Ubiquitous and Context Aware Computing: Overview and Systems

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Outline

- Definition and Motivation for
  - Ubiquitous computing
  - Context aware computing
- Sample Systems
- Discussion

Ubiquitous computing

- In an ubiquitous computing environment:
  - Computers will be everywhere around us
  - We will not be aware that we are using a computer
  - Computers will have moved into the background
- In contrast to microprocessor-driven household appliances today
  - All the computers will be networked together
  - They will be aware of their environment and adapt to it

Ubiquitous Computing (2)

- An example for an ubiquitous information technique:

Writing

  - Is found almost everywhere around us:
    - Books, magazines but also
    - Street signs, billboards, even candy paper
  - In ubiquitous computing, computers will be just as immersed in our daily lifes

Ubiquitous Computing (3)

- Example of a technology becoming ubiquitous:

Electric motor

  - At the beginning of the 20th century a factory would have one motor, driving several machines
  - With the advent of cheap electric motors, every machine could have its own motor
  - Today there are usually several motors working in one machine, e.g. a modern car

Paradigms for Computing Systems

- Mainframe: Many users per computer
- Personal Computer: One user per computer
- Ubiquitous Computing: Many computers per user

We are currently moving from personal computing to more ubiquitous computing

But all three paradigms will probably coexist

Human Attention

- The limiting factors of computing today are (in most cases)
  - Not processor speed anymore
  - Nor memory size, but

Human Attention

- The computer has to find out somehow, what the user wants it to do

Context awareness

- When two human beings communicate, a lot of context is implicitly available from the situation
- When communicating with a computer, the context of the situation is usually lost
- Explicit vs. Implicit communication

Goal:

The computer does, what the user wants

Context awareness in mobile and ubiquitous computing

- Context awareness is especially important for mobile and ubiquitous computing:
  - The situation may change dynamically
    => rich context available
  - The user might be preoccupied e.g. by walking or driving a car
    => explicit user input may be sparse
    => the use of implicit input is necessary

Why context is difficult to use

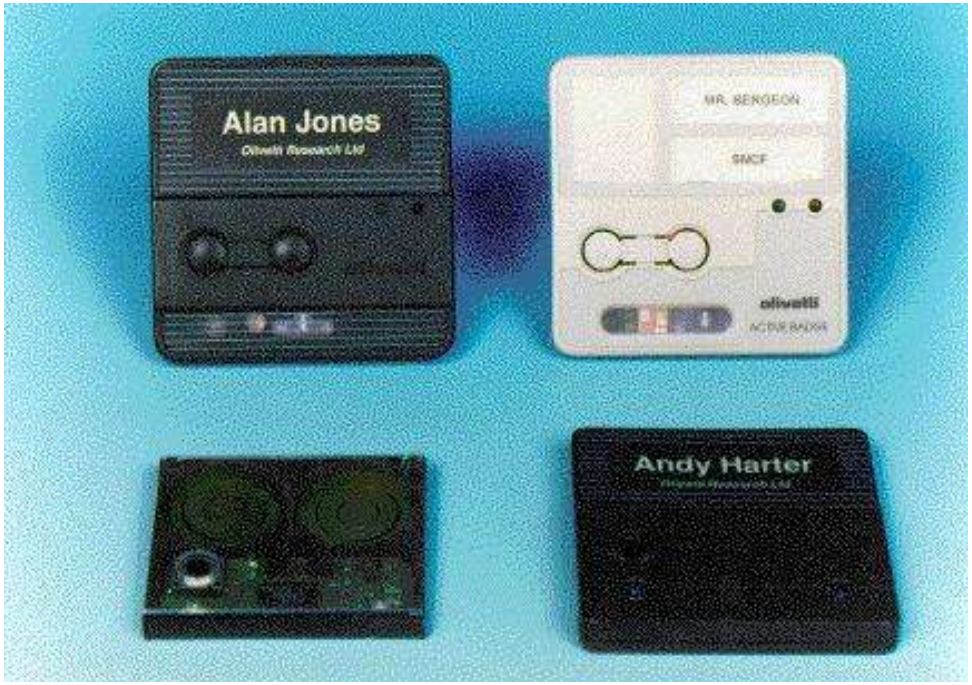
- Context is acquired from non-traditional devices
- Context must be abstracted to make sense
- Context may be acquired from multiple distributed and heterogenous sources
- Context is dynamic

