Building Invisible Interfaces

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My goals for this talk

That you will come to know

- the "ubicomp" perspective of new UI research
- some deep problems with VR, agents, GUIs, voice, magic, seamlessness, . . .
- some of our work at PARC
- some new systems challenges of the ubicomp perspective

That some of you will think deeply and then

- choose to work from a ubicomp perspective, *or*
- attack the root ideas of ubicomp

PARC and Xerox

Xerox Palo Alto Research Center is 24 years old

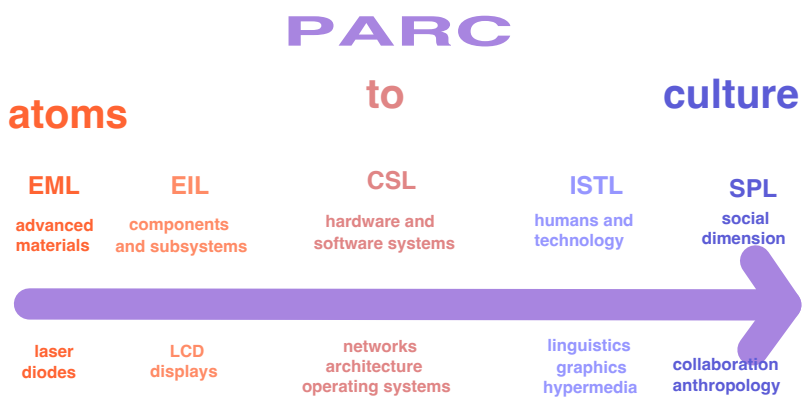
- one of four research centers, PARC's focus is "systems"
- PARC's research in every Xerox product, including toner

PARC-generated product technology

- laser printing, multiprocessors, quad-spot diodes, ...

PARC-generated Xerox startup companies

- synoptics, spectra-diode, parcplace, U.S. display consortium, ...

