Instrumented Environments

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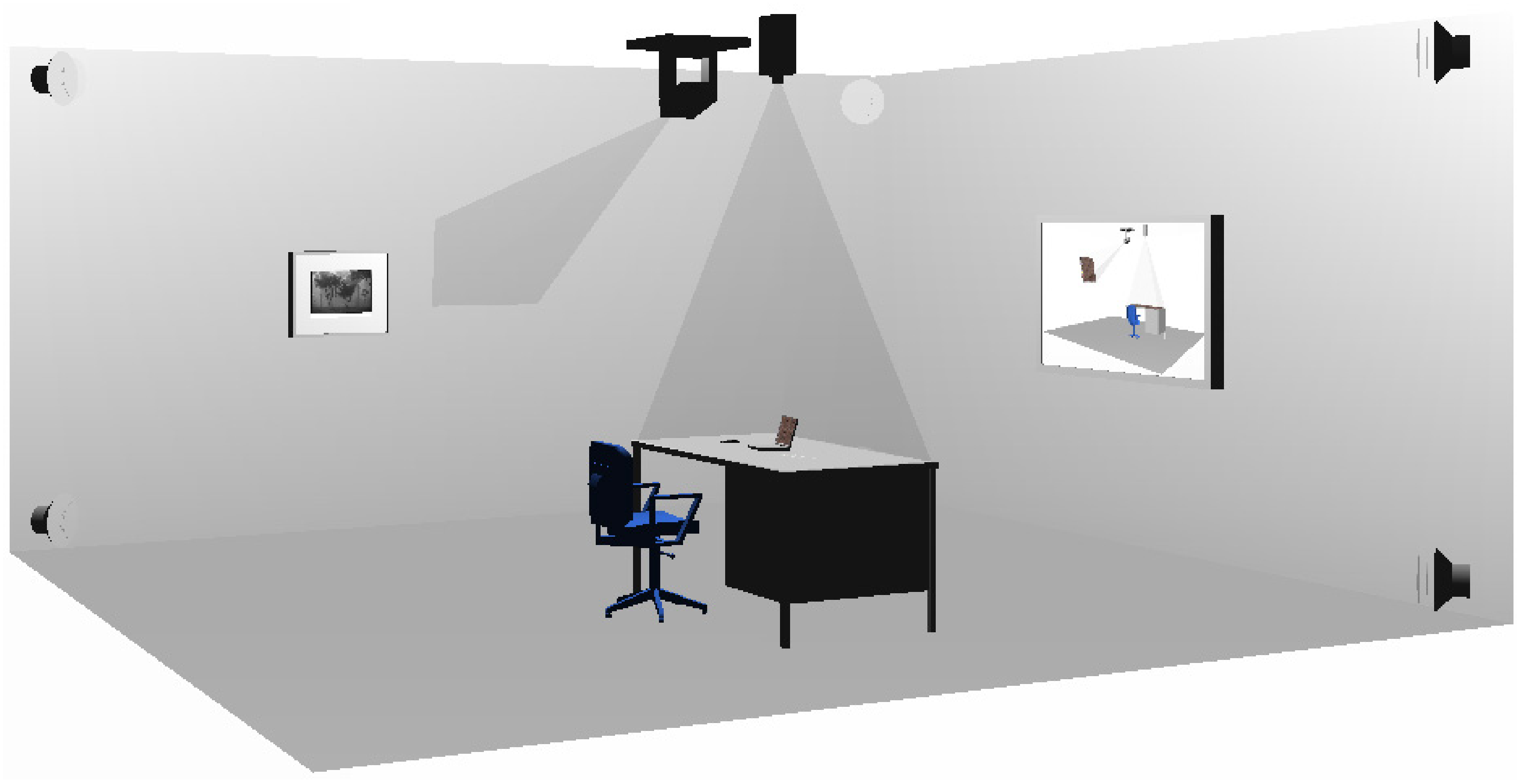
Mon, 10-12 Uhr, Theresienstr. 39, Room E 46



Topics Today

- Actualities
  - Instrumented environments seen in Korea
  - Notion of “Ubiquitous robots”
- Some network technologies for IE
  - Wired
  - Wireless
  - Optical
- Some positioning technologies

Instrumented Country?!?

- Car info system
  - Position via GPS
  - Map data via mobile net
  - Device cost ~200$
  - Subscription ~30$/year
- Services:
  - Speed limits:
    - Cameras + distance
    - Actual measured speed
  - Sharp turns, bends, stops, traffic lights
  - Navigation if connected to a Laptop
- Interface:
  - 3 digit LED display for speed
  - Use of „sound icons“ (3 beep = 300m, 2 beep = 200m)
  - Speech output (constant chatter!)

Instrumented Bedroom

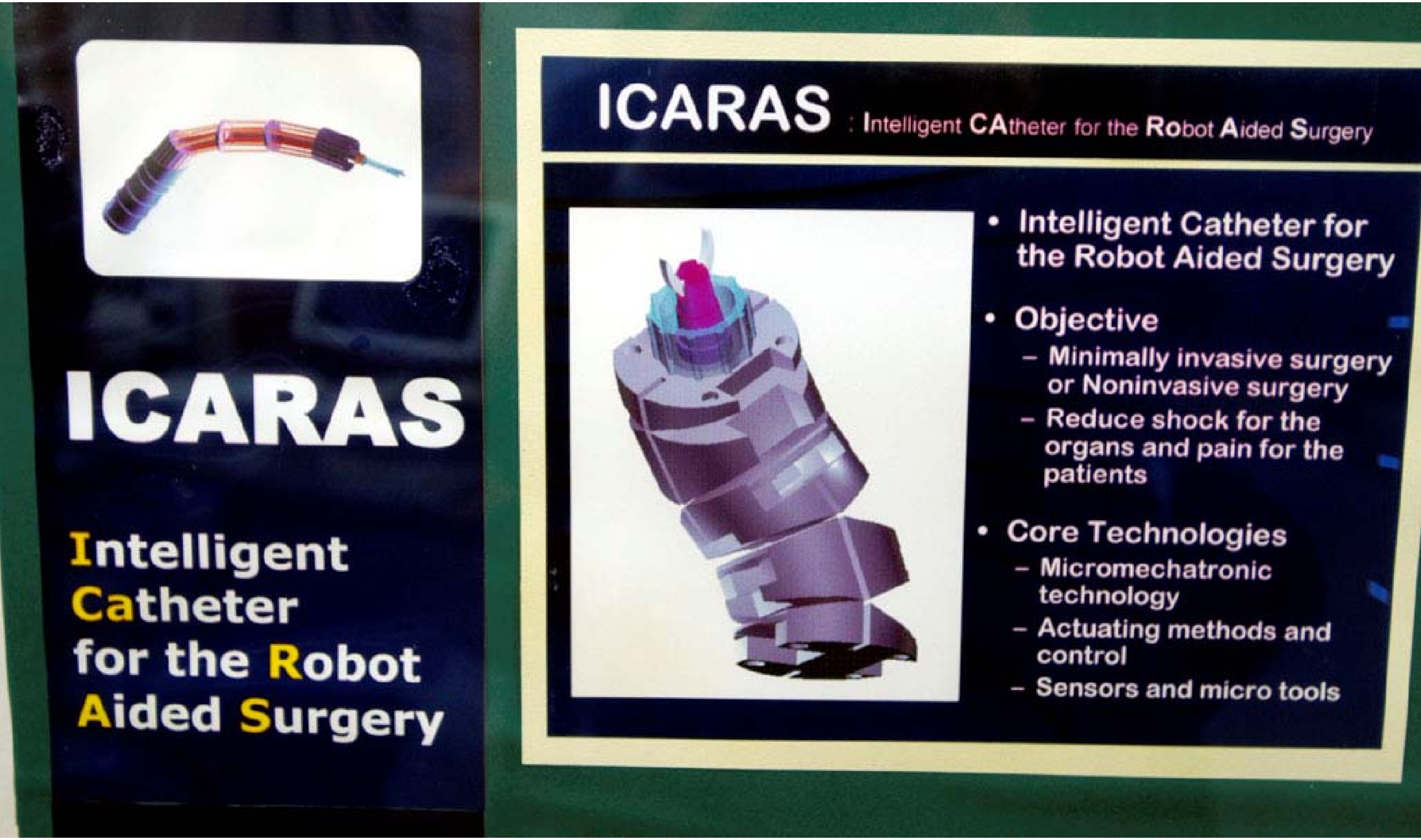
- Support for disabled people
  - Robot person lift
  - Robot wheelchair
  - Robot bed
  - Fridge/oven combi
  - Sensing mattress
- Interface:
  - Control via voice input
  - Feedback via talking head („yes, master..“)
  - Gesture input (e.g., for TV for spastic patients)

Instrumented Bedroom (2)

