Ubiquitous Computing
L4 UbiComp System and Environment

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- Considering the technological changes across computing's first three generations, how might the next serve humanity?
- Three critical technologies:—
  - the cloud,
  - the crowd, and
  - the shroud of devices connecting the physical and digital worlds
- Those three define the fourth generation of collective computing.

Why Build Ubicomp Systems? [2]

- The answer in chapter-2, page 51- 52
- Make as Home Work (HW) a mini_project setting your objectives and following the design approach?

Three Environment

Elements of the environment:

- *Computing environment (ICT env.)* —available processors, devices accessible for user input and display, network capacity, connectivity, and costs of computing, etc.
- *User environment (and human)*—location, collection of nearby people, and social situation, etc.
- *Physical environment*—materials, medium, lighting and noise level, etc.

- Augmented Reality (AR) is characterised as being immersed in a physical environment in which physical objects can be linked to a virtual environment. AR can enhance physical reality by adding virtual views to it e.g., using various techniques such as see through displays and homographic views.
- Virtual Reality (VR) immerses people in a seamless, non embodied, computer generated world. VR is often generated by a single system, where time and space are collapsed and exists as separate reality from the physical world.

Main UbiComp Properties

- Distributed and Integrated system
- Uses natural interfaces and easy to use with calm computing,
- Context awareness,
- Autonomy, and
- Artificial intelligence.

Distributed Advantages

Table -2 Distributed system properties

Distributed System, middleware, set of generic services	
Universal, seamless, heterogeneous	Able to operate across different homogeneous environments, seamless integration of devices and environments, taking on new contexts when new resources become available
Networked	UbiCom devices are interlinked using a network which is often wireless
Synchronised, coordinated	Multiple entity interaction can be coordinated synchronously or asynchronously over time and space interactions
open	New components can be introduced and accessed, old ones can be modified or retired. Components can be dynamically discovered
Transparent, virtual	Reduces the operational complexity of computing, acting as a single virtual system even although it is physically distributed
Mobile, nomadic	Users, services, data, code and devices may be mobile

1. Computers need to be networked, distributed and transparently accessible.

2. Human computer interaction needs to be hidden more.

3. Computers need to be context aware in order to optimise their operation in their environment. It is proposed that there are two additional core types of requirements for UbiCom systems:

4. Computers can operate autonomously, without human intervention, be self governed, in contrast to pure human computer interaction (point 2).

5. Computers can handle a multiplicity of dynamic actions and interactions, governed by intelligent decision making and intelligent organisational interaction. This may entail some form of artificial intelligence in order to handle:

