Personal post-PC appliances

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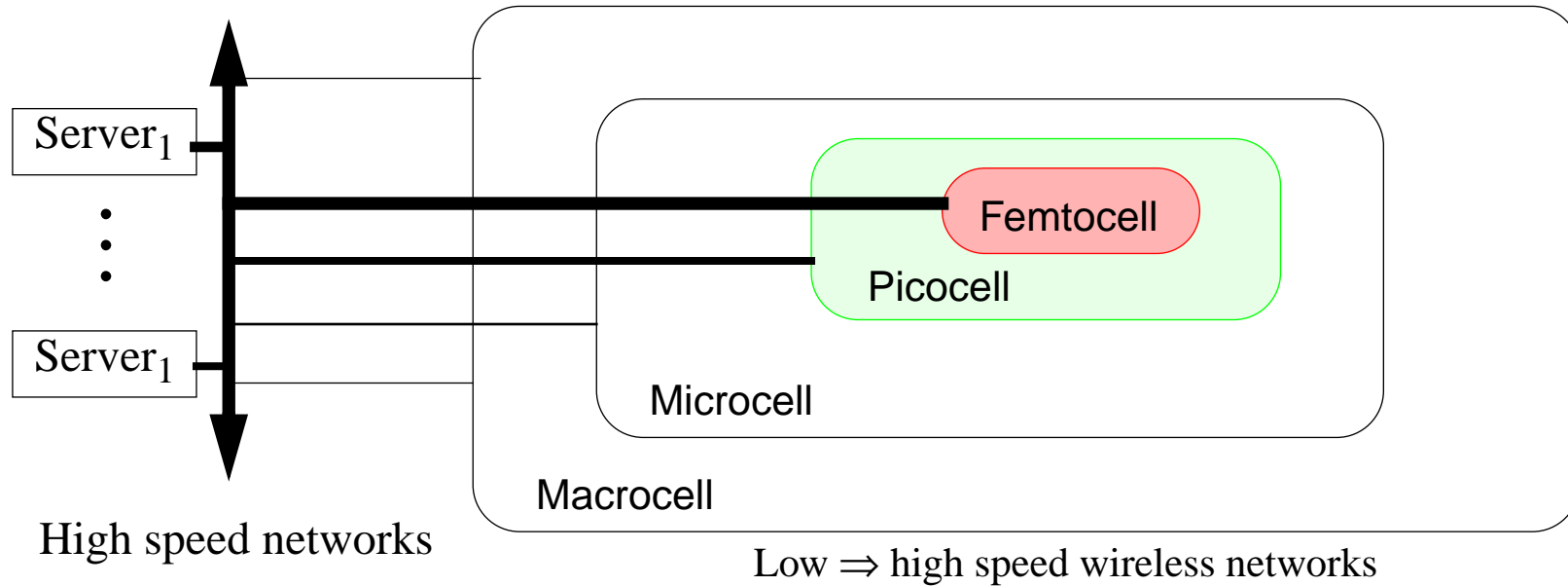Royal Institute of Technology (KTH), Stockholm, Sweden

http://www.it.kth.se/~maguire

The Fifth Annual Workshop on Frontiers in Distributed Information Systems, FDIS: Aspen '99, 9 June 1999, Aspen, Colorado

Bottlenecks

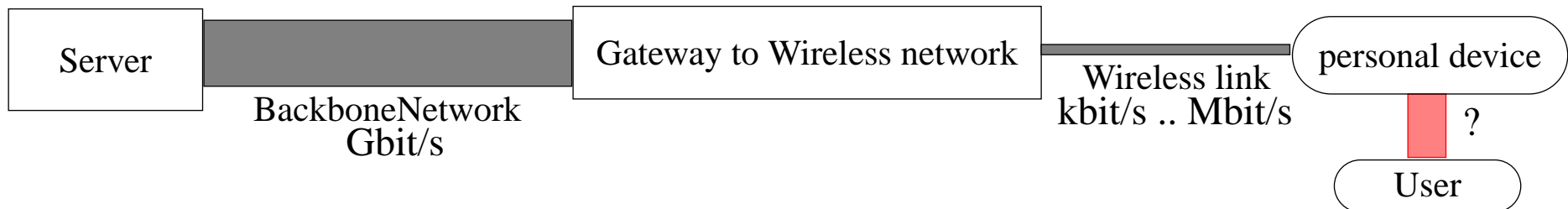- Server and Network Bandwidth and latency

High speed networks

Low $\Rightarrow$ high speed wireless networks

- User Bandwidth and latency

- Power and Energy $\Rightarrow$ need a computational theory of O(energy)

- Imagination!

Wearables

"… It will be possible to put a 100+ MIPS CPU and a 0.5 GFLOP DSP in a $200 Nintendo Game Boy within 2 years, for less than $25 bucks of Si cost. With this kind of cheap, available cycle time, how hard would it be to add a communications cartridge/dongle into a game slot? …"

-- John Novitsky
of MicroModule Systems,
and of Microprocessor Report[1]

Who are the competitors?

Ericsson, Lucent, Nokia, Siemens, … or Nintendo

⇒Telecom (only) companies have no future - perhaps even the traditional datacoms have a problem!

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1. From Wearables mailing list Wed, 17 Sep 1997 19:22:17 -0700.
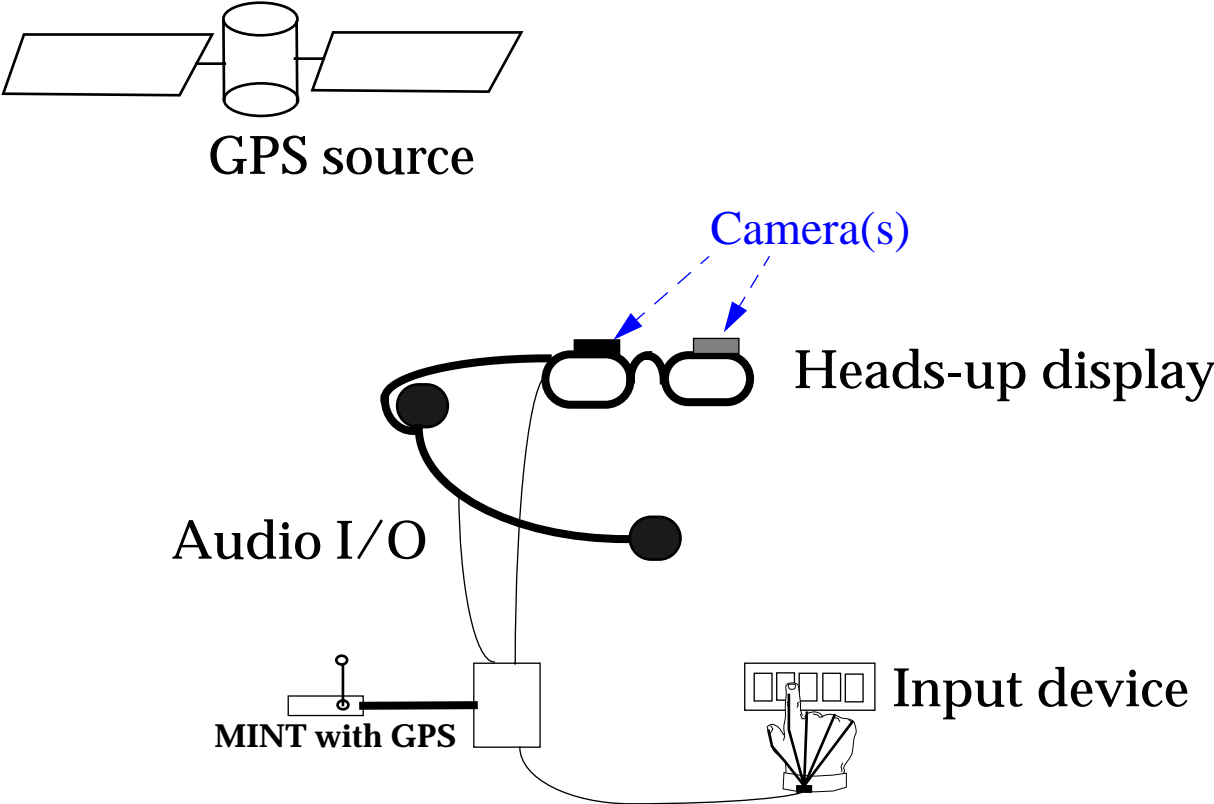
Near Future systems

Personal Portal

GPS source

Camera(s)

Heads-up display

Audio I/O

MINT with GPS

Input device

Figure 1: Vision-2, 2000 - high level of integration

Evolution of new varieties of networks

Already we have: WANs (Wide Area), MANs (Metropolitan Area), LANs (Local Area Networks)

VANs   Vehicle Area Networks

Very local networks

DANs   Desk Area Networks

The computer/printer/telephone/… will all be part of a very local area network on your desk.

