II2302: Sensor Based Systems 2022

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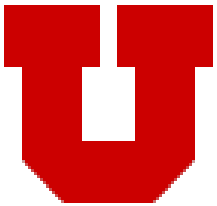


- I received my degree in Bioengineering from the University of Utah.

- Then spent 20 years at Hewlett Packard Laboratories. HP designed a lot of products. Hardware Systems, 3D Graphics, Imaging, Embedded Systems, Sensors and Personal Devices.

KTH Informations- och kommunikationsteknik
(Now, EECS)

- Professor for IT Product Development at the KTH School of ICT in Kista, Sweden

Course Goal

To understand and apply knowledge of system design using sensor technologies and the future systems that will use these devices.
This course looks at various systems that exploit sensors to create value.

1. Sensor and actuator Technologies in ICT system design.
   - Next generation devices and systems.
2. Role of context measurement in systems and applications.
   - How apps will use context, and new service opportunities.
3. Multi-sensor models and methods.
   - Where “Internet of Things” and data for Machine Learning is going.
4. Role of applications, services and connectivity.
   - Ties the system together. Without it, the devices aren’t as useful.

Course Logistics

- Discussion.
- Project sessions and applied work in the Mentorspace.
- Course website: **https://people.kth.se/~msmith/II2302_2022.html**

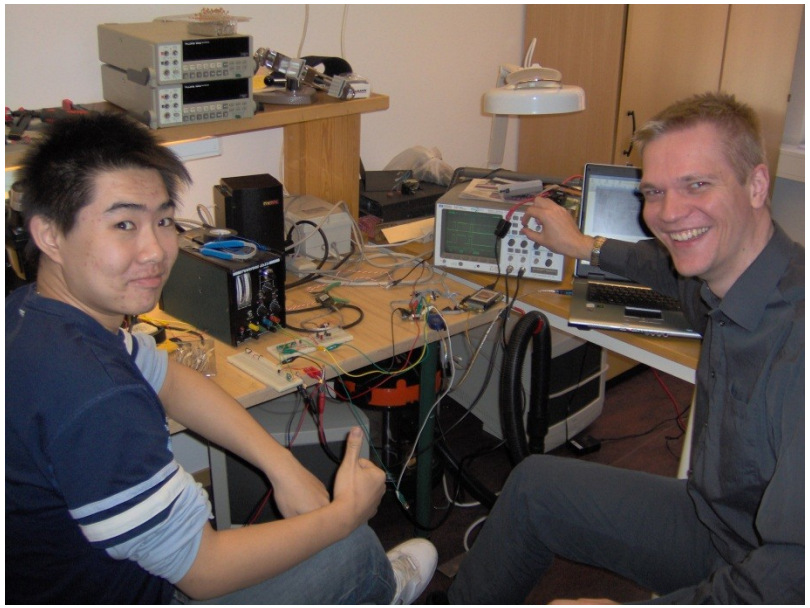
• Project sessions and final project report	40%
• One or more homework assignments	25%
• Final project presentation and demo	35%
Total:	**100%**

The project presentation and demo are very important.
It will be on March 16, 2022 at 14:00 in the Mentorspace.
Watch the course web page for any details and notices!

Project Sessions

- Project sessions are once per week.
- They are hands-on and applied. The idea is to discover things.
- Your group needs to give technical updates every week.
- We can use some project time to talk about embedded topics.

- The project sessions are in the Mentorspace.



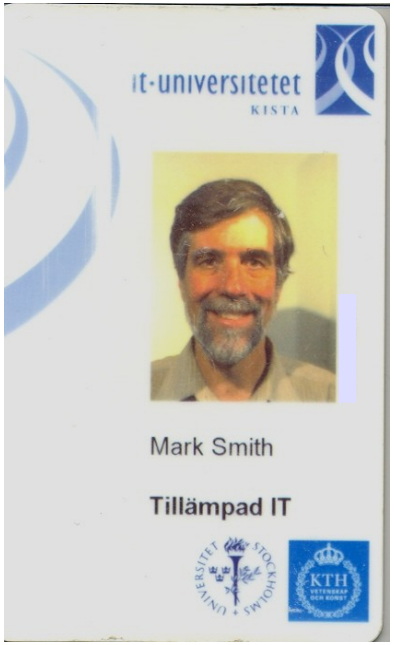
Putting it Into Context: Why study sensors?