Ubiquitous computing systems

- Todays ubiquitous computing systems are mostly not usable for any real world problems yet
- But they provide building blocks for useful applications in the future
- The selection of the following sample systems is arbitrary and by no means complete

Active Badges

- Active badges were developed between 1989 and 1992
- Badges send out infrared signals
- A network of detectors inside a building locates the badges
- When all employees carry an active badge, it is possible to locate their positions
- Phone calls can be routed to the closest phone

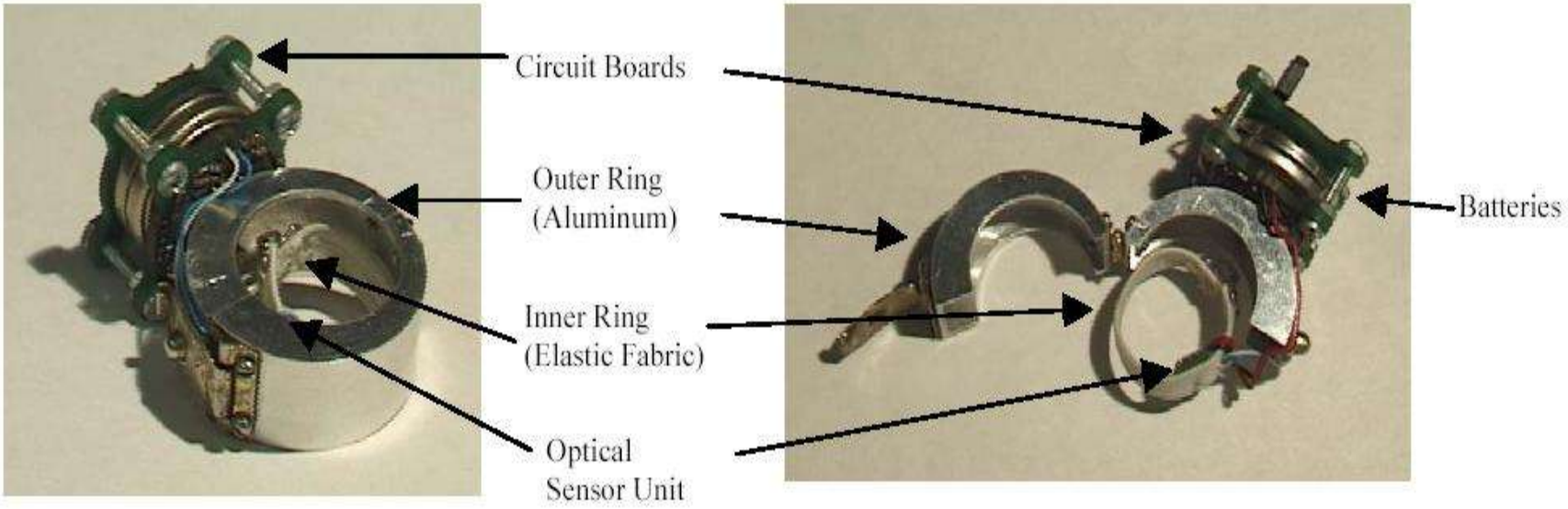


Active Badges (2)

- A signal is sent only every 15 seconds
  - Less power consumption
  - Less chance of interfering with other badges in the same room
  - People move slowly enough for the system to still be accurate
- When placed in a dark surrounding, the badge is switched off
  => No power switch needed
- Privacy concerns