- ♦ wireless links $\Rightarrow$ No longer will you have to plug your printer into your computer (PDA/…) into your computer
- ♦ active badges$\Rightarrow$ No longer will you have to sign in/out of areas, write down peoples names at meetings, … the system can provide this data based on the active badges

Olivetti and Xerox are exploring "Teleporting" your windows environment to the workstation nearest you, on command, if there are multiple choices probe each one (currently a "beep" is emitted to tell the user which).

BANs   Body Area Networks

Users will be carrying multiple devices which wish to communicate:

- ♦ thus there will be a need for a network between these devices which you carry around; and
- ♦ personal devices will wish to interact with fixed devices (such as Bankomat machines, vehicle control systems, diagnostic consoles (for a "mechanic" or repairman), …) and other peripherals.
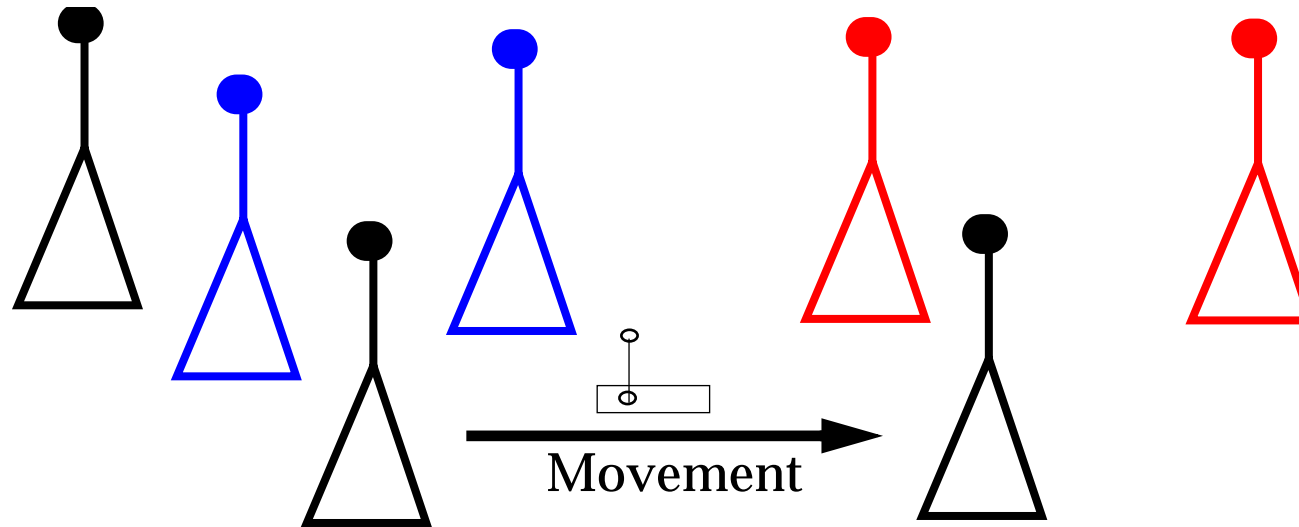
Situational awareness and Adaptability

Figure 2: Where am I? What am I? Who am I?
Where am I going? When will I be there? What should I become? Who should I become?

- Location dependent services

- Predicting location to reduce latency, reduce power, hide position, …

- Adapting the radio to the available mode(s), purposely changing mode, …

- Reconfigure the electronics to adapt, for upgrades, for fault tolerance, …; Reconfiguration vs. powering up and down fixed modules (what are the "right" modules, what is the "right" means of interconnect, what is the "right" packaging/connectors/…, needed speed of adaptation)

- "right" level of independence; spectrum from Highly Independent $\Rightarrow$ Very Dumb

Location Dependent service(s)

How do I know where I am?

- Outdoors: GPS or from the network operators knowledge [resolution: 100m to sub-centimeter]
- Indoor: IR and RF beacons, triangulation, knowing what you can **see** or **hear**

What can I do with this knowledge?

KTH students built a JAVA Applet which gets data from GPS unit and dynamically displays a list of the information available - as a function of where you are:

- ♦ if near bus, subway, train stop - you get transit information - potentially with real-time schedule - since the system knows current location of vehicles
- ♦ list of restaurants, shops, etc. where you are and in the direction you are headed
  - ◆ the scope is based on your velocity vector - so if you move quickly it reduces detail, but increases the scope
- ♦ map information with updated position

How do I know who I'm with or what I'm near?

- Olivetti, Xerox, and MIT - using IR emitters as "ID" tags
  - ♦ Olivetti put them on people, equipment, …
  - ♦ Xerox put them on electronic notepads, rooms, …
  - ♦ MIT Media Lab is putting them on people + lots of inanimate objects (clock, fish tank, …)

Human centered

- Computer - human interaction is currently focused on the computer (computer-centric)
  - ♦ Currently computers know little about their environment
    - ◆ Where are we?
    - ◆ Who is using me?
    - ◆ Is the user still there?
- Evolving Environment awareness
  - ♦ Give computers senses via sensors
    - ◆ Environment
    - ◆ User identity and presence
- Badge as a smart card replacement
    - ◆ biometric signature of the person currently using the badge
    - ◆ the badge ensures that only you can use it
- You wear your own personal user interface
  - ♦ interface can be consistent across all appliances
    - ◆ not because each appliance supports the interface, but because the user's own interface provides consistency
- Make the human the focus of the computer's interaction ($\Rightarrow$ human-centric)

Requirements

- Systems with which humans wish to interact:
  - ♦ traditional computers, desktop workspaces, domestic appliances, building and automotive systems, doors, elevators (lifts), environmental control, seats and mirrors, etc.

- Systems to provide sensor data:
  - ◆ location, orientation, light, heat, humidity, temperature, gas analysis, biomedical, …

- Systems to correlate the sensor information and provide it in a useful way to the computer systems:
  - ♦ Spatial and temporal sensor fusion,
  - ♦ 3D and 4D databases,
  - ♦ Machine Learning, and
  - ♦ Prediction (based on pattern extraction)

- Agents and actuators to provide intelligent control of the environment

- wireless/wired/mobile communications infrastructures to link it all together
  - ♦ must assure privacy and security

# Dumb Badge, Smart Badge, and Intelligent Badge

- Dumb Badge just emits its ID periodically

- Smart Badge - [an IP device] Location and Context Aware (i.e., a sensor platform)

