Personal Computing & Communication:

The Virtual Convergence of Telecom and Datacom for New Services

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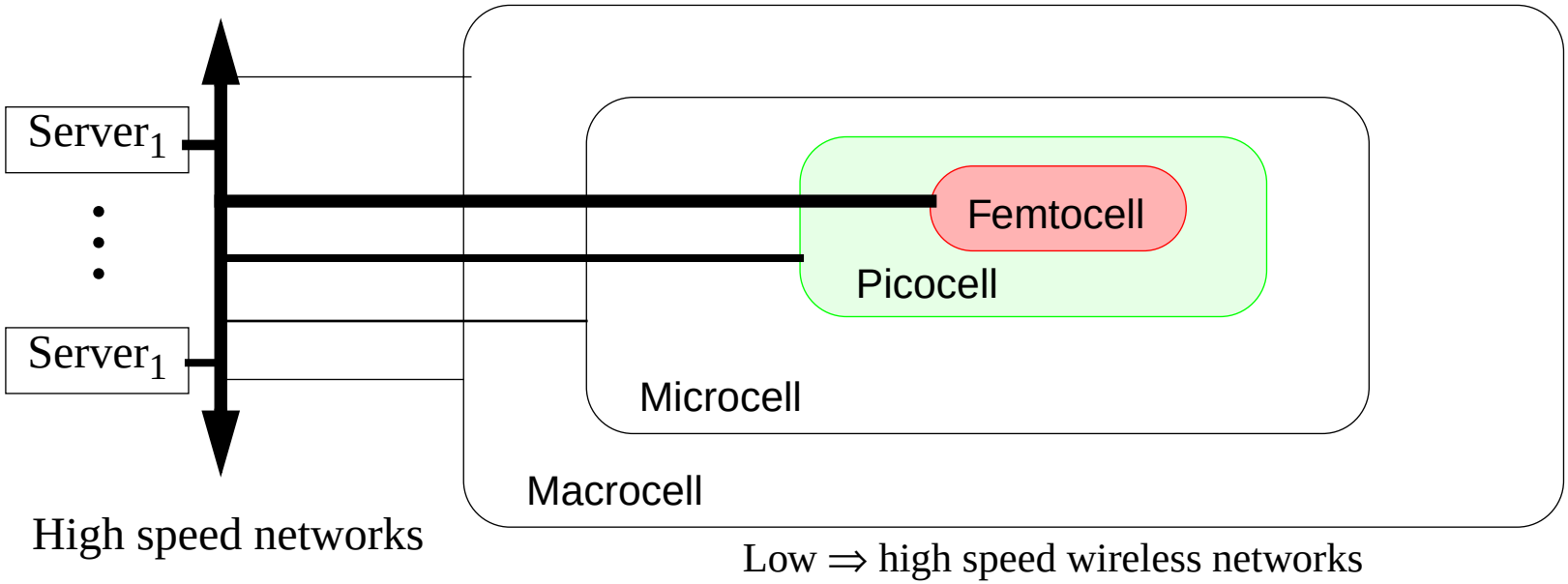
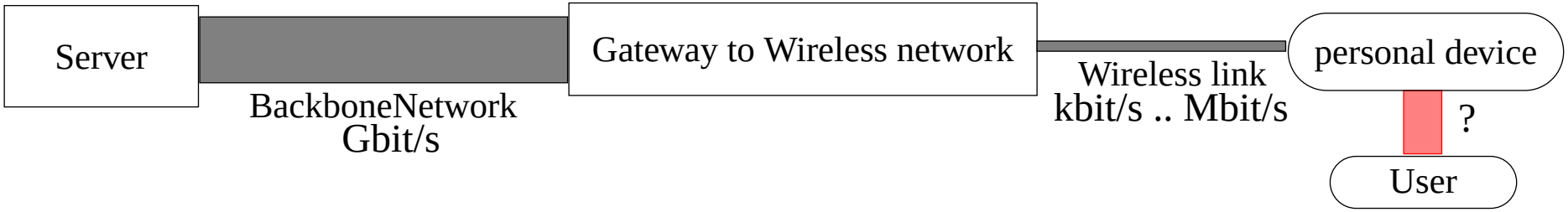
Bottlenecks

- Server and Network Bandwidth and latency



- User Bandwidth and latency



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

Infinite Bandwidth - wired and wireless!

Guilder's Law: network speeds will triple every year for the next 25 years - dwarfs Moore's law

Dense Wavelength Division Multiplexing is starting to be introduced

- Nortel Networks' OPTera* 1600G technology that transmits 10 Gbps over 160 channels = 1.6 Tbps
- Qwest running OC-192c (10 Gbps) per wavelength from NY to California, 128 lambdas
- Enkido providing OC768 (40Gbps) service to Deutsche Telecom in Manhattan in one lambda!

(Martin) Cooper's Law:

> "... the number of "conversations" (voice or data) that can theoretically be conducted over a given area in all of the useful radio spectrum has doubled every two-and-a-half years for the past 104 years. The rate of improvement in use of the radio spectrum for personal communications has been essentially uniform for 104 years. There have been a few bumps along the road but that was true for Moore's law as well." -- from Martin Cooper, "The Wireless Future: The Revolution has Begun", Napa Valley Telecommunications Round Table, CATO Institute, July 17, 1999

Deregulation ⇒ …

- Deregulation ⇒ New regulations
- Deregulation ⇒ New operators
- Deregulation ⇒ New Suppliers
  - ♦ Billing, bandwidth, operations and maintenance, … -- all become available as services
  - ♦ Just as we have FABless VLSI companies (VLSI Technology, …), stockless distributors (Amazon.com, …) ⇒ networkless data/telecom operators!
- replacing multiplexors with Routers/Switches/… << 1/10 circuit swi. cost
- Standard telco interfaces being replaced by datacom interfaces
- New Alliances - coopetition ⇒ emergence of Collaborative Planning, Forecasting, and Replenishment (CPFR)
- IP based Unified Communications - building on VOIP
  - ♦ Voice-mail delivery via MIME and SMTP to mail servers, then via LDAP, IMAP, and MIME to user
  - ♦ conversion to/from audio and text formats, filtering, alerting, etc.
  - ♦ Replacing both the wireless & wired voice network's infrastructure with IP
  - ♦ Using Mobile IP to deliver packets even to mobile users