What makes these systems new and unique is the way they are designed and deployed.

- The sensors, transducers and the device platforms that support them are highly integrated. How do you make these platforms?
- Sensors and transducers are being designed as part of everyday objects. Clothing is a good example.
- It isn't about just using raw data, like measuring temperature. It's about using measured data to infer something else.
- Sensor based systems are helping to drive the development of the Internet and data that is in it. It drives ML and AI business.
- Sensors allow the design of a lot of thought provoking new ideas.

Integration

The sensors, transducers and the platforms that support them are highly integrated.



Identity Cards are ubiquitous
Work with Smart Spaces.
New ones use RFID.
Future ones will have more sensors.

A modern smartphone:
HTML5 browser
color display with user interface,
camera, streaming video and audio, email,
MMS, EDGE and Bluetooth radio technology.

Putting it Into Context: What's New Here?

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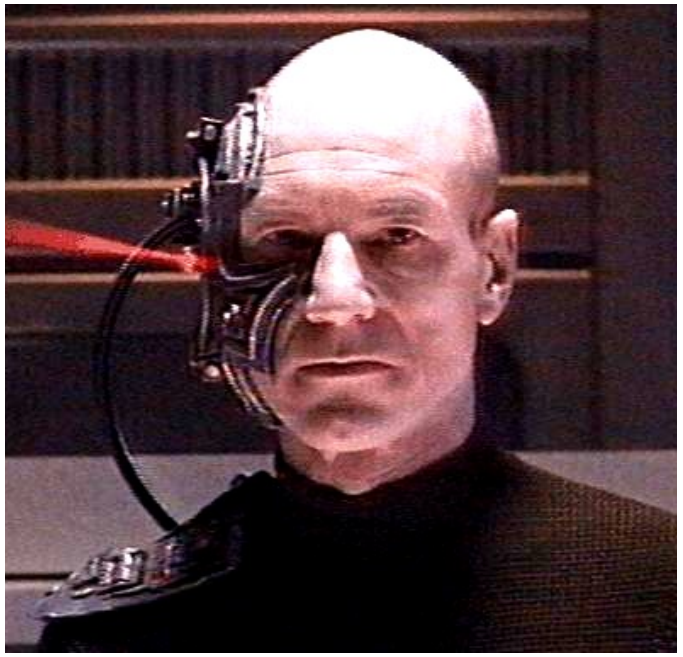
The beginnings of clothing with sensors and processors (Early 1990s)

