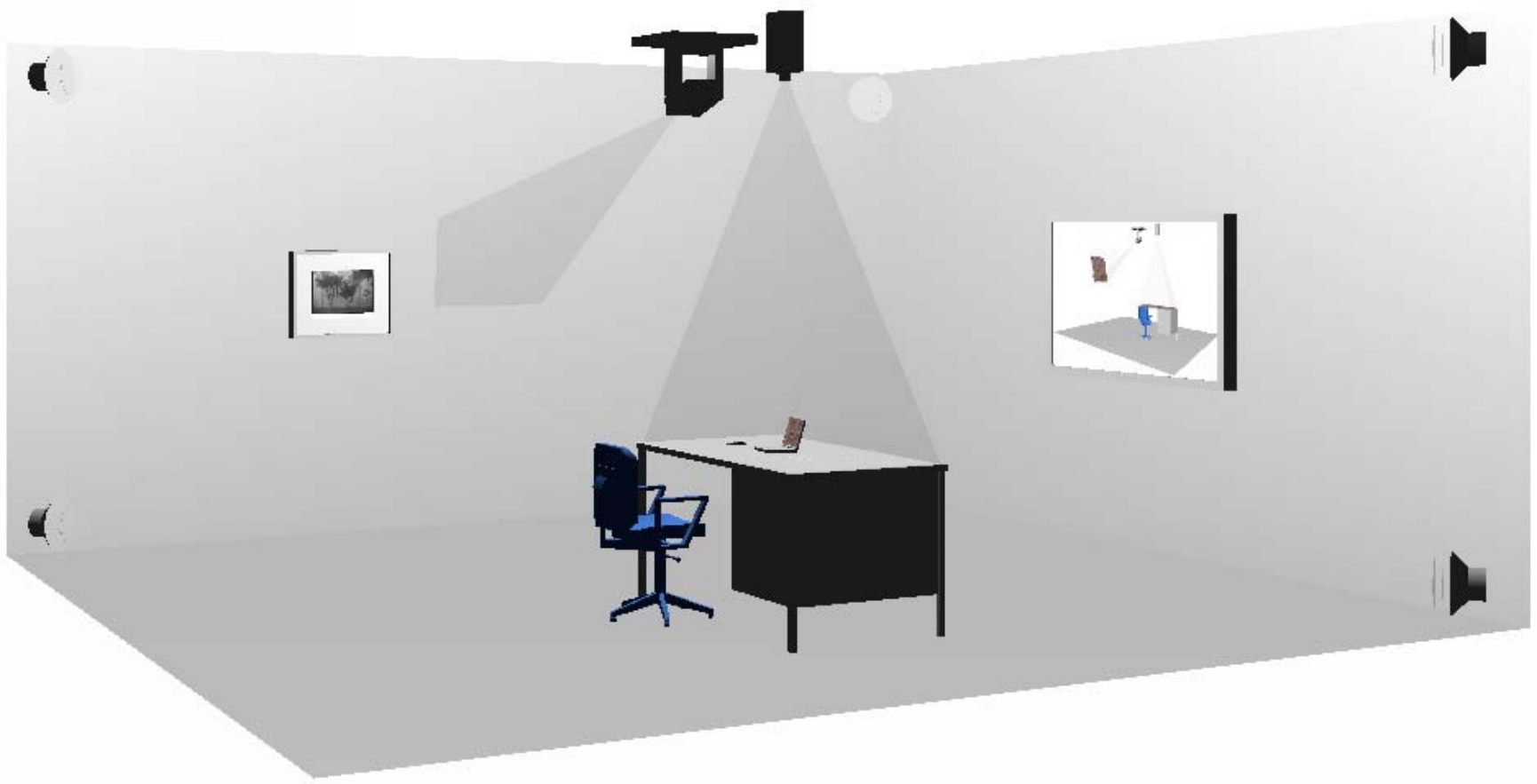
# Instrumented Environments

Andreas Butz, butz@ifi.lmu.de, www.mimuc.de

Fri, 12:15-13:45, Theresienstr. 39, Room E 045



# Active artifacts (i.e. instrumented objects)

- Concept:
  - Determine activity where it occurs
  - Add “self perception” to everyday things
  - Communicate their own state
  - The artifact digitally “supports” its own applications
  - Example: MediaCup
    - http://mediacup.teco.edu/

# Mediacup (Teco, Univ. Karlsruhe)

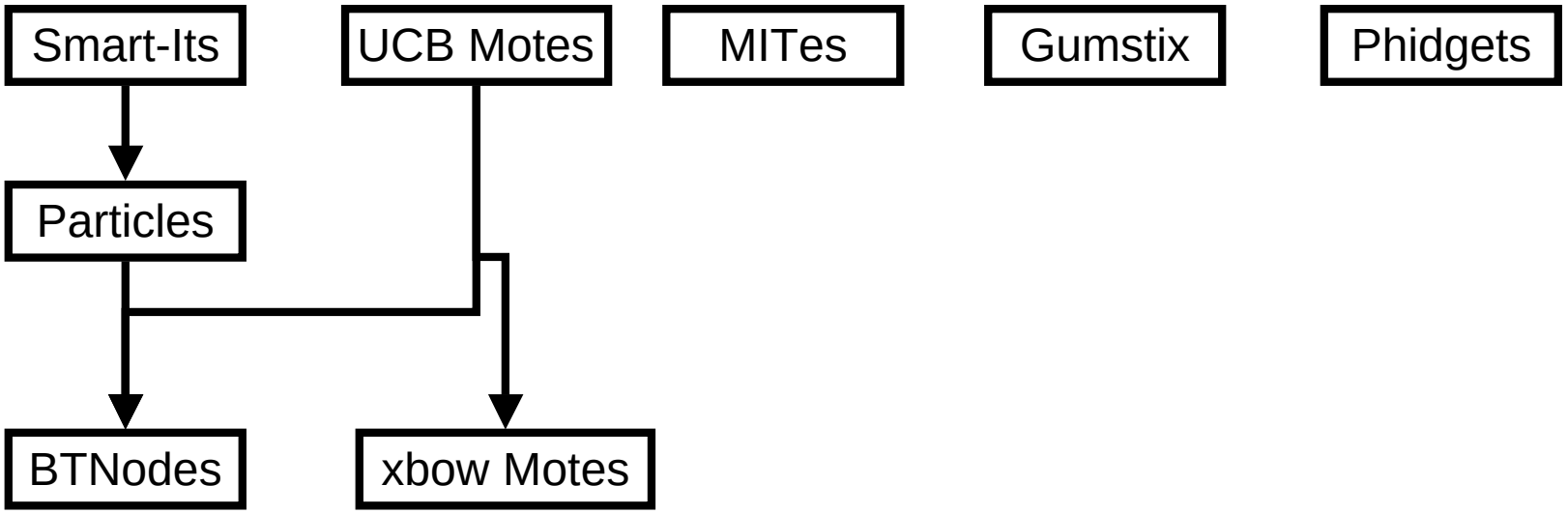
- First experimental „active artifact“, 1999
- Technical Info:
  - PIC-Microcontroller, 15k/384Byte, low-energy
  - IrDA physical level communication
  - 3 acceleration, 1 weight, 1 temperature sensor
  - 2 condensers as power supply
- „Self perception“:
  - Reading out sensors periodically
  - Compute important events : in the shelf, full, empty, currently in use, etc...

# Mediacup

- Small number of cups
- In use since 1999
- 95% correct recognition of Multi sensor events
- Important design criterion: Energy consumption, heavy influence on outward appearance

