Roots of Ubiquitous Computing

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What?

- Integrating computers into the environment
- Coined by Marc Weiser, Xerox, ‘88
- Inspired by SciFi (Philip K. Dick story)
- Goals:
  - more natural, casual interaction with IT
  - Make computers “disappear”, “invisible”
  - While functionality is ubiquitously available
- All objects become smart & connected

Mark Weiser's vision (1988-on)

- **Best articles:**
  - **"The Computer for the 21st Century", Scientific Am. 09-91**
  - **"Some Computer Science Issues in Ubiquitous Computing" CACM 07-93**
- **"Disappearing technologies" are most profound ones**
  - **Eg writing: is ubiquitous, does not require active attention, ready for use at a glance**

Information Technology is not (yet) a "disappearing technology"

- Computer remains in world of its own, not integrated in environment
- Approachable only through complex jargon that has nothing to do with tasks being used for
- Not just UI issue, also hardware form

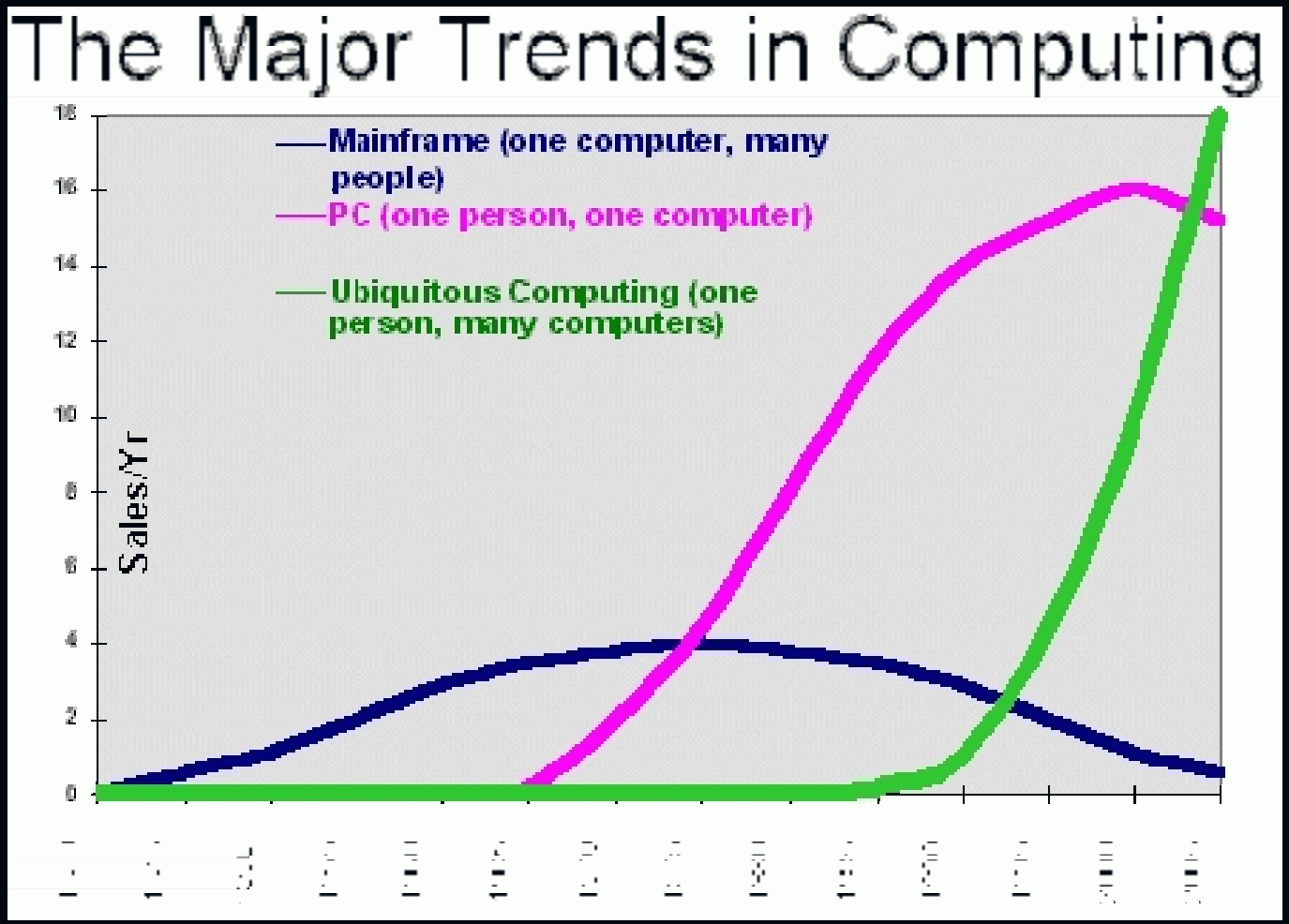
What does it mean for a technology to "disappear"?