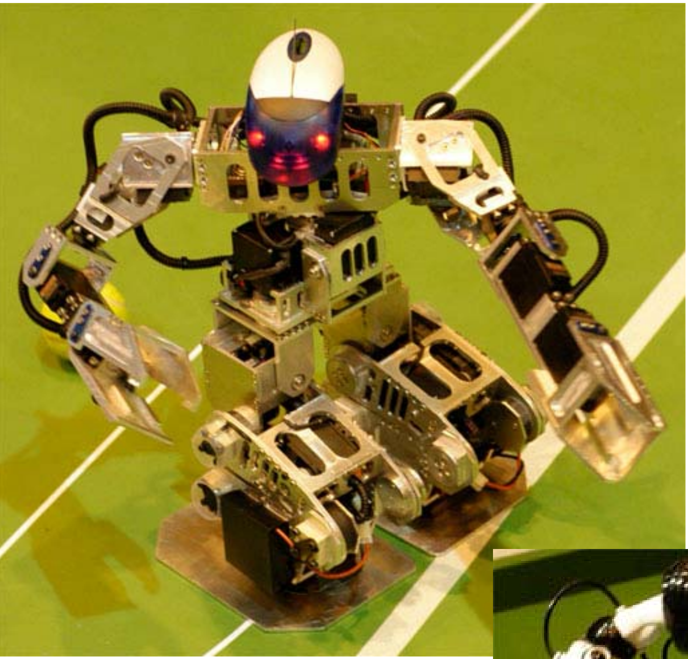
http://hwrs.kaist.ac.kr/

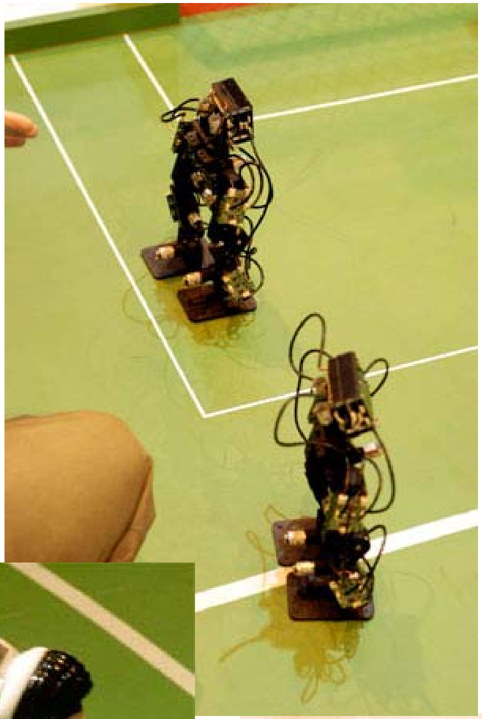
- Patient can move betw. bed + wheelchair
  - Wheelchair will come automatically
  - Lift will act on commands
  - Bed will adapt shape on command
  - Fridge will heat up meal
- Sensing mattress can tell whether…
  - patient is in right position
  - patient has fallen off
- Safety + self-determined life
  - Nurse not constantly needed
  - Environment can call if there seems to be a problem
  - Sense of Mastery („yes, master..“)