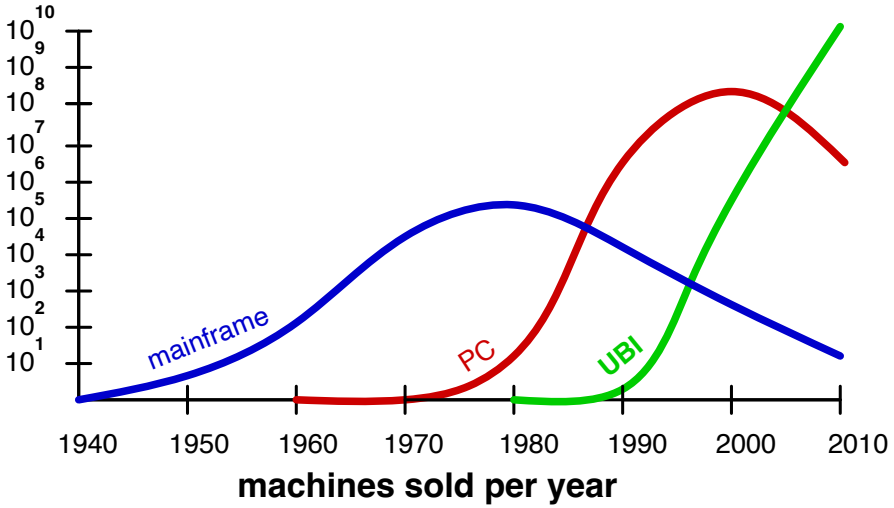


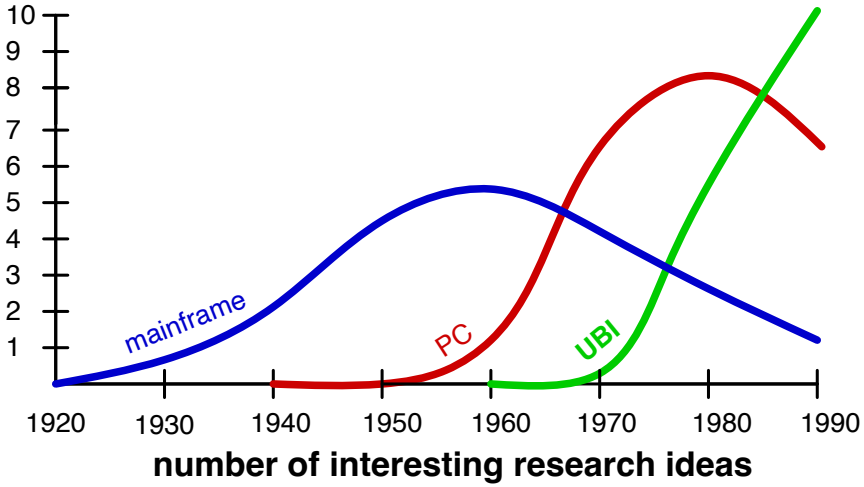
Three revolutions in computing

1950, mainframe computing:
one computer used by many people

1975, PC computing:
one computer used by one person

2000, ubiquitous computing:
many computers used by one person
they had better be nearly invisible





Good technology is invisible

"invisible" technology stays out of the way of the task
like a good pencil stays out of the way of the writing
like a good car stays out of the way of the driving

bad technology draws attention to itself, not the task
like a broken, or skipping, or dull pencil
like a car that needs a tune-up

computers are mostly not invisible
you can hardly fail to notice when you use a computer
they dominate interaction with them

ubiquitous computing is about "invisible" computers

Examples of Invisible Technologies

Electricity

- **Electric motors hidden everywhere (20-30 per car)**
- **Wired and wirelessly ubiquitous**

Literary Technology

- **Continuously surrounding us at many scales**
- **Used trivially and profoundly**
- **Literally visible, effectively invisible**

How to Build Invisible Technologies?

start from arts and humanties: Philosophy, Phenomenology, Anthropology, Psychology, Post-Modernism, Sociology of Science, Feminist Criticism, Your own experience...

This is the most important part of the talk.
You may not get it on first hearing. Patience.

When I am done you'll know what is wrong with:

creating an entertaining and dramatic user interface
computers magically meeting our desires
a computer idealized as an assistant
virtual reality as the ultimate user interface

Your Personal Experience:
the flow state

Remember the last time you spent several productive hours. It had some of the following characteristics:

- time passed unnoticed
- you were unaware of your surroundings
- it took you about half an hour to get engaged
- consciously you focused on a goal
- unconsciously you drew on tacit skills and knowledge
- the situation was very rich with details and nuances that you unconsciously took into account

The things you *did not think about* -- the tacit, the context, the world -- made you smart.

Philosophy of Polanyi: "The Tacit Dimension"

perception and thinking are always involve both "distal" and "proximal" elements

distal is the current surface of thought
proximal is closer to us, and tacitly focuses on the distal

for instance:

distal: words coming out of my mouth
proximal: my muscle and brain activity when speaking

the "tacit dimension" is easily overlooked, and more important to understand, than the more available distal

Post-Modernism (Toulmin's *Cosmopolis*)

Modernism's origins in the 1600's

vision of human rationality as adequate to all things

a particular historical response to chaos in European affairs

Modernism the major Western world-view 1600-2000

fueled advances in all fields of human endeaver

is breaking down as omnisciently adequate

Post-Modernism

human nature is not fully explained by logical categories

idealized logic has distracted us from real life and nature

Example

Example: Taylorism vs. Empowerment

Taylorism is modernist ideal of measured time and motion

Empowerment is the post-modernist letting be of a whole person in a complete situation for action.

A return to the 'whole person'

rational analysis is only a small part of the successful person

planning is only a small part of thinking and work

Feminist Deconstructionism

Standpoint theory

full history of a person in a culture and world is their *standpoint*

standpoints influence our perception of the world around us

every "objective" view also has a standpoint

Standpoints are enacted through peoples lives

standpoints are not reducible to a plan or analysis method

standpoints accessed only via the individuals embodying them

Example Consequence: Strong Objectivity (Harding)

Physics is only *weakly* objective because it presumes knowledge to be independent of knower

Strong objectivity recognizes that knowledge from any one standpoint is limited

Example

Old business attitude of hiring women and minorites

its the law

its the right thing

New business attitude of hiring women and minorites

diversity of perspective is valued

different lives provide the most difference in perspective

diverse workforce provides business advantage

(this does not mean you should start trusting businesspeople)

