SSC0156 – Computação Pervasiva

Chapter 2

Applications

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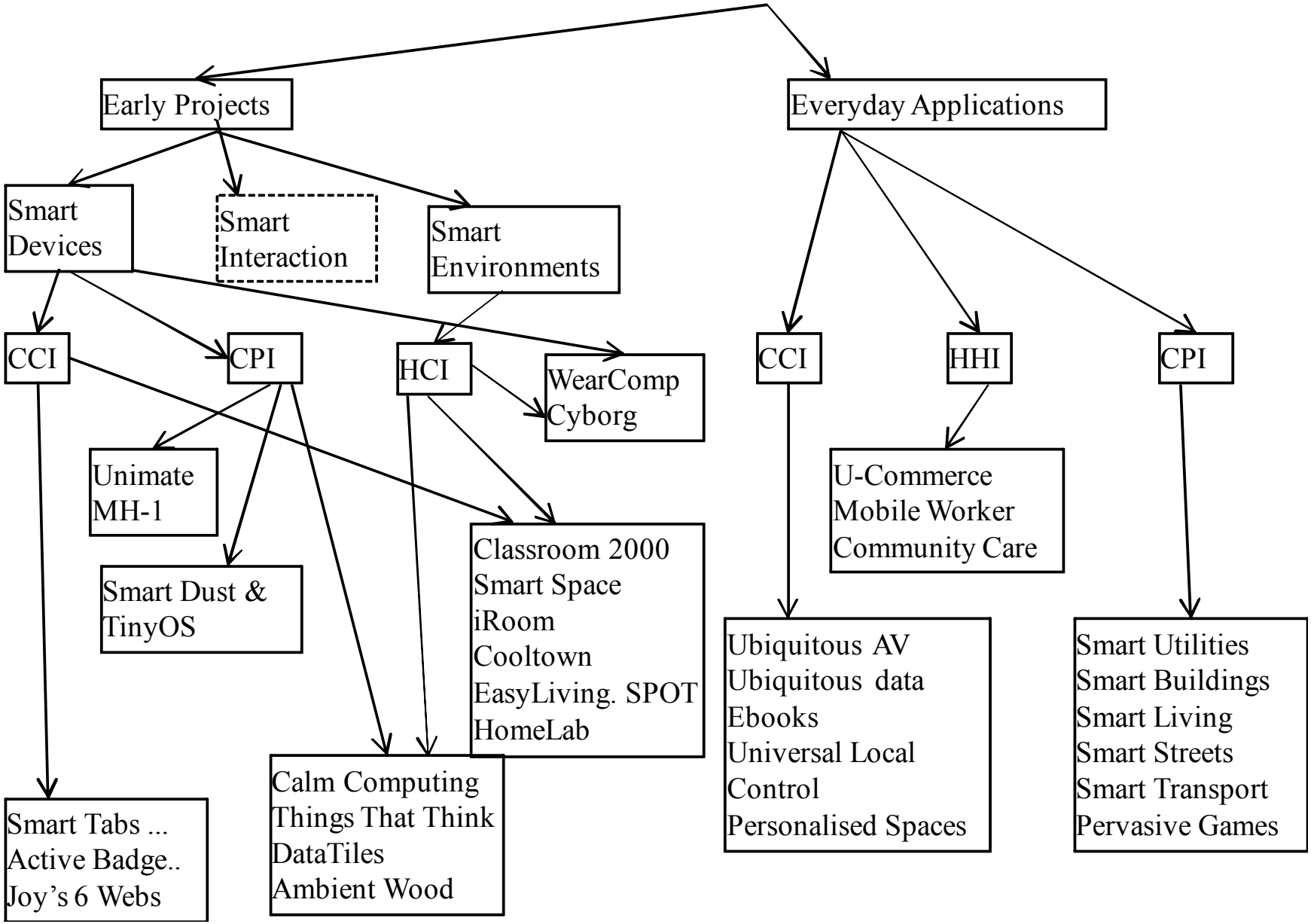
Overview

- **Early UbiCom Research Projects √**
- Everyday Applications in the Virtual, Human and Physical World
- Some example projects in more detail