- **Not (just) consequence of technology**
- **But of human psychology**
  - **When people learn something sufficiently well, they cease to be aware of it, they can focus beyond the technology on their (true) goals/tasks**
  - **Called "compiling" by H. Simon, or "periphery" by J. Seely Brown**

Ubiquitous computing constitutes a reversal of some other HCI trends

- **Ubiquitous computing does not mean:**
  - **Computers that can be carried everywhere (info accessible everywhere) ***
  - **Multi-media computers (using more sensors/output modalities)**
  - **Virtual reality (create a world inside the computer, rather than enhance the real world with computer data)**
  - **“Intimate” computers such as agents ***
  - **Computers one can talk to (that have Common sense)**

Weiser's waves of computing



How do technologies disappear into the background?

- **Example: electric motors becoming cheaper**
  - **From one motor/workshop to one motor/tool**
  - **Current car has 22 separate motors**
- **Many current-day computers are already invisible, proliferation of devices is taking place**

Xerox Parc Experiments in Ubiquitous Computing (88-94)

- **Focus on devices that transmit & display information**
- **Two important issues:**
  - **Location (UC's must know where they are so they can adapt their behavior)**
  - **Scale (different scales needed to suit different tasks): tabs (post-it), pads (paper) and boards**
    - **Typical room: hundred tabs, 10-20 pads, 1-2 boards, all inter-connected**

Some TAB examples

- Pressure sensitive screen, 3 buttons, location-aware, IR receiver
- Challenges: size, weight, power
- Some applications:
  - Used as active badges for people or objects
  - Tabs as extensions of computer screens (to make programs/file portable to another machine)

Some PAD examples

- Notebook-sized device, pen for writing
- Differ from conventional portable computers: intended as “scrap computers”; no individualized identity or importance; spread many around the desk, in drawers, etc
- Increase desk size of current computers (to multiple Pads)
- Applications can move from pad to pad *

Some BOARD examples

- Number of purposes: video screen, bulletin board, white board, flip chart, electronic bookcase (download things onto a PAD)
- “Liveboard”: works with wireless, electronic “chalk”, is interactive
  - permits collaboration at a distance
  - Also used as personalized bulletin boards (if user wears active badge)

=> resulted in commercial electronic whiteboards

Applications of Tabs, Pads & Boards explored at Parc

- **Location-awareness of people & things**
  - Automated call forwarding based on location of people
  - Automatic login to computers
  - Automatic diaries (eg meeting)
  - Map of activity in building and where individual people are
  - Locating objects
- **Collaboration among people**
  - Shared drawing using board or pad (pen, multiple users, multiple pages, gesture recognition, etc)

Movies of Tabs, Pads & Boards

- **http://www.ubiq.com/hypertext/weiser/UbiMovies.html**

Power of Ubiquitous Computing

- Does not come from any one device but from interaction of all of them
- Also from fact that tabs can animate inert objects
  - Beep to locate misplaced book
  - Audience feedback & participation

Technological Challenges in Ubiquitous computing

- **Cheap, small, low-power computers**
- **Wireless & ad-hoc networking ***
- **Software for ubiquitous applications ***
  - **New operating systems**
  - **Applications that can move**
  - **New interaction paradigms**

*** Hardest challenges**

Scenario

Sal awakens: she smells coffee. A few minutes ago her alarm clock, alerted by her restless rolling before waking, had quietly asked "coffee?", and she had mumbled "yes." "Yes" and "no" are the only words it knows.