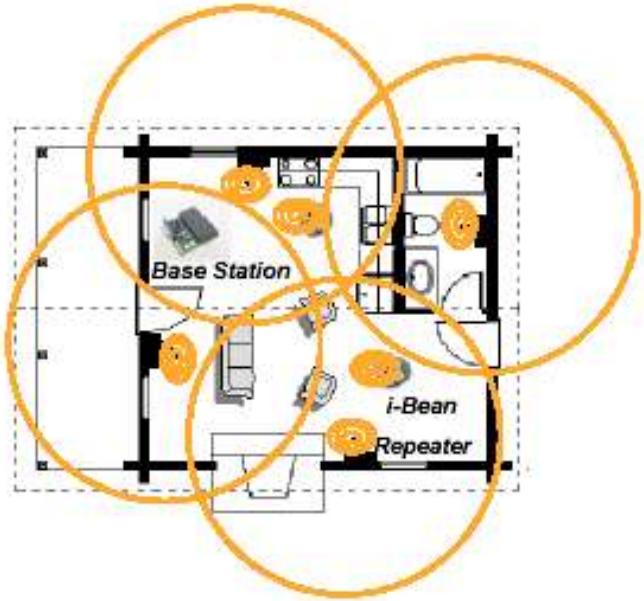
i-Bean

- Wireless sensor device
- Attached to a persons ring finger
- Measures arterial blood volume waveforms and blood pressure
- Can be used for long-term monitoring of vital signs



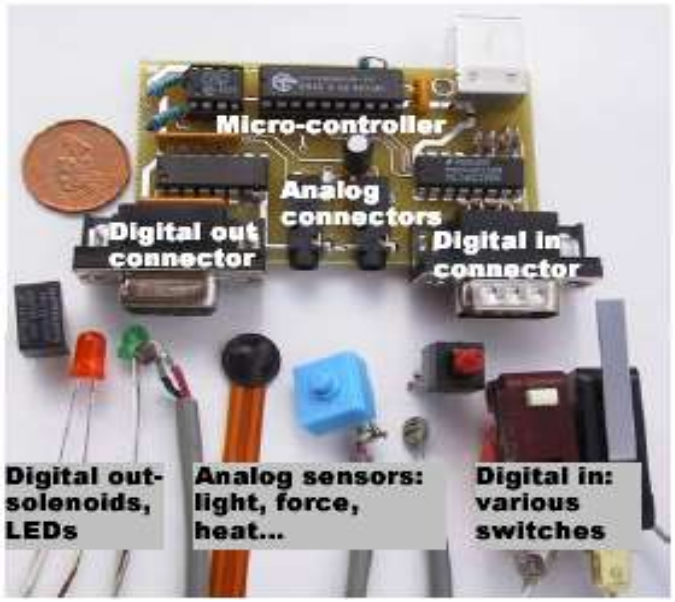
i-Bean (2)

- To allow for low power consumption a repeater network is used
- The data from one or several i-Beans is dynamically routed using the shortest path available
- The form of a finger ring makes it more comfortable to wear the sensor for extended periods of time



Phidgets

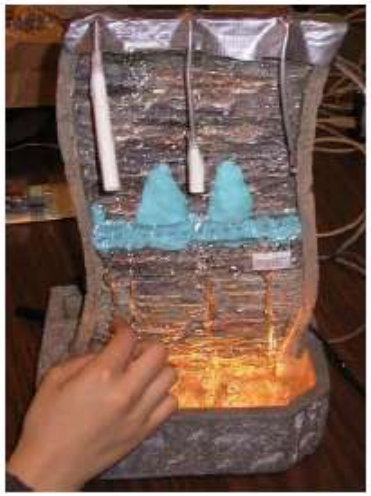
- Phidgets try to build a physical analogy to graphical user interface widgets:
- Easy to use building blocks to create physical user interfaces:
  - Sensors and actors are attached to a computer via USB
  - API can be used from standard programming languages