- Intelligent Badge - add local processing for local interaction by the user

Acknowledgment:
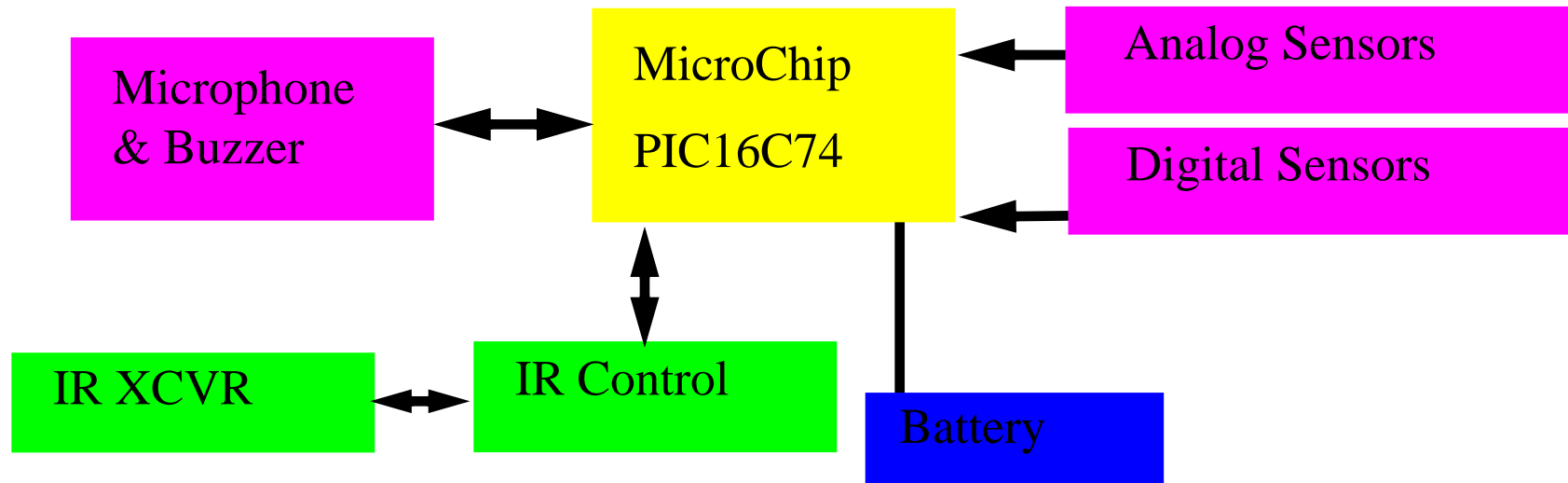
All of the badge work is done in cooperation with:

- Dr. Mark T. Smith - Hewlett-Packard Research Laboratories, Palo Alto, California, USA

- Dr. H. W. Peter Beadle
    - Formerly: University of Wollongong, Wollongong, Australia
    - Currently: Assistant Director, Motorola Australian Research Centre, Botany, NSW, Australia

Badge Prototype and Badge 1
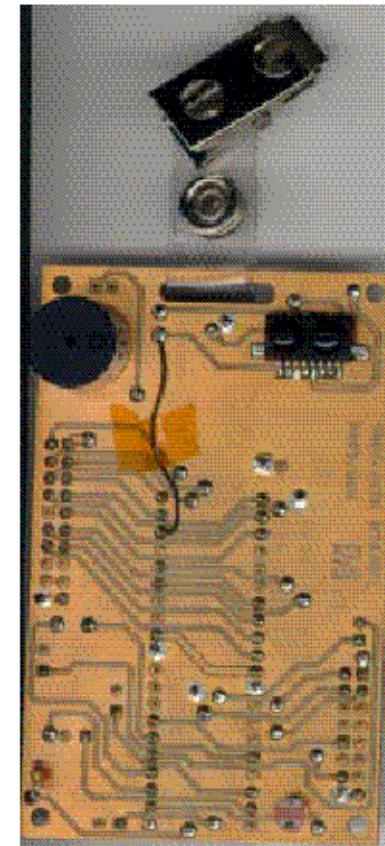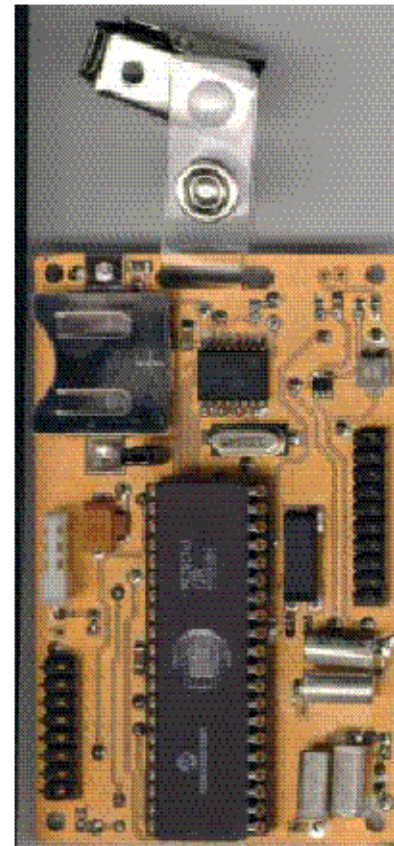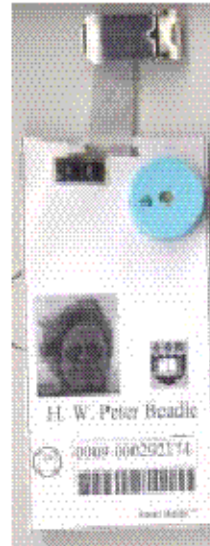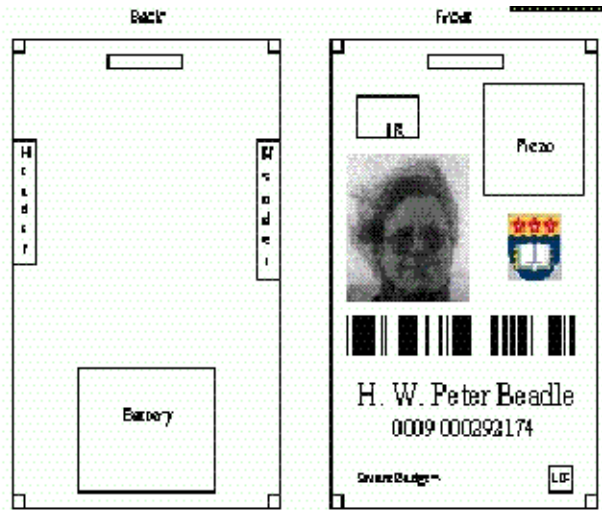
- Sound, Light, Temperature, Humidity, Orientation, Adjacency
- Beeps
- PIC 16C74A-jw based
- 5 MIPS
- 4m range
- 98mA average power

Smart Badge 1

Microphone & Buzzer	**MicroChip PIC16C74**	**Analog Sensors**
		Digital Sensors
IR XCVR	**IR Control**	**Battery**

Conceived in January 1997; Used in the "finger" course in May 1997

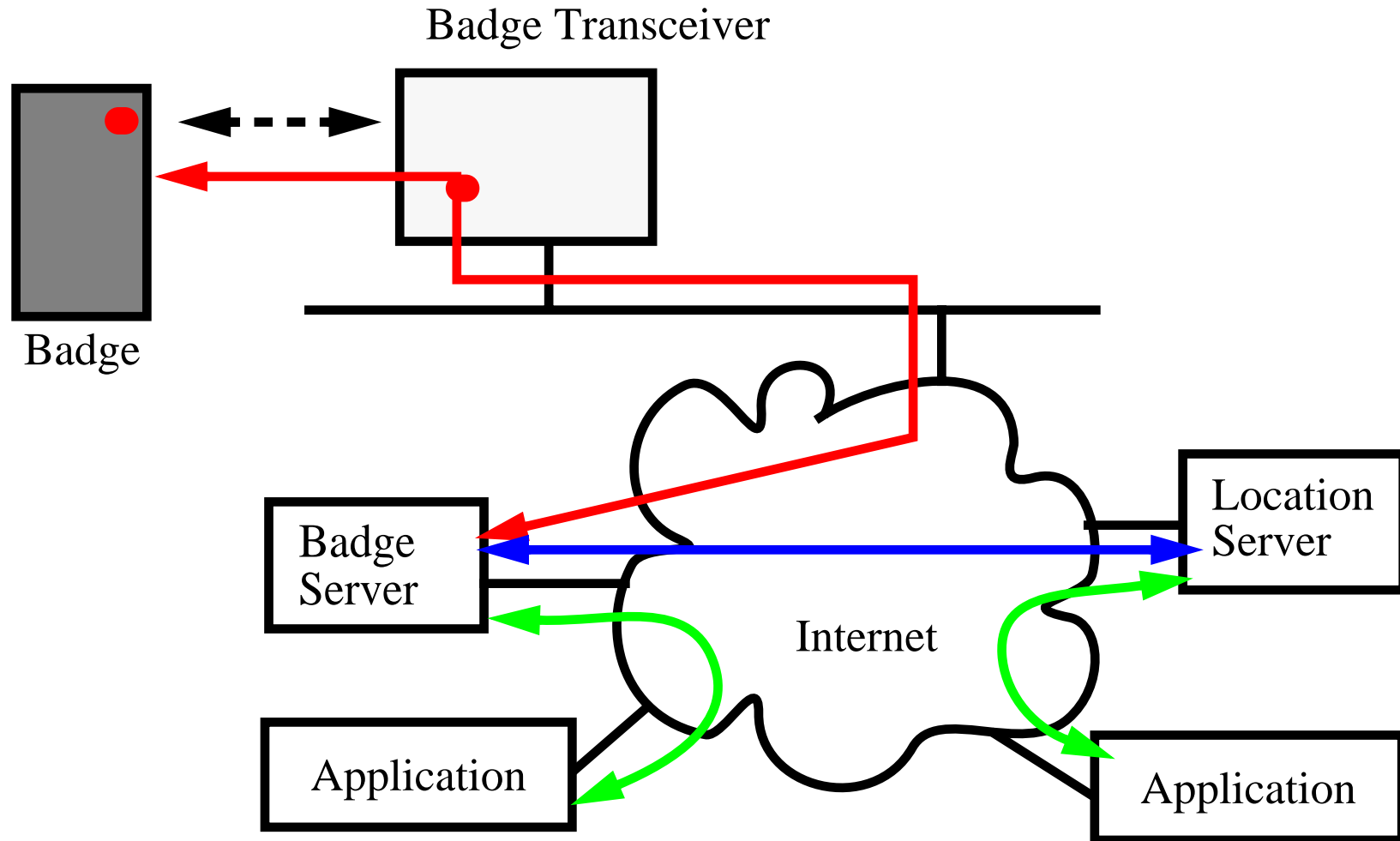URL: http://www.it.kth.se/edu/gru/Fingerinfo/telesys.finger/Mobile.VT97/mobile.vt97.html