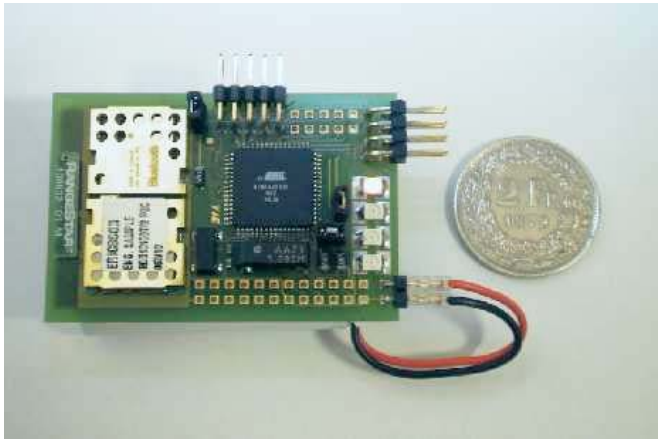
# HW Toolkits

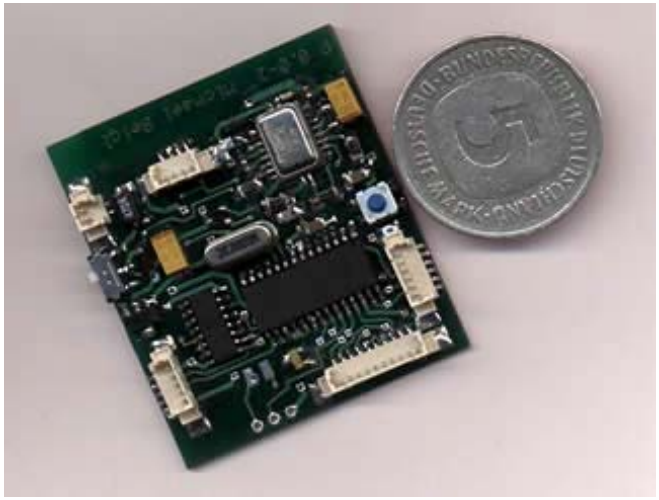
# Genealogy of HW toolkits



# Smart-Its (TeCo, Univ. Karlsruhe)

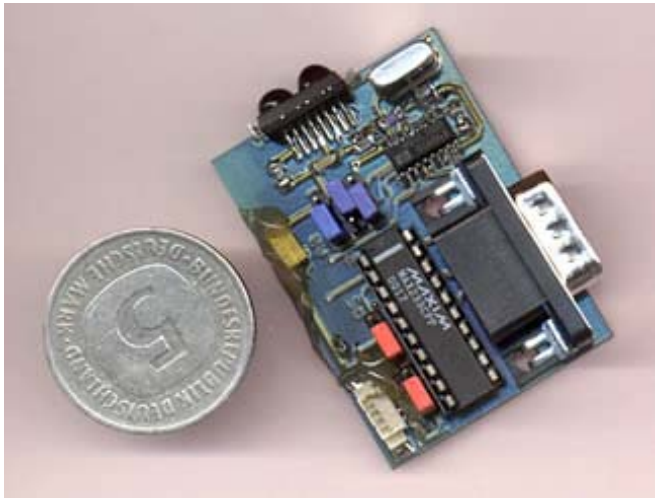
http://smart-its.teco.edu/

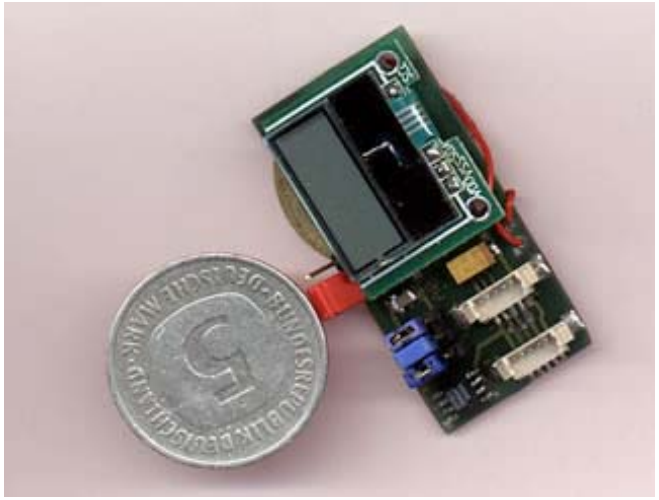




- Development under the EU project Smart-Its (2001-2003)
- 2 base module configurations:
  - Atmel's ATmega103L microcontroller with 128 kB flash memory and 4 kB of SRAM. Ericsson Bluetooth modules
  - PIC 16F876 (20 MHz) for processing, RFM 868 MHz for communication (128kbit/s), on board sensors and an I2C interface for sensor/actor boards.

# Smart-Its sensor modules

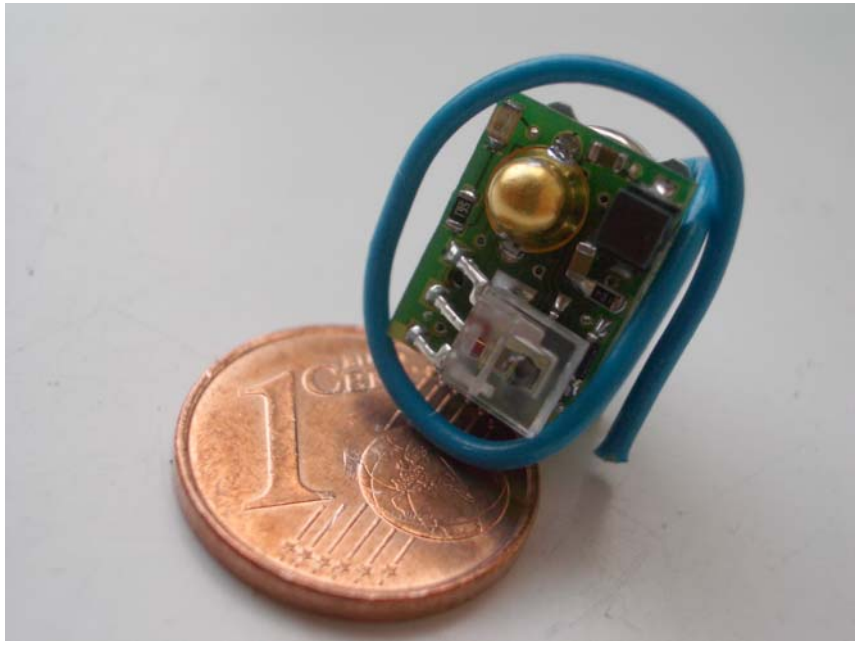




- RS232 Add-On (AR 0.0-0)
  - Interfaces to Smart-Its
  - RS232 level
  - IrDA physical layer
  - Power supply through main board
- I/O Add-on for Temperature, Display, Sound (TDS 0.0-0)
  - Interface: I2C
  - 8 char x 2 line display
  - High-Resolution temperature sensor
  - Piezo sound
  - Power supply through main board

# Particles (TeCo, Univ. Karlsruhe)

http://particle.teco.edu/



- Currently used in the Embedded Interaction Group (Albrecht Schmidt)
- …and of course many others…
- Detailed discussion by Paul Holleis…

# Instrumented Environments
# **Particle Programming**

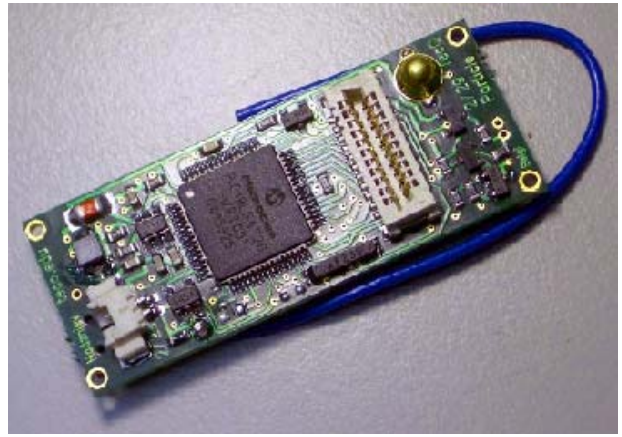
Paul Holleis, paul@hcilab.org, www.hcilab.org

Research Group
Embedded Interaction

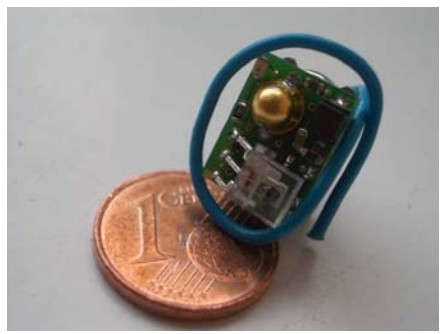
http://www.hcilab.org

# Hardware Description

# Hardware Details

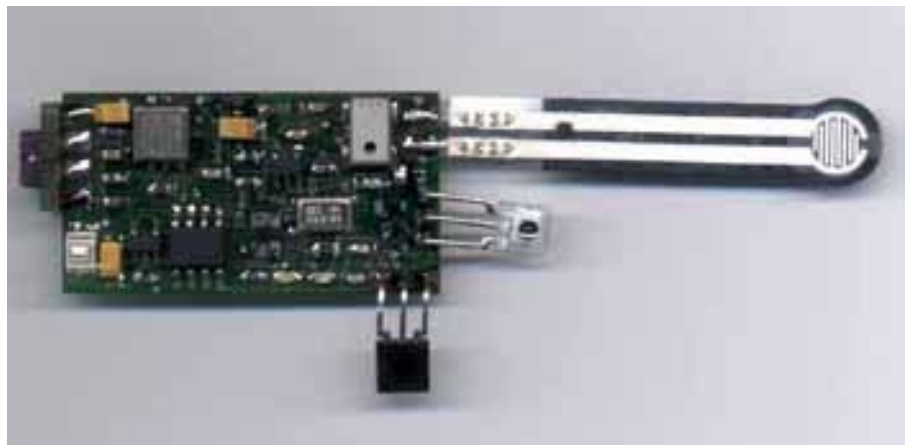


- Particle 2/29 (ca. 130 Euro)
  - Processor: PIC 18F6720 at 20 MHz, Internal Memory: 128kbyte program Flash, 4kbyte RAM, 1kbyte EEPROM
  - Additional Memory: 512 kbyte FLASH for data
  - RF Communication (ca. 15 meters)
  - 21 pin multi purpose connector
  - Speaker, 2 LEDs, AAA battery

