

What is Pervasive Computing?

Dr. Dirk Husemann
IBM Zurich Research Lab
hud@zurich.ibm.com

28 November 2000

A Quote

I think there is a market for maybe **five computers worldwide**. — THOMAS J. WATSON,
CHAIRMAN OF IBM, 1943

A Quote

I think there is a market for maybe **five computers worldwide**. — THOMAS J. WATSON, CHAIRMAN OF IBM, 1943

The second important trend we are preparing for is called “pervasive computing” . . . So the networked world . . . will extend further to interconnect perhaps a **trillion “intelligent” devices**. — LOUIS V. GERSTNER, JR., CHAIRMAN AND CEO OF IBM, 1999 (1)

Ubiquitous Computing (1)

The “UC” era will have lots of computers sharing each of us . . . imbedded in walls, chairs, clothing, light switches, cars - in everything. UC is fundamentally characterized by the connection of things in the world with computation. This will take place at a many scales, including the microscopic. — MARK WEISER, CALM TECHNOLOGY(2)

Ubiquitous or Pervasive?

Ubiquitous or Pervasive?

Ubiquitous: existing or being everywhere at the same time, constantly encountered (3)

Pervasive: diffusing throughout every part of (4)

Ubiquitous or Pervasive?

Ubiquitous: existing or being everywhere at the same time, constantly encountered (3)

Pervasive: diffusing throughout every part of (4)

- Ubiquitous is now. . .

Ubiquitous or Pervasive?

Ubiquitous: existing or being everywhere at the same time, constantly encountered (3)

Pervasive: diffusing throughout every part of (4)

- Ubiquitous is now... Boring!

Ubiquitous or Pervasive?

Ubiquitous: existing or being everywhere at the same time, constantly encountered (3)

Pervasive: diffusing throughout every part of (4)

- Ubiquitous is now... Boring!
- Pervasive is not yet...

Ubiquitous or Pervasive? **Pervasive!**

Ubiquitous: existing or being everywhere at the same time, constantly encountered (3)

Pervasive: diffusing throughout every part of (4)

- Ubiquitous is now... Boring!
- Pervasive is not yet... **Exciting!**

Pervasive Computing (PvC)

- **Computers disappear**, blending into the environment

Pervasive Computing (PvC)

- **Computers disappear**, blending into the environment
- **“Age of calm technology”**

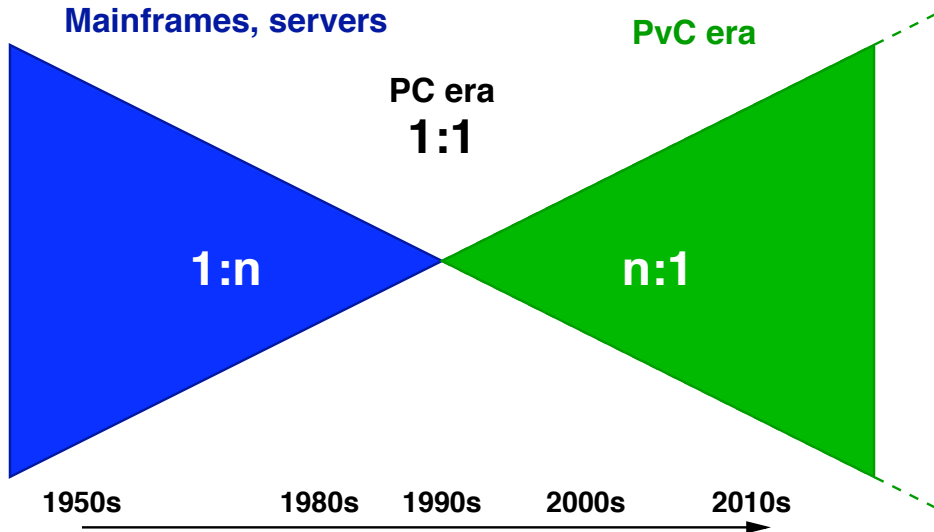
Pervasive Computing (PvC)

- **Computers disappear**, blending into the environment
- **“Age of calm technology”**
- **Interconnectedness**