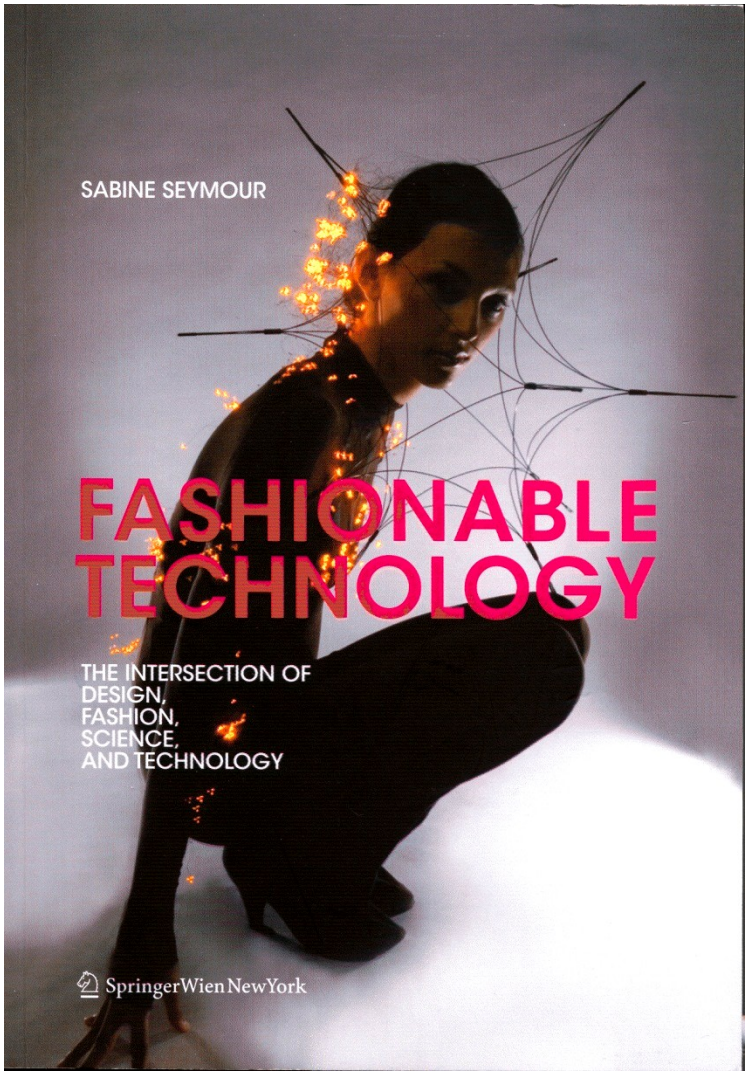


Often called “Cyborgs”. (Hollywood liked it, but almost nobody else did).

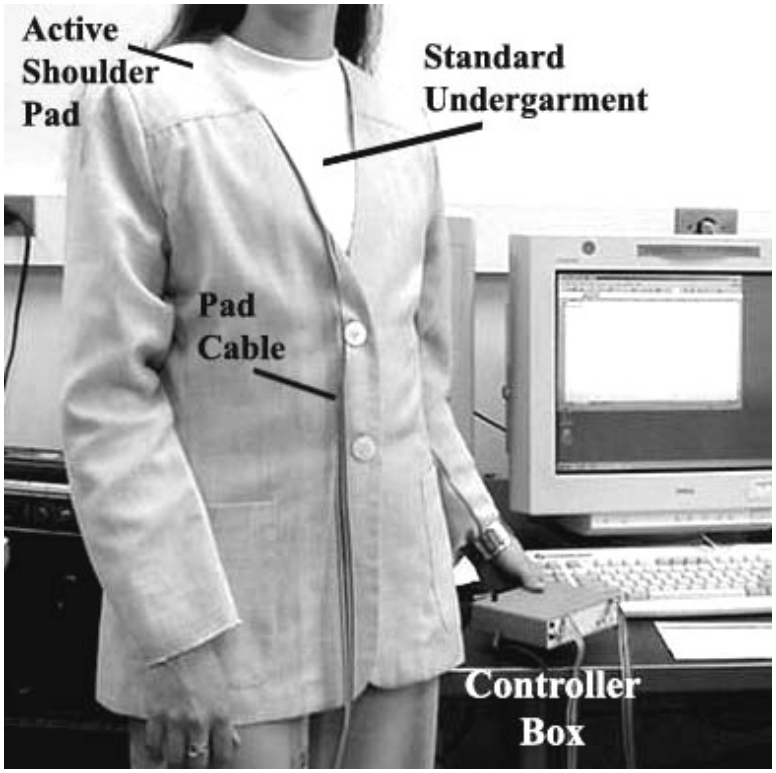
Wearable Sensors and Actuators today

What started out as “wearable computing” is becoming much more.

- Sensors and actuators become a driver of fashion.
- It becomes a communication mechanism.
- What are the tools and methods to design this?
- Wearable computing continues to be a significant research area.



Research: Clothing and actuators



Seventh International Symposium on Wearable Computers, October 21 - 23, 2003
A Shoulder Pad Insert Vibrotactile Display
Aaron Toney, Lucy Dunne, Bruce H. Thomas, Susan P. Ashdown

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Example: New Measurement Applications

For example, using measured data to determine who a person is.

For example, using a scan of hand shape as a biometric for identification purposes.