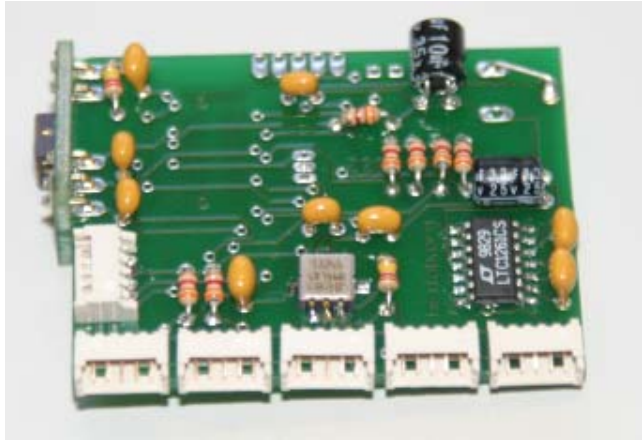


# Hardware Details
# Addon Boards

- spart (was 150 Euro)
  - 2xADXL210 acceleration sensor
  - Own Processor PIC 18LF452
  - Force sensor, pressure sensor
  - Temperature sensor
  - Microphone
  - 2 LEDs

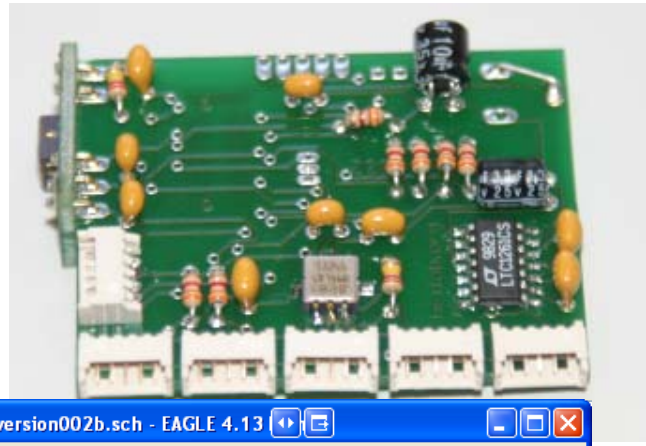


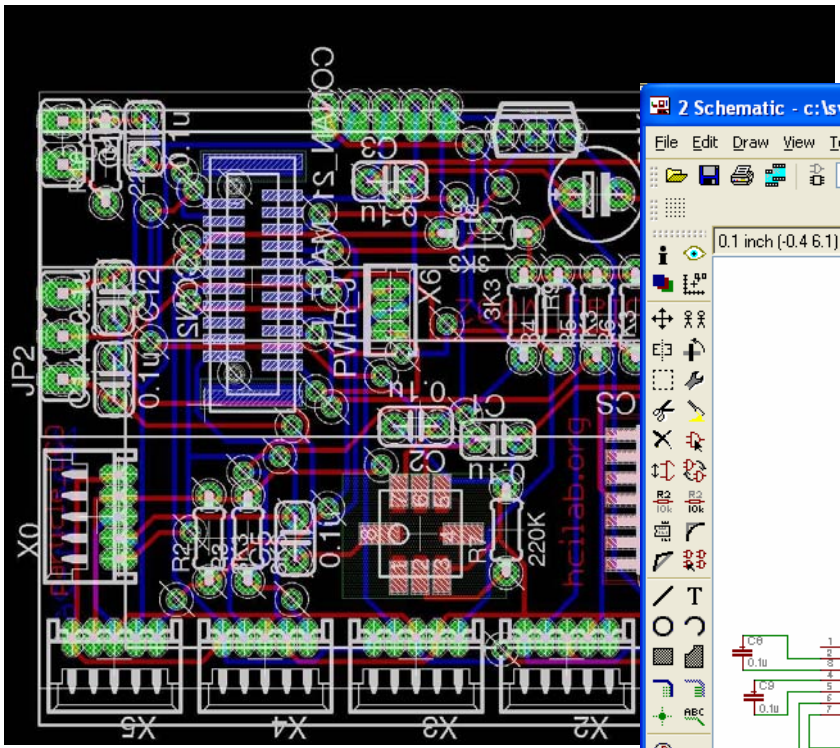
# Hardware Details
# Addon Boards

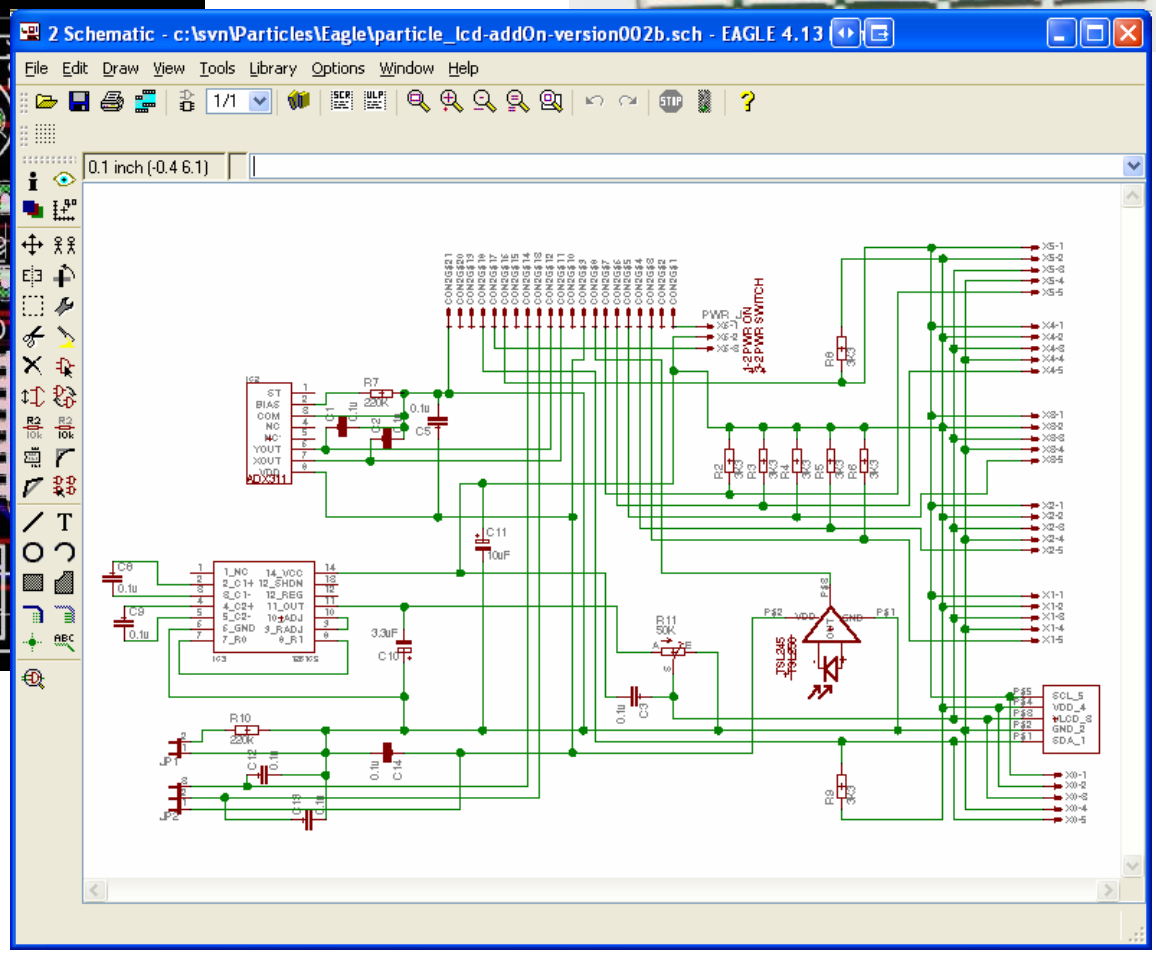


- Display addon board
  - cost: ca. 100 Euro + a few hours work
  - 3 axis acceleration
  - Up to 6 displays (96x40 pixel black-white)
  - Web (HTTP) based control


