Pervasive Computing –
A Case for the Precautionary Principle?

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Basic approach:

- Raw Materials
- Production
- New Products
- Use
- Used Products
- Recycling/Disposal

**Life Cycle of Technical Products**

**Nature**

**Opportunities**

**Risks**

**Society**

Life Cycle Assessment (LCA) & Technology Assessment (TA)
Projects on ICT Impacts

- Sustainability in the Information Society (ETH Council 2001-2005)


- The Future Impact of ICT on Environmental Sustainability (IPTS 2003-2004)

- Risks and Opportunities of the Use of RFID-Systems (BSI 2004)

I. The Precautionary Principle
   - What is it?
   - Qualitative risk assessment criteria

II. Technology Assessment for Pervasive Computing
   - Major social and environmental impacts
   - Conclusions
I. The Precautionary Principle

“When an activity raises threats of harm to human health or the environment, precautionary measures should be taken even if some cause and effect relationships are not fully established scientifically.”

Wingspread Conference on the Precautionary Principle, 1998

“Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing cost-effective measures...”

Principle 15 of the Rio declaration, UN sustainable development summit, 1992
Example: Ozone depletion

- Early warnings by chemists Norrish and Neville that Chlorofluorocarbons (CFCs) could destroy ozone layer by catalytic reaction, 1934
- Loss of ozone first noticed in 1970ies (Brit. Arctic Surveys)
- Dramatic losses confirmed in 1985
- Montreal Protocol banning the release of CFCs in 1987
**Prevention**: to minimize risks based on proven cause-effect relationships ("proof before action" principle)

**Precaution**: to minimize risks even if cause-effect relationships are uncertain (precautionary principle)
cause-effect relationship

certain

prevention

probability of the cause
not known to be high

precaution

social impacts of pervasive computing

new influenza pandemic (e.g. H5N1 virus)

fatalities due to cigarette smoking

depletion of ozone layer due to CFCs before ozone hole was discovered

probability of the cause
known to be high

cause-effect relationship
uncertain

Lorenz M. Hilty, SPC 2005, Boppard, April 6, 2005, Page 8
Qualitative Risk Assessment

When a risk **cannot be quantified** due to uncertainty, how is it still possible to rank risks?

Some criteria for the **qualitative characterisation** of risks discussed in literature:

- **ubiquity**: geographical range of potential harm
- **persistence**: duration of potential harm
- **irreversibility**: the possibility of restoring the situation which existed before the harm occurred
- **delay effect**: the period of time between the original event and the actual consequences
- **mobilisation potential**: the encroachment on individual or social interests or values
- **voluntariness**: a risk which is entered into voluntarily is more acceptable than an involuntary risk
- **controllability**: if a risk appears to be controllable, it is more likely to be accepted
- **fairness**: if the benefits of taking the risk and potential harm are distributed unequally, the risk is less acceptable
II. Technology Assessment for Pervasive Computing

Main risks identified in technology assessment studies for pervasive computing:

- Restrictions of freedom of choice
- Stress caused by time-rebound effects
- “Dissipation” of responsibility
- Threats to environmental sustainability
‘Dissipation’ of responsibility (1)

- It is difficult to assign responsibility and liability for accidents already in today‘s computer-controlled environments.
- Interlinking the virtual with the physical world has an important implication: It extends the search space for the cause of an (undesirable) effect.

Objection:
- Everything will be tracable, accountable („liability tracing“)

Reply:
- Who has the control over the content?
- There is still the problem to assign responsibility and liability.
The problem exists even in limited contexts such as aviation:

Accidents with the world's first fly-by-wire commercial airliner A320:
- 1988, Habsheim (France): The plane crashed into a forest because the computer assumed the pilots were trying to land, while they were making a low and slow-speed pass at an air show.
- 1993, Warsaw: The plane hit an earth wall at end of the runway because the computer assumed the plane was still in the air (wheels not turning fast enough due to wet runway) and refused to activate reverse thrust.
Who is responsible for this type of accidents?

- There is no single cause of accident.
- All technical systems did exactly what they were supposed to do.
- In particular: There were no coding errors in the software.