Ubiquitous Computing Applications and Projects



Early UbiCom Research Projects

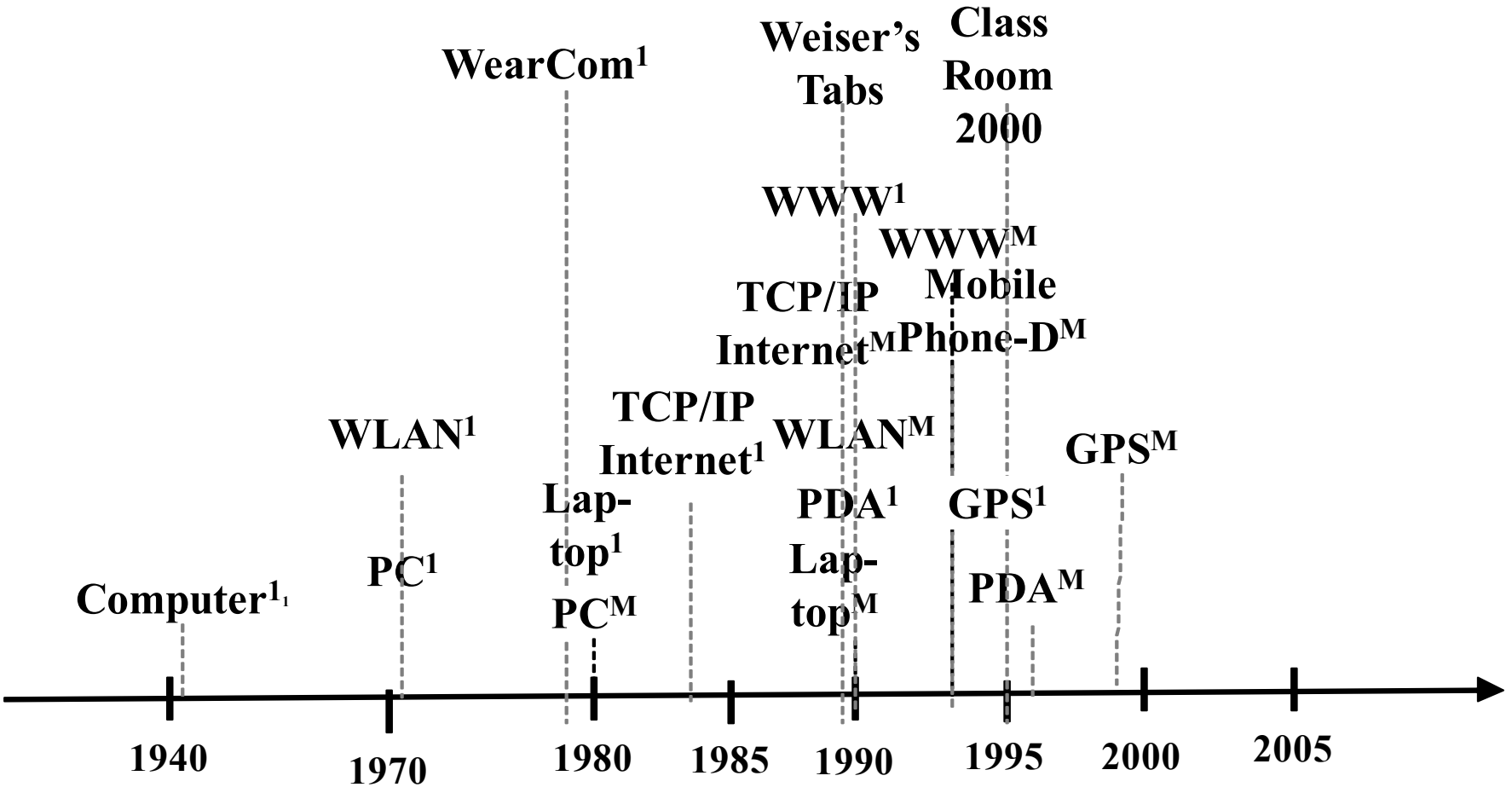
- **Smart Devices: CCI √**
  - **PARC Tab, MPad & LiveBoard; Active Badge, Bat and Floor**
- Smart Environments: CPI and CCI
  - Classroom 2000, Smart Space and Meeting Room, Interactive Workspaces and iRoom, Cooltown, EasyLiving and SPOT, HomeLab and Ambient Intelligence
- Smart Devices: CPI
  - Unimate and MH-1 Robots, Smart Dust and TinyOS
- Smart Devices: iHCI
  - Calm Computing, Things That Think and Tangible Bits, DataTiles, WearComp and WearCam, Cyborg
- Other UbiCom Projects

What ICT Environments Were Like

- Late 1980s, when much of the early work on UbiComp started
  - ???

- A distinction has been made in the history between the availability of the first prototypes or ICT product (1) and the first widespread commercial uptake of an ICT product (M).
  - Difference between the (1) and (M) phases seems to be averaging about 10 years give or take a few years.
- Today, it is hard to imagine such a world, where people were often unreachable if away from a fixed phone point and computing was only available at a desk computer, attached to the wired Internet.

Short History of ICT Technology



Could also note when specific PC technologies arose, e.g., hard-disk, mouse, removal memory cards, etc

Active Badge, Bat and Floor

Active Badge (forerunner of ParcTab) at Cambridge University / Olivetti

- 1st context-aware computing application
- Designed an aid for a telephone receptionist
- Active Badge periodically sends infrared signals to sensors embedded in rooms throughout the building.
- Limited Location determination accuracy
- See http://www.cl.cam.ac.uk/research/dtg/attarchive/bat/

Active Badge, Bat and Floor

Active Bat

- Uses ultrasound, greater accuracy ~ 3 cm.
- Base station used for position determined

Active Floor

- Identification by person's gait,
- Pros and Cons
- Special Floor design.

PARC Tab, MPad, LiveBoard

- 3 main intertwined devices and applications known as *Boards, Pads and Tabs developed at PARC*, Large wall-display program called LiveBoard

- Smaller computers Book-sized MPad

- Palm-sized ParcTab computer

- See http://www.parc.com

ClassRoom 2000

- To capture the live experiences of the occupants and to provide that record to users for later access and review.
- 1995, *Classroom 2000* (led by Abowd, Georgia Institute of Technology)
- Most research focussed on development of multimedia-enhanced materials
- Classroom 2000 researched content generation by instrumenting a room with the capabilities to automatically record a lecture

- See http://www.cc.gatech.edu/fce/eclass/pubs/

Smart Space and Meeting Room Projects

- NIST (1998-2003): use of pervasive devices, sensors & networks for context-aware smart meeting rooms that sense ongoing human activities and respond to them
- Meeting Room design.
- 2 sets of tools were used to manage sensor data.
- When people talk, system takes dictation, records a transcript of the meeting, tracks individual speakers, follow what the conversation is about and triggers associated services from the Internet.
- Design supports an iHCI model for taking notes and for assisting speakers by intuitively providing further information.
- See http://www.nist.gov/smartspace/talksAndPubs.html