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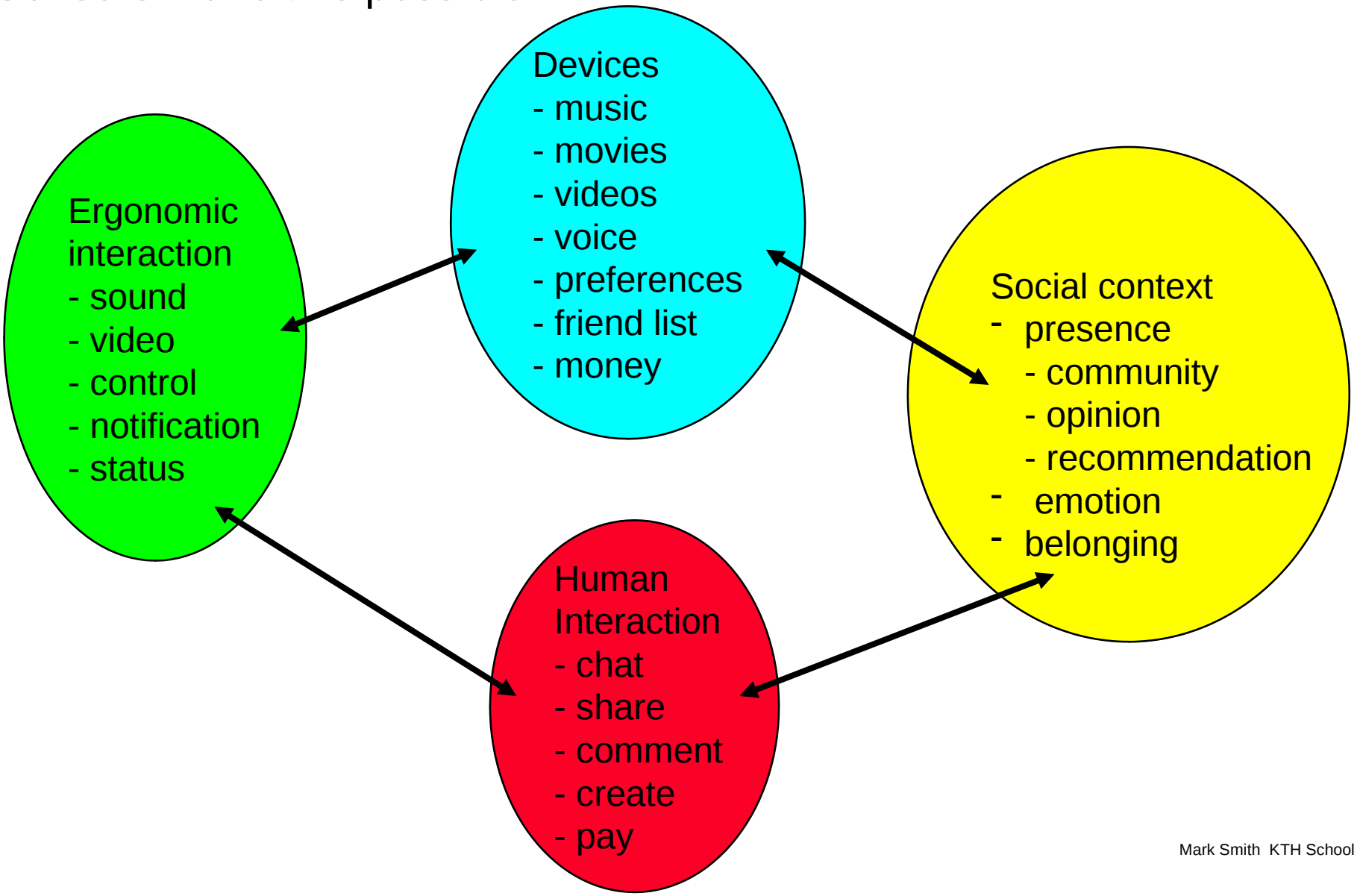
