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Will Pervasive Computing be Manageable?

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Contents

- What is pervasive computing
- Current technology
- Mobile computing
- Context adaptation
- Intelligent environment
- Adaptive architecture
- Security, privacy and management

What is Pervasive Computing?

- Technology View
 - Computers everywhere embedded into fridges, washing machines, door locks, cars, furniture, people
 - → intelligent environment
 - Mobile portable computing devices
 - Wireless communication
- User View
 - Invisible implicit interaction with your environment
 - Augmenting human abilities in context of tasks
- Ubiquitous = mobile computing + intelligent environment

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Mobility

- Mobile computing
 - Computing & communication on the move
 - Mostly voice based or embedded?
- Nomadic computing
 - Intermittent connectivity
 - Usual environment available
- Mobile agents
 - Mobile code and data

Contents

- What is pervasive computing
- Current technology
 - Current & near term gadgets
 - Wearable computing
- Mobile computing
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Current Technology 2



Matchbox computer



Web Server



Best friend

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Wearable Computers



Watch phone



Watch video



Designer Gear



Wearable or luggable?





See http://wearables.www.media.mit.edu/projects/wearables/mithril/index.html OV2001: M. Sloman

The Whisperer



NTT DOCOMO UNVEILS A WRISTWATCH-SHAPED TELEPHONE HANDSET

- Convert audio signals to vibrations sent via finger
- Send commands by tapping fingers in various rhythms



Bluetooth alternative

Usability

- Common user interface for workstation and mobile device applications
 - Adaptive information display
- Replicate characteristics of paper-based notebooks for annotatablity, robustness, universality
- Flexible voice based input-output
 - Voice recognition + text to speech conversion
- Gesture recognition
- WAP phone is not a useable computing device!!
- Remove human from loop intelligent agents?

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Brainwaves!





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- What is pervasive computing
- Current technology
- Mobile computing
 - Issues
 - Wireless communication
 - Ad-hoc networking
- Context adaptation
- Intelligent environment
- Adaptive architecture
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Mobility Issues



- How to integrate mobile communicators into complex information infrastructures?
- What effect will they have on work and leisure?
- Privacy
- How to develop and manage adaptable, context-aware software systems?
- What support is needed within the network?





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Wireless Communication

- GSM phone 9.6 Kbps
- Wireless LAN IEEE 802.11b 200 m range 2.4 Ghz band: 11 Mbps
- Bluetooth 10 m range
 2.4 Ghz band: 1 data (700 kbps) & 3 voice channels
- UMTS 3G mobile
 114 kbps (vehicle), 384 Kbps (pedestrian),
 2 Mbps (stationary)
- HIPERLAN & IEEE 802.11a
 5 Ghz band: currently 20 Mbps eventually 54 Mbps
- HomeRF derived from DECT 10Mbps
- InfraRed direct line of sight: 4Mbs

Wireless Problems

- Too many similar standards
- Shortage of spectrum
 Use low power + multiple base stations with intelligent antenna.
- Overlapping spectrum usage can cause interference eg Bluetooth and IEEE 802.11
- Unregulated bands lead to chaos
- Health risks?



- Use other devices as routers
- But, security concerns and usage of scarce battery power for relaying – possibly more suited to sensor than user networks
- See http://tonnant.itd.nrl.navy.mil/manet/manet_home.html

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Ad-hoc Network Applications

- Military battlefield
- Disaster teams
- Autonomous robots eg searching buildings, mapping toxic spills
- Meetings exchange visiting cards and information
- Car trains on motorways 100 KmPH, 2m apart automatic steering and braking



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Ad-hoc Collaborative Working

- Support for cooperative working
- Group management protocols
 - Public and private groups
- Service discovery
- Dynamic adaptation to other device interfaces

Integration of Mobile Systems

- Not stand alone devices.
 - Need to interact with complex legacy information systems eg large databases – merging updates, displaying tables etc.
- Systems development
 - Requirements specification for adaptable systems
 - Component composition to meet global QoS, security, reliability & performance requirements.
- Mobility models
 - Behaviour specification and analysis
 - Modelling context aware systems
- Interaction paradigms
 - Event-based not object invocation or RPC

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Context Awareness

- Context defined by:
 - Current location Need location detection eg GPS or base station Indoors – radio beacon, IR
 - User activity Walking, driving a car, running for a bus – how to detect this?
 - Ambient environment In theatre, alone, in meeting Local resources or services available
 - Device capabilities
 Screen, input, processing power, battery life
 - Current QoS availability particularly for radio links







Adapting Vector Maps

- Maps can be...
 - Split into features and presented in part
 - Encoded at different scales different feature detail
 - Selective adaptation can consider content being degraded

See http://www.doc.ic.ac.uk/~dc/



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Mobile Medicine Healthcare Everywhere

Applications

- Automated monitoring
 - Implanted devices
 - Smart clothing
 - Swallow/inject intelligent sensors and actuators
- Accident and emergency support
- Patient record access and integration

Benefits

- High →lower risk monitoring
- Mobility for chronically ill
- Greater out-of-hospital patient management
- Mass data & analysis