Interactive Workspaces Project

- Interactive Workspaces project (Stanford University, 1999) investigated design and of rooms (iRooms) to create applications integrating the use of multiple types of devices of varying form factors
- Large displays that can be integrated to portable devices
- Also developed several interaction patterns for interacting with large high resolution displays
- Typed drag and drop support:
- See http://graphics.stanford.edu/papers/iwork-overview/

Cooltown

- HP Project , 2000-2003, to develop a vision of UbiCom to support:
  - Key feature of Cooltown is that each physical and virtual world resource has a Web presence (URL)
- 3 important benefits of using the Web for Mobile users situated in the physical world:
  - Ubiquitous access
  - Just Enough Middleware
  - Local means local:

EasyLiving & SPOT

- EasyLiving project (Microsoft, 1997-2003) developed intelligent environments to support dynamic aggregation of diverse I/O devices into a single coherent user experience.
- SPOT devices (Microsoft, 2003) designed to listen for digitally encoded data such as news stories, weather forecasts, personal messages, traffic updates, and retail directories transmitted on frequency sidebands leased from commercial FM radio stations
- Such devices could provide valuable broadcast notifications and alerts to millions of people

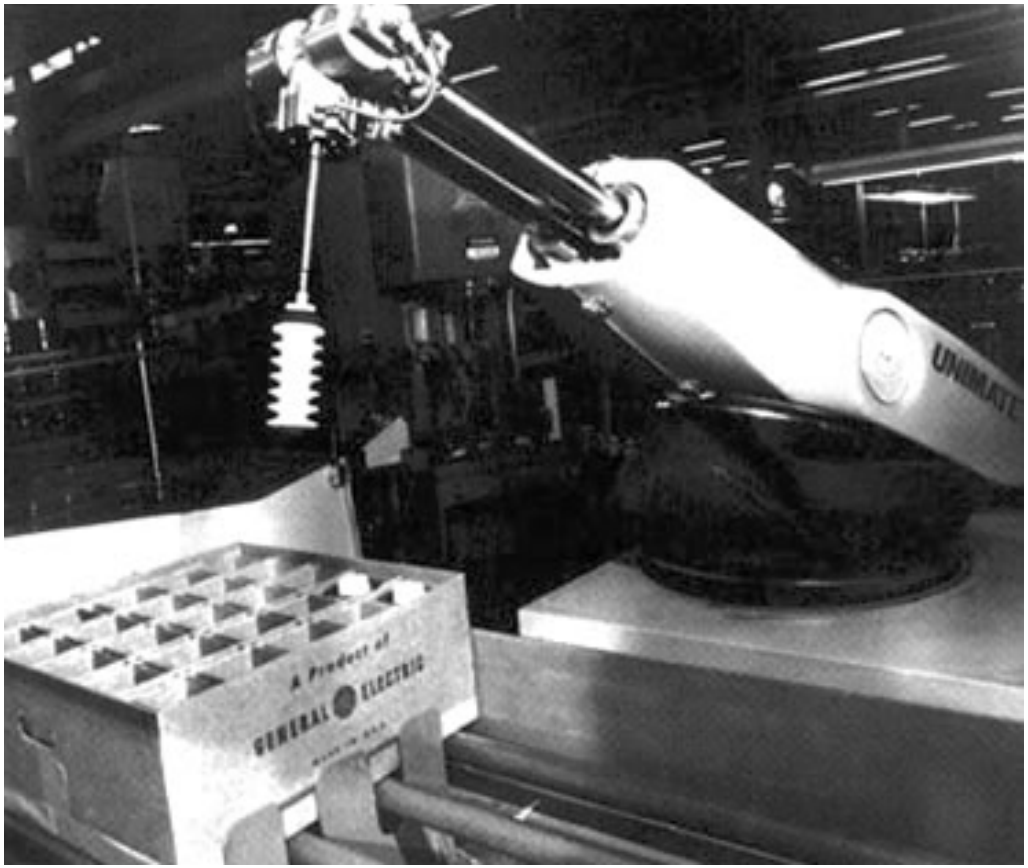
Ambient Intelligence (AmI)

- Proposed by Philips in late 1990s as a novel paradigm for consumer electronics that is sensitive responsive to the presence of people
- Recognize “particular” voices and movements
- & became part of a EU Research Framework (FP6 IST)
- Key properties of AmI systems are:
  - User-aware / iHCI: watch a football match together in a distributed manner
  - Intelligence: to control lights and sound environments
  - Balance and organize: organizes lives by issuing alerts of upcoming programs depending on personal importance

Smart Devices: Unimate and MH-1 Robots

- Machines are used to perform physical tasks that are very labour intensive and repetitive or are too dangerous or difficult for humans to implement directly.
- Automated machines that just do one thing are not robots.
- Robots have the capability of handling a range of programmable jobs.
- 1961, Ernst developed the MH-1
- 1st first industrial computer controlled robot, the Unimate designed by Engelberger

Unimate Robot



See http://www.thocp.net/reference/robotics/robotics2.htm

Smart Dust

- Micro fabrication and integration of low-cost sensors, actuators and computer controllers, MEMS (Micro Electro-Mechanical Systems)
- Can be sprayed & embedded throughout the digital environment
- Creating a digital skin that senses physical & chemical phenomena
- See Smart Dust project (Pister, UCB)