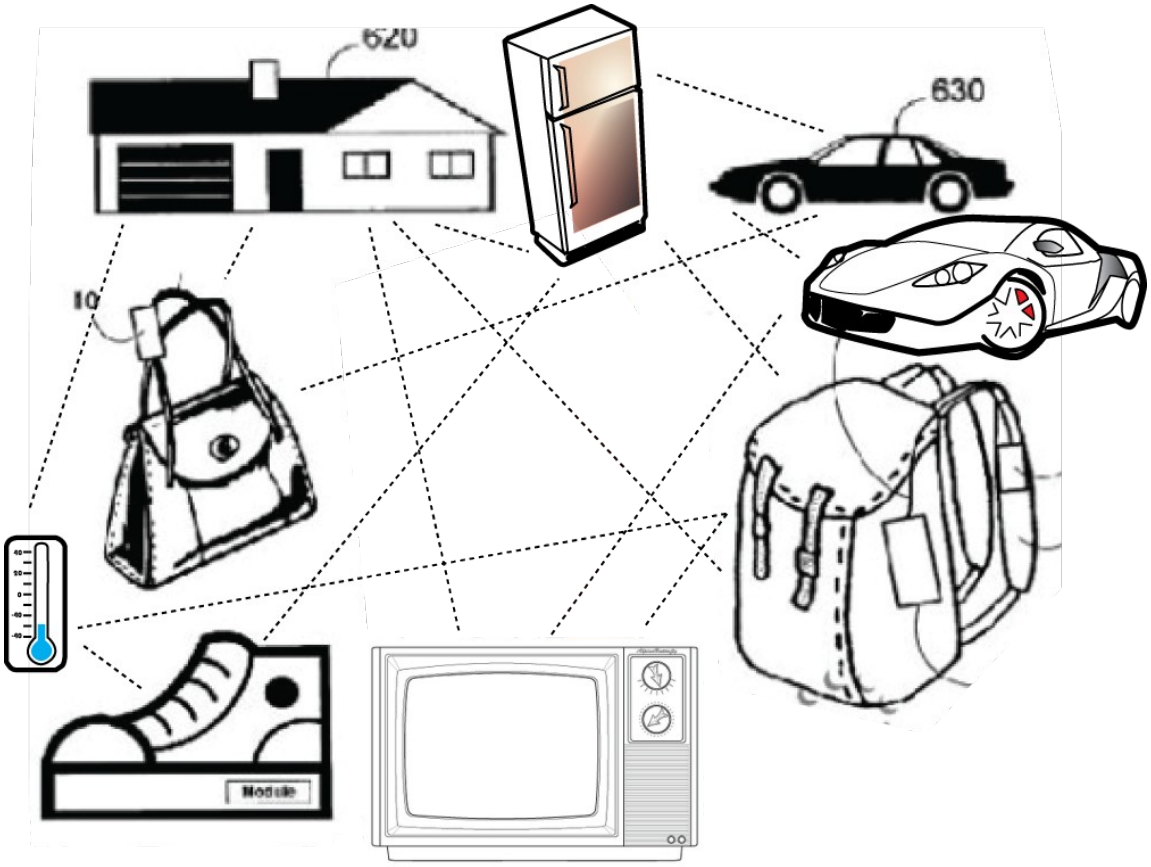
Example: Current and future social networks