Sal looks out her windows at her neighborhood. Sunlight and a fence are visible through one, but through others she sees electronic trails that have been kept for her of neighbors coming and going during the early morning. Privacy conventions and practical data rates prevent displaying video footage, but time markers and electronic tracks on the neighborhood map let Sal feel cozy in her street.

Glancing at the windows to her kids' rooms she can see that they got up 15 and 20 minutes ago and are already in the kitchen. Noticing that she is up, they start making more noise.

At breakfast Sal reads the news. She still prefers the paper form, as do most people. She spots an interesting quote from a columnist in the business section. She wipes her pen over the newspaper's name, date, section, and page number and then circles the quote. The pen sends a message to the paper, which transmits the quote to her office.

Electronic mail arrives from the company that made her garage door opener. She lost the instruction manual, and asked them for help. They have sent her a new manual, and also something unexpected -- a way to find the old one. According to the note, she can press a code into the opener and the missing manual will find itself. In the garage, she tracks a beeping noise to where the oil-stained manual had fallen behind some boxes. Sure enough, there is the tiny tab the manufacturer had affixed in the cover to try to avoid E-mail requests like her own.

On the way to work Sal glances in the foreview mirror to check the traffic. She spots a slowdown ahead, and also notices on a side street the telltale green in the foreview of a food shop, and a new one at that. She decides to take the next exit and get a cup of coffee while avoiding the jam.

Once Sal arrives at work, the foreview helps her to quickly find a parking spot. As she walks into the building the machines in her office prepare to log her in, but don't complete the sequence until she actually enters her office. On her way, she stops by the offices of four or five colleagues to exchange greetings and news.

Scenario (cont.)

Sal glances out her windows: a grey day in silicon valley, 75 percent humidity and 40 percent chance of afternoon showers; meanwhile, it has been a quiet morning at the East Coast office. Usually the activity indicator shows at least one spontaneous urgent meeting by now. She chooses not to shift the window on the home office back three hours -- too much chance of being caught by surprise. But she knows others who do, usually people who never get a call from the East but just want to feel involved.

The telltale by the door that Sal programmed her first day on the job is blinking: fresh coffee. She heads for the coffee machine.

Coming back to her office, Sal picks up a tab and "waves" it to her friend Joe in the design group, with whom she is sharing a virtual office for a few weeks. They have a joint assignment on her latest project. Virtual office sharing can take many forms--in this case the two have given each other access to their location detectors and to each other's screen contents and location. Sal chooses to keep miniature versions of all Joe's tabs and pads in view and 3-dimensionally correct in a little suite of tabs in the back corner of her desk. She can't see what anything says, but she feels more in touch with his work when noticing the displays change out of the corner of her eye, and she can easily enlarge anything if necessary.

A blank tab on Sal's desk beeps, and displays the word "Joe" on it. She picks it up and gestures with it towards her liveboard. Joe wants to discuss a document with her, and now it shows up on the wall as she hears Joe's voice:

"I've been wrestling with this third paragraph all morning and it still has the wrong tone. Would you mind reading it?"

"No problem."

Sitting back and reading the paragraph, Sal wants to point to a word. She gestures again with the "Joe" tab onto a nearby pad, and then uses the stylus to circle the word she wants:

"I think it's this term 'ubiquitous'. Its just not in common enough use, and makes the whole thing sound a little formal. Can we rephrase the sentence to get rid of it?"

"I'll try that. Say, by the way Sal, did you ever hear from Mary Hausdorf?"

"No. Who's that?"