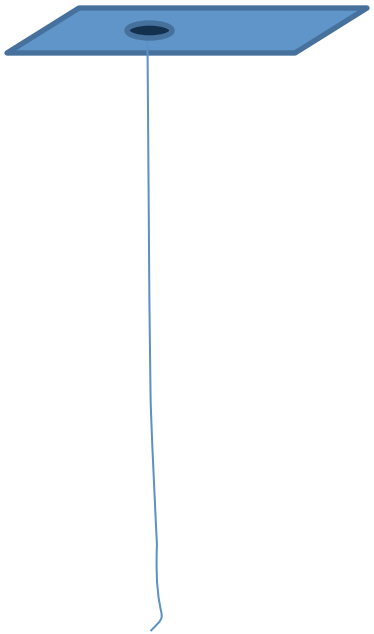
Smart Dust

Photo: courtesy of Brett Warneke

iHCI: Calm Computing

- Weiser noted whereas computers and games for personal use have focused on the excitement of interaction, when computers are all around we will interact with them differently. We often want to compute while doing something else.
- Calm technologies are said to calm us as they can empower our periphery in three ways:
  - To engage the centre of our locus
  - To enhance our peripheral reach by bringing details into the periphery (e.g. video conferences let us focus on facial expression comparing to telephone calls)
  - To offer location awareness

iHCI: Calm Computing



- Example of calm technology was the “Dangling String” created by artist Natalie Jeremijenko, situated at PARC
- String jiggled in proportion to the degree of subnet activity

iHCI: Tangible Bits & Things That Think (TTT)

- In 1997, and still to a large extent 10 years later, GUI-based HCI displayed its information as "painted bits" on rectangular screens in the foreground
- Not only visual, but now sense
- Move off the desktop to things
- In contrast, Tangible Bits project (led by Ishii, MIT, 1997) aimed to change "painted bits", into "tangible bits" by leveraging multiple senses & multimodal human interactions within the physical world
- "Tangible User Interfaces" emphasize both visually intensive, hands-on foreground interactions, and background perception of ambient light, sound, airflow, and water flow at the periphery of our senses.
- See http://ttt.media.mit.edu/, http://tangible.media.mit.edu/,

DataTiles

- DataTiles project (Sony, 2001, led by Rekimoto) focussed on interactive user interfaces that use task specific physical objects as alternatives to conventional HCI.
- No longer use conventional input devices such as mouse and keyboard
- E.g. knob and dial can be rotated
- System consists of acrylic transparent tiles with embedded RFID tags
- Advantages?

DataTiles

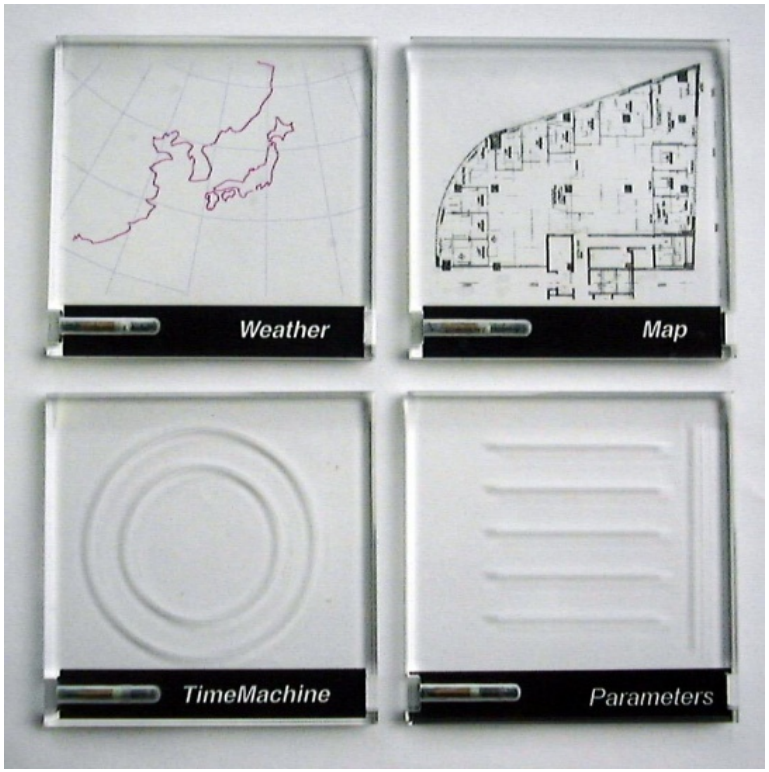


Photo courtesy of Sony Computer Science Laboratories, Inc.

- Allows users to manipulate data in form of tangible “tiles”
- Combinations of data streams and functions make it possible to create new applications

WearComp and WearCam

- Mann's experiments with wearable computers started in late 1970s.
- Main application was recording personal visual memories that could be shared with other via the Internet.

Photo courtesy of http://en.wikipedia.org/wiki/Wearable_computing

WearComp and WearCam

Later generations of WearComp supported three key features.

1. Wearable computer was hidden. Customised glasses used as HUD (head up display), conductive fabric used as BAN.
2. Mediated reality was supported, reality may be diminished or otherwise altered as desired, not just augmented.
3. Thirdly, Homographic Modelling was supported in the display.

- See http://www.eecg.toronto.edu/~mann/

Cyborg 1.0 and 2.0

- Implanted into human mobile hosts are a form of embedded device.
- Cyborg 1.0, a silicon chip transponder implanted in a forearm which remained in place for 9 days (1998, Warwick)
- Cyborg 2.0 (2002, Warwick) new implant in his lower arm could send signals back and forth between the nervous system and a computer
- See http://www.kevinwarwick.com/

Cyborg 2.0

Electrode array surgically implanted into Warwick's left arm and interlinked into median nerve fibres is being monitored.

