Personal Computing and Communication:

Personal post-PC appliances + Applications

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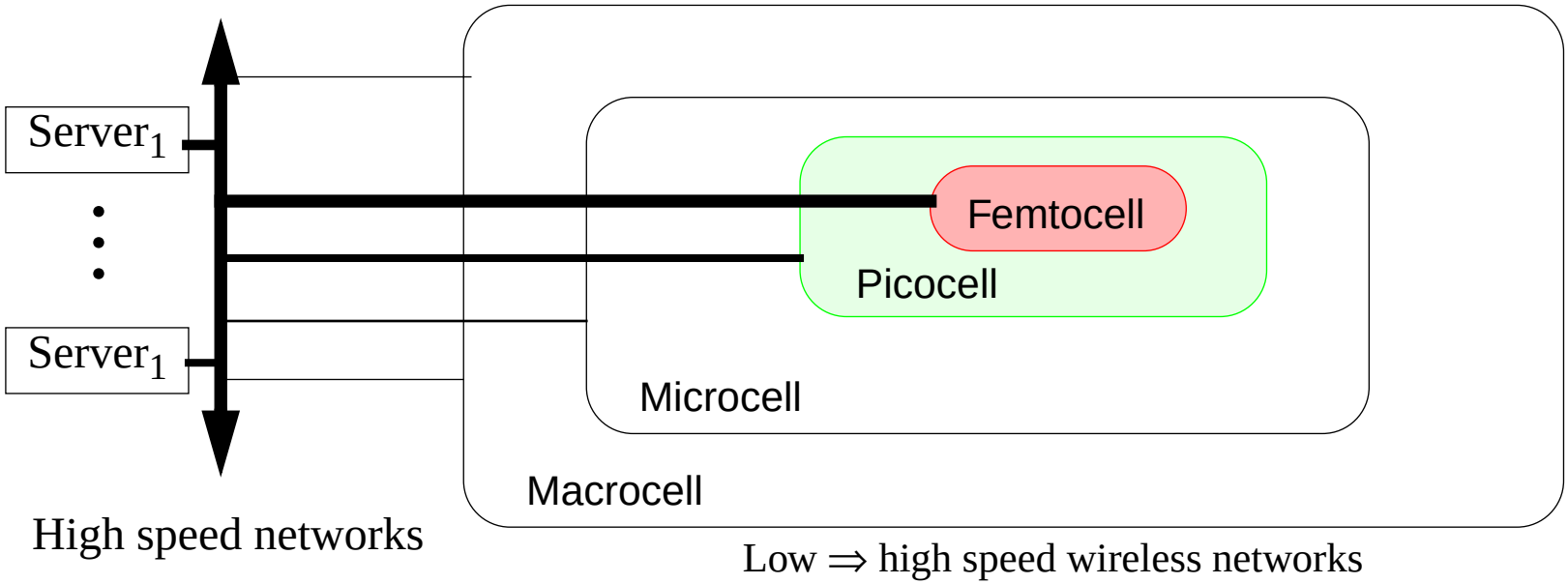
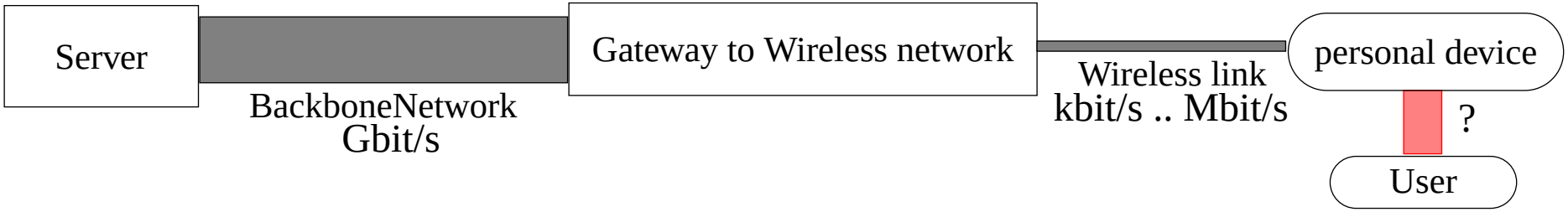
Lucent Technologies, Bell Labs, Murray Hill, NJ
3 November 1999

Bottlenecks

- Server and Network Bandwidth and latency

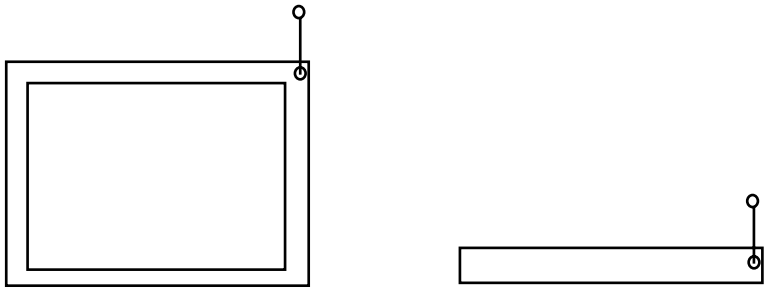


- User Bandwidth and latency



- Power and Energy ⇒ need a computational theory of O(energy)
- Imagination!

Student Electronic Notebook Project (Columbia Univ. and IBM)



Front view **Side view**

Figure 1: Vision-0, 1991 - Pen based (PDA) view

- IBM built the prototype hardware based on PS/2 model 55 motherboard, used off the shelf radios+LCD+resistive overlay, added some glue logic (to deal with microchannel to AT interface conversion), and used flex circuits for the bus connections.
- IBM designed and made the packaging {they did no thermal design or analysis}.
- Columbia developed a diskless version of IBM's AIX Operating System, Mobile*IP protocol, radio device drivers, and a multicast file distribution protocol.
  - ✔ project required coordination across 2 product divisions + research lab + university (video conf.+travel)
  - ✔ System worked
  - ✘ Very unreliable hardware

Infinite Bandwidth

Guilder's Law states that network speeds will triple every year for the next 25 years.
This dwarfs Moore's law that predicts CPU processor speed will double every 18 months.

MCI network backbone:

- 1995 capable of moving 45 Mb/s
- 1996 already 1.2 Gb/s
- 1999 at or above 40 Gb/s
- by 2000 (actually Q4 1999) - 1.6Tbps - via Dense Wavelength Division Multiplexing (DWDM)

Telia installing a 60 Gbps transatlantic fiber

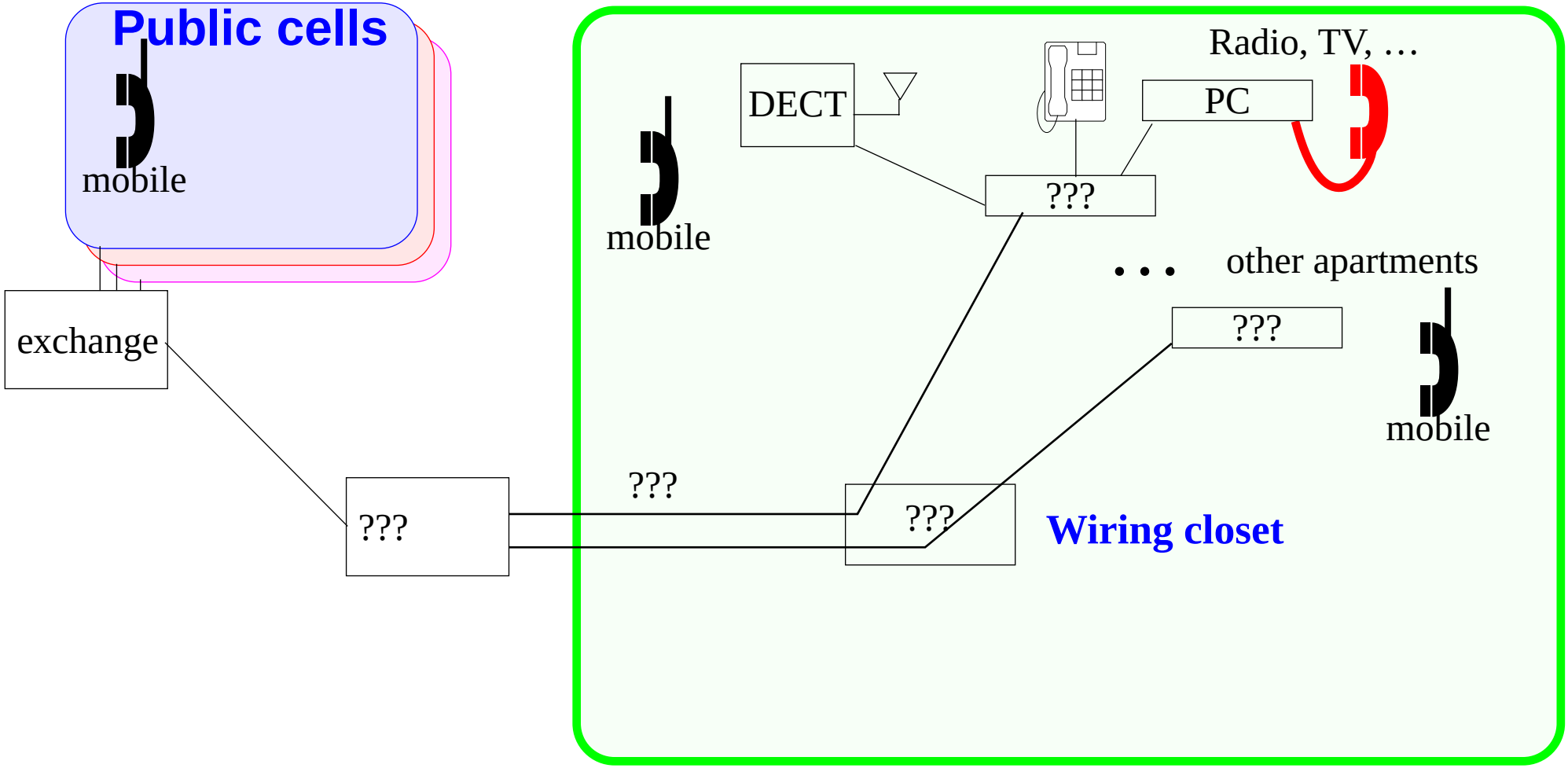
Deregulation ⇒ Trends

- replacing multiplexors with Routers/Switches/… << 1/10 circuit swi. cost
- Standard telco interfaces being replaced by datacom interfaces
- New Alliances:
  - HP/AT&T Alliance - a specific application: electronic commerce
  - 3Com/Siemens, Bay/Ericcson, Cabletron/Nortel, Alcatel integrating Cisco IOS software technology, Ericsson Radio Systems & Cisco Systems collaborate wireless Internet services
- future developments building on VOIP
  - ♦ Fax broadcast, Improved quality of service, Multipoint audio bridging, Text-to-speech conversion and Speech-to-Text conversion, Voice response systems, …
  - ♦ Replacing the wireless voice network's infrastructure with IP:
    U. C. Berkeley's ICEBERG: Internet-based core for CEllular networks BEyond the thiRd Generation