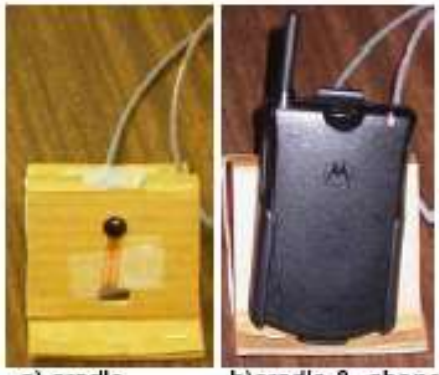


Phidgets (2)

- Special requirements for Physical Widgets:
  - Connection manager
  - Identification
  - Simulation mode

- Some interfaces built with Phidgets:





a) cradle b)cradle & phone

c) missed calls dial

Project Aura

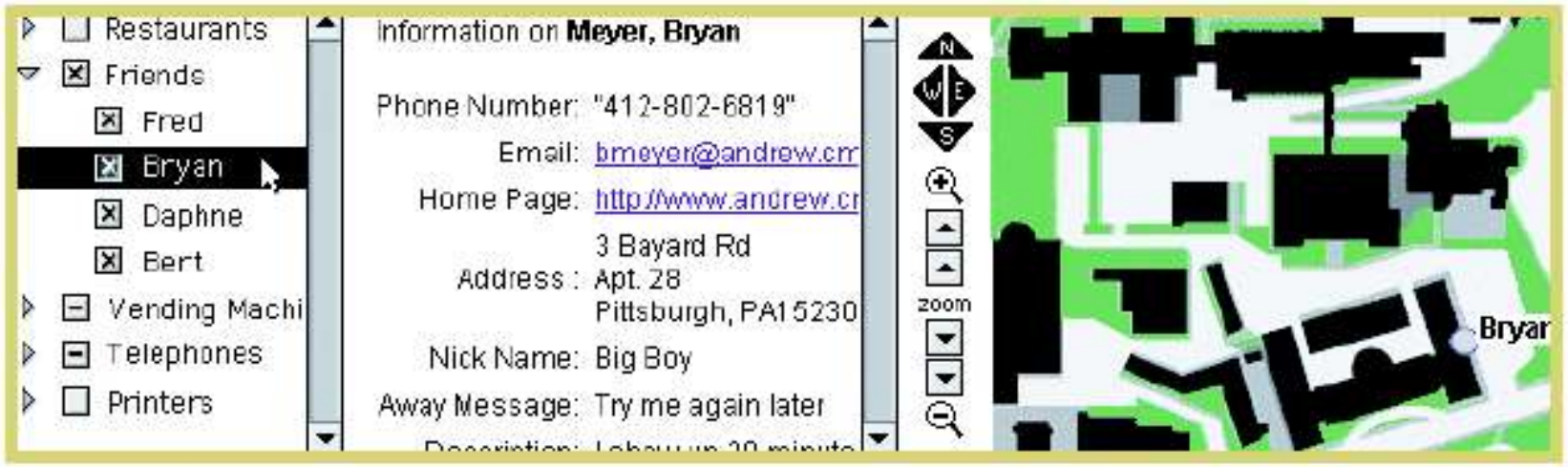
- Hardware and software for ubiquitous computing is available
- The challenge is the integration of the existing technologies
- Basic principles:
  - Proactivity: Anticipate requests instead of only reacting
  - Self-tuning: Dynamically adapt performance to demand

Project Aura (2)

- Techniques implemented in project Aura:
  - Cyber foraging: Use staging servers to reduce the impact of end-to-end internet latency for mobile devices
  - Wireless bandwidth advisor: Estimate future available bandwidth
  - WaveLAN-based people locator: Use the signal strength and the location of access points to find the position of people