Photo Courtesy of University of Reading

R&D UbiCom Applications

- There are many other innovative UbiCom projects, only a selection of these is given here.
- Two of the main conferences that cover a greater range of UbiCom projects are:
  - IEEE http://www.UbiCom.org
  - ACM http:// www.percom.org
- Research here (add-link) for what your institute is doing in this area

Analysis of Early Projects Achievements and Legacy

- Focus on 3 basic UbiComp properties: iHCI, context awareness and distributed access
- Many innovative iHCI projects

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Analysis of Early Projects: Distributed Access Support

- Early work at PARC and by Olivetti, late 1980s was focussed on basic smart mobile device model design for Tabs and Pads.
- Proprietary communication & location-awareness for mobile users : no commercial mobile ICT devices, widely available wireless networks.
- Late 2000s, mobile devices and wireless networks are widely available
- Service discovery of local network resources was weak and the discovery of other local environment resources is still virtually non-existent
- -> Much of the vision of Cooltown is not routinely available.
  - Reasons for this?

Analysis of Early Projects: context-awareness

- Context-awareness: mainly location awareness
- Early achievements based upon (local not global) location awareness indoors with heavily instrumented environment.
- Location-determinism today tends to be supported mainly as stand-alone devices and services that are not readily interoperable.
- GPS for outdoor use.
- Systems for indoor use are available today based, e.g., based upon trilateration using WLAN but not ubiquitous (See Chapter 8)

Analysis of Early Projects: iHCI

- Electronic boards
  - Allow users to collaboratively edit text and graphics were prototyped at PARC in the early 1990s -> later became commercial products.
  - Used in Classroom 2000 in 1995-1998 by Abowd et al. -> now routinely used in many educational establishments that support distance learning.
- Wearable smart devices
  - still in infancy, several products are available but they are not yet in pervasive use.
- iHCI
  - is a continuing research initiative.
  - Very many variations – not clear which will catch on, if there is a mass market for each of these.

Student Project Ideas

- ???

Overview

- Example Early UbiCom Research Projects
- **Everyday Applications in the Virtual, Human and Physical World √**
- Some Example Projects in More Detail

Everyware UbiCom Applications

- Vision: ubiquitous computer systems to support people in their daily activities in the physical world tasks to simplify these and to make these less obtrusive.
- People will live, work, and play in a seamless computer enabled environment that is interleaved into the world.
- Bushnell (1996) coined variations of term *ware* such as deskware, couchware, kitchenware, autoware, bedroomware and bathware to reflect the use of ubiquitous computing for routine tasks.
- Greenfeld (2006) used the term *everyware* to encompass the many different types of ware

Everyware UbiCom Applications

- Many ways to categorise UbiCom applications from an end-user perspective:

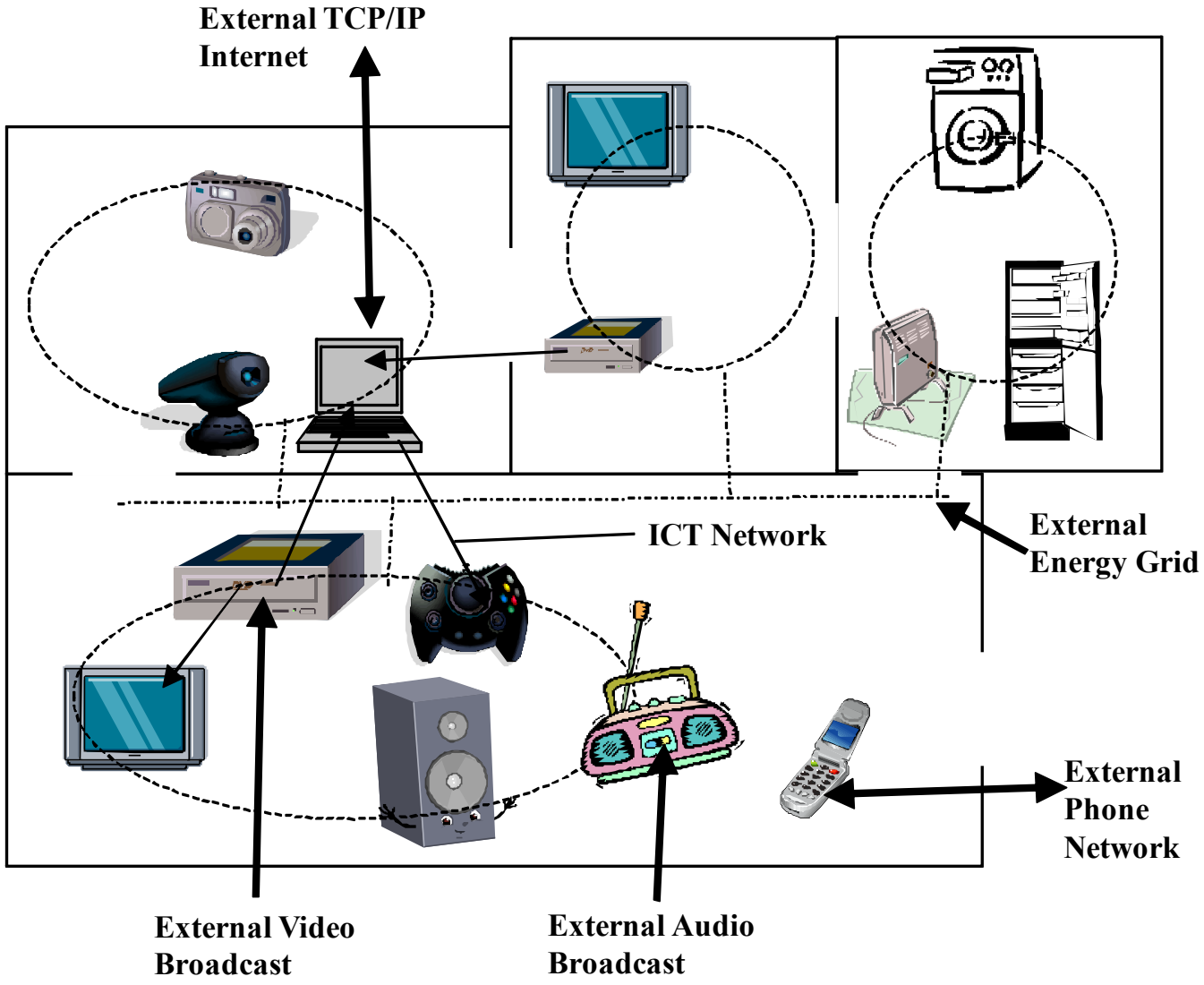
- Here we categorise applications with respect to:
  - smart mobile device versus smart environment
  - by type of environment interaction such as CCI, HCI and CPI.