See: "*Strategies for Navigating the Convergence of Voice and Data Networks*", by Pedro Arroyo, Ray Gilstrap, Randy Huang, Peter Laudat, a report for EE290X: Strategic Computing and Communications Technology, U. C. Berkeley, 11 May 1998, http://haas.berkeley.edu/~laudat/finalproject.html

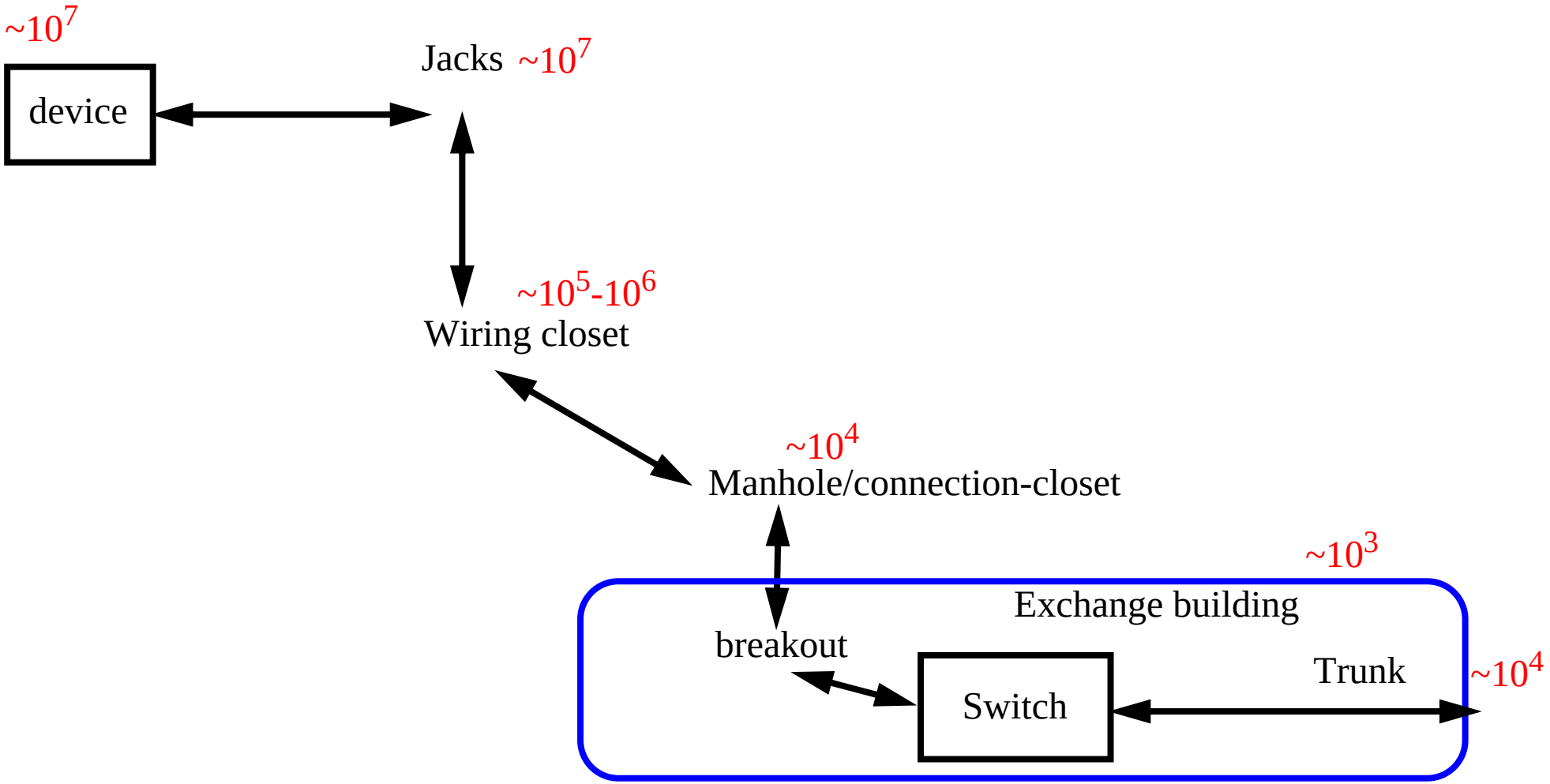
⇒Telecom (only) operators have no future
⇒Telecom (only) companies have no future

New fixed infrastructure

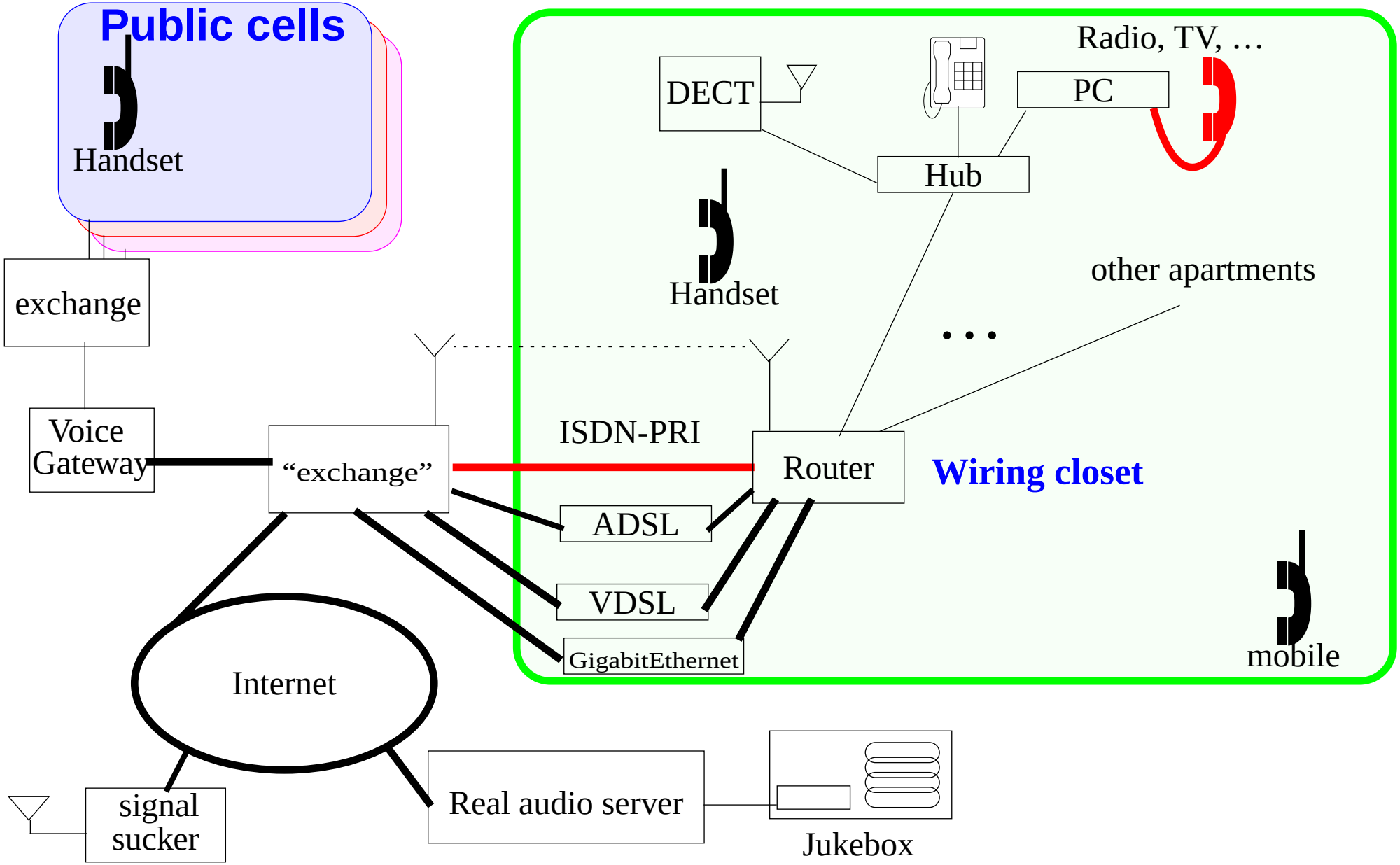


Orders of magnitude

Numbers shown below are my approximation of the actual numbers for Sweden

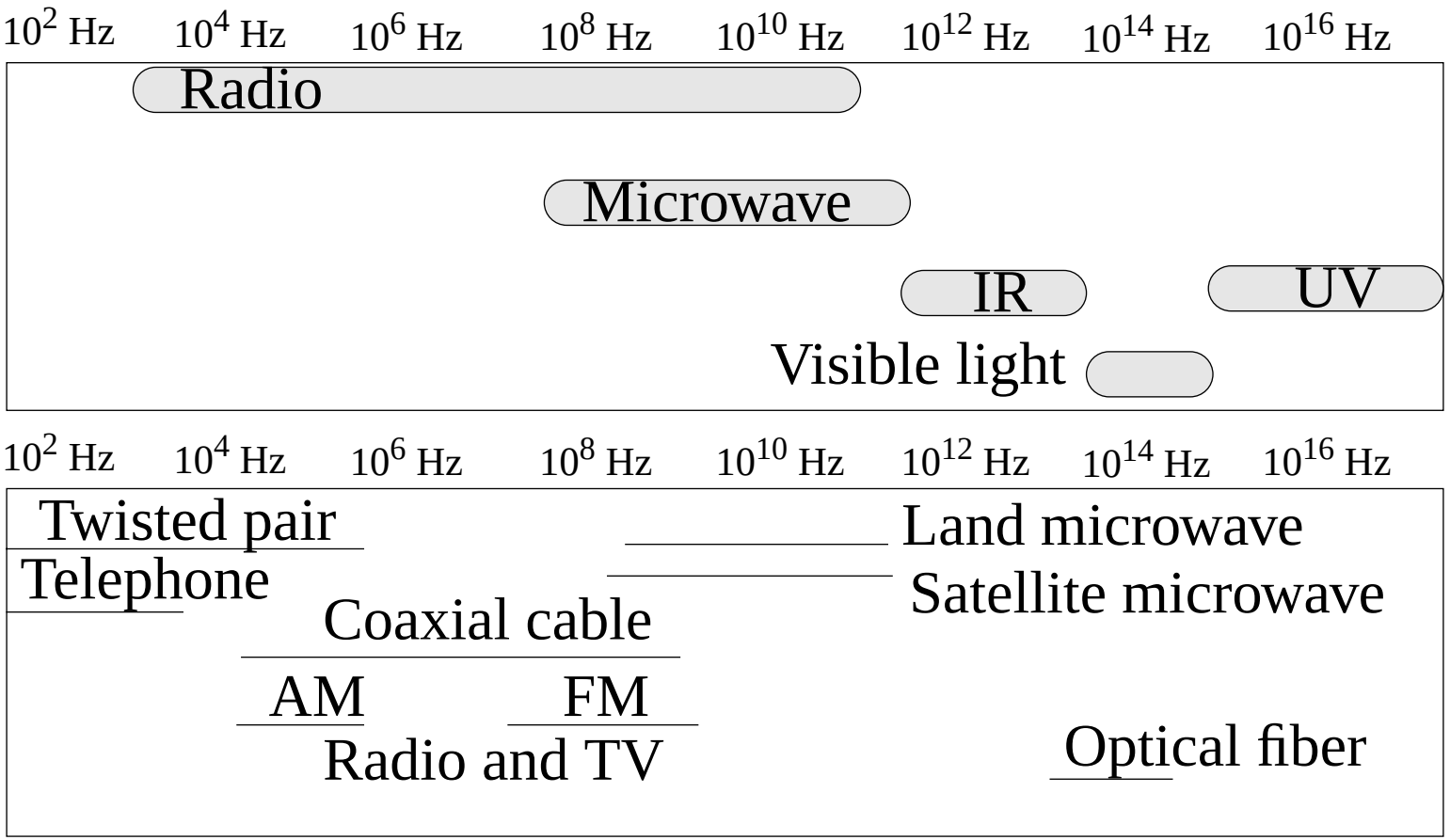


A new infrastructure- How do we implement it and pay for it?