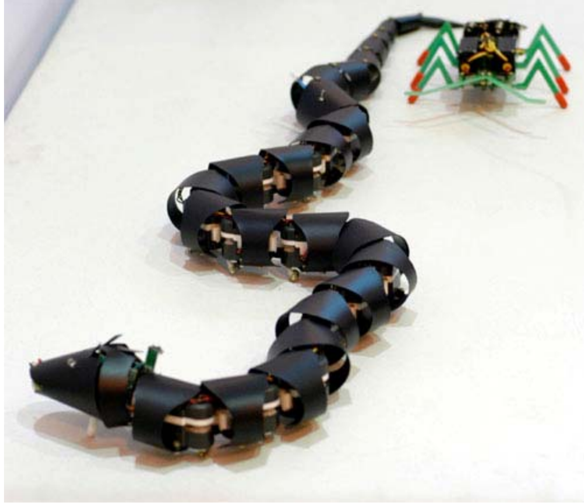
More medical robots…

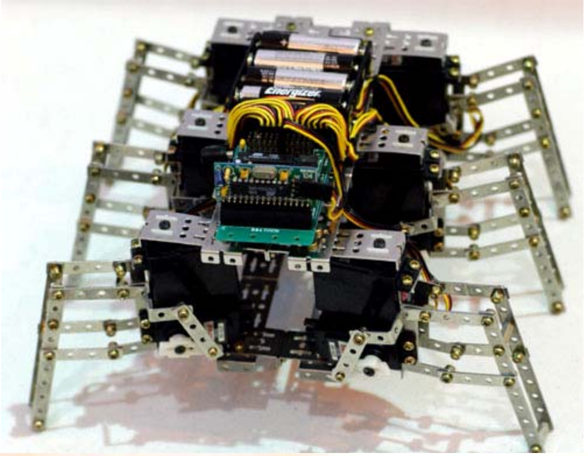


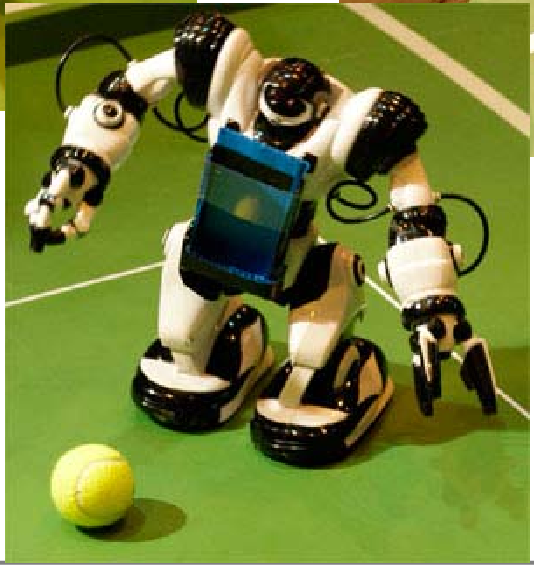
Robot shapes

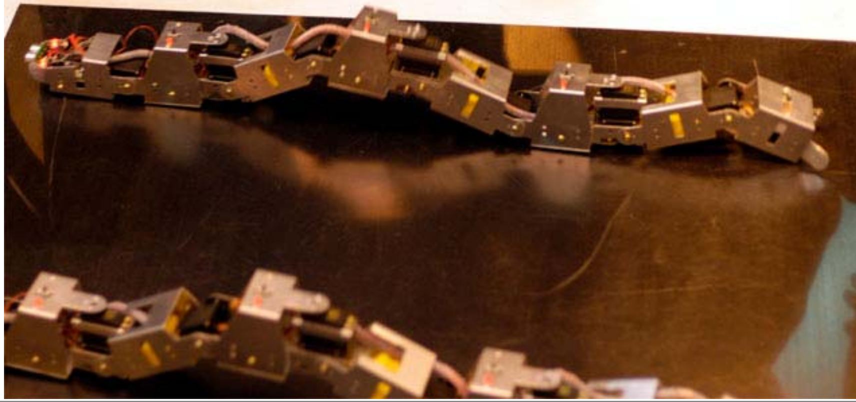




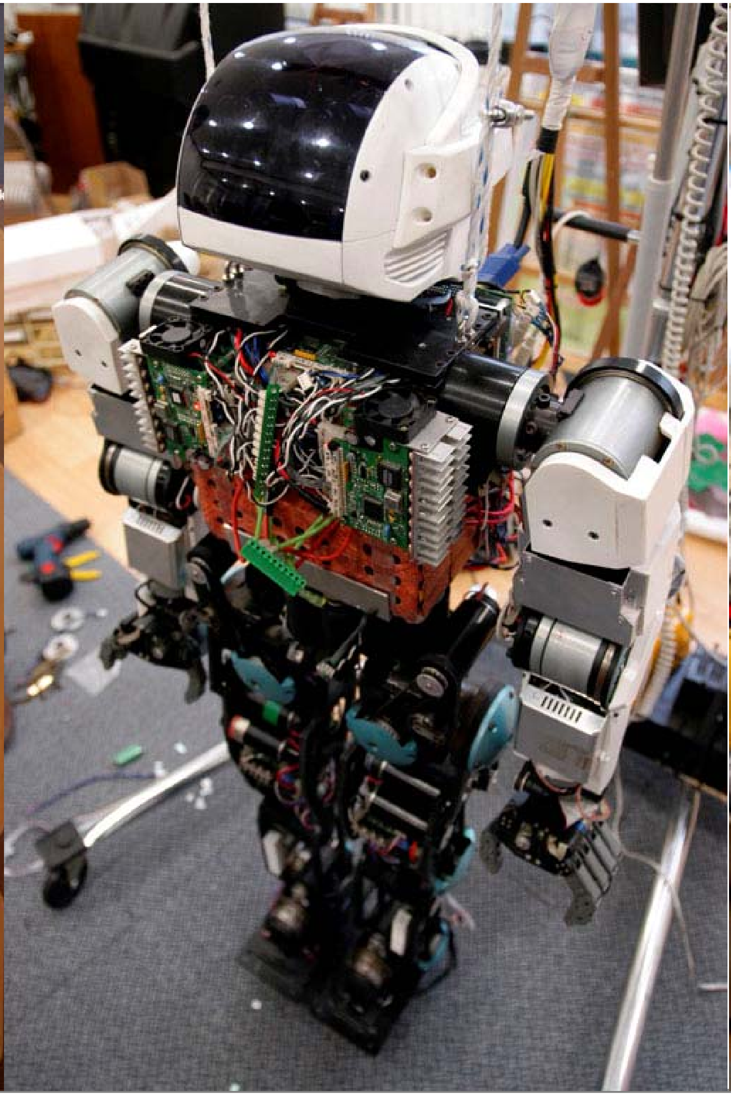


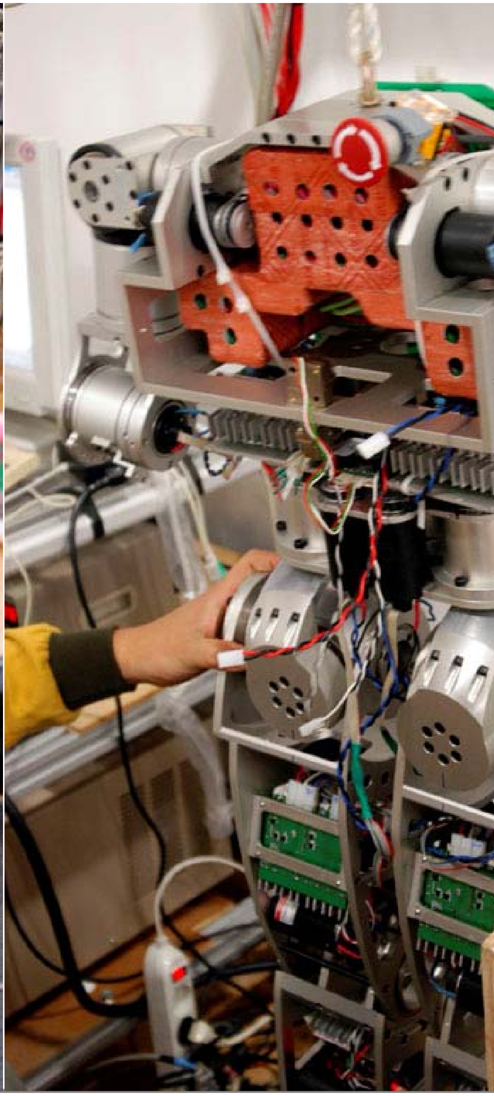






Large humanoid robots





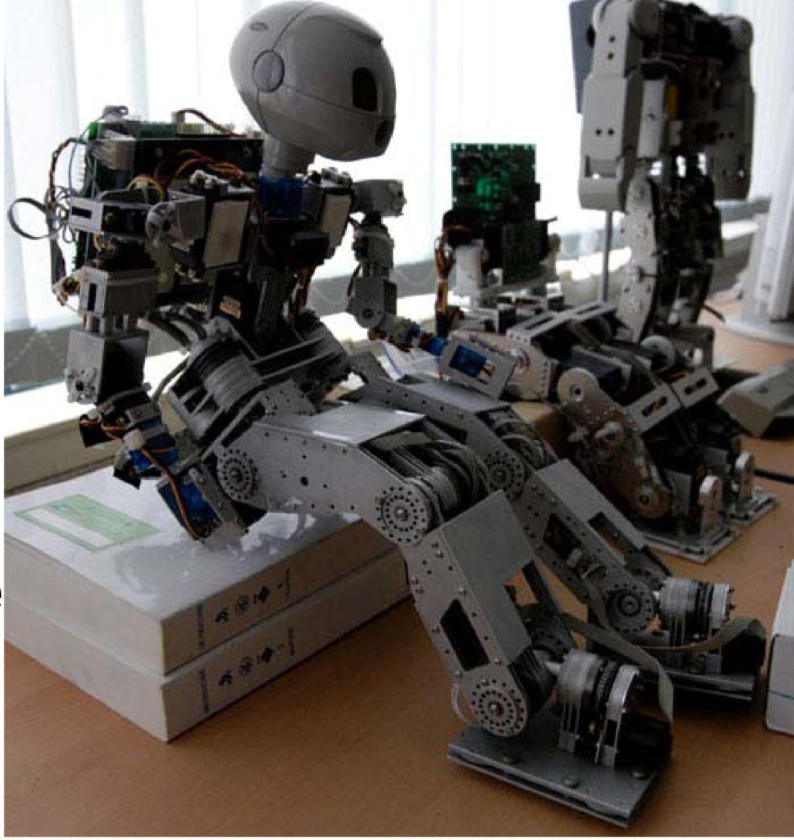
Robot disciplines

- RoboMarathon (42.2m way following)
- RoboBalancing - Beam
- RoboDancing
- RoboWeight-Lifting
- RoboBoxing
- RoboBasketball
- RoboSoccer in different leagues

- Dash (walk forward and backward)
- Stair climbing
- Search and rescue
- Mine sweeping

- www.iroc.org

Notion of Ubiquitous Robots



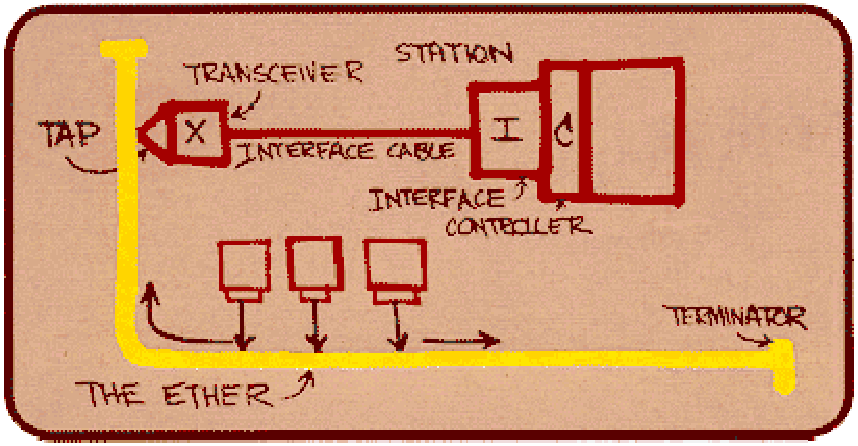
- Three types of robots:
  - SoBot: software agent
  - EmBot: embedded device
  - MoBot: mobile robot →
- SoBots can…
  - roam among machines
  - talk to other sobots
  - learn about environment and users
  - use EmBots or MoBots as their „body“
  - adapt to „senses“ and „limbs“ of the „body“

Now:
back to earth….

Some wire-based network technologies for IE

- Ethernet (classic and mostly used today)
- 1-wire bus (for small & low power devices)
- Powerline (for instrumented homes)

Ethernet (here: 10Base2)



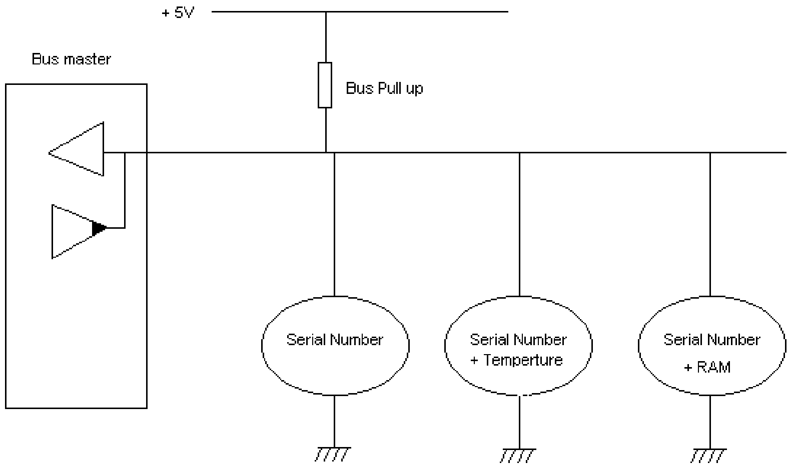
First sketch of the Ethernet by Bob Metcalf in 1976

- Developed by Bob Metcalf (Xerox PARC)
- Open standard since 1980 (DEC, Intel, Xerox)
- IEEE standard since 1986
- Main Components:
  - Physical medium (cable)
  - Access rules inside the Ethernet interface
  - Ethernet frame with well-defined number of bits
- No central component
- Solve collisions by random

1-Wire bus

- Ethernet needs a separate power supply for each connected device
- Problem with Ubicomp: lots of small devices with low power consumption
- Solution: Use the data cable to supply power (i.e. power over Ethernet or 1-Wire bus)
- 1-Wire bus needs only one cable (+ ground)

1-Wire bus



- Developed by Dallas Semicond.
- Bidirectional communication
- “master” provides “slaves” with power

- The slave obtains power over the data cable
- The slave uses a capacitor to store the energy needed for proper operation (starting with 2,8 Volts)
- To send a logical 1: pull down voltage on data cable for less than 15 μs and…
- To send a logical 0: pull down voltage on data cable for more than 60 μs

1-Wire bus

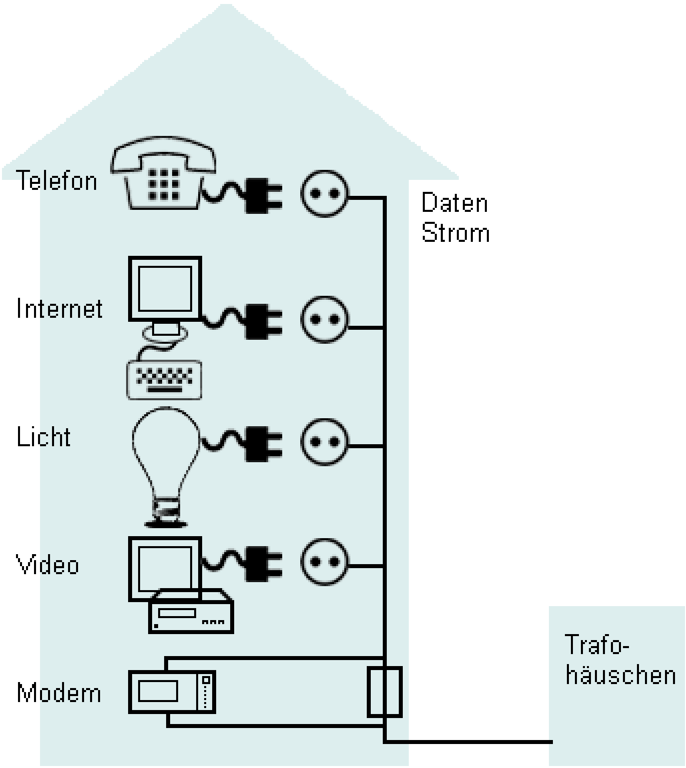
- Each slave has a unique (48-bit) Id
- Different types of slaves are available: NVRAM, EEPROM, temperature sensors, simple clocks, etc...
- Data cable may reach up to 300 meters
- Theoretically infinite number of slaves, but since reading is sequential there is a practical limit (e.g. Reading of 500 ids takes approx. 12 s).

- Some applications:
  - identification of persons
  - sense real world states

- Advantage: Integrity of data cables can be tested easily.

Power Line Communication

- Uses existing in-house power cables
- E.g., PLC-ethernet bridge with 14MBit/s
- Some Applications:
  - LAN, Internet access
  - Telephone – Voice over IP
  - Video on Demand, surveillance
  - Reading out energy counters
  - Remote control of devices
- http://www.homeplug.org/



Problems of Power Line

- Quality of connection depending on
  - Different circuits and phases (fix by adding a capacitor between them)
  - Background noise
    - Household appliances: e.g. TV, Radio (narrow bandwidth noise)
    - Electrical engines (e.g. drill, broad bandwidth noises)
    - Switches (e.g. for lights, single bursts)

Radio-based technologies

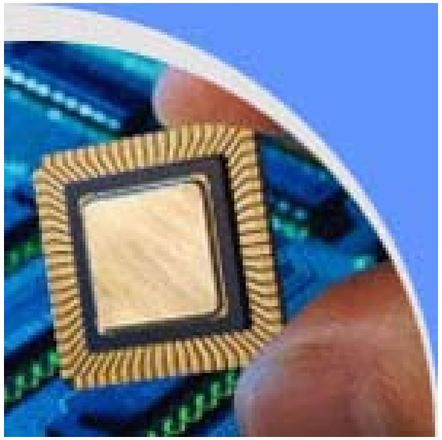
- Large cells (>100 m): e.g. WLAN, GSM, UMTS
- Small cells (10 - 100 m): e.g. Bluetooth
- very small cells (1 - 30 m): RF module

WaveLan IEEE 802.11b

- Basically like ethernet on air (2.4 GHz)
- All stations send and receive on the same frequency.
- Repetition on collision
- High frequency means small range (50-500 m)
- Advantage: already widespread

Bluetooth http://www.bluetooth.com/

Idea: radio networks with small range replace today's cables and provide a bridge to existing networks.