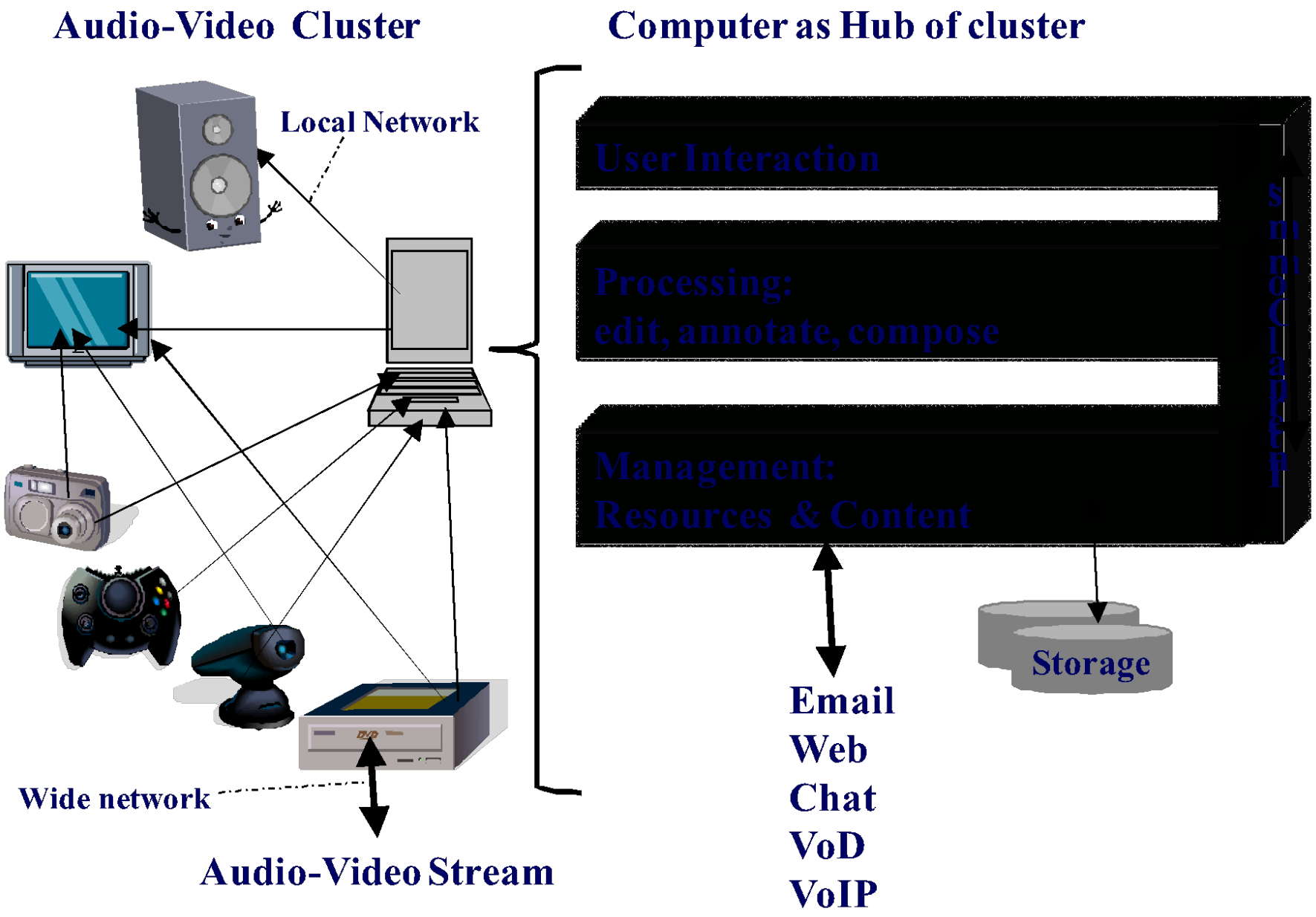
Everyware UbiCom Applications: CCI

- Ubiquitous Networks of Devices: CCI
  - Human Computer Interaction
  - Ubiquitous Audio-Video Content Access
  - Ubiquitous Information Access and Ebooks
  - Universal Local Control of ICT Systems
  - User-awareness and Personal Spaces

Ubiquitous MM Content Access

- Multi-media (MM) content via any network & access device
- Broadcast MM content, professionally, created by third-parties, copyright, non-interactive, downloaded, read-only content, stored & manipulated in access device.
- User generated, locally created content that is modifiable
- From 1 to many content services per network
- Appliances are often not connected to network (e.g. washing machines are not connected to networks)
- Currently, answerphone messages cannot be recorded and emailed subsequently.
  - Lack of system integration


External TCP/IP
Internet
ICT Network
External
Energy Grid
External
Phone
Network
External Video
Broadcast
External Audio
Broadcast


Audio-Video Cluster
Computer as Hub of cluster
Local Network
User Interaction
Processing:
edit, annotate, compose
Management:
Resources & Content
Storage
Email
Web
Chat
VoD
VoIP
Wide network
Audio-Video Stream