# Hardware Details
# Addon Boards

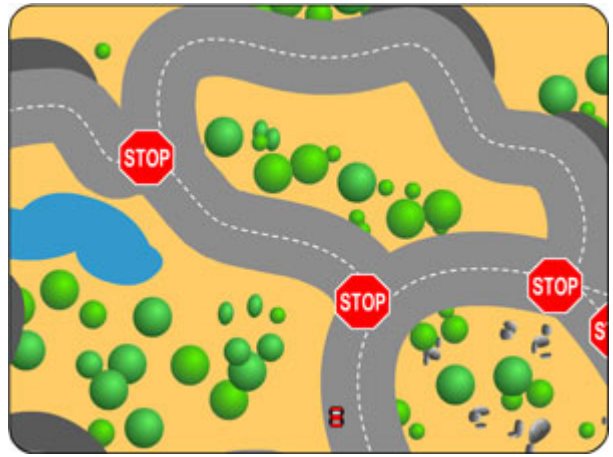






# Sample Applications

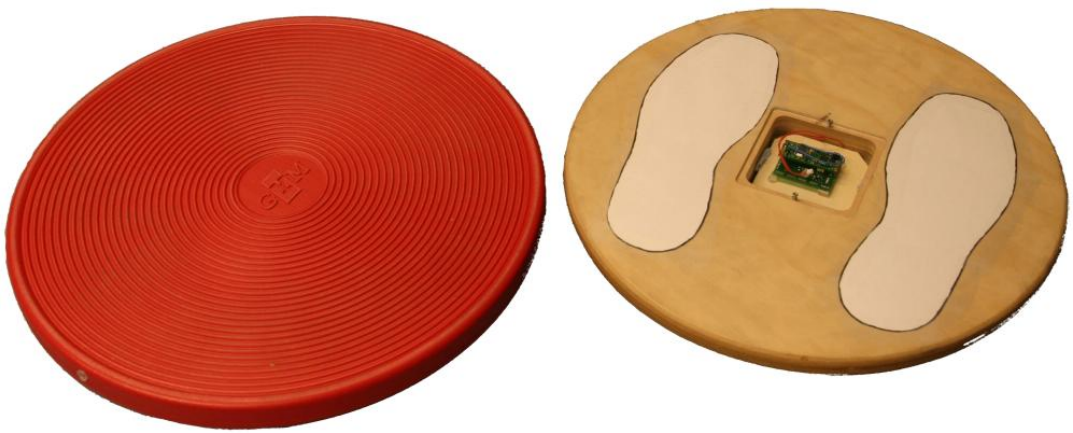
# Sample Applications




- Virrig Race / Learning Game
  - 4 ball switches (or 3D acceleration)
  - Transmission

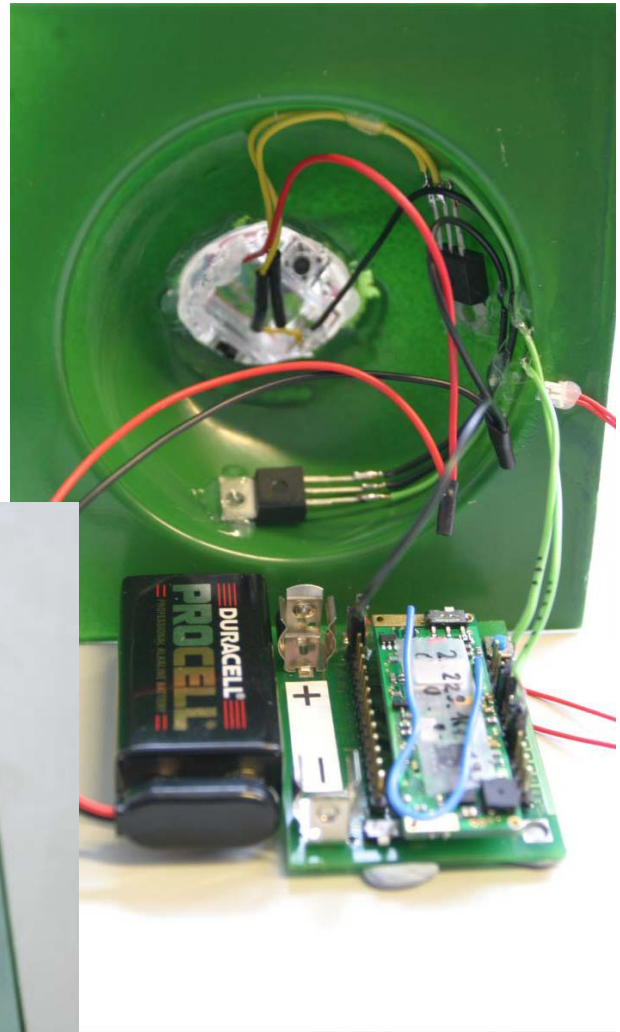
# Sample Applications

- Therapy Top
  - 3D acceleration sensors
  - Preprocessing
  - Transmission

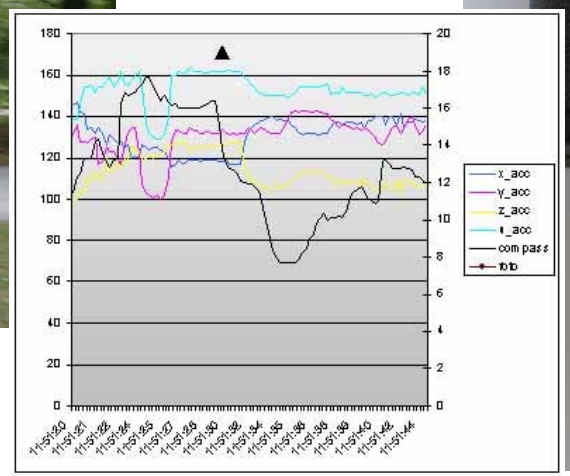
# Sample Applications

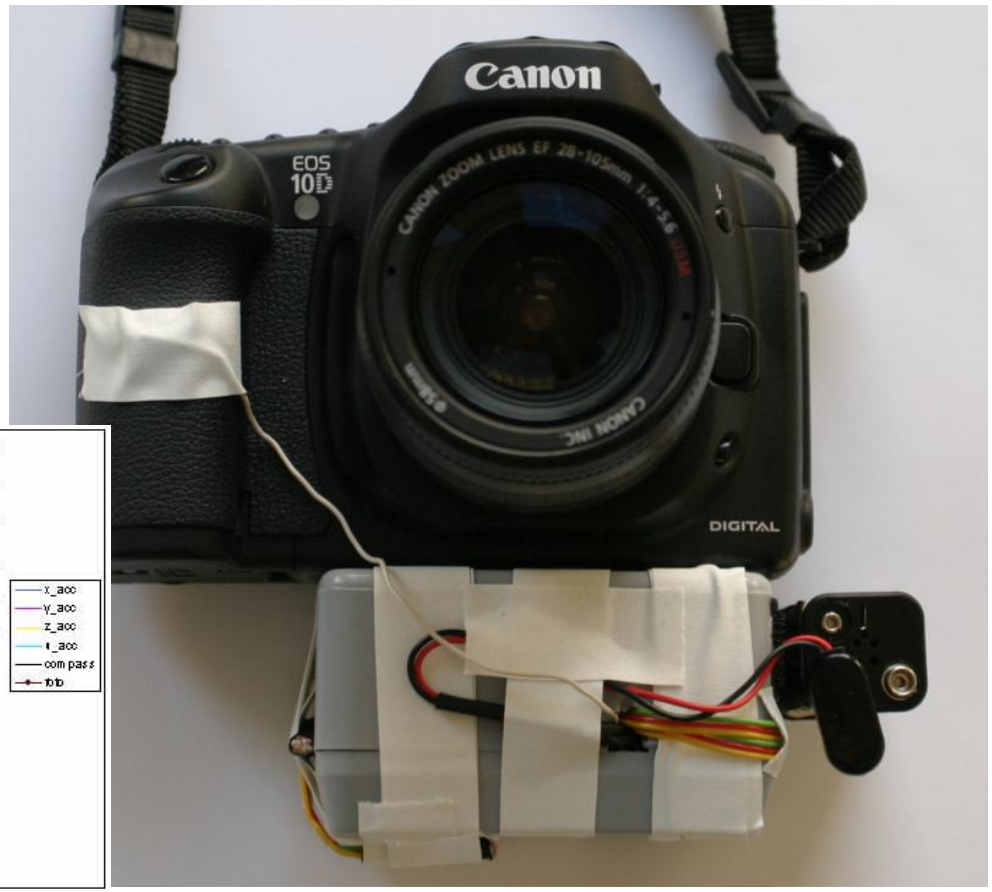
- (Ambient) Wardrobe Display
  - Pressure sensors
  - LEDs
  - Text display