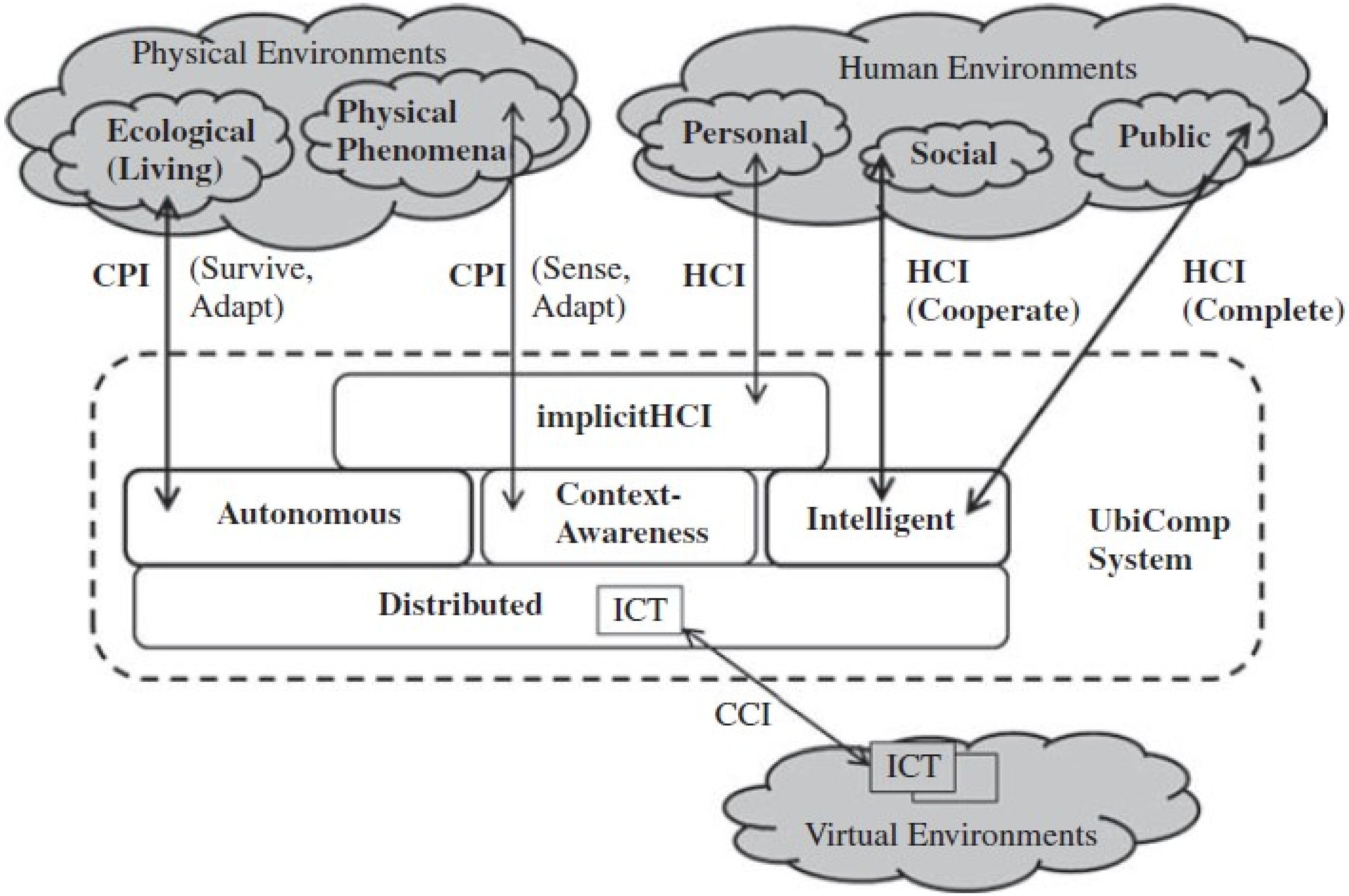
   (a) incomplete and non deterministic interactions;

   (b) cooperation and competition between members of organisations;

   (c) richer interaction through sharing of context, semantics and goals.

Interactions

- Human to Human Interaction (HHI) has been well studied by researchers
- How can we use some of the lessons about HHI to facilitate HCI?
- Implicit Human Device Interaction (iHCI)
- Recognize that ***<u>Interaction</u>*** is a shared ***<u>responsibility</u>*** and requires management and repair.
- Failure and discovery



A UbiCom system model. The dotted line indicates the UbiCom system boundary

Physical Interaction (CPI)

- Computer to physical Interaction (CPI)
- Physical World to Physical World Interaction (P2P) refers to interactions within nature that are (as yet) not mediated by any significant ICT system. There are a variety of simple animal life interactions used in nature, in contrast to the more complex human to human interaction.

Connecting the Physical World with UbiComp Systems

- GPS systems for location awareness.
- Localization and using physical and virtual environment to capture images.
- RF identification (RFID) tags (passive and Active).
- Sensors and WSN
- Microelectromechanical systems (MEMS)
- Sensor and Actuation; the sensor transducers a particular form of energy (heat, light) into information. Actuation lets a node convert info into action, but its main role is to enable better sensing.

Ubiquitous Networks of Devices: CCI

- The ubiquitous network development is envisaged along three dimensions [3]:
  - any place: at the PC, in other rooms, outdoors, in moving vehicles.
  - any time: while indoors at the PC, indoors not at the PC, out and about (at a destination away from home, e.g., shops, cinema, and friends, etc.) and on the move.
  - any object: PC to PC, person to person, person to object and object to object.