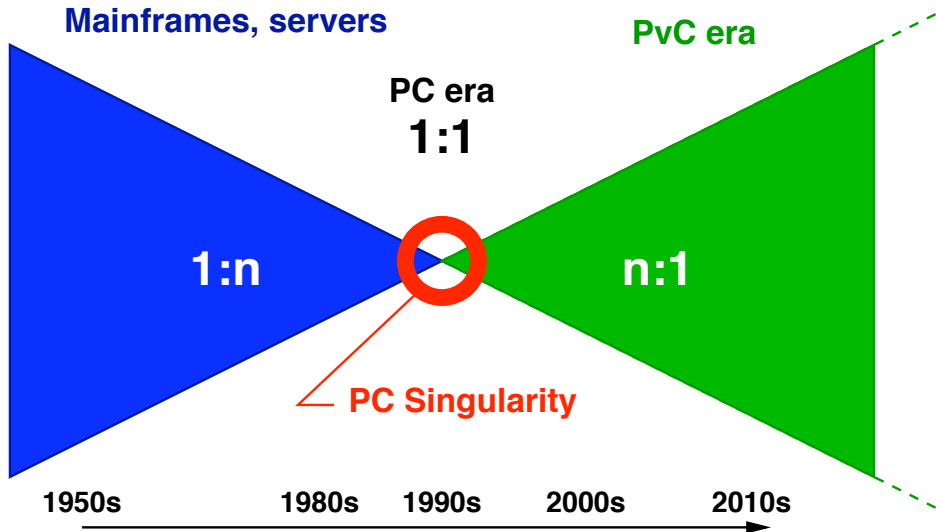
Pervasive Computing (PvC)

- **Computers disappear**, blending into the environment
- **“Age of calm technology”**
- **Interconnectedness**
- Wide range of computer science fields: networking, user interfaces, operating systems, distributed systems, security, data bases, . . .

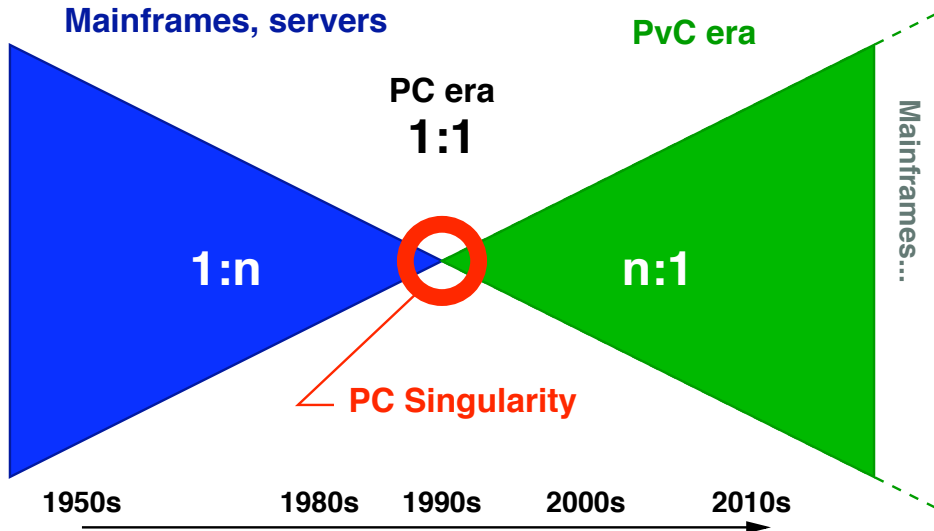
Past the PC Singularity



Past the PC Singularity



Past the PC Singularity



PvC: Just a Passing Fad?

PvC: Just a Passing Fad?

- Pervasive computing (PvC): an old dream of human-kind

PvC: Just a Passing Fad?

- Pervasive computing (PvC): an old dream of human-kind
 - Fairy tales: *The forty thieves*: **Open, Sesame**

PvC: Just a Passing Fad?

- Pervasive computing (PvC): an old dream of human-kind
 - Fairy tales: *The forty thieves*: **Open, Sesame**
 - Science fiction: *StarTrek*: **“Computer, please”**

PvC: Just a Passing Fad?

- Pervasive computing (PvC): an old dream of human-kind
 - Fairy tales: *The forty thieves*: **Open, Sesame**
 - Science fiction: *StarTrek*: **“Computer, please”**
 - Recent fiction: *Harry Potter*: **Omniocular, Quick-Quotes Quill, Marauder’s Map, Remembrall** (5, 6, 7, 8)

PvC: Just a Passing Fad?