Free space (air, vacuum, …) vs. Guided (wires, cable, fiber, ...)

Electromagnetic spectrum:



Note the scale is **logarithmic** ⇒ there is more bandwidth available in fiber than all of the 100 Hz through microwave range!

Intranet Telephone System

On January 19, 1998, ***Symbol Technologies*** and Cisco Systems announced that they had combined the Symbol Technologies' ***NetVision***™ wireless LAN handset and Cisco 3600 to provide a complete wireless local area network telephone system based on Voice-Over-IP technology.

The handset use Symbol Spectrum24™ wireless LAN (IEEE 802.11) infrastructure and a voice gateway via Cisco 3600 voice/ fax modules.

The system conforms to H.323 (from Intel Corporation's DataBeam Corp. - their H.323 toolkit licensing and development agent.

Seamless roaming via Symbol's pre-emptive roaming algorithm with load balancing.

Claim: each cell can accommodate ~25 simultaneous, full-duplex phone calls.

Wireless LANs

"The wireless workplace will soon be upon us[1]

> Telia has strengthened its position within the area of radio-based data solutions through the acquisition of Global Cast Internetworking. The company will primarily enhance Telia Mobile's offering in wireless LANs and develop solutions that will lead to the introduction of the wireless office. A number of different alternatives to fixed data connections are currently under development and, *later wireless IP telephony will also be introduced.*
>
> …
>
> The acquisition means that Telia Mobile has secured the resources it needs to maintain its continued expansion and product development within the field of radio-based LAN solutions. *Radio LANs are particularly suitable for use by small and medium-sized companies as well as by operators of public buildings such as airports and railway stations.*
>
> Today's radio-LAN technology is based on *inexpensive products that do not require frequency certification*. They are *easy to install* and are often used to replace cabled data networks in, for example, large buildings.
>
> …"
>
> [*emphasis* added by Maguire]

1. Telia press annoucement: 1999-01-25

Low Earth Orbit (LEO) Satellites

When you are away from dense infrastructures there are few people and little interference, hence you might as well use LEO!

$\therefore$ UMTS is too little and too late!

- Wireless LAN already beats it in the local area
- LEO will soon beat it in the wider areas which are less populated

$\Rightarrow$ UMTS has no future

(it is just one more bad telecom idea, like ATM and fixed circuit-switched telephony)

$\Rightarrow$ National governments will be largely irrelevant

- wireless LANs use unlicensed spectrum
- LEO licenses are assigned

1999

- Internet Telephony (since multimedia PCs - built-in support for stereo audio)
- Internet Videoconferencing (digital color cameras attached to multimedia PC)
- mobile internet multimedia computers
  - ♦ especially in local area settings - using wireless LANs, DECT, …
  - ♦ perhaps in urban and campus settings - this could challenge cellular telephone systems
- new scanner technology adding more image data
- more audio data - MP3, …
- cable modems
- ADSL (VDSL, …) ==> new use of telephone access net to build new fixed and mobile infrastructure
- using your cellular phone as a cordless phone in your building or campus
- using power distribution lines for Mb/s access: NorWeb Direct Power Link technology + others
- using data networks as backbone - even for your cellular network (GSM on the Net)
  - ♦ doing VOIP in terminals means no coding/decoding in the BTS - which saves 64% of the processing
- Lucent's R/Evolutionary Networking - to deliver via packet networks all features and services available on public networks (including 3-way calling, caller ID, call waiting, and 911 access)
  - ♦ using PathStar enables replacement of Class 5 switches

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, Sega, Swatch, …

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

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

Near Future systems

Personal Portal

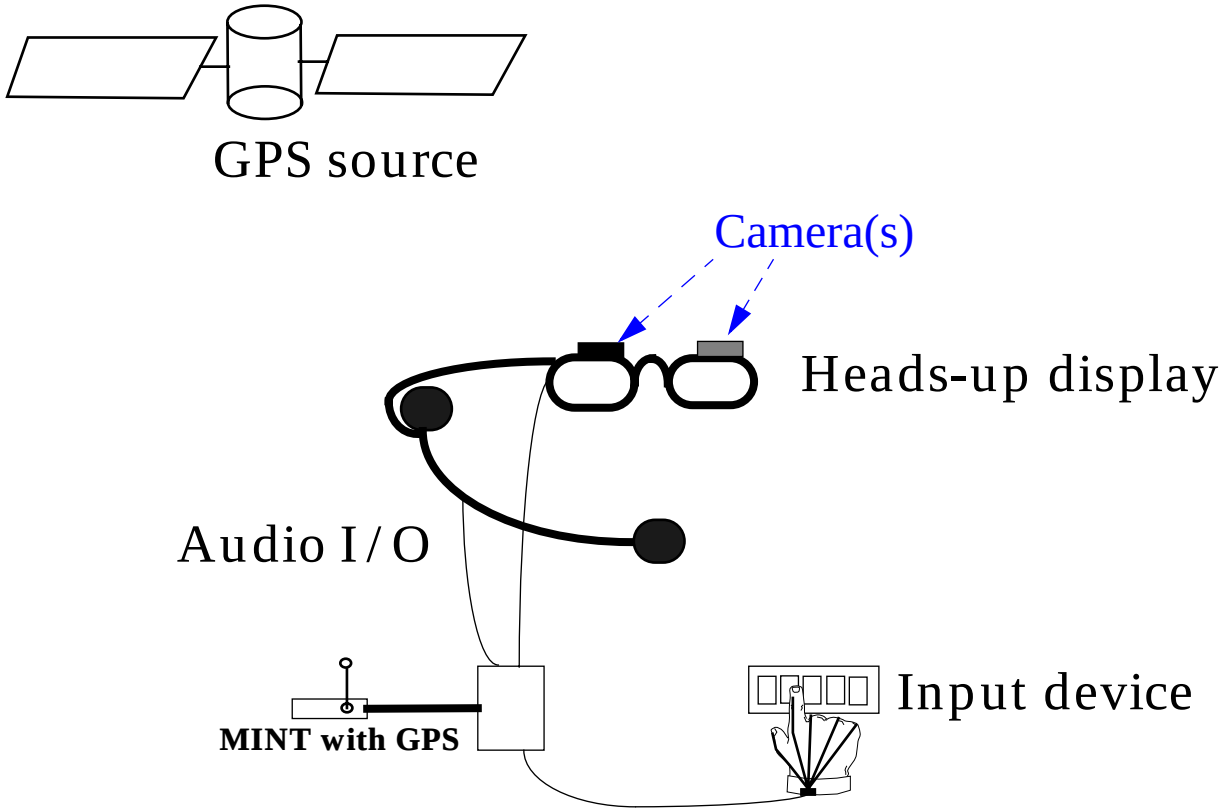


Figure 2: Vision-2, 2000 - high level of integration

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 ⇒ No longer will you have to plug your printer into your computer (PDA/…) into your computer
- active badges⇒ 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

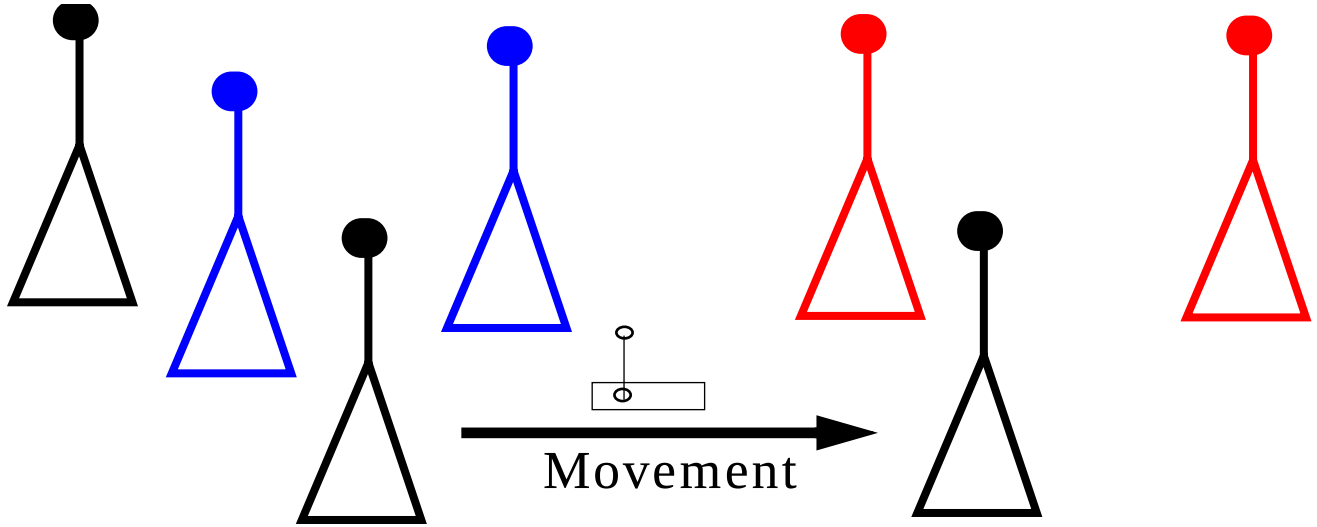


Figure 3: Where am I? What am I? Who am I?
Where am I going? When will I be there? What should I become? Who should I become?

