Beyond the Desktop: Pervasive and Ubiquitous Computing

IAT351
Week 10 Lecture 1
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Administrivia

- Assignment 4 out
- Final projects are in review, looking good

- TSSU pickets Wednesday, no TA in lab

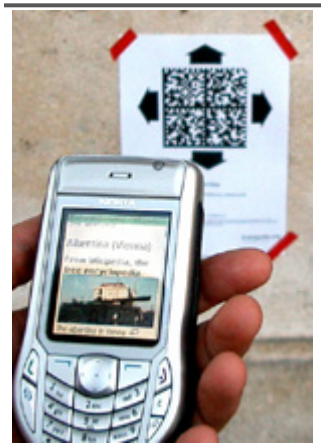
- Presentations will take the form of 5- minute madness in the last week of class

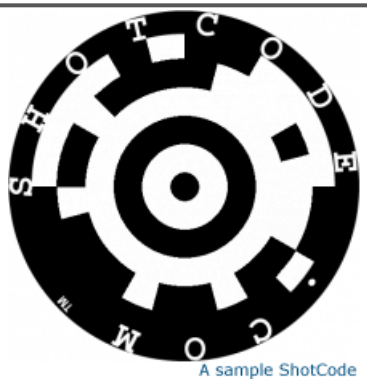
Taking computing beyond the desktop

- Make it **mobile**
- **Connect it**
- Plug it into the **ecosystem**
- **Instrument** the person
- **Instrument** the physical surroundings
- Make it everywhere – *pervasive, ubiquitous*
- Make it appropriate – *context sensitive, autonomous*

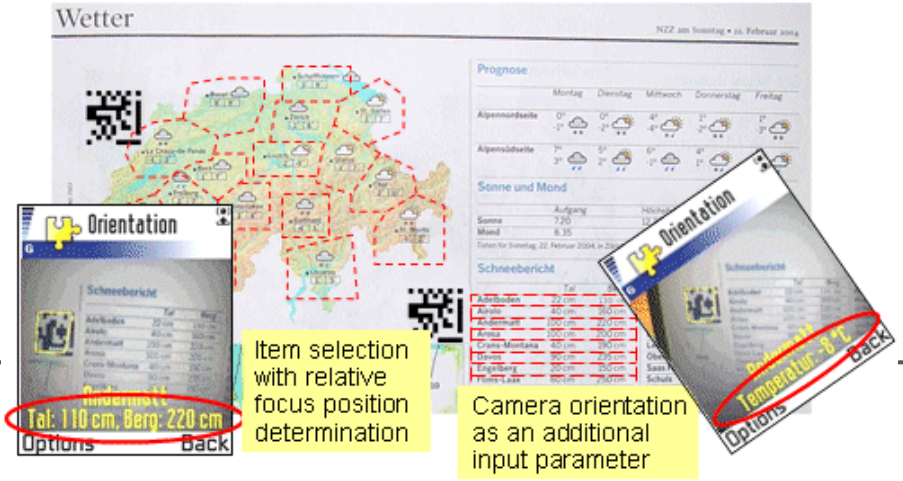
System/Service Design

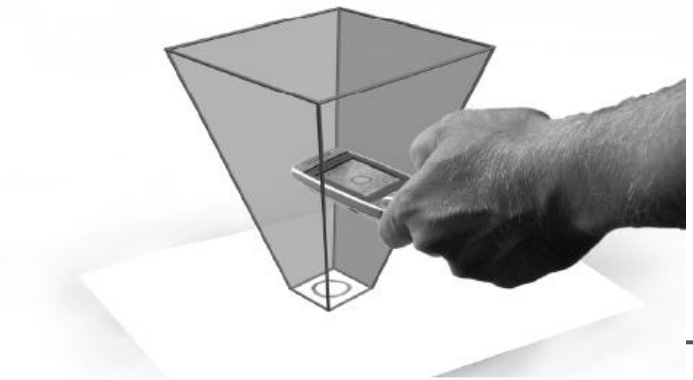
Marker Based Interactions on Camera Phones