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
- 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)

Situational awareness and Adaptability

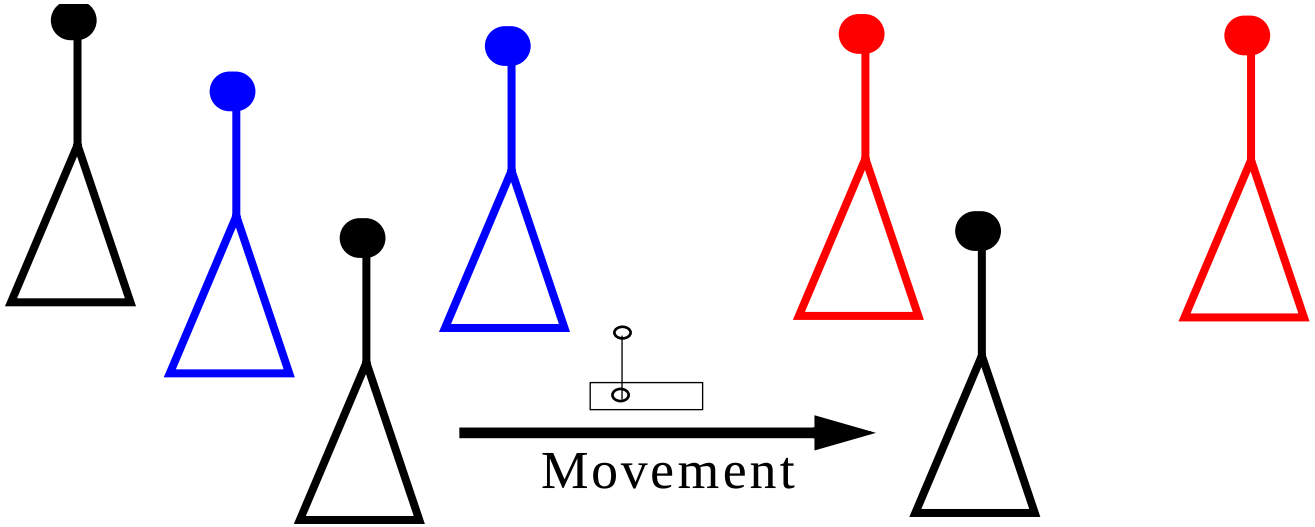


Figure 1: Where am I? What am I? Who am I?
Where am I going? When will I be there? What should I become? Who should I become?

- 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

Multiple vs. Reconfigurable Radios

Multiple types of basestations due to multiple types of networks:

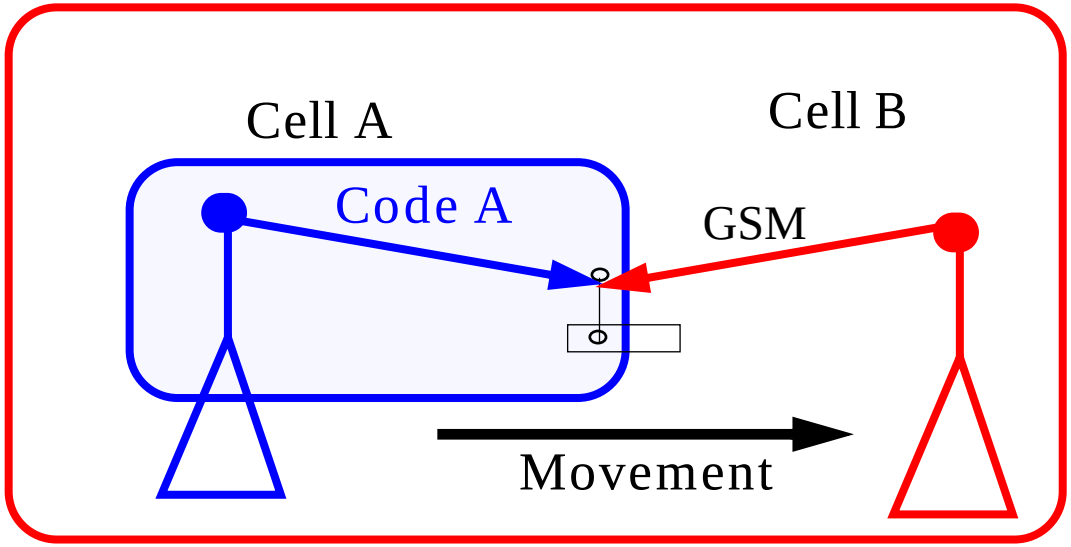


Figure 2: Two different types of networks

- Software Defined Radios
- Emergence of Cognitve Radios -- that decide what kind of radio they *should* be
  - ♦ doctoral dissertation by Joe Mitola III (8th of June 2000)

More and 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)

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

Napster -- distributed digital audio collection and local MP3 play out -- 9 million users in 6 months

Fully distributed servers (Gnutella, …) which build on the ideas of Napster

Speaker recognition and Speech recognition

Speech interfaces are now becoming main stream technology, e.g., Microsoft's Multimodal interactive notepad (MiPad) - using their Talk and Tap technology

If your telephone/PDA/… are always listening to you they know what you sound like (so there is a very good model of your voice and speech)

- you will have a DB of all your "callers" - so that the system can recognize them and treat them as **you** want them to be treated
- you will have a DB of all your calls/meetings/mumblings/… -- this will help augment your memory and will also help the recognition systems to work better and better
- if you want to speak with someone you might first exchange synthesizers -- so you only have to send annotated text ⇒ very low bandwidth, but high quality speech
- you can buy/rent/… a voice which you like {you too can sound like James Earl Jones or Marilyn Monroe}
- coupled with translation technology you will have real-time foreign language translation

Near Future systems (on the user's side)