Machine Learning uses media, ideas, and opinion, not just devices.
Sensors make this possible.



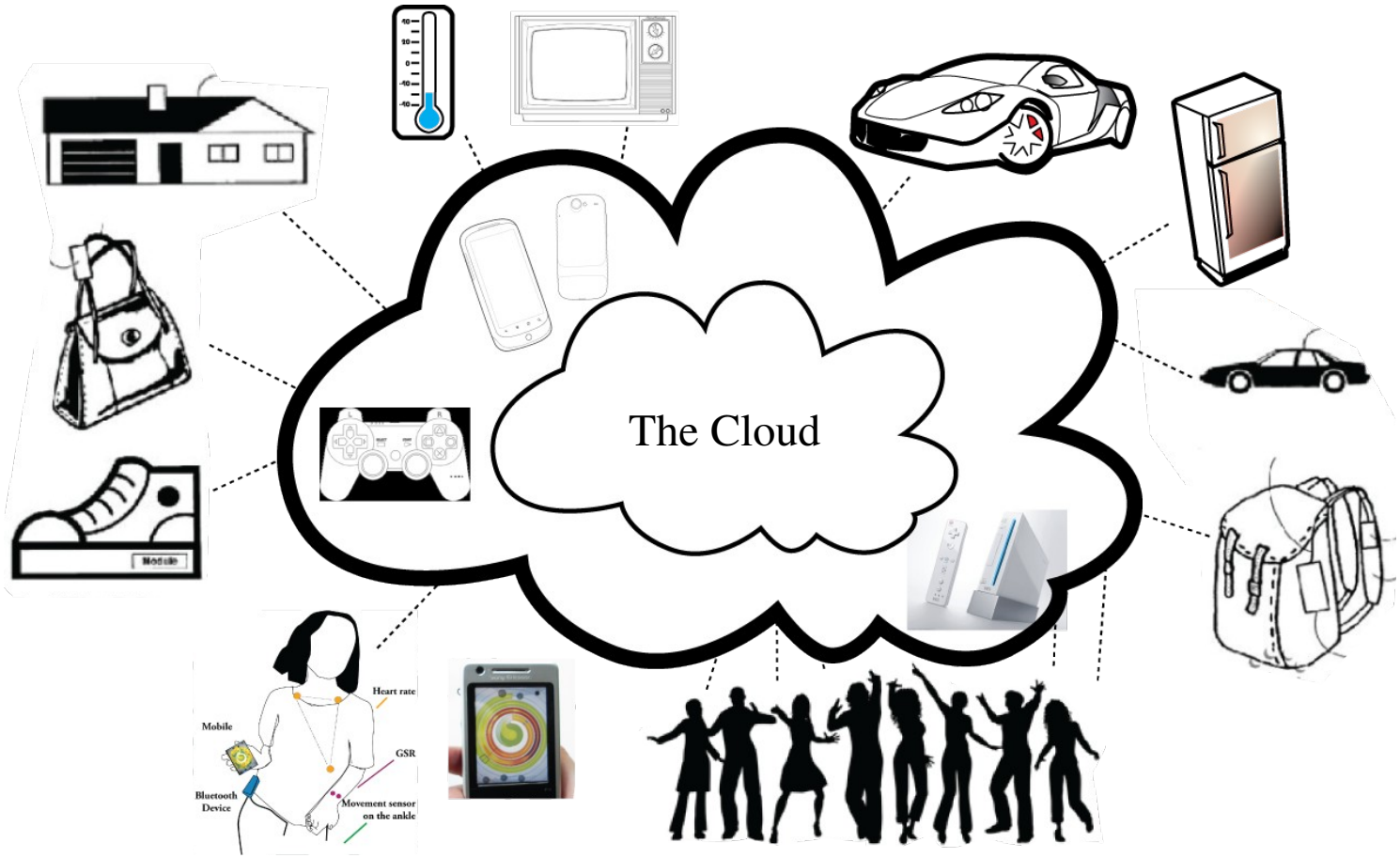
The 90’s idea of the connected world



- Devices with sensors and connectivity started here.
- Your world is a collection of people and things
- Command and control is primarily local
- But, it did drive early thoughts of networked control and free exchange of data.

Internet of Things is centrally mediated

This is a very different model where sensors are central



Sensor based devices takes us to the Social *Internet of Things*

The vision is that sensor based devices will soon number in the billions.

Forget the traditional devices like phones. Look at everything else.

- Every piece of clothing. (UHF RFID too!)
- Every door has a wireless lock. (Think Amazon here.)
- Every car has multiple RFID and wireless connections.
- Every bus, subway, airplane and train.
- Every place you can park a bus, airplane, subway or train.
- Every seat in every car. Everything else in the car as well.
- Every store. (Payment is wireless, resource metering is wireless.)
- Every sign, poster or notice. (NFC driven)
- Every piece of mail, packages, freight.
- Every item of food.
- Every sensor in every space where people exist.

Some refer to this as the Machine-to-machine (M2M) world.

- M2M connected devices become *Social Objects*.
- We are no longer just living in a locally controlled container for people and things
- Our devices can be part of the social network and can interact with us and others in that role.
- Sensors and actuators make this possible. Without the sensors, the M2M model would have no data to exchange.

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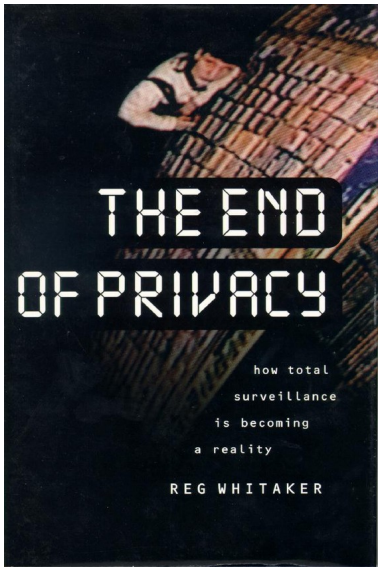
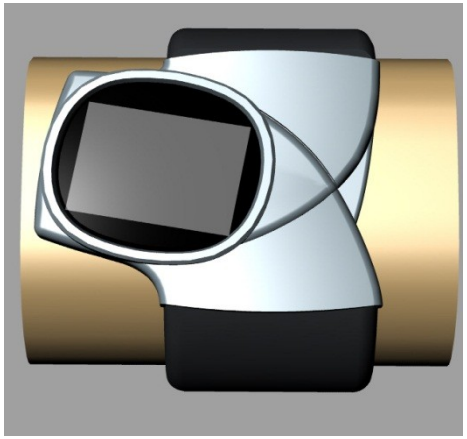
Examples: Innovative new devices, environments and challenges