Examples:

BT Headset for mobile phones

Phones, Fax, PDA, Computer, keyboard, printer, joystick, fridge, microwave, heating, car......

Bluetooth

Principle: establish, enlarge and shut down ad-hoc networks, depending on proximity of Bluetooth enabled devices

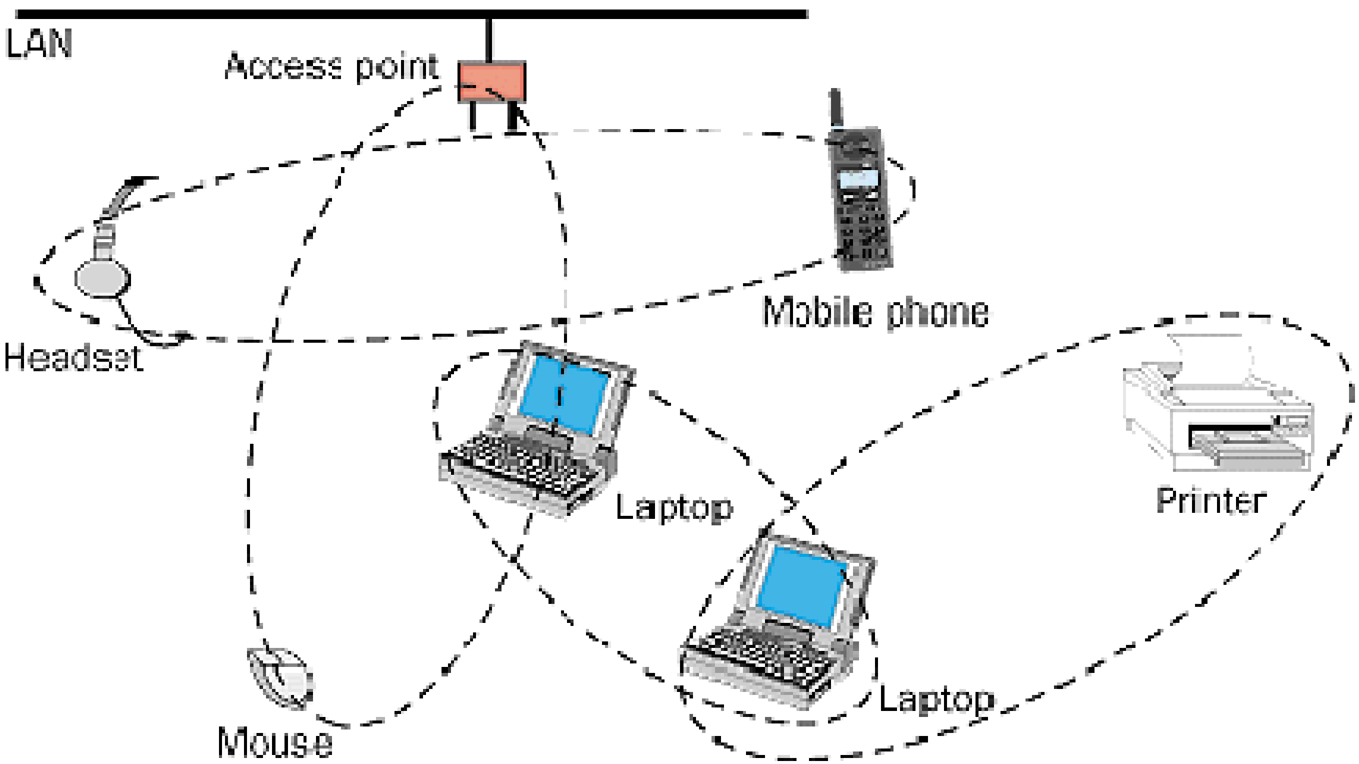
Technical facts:

Speed	ca. 1 MBit/s
Size of cell	10 or 100 Meter
Frequency	2.4 GHz

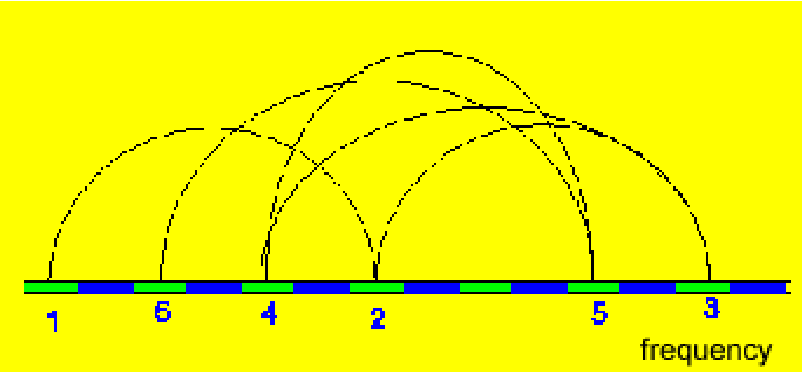
Consortium: 3Com, Ericsson, IBM, Intel, Lucent, Microsoft, Motorola, Nokia und Toshiba

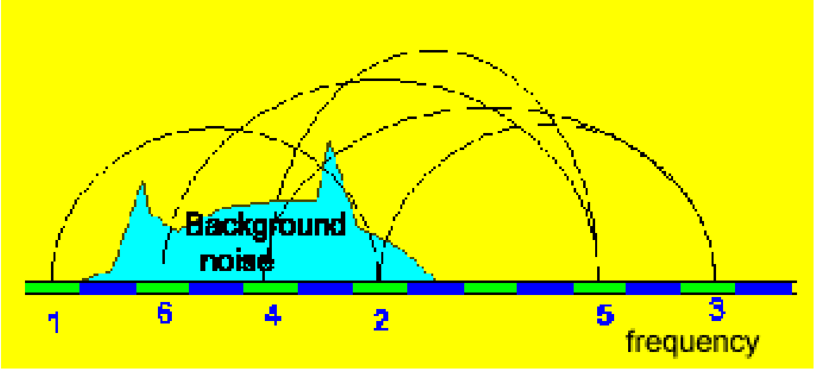
Bluetooth Pico-nets (ad-hoc networking)

