Vom Verschwinden des Computers

Die Vision des Ubiquitous Computing

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Computing: A Clear Trend

One computer (mainframe) for many people
One computer (PC) for everyone
Many computers for everyone

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The Trend... What's Next?

Many computers for everyone

The Qualitative Growth of the Internet

Email

WWW

Mobile Internet

Internet time line

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The Qualitative Growth of the Internet

- Networked embedded systems
  - machines talking to machines

2003

Mobile Internet

Ubiquitous Computing

Internet time line

Email
WWW

Research network
people to people
people to machines
machines to machines

Ubiquitous Computing

- Information technology will be everywhere
- Everyday objects will become smart
  - embedded processors
- ...and they will all be interconnected
  - wireless communication

image source: "Die Zeit"
Outline

- 4 Technology Trends
- The Vision
- Real World meets Cyberspace
- Consequences

1. Moore’s Law (1965)

"It's been 18 months and my computer's power hasn't doubled."
1. Moore’s Law (1965)

Moore’s Law
Electronics, April 19, 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.
Cramming more...

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.
Cramming more...

- "...factor of two per year..."
- "...by 1975, the number of components per integrated circuit ... will be 65,000"

Storage Density Trend

Generalized Moore's Law:
Most important technology parameters double every 1 - 3 years:
- computation cycles
- memory
- magnetic disks
- bandwidth

Problems:
- increasing cost
- energy
2. Progress in Communication Technologies

- **Fiber optics**: from Gbit/s to Tbit/s
- **Wireless**
  - mobile phone: GSM, UMTS
  - wireless LAN (> 10 Mbit/s)
  - Bluetooth
- **Body** area networks

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Telecommunication and Information Everywhere – an Old Vision

> “O, du göttliches Telefon, was bist du eine praktische Erfindung! Da kann man in der Kneipe die Vorlesung hören und braucht das Trinken nicht zu versäumen.”

Carl Stauber (1882): „Die Zukunft des Telefons“
**Picture Phone – Vision and Reality**

„Hello, Dorothy... You're looking well!“
A vision in 1929 (from a journal ad)...

...and reality some 70 years later

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**3. Better Sensors**

- Miniaturized cameras, microphones,...
- Fingerprint sensor
- Radio sensors
  - without power supply
- Location sensors
  - e.g., GPS
- ...

POSITION
N 047° 23'17"
E 008° 34'26"
4. New Materials

- Whole eras named after materials
  - e.g., „Stone Age“
- More recently: semiconductors, fibers
  - information and communication technology

- Organic semiconductors
  - → change the external appearance of computers
- „Plastic“ laser
  - → opto electronics, flexible displays,...
- ...

Example: Flexible Substrates
Smart Paper, Electronic Ink

Micro capsules

Positively charged white pigment chips
Clear fluid
Negatively charged black pigment chips
Bottom electrode

Top transparent electrode

An electronically charged pencil rotates the "pixels"
All Trends Together Lead to a New Era

- **Progress** in
  - computing speed
  - communication bandwidth
  - material sciences
  - sensor techniques
  - computer science concepts
  - miniaturization
  - energy usage
  - battery technique
  - display technologies
  - price
  - ...

→ **Ubiquitous Computing**

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The Vision

“\textit{In the 21st century the technology revolution will move into the everyday, the small and the invisible...}”

Mark Weiser (1952 – 1999), XEROX PARC

- Small, lightweight, cheap, mobile processors and sensors
- in almost all everyday objects (\textit{“embedded computing”})
- on your body (\textit{“wearable computing”})
- embedded in the environment (\textit{“sensor networks”})

The Vision

- in almost all everyday objects (\textit{“embedded computing”})
Embedded Computing Enables "Cooperating Smart Things"

Real world objects are enriched with information processing capabilities

- Embedded processors
  - in everyday objects
  - small
  - cheap
  - lightweight

- Wireless communication
  - spontaneous networks

- Sensors

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- on your body ("wearable computing")
Wearable Yesterday

Wearables Today
Ubiquitous Information with Tomorrow’s Wearables?

- Headsets of mobile phones as jewellery?

Retina Eyeglass Display?

Eyeglass with tiny laser and mirrors projects an image directly onto the retina

image source: Microoptical Corporation

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Smart Glasses

You could wear a pair of glasses with a small amount of face recognition built-in, look at a person, and his name would pop up in a balloon above his head. You could know instantly who the person is, even if you don't immediately recognize him. I look at my tree, and a little balloon pops up saying, "Water me," I look at my dog, it says, "Take me out," or I look at my wife, it says, "Don't forget my birthday!" I'm being facetious here, but there are more serious possible applications for this kind of technology. "M. Satyanarayanan (CMU)

The Vision

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The Vision

- embedded in the environment ("sensor networks")

Wireless Sensor Networks

- Embed numerous distributed devices to monitor the physical world
Wireless Sensor Networks

- Embed numerous distributed devices to monitor the physical world
- Network these devices so that they can coordinate to perform higher-level tasks
- Combine sensing, communication and computation into a complete architecture
  - possible by advances in low power wireless communication technology
  - MEMS bringing rich array of cheap, tiny sensors
Sensor Networks – Vision

- Dense **instrumentation** by massively distributed networks of tiny processing elements
  - computationally-augmented environments („smart spaces“)
  - environmental, in situ monitoring
  - surveillance and security
  - military
  - emergency analysis
  - traffic monitoring
  - medical monitoring
  - condition-based maintenance

- **SF**
  - smart paint?
  - ingestible device networks?