# Sample Applications

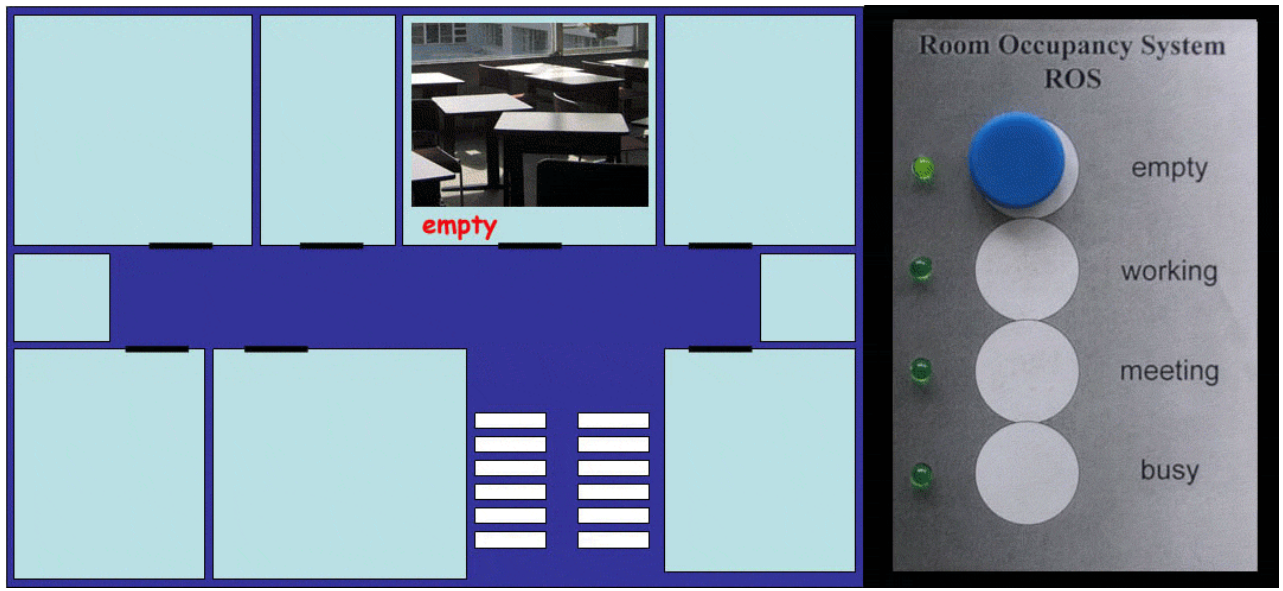
- Context-Aware Photography
  - 3D acceleration
  - Compass
  - Light sensors
  - Touch sensor



# Sample Applications

- Room Occupancy System
  - Hall effect (magnetic) sensors
  - LEDs
  - Transmission

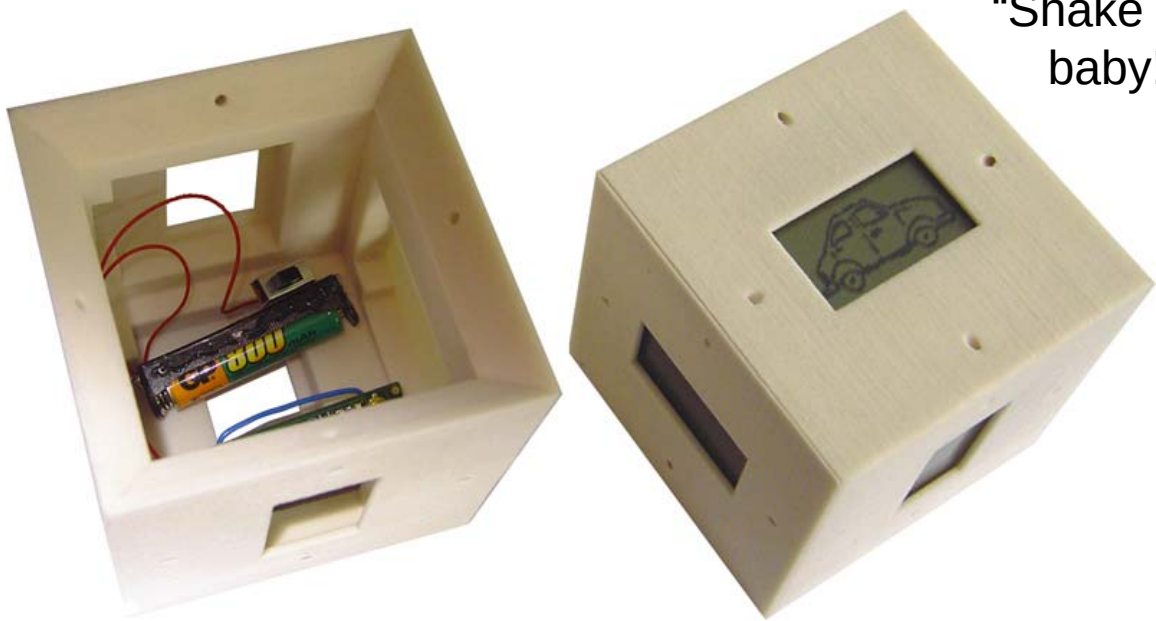


# Sample Applications

- (Ambient) Wardrobe Display
  - Pressure sensors
  - LEDs
  - Text display

# Sample Applications

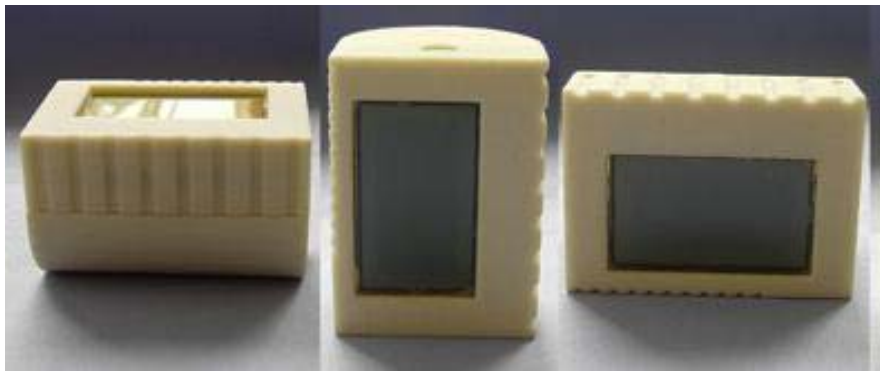
- Display (Learning) Cube
  - 3D Acceleration
  - 6 Displays
  - Transmission and reception

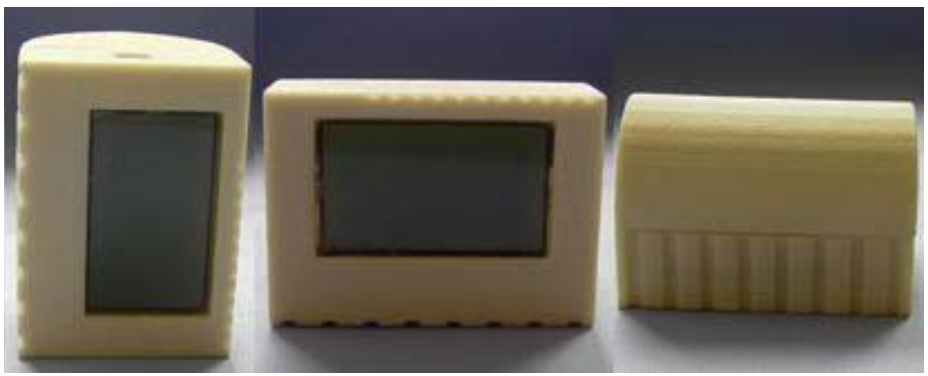


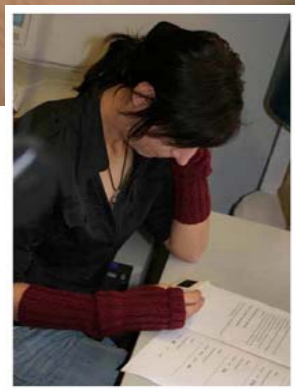
"Shake it baby!"

# Sample Applications

- Display Interaction





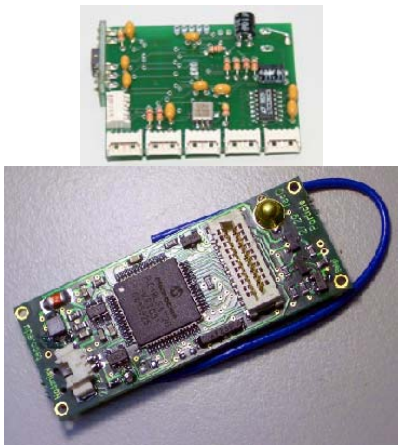
# Infrastructure

# Hardware Infrastructure

- Particle Computer
- Programmer
- Bridge
  - Conversion RF <-> UDP
  - XBridge (Ethernet)
  - USBBridge


# Software Infrastructure

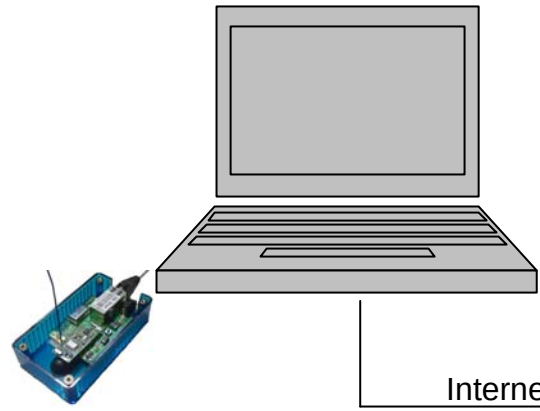
Microcontroller



20 MHz CPU
512 KB Flash
4 KB RAM

radio frequency
communication

PC




3000 MHz CPU
100.000.000 KB Harddisk
1.000.000 KB RAM

# Software Infrastructure

- Microcontroller Programming
  - Close to hardware (C, Assembler)

- PC Programming
  - UDP access (C++)
  - High-level language binding libraries (Java, Ruby, .NET, C#)
  - Abstract toolkits