Examples: what's wrong with:

creating an entertaining and dramatic user interface --
draws attention to the machine itself;
confuses entertainment with use

computers magically meeting our desires --
assumes everything important can be articulated;
ignores tacit and standpoint

a computer idealized as an assistant --
idealizes the anthropomorphic ;
insults human assistants; misplaces trust;

virtual reality as the ultimate user interface
reduces the human being to just a bundle of senses
ubicomp is the inverse of virtual reality

What we tried to do: unique features of ubiquitous computing

start from social science insights
- radically reinvents technology to fit people
- aims for true human effectiveness

avoid personal computer - make computers "invisible"
- no *thing* in the office humming on the desk
- ease of use so effective you don't notice the computer

many, many "displays"
- including audio, visual, environmental
- including electronic postit notes stuck to things

casual, low-intensity computer use
- displays for menus, for icons, for each window
- displays for background attention

Two misleading concepts

Seamless
is a seamless building one in which you never notice as you move from place to place?
making everything the same is easy;
hard is letting everything be *itself*, *with* other things
goal: seamful systems, with beautiful seams

Interface
implies boundary, difference, transduction
but the unit of design should be social people, in their environment, plus your device
talking "interface" trivializes the problem to the boundary
(but there is no better word, so I too say "user interface")

Where is the talk going

So far we have discussed:
- Xerox PARC, and its context for this work
- The foundations of new thinking about Invisible Technology, Post-Modernism, etc.
- some goals of ubicomp design

Coming up:
- A walk through some new technology
- A taxonomy and description of new research challenges

Ubiquitous Computing Phase I devices

three sizes of devices; fill everyday space

- tabs -- tiny wireless handhelds - hundreds/person
- pads -- booksized X terminals - tens/person
- boards -- whiteboard computers - one/person
- each device is a doorway to networked information

mobile infrastructure to make them useful

- capable of 100's of devices per person
- capable of self-configuration maintenance
- both radio and infrared, in-building only

mobility is nearer-term focus, prior to true ubiquity

videotape

our attempt at ethics

Demonstrate technical feasibilty of non-invasive design

- enable individual control over privacy

Try to model ethical behavior

- get human subjects committee approval for trying new technology

Communicate to public about dangers of one's work

- grit teeth, cooperate with media "scare" stories
- don't leave it to others to say the negative

Some dimensions of our research

applications
toolkits
real-time programming techniques
operating system
protocol
cellular handoff
bandwidth
physical wireless layer
wired connection
physical device

physical device

TAB	PAD
2x3x0.5"	9x11x1"
2 week battery life	4 hour battery life
7 oz.	5 pounds
8051 processor	683xx processor
128k NVram	4 MB ram
I^2C external bus	PCMCIA card
resistive touch screen	electro-pen sense
128x64 mono display	640x480 4 level display

Systems Research Problems

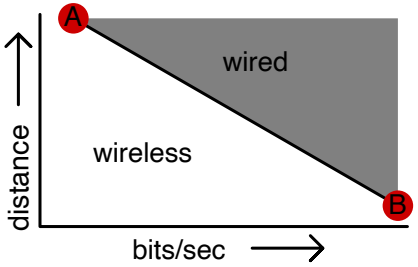
Research driven by new figures of merit
- Bits/Sec/M^3
- Instructions/joule

Only two things are different in ubiquitous systems
- traditionally variable things are now static
- traditionally static things are now variable

coming up: UI implications of new systems problems
- the problem of bandwidth
- the problem of energy

The problem of bandwidth: Bits/sec/M^3

On Earth Today: 10^{10} people, 10^{12} M^2 land.
Assume 10^{12} Ghz total radio spectrum, 1 bit/sec/hz.
A - 100 bits/sec/person worldwide
B - 1 terabit/sec/person within one meter



requires new radios: "nearfield"

4 meter range, 250k/bps bandwidth
r^6 power drop, excellent cell boundaries
5 Mhz carrier, excellent in-room penetration
very simple construction
low cost (< $10 transceiver and digital interface)
maximize *bits/sec/M^3*
use microwatts of power
locate users

bandwidth assumptions of wireless

old: bandwidth is constant for a given connection

new: bandwidth varies widely during use

- because different cells have different congestions
- because mobile-IP is hiding your real network topology
- because sometimes you plug in

UI research problem: how much to hide from the user

- applications with feedback on current bandwidth?
- separate control panel for user monitoring of bandwidth?
- indirect feedback through performance?

