Some Computer Science Issues in Ubiquitous Computing

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Background

Mark D. Weiser (1952 ~ 1999)

- Chief Scientist at XEROX PARC*
- Father of Ubiquitous Computing
  - Coined the term "ubiquitous computing" in 1988

"In the 21st century the technology revolution will move into the everyday, the small and the invisible…"

"The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it"

**PARC: Palo Alto Research Centre Incorporated*

Ubiquitous Computing

- Next generation computing environment/framework

- GOAL
  - Interacting with hundreds of
    - nearby
    - wirelessly
    - interconnected computers
  - Invisible to the user
    - Disappearing from user's awareness

- "intimate computer"
  "rather like a human assistant"

Ubiquitous Computing Principles

- The purpose of a computer is to help you do something else
- The best computer is a quiet, invisible servant
- The more you can do by intuition the smarter you are; the computer should extend your *unconscious*

From one of his talk “Computer Science Challenges for the Next 10 Years”
Weiser, Mark (Nov. 1, 1996)
Youtube: *https://youtu.be/7jwLWosmmjE*

XEROX PARC Prototypes

- Inspired by everyday life objects which capture or convey information
- New kind of computer
  - Concrete information conveyer
  - Many sizes & shapes
  - Inexpensive
- 3 different sizes of devices
  - **Tab** analogous to tiny individual notes, post-it
  - **Pad** analogous to scrap paper, cluttered office desk, messy front-hall table
  - **Board** analogous to office whiteboard, home magnet-covered refrigerator, bulletin board

XEROX PARC Prototypes

Live Board

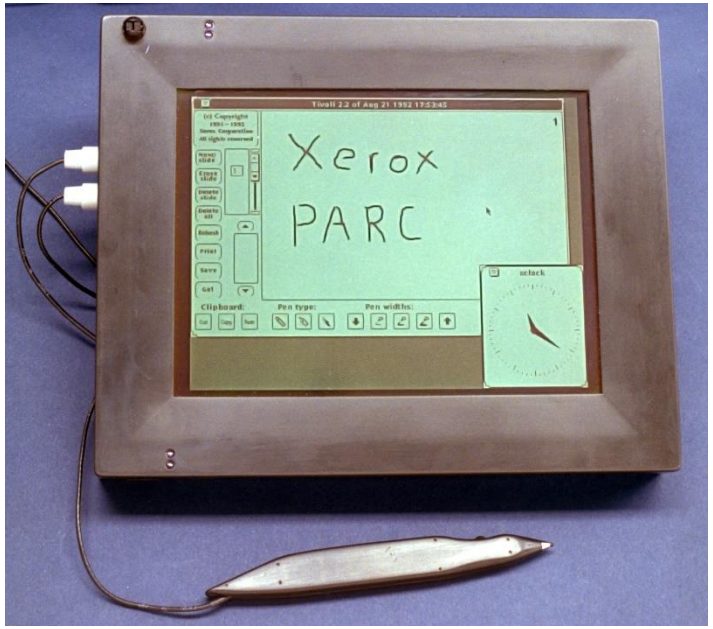
ParcTab

Source

. Liveboard (http://www.kraka.com/DesignPortfolio/liveboard.html)

. Liveboard: A large interactive display supporting group meetings, presentations and remote collaboration. Elrod, S., Bruce, R., et al. CHI'92

XEROX PARC Prototypes



ParcPad

Necessities

- Correct balance of features
- Requirements for particular features
  - Pen emphasis, connection to research environments
- Ease of expansion and modification

Source

. Liveboard (http://www.kraka.com/DesignPortfolio/liveboard.html)

. Liveboard: A large interactive display supporting group meetings, presentations and remote collaboration. Elrod, S., Bruce, R., et al. CHI'92

The Computer Science of Ubicomp

- Hardware Components
- Network Protocols
- Interaction Substrates
- Applications
- Privacy of Location
- Computational Methods

Issues – Hardware Components

- Low Power
  - High Performance vs. Power Consumption
  - Using additional chip area to reduce power *rather than to increase performance*
  - Reducing clock frequency by increasing pipelining or parallelism
- Wireless
  - Near-field radio communications
    - Reuse same frequency
    - Transceivers with low power
- Pens
  - Casual use, No training, Naturalness, Simultaneous multiple use
  - New IR(infrared) pen

$$Power \propto Voltage^2$$

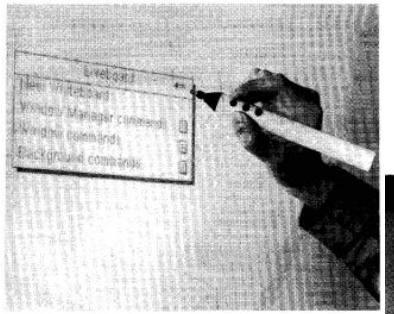


Figure 4: Popping up a menu by pressing the pen tip against the screen.