# Software Details
# PIC Programming

```
void main()
   // init code

   #define KNOB_PIN PIN_CONN_03

   while(true)
      if (input(KNOB_PIN)) {
         SendMessage('1');
         PCLedRedOn();
      } else {
         SendMessage(,0');
         PCLedRedOff();
      }
}
```

```
SendMessage(char data) {
   ACLAddNewType(103, 97);
   ACLAddData(data);
   ACLSendPacket(2);
}
```

# Software Infrastructure

- Microcontroller Programming
  - Close to hardware (C, Assembler)

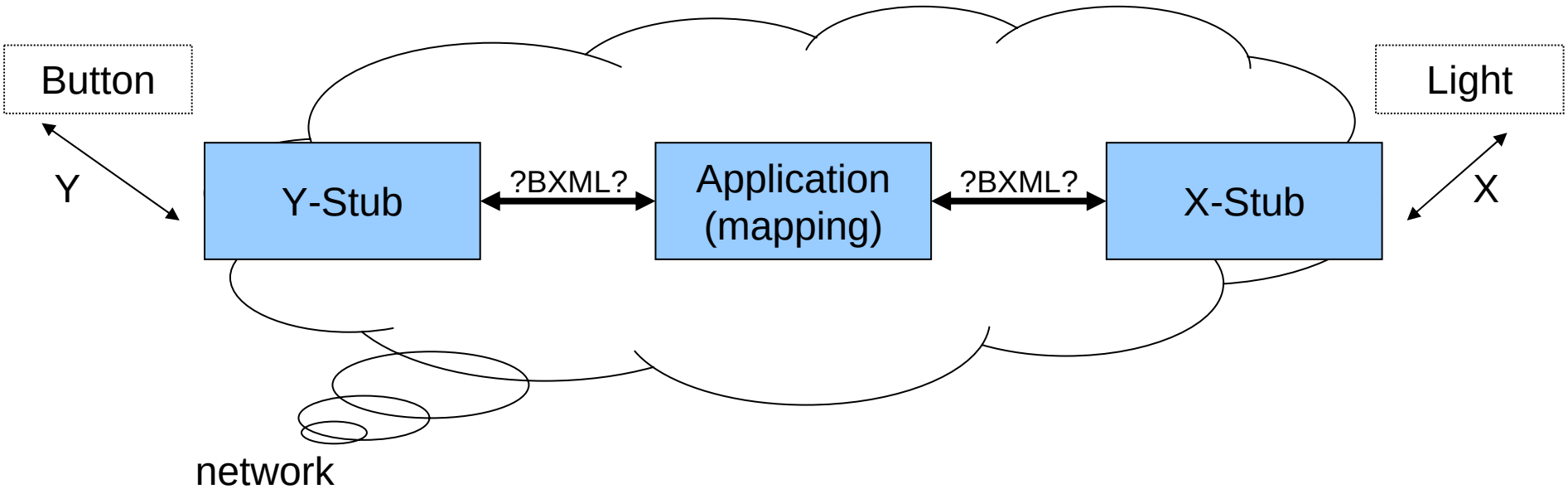
- PC Programming
  - UDP access (C++)
  - High-level language binding libraries (Java, Ruby, .NET, C#)
  - Abstract toolkits

# Software Details
# PC Programming

```
void main()
   ParticleSocket rsocket = new ParticleSocket();
   ParticleSocket ssocket = new ParticleSocket();

   ParticlePacket packet = rsocket.receive(ssocket);

   ParticleTuple packet.firstACL();
   short[] data = tuple.toArray();

   if (data[0] == 1)
      // …
   else
      // …
}
```

# Software Details
# PC Programming - Toolkit

- www.eitoolkit.de (wiki on medien.ifi.lmu.de)
- Component based system
- Software proxy components
- Multi-clicky-bunti?



# Instrumented Environments
# **Particle Programming**

Idee für / Wunsch nach Projektarbeit oder Diplomarbeit?


➔ Paul Holleis, paul@hcilab.org, www.hcilab.org/paul
➔ Matthias Kranz, matthias@hcilab.org, www.hcilab.org/matthias
➔ Albrecht Schmidt, albrecht@hcilab.org, www.hcilab.org/albrecht

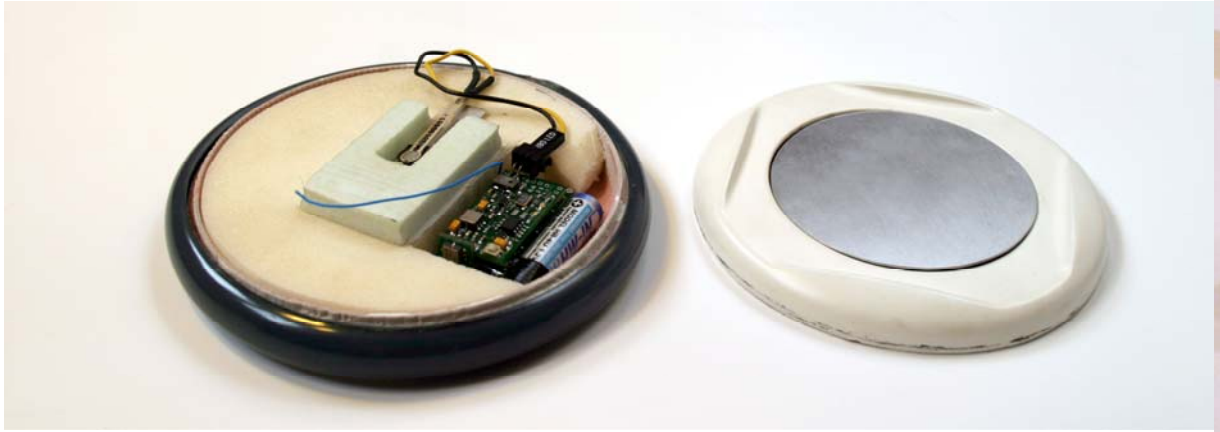

Research Group
Embedded Interaction

http://www.hcilab.org

# A beer mat for pub interaction

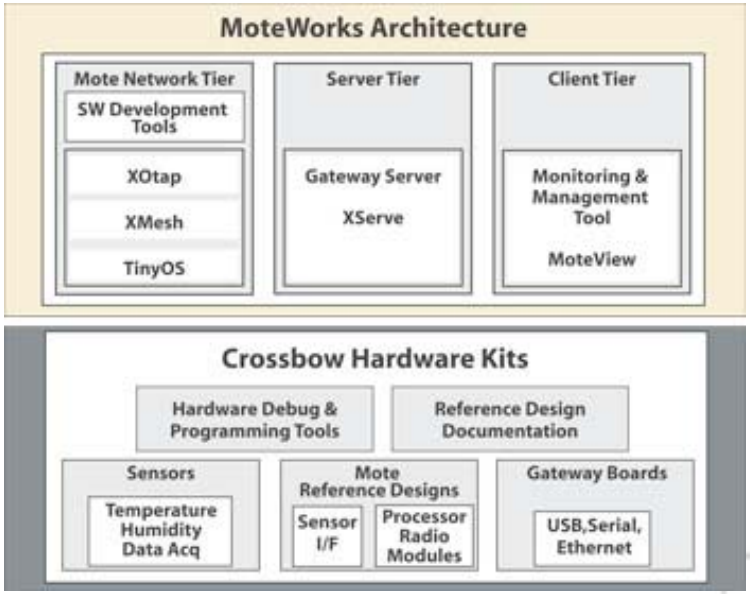
[Butz, Schmitz, Ubicomp 2005]

- Device to be put under an actual cardboard beer mat
- Senses weight and gravity
- Shake to order a new drink
- Raise glass (and flip mat) for voting



# Motes (UC Berkeley, crossbow)

http://www.xbow.com/de/Funksensor-Netzwerk.htm
http://www.xbow.com/wireless_home.aspx




- Developed at UC Berkeley, now spin-off
- See Video


# Motes base units

- 3 Mote Processor/Radio module families:
  - MICAz (MPR2400)
    - radio works on the global 2.4GHz ISM band and supports IEEE802.15.4 and ZigBee.
  - MICA2 (MPR400)
    - available in 315,433,868/900MHz configurations
  - MICA2DOT (MPR500)
    - available in 315,433,868/900MHz configurations
- TinyOS operating system

# Motes Sensor Boards

- MDA100 - precision thermistor, light sensor, and general prototyping area.
- MTS300/MTS310 - supports a variety of sensor modalities for the MICA, MICA2 and MICAz
- MDA500 - sensor and data acqusition board for external signals to the MICA2DOT mote
- MTS400/420 - environmental monitoring for the MICA2 and MICAz with built-in sensors and an optional GPS
- MDA300 - supports data acquisition and environmental monitoring for the MICA2 and MICAz
- MTS510 - Light/Accel/Microphone Sensor Board for MICA2DOT

# Mote network base stations

- MIB510 - RS-232 serial interface to the MICA family of Motes.
- MIB520 - USB for the MICA2/MICAz Motes for both communication and in-system programming
- MIB600 - Ethernet Interface board and Mote programming
- Stargate - Linux single board computer with Compact Flash, PCMCIA, Ethernet, USB Host, …