- 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 ⇒ 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

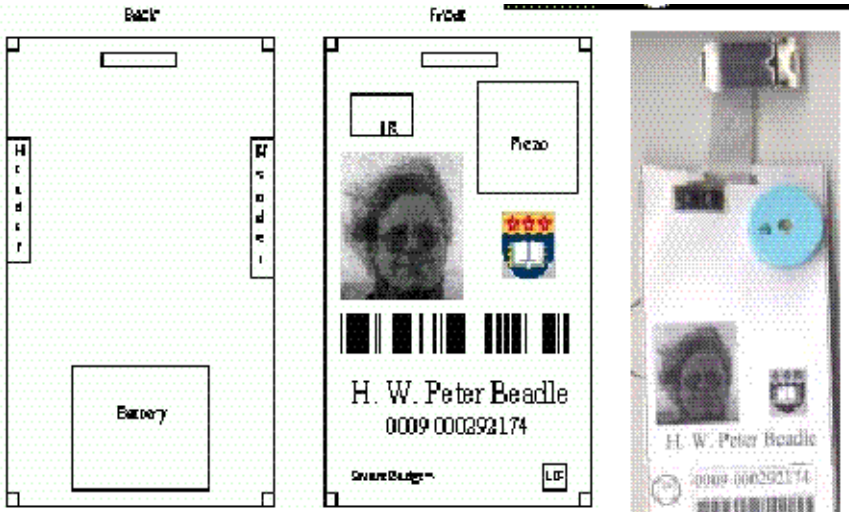
- Dumb Badge just emits its ID periodically
- Smart Badge - [an IP device] Location and Context Aware (i.e., a sensor platform)
- Intelligent Badge - add local processing for local interaction by the user

Acknowledgment:

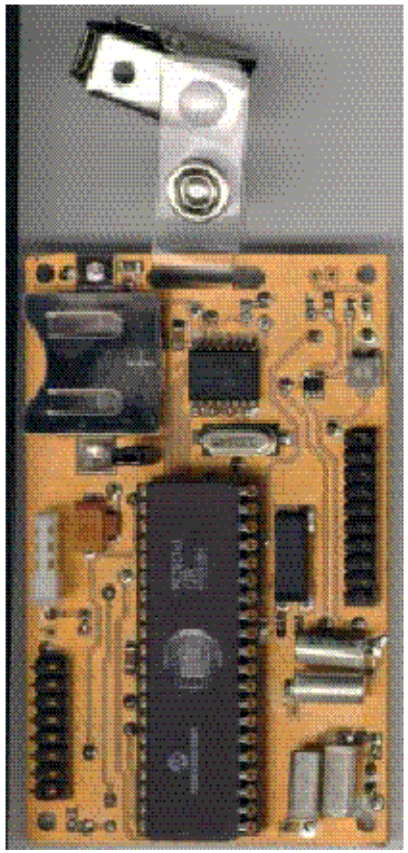
All of the badge work is done in cooperation with:

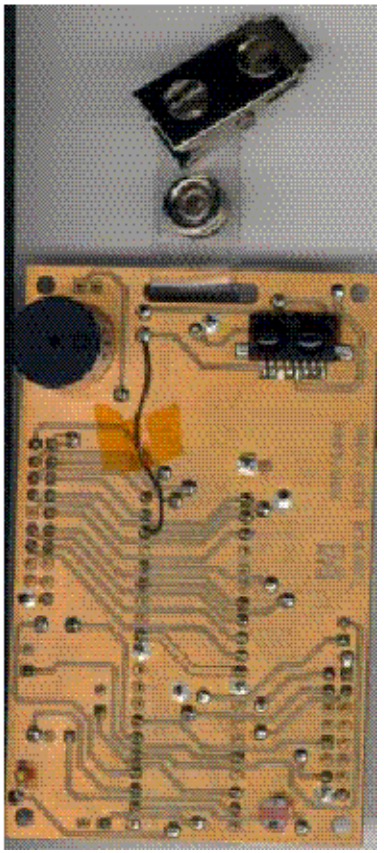
- Dr. Mark T. Smith - Hewlett-Packard Research Laboratories, Palo Alto, California, USA
- Dr. H. W. Peter Beadle
  - ♦ Formerly: University of Wollongong, Wollongong, Australia
  - ♦ Currently: Assistant Director, Motorola Australian Research Centre, Botany, NSW, Australia

Badge Prototype and Badge 1

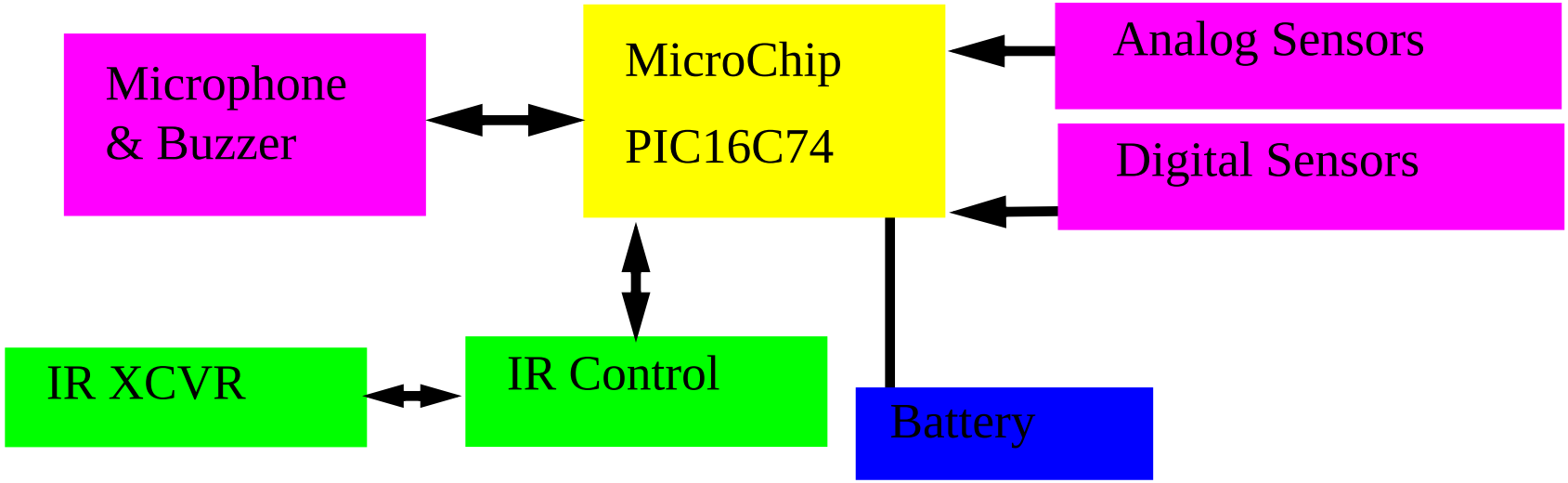


- Sound, Light, Temperature, Humidity, Orientation, Adjacency
- Beeps
- PIC 16C74A-jw based
- 5 MIPS
- 4m range
- 98mA average power





Smart Badge 1



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

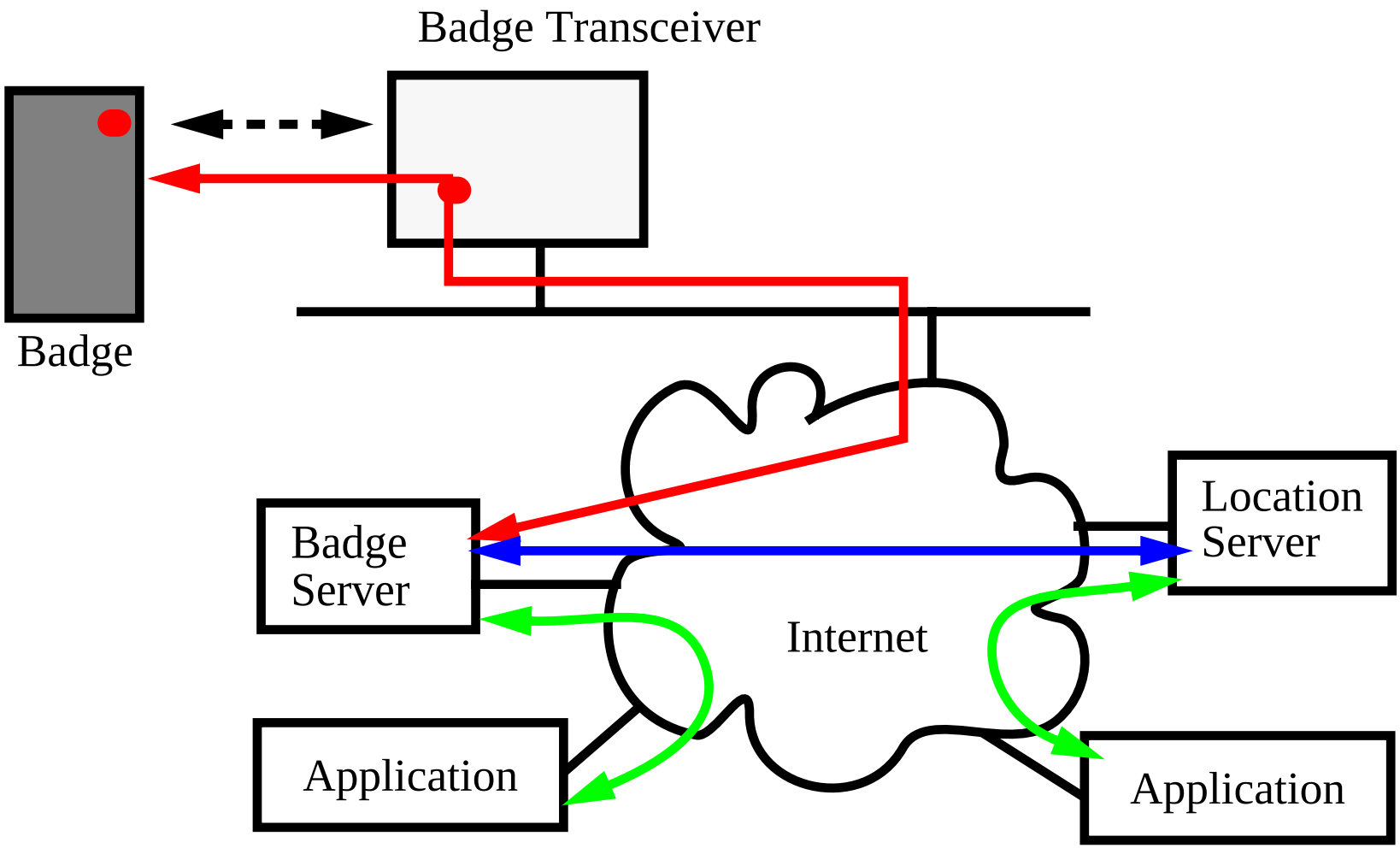
85x55mm $\Rightarrow$ 46.75 mm^2 - component cost ~US$30