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A Sensor Node

(image source: David Culler (Berkeley))
Networked Microsensors...

...and the End of the World As We Know It
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Responsive Objects

- An objects tells something about itself
  - e.g., by displaying a dynamically generated homepage

- Content
  - depends on circumstances such as context and privileges

Image source: Nokia
Cf. Cooltown project (HP)
Responsive Objects

- Label
- Directory
- Location
- Context

- Who operates directories?
- Who controls information and interpretation?
- Economic / legal / political issue?

Electronic Labels (RFID)

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Electronic Labels (RFID)

Identify objects from distance
- small IC with RF-transponder

Wireless energy supply
- magnetic field (induction)

Read and write a few 100 bits "over the air"
- ~ 1 m
Small RFID Chips

The μ-Chip

image source: Hitachi
Smart Playing Cards

- Support people playing a **card game** by an unobtrusive smart environment
  - playing cards equipped with **RFID labels**
  - **RFID antenna** is placed under the table

- **Features:**
  - count score
  - determine **winner**
  - **hints** for beginners
  - cheat alarm

- **Display:**
  - wireless **PDA**
  - nearby screen

Smart Medical Cabinet

- **Tagging of medicine packages with RFID labels**
- **Automatic content monitoring** and display of related information:
  - prescription
  - expiry date
  - drug recalls
- **Optional:**
  - alerts via **SMS**
  - **spoken language** to help **blind persons** to take the right medicine („talking medicine“)
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Imagine an „Internet of Things“

- Detailed and timely knowledge of product location and life cycles, individual and dynamic prices for goods, ...
  - higher taxes if product is transported by plane
  - milk bottle reduces its price with its age
Imagine an „Internet of Things“

- Detailed and timely knowledge of product location and life cycles, individual and dynamic prices for goods,...
  - higher taxes if product is transported by plane
  - milk bottle reduces its price with its age
  - car insurance depends on usage patterns...

Privacy in a Ubicomp World?

- Privacy is already a concern with the WWW
  - what do they do with my personal data?
  - are my page visits and mouse clicks analyzed?

- Much more dramatic in a ubicomp world!
  - many events of very elementary actions are registered
  - could be assembled to perfect profiles
Privacy Challenges

- Unlimited **coverage** (sensors everywhere)
- Loss of awareness („invisible computing“)
- New **types of data** (location, health, habits, ...)
- More knowledge through **context**
- Explicit **notice, consent** by user difficult
- ...

- And what about **trust**?
  - trusting smart everyday things?

Ron Rivest: The Digital Revolution Reverses Defaults

- What was once **private** is now **public**
- What was once **hard to copy** is now **trivial to duplicate**
- What was once **forgotten** is now stored **forever**
General Impact: Evolution vs. Revolution

- Technology and science have a major impact on our society and the world we live.
  - Historically: industrialization, electricity, trains and automobiles, electronic mass media
  - Implies therefore eventually also ethical questions
  - Social adaptation to technical impacts needs some time since this is an evolutionary process (willingness to learn, generational aspects,...)

Conclusions

- Ubiquitous computing technologies will have a major impact
- Economic, social, cultural, political consequences?
- Challenges
  - Technical infrastructure
  - Security, privacy, dependability

*The Internet only connected computers, now we begin to network all things*
Vom Verschwinden des Computers

Total vernetzt

Friedemann Mattern (Hrsg.): *Total vernetzt - Szenarien einer informatisierten Welt*. Springer-Verlag, 2003

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Agenda

09:30 Gisbert Freiherr zu Putlitz: Begrüßung
09:35 Thomas Weber: Grußwort
09:45 Friedemann Mattern: Vom Verschwinden des Computers - Die Vision des Ubiquitous Computing
10:20 Kurt Rothermel: Digitale Weltmodelle - Grundlage kontextbezogener Anwendungen
10:55 Claudia Eckert: Mobil, aber sicher!
11:30 - 11:50 Pause
11:50 Günter Müller: Geduldige Technologien für ungeduldige Patienten
12:25 Edgar Fleisch: Betriebswirtschaftliche Anwendungen des Ubiquitous Computing - Beispiele, Visionen und Nutzenüberlegungen
13:00 - 14:30 Mittagspause
14:30 Ralf Guido Herrtwich: Kommunikation rund ums Automobil
15:05 Dieter Wybranietz: Die Zukunft der Telekommunikation - Convenience als Innovations- und Wachstumstreiber
15:40 Natascha Adamowsky: Totale Vernetzung - totale Verstrickung?
16:15 - 16:45 Pause
16:45 - 17:20 Christoph Hubig: Selbstständige Nutzer oder verselbstständigte Medien? - Die neue Qualität der Vernetzung
17:20 - 18:00 Alois Knoll: Zielvorstellungen und Ansätze für autonome „smarte“ Serviceroboter
18:00 - 18:30 Diskussion
19:30 Wolfgang Wahlster: Virtuelle Gesprächspartner - sprachverstehende und sprechende Computer im Alltag

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