- Pervasive computing (PvC): an old dream of human-kind
 - Fairy tales: *The forty thieves*: **Open, Sesame**
 - Science fiction: *StarTrek*: **“Computer, please”**
 - Recent fiction: *Harry Potter*: **Omniocular, Quick-Quotes Quill, Marauder’s Map, Remembrall** (5, 6, 7, 8)
- Strong desire for smart and adaptive environments and devices
 - Adapt to **location & device context**
 - Adapt to **user’s preferences & intentions**

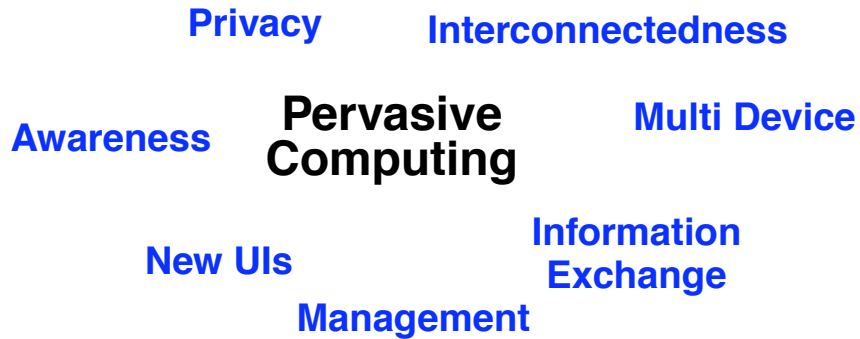
PvC: Just a Passing Fad? **No!**

- Pervasive computing (PvC): an old dream of human-kind
 - Fairy tales: *The forty thieves*: **Open, Sesame**
 - Science fiction: *StarTrek*: **“Computer, please”**
 - Recent fiction: *Harry Potter*: **Omniocular, Quick-Quotes Quill, Marauder’s Map, Remembrall** (5, 6, 7, 8)
- Strong desire for smart and adaptive environments and devices
 - Adapt to **location & device context**
 - Adapt to **user’s preferences & intentions**

