# Instrumented Environments

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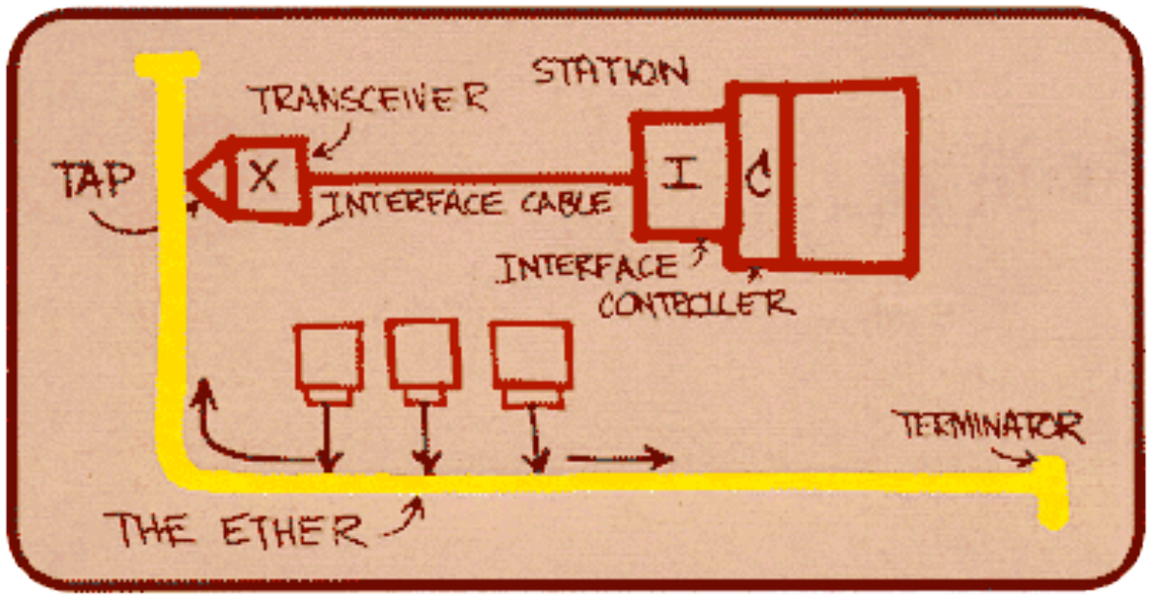
# Topics today

- Networking
  - Wire-based
    - Ethernet
    - 1-wire-bus
    - Network surface: Pin& Play
    - Power Line
  - Wireless
    - WLAN
    - Bluetooth
    - Custom
  - Infrared

# Ethernet (here: 10Base2)



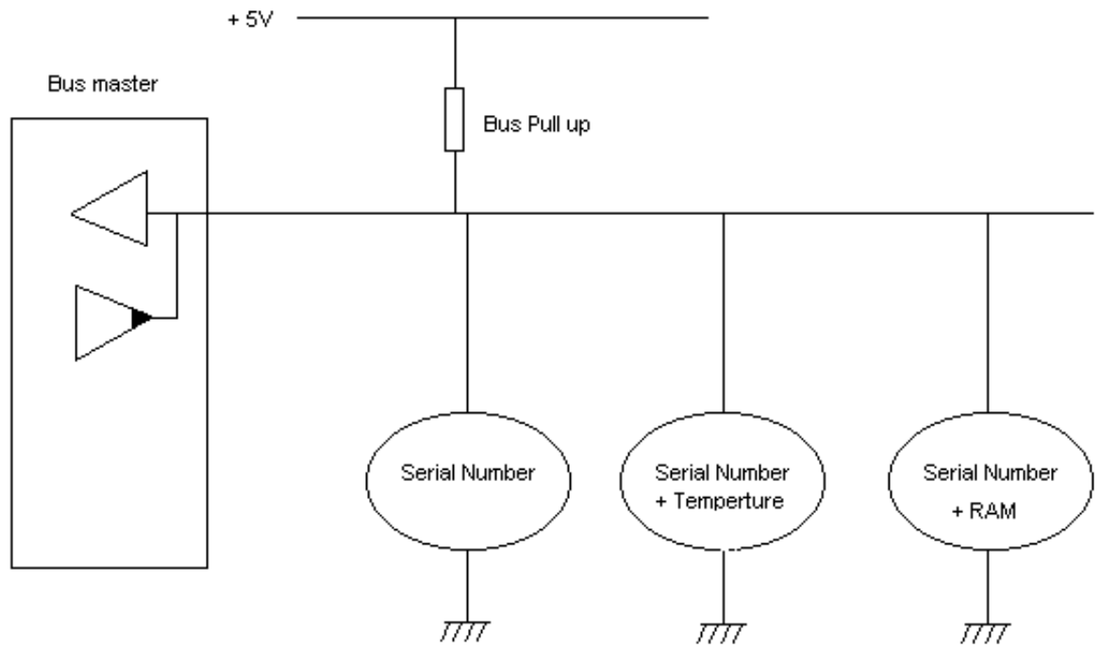

First sketch of the Ethernet by Bob Metcalf in 1976

- 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
- CDMA/CD: Carrier Detect Multiple Access with Collision Detectio
- Deal with collissions by random timeout

# 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 Semiconductor
- 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