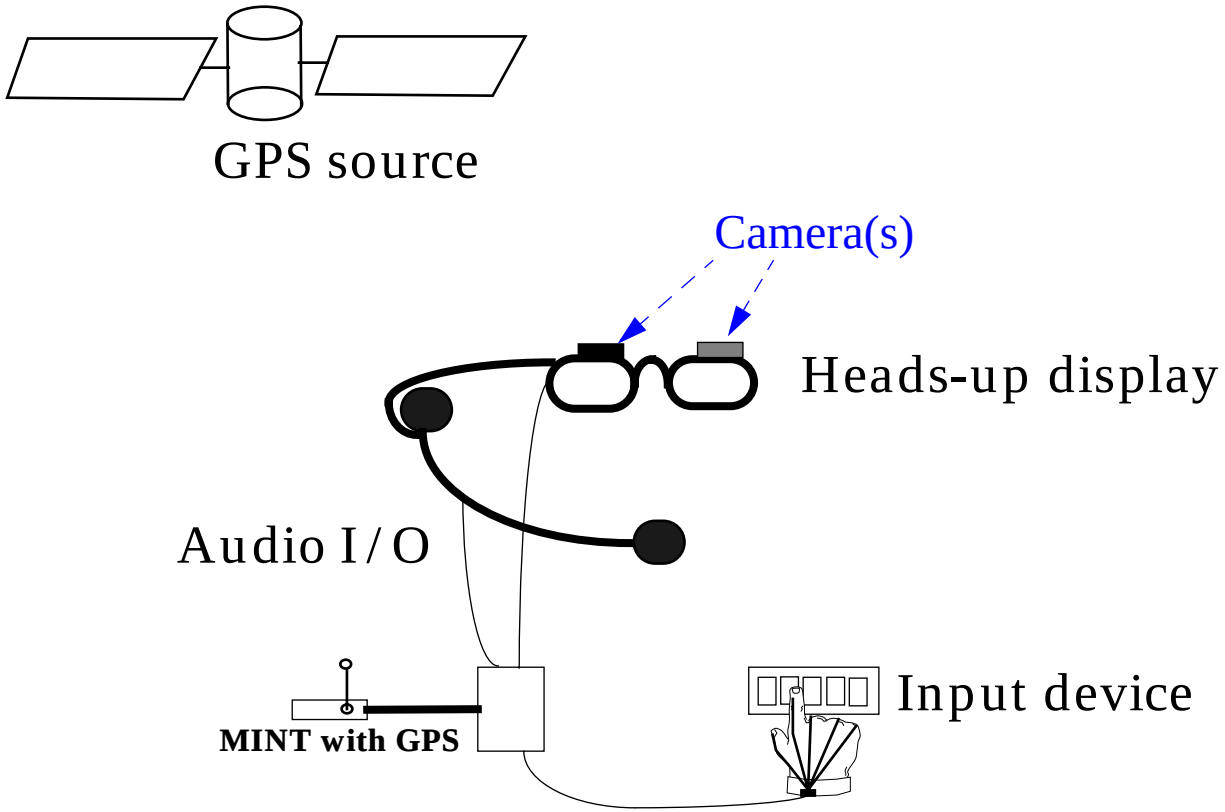
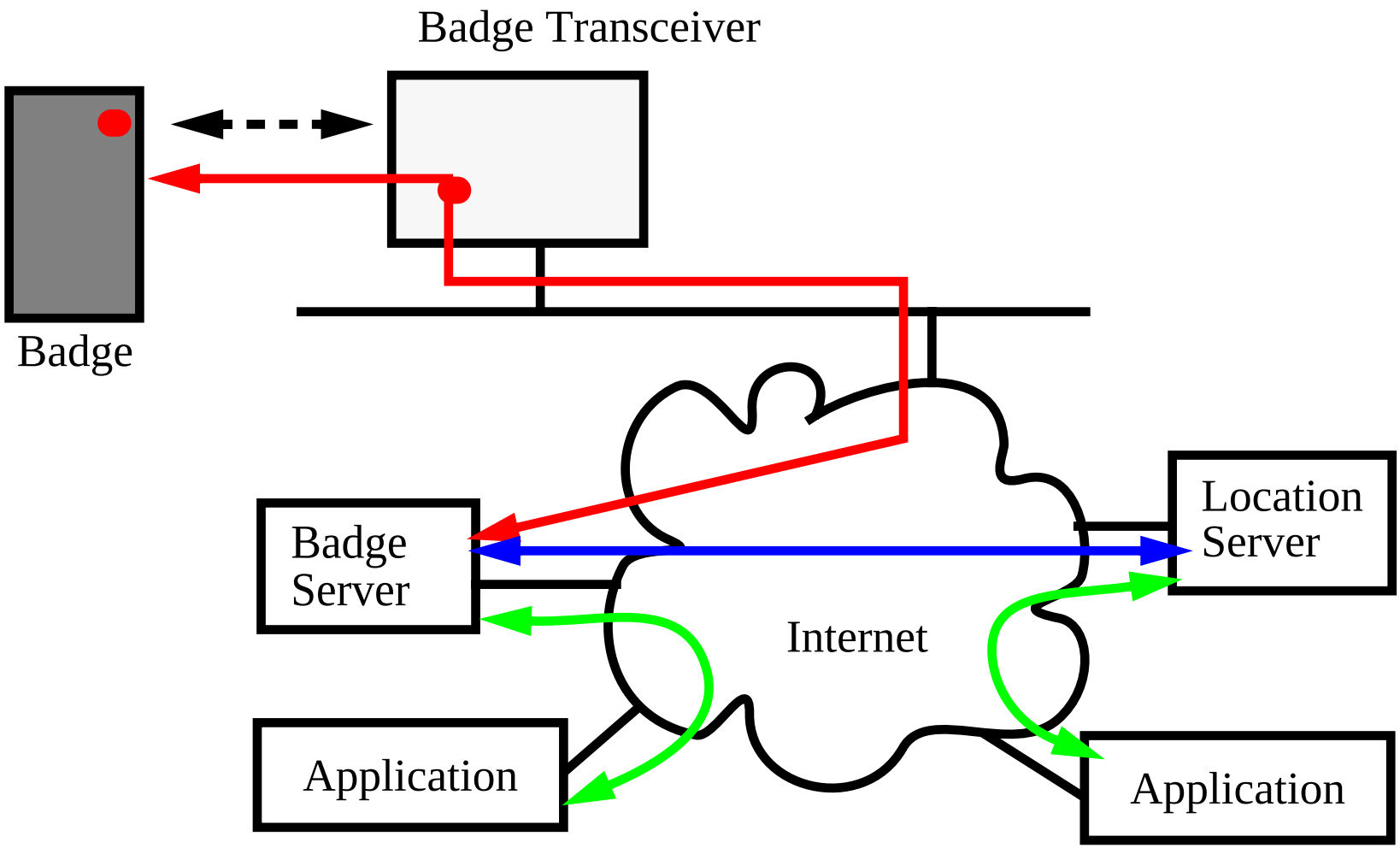