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, …

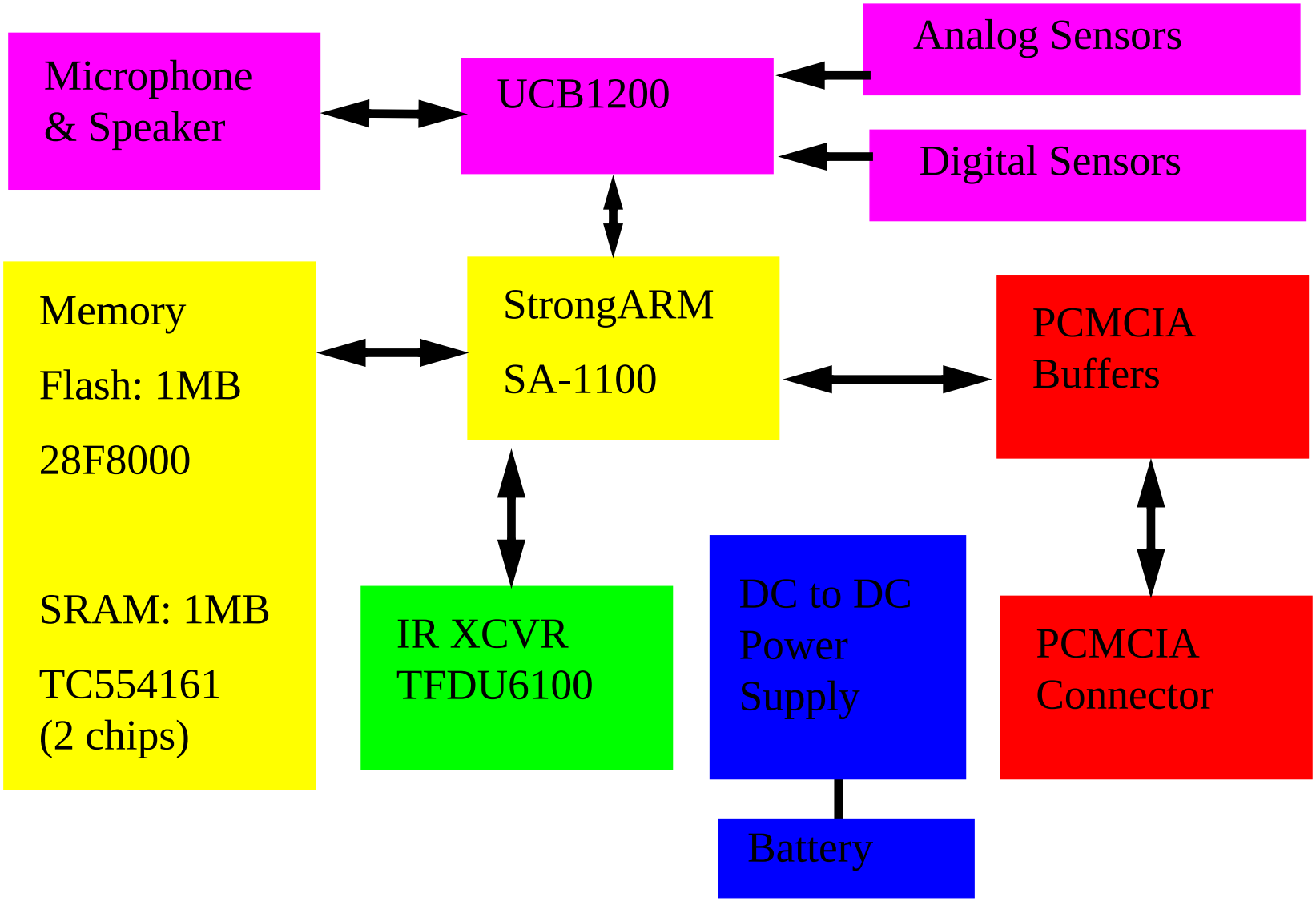
Badge Communications Model

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

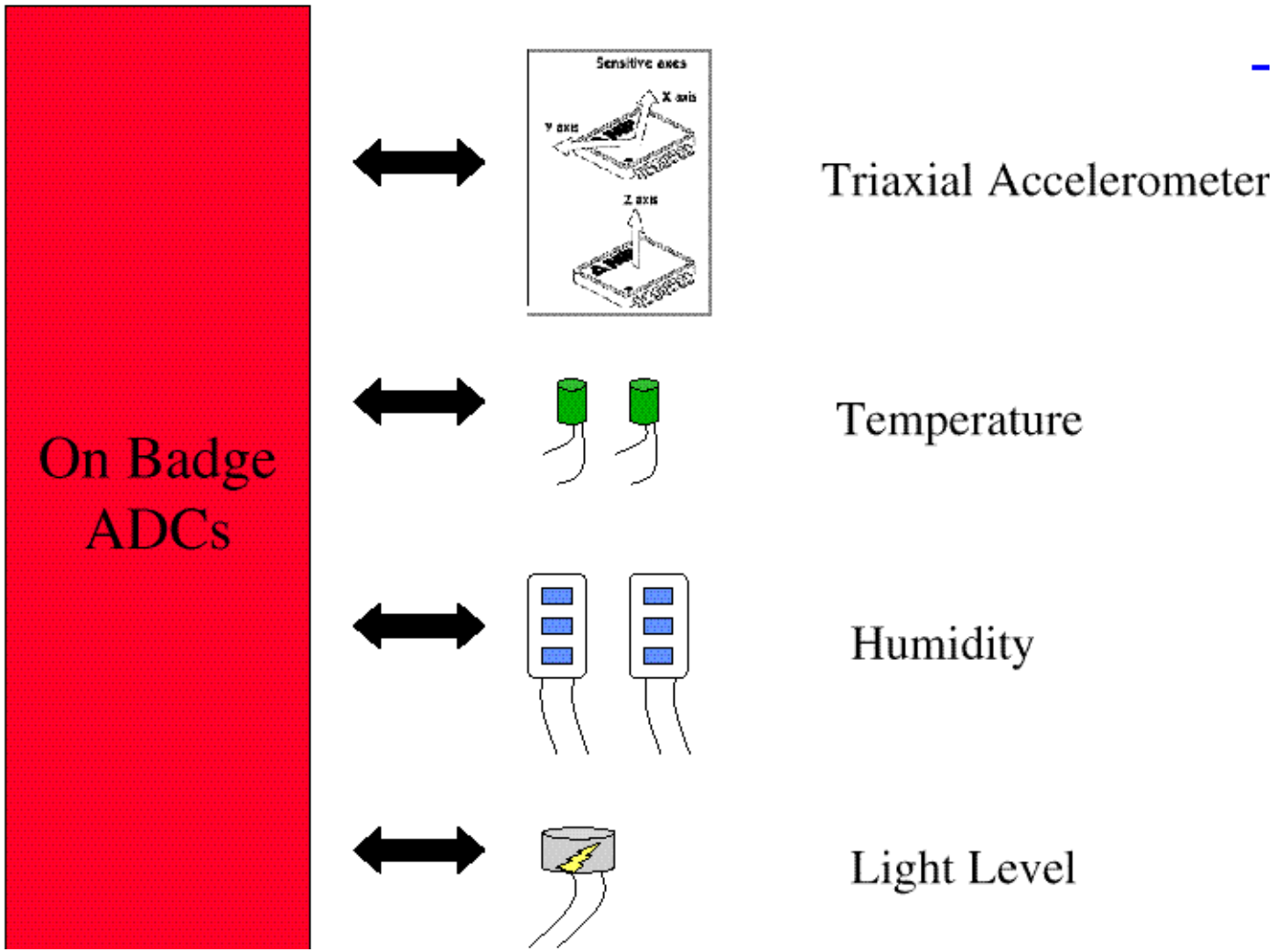


⇒ Banks as intermediaries (**if** they have **any** future role)