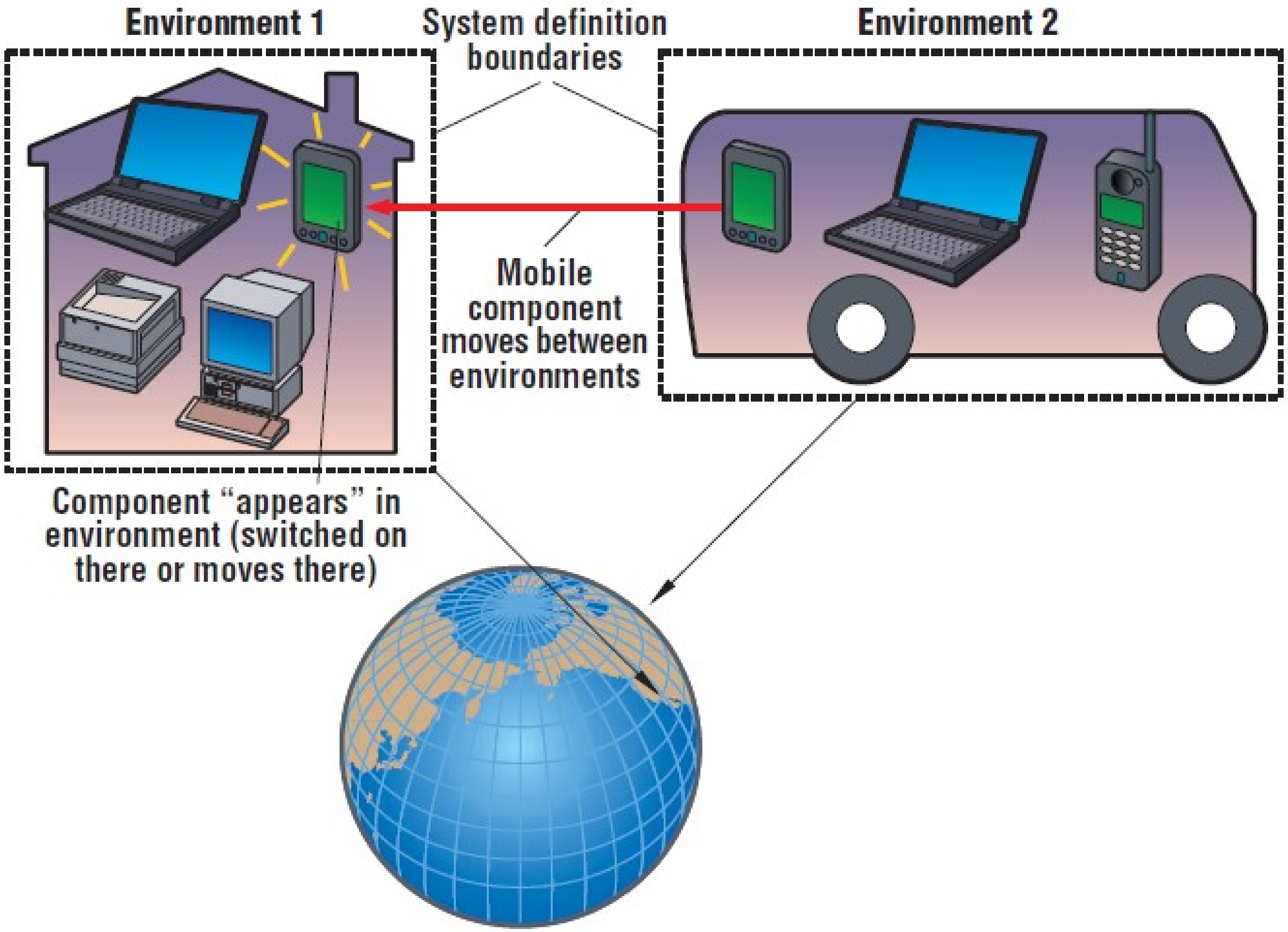
Uncertain Interaction

- Sensors produce concrete data with uncertain or ambiguous interpretation
  - Location Data (GPS)
  - Temperature
- Computers can make bad/wrong decisions based on uncertain data
  - Interrupting user
  - Making poor decisions on user's behalf
  - Communicating wrong information

- Complexity and Uncertain Interaction

- The need for Integrations

- Ubicomp system designers should divide the ubicomp world into environments with *boundaries that demarcate* their content. A clear *system* <u>*boundary criterion*</u>*—often,*
- but not necessarily, related to a boundary in the physical world—should exist. A boundary should specify an environment's scope but doesn't necessarily constrain interoperation.



The ubiquitous computing world comprises *environments* with boundaries and components appearing in or moving between them

Environments: There are *components—units of software that* implement abstractions such as services, clients, resources, or applications.

- An environment can contain infrastructure components, which are more or less fixed, and *spontaneous components* based on devices that arrive and leave routinely.