Each Pico-net has one master and up to 6 slaves



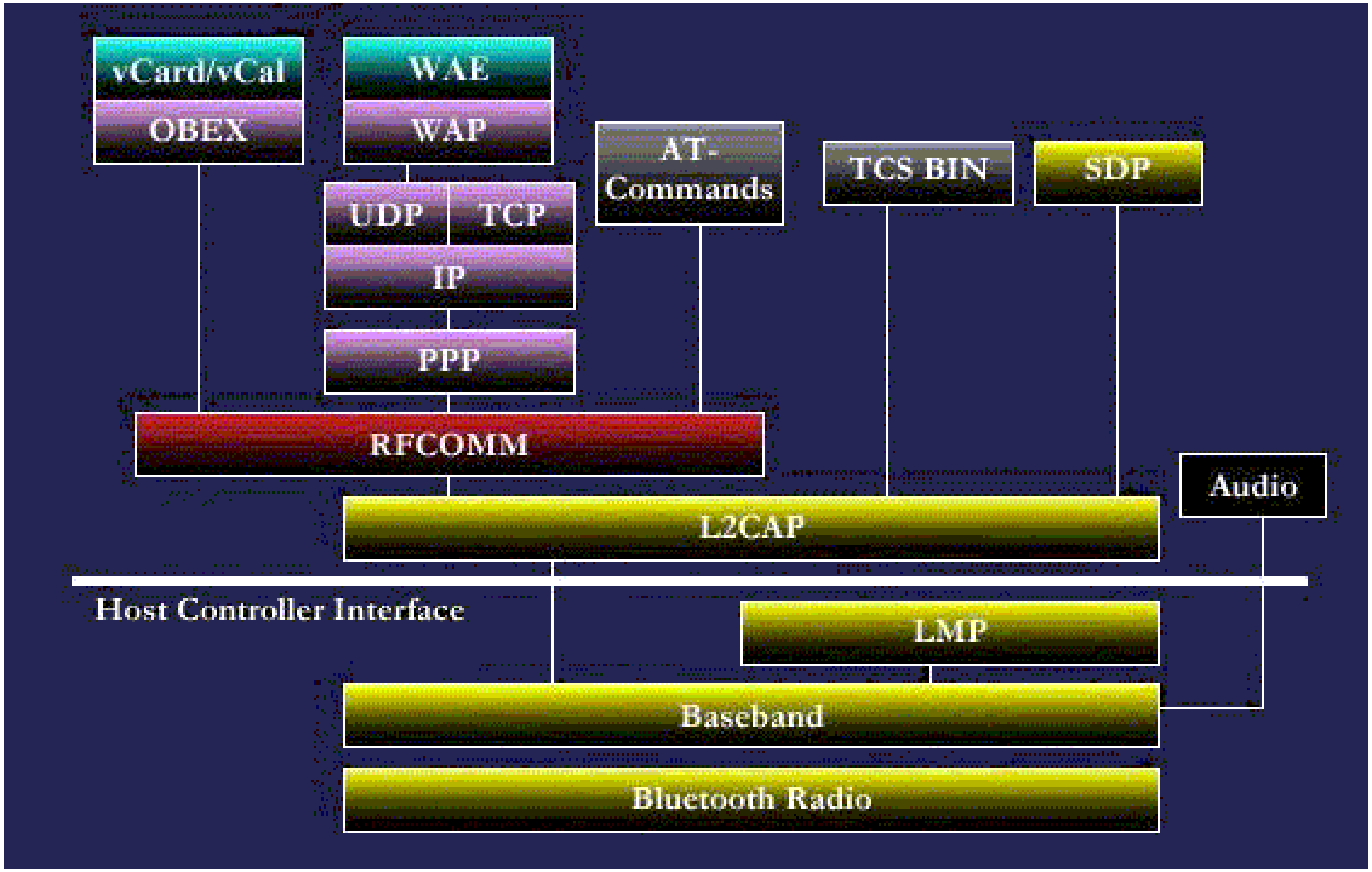
Frequency Hopping



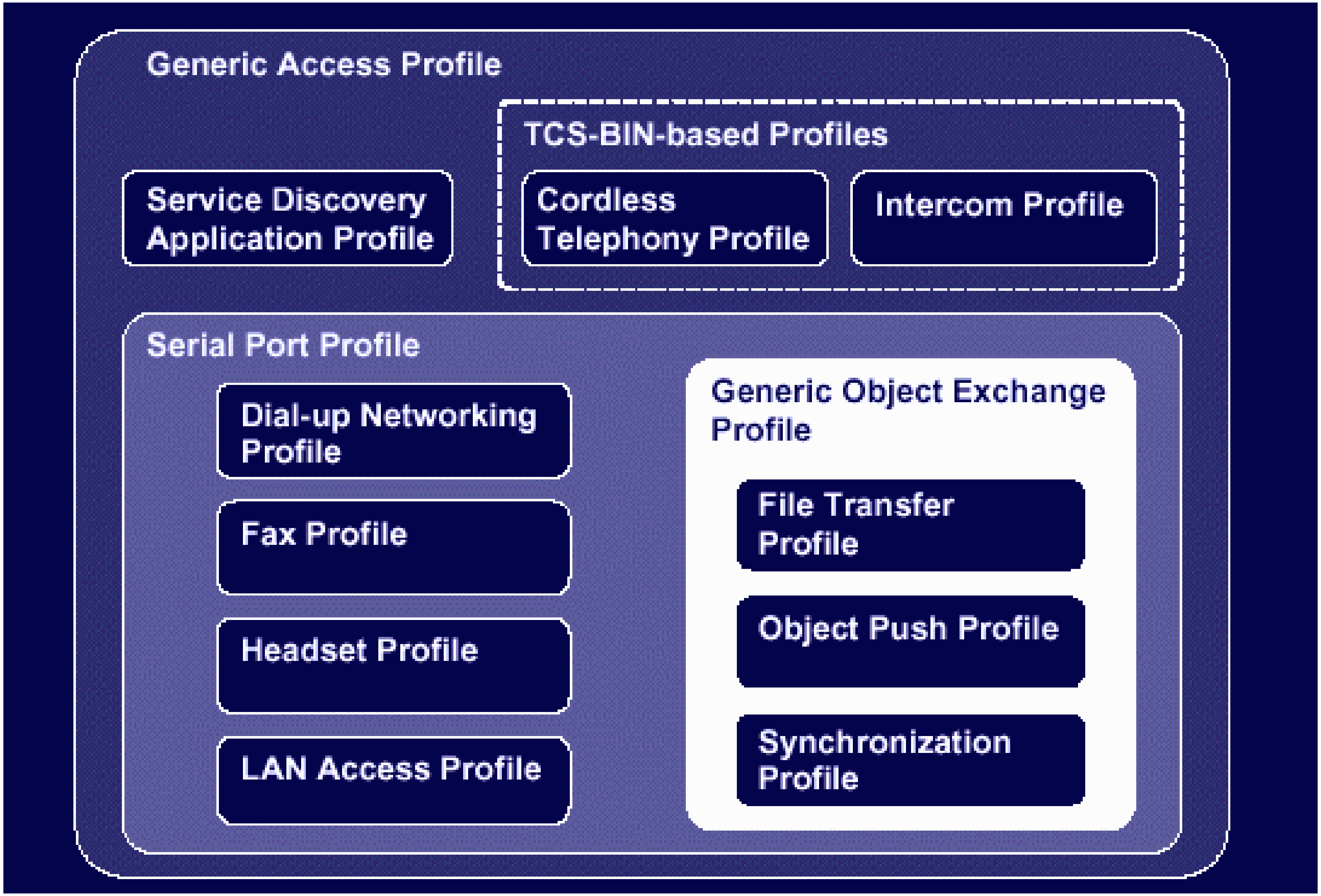


- Schema-based change of frequencies
- Fast hopping and small package sizes reduce the probability of collisions

Bluetooth Specification (part of) Protocol Stack



Bluetooth Profiles



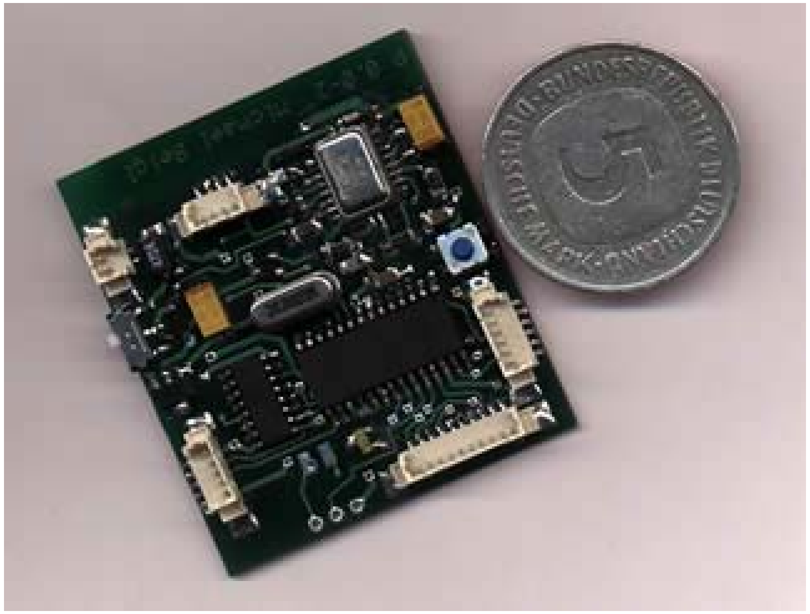
Each profile is a vertical cut of the bluetooth protocol stack

Problems of Bluetooth

- Lots of noise on 2.4 GHz (e.g. microwave oven and WLAN)
- Small bandwidth (worst case < 1/7 MBit/s)
- Still less widespread than infrared (on European and American market)
- Still complicated interfaces
  - Inconsistency of supported profiles

Small RF Devices

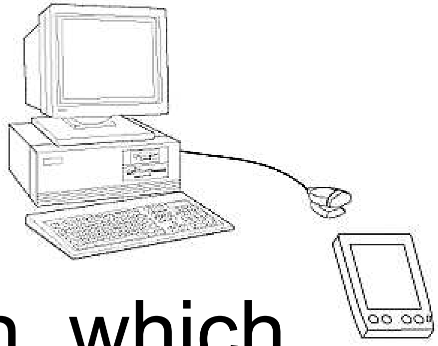
- Cheap solution, needs individual adjustments
- Small range (1-30m), low power consumption
- low bandwidth: 115 KBit/s
- Small form factor
- Examples:
  - Smart-Its
    www.smart-its.org/
  - Berkeley Motes
    www.tinyos.net/



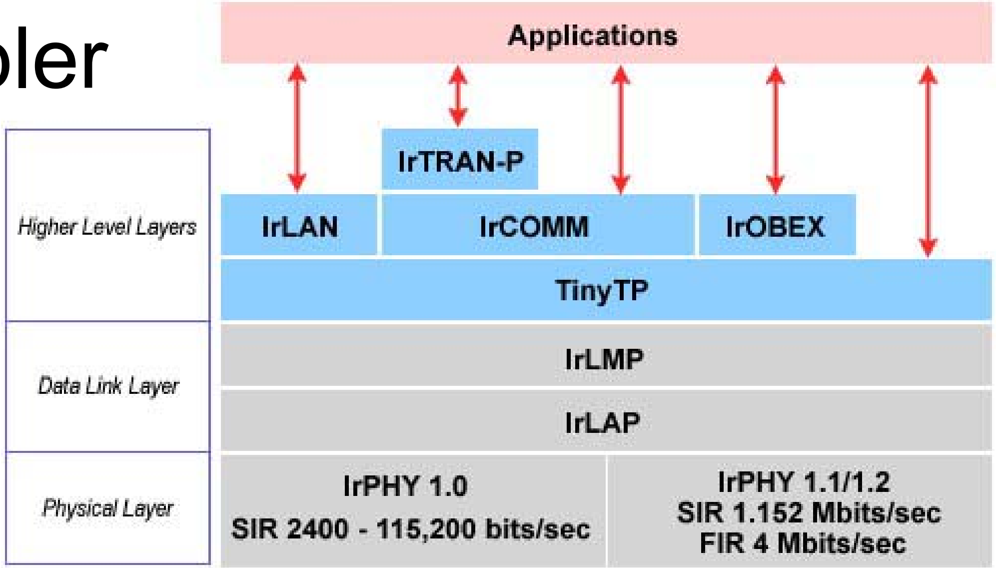
Infrared communication

- Uses non visible light (900nm)
- Does not travel through objects (needs line of sight)
- Analog: IrRemote
  - Modulated carrier
  - Good range (up to 20 m), small bandwidth
- Digital (IrDA)
  - Uses single light flashes for 1 and 0
  - Small range, high bandwidth (up to 4 Mbit/s)
  - Bidirectional communication between 0 and 2 meters