Privacy Problems*

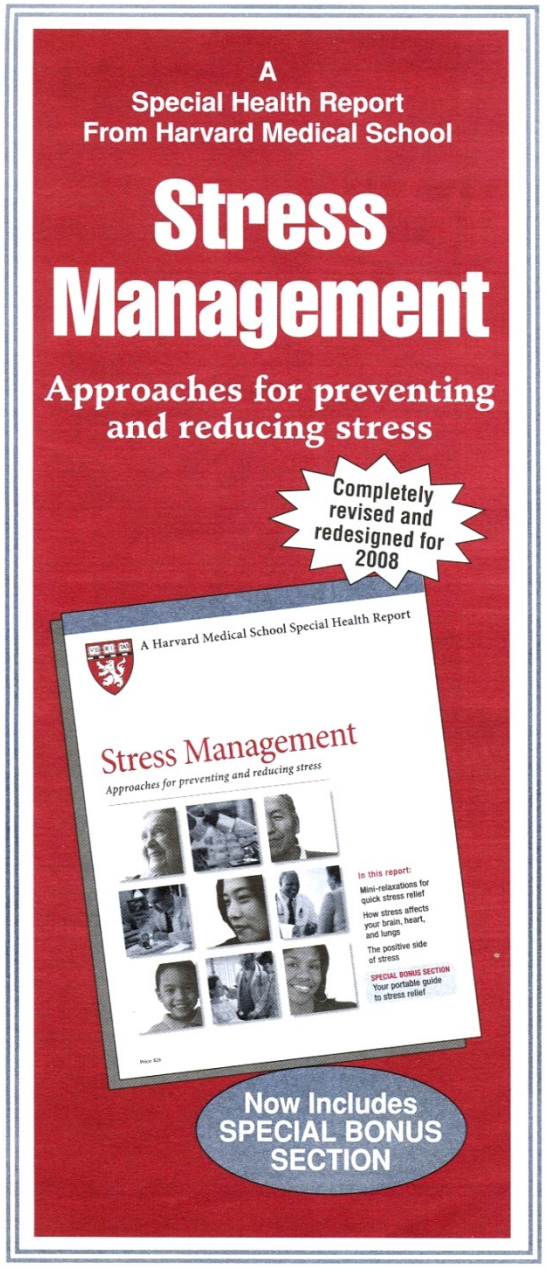
"Smart" Environments
Personal Transaction Servers
New Worn Devices



Interactive media devices

*The End of Privacy, How Total Surveillance is Becoming a Reality, Whitaker, R., ISBN 1565843789, New Press, December 1998

In Healthcare as well



This is a publication from Harvard Medical School in the USA.

Technology used in devices for health management are very much in demand in the market place.

All this gives new Solutions and Service models with associated *business opportunities*.

These are new service related problems that can be addressed.
It is also a way to show real value add in new products!

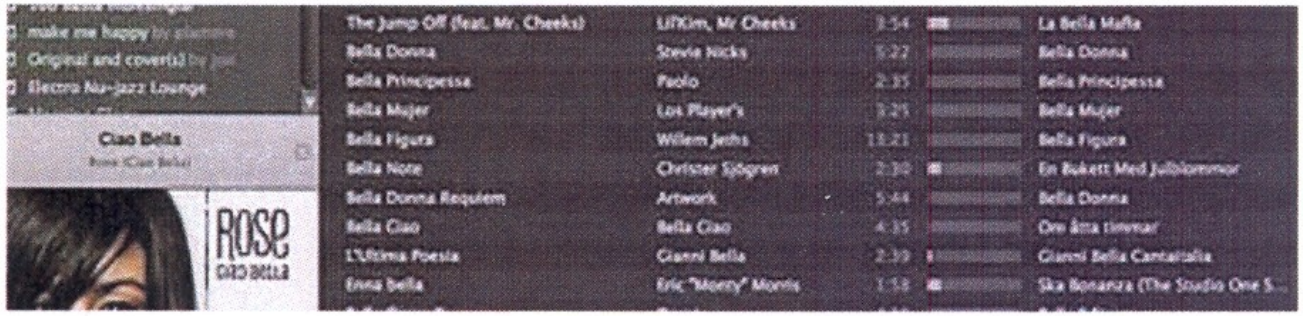
- User representation in cyber space: New ways to do this.
- User Device Configuration: We still don’t do this well.
- User Interface: Going beyond touch screens.
- Interoperability: Making things work together
- User data problems: How to manage this ethically
- M2M device management: A growing need.
- Using Machine Learning (statistics) and AI to add value.