Network Protocols and Apps

- Three types of wide area ICT networks can be ubiquitous at this time:

  (1) Integrating GSM and other wireless telecoms networks (5G and 6G networks);

  (2) TCP/IP based wireless access networks attached to a wired Internet backbone; satellite networks including Global Positioning System (GPS) networks.

  (3) A network of heterogeneous networks (IoT), is increasingly being used as a universal backbone network to deliver many different logical media applications, e.g., email, Web, video and audio data over a variety of physical media networks

Heterogeneous Execution Environments

- Most UbiComp applications and systems inherently live in a heterogeneous environment.
- Ubicomp applications often involve a wide range of hardware, network technology, operating systems, input/output capabilities, resources, sensors, etc., and
- In contrast to the traditional use of the term *application*, which typically refers to software that resides on one—at most, two—physical nodes, a UbiComp application typically spans several devices, which need to interact closely and in concert in order to make up the application.

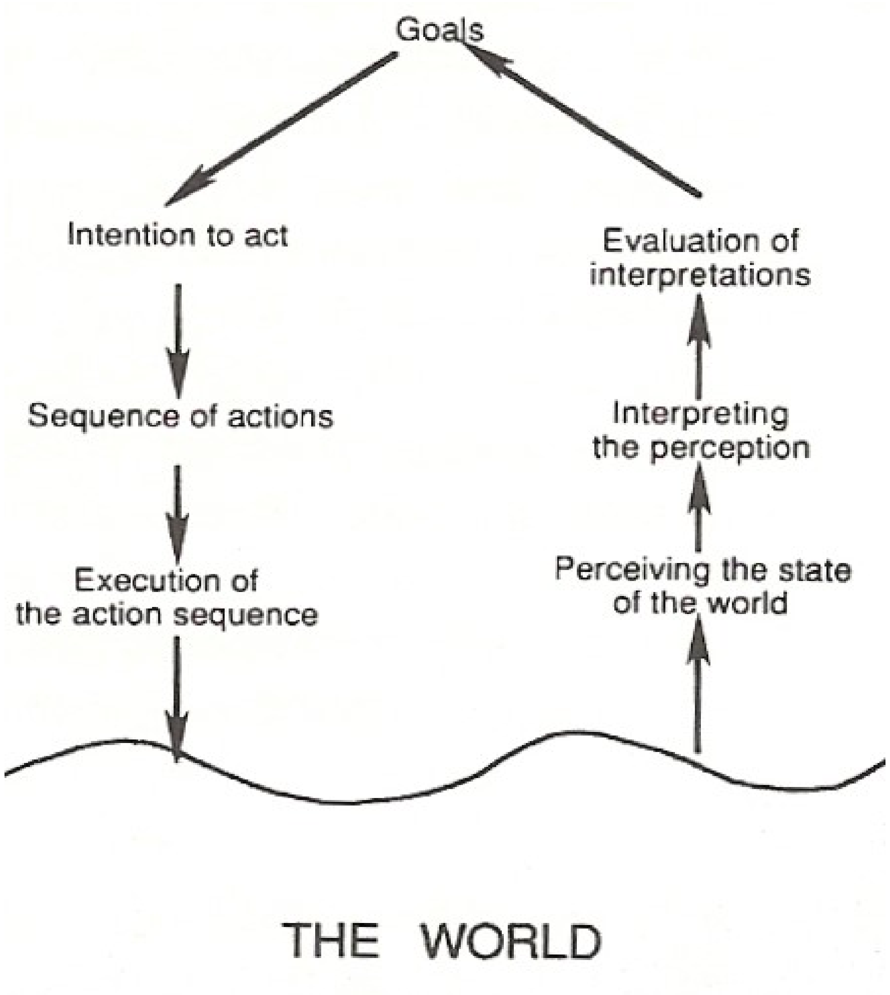
Fluctuating Usage Environments

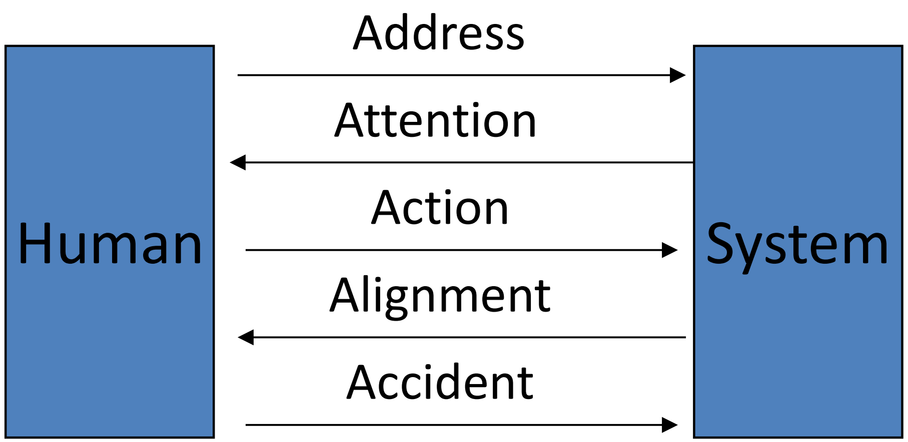
- Targeted at handling three types of fluctuation in usage environment:
  - (1) changing location of users,
  - (2) changing context of the computer, and
  - (3) multiple activities (or tasks) of the users.

Volatile Execution Environments

- *Service discovery*, that is, technologies and standards that enable devices to discover each other, set up communication links, and start using each others' services.
- Several service discovery technologies have now matured and are in daily use in thousands of devices. These include Jini, UPnP, Bonjour/multicast DNS (mDNS), and the Bluetooth discovery protocol.

Stages of Action vs. Conversation Issues