85x55mm $\Rightarrow$ 46.75 mm^2 - component cost ~US$30

24 systems made using milling machine and hand assembly

Subsequently used for course at Univ. of Wollongong and thesis projects at: KTH, Wollongong, Ellemtel, Ericsson Radio, …

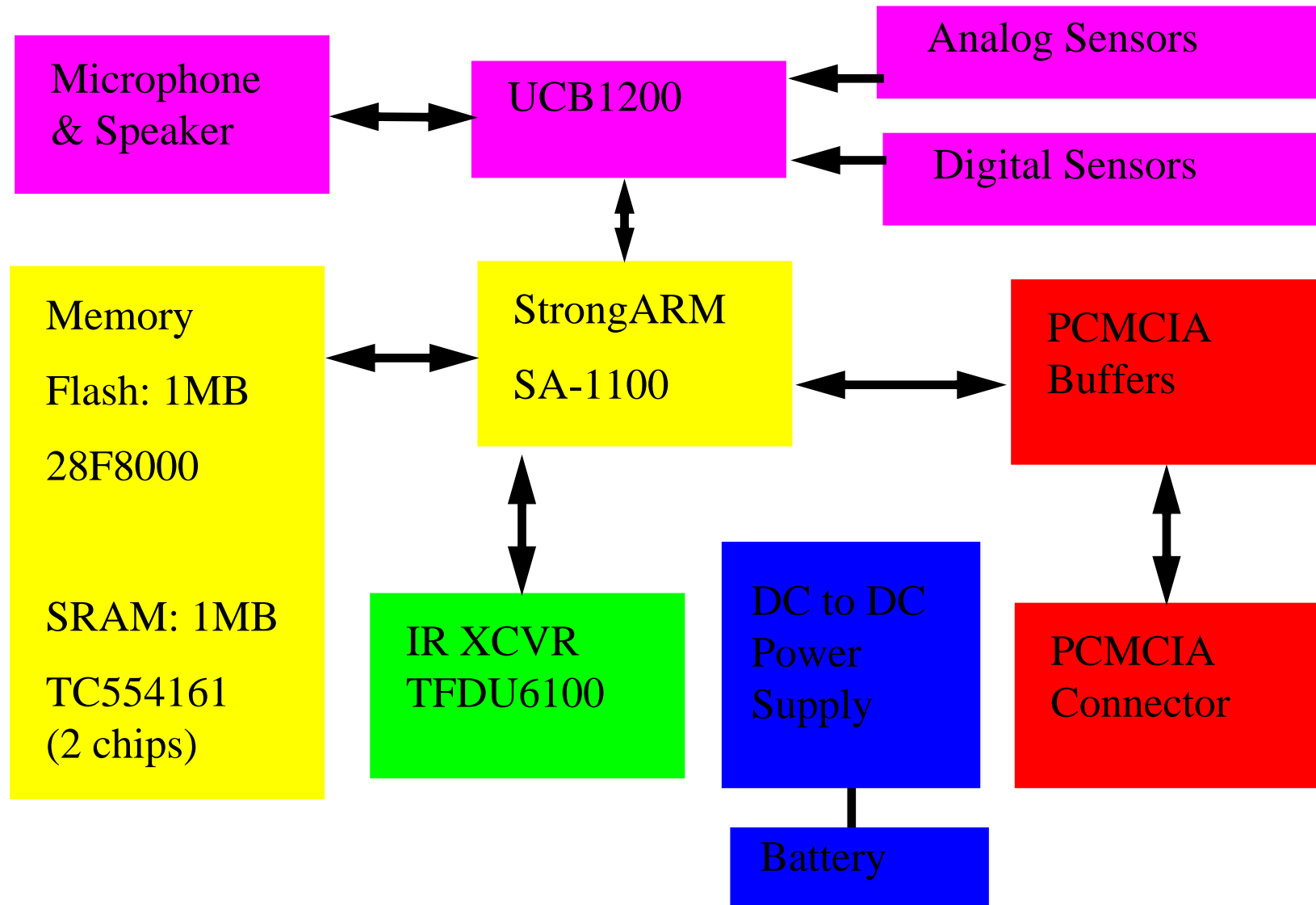# Badge Communications Model

Badges are IP devices (or should be), they communicate via network attached access points.

Badge Transceiver

Badge

Location Server

Badge Server

Internet

Application

Application

$\Rightarrow$ Banks as intermediaries (**if** they have **any** future role)