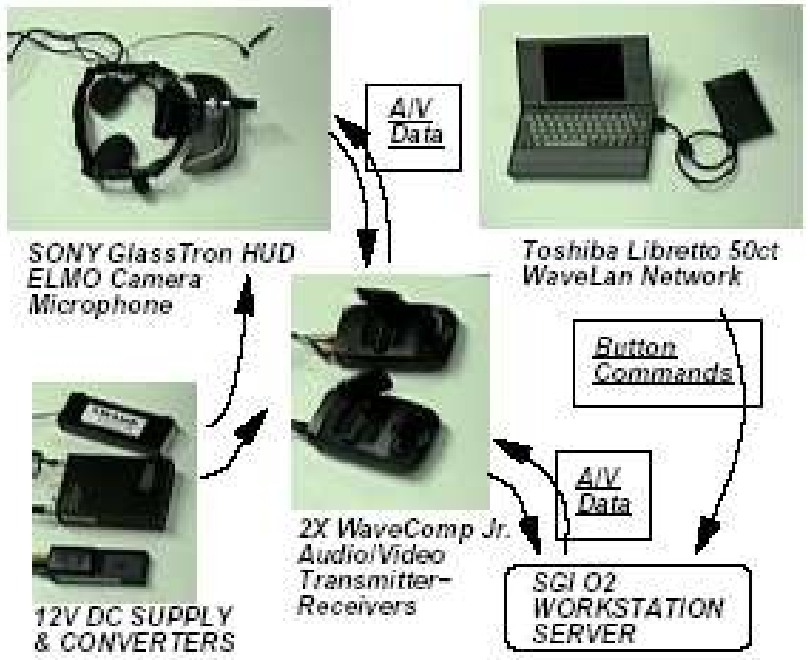
Portable Help Desk

- Portable Helpdesk is an application of project Aura
- The user can locate people and equipment close to him
- Two interfaces:
  - Graphical interface on a laptop computer
  - Audio interface using voice recognition



DyPERS: Dynamic Personal Enhanced Reality System

- Wearable system using augmented reality
- A head mounted camera and microphone can be used to record video sequences
- Theses sequences can then be associated to an object
- When a grapics workstation connected through wireless transceivers detects an object, it replays the associated video sequence



DyPERS: Dynamic Personal Enhanced Reality System (2)

- Possible uses of DyPERS:
  - A conversation could be recorded and associated with a business card
  - A TO-DO list could be stored on the users watch or other personal items
  - A story teller can associate the story to a picture book
  - A teacher could associate object with their words in a foreign language
  - Assembly instructions could be associated with the unassembled parts
  - A person with poor vision coul listen to audio descriptions of the things he is looking at

