Personal Computing and Communication: A Status Update

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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!
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

Who are the competitors?

Ericsson, Lucent, Nokia, Siemens, … or Nintendo

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Near Future systems

Figure 1: Vision-2, 2000 - high level of integration
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 (⇒ 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
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 ⇒ 46.75 mm² - 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.

Diagram:
- Badge
- Badge Transceiver
- Badge Server
- Location Server
- Application
- Internet
Smart Badge 3

- Microphone & Speaker
- Memory
  - Flash: 1MB 28F8000
  - SRAM: 1MB TC554161 (2 chips)
- UCB1200
- StrongARM SA-1100
- PCMCIA Connector
- Analog Sensors
- Digital Sensors
- IR XCVR TFDU6100
- DC to DC Power Supply
- Battery
- PCMCIA Buffers
- Microphone & Speaker
- Memory
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- Battery
- PCMCIA Buffers
Smart Badge Sensors

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

High integration (goal of MEDIA project)

<table>
<thead>
<tr>
<th>Before</th>
<th>Chips</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td>radio</td>
<td>5</td>
<td>radio + LAN</td>
</tr>
<tr>
<td>µP</td>
<td>1</td>
<td>µP</td>
</tr>
<tr>
<td>LAN</td>
<td>1</td>
<td>MR</td>
</tr>
</tbody>
</table>

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](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

radio

ISDN/xDSL/LAN

Digital

Radio MAC_1

"LAN" MAC

Access Point Server

Rado MAC_2

Agents

SNMP -- ??

"LAN" MAC

ISDN/xDSL/LAN
```
Radio Part MAC

Open questions:

- How many radio we need?
- What is the right number of receivers that a typical mobile user would want to have?
- What is the relationship between the number of radios and: the data rates that a user can source and sink? a user’s context switching time?
- We think that its best to have two radios. One is used as the current communication channel and the second is time-multiplexed:
  - to look for other access points,
  - when bursts of extra bandwidth are needed,
  - to acquire information which is used to determine your location and heading,
  - as a secondary channel to listen to (and perhaps transmit) contents which is not available via the main communication channel,
  - listen to non-traditional communication emissions in your environment, etc.

It is also important to note that the authentication and privacy features were defined to provide “wire-line” features. However, these features are *optional* and need *not be implemented* in a given device.
Future home/office/… network accesspoints

Radio
Fiber
TP
Coax
…

Gateway

Softradio

Handset

Toaster

…

Radio

PC

TV

Softradio
Personal Computing and Communication (PCC)

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

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**Other Wearables**

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

[http://www.watch.impress.co.jp.pc/docs/article/980911/ibm.htm](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**: 320x240 with 256 colors - to headsup display
- **Serial Interface**: USB
- **Card Bus Controller**: TI1251
- **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
Intel Embedded PC

http://developer.intel.com/design/platform/embedpc/index.htm

Support chips:

Northbridge - provides all memory interfaces and control + host to PCI transaction control

- controls cache fetches, write-backs, and coherency
- HX Northbridge: FPM and EDO memories, Error Checking and Correction (ECC) + parity support
- TX Northbridge: FPM, EDO and SDRAM memories; ECC and parity are not supported

Southbridge (aka PIIXx device)

- Connects the PCI bus to the ISA bus as well as other peripheral devices, including Universal Serial bus (USB) and IDE bus for hard disc drives
- Timers, counters, DMA, BIOS; Interrupt control of legacy ISA devices; PCI reset and interrupt control
# IBM MicroDrive 340MB


<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
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<tbody>
<tr>
<td>Capacity</td>
<td>340MB / 170MB</td>
</tr>
<tr>
<td>Number of heads</td>
<td>2 / 1</td>
</tr>
<tr>
<td>Number of disks</td>
<td>1</td>
</tr>
<tr>
<td>Rotational rate</td>
<td>4,500RPM</td>
</tr>
<tr>
<td>Seek time (typical read) average</td>
<td>15ms</td>
</tr>
<tr>
<td>Voltage</td>
<td>3.3V</td>
</tr>
<tr>
<td>Dimensions</td>
<td>36.4x42.8x5.0mm</td>
</tr>
<tr>
<td>Weight</td>
<td>20g</td>
</tr>
<tr>
<td>Interface</td>
<td>CompactFlash Type II (CF Type II)</td>
</tr>
</tbody>
</table>
IBM Wearable work

User interface and devices - from User System Ergonomic Research:

http://www.almaden.ibm.com/cs/user/userproj.html

The above URL is useful for additional background about TrackPoint devices.

Specifically the TrackPoint Mouse:

http://www.almaden.ibm.com/cs/user/tp/tpmouse.html
Displays

A summary of links is at:


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/).
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, …
Wireless (Radios, IR)

IEEE 802.11

<table>
<thead>
<tr>
<th>Frequency Hopping</th>
<th>BayStack 660 Wireless LAN PC Card</th>
<th>$569</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>BayStack 660 Wireless LAN Access Point</td>
<td>$1,799</td>
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<tr>
<td>Direct Sequence</td>
<td>BayStack 650 Wireless LAN PC Card</td>
<td>$499</td>
</tr>
<tr>
<td></td>
<td>BayStack 650 Wireless LAN Access Point</td>
<td>$1,499</td>
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</tbody>
</table>


GSM - Ericsson GC25

- PCMCIA Type III card

Ericsson Mobile Office DI 27

- clip on IR interface for 900 series phones
- contains an ARM 7 processor
Conclusions

- 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.