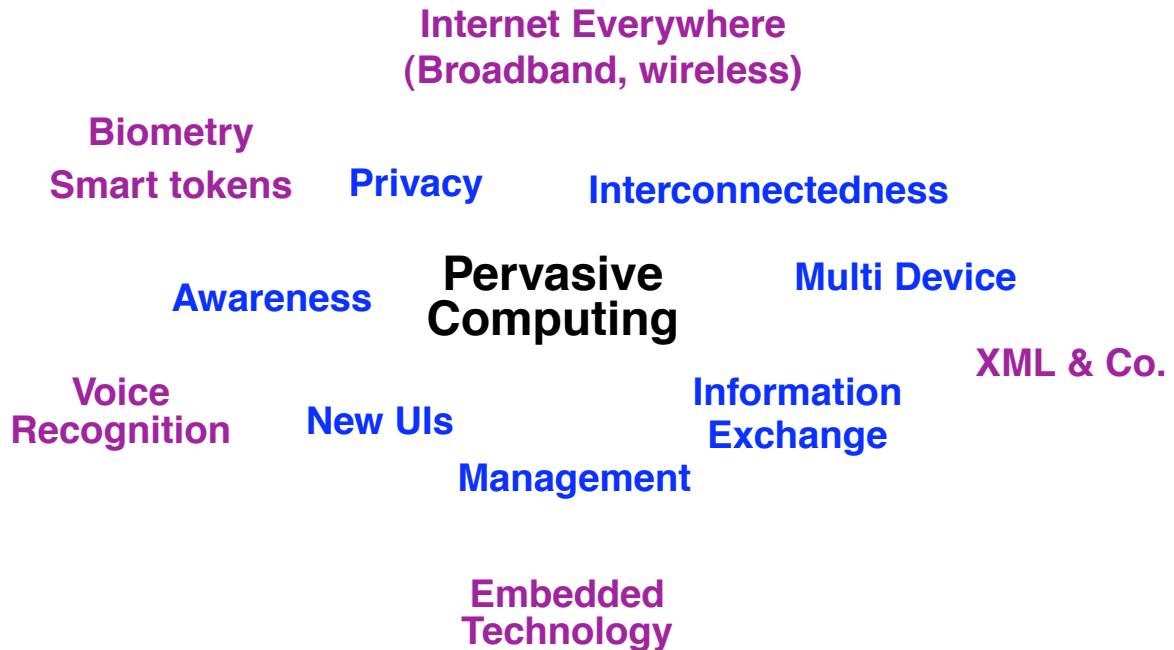
PvC Issues & Enablers

Pervasive Computing

PvC Issues & Enablers



PvC Issues & Enablers



Awareness

Aware: (. . .) implies vigilance in observing or alertness in drawing inferences from what one experiences (9)

Awareness

Aware: (. . .) implies vigilance in observing or alertness in drawing inferences from what one experiences (9)

- **Applications & environments observe us**

Awareness

Aware: (. . .) implies vigilance in observing or alertness in drawing inferences from what one experiences (9)

- **Applications & environments observe us**
- Different behaviour depending on
 - **Location** context: Where am I? Where are you?

Awareness

Aware: (. . .) implies vigilance in observing or alertness in drawing inferences from what one experiences (9)

- **Applications & environments observe us**
- Different behaviour depending on
 - **Location** context: Where am I? Where are you?
 - **Activity** context: What am I doing now? What are you doing?

Awareness

Aware: (. . .) implies vigilance in observing or alertness in drawing inferences from what one experiences (9)

- **Applications & environments observe us**
- Different behaviour depending on
 - **Location** context: Where am I? Where are you?
 - **Activity** context: What am I doing now? What are you doing?
 - **Mood** context: Am I happy? Am I grumpy?

Awareness

Aware: (. . .) implies vigilance in observing or alertness in drawing inferences from what one experiences (9)

- **Applications & environments observe us**
- Different behaviour depending on
 - **Location** context: Where am I? Where are you?
 - **Activity** context: What am I doing now? What are you doing?
 - **Mood** context: Am I happy? Am I grumpy?
- **Correlation, rules, events** (messaging systems)

Privacy

- Already a sensitive and difficult issue in the Internet context
- PvC: More complicated, “worse”

Privacy

- Already a sensitive and difficult issue in the Internet context
- PvC: More complicated, “worse”
 - Who gets **access to my environment?**

Privacy

- Already a sensitive and difficult issue in the Internet context
- PvC: More complicated, “worse”
 - Who gets **access to my environment?**
 - Who gets **access to stored data?** (Life captured on nanoscale “disk”?)

Privacy

- Already a sensitive and difficult issue in the Internet context
- PvC: More complicated, “worse”
 - Who gets **access to my environment?**
 - Who gets **access to stored data?** (Life captured on nanoscale “disk”?)
 - How do I control **flow of information?**

Privacy

- Already a sensitive and difficult issue in the Internet context
- PvC: More complicated, “worse”
 - Who gets **access to my environment?**
 - Who gets **access to stored data?** (Life captured on nanoscale “disk”?)
 - How do I control **flow of information?**
 - How can I monitor **privacy violations?** Intrusion detection for PvC devices?

Privacy

- Already a sensitive and difficult issue in the Internet context
- PvC: More complicated, “worse”
 - Who gets **access to my environment?**
 - Who gets **access to stored data?** (Life captured on nanoscale “disk”?)
 - How do I control **flow of information?**
 - How can I monitor **privacy violations?** Intrusion detection for PvC devices?
- **Friend-foe recognition**

Privacy

- Already a sensitive and difficult issue in the Internet context
- PvC: More complicated, “worse”
 - Who gets **access to my environment?**
 - Who gets **access to stored data?** (Life captured on nanoscale “disk”?)
 - How do I control **flow of information?**
 - How can I monitor **privacy violations?** Intrusion detection for PvC devices?
- **Friend-foe recognition** . . . in downtown London!