Figure 3: Vision-2, 2000 - high level of integration

Reintermediation -- Communications Model

To preserve personal privacy, anonymity, … :



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

Images, Displays & Cameras

Microoptical eyeglasses display: http://www.microopticalcorp.com/, Displaytech, Inc. and Hewlett-Packard Company each with Reflective Microdisplay Components, …

Cameras

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

More Images on-line

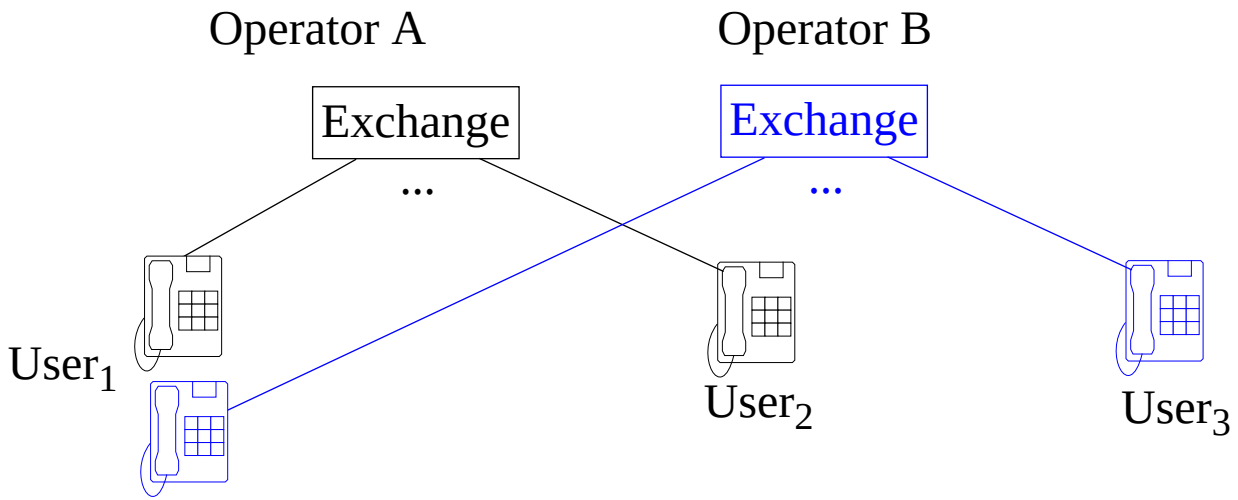
- HP CapShare 910 - Handheld scanner - with automatic stitching - produces PDF
- Network attached "copiers" - really a scanner + printer
- CrossPad® - Personal Digital Notepad - from pen strokes to digital stroke info
- Web cameras - networked cameras, cameras notebooks, cameras on your eyeglasses

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?

Initial telephone systems and users



Initially: For two users to communicate they must have telephones connected to the same operating company; the operator provided the mapping between an incoming call and the outgoing line (subscriber telephone).

What could be done?

Note that the plug board version of this system featured mobility support, speaker recognition and speech recognition:

> Caller: Put me through to Chip?
>
> Operator: Hi Sam! He is at the barbershop now, I'll put you through to there.

Locating the user

If only mobile users originate calls, then it does not matter where the user is! However, if we want to reach a mobile user, then:

- we can track the user continuously, or
- we can start looking for the user where we last saw them and then expand our search, or
- we can guess where the user might be: based on their patterns of movement (past behavior) or based on their schedule (expected future behavior), or
- the user tells us where they are: based on a schedule OR a page

$\Longrightarrow$ location dependent systems

- emergency services - such as E911
- warning services (avalanche area, construction, traffic delays, …)
- advertisements for nearby: hotels, restaurants, shops, …
- maps and directions

New objects in Web space: URLs or URNs on everything

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

Wireless labels - Motorola's BiStatix RFID tags -- combining a chip less than 3 mm^2 with conductive ink. Tags can be read/writable or locked against further writes.

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

Mapping from Real space to Cyber Space

alliance: Motorola, Symbol Technologies, AirClic, and Connect Things

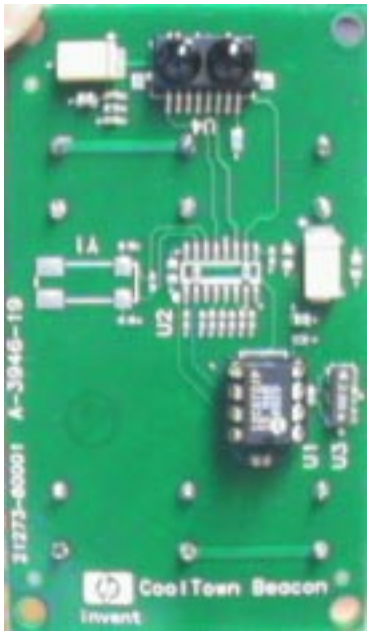
- mobile phones + bar code scanner
- bar code in print ads, on products, …

⇒ access to the associated Internet site via a registry of Web codes

Emitting a URL via IR:

Henrik Gustafsson's Matchbox Badge (1998)

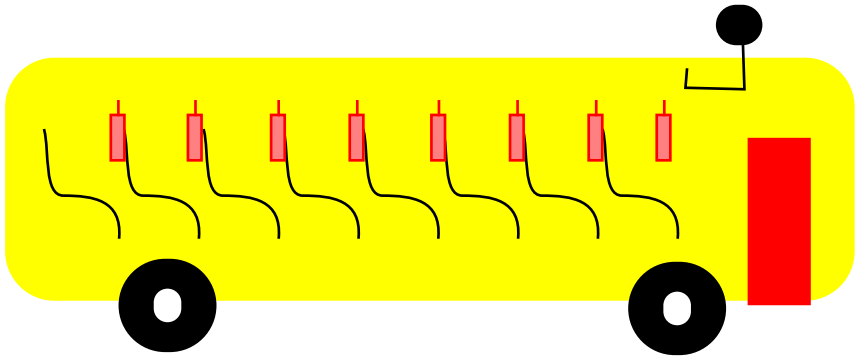
HP's CoolTown Beacons (1999)