Smart Badge 3

Smart Badge Sensors

On Badge ADCs

Triaxial Accelerometer

Temperature

Humidity

Light Level
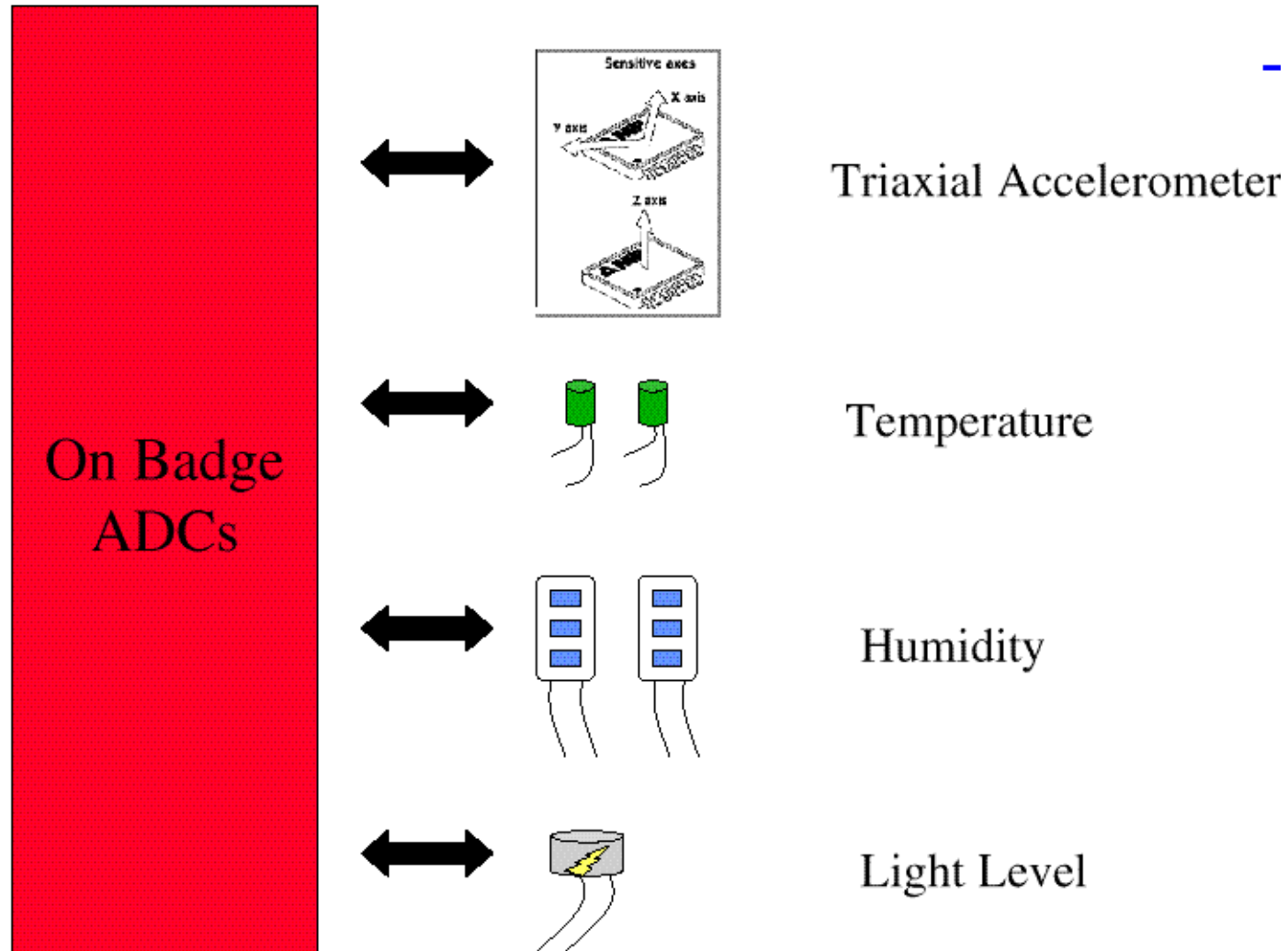
Details of the 3rd version:
http://www.it.kth.se/edu/gru/Fingerinfo/telesys.finger/Mobile.VT98/badge3.html

Badge 3
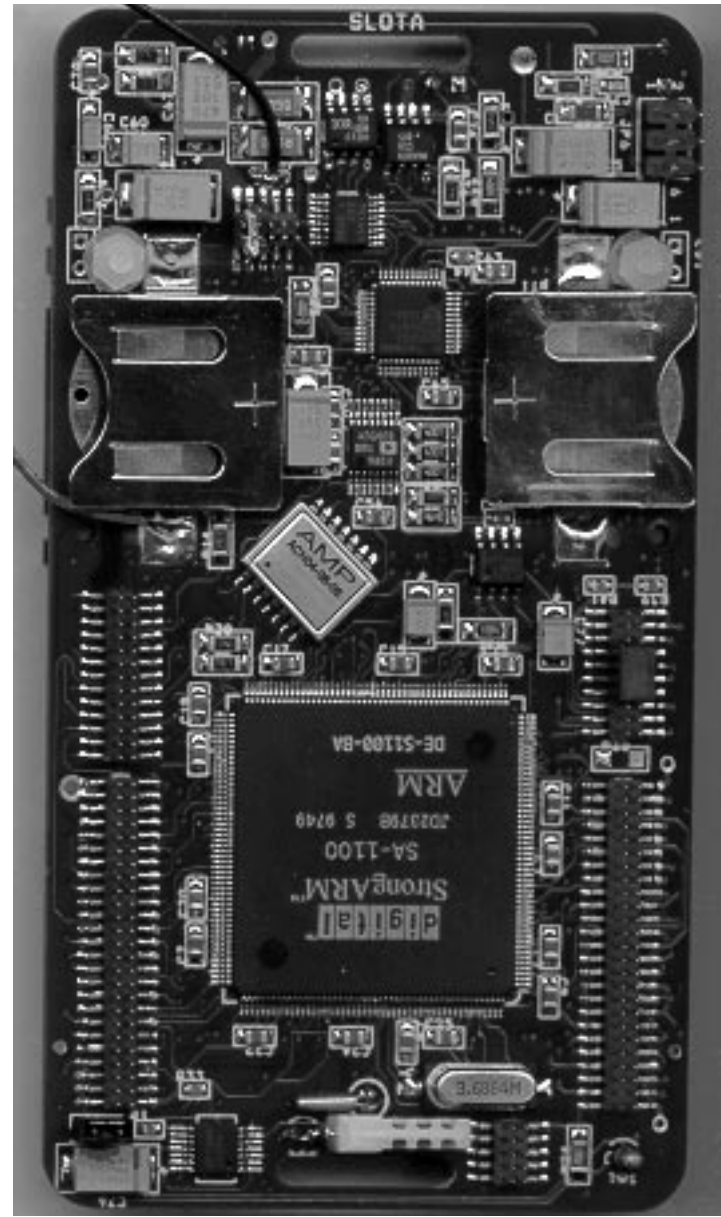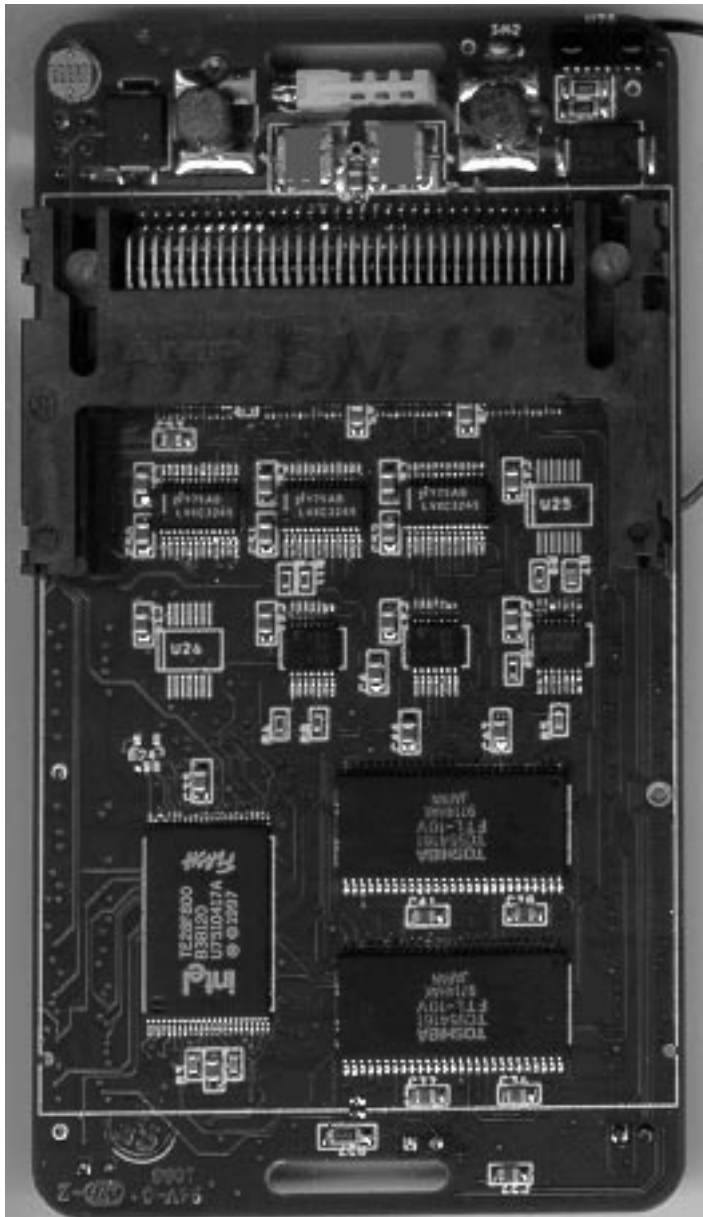
IBM Visionpad

picture edited out

Figure 3: from http://www.zdnet.com/zdnn/stories/news/0,4586,2169690,00.html

Possible limited rollout of the Visionpad by the end of the 1999 at ~$3,000

IBM Embedded Systems in Japan: ThinkPad 560X (Prototype)

http://www.watch.impress.co.jp/pc/docs/article/980911/ibm.htm

CPU	Intel Pentium with MMX @ 233MHz
Memory	64MB(EDO)
Framebuffer	NeoMagic MagicGraph 128XD 2MB
Hard disk drive	IBM Microdrive 340MB
Display	320x240with 256 colors - to headsup display
	800x600 - external video
Serial interface	USB
Card Bus Controller	TI1251
	Intel NorthBridge + SouthBridge
Mouse	Trackpoint + 3 buttons on a cord
Audio interface	Crystal CS4237B + external headset+microphone
IR communications	IrDA 1.1
Audio - software	ViaVoice Gold
OS	Windows 95/98
Size	80 x 120 x 26mm
Weight	299g + 50g

Displays & Cameras

A summary of displays

http://lcs.www.media.mit.edu/projects/wearable/display.html

Basically the status is that for low power, small size, low resolution - Kopin's technology is still in the lead (used in the Microoptical eyeglasses display: http://www.microopticalcorp.com/).