Interconnectedness

$$\text{PvC Interconnect Rate (PIR)} = \frac{\text{networked CPUs}}{\text{All CPUs}}$$

Interconnectedness

$$\text{PvC Interconnect Rate (PIR)} = \frac{\text{networked CPUs}}{\text{All CPUs}}$$

- Currently: PIR \ll 1

Interconnectedness

$$\text{PvC Interconnect Rate (PIR)} = \frac{\text{networked CPUs}}{\text{All CPUs}}$$

- Currently: $\text{PIR} \ll 1$
- PvC: $\text{PIR} \approx 1$

Interconnectedness

$$\text{PvC Interconnect Rate (PIR)} = \frac{\text{networked CPUs}}{\text{All CPUs}}$$

- Currently: $\text{PIR} \ll 1$
- PvC: $\text{PIR} \approx 1$
- **Interconnectedness** (*Internet everywhere*)
 - **At large: Broadband** (personal servers)
 - ◆ xDSL, cable, WLL, DIRC (10)

Interconnectedness

$$\text{PvC Interconnect Rate (PIR)} = \frac{\text{networked CPUs}}{\text{All CPUs}}$$

- Currently: $\text{PIR} \ll 1$
- PvC: $\text{PIR} \approx 1$
- **Interconnectedness** (*Internet everywhere*)
 - **At large: Broadband** (personal servers)
 - ◆ xDSL, cable, WLL, DIRC (10)
 - **In the small: Wireless** (device–environment, ad-hoc)
 - ◆ IR/AIR, Bluetooth, 802.11, etc.

Multi Device Computing (1)

- Transactions across multiple devices

Multi Device Computing (1)

- Transactions across multiple devices
- **Sequential multi device computing**

Multi Device Computing (1)

- Transactions across multiple devices
- **Sequential multi device computing**

- **Chaired multi device computing**

Multi Device Computing (1)

- Transactions across multiple devices
- **Sequential multi device computing**
 - Devices cooperating *in sequence over time*
 - Information *relayed* from device to device
- **Chaired multi device computing**

Multi Device Computing (1)

- Transactions across multiple devices
- **Sequential multi device computing**
 - Devices cooperating *in sequence over time*
 - Information *relayed* from device to device
 - Example: **Internet payments via GSM/SMS**
- **Chaired multi device computing**

Multi Device Computing (1)

- Transactions across multiple devices
- **Sequential multi device computing**
 - Devices cooperating *in sequence over time*
 - Information *relayed* from device to device
 - Example: **Internet payments via GSM/SMS**
 - Example: **Data synchronization: SyncML (11)**
- **Chaired multi device computing**

Multi Device Computing (1)

- Transactions across multiple devices
- **Sequential multi device computing**
 - Devices cooperating *in sequence over time*
 - Information *relayed* from device to device
 - Example: **Internet payments via GSM/SMS**
 - Example: **Data synchronization: SyncML (11)**
- **Choiored multi device computing**
 - Devices cooperating *at the same time*

Multi Device Computing (1)

- Transactions across multiple devices
- **Sequential multi device computing**
 - Devices cooperating *in sequence over time*
 - Information *relayed* from device to device
 - Example: **Internet payments via GSM/SMS**
 - Example: **Data synchronization: SyncML (11)**
- **Chaired multi device computing**
 - Devices cooperating *at the same time*
 - Example: **PDA utilizing HiFi for email “display”**

Information Exchange

- Standardized way of exchanging data/information necessary

Information Exchange

- Standardized way of exchanging data/information necessary
 - Easy to parse
 - Easy to generate
 - Debuggable (= human readable)

Information Exchange

- Standardized way of exchanging data/information necessary
 - Easy to parse
 - Easy to generate
 - Debuggable (= human readable)
- **Internet Snake Oil:**

Information Exchange

- Standardized way of exchanging data/information necessary
 - Easy to parse
 - Easy to generate
 - Debuggable (= human readable)
- **Internet Snake Oil: XML**

Information Exchange

- Standardized way of exchanging data/information necessary
 - Easy to parse
 - Easy to generate
 - Debuggable (= human readable)
- **Internet Snake Oil: XML**
 - Tools readily available (Parser, DOM, XSLT, etc.)
 - Standardized yet *flexible*
- *ASN.1* et al.: compact but difficult to parse, create or handle

Information Exchange (2)

- XML as basis for remote invocation: **SOAP**, **WDDX**

Information Exchange (2)

- XML as basis for remote invocation: **SOAP**, **WDDX**
- **SOAP**: “XML RPC”

Information Exchange (2)

- XML as basis for remote invocation: **SOAP**, **WDDX**
- **SOAP**: “XML RPC”
 - Marshalling via SOAP DTD