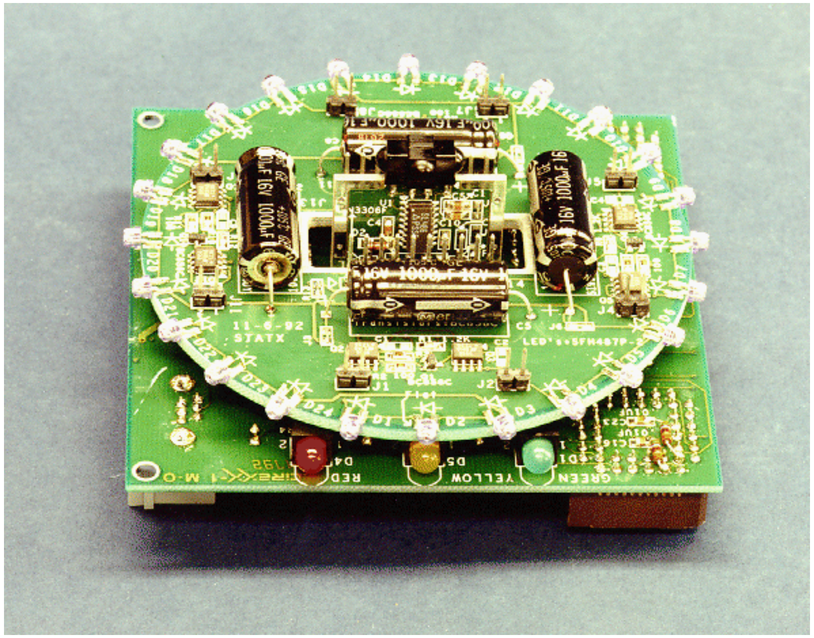
IrDA



- Founded 1993 as an organization, which defines an independent open standard
- The goal was to realize simple point to point solutions to connect devices.
- Protocol stack simpler than Bluetooth
  - LAN
  - Serial
  - ObEX



Long range connections with IR



- Parctab Communication Hub
- Range 7m
- Bidirectional connection
- 9.600/19.200 baud
- analog IR

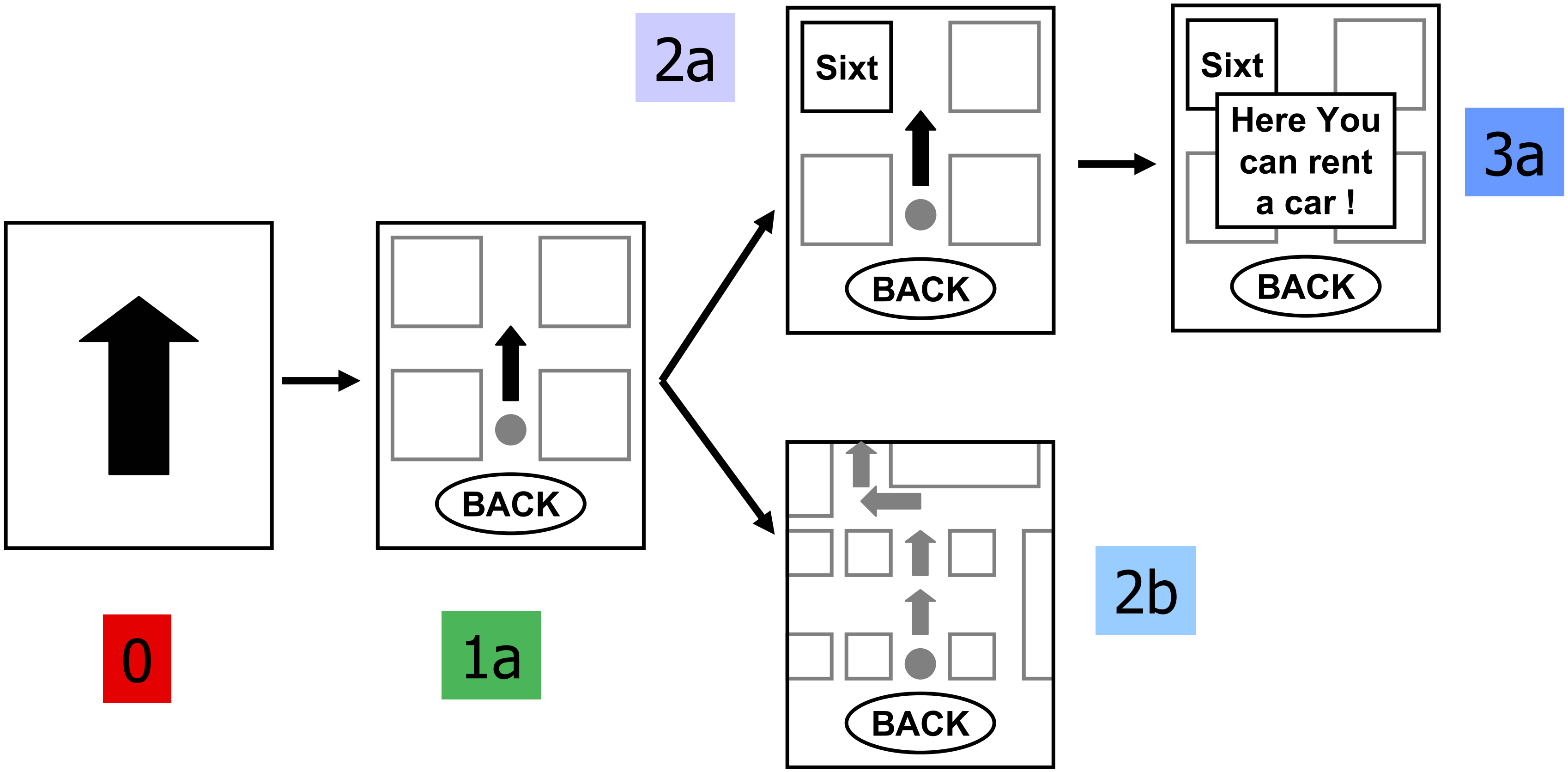
- Eyeled Sender
- Range up to 20 m
- Bi/Unidirectional connection
- 115 Kbaud
- IrDA compatible

Broadcasting structured information

- Cut down presentations to small packets (similar to Videotext)
  - Use different interaction levels
  - First package starts at level 0
  - => Conceptual presentation graph

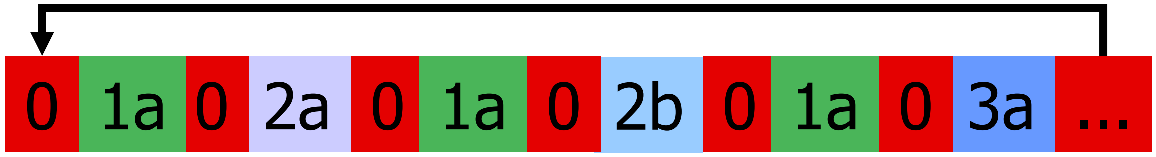
- **Transition between levels:**
  - Qualitative change of information
  - additional information
  - more general or detailed information

Example: Presentation graph



Ideal transmission scheme

- Continuous transmission cycle
- Arbitrary entry point
- Quick availability of level 0
- Levels >0 may take longer
  - Can only be reached by interaction
  - Hide transmission time behind interaction time



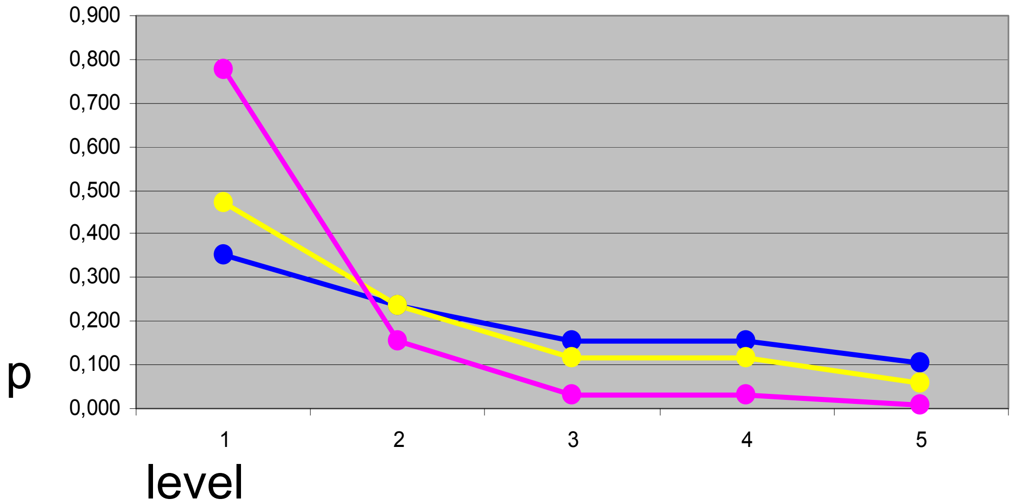
Probabilistic transmission scheme

$$w'_{ik} = \frac{1}{c^{i+1}}, c \geq 1$$

$$S = \sum_i \sum_k w'_{ik}$$

$$w_{ik} = \frac{w'_{ik}}{S}$$

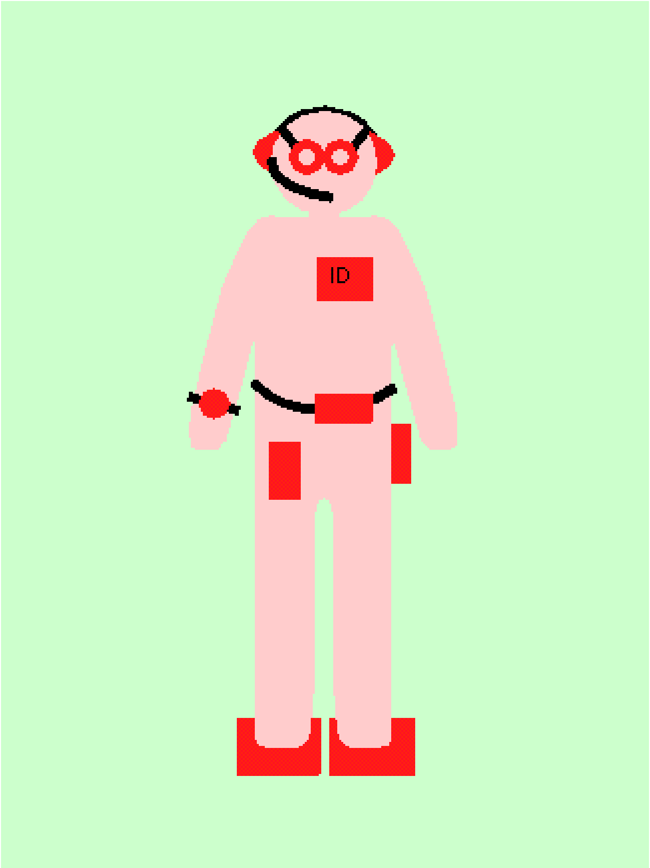
	c=	1,5	c=	2,0	c=	5,0
	w'ik	wik	w'ik	wik	w'ik	wik
0	1	0,351	1	0,471	1	0,776
1a	0,667	0,234	0,500	0,235	0,200	0,155
2a	0,444	0,156	0,250	0,118	0,040	0,031
2b	0,444	0,156	0,250	0,118	0,040	0,031
3a	0,296	0,104	0,125	0,059	0,008	0,006



Personal Area Network (PAN)

- Idea: use the body to transmit information
- Use currents in the nanoAmp. range
- First at MIT (Thomas Zimmer, 1995) then IBM, Intel, Univ. of Washington
- Used in human-human and human-environment communication
- Example: exchange business card while shaking hands.
- Built-in security!