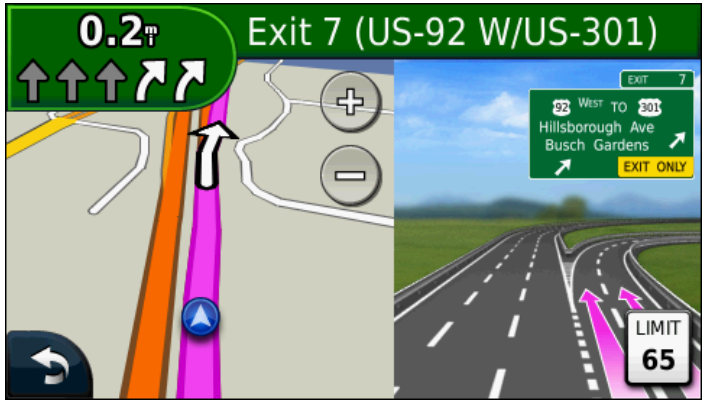


A sample ShotCode





Mixed reality interactions on mobile



Computing everywhere

- pervasive
- ubiquitous
- Context-aware
- Multimodal
- Mixed reality
- Physically diverse
  - Sometimes invisible
- Heterogeneous devices
- Connectivity/networks
- Sensors and actuators

- Usability
- Physical interaction
- Privacy
- appropriateness
- Accuracy
- Cognitive capacity
- Level of autonomy between user and machine
  - Agents
- Implicit vs explicit interaction

Pervasive Paradigms

- Mobile Interfaces
  - Phones, gps, tablets,…
- Ubiquitous Computing
  - Ratio of devices to people
  - Embedded, sometimes invisible
- Context/sensor based computing
  - Automatic doors
  - Tour guides

Pervasive or ubiquitous?

- *Pervasive computing* involves devices like handhelds -- small, easy-to-use devices -- through which we'll be able to get information on anything and everything. That's the sort of thing that Web-enabled cell phones promise.
- *Ubiquitous computing*, though, eschews our having to use computers at all. Instead, it's computing in the background, with technology embedded in the things we already use. That might be a car navigation system that, by accessing satellite pictures, alerts us to a traffic jam ahead, or an oven that shuts off when our food is cooked.

A. McRory. Pervasive? Ubiquitous? Sorry, they don't compute. Computer World, March 2000.

Ubiquitous computing

- Weiser's vision: a 3rd age of computing?

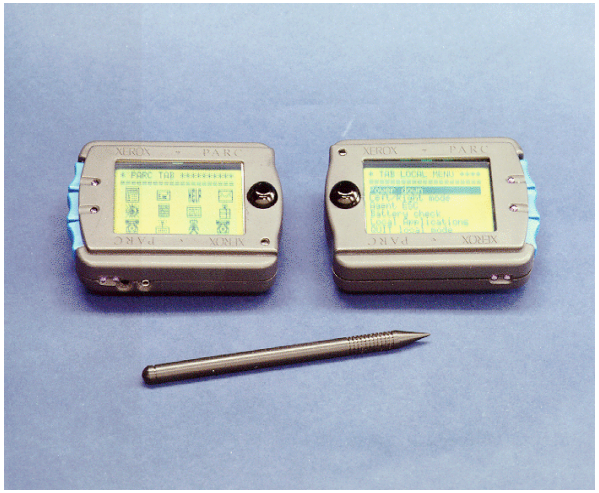
1	Centralised mainframes	1 computer many users
2	Personal computing	1 computer for each user
growth of the Internet, widespread distributed computing		
3	Ubicomp	Many computers per user

M. Wesier & J. Seely Brown (1997). The Coming Age of Calm Technology. In Denning & Metcalfe (Eds.). *Beyond Calculation: The Next 50 Years of Computing*. Springer-Verlag.
http://www.ubiq.com/hypertext/weiser/acmfuture2endnote.htm

Ubiquitous Computing 1990

Weiser et al. (1991-1999):

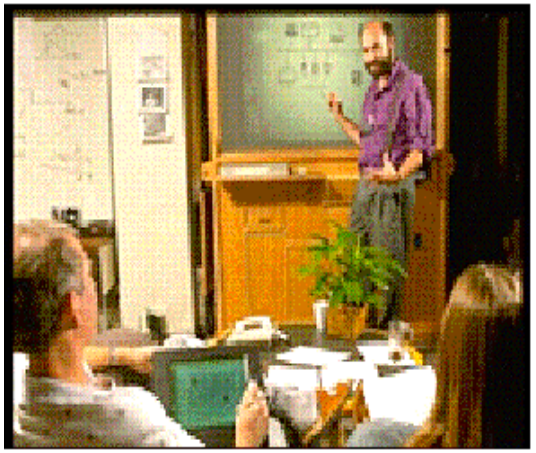
"…a physical world richly and invisibly interwoven with sensors, actuators, displays, and computational elements, embedded seamlessly in the everyday objects of our lives and connected through a continuous network."