Information Exchange (2)

- XML as basis for remote invocation: **SOAP**, **WDDX**
- **SOAP**: “XML RPC”
 - Marshalling via SOAP DTD
 - Transport via HTTP

Information Exchange (2)

- XML as basis for remote invocation: **SOAP, WDDX**
- **SOAP:** “XML RPC”
 - Marshalling via SOAP DTD
 - Transport via HTTP
 - **Synchronous RPC mechanism, object-oriented semantics**

Information Exchange (2)

- XML as basis for remote invocation: **SOAP, WDDX**
- **SOAP**: “XML RPC”
 - Marshalling via SOAP DTD
 - Transport via HTTP
 - **Synchronous RPC mechanism, object-oriented semantics**
- **WDDX**: Sharing structured data over the web

Information Exchange (2)

- XML as basis for remote invocation: **SOAP, WDDX**
- **SOAP**: “XML RPC”
 - Marshalling via SOAP DTD
 - Transport via HTTP
 - **Synchronous RPC mechanism, object-oriented semantics**
- **WDDX**: Sharing structured data over the web
 - Marshalling via special modules into WDDX
 - Transport: any “textual” Internet protocol (HTTP, POP, IMAP, SMTP, FTP,etc.)
 - **“simple, light-weight data exchange mechanism”**

Information Exchange (3)

- Connection oriented, synchronous protocols ill-suited for mobile and portable devices

Information Exchange (3)

- Connection oriented, synchronous protocols ill-suited for mobile and portable devices
- PvC: inherently **asynchronous** world, **events** from different devices & systems

Information Exchange (3)

- Connection oriented, synchronous protocols ill-suited for mobile and portable devices
- PvC: inherently **asynchronous** world, **events** from different devices & systems
- Events map well to message based communication systems

Information Exchange (4)

- **Publish–subscribe systems**
 - Event brokers & filters, distribution content based
 - Example: **Elvin, Gryphon**

Information Exchange (4)

- **Publish–subscribe systems**

- Event brokers & filters, distribution content based
- Example: **Elvin, Gryphon**
- Privacy, private message not well integrated (bank account?)

Information Exchange (4)

- **Publish–subscribe systems**

- Event brokers & filters, distribution content based
- Example: **Elvin, Gryphon**
- Privacy, private message not well integrated (bank account?)

- **Message distribution systems**

- Instant messaging systems
- Distribution address based
- Example: **IRC, Jabber, etc.**

Information Exchange (4)

■ Publish–subscribe systems

- Event brokers & filters, distribution content based
- Example: **Elvin, Gryphon**
- Privacy, private message not well integrated (bank account?)

■ Message distribution systems

- Instant messaging systems
- Distribution address based
- Example: **IRC, Jabber, etc.**
- Privacy through encryption

New User Interfaces (1)

- PvC & keyboards??

New User Interfaces (1)

- PvC & keyboards?? Hmm...

New User Interfaces (1)

- PvC & keyboards?? Hmm. . .
- **Speech** (“Computer, please!”)
 - Natural way of communicating for most people
 - Easy to use
 - Embedding efforts underway
 - Trained: Continuous voice recognition
 - Untrained: Specialized vocabulary
 - Drawbacks: Noise (“cubicle city?”), security (“erase all files”)

New User Interfaces (2)

- **Gestures & body language**
 - Observe body, facial expression, eyes
 - Recognize **mood, humor, state**, etc.
 - Silent technology
 - Drawback: Difficult to capture reliably

New User Interfaces (3)

- **Environmental sensors**
 - Temperature, humidity, smells (pheromones), etc.
 - Indicator: stress, mood, health

New User Interfaces (3)

- **Environmental sensors**
 - Temperature, humidity, smells (pheromones), etc.
 - Indicator: stress, mood, health
- **Brain waves** (12)

New User Interfaces (3)

- **Environmental sensors**
 - Temperature, humidity, smells (pheromones), etc.
 - Indicator: stress, mood, health
- **Brain waves** (12)
 - P300 signal

New User Interfaces (3)

- **Environmental sensors**
 - Temperature, humidity, smells (pheromones), etc.
 - Indicator: stress, mood, health
- **Brain waves** (12)
 - P300 signal
 - Although: Not quite there yet...