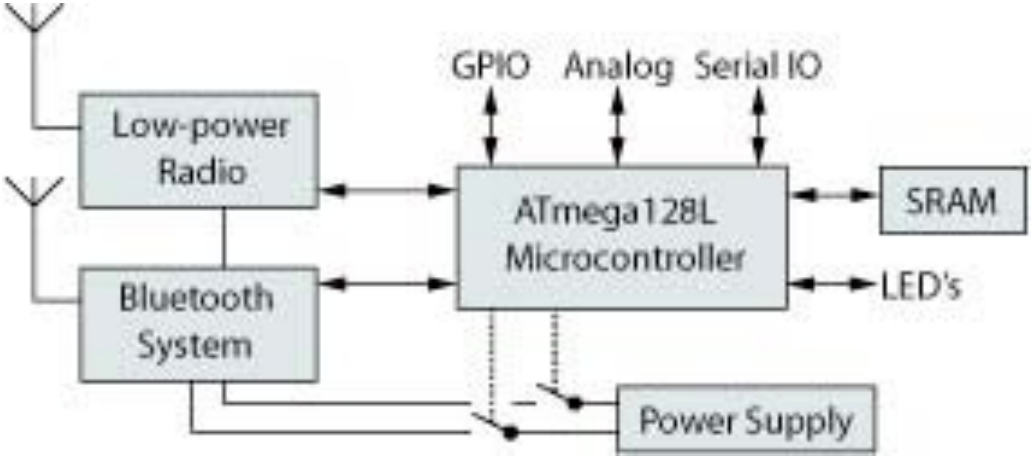
# Cricket Mote

- The MCS410CA or "Cricket Mote" is a location-aware MICA2 Processor/Radio module. The Cricket Mote includes all of the standard MICA2 hardware, as well as an Ultrasound transmitter and receiver. It uses the combination of RF and Ultrasound technologies to establish differential time of arrival and hence linear range estimates.
- → see „Cricket“ in the tracking chapter ;-)

# BTnodes (ETH Zürich)

http://www.btnode.ethz.ch/

- Microcontroller: Atmel ATmega 128L (8 MHz @ 8 MIPS)
- Memory: 64+180K RAM, 128K FLASH ROM, 4K EEPROM
- Bluetooth subsystem: Zeevo ZV4002, supporting AFH/SFH
- Scatternets with max. 4 Piconets/7 Slaves, BT v1.2 compatible
- Low-power radio: Chipcon CC1000 in ISM band 433-915 MHz
- Ext. Interfaces: ISP, UART, SPI, I2C, GPIO, ADC,Timer, 4 LEDs
- Standard C Programming, TinyOS compatible
- http://sourceforge.net/projects/btnode

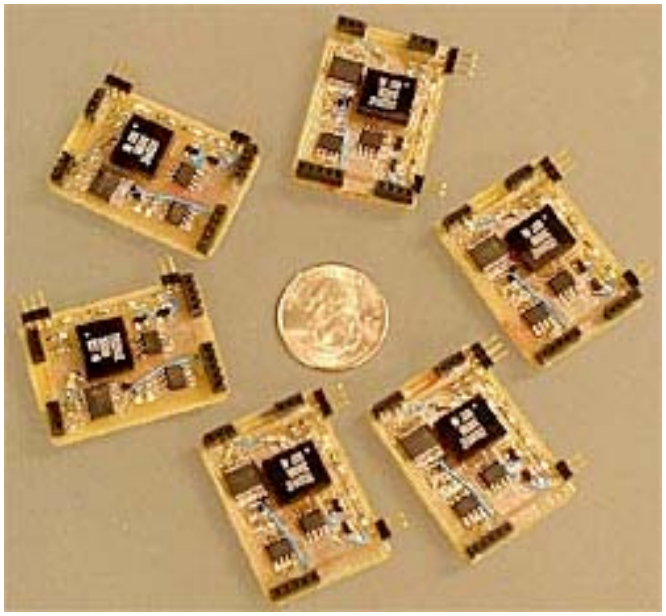



# BTnode Developer kit

- **Contents:**
  - 2 BTnode rev3
  - 1 usbprog rev2
  - 1 Atmel ATAVRISP MK2 programmer
  - 2 USB cable
  - 1 BTnode CDROM
- **Pricing:**
  - EUR520/CHF780

# MITes (MIT environmental sensors)

http://ubicomp.org/ubicomp2004/adjunct/demos/tapia.pdf
http://architecture.mit.edu/house_n/projects.html#mites

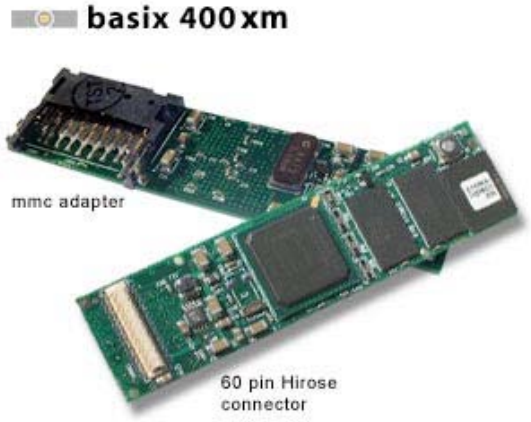


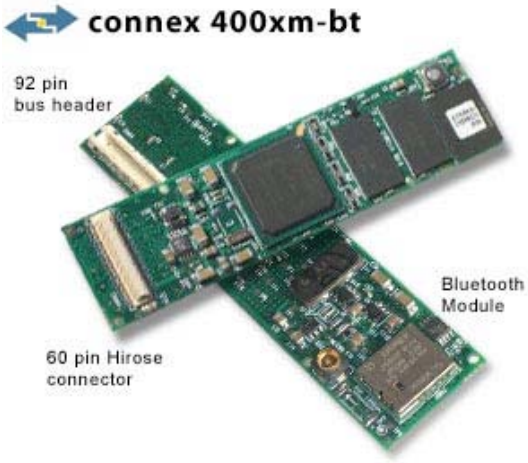

- No technical web page found, only papers
- Apparently used in several MIT projects
- Senses at least movements, light, temperature
- See Video about the PlaceLab (Pervasive 2005)

# Gumstix

http://sourceforge.net/projects/gumstix/
http://www.gumstix.org/

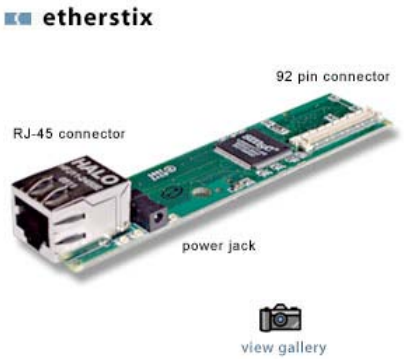
- 80mm x 20mm x 6.3mm
- Intel XScale® PXA255 **400MHz**
- Linux kernel 2.6
- sshd, apache, bluetooth utilities, …
- Network: Bluetooth, usbnet, PPP
- 3.4V - 5.2V takes Li-Ion, Li-Polymer, 3-NiMH, standard 4.5V or 5.0V inputs
- Draws <250 mA at 400MHz without Bluetooth

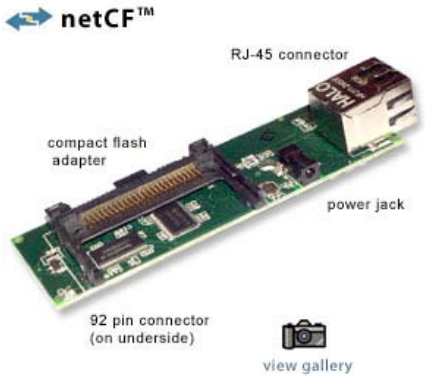
# Gumstix add-ons

- audiostix 2 + audiostix AC97
- Breakout gs
- Cfstix
- Etherstix
- GPSstix
- netCF
- netDUO
- netDUO-mmc
- netMMC
- roboaudio-th
- Robostix
- robostix-TH
- thumbstix-gs
- Tweener
- waysmall – STUART
- waysmall board



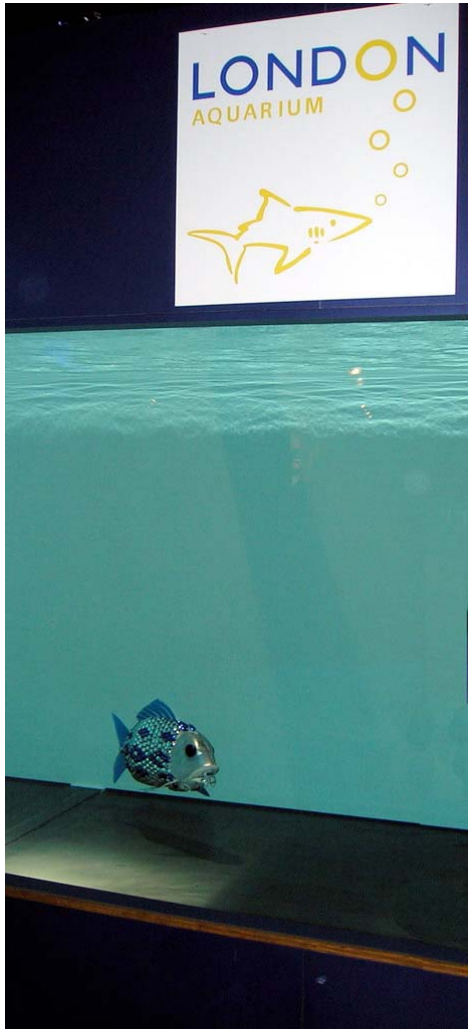







# Gumstix app: robotic fish (Essex University)

- **The world's first autonomous robotic fish are the latest attraction at the London Aquarium.**
  Biologically inspired by the common carp, the new designs can avoid objects and swim around a specially designed tank entirely of their own accord.
- See Video1 and Video2