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

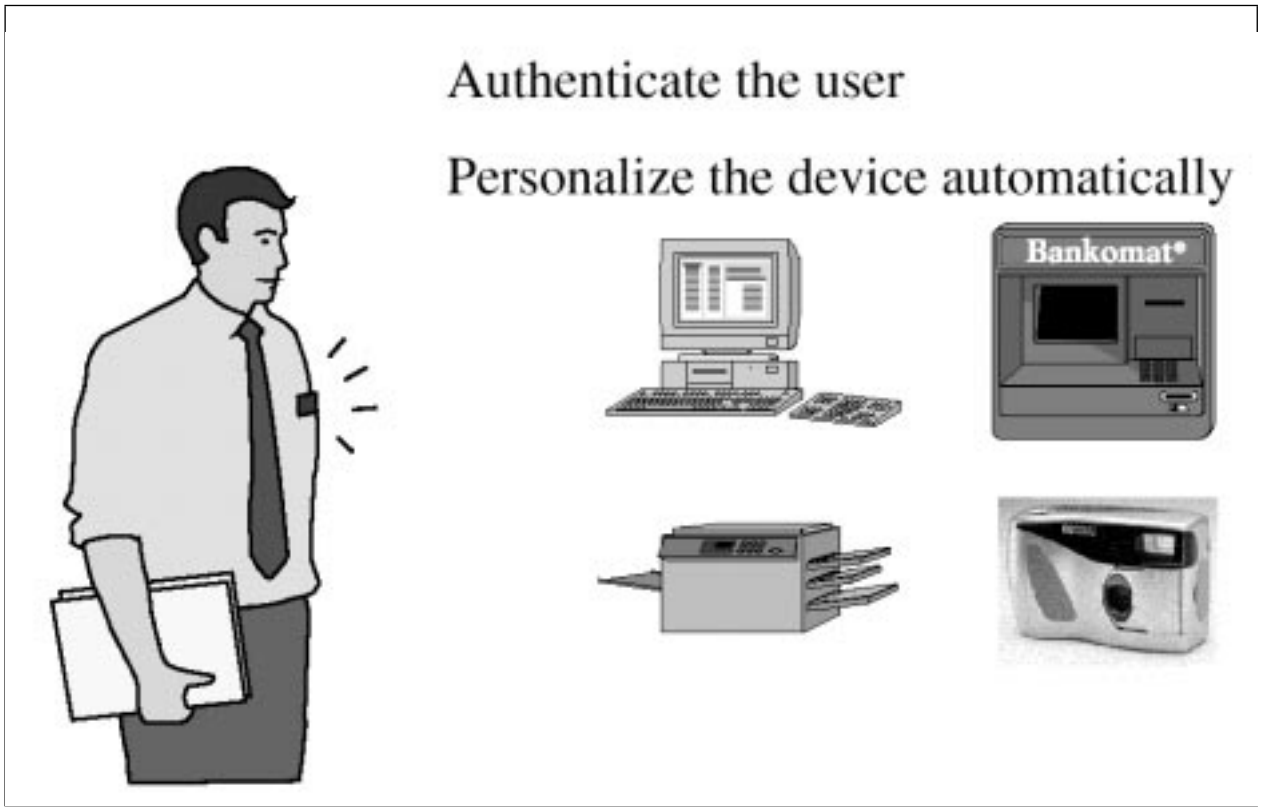
Security guards

- 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
- …

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:

- a “chemlab” on a chip $\Rightarrow$ environmental or personnel monitoring
- golf clubs than can diagnose a player’s swing
- running shoes which track distance, pace, and stress, …

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

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

see:

Tomas Boström, Susanne Eliasson, Per Lindtorp, Fabio Moioli, and Mats Nyström, “Mobile Audio Distribution”, Personal Technologies, Volume 3(4), December 1999

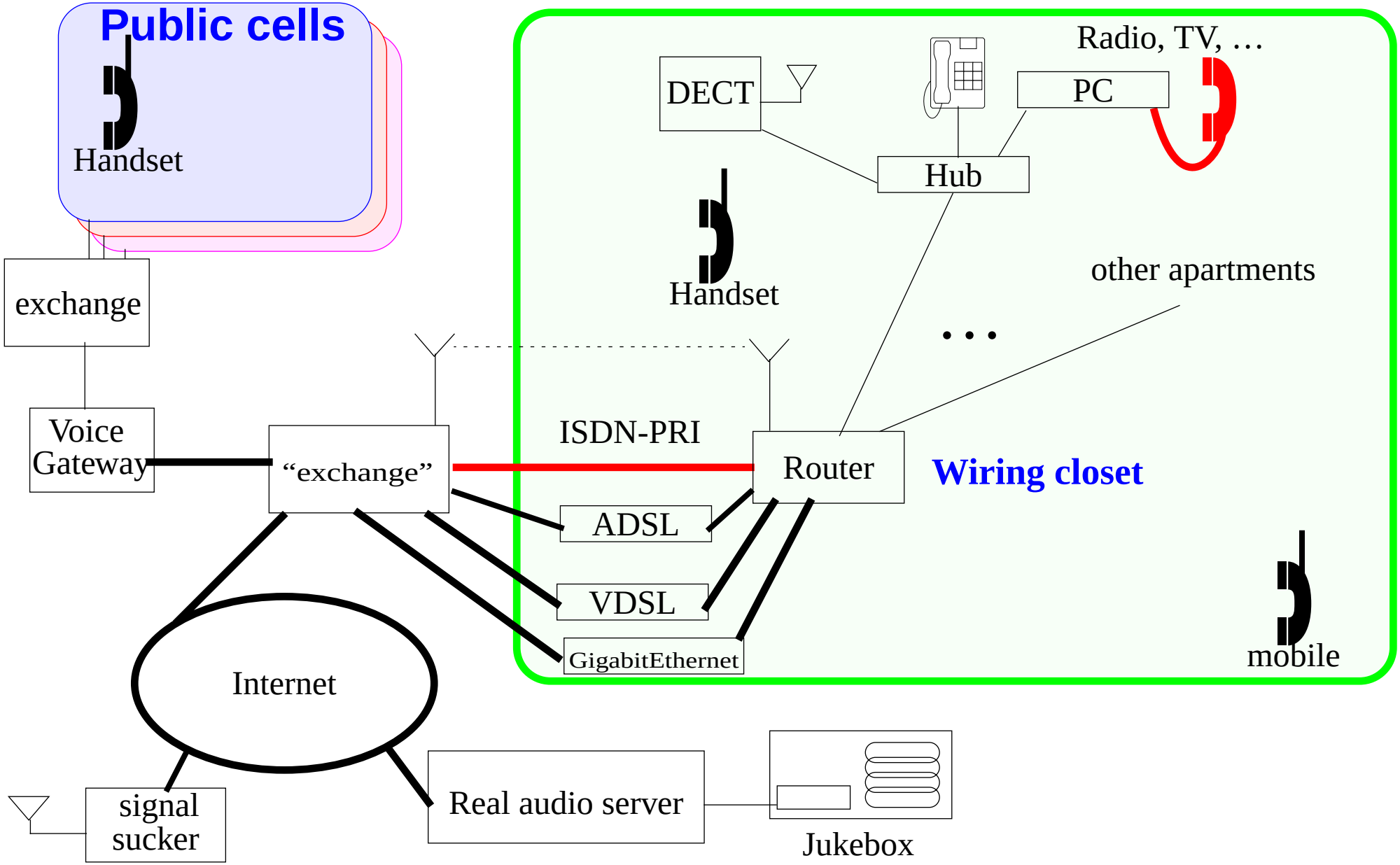
Opportunistic communications will become the norm.