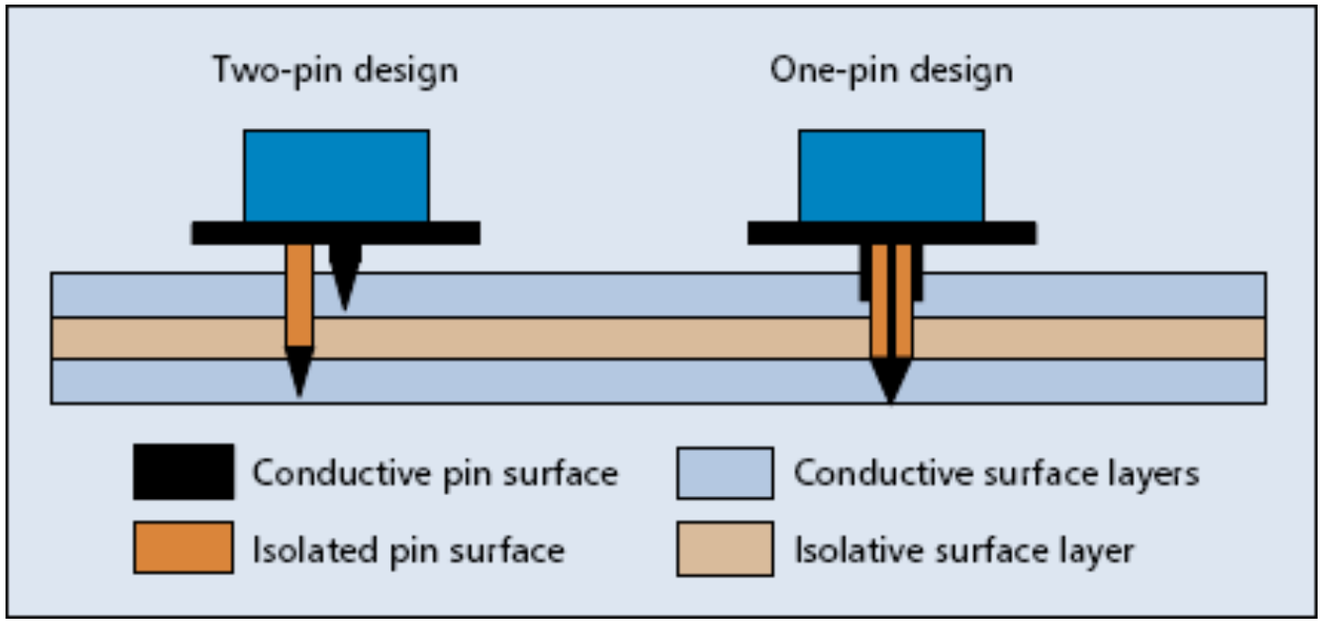
- Each slave has a unique (48-bit) Id
- Different types of slaves are available: NVRAM, EEPROM, temperature sensors, simple clocks, etc...
- Data cable may reach up to 300 meters
- Theoretically infinite number of  slaves, but since reading is sequential there is a practical limit (e.g. Reading of 500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

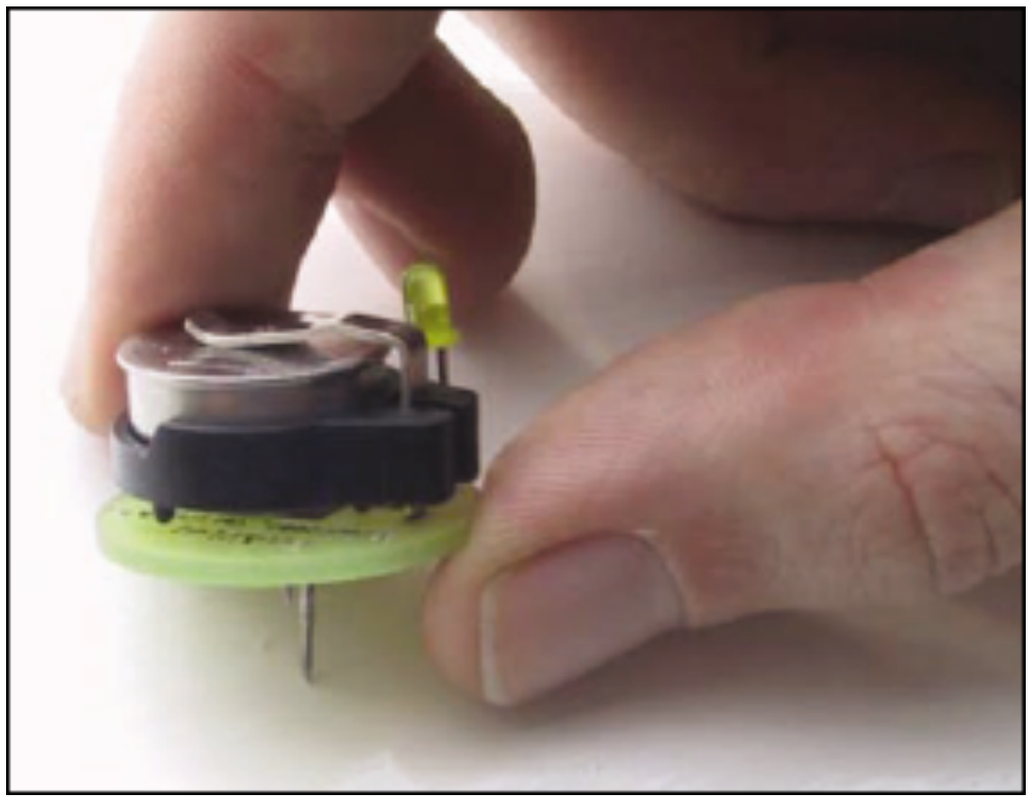
- Some applications:
  - identification of persons
  - sense real world states