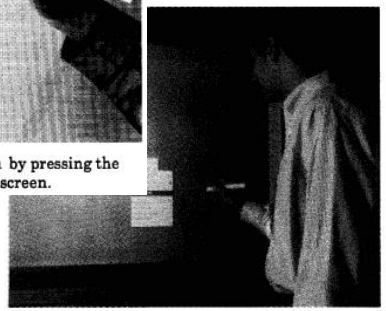


Figure 5: Operating the pen remotely to pop up a menu.

Source

. Liveboard: A large interactive display supporting group meetings, presentations and remote collaboration. Elrod, S., Bruce, R., et al. CHI'92

Issues – Network Protocols (1/2)

- Wireless Media Access
- **MACA**: Multiple Access Collision Avoidance
  - Handshake RTS (Request to Send) / CTS (Clear to Send) btw two stations
  - Fairness by back-off
  - Real-time by NCTS(n) packet type (Not Clear To Send)
    - Guarantee bandwidth for voice or video

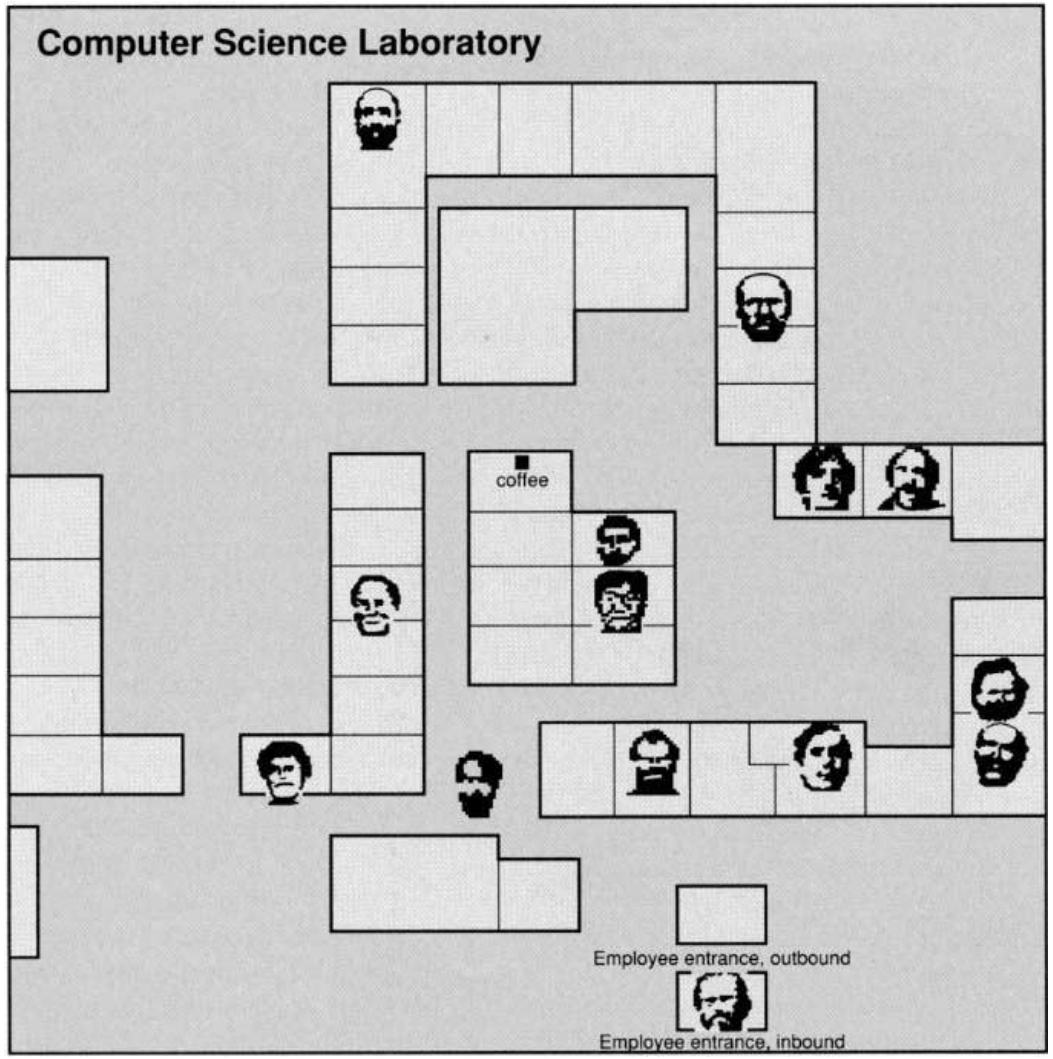
Issues – Network Protocols (2/2)

- Wide-bandwidth range
  - Supporting Gb networking
- Real-time protocols
  - Support multimedia
- Packet routing
  - Support mobility
  - Virtual IP (Sony) / Mobile IP (Columbia University)
    - Adding a second layer of IP address
    - “real” address with forward packets

