An Introduction to Ubiquitous Computing

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Computer Technology Trends
Computers: Size + Number

Le Grand Napoleon

One Computer for many people

One Computer for everyone

Many Computers for everyone

adapted from: F. Mattern, Dagstuhl 2002
Size + Number: What’s next?

Coursework:
Fill this space!
Submit to
hwg@comp.lancs.ac.uk
Yesterday’s Computers filled Rooms

IBM Selective Sequence Electronic Calculator, 1948
So will Tomorrow’s!

IBM Selective Sequence Electronic Calculator, 1948
What makes this possible?

- **Microprocessors** so small that they can be embedded in practically everything
- **Storage** so inexpensive and dense that it can be provided everywhere
- **Wireless networking** for inexpensive short-range connectivity
- **New materials** for new forms of appearance (e-ink, flexible displays, conductive fibers etc)
Scaling down

IBM WatchPad 1.5

Stanford Embedded Web Server

Xerox PARC Keychain Computer
IBM WatchPad 1.5

- Bluetooth module (band joint)
- IrDA port
- 320x240 B/W LCD
- Touch panel
- Battery terminal (right side)
- Microphone
- 3 Buttons
- Fingerprint sensor
- Piezo speaker bottom
- Accelerometer on board
- Stem switch
- Vibrator around here
Moore’s Law

Exponential Increase

- Transistors per die
- “Processing speed and storage capacity double every 18 months”
- Cheaper, smaller, faster
- Similar for communication bandwidth
- Expected to hold at least for another 10 years
Moore’s Law
Electronics, April 1965

Cramming more components onto integrated circuits

With unit cost falling as the number of components per circuit rises, by 1975 economics may dictate squeezing as many as 65,000 components on a single silicon chip.

By Gordon E. Moore
Director, Research and Development Laboratories, Fairchild Semiconductor division of Fairchild Camera and Instrument Corp.

"... has increased at a rate of roughly a factor of two per year (see graph [...]). Certainly over the short term, the rate can be expected to continue, if not to increase. Over the longer term, the rate is a bit more uncertain, although there is no reason to believe it will not remain nearly constant for at least 10 years. That means by 1975 ..."
Moore’s Law
Electronics, April 1965

The future of integrated electronics is the future of electronics itself. The advantages of integration will bring about a proliferation of electronics, pushing this science into many new areas.

Integrated circuits will lead to such wonders as home computers—or at least terminals connected to a central computer—automatic controls for automobiles, and personal portable communications equipment.
Not everything obeys Moore’s Law!

People don’t!

- Human attention is a limited resource
- People’s willingness to devote bigger mind share to computing concerns is not likely to increase
- Past: computing time shared by many people
- Future: human time shared by many computers
Interacting with Computers

Current Paradigm:
Personal Computing
- explicit use, “sessions”
- undivided attention

Need Paradigm Shift!
The Ubiquitous Computing Vision
Weiser’s Vision

Mark Weiser (1952-1999)

• “Father of Ubicomp”
• Chief Technologist at Xerox PARC
• began Ubiquitous Computing Project at PARC in 1988
Weiser’s Vision

Ubiquitous Computing

• Mass-deployment of computing in everyday life („move into the everyday, the small and the invisible”)

• „...[the] next generation computing environment in which each person is continually interacting with hundreds of nearby wirelessly connected computers. The point is to achieve the most effective kind of technology, that which is essentially invisible to the user ... I call this future world Ubiquitous Computing”.
Ubiquitous Computing

Some key points in Weiser’s Vision

- **Contrasting virtual reality**: embed computers in the real world, not the real world in the computer

- **Challenging the Personal Computing paradigm**: too focussed on the machine as opposed to the task

- **Suggesting Ubicomp as a New Era of Computing**, reconsidering the place of computers in our lives.
Ubiquitous Computing

Some key points in Weiser’s Vision

• Key challenge: to overcome the disconnection of computers from the real world situations in which they are used

• “The idea for UC first arose from contemplating the place of today’s computer in actual activities of everyday life. [...] studies of work life teach us that people primarily work in a world of shared situations [...] However the computer today is isolated and isolating from the overall situation, and fails to get out of the way of the work.”
A New Era of Computing

Paradigm Shift in Interaction with Computers

Mainframe Era
- batch processing

PC Era
- direct manipulation

Ubicomp Era
- situated interaction

HWG 20
From Mainframe to PC: “Human Integration”

Mainframe Computing
• Machine-defined user interface
• Shared use
• Requiring Preparation