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

# Pin & Play

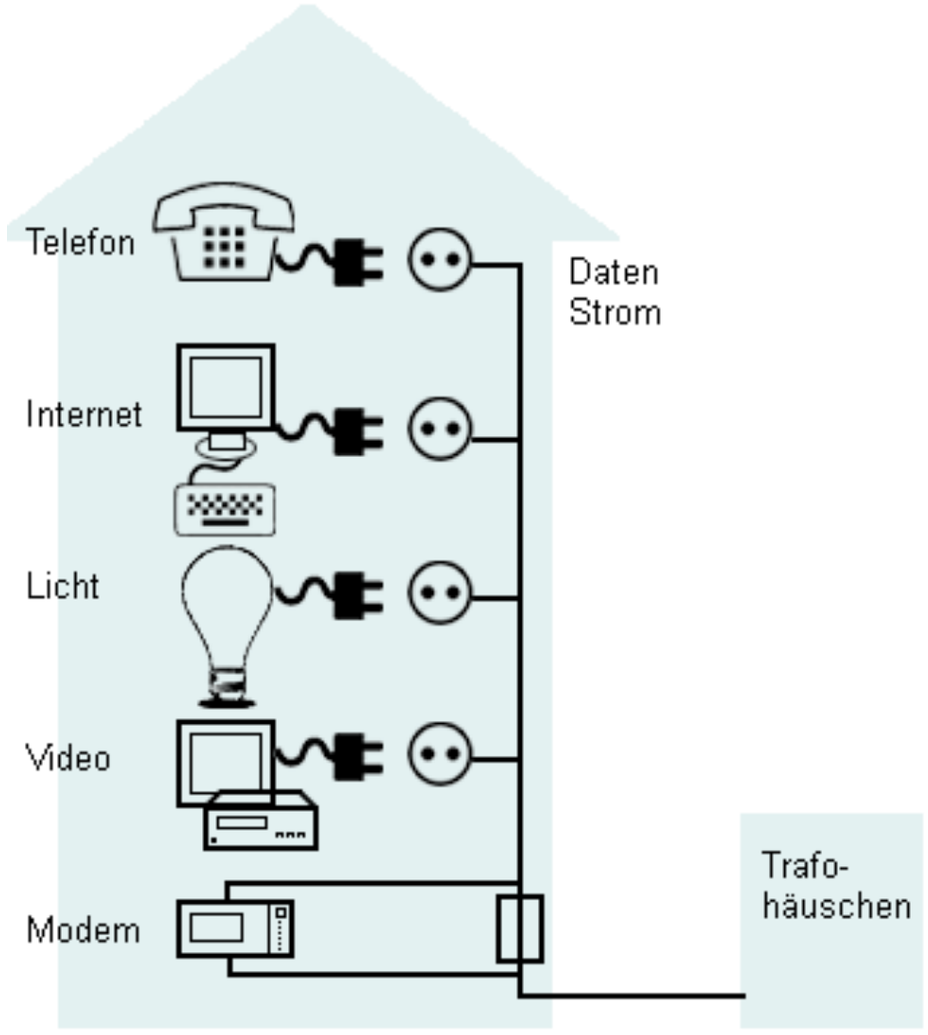
[http://ubicomp.lancs.ac.uk/pin&play/]



# 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 noise)
    - Switches (e.g., for lights: single bursts)

# Radio-based technologies

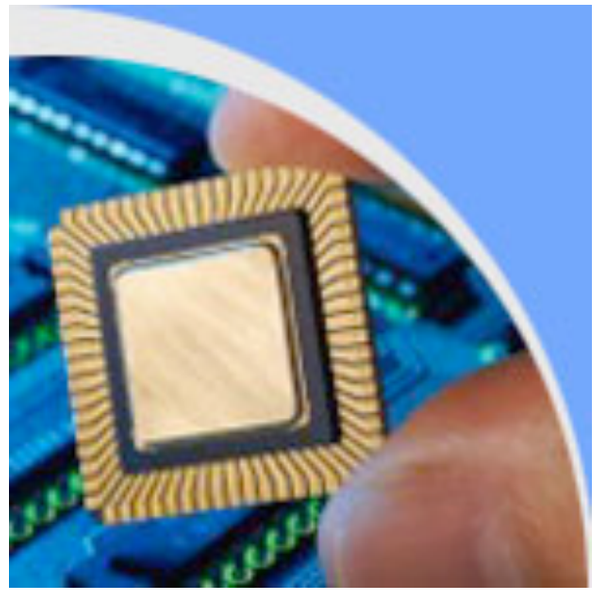
- Large cells (>100 m): e.g. WLAN, GSM, UMTS
- Small cells (10 - 100 m): e.g. Bluetooth
- Very small cells (1 - 30 m): RF module