Extreme portability. automatically turns itself on when interacting and off afterwards

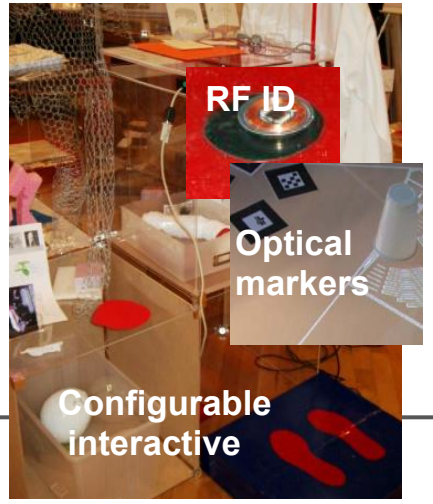
Constant connectivity. always connected to the network infrastructure.

Location reporting.



Ubiquitous Computing 2000’

- Abowd and Mynatt 2000 propose that ubiquitous computing supports the user with
  - Continuously present interface
  - Also addressing the periphery of the user’s attention
  - Connecting the physical and virtual worlds

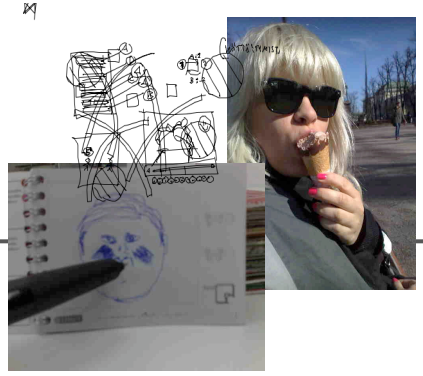


Ubiquitous Computing 2010’

- Ubiquitous computing in everyday environments
  - Fragmented ecology of many devices and “seamfulness” require the active participation and creativity of the user
  - 24/7 connectivity which now has led to the emergence of social computing, the user is not only interested in automation but self expression

MOOD: Espal Ennin kaa
SENDER: kaka-o

TIME: 2009-04-13 20:54:08
RECEIVER: publish at Atwink
PROXIMITY: tuukka koivisto, Kati Gammals



The world is computable

- Heterogeneous media
- Distributed interfaces
- Augmented (mixed) reality
- Enhanced expressiveness
- Social networking
- Context-aware
- No longer applications with GUIs but ecosystem of devices and services

Taking computing beyond the desktop

- Make it **mobile**
- **Connect it**
- Plug it into the **ecosystem**
- **Instrument** the person
- **Instrument** the physical surroundings
- **Reason about** the context

Common goals of ubicomp applications

- Transparent Interaction
  - Remove physical interface between user and the work to be accomplished via the computer
    - REPLACE manipulation interfaces
    - WITH freeform pen interaction, speech, tangible
- Context-Awareness
  - Have information about the environment in which the application operates and react accordingly
- Automated Capture
  - Capture everyday experiences and make record available for later use

Ubicomp

- Keywords/phrases from Weiser's vision:
  - 'Calm' technology
  - Disappearing, Invisible – the disappearance of technology
  - Devices in the periphery of our senses
  - The opposite of virtual reality!

- The computer is *not* the centre of attraction.
  - The best tools are (almost) invisible to their users
  - Human-human and human-computer relationships
  - Hardware and software should merge into "underware"

The purist view of Ubicomp

Ubicomp is NOT

- Virtual Reality
  - May provide and augmented or augmentable reality
- Multimedia
  - Opposite of invisibility
- “Better” HCI alone (voice input, wearables, Tangible User Interfaces)
  - Again, interaction opposes invisibility, calmness
- Intelligent agents
  - Implies a close human-computer relationship

- If there is a distinction, Pervasive is Ubicomp plus these

Ambient

- Dangling string
  - Designed by Natalie Jeremijenko, an artist
  - Small electric motor powered by network activity and attached to a plastic string
  - Visual and audible indication of network traffic