Smart Badge 3

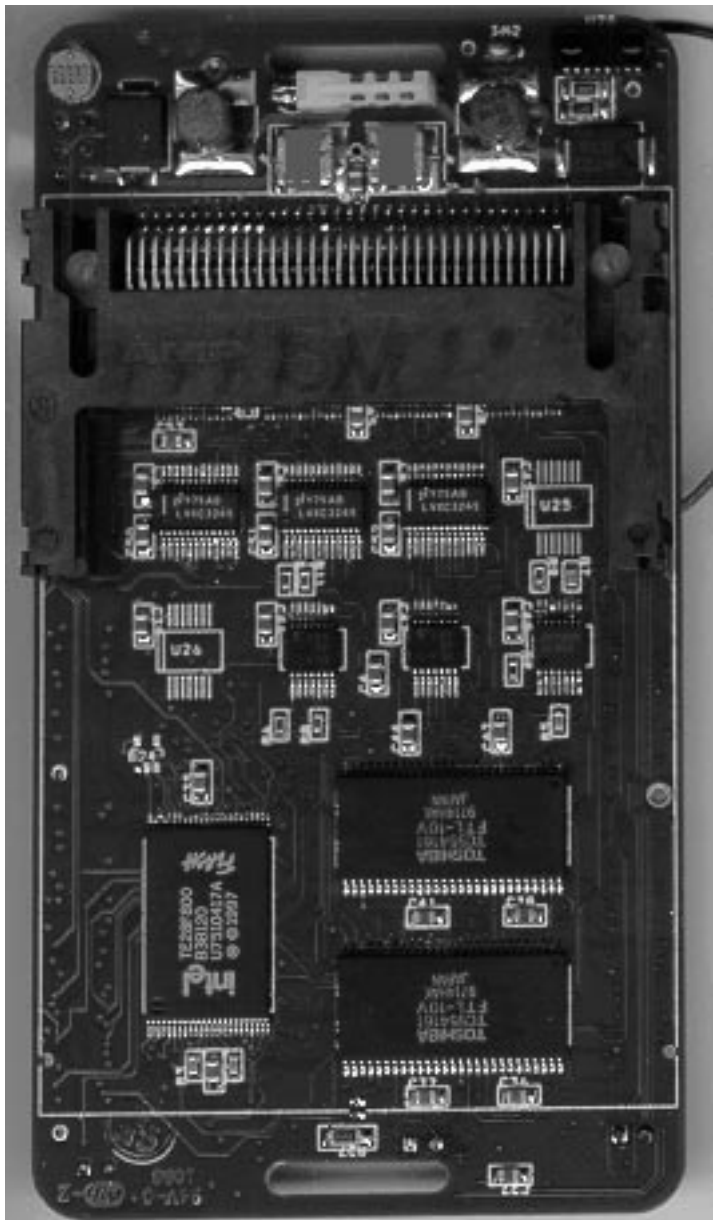


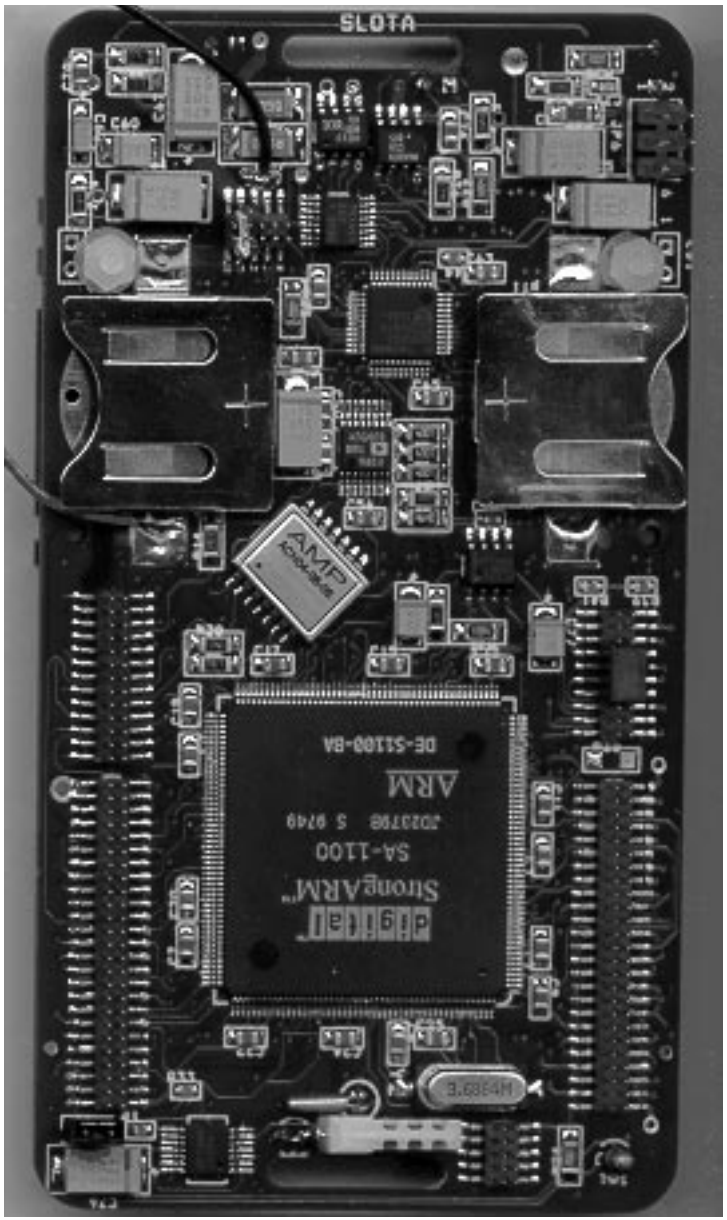
Smart Badge Sensors



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

Badge 3





A view of the packaged badge

As shown by HP at Comdex’98, November 16-20, 1998

IBM Visionpad

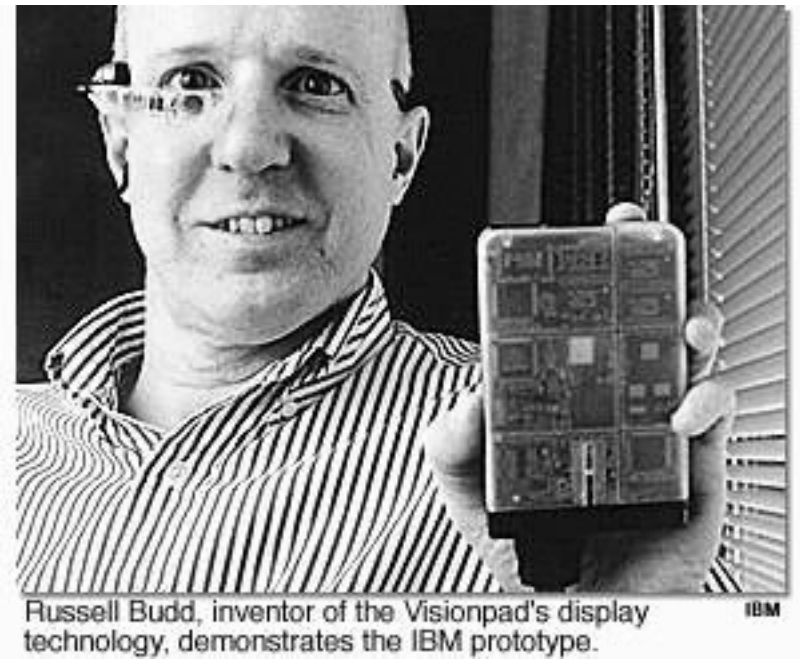


Figure 4: from http://www.zdnet.com/zdnn/stories/news/0,4586,2169690,00.html

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 (Angel) debugger
  - ♦ 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)

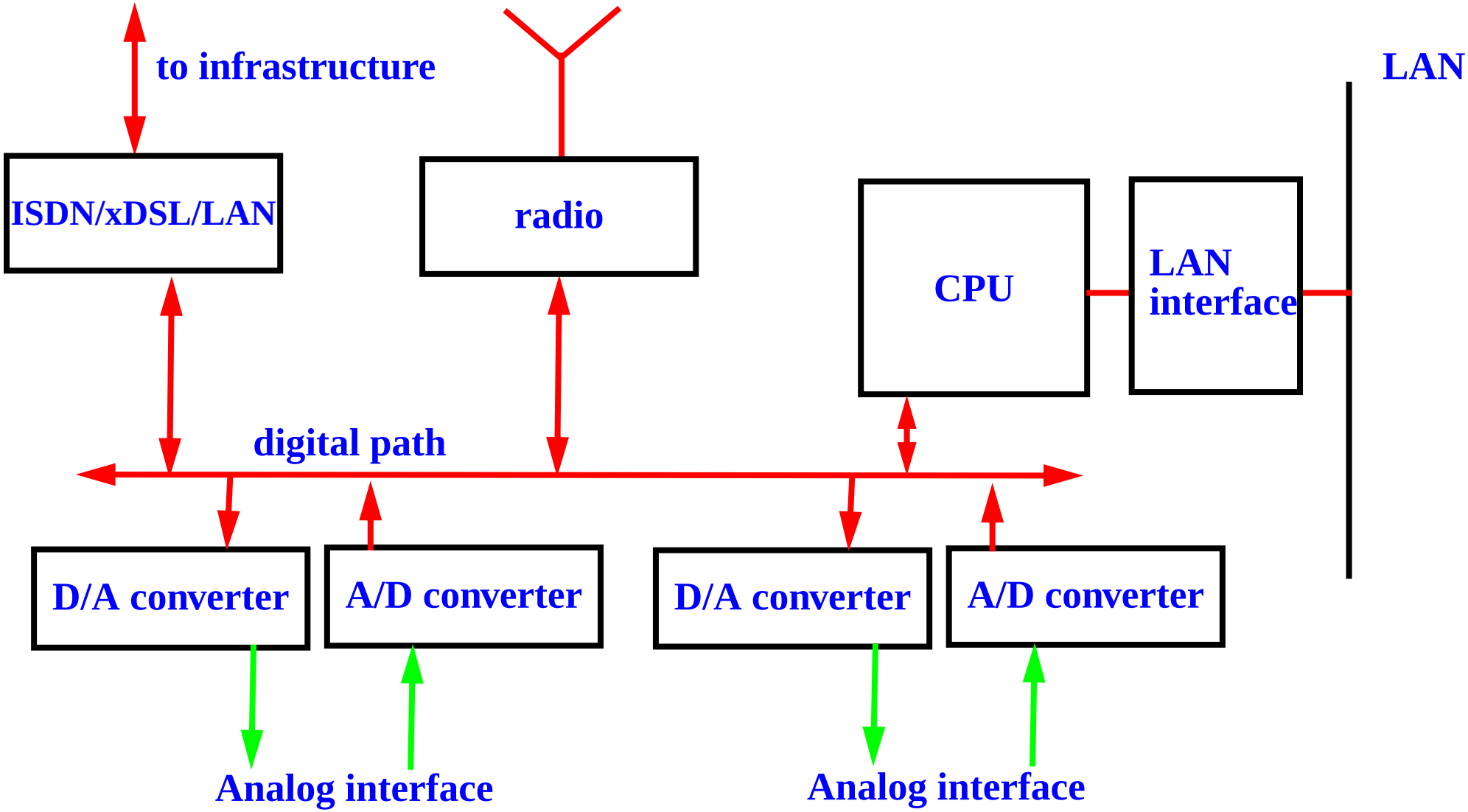
Future

- Inferno (¿Does it has a future?)
  - ✘ 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/)

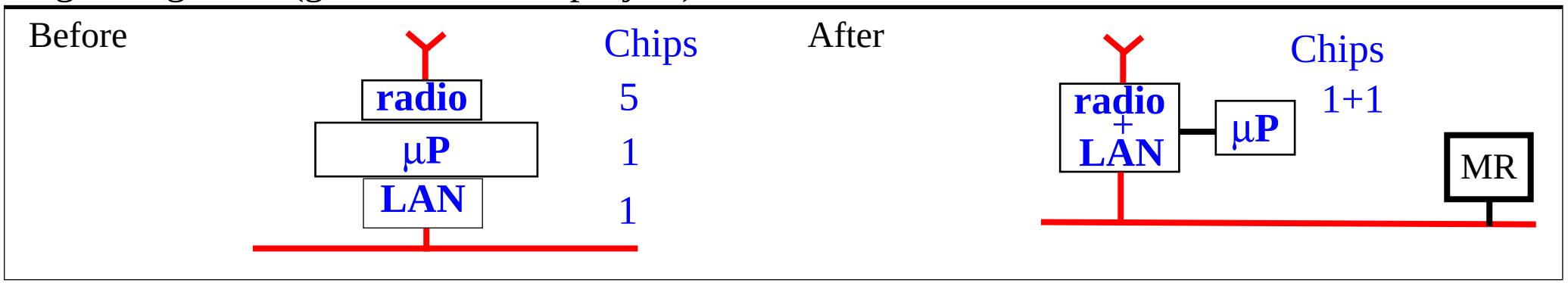
Local access point



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

MEDIA

High integration (goal of MEDIA project)