The IBM micro-display probably uses techniques from laser printers - given the background and earlier patents by Russell Budd.

Displaytech, Inc. and Hewlett-Packard Company (newco) jointly announced their Reflective Microdisplay Components - using ferro-electric liquid crystal, or FLC.

Cameras

Adding cameras to eye-glasses

- Forward looking - so the camera sees what the person is looking at
- Backward looking - so the camera can see the person's eye - for eye tracking, …

Other Wearables

Primarily built on PC (often PC/104) or smart phone base

Most PC based wearables have not taken **power** and **size** into enough consideration

Connectors are a major problem on wearables

- USB is not a small connector
- supporting dual voltage PC Card (aka PCMCIA) required physically large connectors

Xybernaut's MA IV - price $5,000 to $6,000

- 200MHz or 233MHz Pentium with MMX Technology processor
- accessed via keypad and belt-bound mouse, or by a headset microphone and IBM's ViaVoice.
- a 6.3-inch tablet **or** a head-mounted display capable of 640x480-resolution and 256 colors

ViA's ViA II - price $3,200 to $5,000

- Cyrix Corp.'s 180MHz MediaGX processor
- pen-based tablet or voice recognition for input -- partnered with Lernout & Hauspie Speech Products N.V. - to create a new voice recognition package

Software for Badge3

Currently

- Small kernel based on ARM debugger (Angel)

    - ♦ Extended to allow user installed device drivers

    - ♦ Mostly small applications written in C, most of their time is spent doing interrupt drived processing and sleeping

- Vxworks

- HP's own OS designed for low power (expected to become open source)

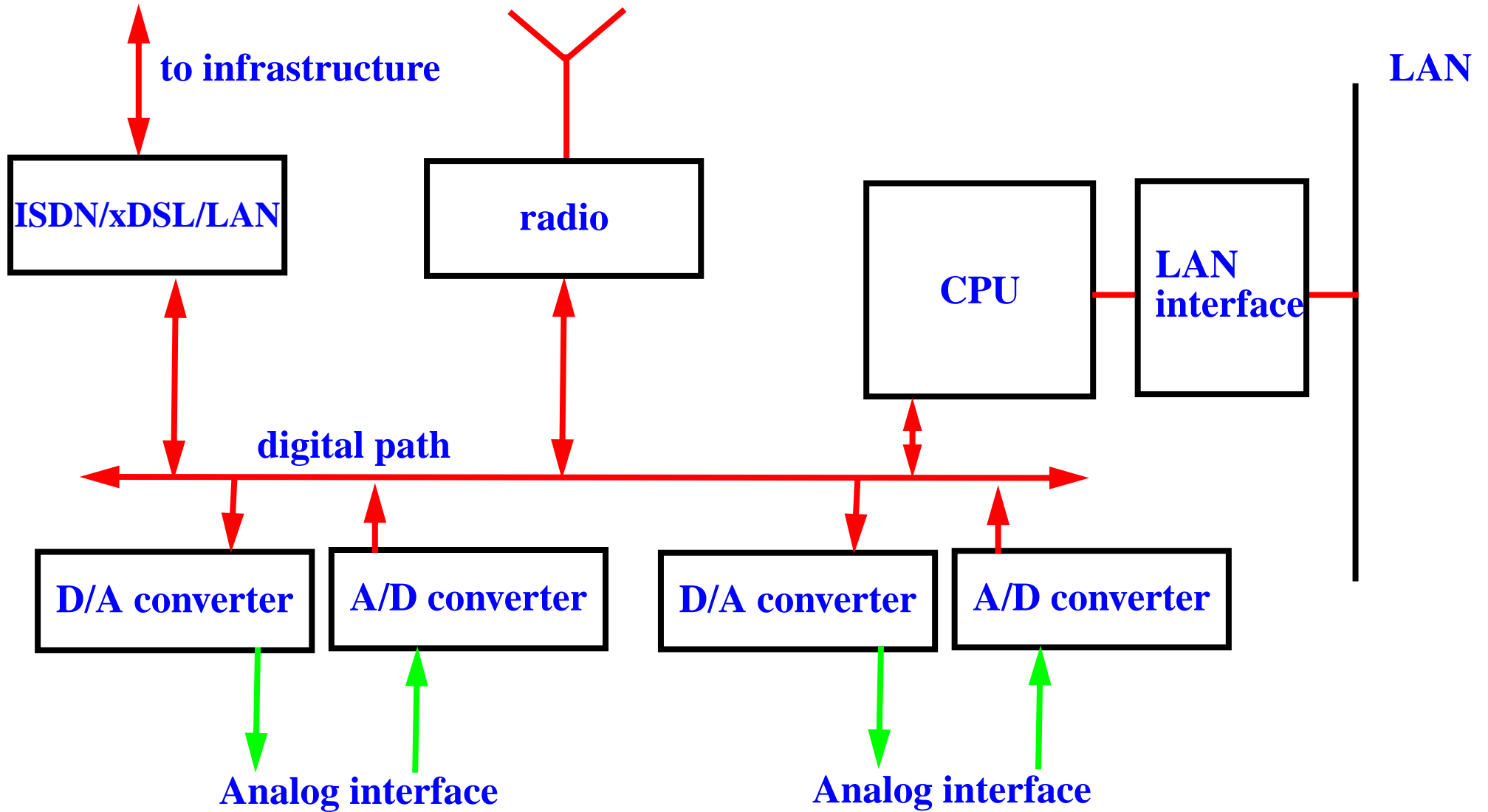**Future**

- Inferno

    - ✘ currently it is too large

    - ✔ provides a VM which makes supporting (and developing) applications easier [my not need much from an OS]

    - ✔ provides security and distributed computing - from the start

- Java

    - ✘ current much too large

    - ✘ does not really provide a based of distributed computing

- Mozart/Oz (KTH) - already open source

Software

- Most of these PC style devices are running Microsoft software (typically Windows CE)

- Some of these systems are using Virtual Machines (Java or Inferno)

- Some are running real-time kernels

- Some are running proprietary kernels: such as that proposed of Symbian (http://www.symbian.com/)

Local access point

to infrastructure

LAN

| ISDN/xDSL/LAN | radio | | CPU | LAN interface |

digital path

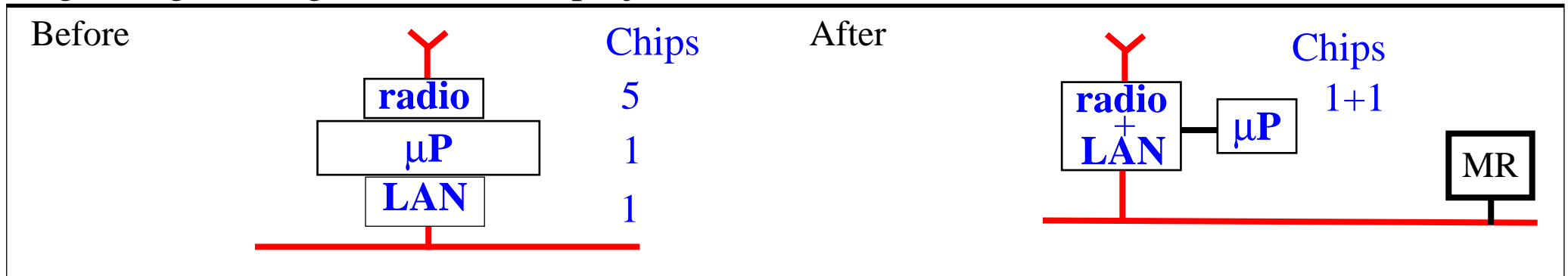| D/A converter | A/D converter | D/A converter | A/D converter |