"You remember, she was at the meeting last week. She told me she was going to get in touch with you."

Sal doesn't remember Mary, but she does vaguely remember the meeting. She quickly starts a search for meetings in the past two weeks with more than 6 people not previously in meetings with her, and finds the one. The attendees' names pop up, and she sees Mary. As is common in meetings, Mary made some biographical information about herself available to the other attendees, and Sal sees some common background. She'll just send Mary a note and see what's up. Sal is glad Mary did not make the biography available only during the time of the meeting, as many people do...

Hard Issues

- **Privacy (e.g. one rogue tab recording things)**
  - **Decentralisation of data (eg location of person stored on that person's machine)**
  - **Encryption**
- **Access, visibility & control**
- **Ubicomp requires difficult integration of human factors, computer science, engineering and social sciences to create new kind of relationship of people to computers**

State of Ubiquitous Computing (15 yrs)

- Lots of labs focused on Ubicomp
- Conferences:
  - Ubicomp
  - Mobiquitous
  - Pervasive Computing
  - …
- Journals:
  - IEEE Pervasive Computing journal
  - Springer Personal & Ubiquitous computing journal
  - …

Many approaches/foci

- Smart rooms
- Ambient Displays
- Tangible Computing
- Smart (connected) objects
- Mobile computing/Pervasive Computing
- Augmented Reality
- Mixed Reality
- Context-Aware Computing
- …

Smart Rooms

- **Ex. Stanford's iRoom**
- http://iwork.stanford.edu/pubs/iclub-300mb.mov
- http://iwork.stanford.edu/photos.shtml#iroomintro