Infrastructure

- Tsubuyaku sensors detect environmental and energy conditions and tweet them

Daily objects

- Mediacup
  - Developed at TECO, Karlsrühe
  - Temperature, and movement sensors
  - IR communication with
    - Other cups
    - Coffee machine
    - Infrastructure

http://mediacup.teco.edu/overview/engl/overview.html

On a large scale

- Stanford iRoom
  - Meeting support
  - Multiple displays
  - Controlled by
    - Keyboard
    - Wireless mice
    - Handhelds

http://iwork.stanford.edu/

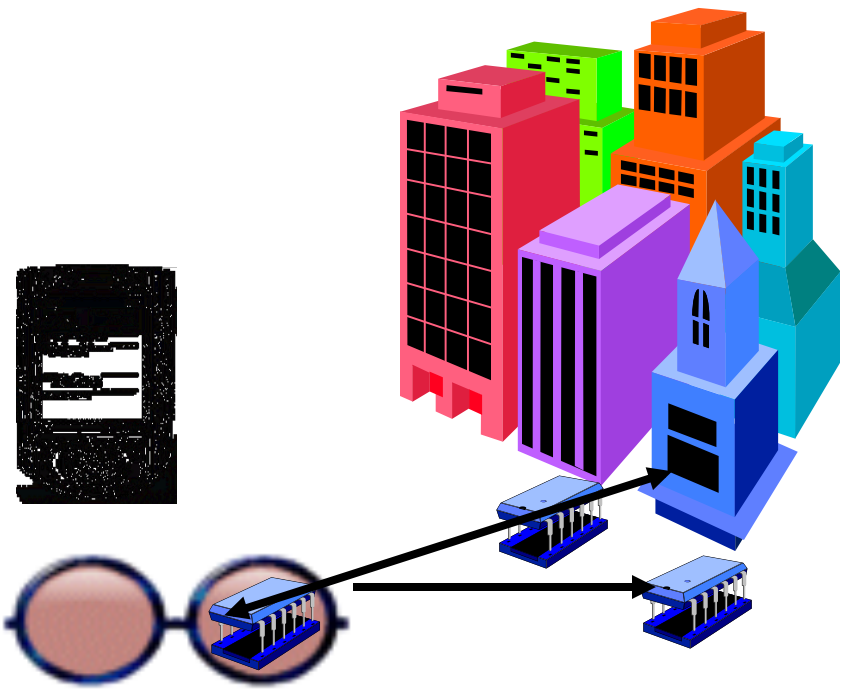
Context-Aware Computing

- Takes your current environment into account in making decisions
  - Turns off cell phone when you enter the lecture hall.
  - When you ask where to go for a meal, notes that it is morning and you are in Taipei before making a recommendation.
  - Knows who wrote on the whiteboard so a copy of the ink can be emailed to the author.
  - Plays music you like when you enter an empty elevator.
  - Notifies your doctor when your heart rate goes too high.

"Context-Aware" Computing

- Makes use of different kinds of information
  - Geographic
  - Temporal
  - Social … ?
  - Activity ?
  - Presence

Location-Aware Computing



- location-based action
  - nearby local printer, doctor
  - nearby remote phone
  - directions/maps
- location-based information
  - real
    - person's location
    - history/sales/events
  - virtual
    - walkthrough
    - story of city
  - augmented
    - touring machine

Slide from lecture by Prasun Dewan

The aware web

- hipGeo travel diary
- a location-aware platform that records and displays the places users go and how they get there
- Shares with others in same location
- Fellow traveler discovery

Location-aware marketing/eCommerce

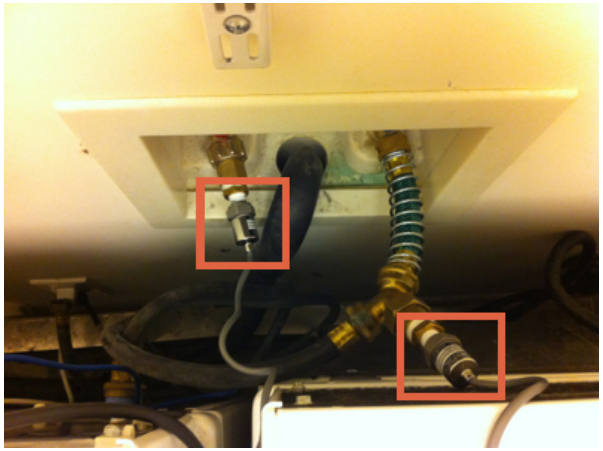
Location-aware help?