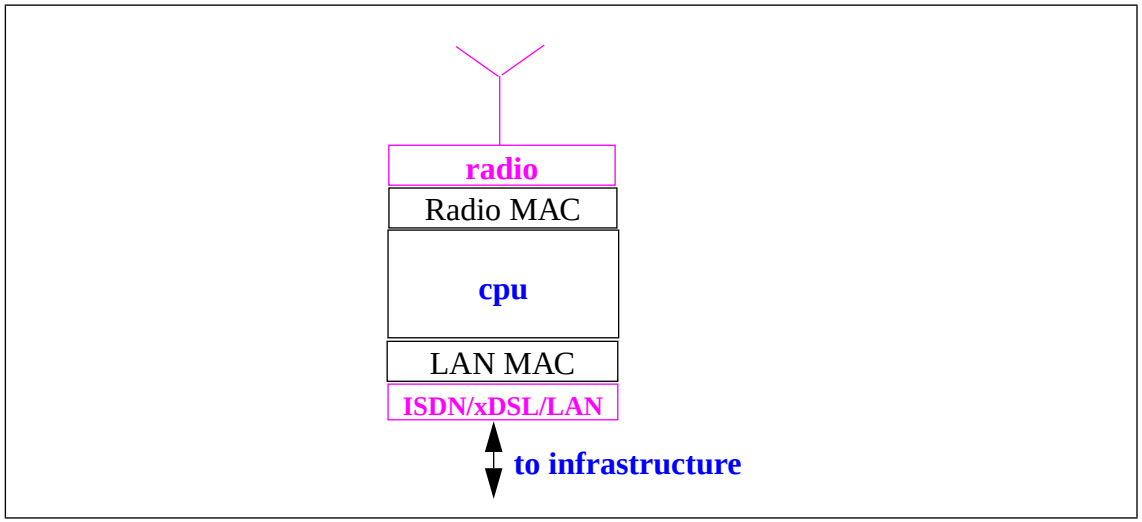


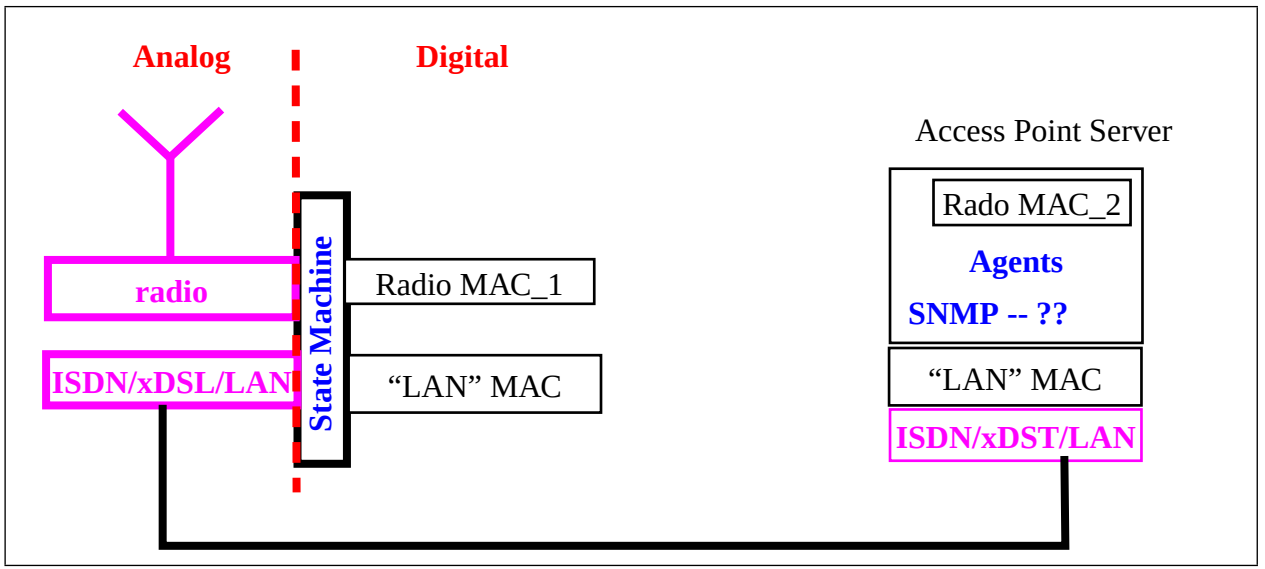
Partners:

- 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





Classic Applications

Voice calls over a full or half-rate channel

OR

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

Semi-Classic applications

dialup PPP: Voice coded as packets, telnet, 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 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

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

⇒ more and more source material

⇒ 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?

CapShare 910

Press photo from HP's web page: (see http://www.capshare.hp.com/press/images/zorro1.jpg)

More than just a communication link

HLR & VLR: information about where the terminal is! via 1 BS

Mobile positioning systems: provide even higher accuracy location information via multiple BSs

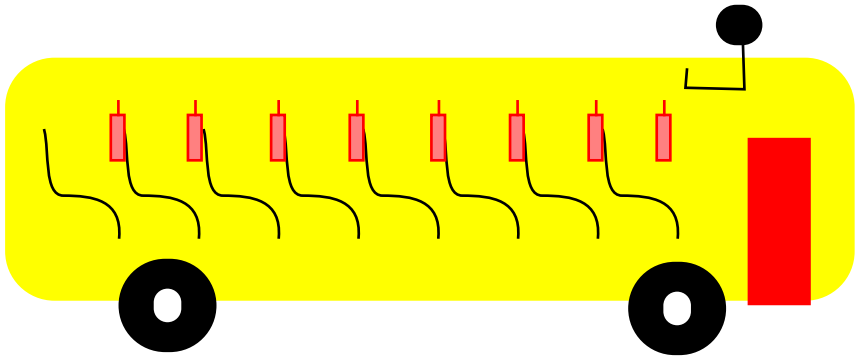
$\Rightarrow$ location dependent systems

- 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 link to wide area network



With location dependent information and services:

- information from bus to bus operator
- package transport - sensors on packages to monitor condition & location

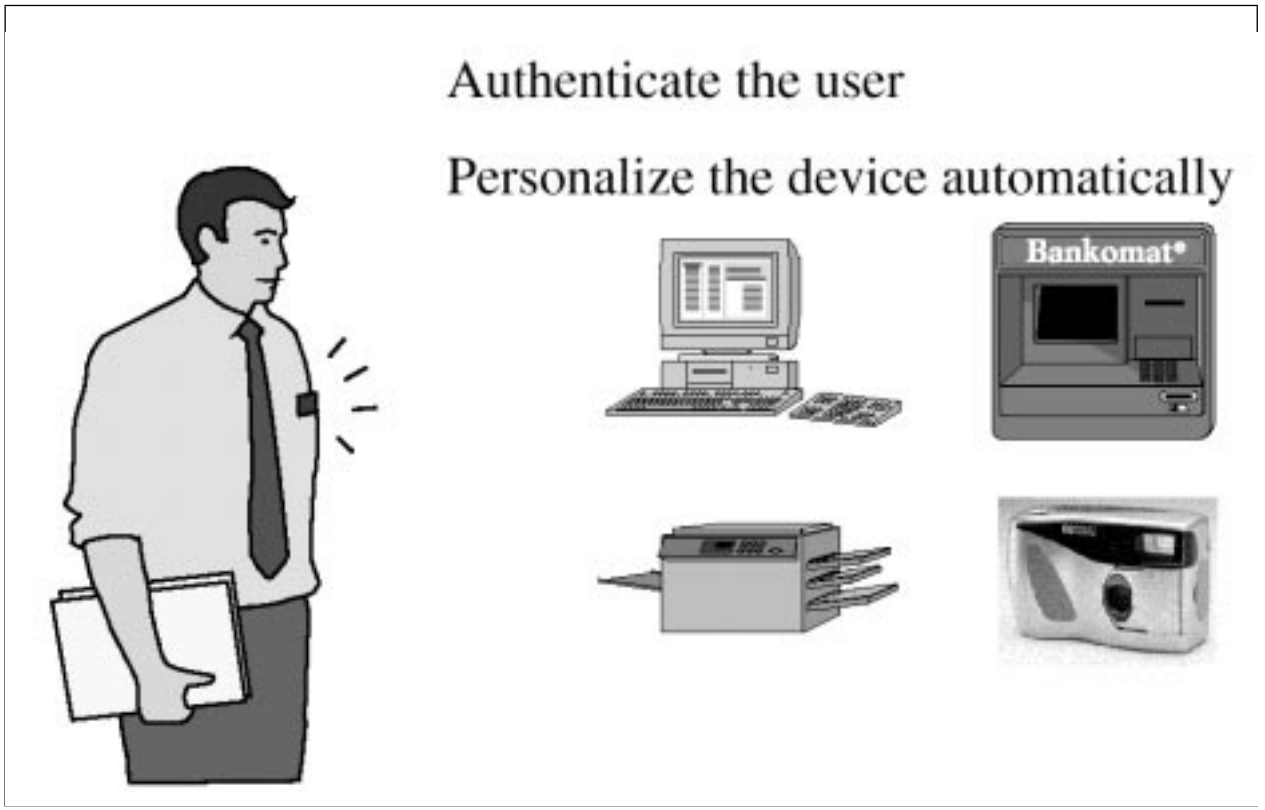
Security guards

- 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
- …

Personal information space

Where are my { friends, employees, pets, socks }

What is the state of my { . . . } ?

Personal Entertainment/Info/...

Personalized data: text, picture, audio, ads, …, play lists

burst download in hostspots (WLAN)

faster than “real-time” (DAB/DSS/… + GPRS)

download in the background (GPRS)

Faster

Slower

Emotional

Toys + communications

Telecom products for children (of all ages!)

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

Other sensor based proposals

See “The broad sweep of Integrated Microsystems” by S. Tom Picraux and Paul J. McWhorter, IEEE Spectrum, December 1998, pp. 24-33.

They point out that combining micronavigators (with 6-degree of freedom accelerometers) with other sensors opens up lots of possibilities such as:

- with a “chemlab” {a chip with an array of chemical sensors, polychromator, …) for chemical analysis on a chip $\Rightarrow$ environmental or personnel monitoring
- interactive toys
- golf clubs than can diagnose a player’s swing
- running shoes which track distance, pace, and stress
- …

They point out that there will be so many such mobile systems that we will willhave to understand and control their “swarm” behavior, i.e., that simple rules of interaction can lead to very complex behaviors.

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 Universal Product code (UPC)[1] subspace mapping to product web pages with safety, ingredients, recipes, etc.

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

http://051000029522.upc.org

or perhaps:

http://029522.051000.upc.org

in item.manufacturer form
more suitable for DNS use

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

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

Disappearing objects[1]

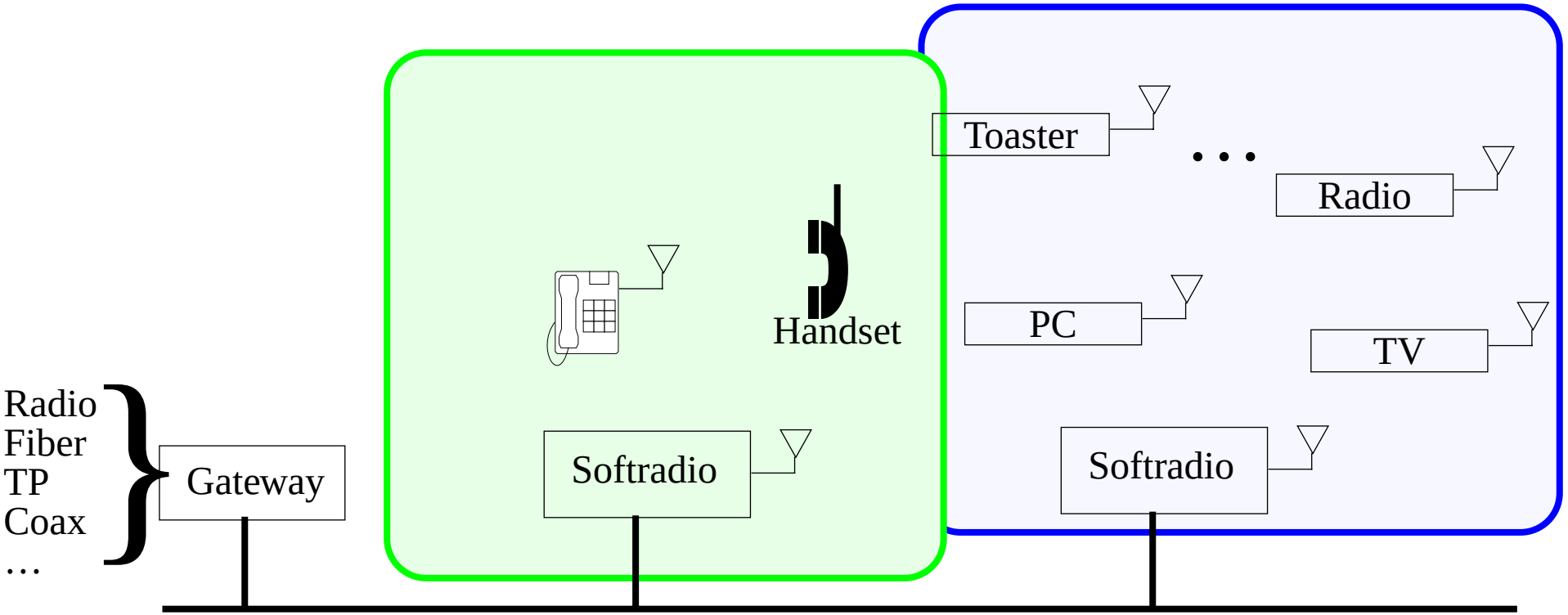
list of products which will disappear (in the sense of having a separate identity)

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.