Analog interface   **Analog interface**

All but the radio are current inside an Ascend Communications Pipeline 25 or 75.
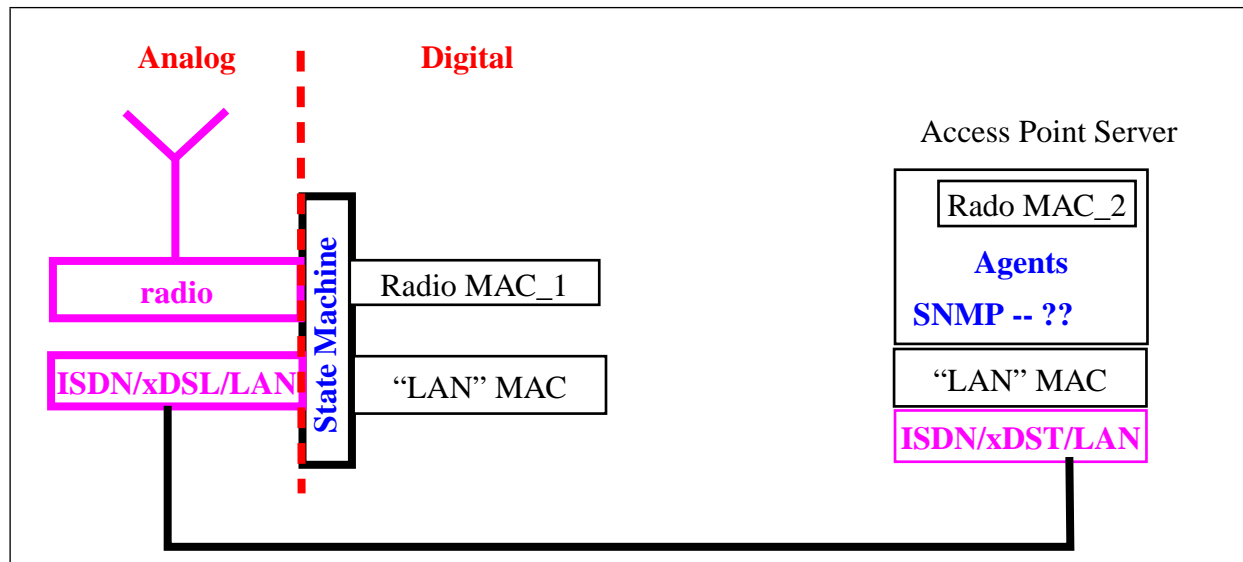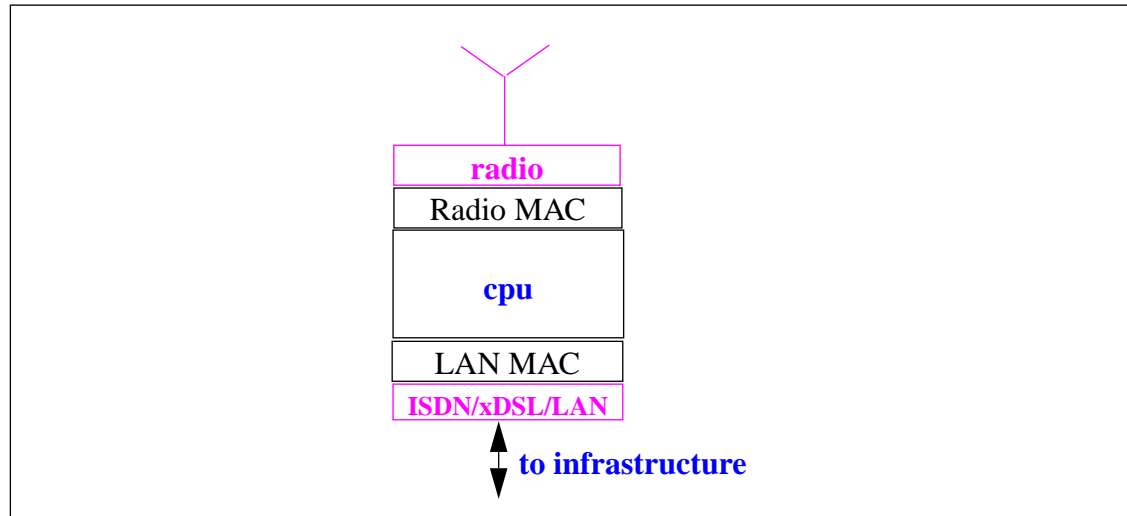
MEDIA

High integration (goal of MEDIA project)

Partners:

- Kungl Tekniska Högskolan (KTH/ELE/ESDlab and KTH/IT/CCSlab)

- Tampere University of Technology (TUT)

- GMD FOKUS (GMD)

- Technische Universität Braunschweig (UBR)

- Interuniversity Microelectronics Centre (IMEC)

- Ericsson Radio Systems AB (ERA)

See http://www.ele.kth.se/ESD/MEDIA for more information

Split the functions between access point and access point server

radio

Radio MAC

cpu

LAN MAC

ISDN/xDSL/LAN

to infrastructure

Analog   **Digital**

radio

State Machine

Radio MAC_1

ISDN/xDSL/LAN

"LAN" MAC

Access Point Server

Rado MAC_2

Agents

SNMP -- ??

"LAN" MAC

ISDN/xDST/LAN

1

Classic applications

Voice calls over a full or half-rate channel

OR

dialup PPP: carrying telnet, FTP, HTTP (WWW), …

Semi-Classic applications

dialup PPP: <u>Voice coded as packets</u>, FTP, HTTP (WWW), …

The result:

- converse while you browse,

- shared whiteboards in a voice conference,

- human assistance while web shopping,

- multiplexing the user's time between tasks,

- …

Key is **multiplexing** of traffic.

More audio on-line

Microsoft® Cordless Phone -
http://www.microsoft.com/products/hardware/phone/overview/default.htm

- voice commands

- voice mail

- (only a serial connection to attached PC - it should have been network attached)

MP3 players - http://www.mp3.com/hardware/

- Diamond Multimedia's new Rio PMP300 Portable Music Player, ...

Mobile RealAudio - http://www.audible.com/audible/tour/real.html

More Images on-line

- <u>HP CapShare 910</u> - Handheld scanner - with automatic stitching - produces PDF
- Network attached "copiers" - really a scanner + printer
- <u>CrossPad</u>$^®$ - Personal Digital Notepad - from pen strokes to digital stroke info
- Web cameras - networked cameras, cameras notebooks, cameras on your eyeglasses

$\Rightarrow$ more and more source material

$\Rightarrow$ scanning and image capture allow parallelism in adding material to the web

Dr. Mark T. Smith of HP Labs asks the question:

> "Given the large numbers of digital cameras, if they labelled their pictures with the location and orientation of the camera at the time of the picture, then how long would it be before you could do a virtual walkthrough of San Francisco?"

With network attached handheld scanners - how long before 90% of all books are scanned?

More than just a communication link

HLR & VLR: information about **where the** <u>terminal</u> **is**! via 1 BS

Mobile positioning systems: provide even higher

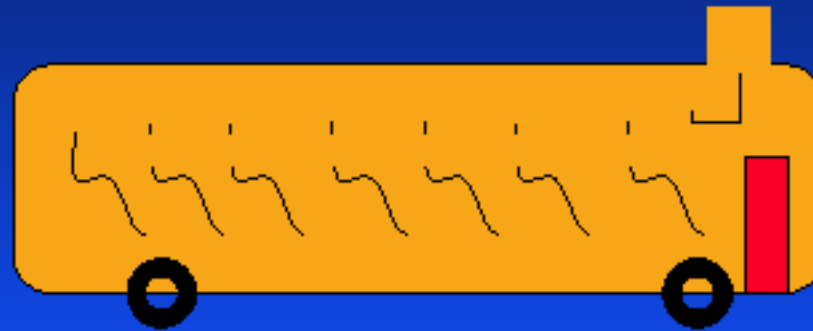accuracy location information   via multiple BSs

$\Rightarrow$ Location <u>dependent</u> services

- emergency services - such as E911

- warning services (avalanche area, construction, traffic delays, …)

- advertisements for nearby: hotels, restaurants, shops, …

- maps and directions

Vehicular entertainment/info/...