# 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

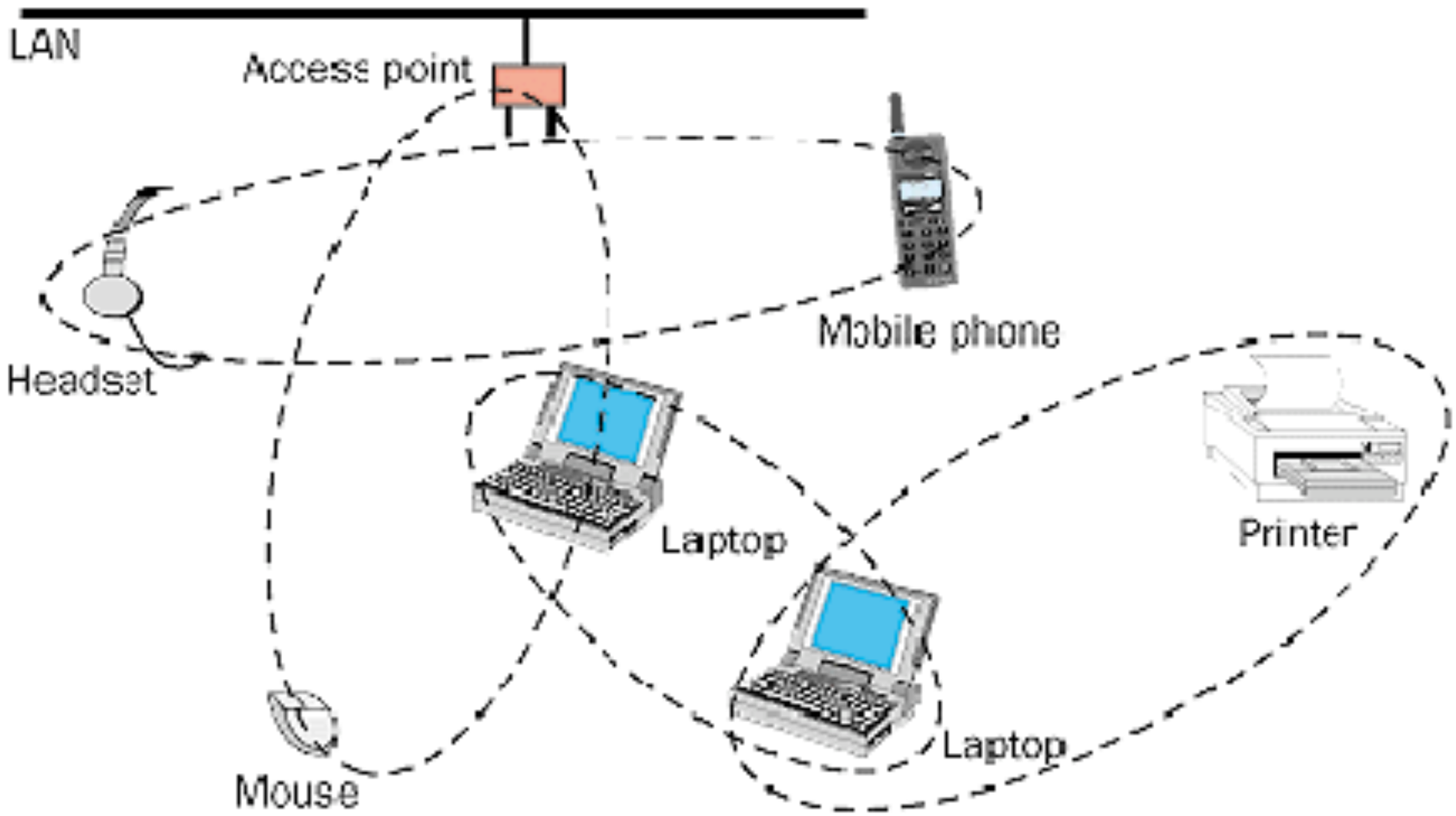
**Technical facts:**

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

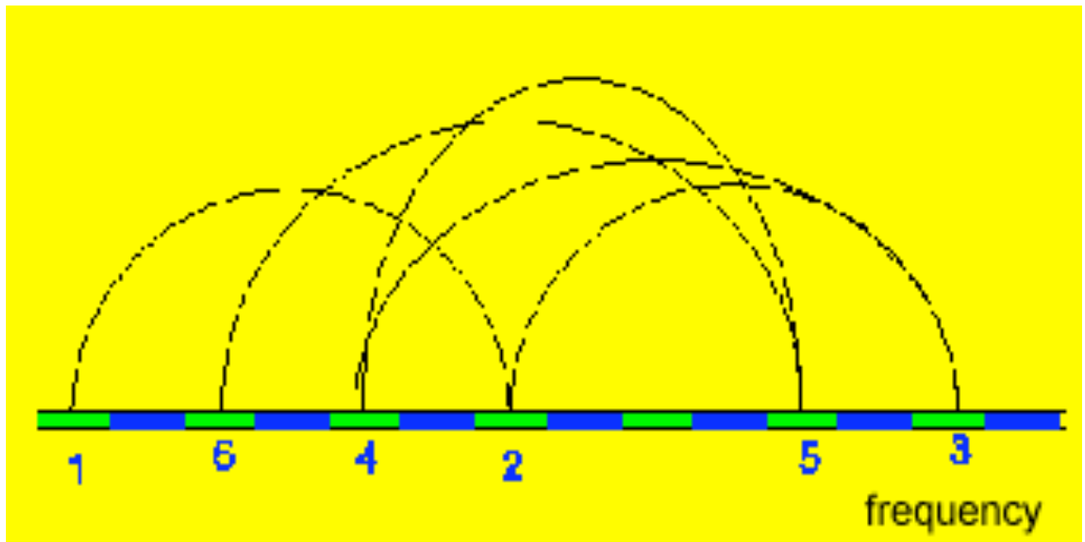
**Consortium:** 3Com, Ericsson, IBM, Intel, Lucent, Microsoft, Motorola, Nokia und Toshiba

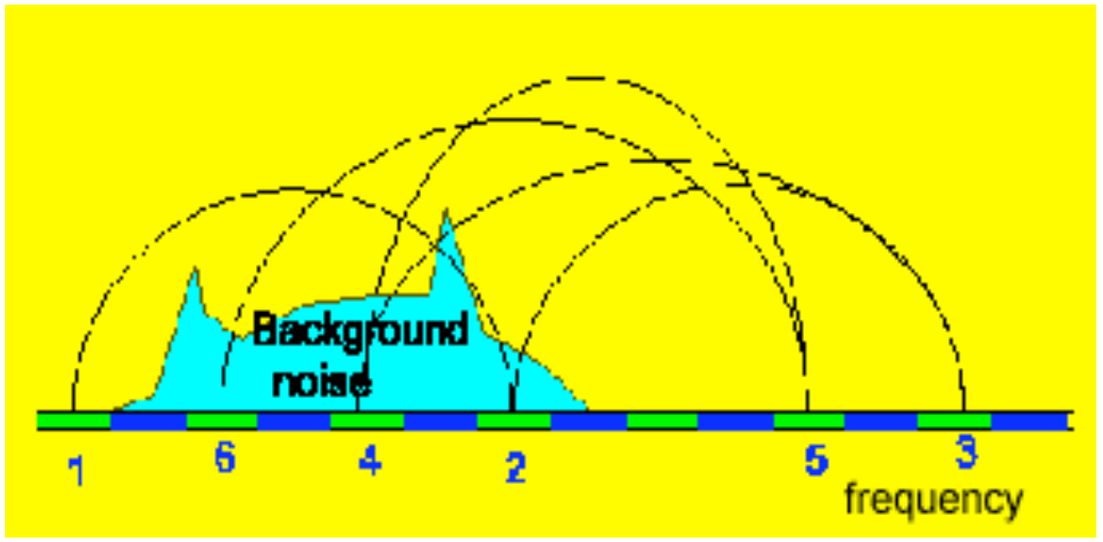
# Bluetooth Pico-nets (ad-hoc networking)