PulsePoint emergency app

Presence sensing

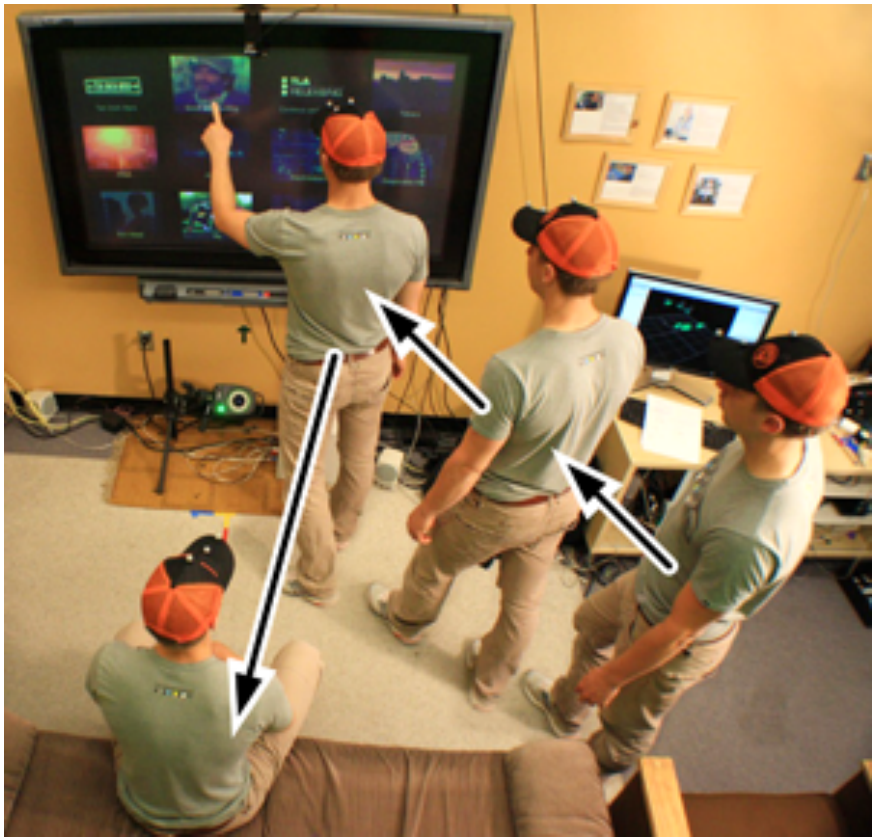
Hiam M. Khoury, Vineet R. Kamat, High-precision identification of contextual information in location-aware engineering applications, Advanced Engineering Informatics, Volume 23, Issue 4, October 2009, Pages 483-49

Activity sensing



Activity sensing through household water use, Georgia Tech, 2012

Proxemics (Ballendat, Marquardt, Greenberg)



- System adjusts behaviour based on spatial relationships
- People, devices
- Range, distance, orientation
- Digital and non-digital

Proxemics (Ballendat, Marquardt, Greenberg)

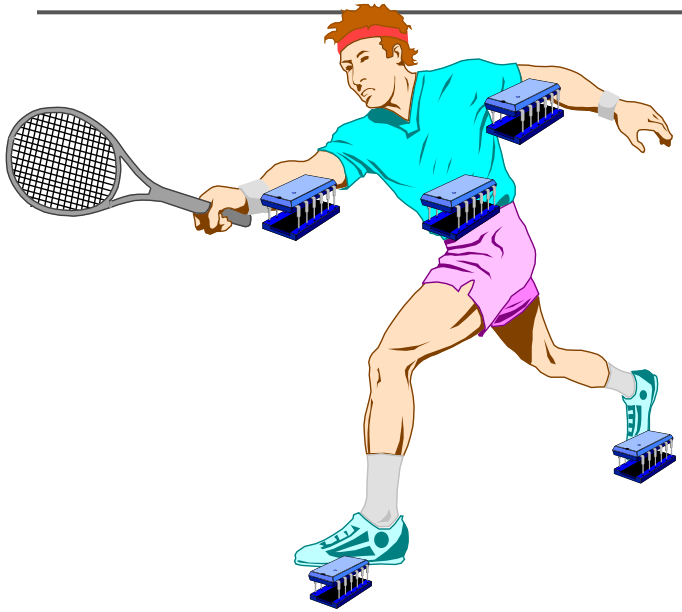
- Non-digital objects can be sensed as digital control objects
- Pen as media controller