Applications

- HomeLab and Ambient Intelligence [5]
- Classroom 2000
- Smart Space and Meeting Room
- Interactive Workspaces and iRoom
- Cooltown
- EasyLiving and SPOT
- HomeLab and Ambient Intelligence

Dey el al. (2000) **Table 1.** Application of context and context-aware categories

System Name	System Description	Context Type				Context-Aware		
		A	I	L	T	P	E	T
Classroom 2000 [1]	Capture of a classroom lecture			X	X			X
Cyberguide [1]	Tour guide		X	X		X		
Teleport [2]	Teleporting	X	X	X			X	
Stick-e Documents [3,4,5]	Tour guide		X	X	X	X		X
	Paging and reminders	X	X			X		X
Reactive Room [6]	Intelligent control of audiovisuals	X	X	X			X	
GUIDE [7]	Tour guide			X		X		
CyberDesk [8,9,10]	Automatic integration of user services	X				X	X	
Conference Assistant [11]	Conference capture and tour guide	X	X	X	X	X		X
Responsive Office [12]	Office environment control			X	X		X	
NETMAN [13,16]	Network maintenance			X		X		
Fieldwork [17,18,22]	Fieldwork data collection			X	X	X		X
Augment-able Reality [19]	Virtual post-it notes			X		X		X
Context Toolkit [24]	In/Out Board		X	X	X	X		
	Capture of serendipitous meetings		X	X	X		X	X
Active Badge [28]	Call forwarding		X	X		X	X	

Location Aware App

- RADAR was the first example of a wireless system allowing mobile computers to locate themselves in a building [an indoor global positioning system (GPS)]. It was designed around the first WiFi (802.11b) radios that were commercially available, and made use of RSSI reception maps in a Microsoft building hosting several access points (APs) with the data collected using a wireless survey tool. By comparing the received signal strength indication (RSSI) reading for each AP measured at a point of interest with the RSSI signal maps on record, the system could automatically determine a mobile computer's most likely location to an accuracy of 2–3 meters (Bahl and Padmanabhan, 2000).