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



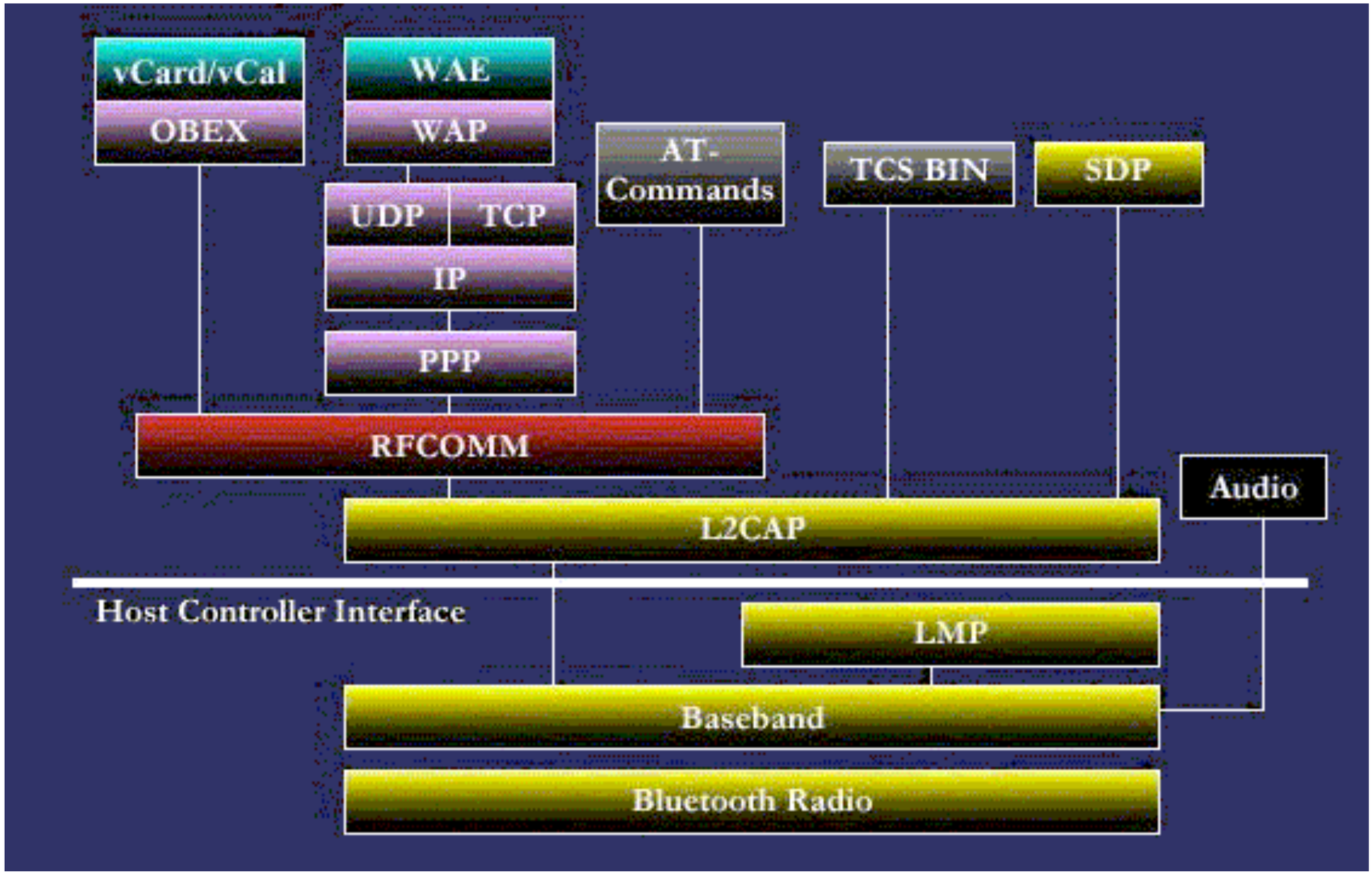
# Frequency Hopping



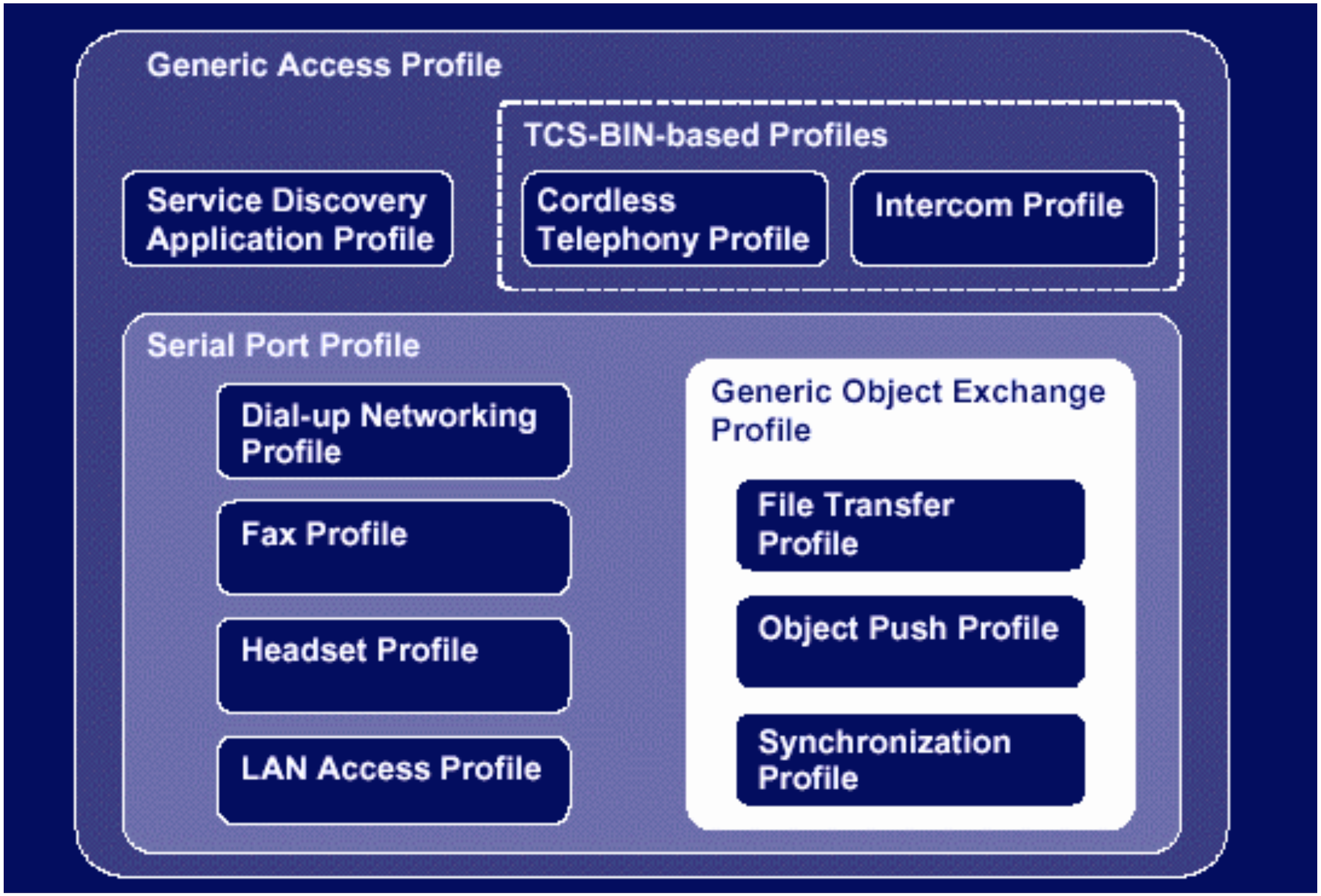




- Schema-based change of frequencies
- Fast hopping and small package sizes reduce the probability of collisions