The problem of energy

low energy computing is good

- less disposing of batteries
- less power generation needed
- easier to keep using

low energy computing is hard

- instructions/joule little better today than ten years ago
- display and backlight and wireless link use most power

possibilities:

- design for better instructions/joule
- reinvent the display
- create "low power" UI

Instructions per Joule

Joule measures energy: 2^{16} joules in a D battery

I/J measures computation per battery

things that don't help I/J

- turn machine off: I/J = 0.
- slow machine down: I/J unchanged.

something that can help

- slow down while lowering voltage
- do this continuously, millisecond by millisecond

UI research problems:

- how to keep the user in the loop?
- "MPG" meter? black tailpipe smoke?

reinvent the "display"

nondisplay displays

- break out of TV model -- instead concentrate on interacting with a human somehow
- blow the drapes, jingle, tingle, get warm, use subtle change

displays themselves

- repaint very slowly? be microscopic? use non-symbols? new-symbols?
- sacrifice everything for contrast
- throw-away displays: 1 oz, 2mm thick, survive 4 ft. drop, 25 milliwatt

New User Interface?

keep doing *something* as long as possible
pushback to user what is hard or easy
"colored button" menus
- color every button according to power-cost of pressing it

will users stand for this?
- like greyed buttons
- like real world

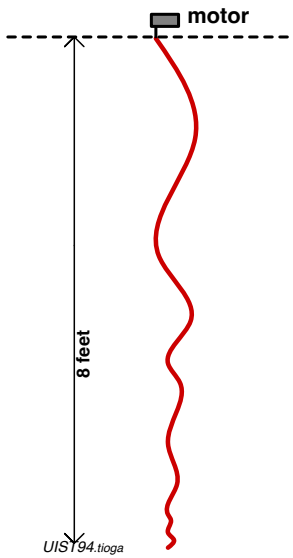
how to predict?
- static? learned? dynamic by system state?

Some new directions in ubicomp UI

Ubivid
- tens of video streams per person per office
- create small town community

Project Jupiter
- on-line community (MUD=multi-user-dimension)
- virtual community "chat" rooms, with multimedia
- some virtual rooms are also real rooms

Casual I/O
- "dangling string" ethernet monitor



Dangling String Interface

freely hangs from ceiling
direct analog connection to ethernet
0.1 turn per packet

spins madly when busy
wiggles gently most of the time
can be heard, peripherally

gives body to something virtual
is part of the environment, like a breeze

created by Natalie Jeremijenko

LambdaMoo and Jupiter

LambdaMoo: self-programmable online community
- 7,000 users, 5,000 user-built rooms, 50,000 active objects
- surface UI is that of textual games: "throw knife at dwarf"
- deep UI is people working/playing/living *together*

Jupiter: LambdaMoo + multimedia + real rooms
- AstroVR: astronomers sharing data and tools in rooms
- Jupiter prototype: multicast video and audio with rooms

glass TTY UI can be ubicomp

Conclusion

Long term: a new world view of what a computer can be.
Short term: fun new science to do, many hard problems

for more info:

"The world is not a desktop." ~~Marc~~ Mark Weiser.
ACM Interactions, V1N1. January 1994.

http://www.ubiq.com/hypertext/weiser/weiser.html

ftp://parcftp.parc.xerox.com/pub/MOO/papers

telnet://lambda.parc.xerox.com:8888

traditionally variable things are now static

Traditionally, CS research tries to time-travel the curves:

- CPU speed doubles every year.
- memory cost halves every 1.5 years.
- other: display quality, headmount tech, ...

Old research method: aimed at when X is Y

X	Y
cpu speed	1000 MIPS on a desktop
memory	practically free
networks	are a gigabit/sec

But in mobile infrastructure, it ain't so

- For the next ten years, all improvements go into size
- Same memory, cpu, and bandwidth as workstations today.

traditionally static things are now variable

bandwidth -- TCP assumptions break
CPU performance (temporally and spatially) -- timing
end-to-end network characteristics -- end-to-end flows
connectivity -- yes? no? maybe?
output: screen bits/pixel, size, number, stability
input: type (pens?, kbd-simulations?), number
physical network: RS-232, cellphone, CDPD, ethernet, ATM
physical location: nearest printer, file server, router
physical security: identity, network access, services