Emotional

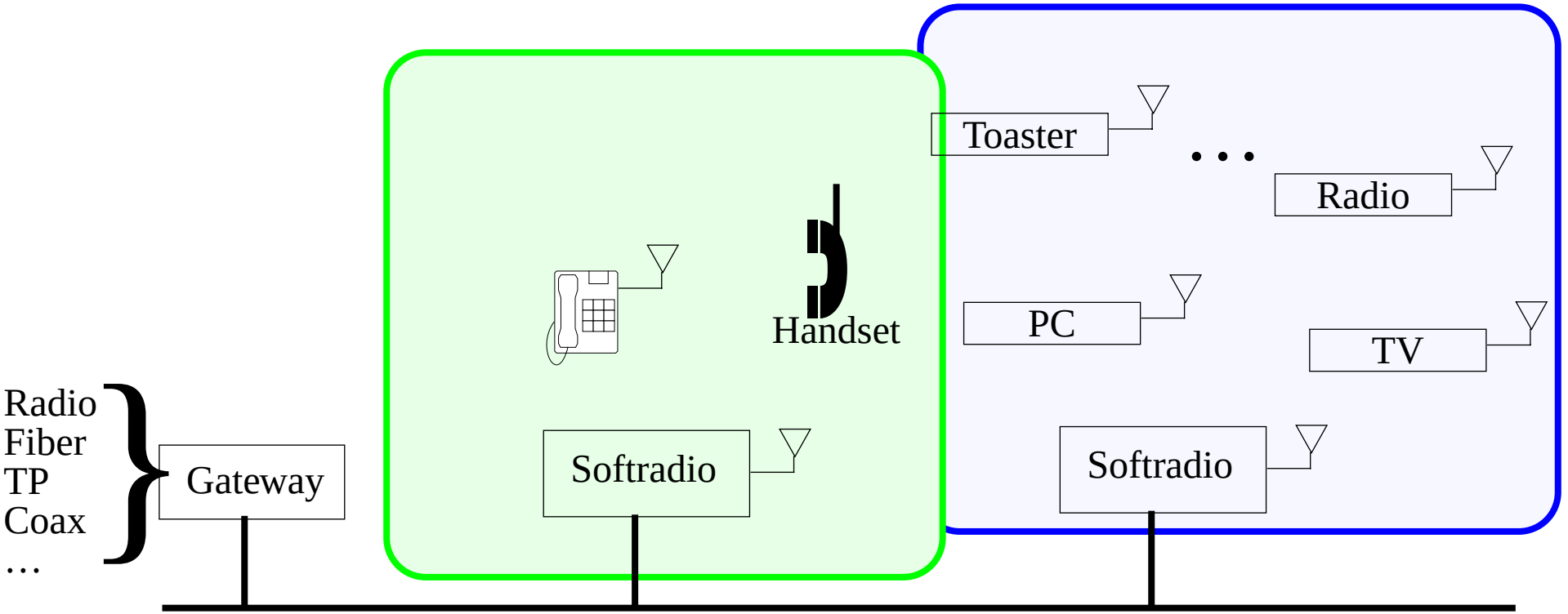
Toys + communications

Telecom products for children (of all ages!)