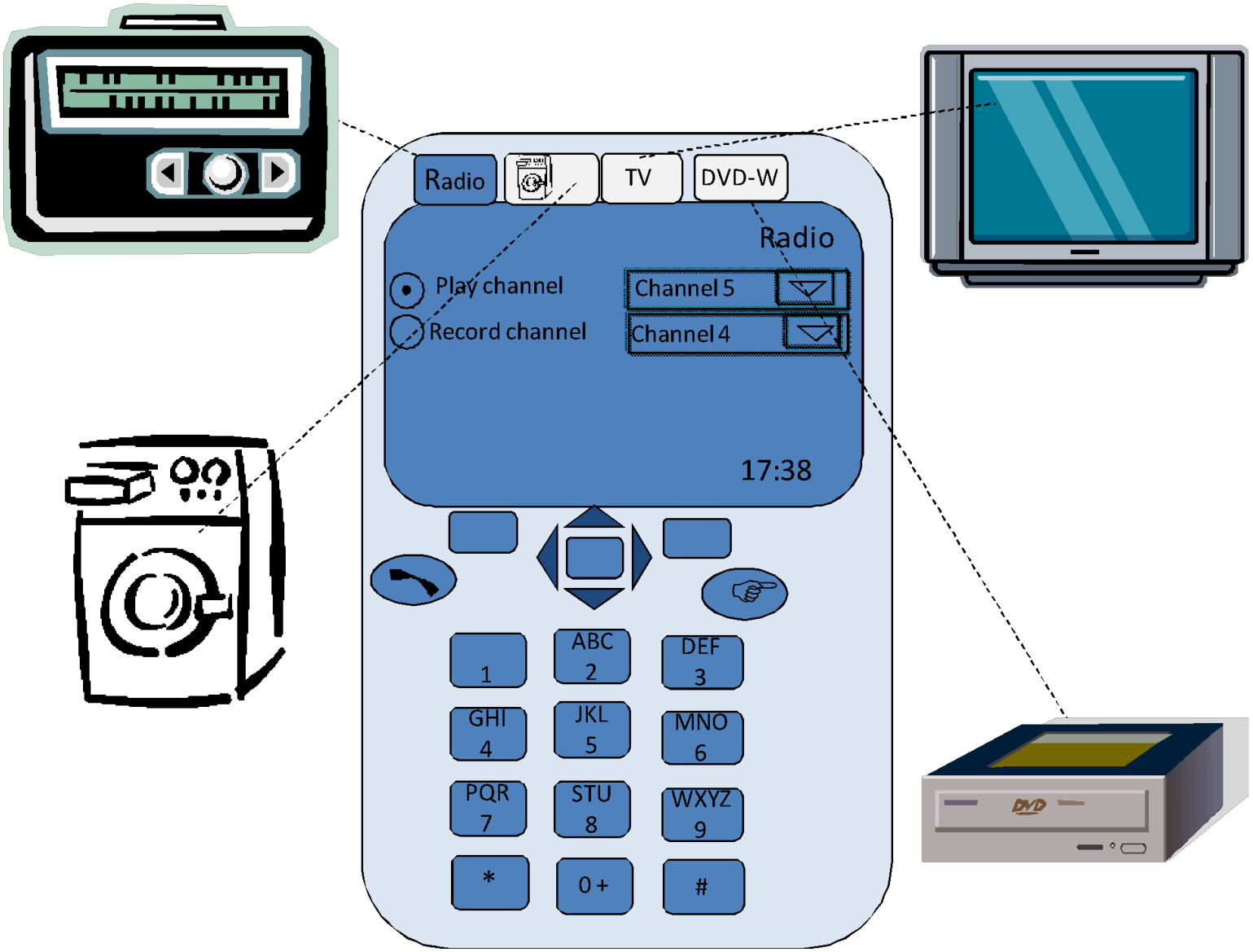
Universal Information Access

- PC still the dominant information access device
- PC suffers from a number of limitations compared to its paper counterpart. What?
- Positioning ICT system in a kitchen can provide instructions for cooking meals.
  - It should be resilient to liquid and food spillages
- Specialised reading devices: ebooks, epaper
  - E.g. www.sonystyle.com, www.amazon.com (kindle, USA only when 1st released)
- Good Content adaptation & layout critical
  - Microsoft Word, Adobe Acrobat, Web browsers have many limitations

Universal Control of Local Devices

- Appliances controlled using Infrared, short-range controller
- Some well known conventions are used to label common function buttons
- No convention for less common functions –> read the manual.
- 1 controller per appliance -> many controllers, discarded each time, appliance is upgraded
- Two types of hand-held universal local control device have been proposed that can be configured for multiple local devices:

- Use of *mobile phones* and PDAs as universal local controllers?
- Focus on control of virtual rather than physical services
  - Users can personalise the configuration of services
  - Each home occupant can access content filtered to their preferences


Radio
TV
DVD-W
Radio
Play channel
Record channel
Channel 5
Channel 4
17:38
1
ABC 2
DEF 3
GHI 4
JKL 5
MNO 6
PQR 7
STU 8
WXYZ 9
*
0 +
#
DVD

User Awareness & Personalisation

- Personalisation: content and services tailored to individuals based upon on knowledge about their preferences and behaviour. Benefits
- Greater convenience, more relevant filtered information
- but trade off against a loss in privacy.
- Users can personalise configuration of services, annotation of content
- Personal preferences could follow a user around
- Mobile devices provide an obvious means for users to personalise their environment
  - e.g. air conditioning, heating configuration

Student Project Ideas

- ???