© 1999 Jessica Bayliss.

New User Interfaces (3)

- **Environmental sensors**
 - Temperature, humidity, smells (pheromones), etc.
 - Indicator: stress, mood, health
- **Brain waves** (12)
 - P300 signal
 - Although: Not quite there yet...
- Generally: **new UIs a boon for disabled persons!**



© 1999 Jessica Bayliss.

Embedded Technology (1)

- Moore's Law outrun by reality
 - Storage: increase in commercially available storage density doubling in less than six months
 - Communications: Wave division multiplexing, currently double capacity every six months
- Example: **IBM Research's Millipede**: Atomic Force Microscope tips operating on polymer films;
77.5 GBits/cm²

Embedded Technology (2)

- Embedded OS more widespread & applicable
 - QNX, RTOS, etc
 - Linux: embedded OS for the masses

Embedded Technology (2)

- Embedded OS more widespread & applicable
 - QNX, RTOS, etc
 - Linux: embedded OS for the masses
- Hardware ever shrinking

Embedded Technology (2)

- Embedded OS more widespread & applicable
 - QNX, RTOS, etc
 - Linux: embedded OS for the masses
- Hardware ever shrinking
- Example: **IBM Wearable PC study (13)**



Embedded Technology (2)

- Embedded OS more widespread & applicable
 - QNX, RTOS, etc
 - Linux: embedded OS for the masses
- Hardware ever shrinking
- Example: **IBM Wearable PC study (13)**
- Example: **web server on a PIC (14)**



<http://www-ccs.umass.edu/shri/iPic.html>

Manageability & Configuration

- Configuring & managing *one* PC already is a time-consuming task

Manageability & Configuration

- Configuring & managing *one* PC already is a time-consuming task
- What about 100 PvC devices?

Manageability & Configuration

- Configuring & managing *one* PC already is a time-consuming task
- What about 100 PvC devices? 1000?

Manageability & Configuration

- Configuring & managing *one* PC already is a time-consuming task
- What about 100 PvC devices? 1000?
- Example: **Moving house**

Manageability & Configuration

- Configuring & managing *one* PC already is a time-consuming task
- What about 100 PvC devices? 1000?
- Example: **Moving house**
- How to control access? How to introduce new devices into an environment?

Manageability & Configuration

- Configuring & managing *one* PC already is a time-consuming task
- What about 100 PvC devices? 1000?
- Example: **Moving house**
- How to control access? How to introduce new devices into an environment?
- Network management for the masses?

Manageability & Configuration

- Configuring & managing *one* PC already is a time-consuming task
- What about 100 PvC devices? 1000?
- Example: **Moving house**
- How to control access? How to introduce new devices into an environment?
- Network management for the masses? Probably not.

Biometry & Personal Authentication

- Biometrics becoming practical as **authentication tools**

Biometry & Personal Authentication

- Biometrics becoming practical as **authentication tools**
 - Iris scanning, finger prints, voice recognition, smell

Biometry & Personal Authentication

- Biometrics becoming practical as **authentication tools**
 - Iris scanning, finger prints, voice recognition, smell
- Smart tokens as **personal proxies**
 - Smart cards, smart rings

Biometry & Personal Authentication

- Biometrics becoming practical as **authentication tools**
 - Iris scanning, finger prints, voice recognition, smell
- Smart tokens as **personal proxies**
 - Smart cards, smart rings
- Privacy concerns: Control over biometric data?

Biometry & Personal Authentication

- Biometrics becoming practical as **authentication tools**
 - Iris scanning, finger prints, voice recognition, smell
- Smart tokens as **personal proxies**
 - Smart cards, smart rings
- Privacy concerns: Control over biometric data?
- Is it really secure?
 - Faked fingerprints? Hacked fingers?

Societal Concerns

- Wondrous new world, yet...

Societal Concerns

- Wondrous new world, yet...
- ...do we want to be under observation all the time? In our private sphere?

Societal Concerns

- Wondrous new world, yet...
- ... do we want to be under observation all the time? In our private sphere?
- ... do we want to be glass citizens? (Singapore)

Societal Concerns

- Wondrous new world, yet...
- ... do we want to be under observation all the time? In our private sphere?
- ... do we want to be glass citizens? (Singapore)
- ... where is the *off-switch*? Is there one? Who gets to toggle it?