Combining sensed data →activity assumptions

- Mute a cell phone ring when user is talking
- Make a ring louder when ambient noise is greater
- Turn off messaging alerts when people are close together

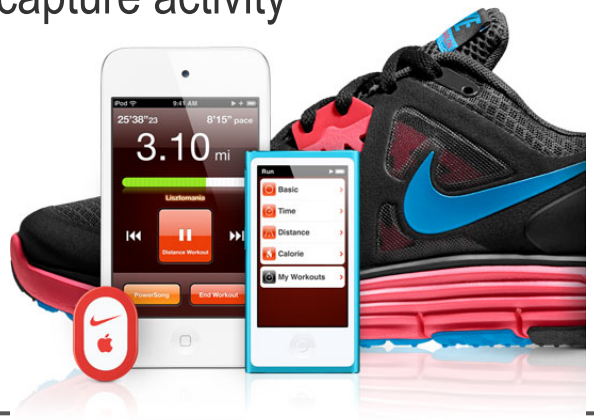
- Adjust lighting levels based on activity in room ??
  - Curse of smart homes!

Wearable Body-Aware Computers



- Computers on body
  - track body relative movements
    - monitor person
    - train person

- Track and capture activity



Slide from lecture by Prasun Dewan

Technologies

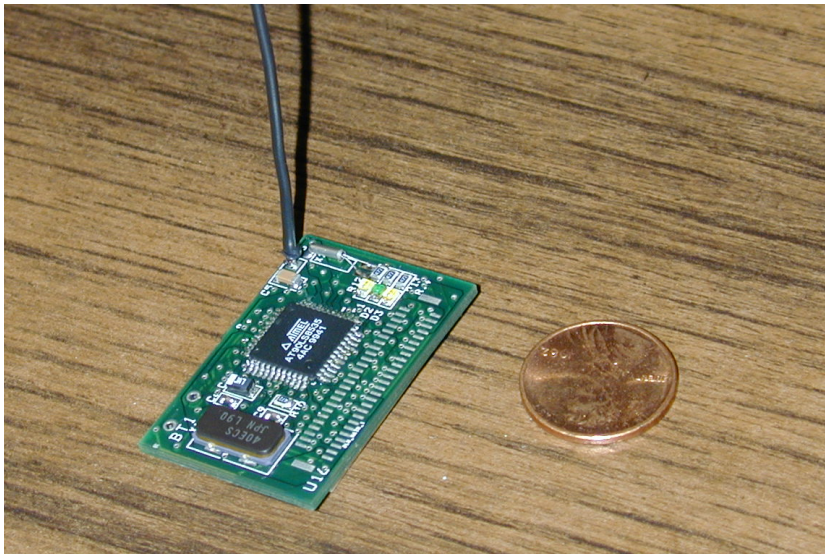
- GPS
- Geo-coding
- Cameras
- Optical recognition
- QR codes
- RFIDs
- Sensors
- networks

Captured

- Position
- movement
- Light
- Proximity
- Termperature
- pressure
- Identity
- Behaviour
- Preferences