Early example: Spotify

Spotify seems simple, but it isn't.

Test: Di.se testar Spotify

Uppdaterad 2008-11-21 08:39



Knappt lanserad men redan omskriven och uppskriven. Den svenska musiktjänsten Spotify har snabbt fått många anhängare. Även testarna på di.se:s redaktion är imponerade.

Martin Lorentzons och medgrundaren Daniel Eks nya musiktjänst Spotify har lyckats med något som få andra nättjänster för musik gjort - att väcka gillande hos både användare och musikbransch.

Programmet består av en enkel spelare med grundläggande funktioner för sökningar och spellistor. Men till skillnad från exempelvis Apples Itunes behöver användaren inte äga musiken för att lyssna på den.

Spotify

Genom avtal med skivbolagen har Spotify lyckats med att skapa en laglig musiktjänst online

From the CEO of Spotify's blog:

"We think music data is social objects, and we focus on building tools around them. We don't necessarily want to be a social network ourselves. That's also a hint on the future."

Daniel Ek

Need to share more than the playlist. How do we use sensors to share how the playlist is used? Who uses it? Where, and in what groups?

The Social IOT relies on context technologies

Sensors are used to measure this context.

- It is about situational awareness. Who is where and doing what.
- In addition to machines, users *themselves* deploy the sensors!

1. Tagging: This makes things machine readable.
2. ID management: It makes things identifiable. Who or what it is.
3. Transaction: Enables explicit events, especially payment.
4. Context management: Allows inference to be made based on things that happen, where they happen, when and with who.
5. It's the combination of people, places, things and events that make up what is shared. That is the shift in communication.

- (ie. It isn't just the playlist. It's also who is listening to it!)

Bases and metrics for Design

In the Mentorspace we use many tools and platforms that have different information and communication technologies. Very much like how real companies do it. What's important to them when they design?

It's about the combination of:

- A *performance* metric, like MIPs or read_cycles/sec
- A *power* metric. Watts
- A *cost* metric. Euros or SEK or USD or any money metric

There are a lot of factors that affect these. Cost is more than just the cost of the part. Power is more than just what the part draws max according to the spec sheet. We will come back to these metrics Throughout the course WRT design and optimization.

Definition: Performance

Performance is a broad term to describe a degree of functionality.
Often (but not always) this is done with respect to time.
Good examples are:

- Microprocessors
  - X million executed instructions per second
- Storage components such as disks drives or memory devices
  - X megabytes written or read per second
- Networks, such as broadband connectivity to homes
  - X megabits per second
- Batteries
  - X Ampere hours or X peak Amps (current delivered instantaneously)
- Services
  - X thousand transactions per second
- Sensors
  - Accuracy and Precision, or sensor measurements per second

Definition: Power

Power as a metric is expressed in Watts.
Power is used as a metric because it has a lot to do with value.

- The clearest link of power to value is due to cost. If something takes more power, one has to pay for the extra power somewhere.
- Low power systems, or using methods to make a system consume low amounts of power often have great value, for example:

- Fewer batteries or longer battery life.
- Bad battery life is a big obstacle!
- The M2M IOT may require that we go beyond batteries
- Less bulk and weight.
- Less installation cost, for example cheaper wiring
- Less power is dissipated as heat which can be expensive to get rid of.
- Sustainability and environmental benefits, ie renewable sources

Why Cost is important

Cost is a complex metric and is expressed broadly. For example, here are four aspects of cost:

- Component Cost. This is especially important for devices and systems that cannot benefit from economy of scale.
- Operating Cost. It's not just what something costs to buy, it's also important to know what something costs to operate. This is especially true for ICT systems.
- Environmental Cost. This includes the cost to the physical environment, for example electronic waste.
- Human Cost. What is the cost to society to use devices like these? Both in a positive and negative sense.
- For example, what is the cost to power 50 billion devices?