, and mobile processors
  - In most everyday objects (embedded computing)
  - On your body (wearable computing)
  - Embedded in the environment (ambient intelligence)
- Visions…
  - Everything, always, everywhere
  - All objects become smart
  - Everything is connected
- …become true because
  - Cheaper hardware (many everywhere)
  - Smaller hardware (mobile, everywhere)
  - Wireless communication (almost) no cost

Conclusions 2

- Various Research discipline involved
  - Hardware development
  - Software development
  - HCI, psychology
  - Electrical engineering
  - Physics, chemistry, biochemistry
- No mature research discipline yet
  - No textbook-like lecture possible
  - Self-contained lecture units

The New Paradigm

- Environment-centric instead of computer-centric
- Context-centric instead of desktop-centric