Everyware UbiCom Applications: HHI

- Human to Human Interaction (HHI)
  - Transaction-based M-Commerce & U-Commerce services
  - Enhancing the Productivity of Mobile Humans
  - Care in the Community

M-commerce and U-Commerce

- M-Commerce: variant of E-Commerce with services over mobile-wireless infrastructure
- U-Commerce Sub-type of eCommerce / mCommerce
  - (Watson et al. 2002)
- Characterised by:
  - Universality: being able to operate everywhere in heterogeneous environments
  - Uniqueness: relating services to a context such as location
  - Unison: service orchestration, allowing multiple parties to work together
  - Ubiquity: being available everywhere

Enhancing Productivity of Mobile Humans

- Productivity can suffer from a bottleneck when people don't have the right information where & when they need it
  - E.g., sales data while travelling
- Mobile users can access calls, email, diary, calendar and notepads
  - Does greater mobile service access empower or enslave us?
- Two-way interaction versus unilateral workflow across time & space
  - e.g. sale staff leading to faster decision making based on local evaluation and knowledge being shared
- Communities of practice
  - Use of more informal information and task exchange that can take place among peers
- Challenges?
  - Collaborative work, workflows, etc.

Care in the Community

- ‘Vulnerable’ individuals at home monitored by friends, family and health professionals situated elsewhere.
- Care home for chronic ill-health, elderly and/or disabled people
- There are two basic kinds of approaches in terms of:
  - whether the subject explicitly asks for help from others or
    - e.g. pull cord system in the UK
  - Whether others can anticipate when the subject requires help.
    - e.g. infrared movement sensors;
    - user not getting out of bed;
    - being less active than usual;
    - low room temperature

Project Ideas

- Mobile services: various
- Combined Indoor and outdoor spatial information system
- Care in the Community: sensing activity
- Etc.

Everyware UbiCom Applications: (HPI, CPI)

- Physical Environment Awareness
- (Physical) Environment Control
- Smart Utilities (See Chapter 1)
- Smart Buildings and Home Automation
- Smart Living Environments and Smart Furniture
- Smart Street furniture
- Smart Vehicles, Transport and Travel
- Pervasive Games and Social Physical Spaces

Physical Environment Awareness

- Services slanted towards specific physical environment contexts, e.g., location awareness, temperature, rainfall, etc.
- Short-range (point-based, static) context determination
  - e.g. tracking keys
- Longer range(regional, roaming) context access
  - Tracking posts
- Sensors for specific physical world phenomena are statically embedded into specific devices and services,
  - e.g., sprinkler systems can water the garden periodically if It does not rain

(Physical) Environment Control

- Mobile phone or other hand held device can use a wireless link to issue simple control instructions
  - E.g., garage door and car door
- Resources may be public, private, commercial
- privately owned, e.g., garage door or car door
- provided as pay per use services, e.g. drinks dispenser

- N.B. control and reconfiguration of many devices is manual not remotely controlled.

Smart Buildings and Home Automation

- Sensors & automation is increasing used in buildings to automate control of light, climate, doors, windows, security, ↑ energy efficiency.
- Sensors & control devices can be put in physical environment in a variety of ways
- Home automation, e.g., X10 powerline protocol (smart grid), seems more common in U.S. vs Europe
- Building today not well suited to keep pace with rapid technological changes and with recent sustainability concerns.

Smart Living Environments and Smart Furniture

- Several smart environment devices can adapt to human activities.
- Doors, lighting, taps and air ventilation can be designed to detect the presence of humans, to be activated by them and to adapt to them.
- *Smart fridge* behaves as a stock-control system
- MediaCup (Beigl et al., 2001): smart cups can warn users if content is too hot
- *Smart chairs* such as SenseChair (Forlizzzi et al., 2005)
- *Smart clocks* e.g., Microsoft wherabouts clock.
- *Smart mirrors: ca*n move to adapt view, e.g., as car moves, can overlay other information, can link to cameras.
- *Smart wardrobe* (suggests outfit according to temperature), s*mart bed*, *smart pillow Smart Mat*, *smart sofa* (*Park et al. 2003).*

Smart Vehicles, Transport and Travel

- Embedded computer systems increasingly being used within vehicles.
- Improves operation such as automatically controlling or providing assisted control.
- Automatically guided vehicles along track (no driver)
- Inform waiting passengers of the status of arriving & departing vehicles.
- Location determination for remote tracking of vehicles
- Access travel info. much more conveniently
- Travel Tickets are also smarter – see smart cards (Chapter 4)
- Access to Internet in moving smart vehicles (e.g. car as mobile routers)

Social Physical Spaces & Pervasive Games

- On detecting friends within a local vicinity, suggest meeting point, e.g., ImaHima
- Local traders electronic offers.
- Many social and economic issues

- Games: a core type of entertainment, social, interactive, application.
- Traditional or pre-electronic games: 2 types of interaction, HPI and HHI, uses game control interface (d-pad interface)
- In pervasive gaming, social activities and games exploit the potential of combining the physical space
- Electronic game types: mobile games, location-based games, *Augmented reality games, Adaptronic games,* Pervasive games..

Project Ideas

- ???

Overview

- Example Early UbiCom Research Projects
- Everyday Applications in the Virtual, Human and Physical World
- **Some Example Projects in More Detail √**

Example 1:

- Instructors to add examples here

Summary & Revision

For each chapter

- See book web-site for chapter summaries, references, resources etc.
- Identify new terms & concepts
- Apply new terms and concepts to old and new situations & problems
- Debate problems, challenges and solutions
- See Chapter exercises on web-site

Exercises: Define New Concepts

- Cooltown etc

Exercise: Applying New Concepts

- (See Web-site: http://www.elec.qmul.ac.uk/people/stefan/ubicom)