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Smart Dust

- Autonomous sensing and communication in a cubic millimeter – "dust motes"
- Sensors for temperature, humidity, light, motion
 With bidirectional radio or laser + battery
- Costs soon < \$1</p>
- Typical Applications
 - Defense related battlefield sensors, motion detectors etc.
 - Inventry control on boxes which communicate with crates, trucks, plane etc to tell you where they are
 - Product quality monitoring vibration, humidity, overheating
 - Car component monitoring
- See http://robotics.eecs.berkeley.edu/~pister/SmartDust/



Future Smart Dust

- Intelligent paper with integrated radio → replace current displays
- Smart paint monitors vibrations and detect intruders or changes colour to react to temperature, lighting etc.
- Intelligent glass can filter sunlight, become opaque → no need for curtains
- Smart garments or injectable sensors for people monitoring
- Download design and printable motes for < 1c mote www.media.mit.edu/nanomedia
- Printable batteries http://www.usatoday.com/life/cyber/tech/review/2001-02-12-batteries.htm

Pervasive Computer Problems

- What means of communication?
 Radio spectrum shortage
 Light based very directional
- Batteries would be impractical power source for 100K processors per person.
 Solar cells are not suitable for all environments.
- Solar cells + capacitors or rechargeable batteries?
- Power not speed is the key issue for future processor designs.



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Intelligent Environment - 1

- Fridge and cupboards tracks consumption and reorder your groceries
- Your car computer reminds you to pick up your order on the way home when you are near the supermarket.

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Intelligent Environment - 2

- Lights, air conditioning, TV automatically switch on and off when you enter or leave rooms
- Sit on your favourite chair and TV switches on to the program you usually watch at this time of the day
- Use communicator/pda for phone + all remote controls TV, video, music, garage door, credit card
- Route input from 'virtual' keyboard to nearest suitable display.
- Automatic detection of new items to control and physical layout in a room or office, using computer vision.





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Adaptive Application Architecure



Application Level Active Network



- See http://www.cs.ucl.ac.uk/research/alpine/



Rule governing choices in behaviour of the system

- Derived from trust relationships, enterprise goals and Service level agreements
- Need to specify and modify policies without coding into automated agents
- Policies are persistent
- But can be dynamically modified
 Change system behaviour without modifying implementation not new functionality

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Policy Based Adaptive Systems

- Authorisation policies
 Derived from trust relationships to define what
 resources or services clients can access, what
 proxylets or code can be loaded into servers, or
 what code loaded into the client can do.
- Obligation Policies Event-condition-action rules to trigger when to perform actions, what alarms to generate etc
- Ponder declarative object-oriented language for specifying policies.
 See http://www.dec.dec.io.co.uk/Decearch/policies

See http://www-dse.doc.ic.ac.uk/Research/policies/



Example Authorisation Policy

inst auth+ facilities {
 subject guests;
 target gym + pool;
 action enter;
 when time.between ("0900", "2100");
}

Obligation Policy

- Defines what actions a subject must do
- Subject based → subject interprets policy and performs actions on targets
- Event triggered obligation
- Actions can be remote invocations or local scripts
- Can specify sequencing or concurrency of actions

Example Obligation Policy

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Roles

- Group of policies with a common subject
- Defines rights (authorisations) and duties (obligation)
- Position in organisation nurse, surgeon
- Mobile 'visitor' roles in hotel or shopping mall policies which apply to mobile user in an environment
- Paramedic attending an accident

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Security

- Interactions cross multiple organisational boundaries
- Specification, analysis and integration for heterogeneous OS, databases, firewalls, routers
- Lessons from history:
 - Cell phones, IR garage doors, CATV decoders
 - Everything worth hacking gets hacked
- Need for secure 'out of the box' set up
- Identify friend or foe → level of trust
- Small communicators, with confidential data, are easily lost or stolen – biometric authentication
- Necessary security technology exists

Privacy

- Location service tracks movement to within metres (cf mobile phones but pay-as-you-go can be anonymous).
- Clearly indicate you are being sensed or recorded + user control to stop recording or control distribution of information
- You are now predictable
 - System can co-relate location, context and behaviour patterns
- Do you want employer, colleagues or insurance company to know you carry a medical monitor?
- Tension between authentication and anonymity business want to authenticate you for financial transactions and to provide 'personalized' service cf web sites
- Constant spam of context dependent advertising

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Management – the nightmare!

- Huge, complex systems
 - Billions of processors
 - Multiple organisations
 - Managing physical world, controlling sensors, actuators
 - Humans will be in the way
- Errors propagate to bring down complete regions
- Hacker and virus paradise
- System propagates false information about individuals or organisation
- Complexity of s/w installation on a workstation or server – how do you cope with billions?



Management Solutions







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- Intelligent agents, mobile agents, policy
- QoS Management
 - Fat pipes and large storage can convert media streams to short traffic bursts in core network but still needed for wireless links
- Adaptive self-management is the only answer
 - Partitioned domains of responsibility
 - Genetic algorithms may be suitable for long-term strategy but need more deterministic solutions for short term decision making
- Remove human from the loop

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- Universal PDA/communicator
- Explosion in embedded sensors/actuators
- Context-aware intelligent environment
- Privacy will be a major issue
- Out of the box security
- Will pervasive computing be manageable?
 - Not by centralised human managers
 - Adaptive self-management is needed
 - Biological paradigms

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