Sensor Networks

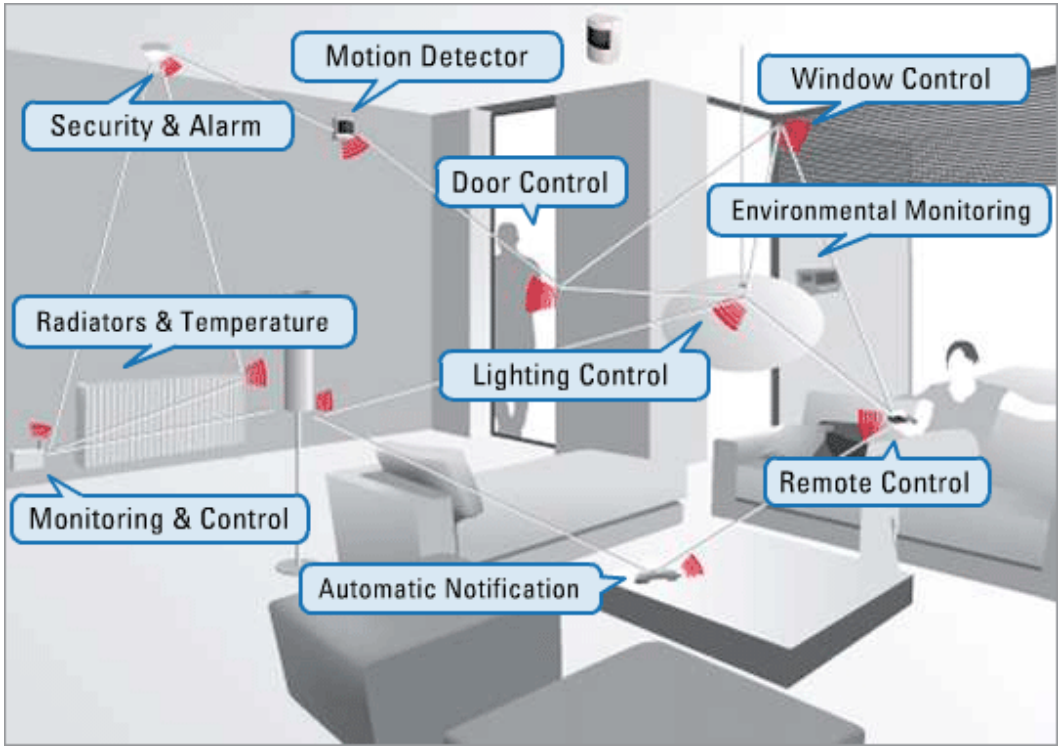
- Berkeley/Intel sensor motes: 1mm^3
- “Smart dust”
- TinyOS
- Mesh networking
  - Low power
  - relays



Slide from lecture by Anind Dey

Sensor networks and emerging protocols

- Zigbee™ communication
- Home Networks
- Appliances
- Smart meters



Emerging interaction paradigms

- Active/explicit/pro-active
- User-initiated
- “pull”
- Transactions
- “typical” applications
- QR codes
- (RFID)
- camera-mediated
  - Access
  - Representation (AR)

- Implicit/automated/reactive
- Occur due to triggering state of user
- “push”
- May be controllable (notification permissions on phone) or automated (building systems, intersections)
- Some forms of over-ride needed
- Sensors
- Camera capture
- May involve handshake with data store

Issues: The Mobile User

- Limited attention span – interactions with the real world are more important than with the device
- User's hands may be occupied
- Tasks may require a high degree of attention so as to avoid danger
- User may adopt a variety of postures and positions
- Interactions with the environment are context dependent
- Interaction with mobile device is high speed, driven by external circumstances

Issues : the invisible interface

- Privacy
- Inappropriate interruptions
- Management overhead is degrees of separation away
- Inaccuracy and side effects
  - Hardware/software problems

- How to derive the correct context?

Context Interpretation

- Sophisticated applications require higher level forms of context
  - Fusion
- Ambiguity:
  - Sensors not 100% reliable, e.g. confidence value
  - Precision / Accuracy / Granularity
  - Different ways to deal:
    - Improve inference
    - Probability/fuzzy model
    - Bring the user into the loop

System Issues (2/2)

- May need a middleware layer to decouple applications and context sensing
  - Collect raw context, translate to application-understandable format, disseminate it
- Centralized context server
- Distributed architecture

Intelligence

- Who is smart? User or system or both
- Who makes the decisions on what actions to take?
- Tradeoff between user cognitive load and effort to make system “smart”

People Issues

- Avoiding embarrassing situations
  - Active Badges + bathrooms
  - Inconvenient phone forwarding
- Avoiding dangerous situations
  - Need to take into consideration cost of mistake
  - Smoke alarms when cooking
  - Lights that turn off when you're still there
  - Woman locked in "smart toilet stall"
- Will adding more context really help here?

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People Issues

- Making it predictable and understandable
  - Setting preferences
  - "I want my cell phone to ring except in theaters and when I'm in a meeting unless…"
  - Why the heck did it do that?
- Privacy
  - What does the computer know about me? What do others know about me?
  - Capturing/collecting lots of information about people, places and devices
  - People uncomfortable when don't know what is being collected and how it's used