Bus/Train/Plane/Truck/Van/Car

- moving network with a link to a wide area network

With location dependent information and services

- information from bus back to bus operator

- package transport - sensors on packages to monitor condition & location

Security guards

- location
- scanner (barcodes or RFIDs)
- camera
- sensors (smoke, chemical, …)
- voice communications

While avoiding the need for private frequency assignment!

Secure IDs

Authenticate the user

Personalize the device automatically

Hotel without a check-in/out desk!

Even more sensors

Temperature

Humidity

Barometric pressure

Light level

Solar radiation

Weight

Acceleration

...

- Distributed Weather data collection
- Environmental monitoring
- Energy and building management (HVAC)
- Intelligent appliances
- Automated customer care (upgrades, emergency support, usage data back to manufacturer to guide development of new products, ...)

Personal Entertainment/Info/...

Personalised data: text, picture, audio, ads, ... play lists

burst download in hotspots (WLAN) ...

Faster

faster than "real-time" (DAB/DSS/... + GPRS) ...

download in the background (GPRS)

Slower

Examples of new services developed by projects in my recent class

- itTraveler, globalAssistant, MobileMap
- Mobile Audio Distribution (MAD),MobileMedia,NEAT
- Securiteam, Epitropos, and SecureID
- MeICQ
- WeatherCast
- King of the Hill
- Emocon

http://www.it.kth.se/   see course 2G1303

New objects in Web space:
URLs or URNs on everything

Henrik Gustafsson'Matchbox Badge
http://www.pcs.ellemtel.net/pcc/TI98/Prototype/equipment.htm

Imagine an International Article Numbering Association (EAN International) or <u>Universal Product code</u> (UPC)[1] subspace mapping to product web pages with safety, ingredients, recipes, etc.

http://051000029522.upc.org

or perhaps:

http://029522.051000.upc.org

in item.manufacturer form
more suitable for DNS use

as computed by:
http://www.milk.com/
barcode/

For decodings see http://www.deBarcode.com/ for UPC or
http://www.upclink.com/ for mapping from ISBN to publisher's information about a book

http://www.icepick.com/ - internet connected trash bin via pen-type barcode scanner

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1. Invented by George J. Laurer of IBM, in 1973

Disappearing objects[1]

list of products which will disappear (in the sense of having a separate identity)

|	
Wired phones	garage door openers
Cordless phones	wireless car door/vehicle security transmitters
Mobile (cellular) phones	GPS units (as a separate single purpose device)
(pocket) radios [Also applies to vehicles]	calculators
stereo receivers	credit cards/checks/cash {the later will soon be outlawed in any case}
tape decks	clocks and watches
TVs	pagers
CD players	computers as PCs/Workstations/... {which we already can not always recognize!}
modems	File Cabinets[a]
answering machines	ATM machines
cable decoders	Maps
FAX machines	Thermometers
newspapers and other periodicals (in print form)	Business Cards
film based cameras (except for pure hobbyists)	Security Badges
VCRs and camcorders	Toll Booths

a. This item and the following 6 were contributed by prof. J.M. Smith, University of Pennsylvania.

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1. This list was originally proposed by G.Q. Maguire Jr. in 1995

Future home/office/… network accesspoints

Radio
Fiber
TP
Coax
…
} Gateway

Toaster

Radio

Handset

PC

TV

Softradio

Softradio
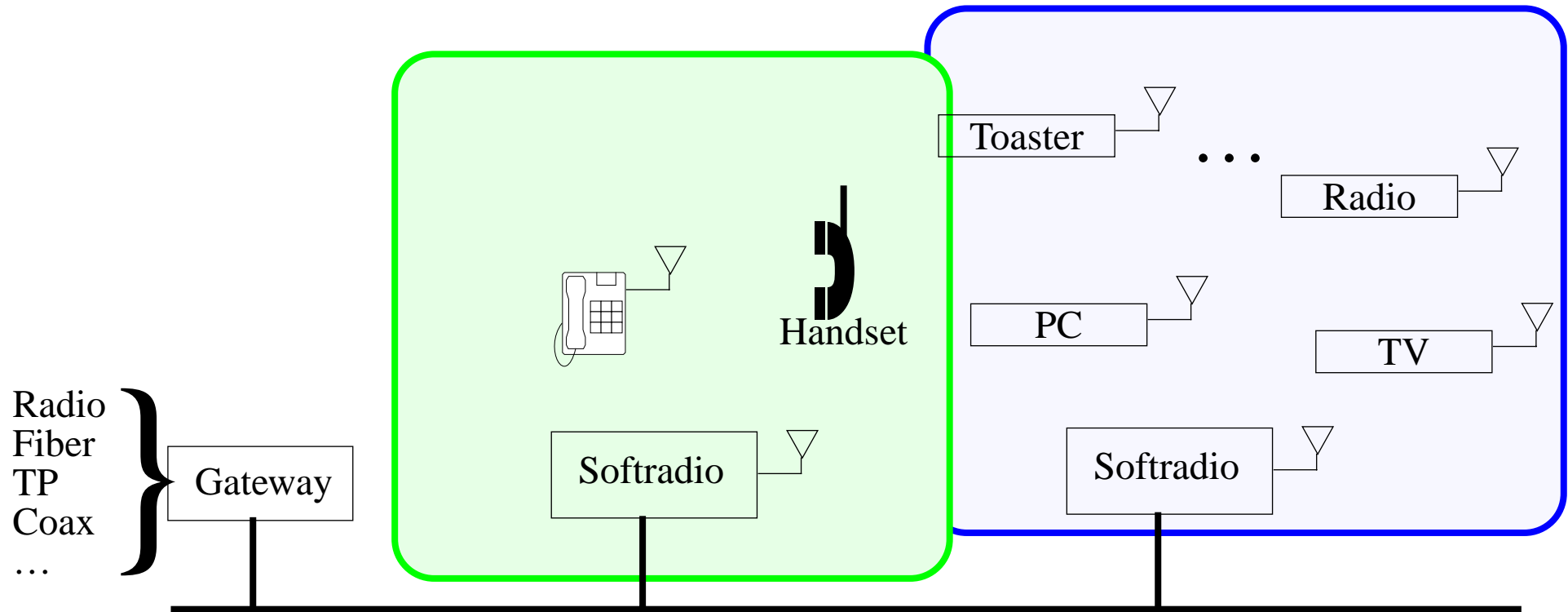
Personal Computing and Communication (PCC)

Upper limit of bandwidth: saturate the senses: sight, sound, touch, smell, taste

$$\Rightarrow \sim 1 \text{ Gbit/sec/user}$$

Current workstations shipping with 1 Gbit/sec interfaces for LAN!

Telepresense for work is the long-term "killer" application

-- Gordon Bell and James N. Gray[1]

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1. "The Revolution Yet to Happen" in Beyond Calculation: The Next Fifty Years of Computing, Eds. Denning and Metcalfe, Copernicus, 1997.

Conclusions

- Telecom operators are reinventing themselves and their infrastructures

- Low cost access points which exploit existing or easily installed infrastructure are key to creating a ubiquitous mobile infrastructure with effectively infinite bandwidth.

- Smart Badge is a vehicle for exploring our ideas:

  - ♦ Exploits hardware and software complexity by hiding it.

  - ♦ Explores allowing devices and services to use each other in an extemporaneous way.

  - ♦ Enables a large number of location and environment aware applications, most of which are service consuming.

  - ♦ Service is where the money is!

- Distributed research - means that the project never sleeps; global operations will be part of the key to success.

- Personal Communication and Computation in the early 21st century: "Just Wear IT!"

- Coming in 20-30 years: "Just implant IT!"

Don't waste! Help stamp out analog phones

Use each jack as a place to put an access point, thus making it possible to have lots of picocells, so that **everything** can be on the net.