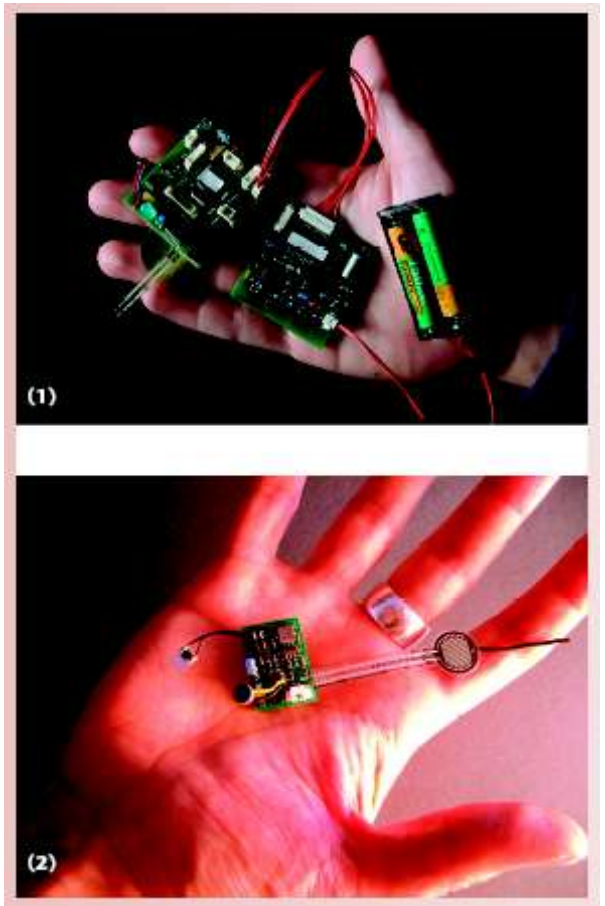
Smart-Its

- Hardware platform to aid the development of ubiquitous computing environments
- Modular approach:
  - Core-board with wireless transceiver
  - Standard sensor board for light, sound, pressure, acceleration and temperature
  - Specialized sensor boards, e.g.: gas sensor, load sensor, video camera, etc.
- Powered by batteries, depending on application they last between a few days and one year

Smart-Its (2)

- Each Smart-It can access the sensors of the Smart-Its around it

- There are different methods to request sensor data:
  - Single value
  - Condition triggered
  - Continous subscription
  - Constant stream



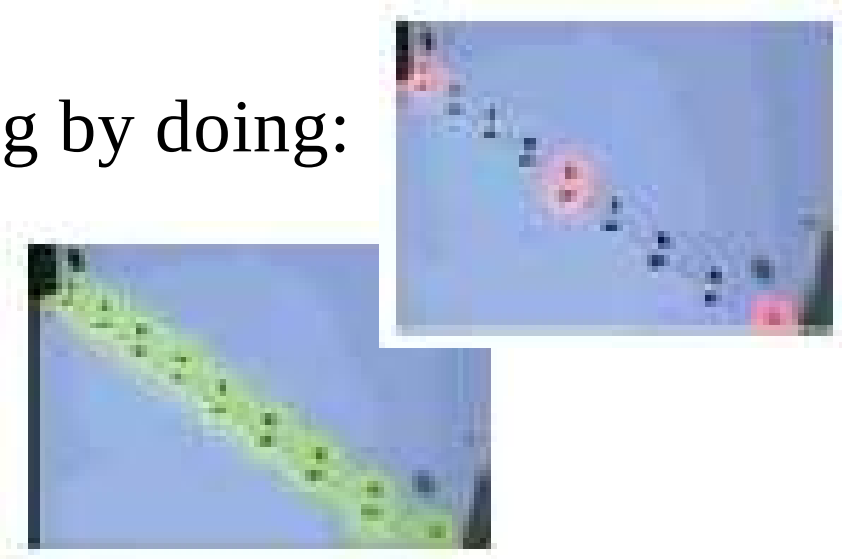
Proactive Furniture Assembly

- A piece of flatpack furniture has been augmented with Smart-Its:
  - Accelerometers to determine the orientation of the different boards
  - Force sensors to observe screw tightening
  - IR sensors to detect the co-location of boards
  - LEDs to guide the user
- The users action are observed and instructions for further assembly are given

Proactive Furniture Assembly (2)

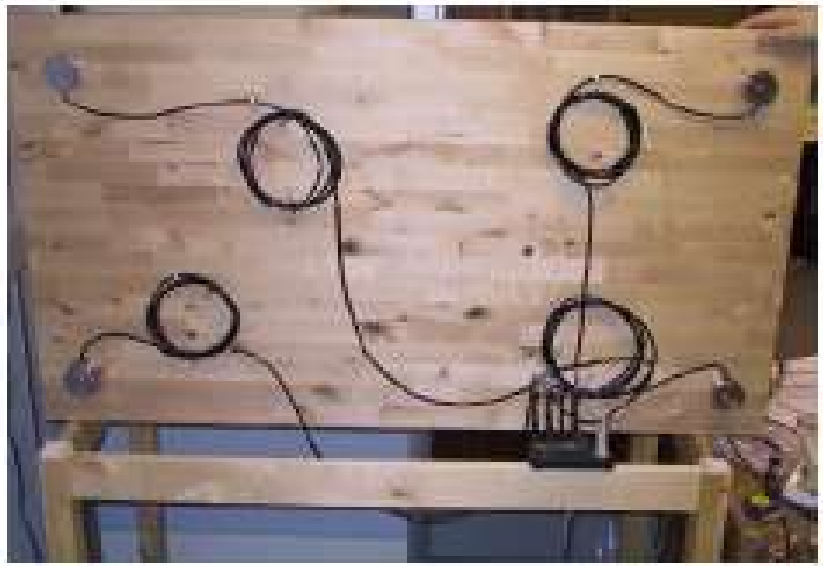
- Instructions are immediatly immersed into the furniture:
  - Blinking LEDs guide the user to the pieces to start with
  - Green or Red light patterns show correct alignment ds
  - Individual LEDs shows where screws have to be tightened
  - Synchronous flashing LEDs indicate that the task has been finished