→ It is arguable whether or not there is a flaw.
Vision of pervasive computing:
The physical and virtual worlds converge

- Real-time mapping from physical to virtual world
- Real-time control of physical processes, bypassing the bottleneck of human intervention

Source: Gross/Fleisch 2004
‘Dissipation’ of responsibility (4)

Source: Gross/Fleisch 2004
Main risks identified in technology assessment studies for pervasive computing:

- Restrictions of freedom of choice
- Stress caused by time-rebound effects or unreliable technology
- “Dissipation” of responsibility
- Threats to environmental sustainability
Classification of ICT Impacts

- First-order impacts, e.g.
  - Electronic waste
  - Energy consumption for production and use of ICT
- Second-order impacts, e.g.
  - Environmental applications of ICT
  - Increased efficiency due to ICT
- Third-order impacts, e.g.
  - Market reactions
  - Long-term adaptation of behaviour
Method

- Scenario development
- System dynamics modelling and simulation

Results

- Highest risks for environmental sustainability:
  - Electronic waste
- Highest potentials for environmental sustainability:
  - Intelligent heat management
  - Enabling a product-to-service shift
Electronic Waste, an Underestimated Problem

- ≈ 7 Million t/a in EU
- ≈ 5 Million t/a in USA, partially exported to Asia
- In most countries, the e-waste mass flow grows faster than GDP
- Contains **toxics**: heavy metals (Pb, Hg, Cd, As), bromine-based flame retardants, etc.
- Contains **precious metals** (Au, Ag, Cu, Ni)
PWB (Printed Wiring Boards) acid washing
Quantitative Analysis of Gold Extraction

**Raw Material**
Process: 0.01
Fused with sodium polysulphide

**Extraction of Pins**
Process: 0.01
The process: The pins are put in a solution of Na$_2$S and hydrogen peroxide. The pins get extraction from PWB.

**Gold Pins**
Output: 2.01
Input: 2.01
1 kg PWB = 1 kg Gold pins
Lot size: 100 kg PWB = 100 kg pins

**Sulphuric Acid**
Process: 0.02
Input: 2.02
Hydrogen peroxide = 1.3 liters
Acid: 10% H$_2$SO$_4$

**Gold Extraction Process**

**PWB after extraction of Pins**
Output: 1.01

**Plastic from PWB**
Output: 1.02
Recycling: 10-15% PWB

**Gold Flakes**
Output: 2.03
At 25% recovery of Gold pins

**Extraction of Gold Flakes**
Process: 0.02
Gold pins are mixed with solution containing sulphuric acid and hydrogen peroxide. The process will be done with a vacuum and gold flakes get separated.

**Metallurgy**
In this process the mercury is mixed with gold, flake and doped and then poured through a cloth filter with impurities get separated. Now the extracted gold is put in a container made of steel and tinned and kept for further processing. Gold which come out on form gold.

**Generation**
Spectra: Gold Doped Acid Flaked Flakes

**Fumes**
Output: 2.02
Fumes containing hydrogen gas

**Contaminated Water**
Output: 2.01
Water containing acid and dissolved brass in dust
Materials from Swiss e-Waste Recycling Processes

Materials from all SWICO Recyclers:
1. Ferrous Metals 39.1 %
2. Non-Fe Metals (Al, Cu, Au, Ag ..) 21.0 %
3. Plastics 14.2 %
4. CRT Glass 13.4 %
5. Mixed Materials with Plastics 5.8 %
6. Cables 2.2 %
7. Printed Circuit Boards 1.9 %
8. Others 1.6 %
9. Hazardous Fractions 0.8 %
Total 100.0 %

Individual figures from recyclers may differ from the above figures – depending on their specific recycling processes.
Will ongoing miniaturization reduce the mass flow?

Example: mobile phones in Switzerland
Conclusions

- An important **social impact** of pervasive computing is that it increases the complexity of cause-effect relationships in everyday life, making it more difficult to assign responsibility and liability.

- The **environmental impacts** of pervasive computing can be either positive or negative below the bottom line, depending on how we design and use this technology.

- You can contribute to shape this technology in a way that minimizes its risks and maximizes opportunities.
More information:

Technology and Society Lab: www.empa.ch/tsl

SIS Program: www.empa.ch/sis
Visions of the Information Society
Final Conference of the Sustainability in the Information Society (SIS) Program

Empa, St.Gallen, Switzerland, November 3 – 4, 2005

Registration: www.empa.ch/vis2005