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

Future home/office/… network accesspoints



Personal Computing and Communication (PCC)

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

$\Rightarrow$ ~1 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]

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

Uploading ourselves to the net

In Bob Metcalf's speech at MIT: http://web.mit.edu/alum/president/speech.html

One of great insights of this talk is that the internet is the way to immortality[1]:

> Now, for the next 50 years, the web will drive electronic commerce into the information age, ubiquitous computers will disappear into the woodwork, and we'll start uploading ourselves into the Internet to become at last immortal.
>
> -- Robert M. Metcalfe
> June 26, 1997

1. Robert M. Metcalfe, "Internet Futures", MIT Enterprise Forum, June 26, 1997.

Future Systems

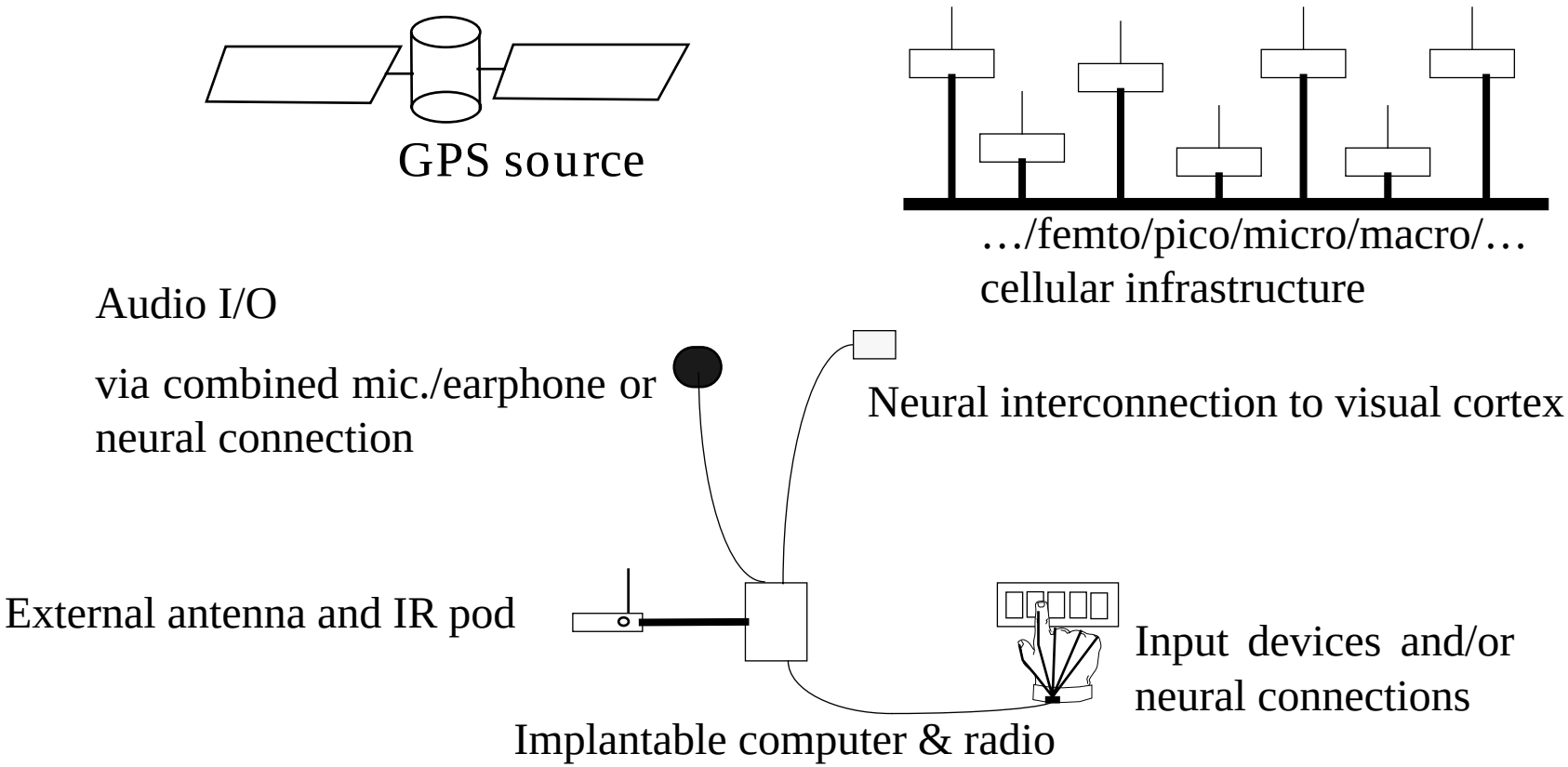


Figure 5: Vision-3, 2005-2015 - very high level of integration

Bionic Technologies, Inc.’s Intracortical Electrode Array

Acute microelectrode assembly (10x10 array, 100 active electrodes) $1,250.00

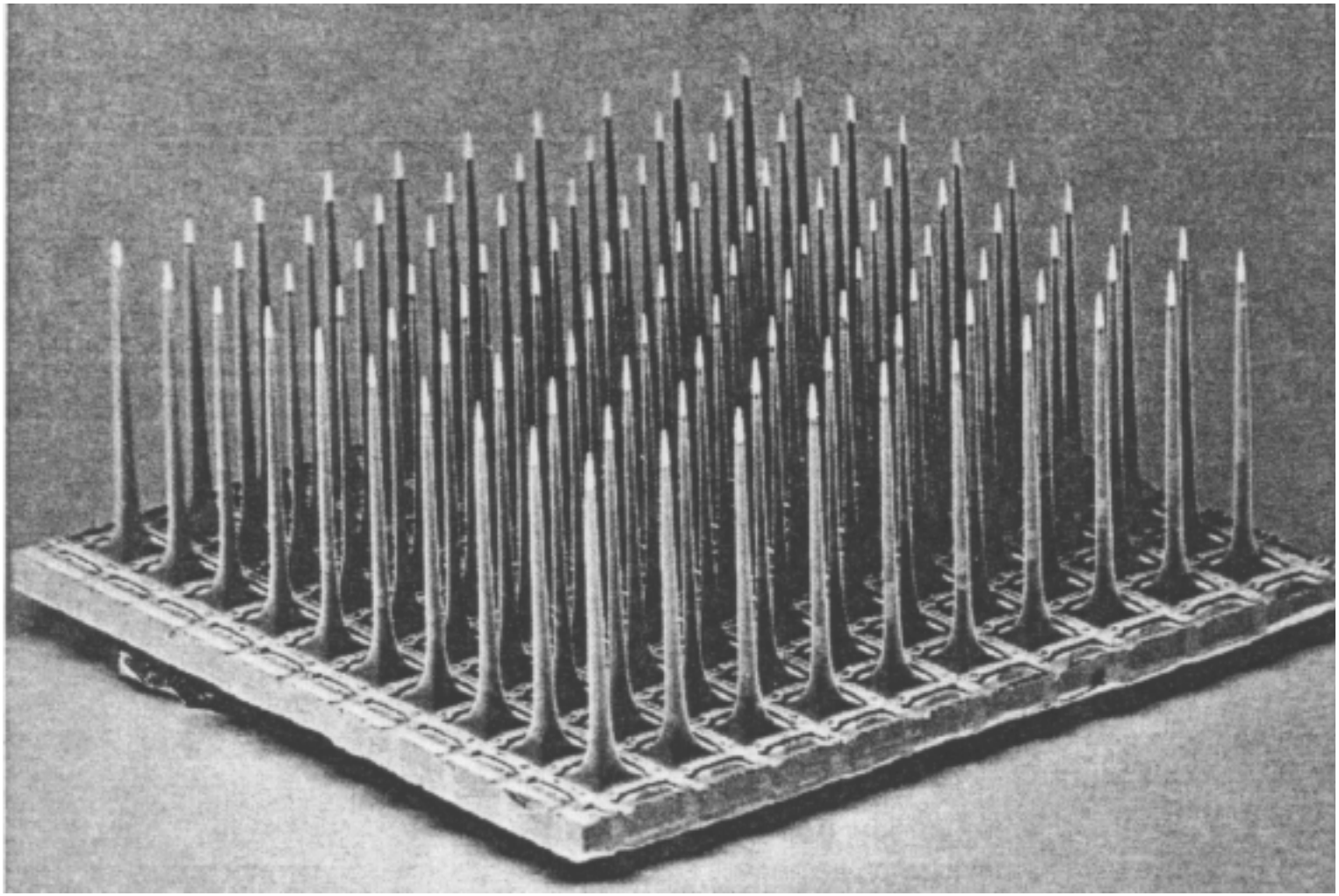


Figure 6: 10 x 10 silicon electrode array (each electrode: 1.5mm long, 0.08mm wide at base, 0.001mm tip), Built at the Univ. of Utah, by Richard A. Normann, et al.; from Scientific American, March 1994, pg. 108.

Non-metalic bi-directional neural interfaces

Neurochip: Neuron silicon circuits http://mnphys.biochem.mpg.de/ :

(a) Silicon-Neuron Junction (input to the nerve) (b) Neuron transistor (output from the nerve)

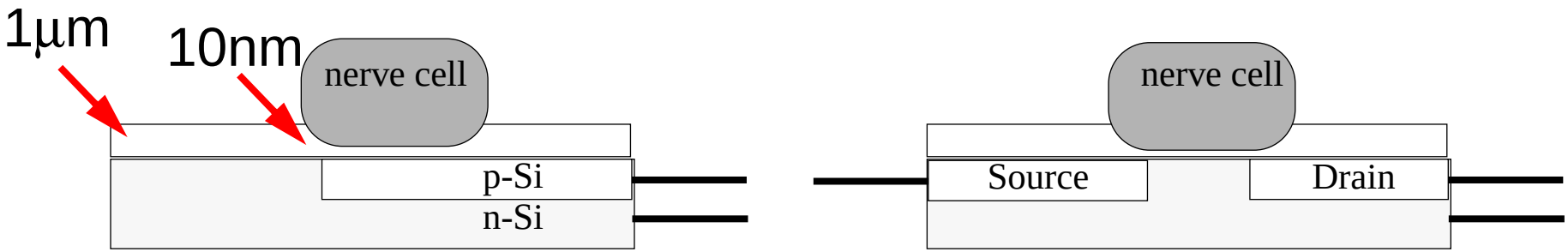


Figure 7: (a) Capacitive coupling of data into nerve and
(b) using the charge in the nerve to control a transistor's gate for getting data out of the nerve

(a) Peter Fromherz and Alfred Stett, "Silicon-Neuron Junction: Capacitive Stimulation of an Individual Neuron on a Silicon Chip" Phys.Rev.Lett. 75 (1995) 1670-1673

(b) P.Fromherz, A.Offenhäusser, T.Vetter, J.Weis, "A Neuron-Silicon Junction: A Retzius-Cell of the Leech on an Insulated-Gate Field-Effect Transistor" Science 252 (1991) 1290-1293.

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.