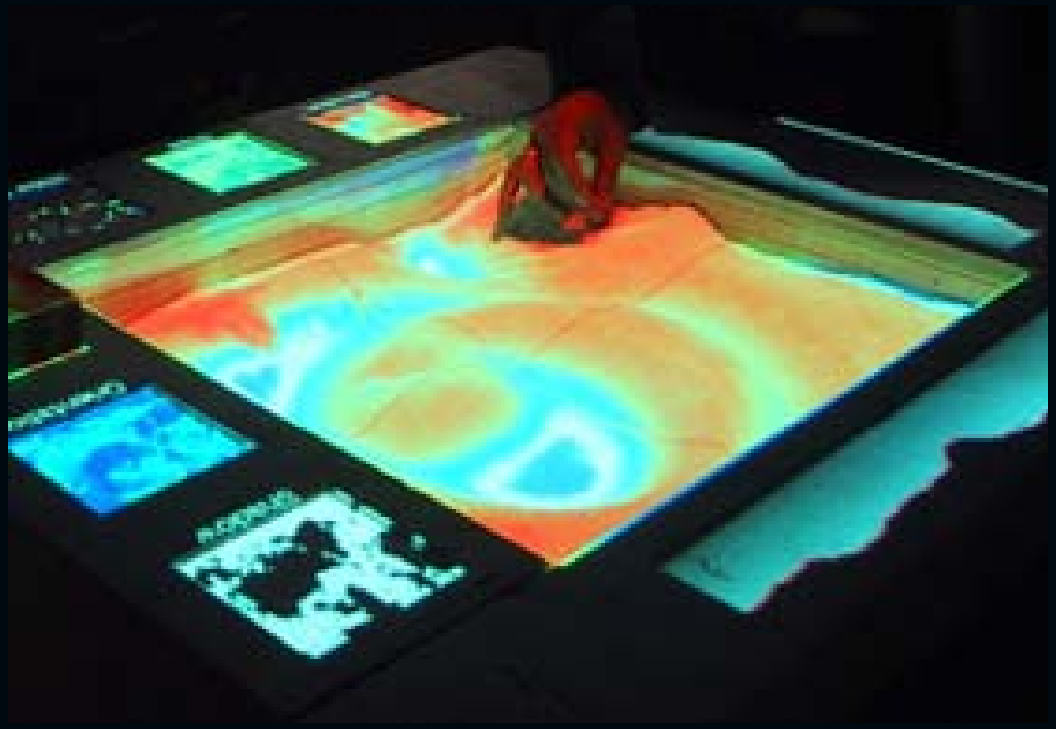
Ambient Displays

CARL ZAFF FOR TIME

MOOD OF THE MARKET

The Ambient Orb may look like a crystal ball on acid, but it's really more of a giant mood ring—plugged straight into the fluctuations of the stock market or anything else you care to track. The orb can be wirelessly configured to track any individual stock, any market index or your personal portfolio. It glows in shades ranging from bright green (when stocks are doing extremely well) to yellow (things are quiet) to bright red (avoid open windows). But those are just the standard settings. The $299 orb, made by Ambient Devices, based in Cambridge, Mass., can alert you in colors you choose to any information that can be constantly updated online, from the water temperature in Maine to your mom's blood pressure. "People want information, but they don't want to invest a lot of time in getting it," says Ambient president David Rose. "This makes getting information a 'glanceable' thing."

Tangible Computing



http://tmg-video.media.mit.edu/sandscape/sandscape_352x240.mpg

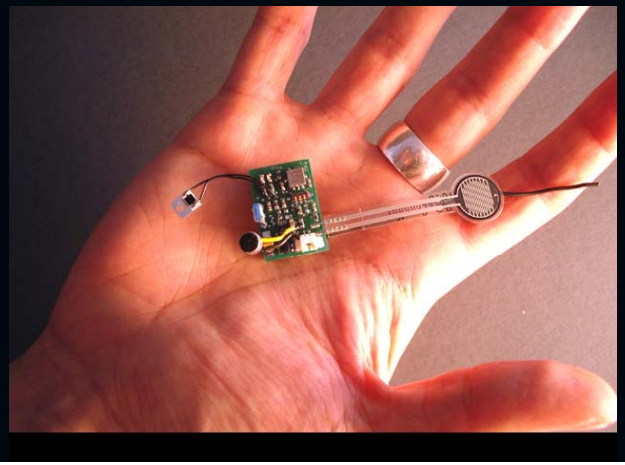
Mixed Reality

- **Physical & digital objects can co-exist & interact in real-time**
- **Focus on workspaces & documents**
- **Examples**
  - **digital desk (Wellner): http://video.google.com/videoplay?docid=5772530828816089246&q=digital+desk**
  - **Interactive desk (Hitachi)**
  - **Electronic tags (eg Roy Want and others)**
  - **…**

Smart (Connected) Objects

- **Focus is on generic platforms (HW/SW) for attaching computation, sensing & networking to artefacts**
- **Ex: smart-its**

  http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=1255810



Mobile Computing/Pervasive Computing

Augmented Reality

Context-Aware Computing

- **Interface adapts based on situation (what, how, where, who)?**
- **Focus so far primarily on location-aware computing**
- **Eg city guides, museum guides, etc**

State of Ubiquitous Computing

- **Evaluation**
  - **Lots of predictions came true:**
    - **Proliferation of devices (cell phone, PDA, laptop, desktop, …)**
    - **Electronic Whiteboards**
    - **[Pen Pads]**
  - **But current technology is far from "invisible" and one device is still used for many functions; radical change in HCI has NOT happened yet**
  - **A lot of Ubicomp research is not true to**

Pros of Ubiquitous Computing

- **UC does not pose barrier to personal interactions**
- **UC makes computer “get out of the way”, direct interaction with domain**
- **Obtaining info on things is trivial**
- **Everything is easier/faster to do**
- **Will improve computer access**
- **Helps overcome information overload problem (machine fits human environment, info available at fingertips)**

Limits/Cons of Ubiquitous Computing

- **The current computer is:**
  - **Generic**
  - **Adaptive**
  - **Programmable (extensible)**
  - **A tool for modeling/simulation**
- **Space**
- **Cost**
- **…**

Will UC become the dominant HCI metaphor (by 2010 acc. to Weiser)?