Societal Concerns

- Wondrous new world, yet...
- ... do we want to be under observation all the time? In our private sphere?
- ... do we want to be glass citizens? (Singapore)
- ... where is the *off-switch*? Is there one? Who gets to toggle it?
- Legal issues
 - Who owns data that concerns me?

Societal Concerns

- Wondrous new world, yet...
- ... do we want to be under observation all the time? In our private sphere?
- ... do we want to be glass citizens? (Singapore)
- ... where is the *off-switch*? Is there one? Who gets to toggle it?
- Legal issues
 - Who owns data that concerns me?
 - Who can get access (and how easily) to my *Life-on-a-Drive* brain enhancer?



Wrapping Up

- Pervasive computing addresses old dream of mankind:
 - **Smart & adaptive devices & environments**

Wrapping Up

- Pervasive computing addresses old dream of mankind:
 - **Smart & adaptive devices & environments**
- PvC Issues & Enablers:
 - Awareness, privacy, social issues
 - Multi device, new UIs, information exchange
 - Internet everywhere (wireless, broadband)
 - Biometrics, embedded technology
 - XML & Co.

Stay Tuned...

- Next:

Stay Tuned...

- Next: **Ad Hoc Pervasive Computing**
 - How ad hoc is ad hoc?
 - Wireless networks
 - Service discovery
 - Applications

Stay Tuned...

- Next: **Ad Hoc Pervasive Computing**
 - How ad hoc is ad hoc?
 - Wireless networks
 - Service discovery
 - Applications
- Followed by:

Stay Tuned...

- Next: **Ad Hoc Pervasive Computing**
 - How ad hoc is ad hoc?
 - Wireless networks
 - Service discovery
 - Applications
- Followed by: **Current Research in Pervasive Computing**
 - CoolTown, PEN, Fabric Area Networks, DABWeb...

Thank You...

Thank You...

... For Your Time and Interest!

References

- (1) L. V. Gerstner, "1998 shareholders speech." [World Wide Web site](#), April 1998.
- (2) M. Weiser, "The coming age of calm technology." [World Wide Web site](#), October 1996.
- (3) Britannica.com, "Merriam Webster's Collegiate Dictionary: Main Entry: Ubiquitous." [World Wide Web site](#). Cited 16 November 2000.
- (4) Britannica.com, "Merriam Webster's Collegiate Dictionary: Main Entry: Pervade." [World Wide Web site](#). Cited 16 November 2000.
- (5) J. K. Rowlings, *Harry Potter and the Philosopher's Stone*. Bloomsbury Children's Books, June 1997.
- (6) J. K. Rowlings, *Harry Potter and the Chamber of Secrets*. Bloomsbury Children's Books, July 1998.

- (7) J. K. Rowling, *Harry Potter and the Prisoner of Azkaban*. Bloomsbury Children's Books, July 1999.
- (8) J. K. Rowling, *Harry Potter and the Goblet of Fire*. Bloomsbury Children's Books, July 2000.
- (9) Britannica.com, "Merriam Webster's Collegiate Dictionary: Main Entry: Aware." [World Wide Web site](#). Cited 17 November 2000.
- (10) DIRC Technology GmbH & Co. KG, "DIRC: Digital Inter Relay Communication." [World Wide Web site](#). Cited 20 November 2000.
- (11) SyncML, "Building an Industry-Wide Mobile Data Synchronization Protocol: SyncML Whitepaper." [World Wide Web site](#), 2000. Cited 22 November 2000.
- (12) ABC News, "Cutting Edge: Brain Waves Turn It On." [World Wide Web site](#), June 2000. Cited 20 November 2000.
- (13) IBM Corporation, "Wearable PC Technology Presentation." [World Wide Web site](#). Cited 20 November 2000.
- (14) H. Shrikumar, "Got a Match?." [World Wide Web site](#), July 1999. Cited 20 November 2000.

Credits

Permission to include the photo of the *iPIC web server* was kindly granted by [Cris Pedregal Martin](#); likewise I am indebted to [Jessica Bayliss](#) for giving me permission to include the picture of the “brainwaved car driver”.

Created with pdfLaTeX, FoilTeX, XFig, hyperref and PPower4.