# Gumstix controls flying robot

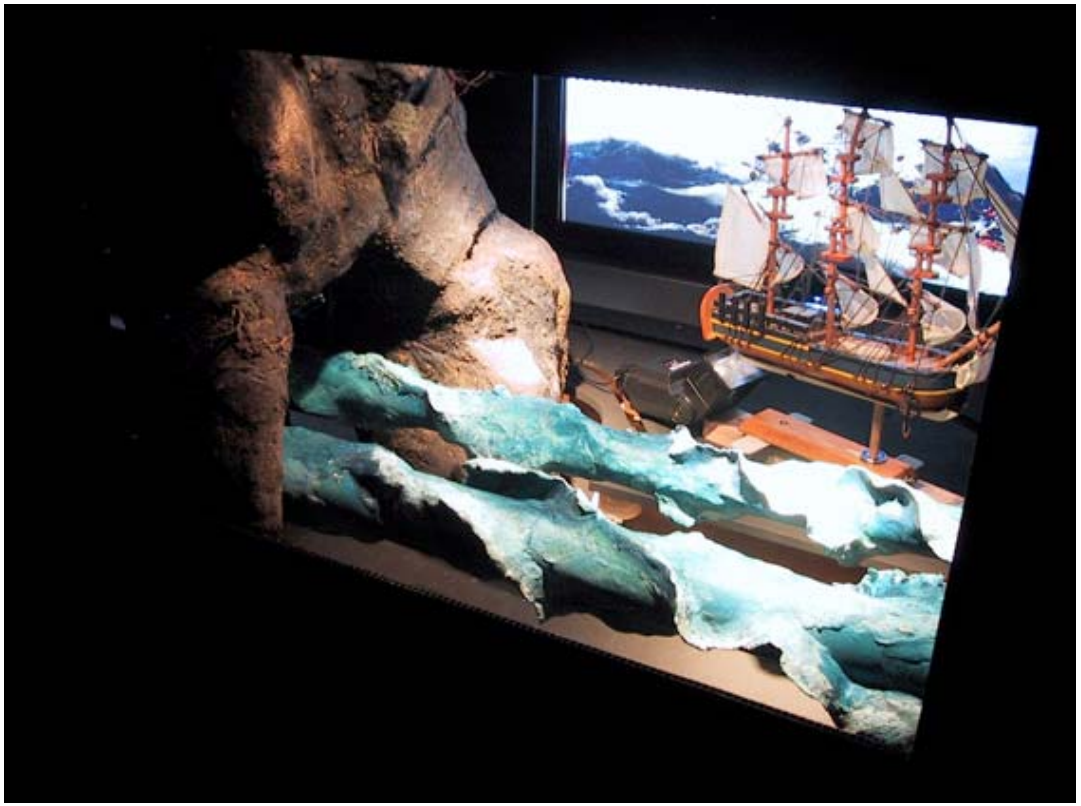
http://cswww.essex.ac.uk/staff/owen/research.htm

# Phidgets (U Calgary, Phidgets, Inc.)

http://phidgets.com/


- Connected to host via USB
- Input modules
  - Analog + digital inputs
  - Sensors, touch sensors,
  - RFID
- Output modules
  - LEDs, Displays
  - Motors, Servos
  - Relay
- Driver support for Windows, MacOS X, Linux
- Java API available

# Phidget app: museum installation



- Various Phidgets were used in this museum installation:
  - quadservo controller connected to marine
  - electronic speed controller powering halogen lighting
  - interfacekit 0/0/4 for triggering 2 flashes for lightning
  - motor controller for wave rollers and ship movement

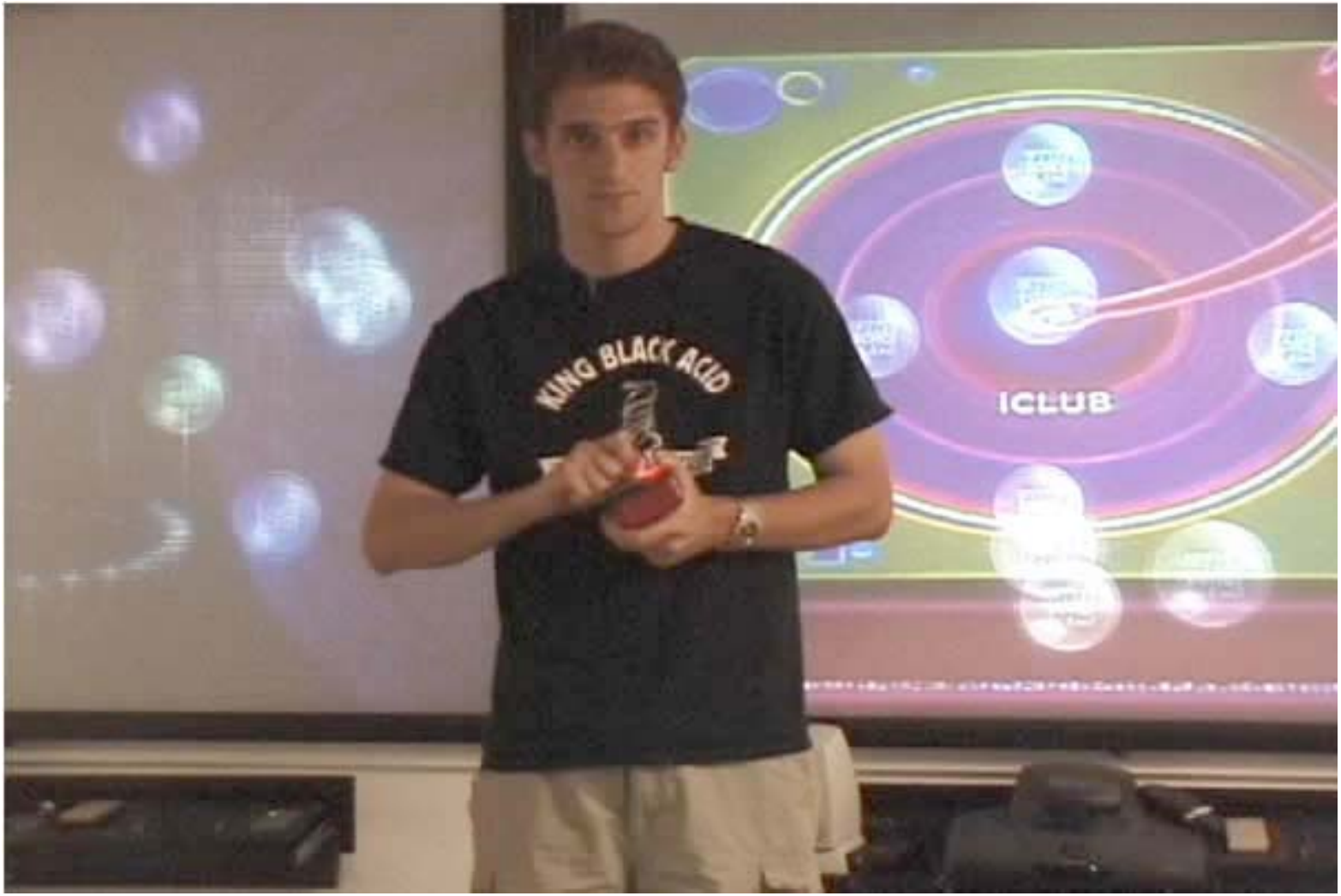
# iStuff (Stanford)

http://hci.stanford.edu/research/istuff.html


- Set of input devices for prototyping interaction in instrumented environments
- Also includes software infrastructure (→ event heap)

# iStuff app: iClub

http://iwork.stanford.edu/photos.shtml#iclub



# Workshop Digitalphotographie

- Kein Schein, freiwilliges Angebot
- Dauer: 1 Woche: 4.-8. September
- Morgens ca.1/2 - 1 Stunde Folien
  - Technische Grundlagen (Optik, Kamera)
  - Bildgestaltung durch
    - Bildaufbau & Perspektive
    - Zeit, Blende
    - Licht


- Tagsüber praktisches Photographieren
  - Vermutlich Architektur + Natur
  - Benötigt: eigene Kamera + Stativ
- Abends Bildbesprechungen am Rechner
- Bei Interesse email an butz@ifi.lmu.de