Figure 5 Locations and applications for PAN devices include head-mounted display, headphones, identification badge, cellular phone (in waist pack), credit and phone cards (in wallet), watch with display, microphone and speaker, and "power sneakers" (self-powering computer shoe inserts).



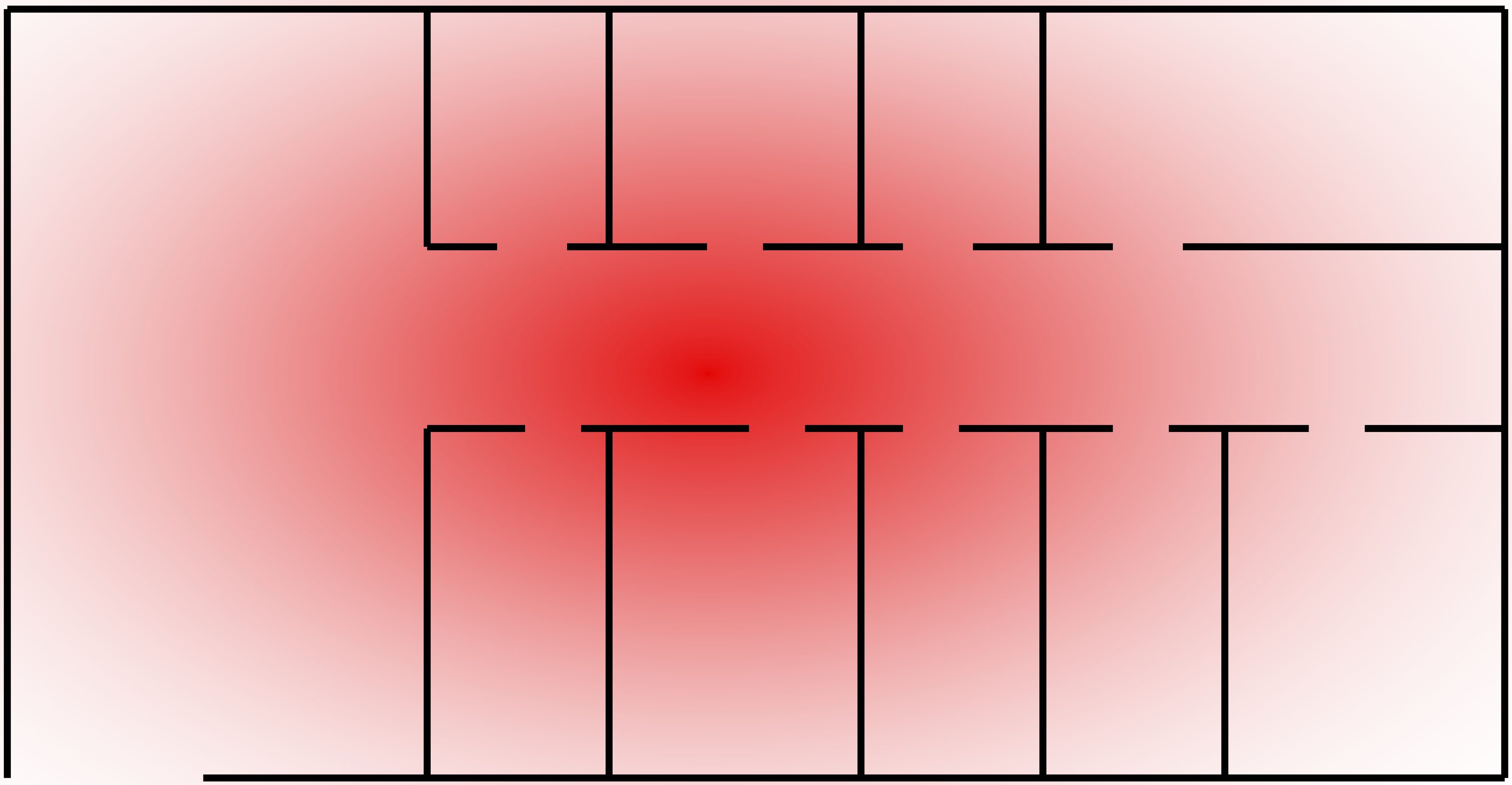
Some positioning and tracking technologies for IE