UbiComp System Design Approach [2] page 53

1- Setting Your ideas and objectives

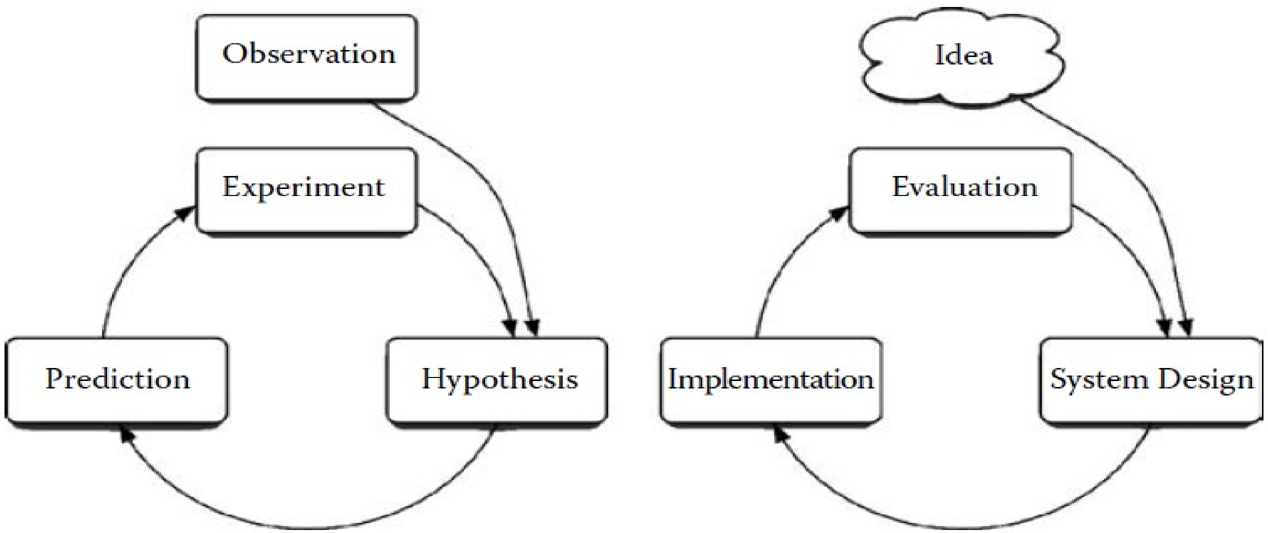
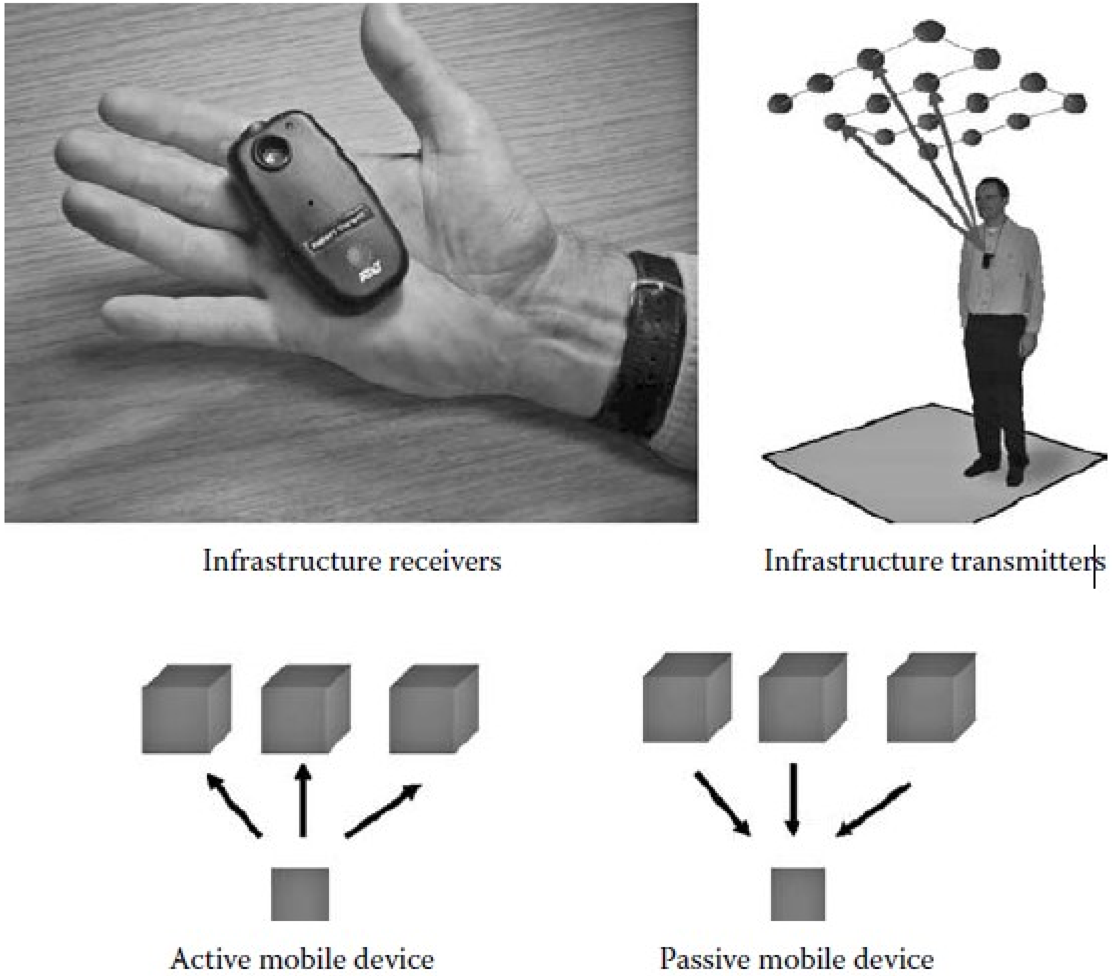