# Bluetooth Specification (part of) Protocol Stack



# Bluetooth Profiles




Each profile is a vertical cut of the bluetooth protocol stack

# Problems of Bluetooth

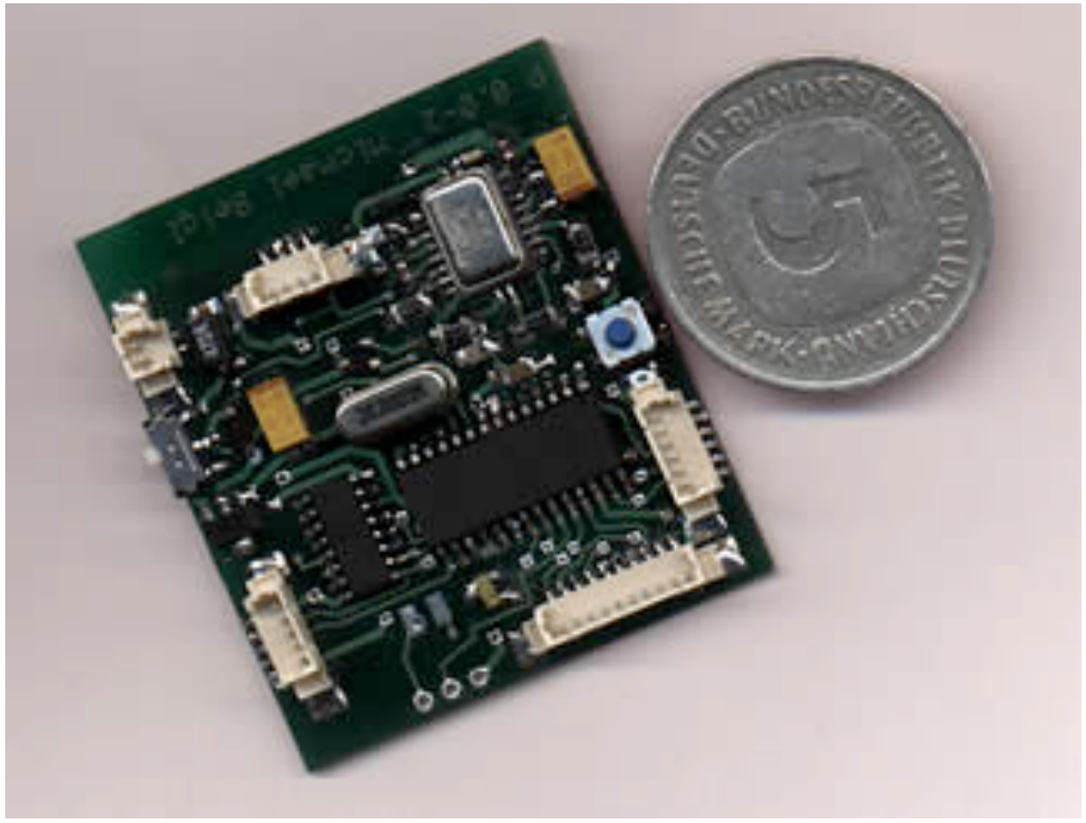
- Lots of noise on 2.4 GHz (e.g. microwave oven and WLAN)
- Small bandwidth (worst case < 1/7 MBit/s )
- Still complicated interfaces
  - Inconsistency of supported profiles
  - Partially implemented profiles