- The system supports learning by doing:
  - Explorability
  - Predicatbility
  - Intrinsic guidance



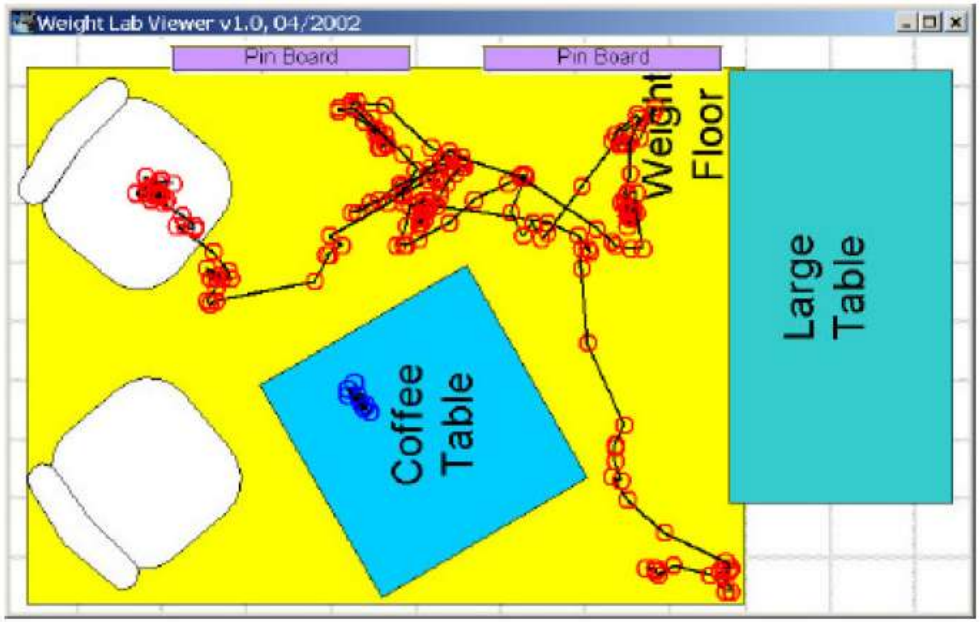
Load Sensing Furniture

- Furniture, e.g. tables or chairs can be equipped with load sensors
- Objects put down on a table can be detected, the weight can be measured
- By comparing the different loads in each corner also the position of an object on a table top can be detected
- This can even be used as a pointing device to control a mouse cursor



Load Sensing Furniture (2)

- When a whole office floor is put on load cells, the location and interaction of people in the room can be measured
- Sample application: "Don't leave your things behind"
- Warns the user if he leaves the room with less weight than he had when entering the room



A-Life System

- Smart-Its with oxygen sensors and oximeters are attached to a person at risk of being buried by an avalanche (e.g. skiers, snowboarders)
- Rescuers can use a handheld device to find the victims, but also to find out about their conditions:
  - Vital signs
  - Possible air pockets
- That way the rescue of several victims can be prioritized by urgency

Points to start a discussion

- Ethical concerns - how far should we let a computer go in making decisions for us?
- Privacy concerns - how to make sure privacy is honored in ubiquitous computing systems?
- Any *really* useful applications you can think of?