FIGURE 2.1 Compare scientific method (on the left) with the role of experimentation in ubicomp system design (right) (paraphrased from Feitelson, 2005). As one experiment may enable a hypothesis to be refined leading to further experiments cyclically, so a system design may lead to another and be iteratively refined. Importantly, developing and evaluating a system may uncover a hypothesis that can be experimentally tested, and vice versa.



- [2]

FIGURE 7.7 Top: Active Bat tags and example placement of receivers (http://research.microsoft.com/en-us/people/shodges/past.aspx). Bottom: Active (e.g., Active BAT) versus passive (e.g., Cricket) approach to location tracking systems.

• [2]

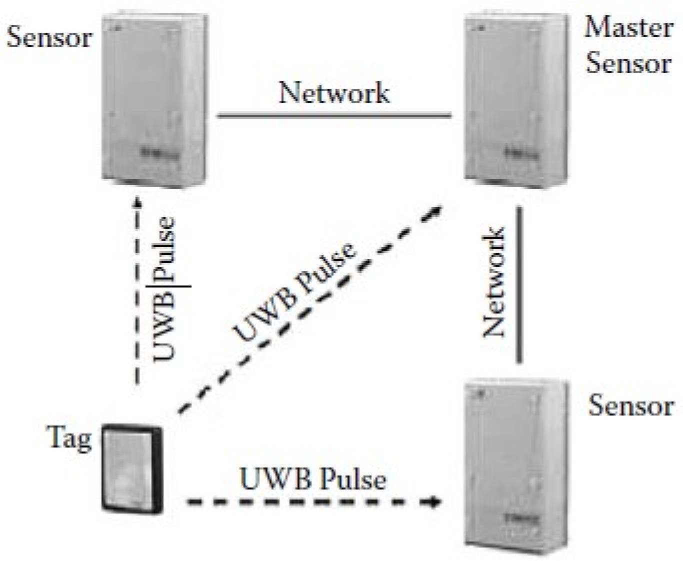


FIGURE 7.9 Top: Infrastructure architecture for Ubisense. Bottom: Ubitags are shown on the left and Ubisensor on the right (http://www.ubisense.net).

Change of direction From Weiser's Views [6]

- Three themes that have dominated are context awareness, ambient intelligence and monitoring/tracking.
- Focuses on engaging rather than calming people:
  - **Playful and Learning Practices**
  - **Scientific Practices**
  - **Persuasive Practices**

Questions

- In terms of the six forms for UbiCom: tabs, pads, boards, dust, skin and clay, how would you classify the vibrating string form Calm Computing artefact?
- What is Ambient Intelligence? Give some examples. Does smart environment interaction really need intelligence?
- Think up your own tangible UbiCom devices and discuss their benefits and design challenges.

References

[1] Weiser, M., The computer for 21st century, 1991.

[2] John Krumm, Ubiquotous Computing Fundamentals, 2010.

[3] Murakami, T. (2004) Ubiquitous networking: business opportunities and strategic issues. Available via Nomura Research Institute home page, http://www.nri.co.jp/english/.

[4] Spinellis, D.D. (2003) The information furnace: consolidated home control. Personal and Ubiquitous Computing, 7(1): 53 69.

[5] Weber, W. (2003) Ambient intelligence industrial research on a visionary concept. Proceedings of 2003 International Symposium on Low Power Electronics and Design, ISLPED ’03, pp. 247 256.

[6] Yvonne Rogers, Moving on from Weiser’s Vision of Calm Computing:Engaging UbiComp Experiences, Springer-Verlag Berlin, LNCS 4206, pp. 404 – 421, 2006.