# Custom 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

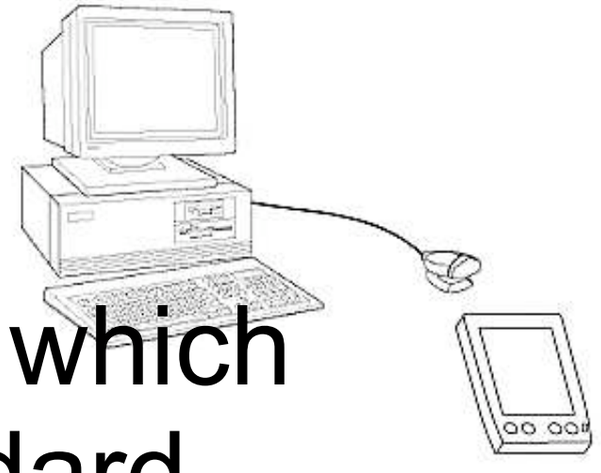
    www.tinyos.net/



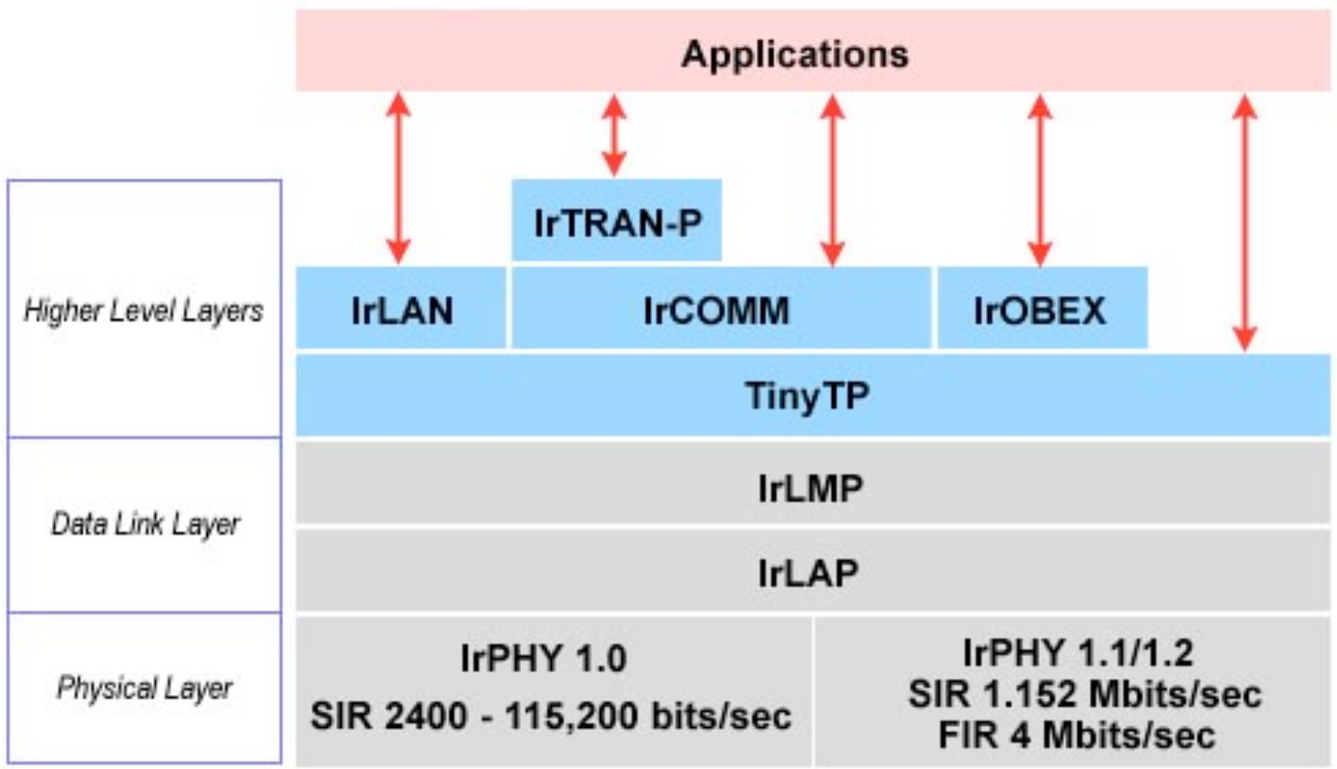
# Infrared communication

- Uses invisible 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

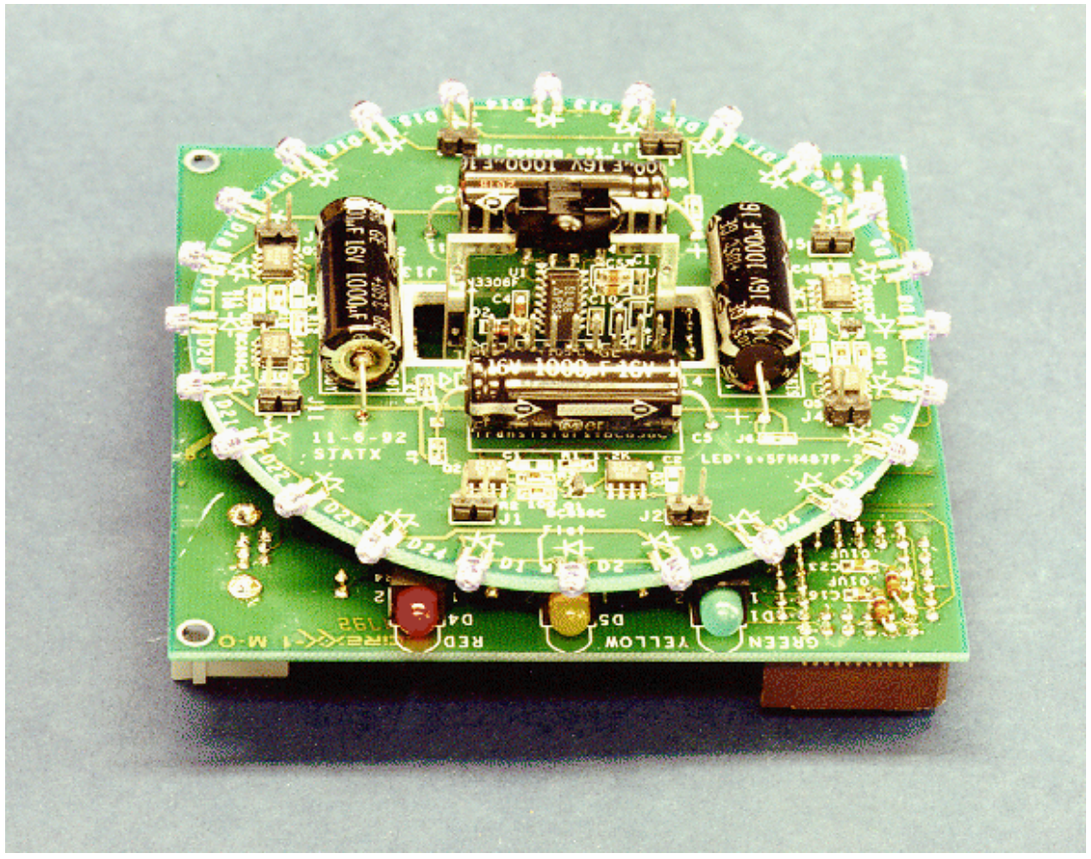
# IrDA



- 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

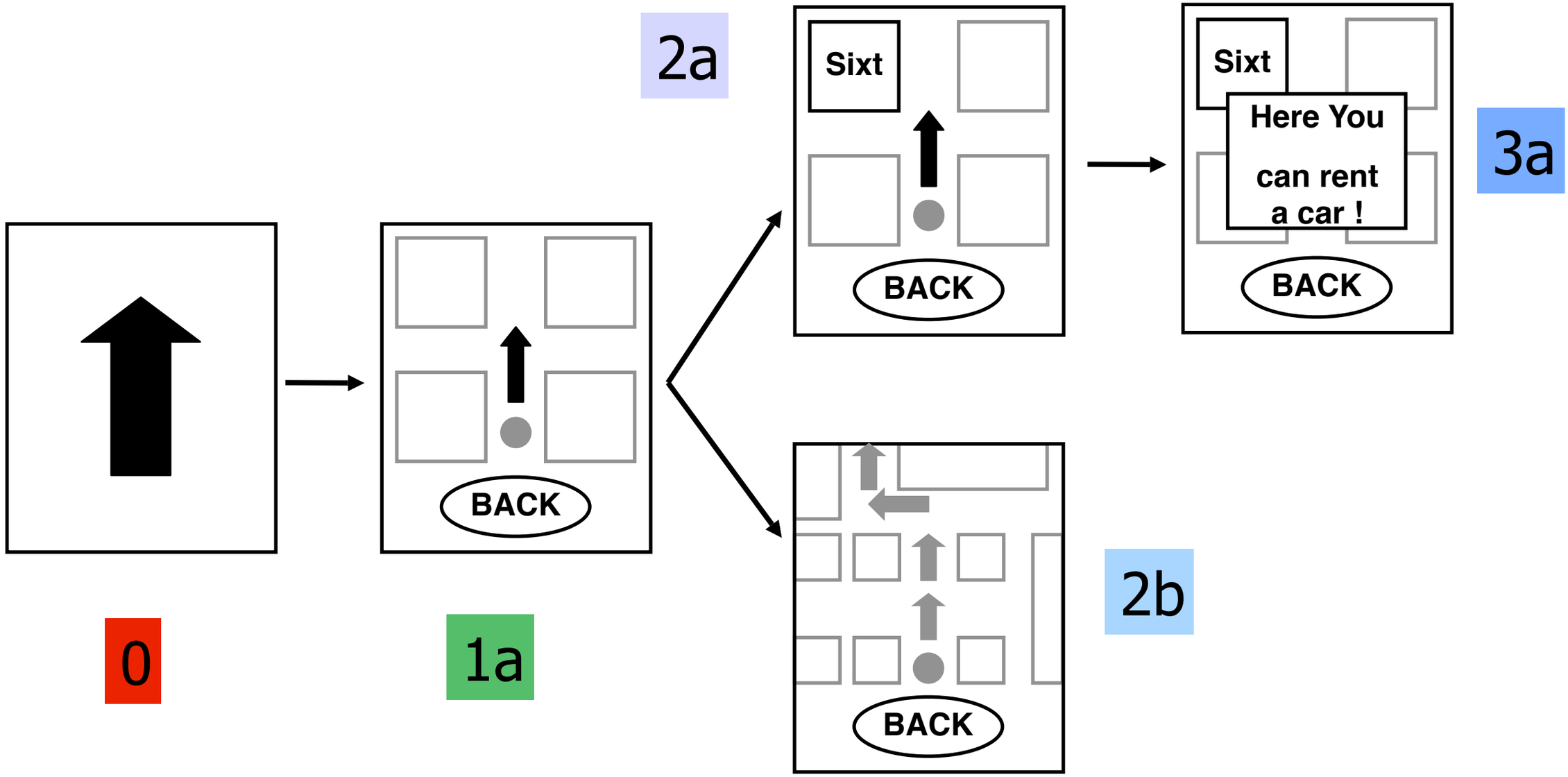
- Eyeled Sender
- Range up to 20 m