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



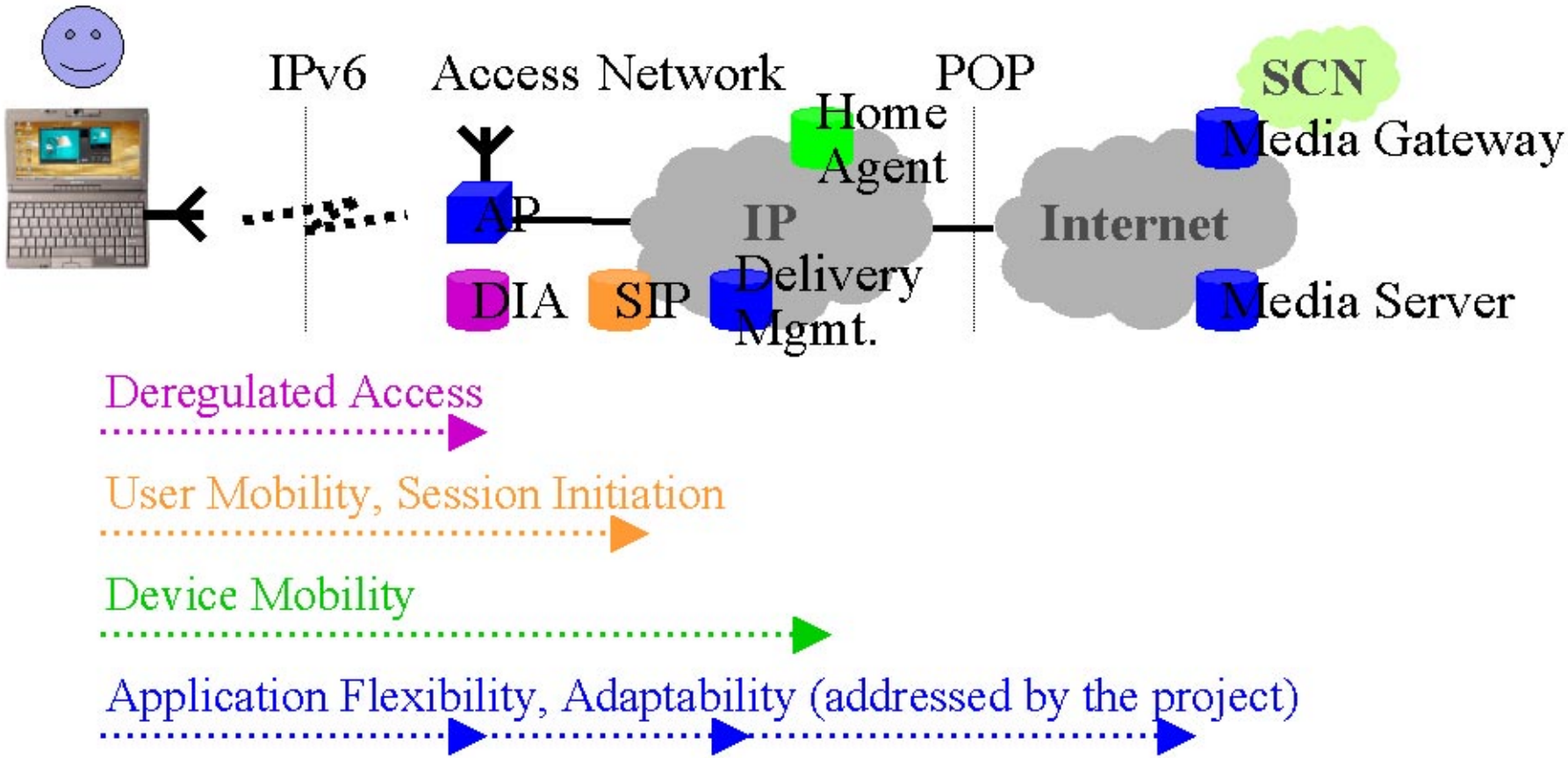
Future home/office/… network accesspoints



Ericsson's e-box: A network operator oriented home gateway:
http://www3.ericsson.se/review/pdf/1999015.pdf

Open Services Gateway Initiative (http://www.osgi.org/)