Issues – Interaction Substrates

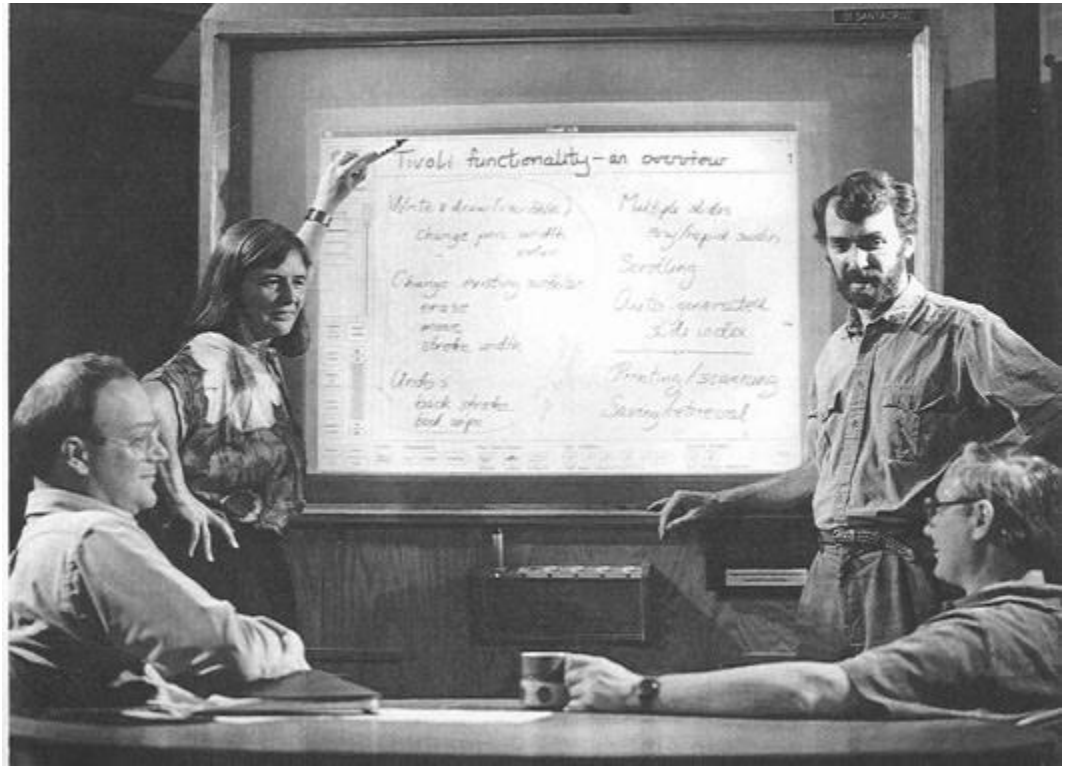
- Tabs
  - Very small interaction area
  - **Touch printing** that uses only a tiny area
- Live boards
  - High interaction area; 400 times of the tab
  - Conventional pull-down or pop-up menus
    - Requires walking across the room
  - **Location-independent interaction**; popped up at any location
- X-Window System
  - Move frequently from device to device; bring windows along
  - **Migration tool** with low bandwidth

Issues – Applications (1/2)



- Locating People
  - Display of CSL activity from personal locators
  - Active badge system
- Example Uses
  - Automatic phone forwarding
  - Locating an individual for a meeting
  - Watching general activity

Issues – Applications (2/2)



- Shared Drawing
  - Pen-based drawing on a surface
  - Simultaneous & Multi-user support on same/different pages
- Issues for Optimal
  - Multiple vs. One Cursor
  - Gesture or NOT
  - Single application with multiple windows VS. Many independent applications

Issues – Privacy of Location

- Cellular systems
  - Traveling pattern can be deduced from the roaming data
- Preserving privacy of location
  - Central database of location information
    - Packet snooping, traffic analysis on source addresses
  - Storing information at each person's PC/Workstation

- ONLY society can cause the right system to be used

Issues – Computational Methods

- Optimal Cache Sharing
  - Low Bandwidth & High Processing power

- Solutions
  - Optimal strategy for partitioning memory between compressed and uncompressed pages
  - Methods to handle cache misses over high latency mediums

Conclusion

- First phase of ubiquitous computing
- Enter most productive period
  - *at the time of 1993*
- Ubicomp
  - Provide a framework for interesting and productive work for many more years
- Many of the issues and challenges had been solved!

Supplements - Virtual Reality VS. Ubicomp

- Virtual Reality
  - Goal
    - Taking over human sensory and affector systems
  - Problem
    - Cost
      - Cannot produce a simulation at reasonable cost
    - Can't fool the user
  - *Puts people **inside** a computer world*

- Ubiquitous Computing
  - Goal
    - Personal digital assistants
    - Autonomous agents
  - *Forces the computer to live in the world **with** people*