- Bi/Unidirectional connection
- 115 Kbaud
- IrDA compatible

# 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

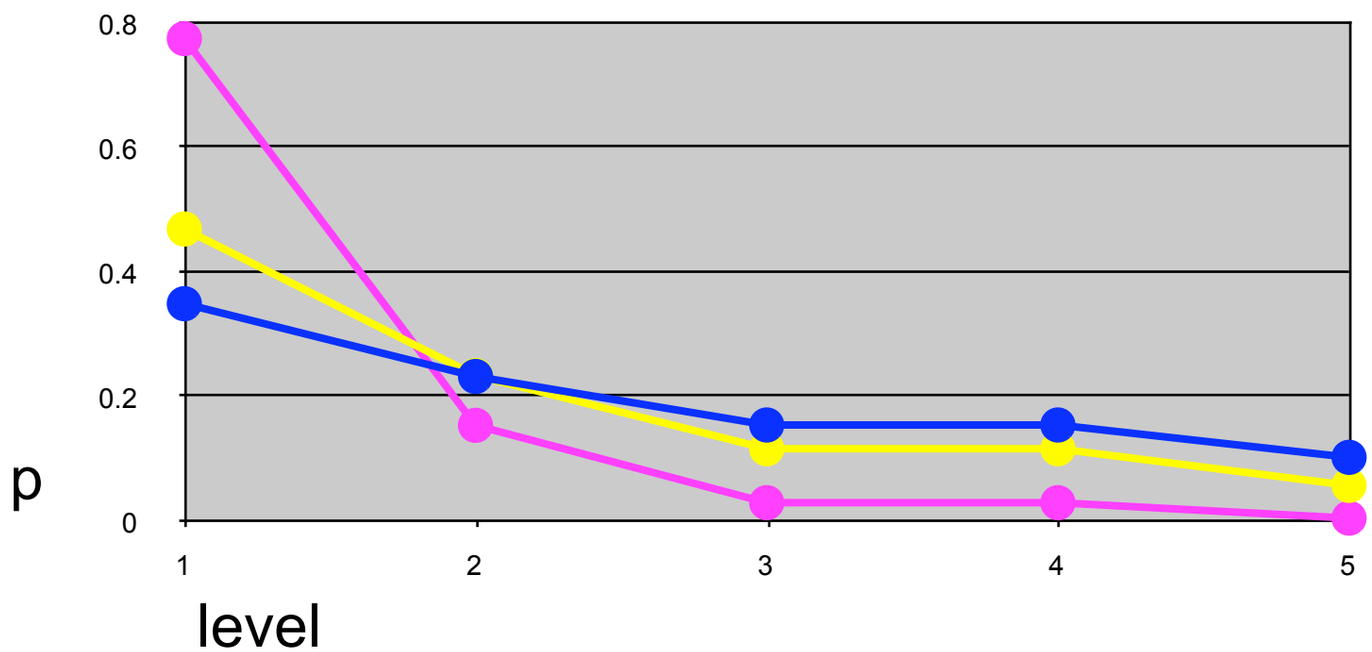
# Probabilistic transmission scheme

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

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

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

| | 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 |



# Body Network

[e.g., http://www.skinplex.net/]