Theo Kanter's Overview



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

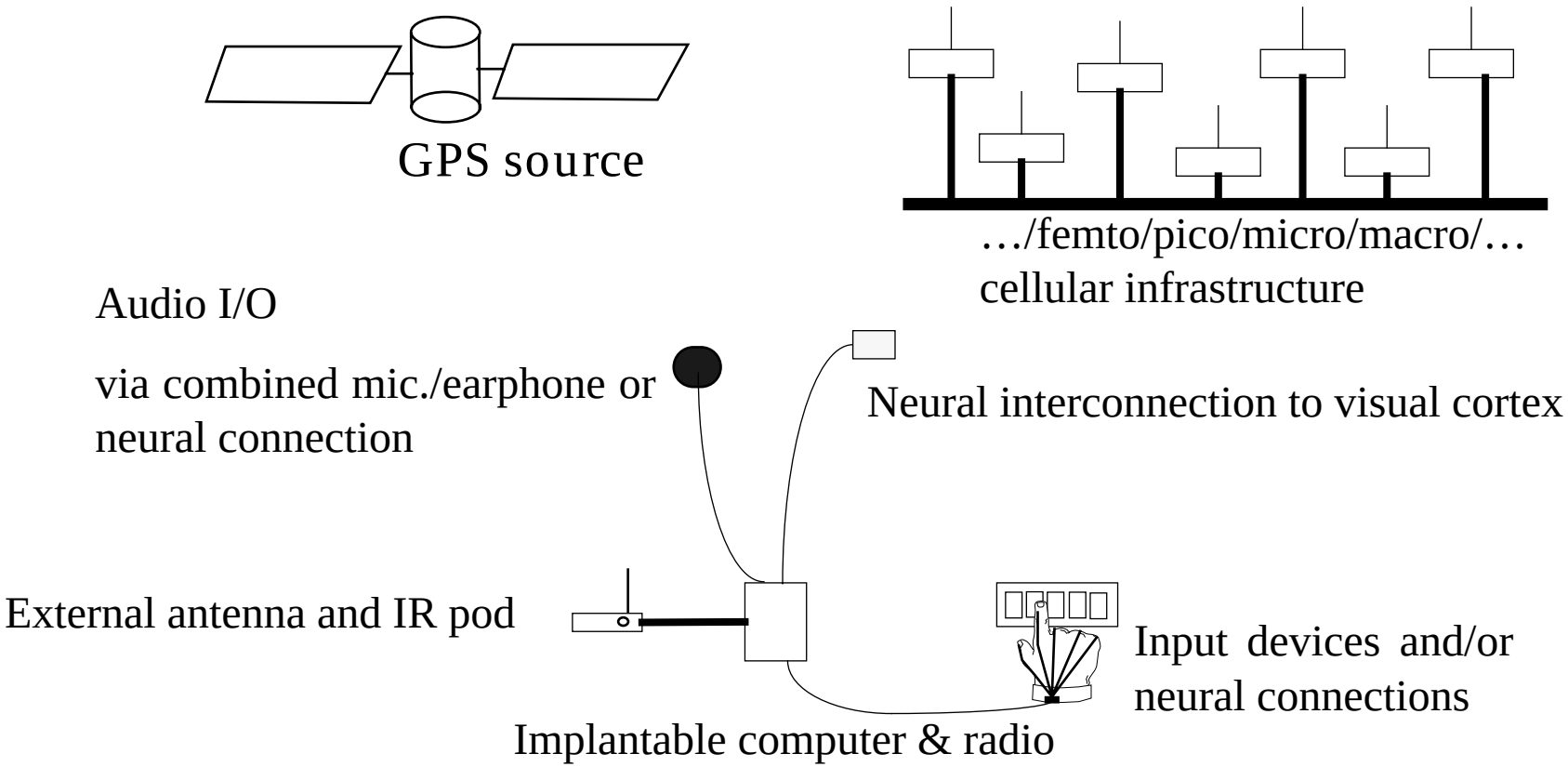


Figure 4: Vision-3, 2005-2015 - very high level of integration

Bionic Technologies, Inc.’s Intracortical Electrode Array

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

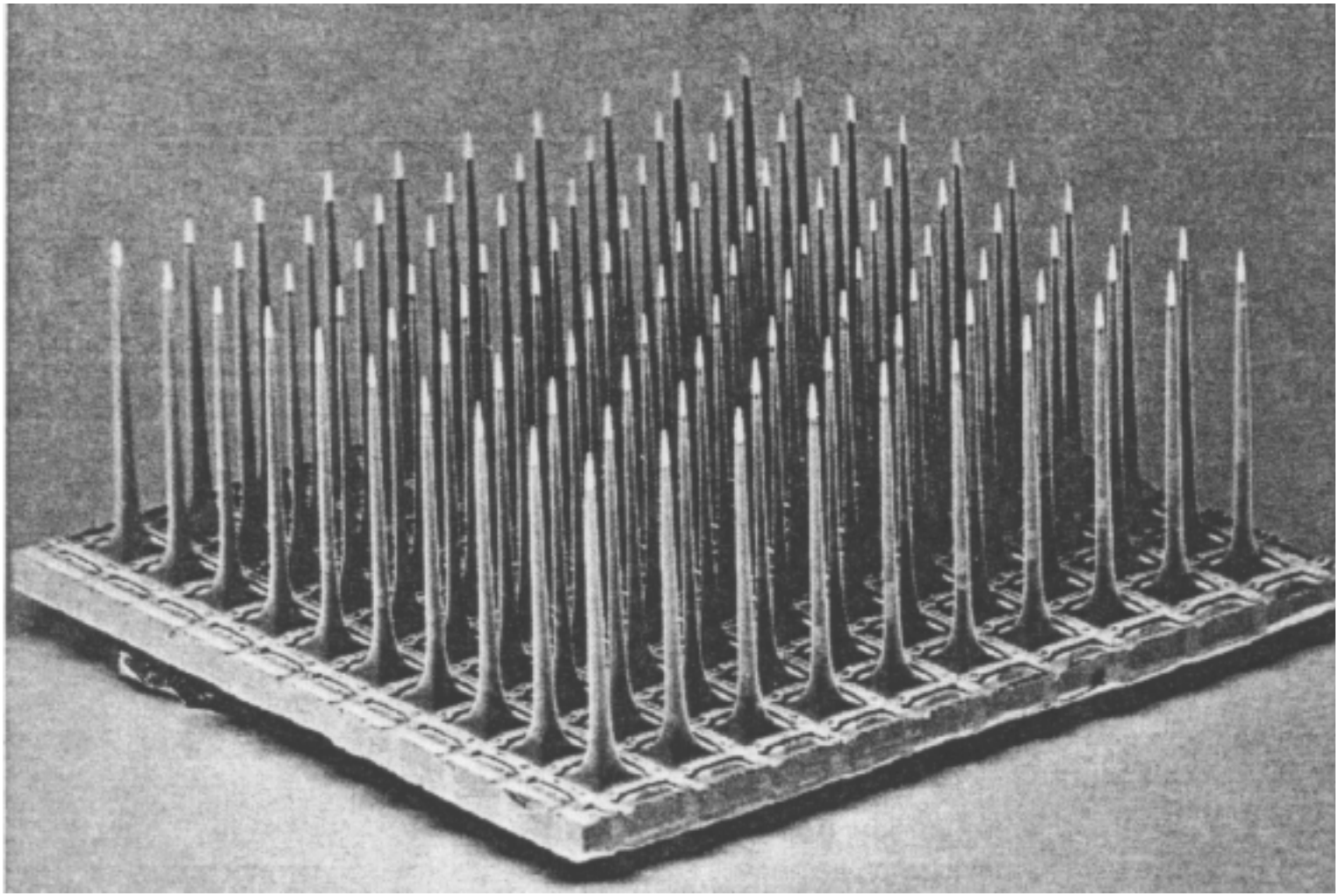


Figure 5: 10 x 10 silicon electrode array (each electrode: 1.5mm long, 0.08mm wide at base, 0.001mm tip), Built at the Univ. of Utah, by Richard A. Normann, et al.; from Scientific American, March 1994, pg. 108.

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)

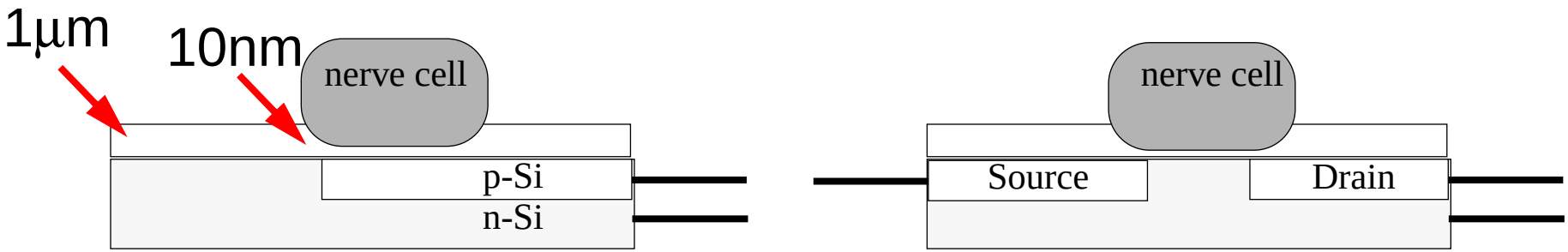


Figure 6: (a) Capacitive coupling of data into nerve and
(b) using the charge in the nerve to control a transistor's gate for getting data out of the nerve

(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

- No longer fashionable to be a telecom
- Telecom operators&vendors reinventing themselves & 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.
- Service is where the money is!
  - Note: e-currency -- provides new opportunities to “mint” money
- 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.