- Types
  - Cells
  - Signal strength
  - Signal runtime

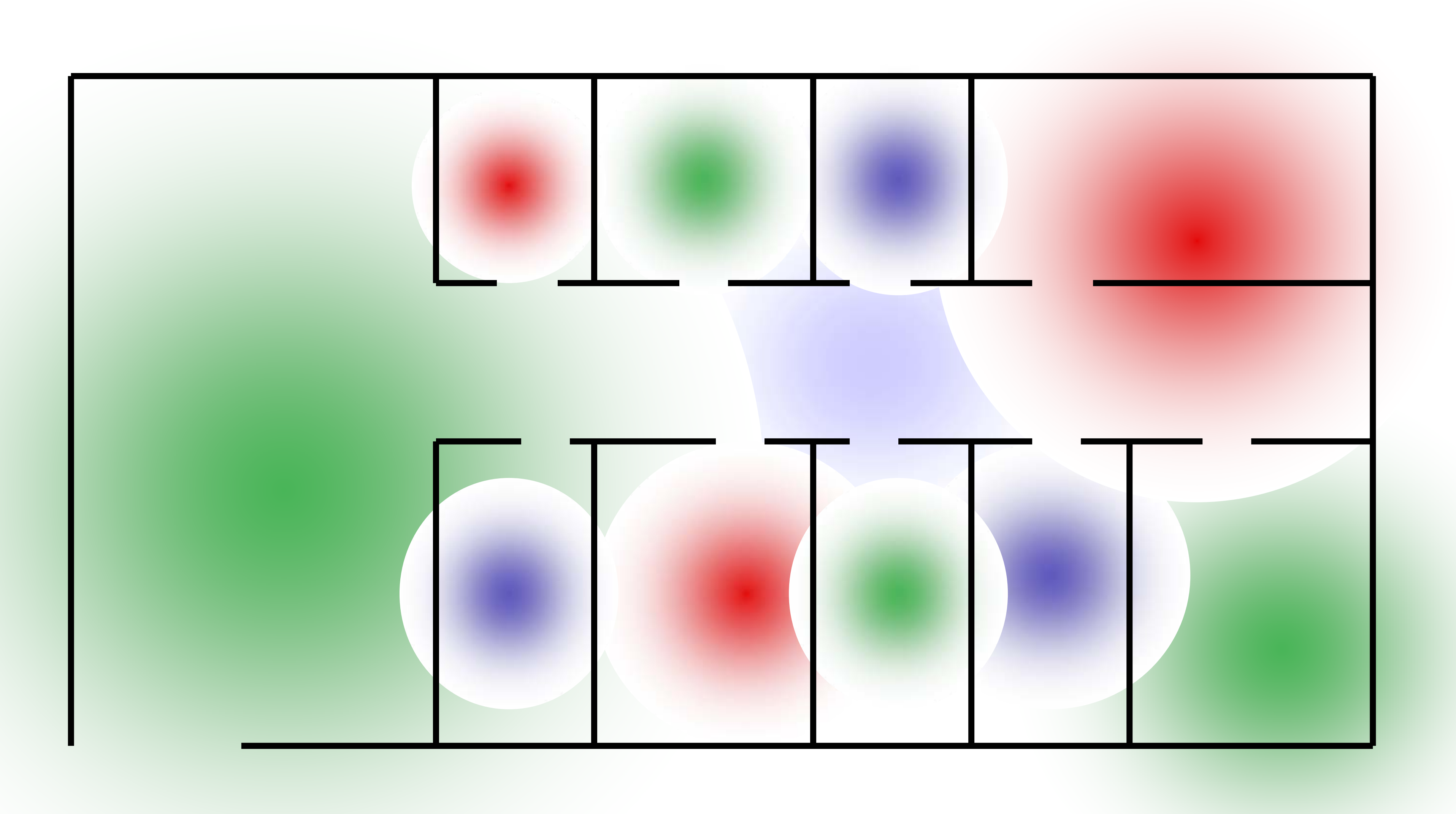
Cell-based Localization

- Each sender has a unique Id, which can be identified

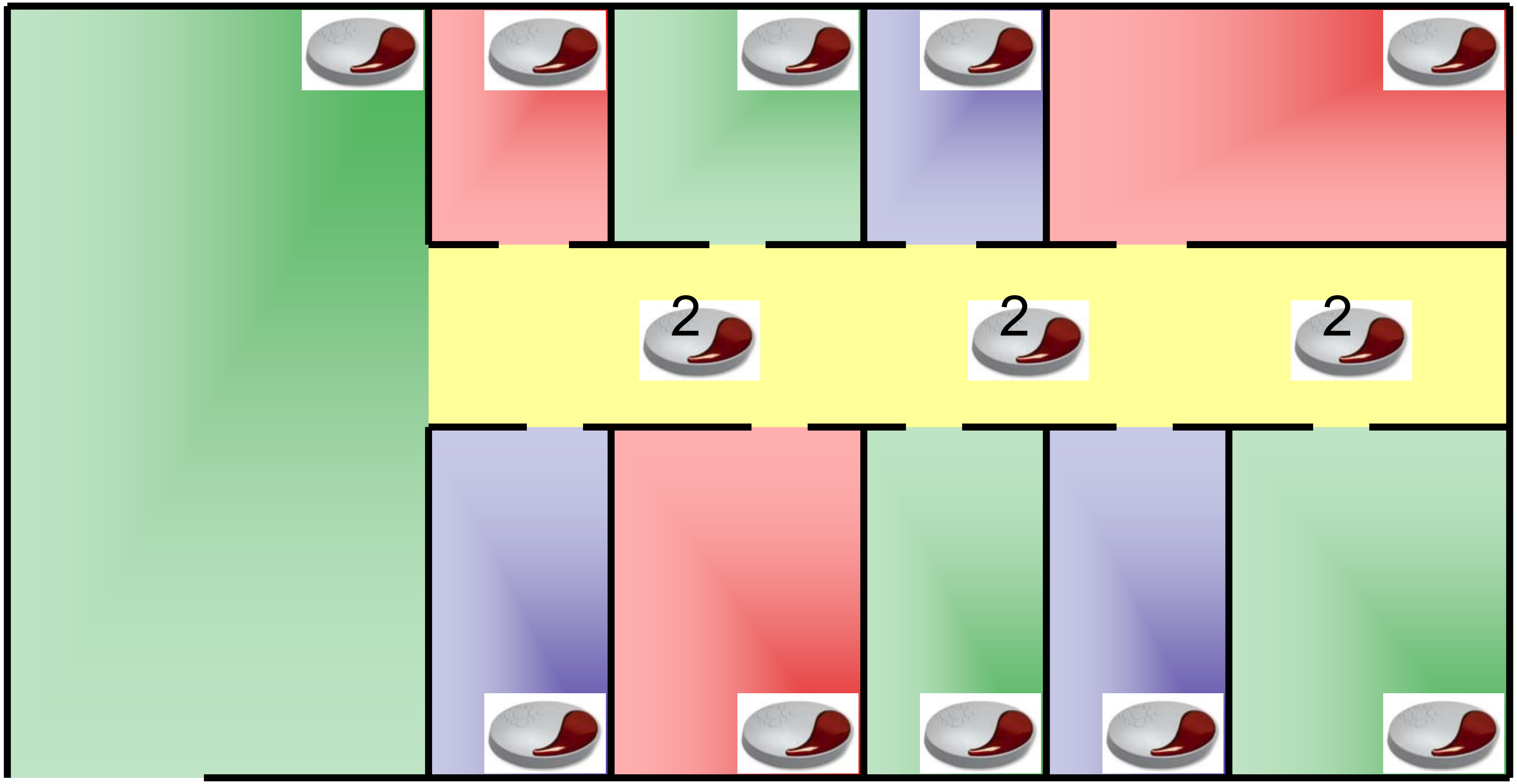
Radio transmission (large cells)



Radio transmission (small cells)



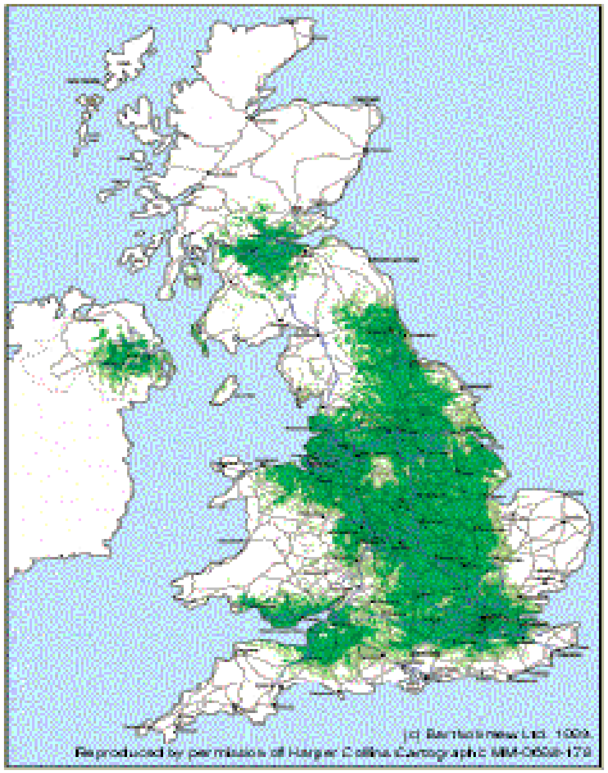
Infrared transmission



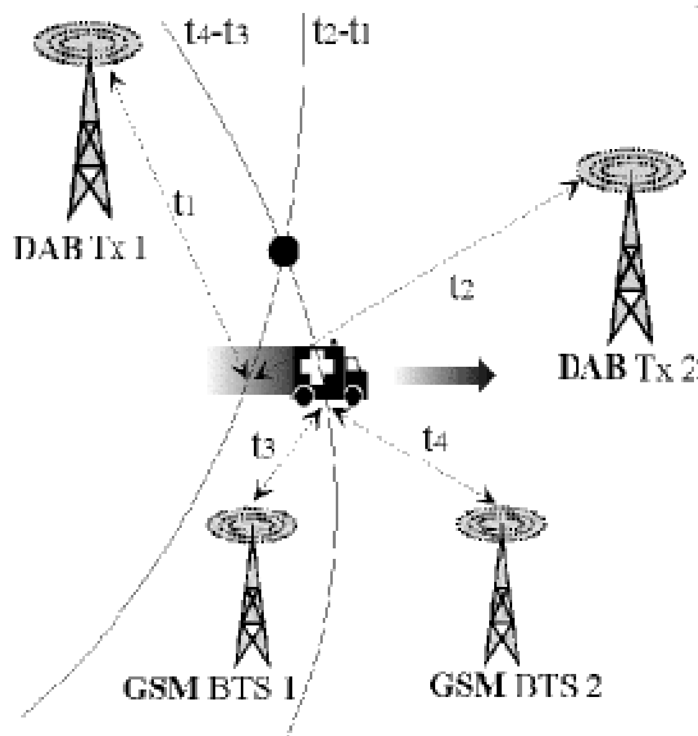
Measuring signal strength

- Radio:
  - Triangulation: approximate the distance by measuring the signal strength from several senders
  - Signal strength is heavily dependent on the environment (radio)
- IrDA:
  - no measurement of signal strength possible
- Acoustics:
  - problems with noise
  - Precision highly variable
- Machine Learning approaches possible

GSM + DAB



DAB coverage in the UK



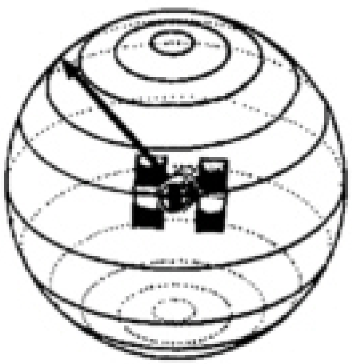
Combined GSM/DAB Signals

DAB = Digital Audio Broadcast

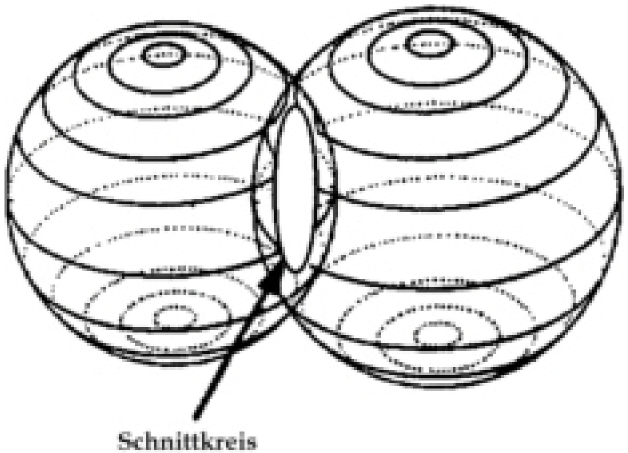
Positioning by signal runtime

- Measuring signal runtime from known senders
- More accurate than signal strength measurement but also more difficult
- Problems
  - Radio: Multi-path, atmospheric distortions
  - Good placement of senders necessary
- Enhance results by introducing reference points

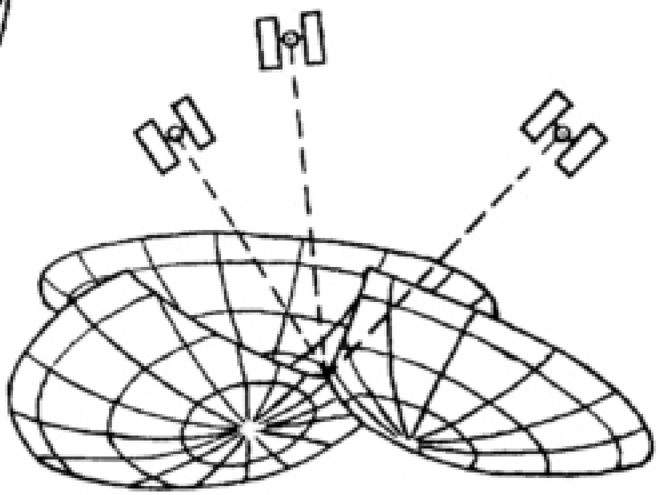
Global Positioning System (GPS)



one satellite



two satellites



three satellites

Differential GPS

- Enhancement of precision by using a correct reference signal
  - Need to know the exact position of a receiver
  - Send the difference between actual and measured position to the mobile device
- Problem: Delay of correction signal
- Used to be important because of errors (300m) induced into GPS by US military

Pseudolites: artificial GPS Satellites (IntegriNautics)

- For areas with low GPS coverage
- High precision
  - Automatic farming, landing airplanes
- Use together with standard GPS receiver
- Problems with indoor use
  - Overriding signals
  - Multipath effects