Paradigm Shift to Personal Computing
• Taking the Human in the Loop
• User interface software as main concern
• Human-Computer Interaction as discipline
**From PC to Ubicomp: “Physical Integration”**

**Personal Computing**
- Direct manipulation
- Isolated: not aware of context
- Isolating: Monopolizing attention

**Paradigm Shift to Ubiquitous Computing**
- Taking context of human-computer use into the loop
- Context: “what surrounds”
  - i.e. the location, the environment, the user’s activity, the situation
Physical Integration
Physical Integration

A Broad Concept

- Anything that relates computer use to physical circumstance
- Many ways in which we can think about physical integration
  - Location- and context-awareness: modelling the environment in the computer
  - Situated computing: directly linking computer services to real situations
  - Digital Presence: giving physical entities a digital presence
  - Tangible interaction: merging interaction with manipulation of physical world
Location-aware Computing

Location is universal

- Everything has a location: people, places, things, activities, events, situations
- Location information can be wonderfully processed in computers
  - powerful index to occurrences in the physical world
  - Geometric and symbolic modelling, location arithmetics and spatial reasoning

"if a computer merely knows what room it is in, it can adapt its behavior in significant ways without requiring even a hint of artificial intelligence" (M. Weiser)
Location-aware Computing

**Active Badge Project**
- ORL Cambridge, 1988-
- Indoor Location System
- Pioneered use of location in interactive applications

**ParcTab Project, Xerox PARC**
- Tab Computers with location infrastructure
- Inferring: user location, proximity of resources,...
- various applications
Location-aware Computing: Privacy

Big Brother, pinned to your chest

Business Week '92

Track People with Active Badges

New York Times '92

Badges monitor staff

Glamour Mag '93

PC World '90

Orwellian Dream Come True: A Badge That Pinpoints You

By Lorraine Kline

Visions of an electronic sweatshop.

By Karen Flowers, editor of the New York Times, the badge becomes the focal point of the ultimate surveillance system. It allows the company to track a worker's location down to the second, even when the employee is not in the office. The badge also monitors the worker's work habits, such as the time spent in front of the computer, the number of phone calls made, and the frequency of breaks. This information is then used to adjust the worker's schedule and productivity.

By Caroline Jones

The badge, which measures about 3 inches square, is clipped onto a belt around the worker's waist. It contains a microchip that transmits data via radio waves to a central computer system. The system is capable of tracking a worker's location within a 100-yard radius of the company's campus.

By John S. Carroll

The badge is a key component of the company's new security system, which also includes surveillance cameras and motion detectors. The badge's data is used to create a detailed profile of each worker's habits, including the times they arrive and leave the building, the duration of their breaks, and their work habits.

By Mark Anderson

The badge is part of a larger trend towards increased surveillance and control in the workplace. As companies seek to increase productivity and reduce costs, they are turning to technology to monitor their employees. The badge is just one example of how companies are using technology to track and control their workers.
Context-aware Computing

Beyond location

- Modelling user activity and situation
- Context acquisition
  - Sensor integration, perceptual computing
  - New type of sensing problem: associating sensor observations with user-level context
  - User activity: unstructured and unbound
- Context-aware applications
  - Associating observations with behaviour
  - Dealing with uncertainty
Context-aware Computing

TEA Mobile Phone
(Karlsruhe/Starlab/Nokia, 1998-2000)

Phonebook with dynamic context information
Situated computing

Context-aware vs. Situated

- Context-aware: acquire context continuously, react to it
- Situated: anchor service in particular situation
- iLink example
iLink, Accenture
Digital presence

Real World Entities with Digital Presence

- Context-aware: probing into the physical world
- Digital Presence: real things as “server” with information about themselves

Cooltown, HP Labs

- “Web Presence for People, Places, Things”
- Extending the Web to the Real World
  - the web maintains links between people, places, things as context for services
- New services based on queries that concern real places, real people, real things
Tangible Interaction

Physical Interaction Experience

- Physical affordances: suggesting and guiding action
- Spatial organisation of action/communication
- Ambient interaction: “spatial attention model”

- Blurring the difference between action in the real world and interaction with computers
Bishop’s Marble Answering Machine

- Physical interaction with digital information
Wellner’s Digital Desk

- Why a desktop metaphor when you can have a real desktop
- Seamless transitions: physical and digital interaction
Summary

- Technology trend vs. human attention to computing concerns
- Ubicomp: a new paradigm for interaction with computers
- Physical Integration: connecting computers to the physical reality in which they are used

- Can we integrate computers in their environment, so they become almost indistinguishable from it?
  - “Examples of the Disappearing Computer”
Readings

Weiser’s Vision

Related Material

Physical Integration