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Ubiquitous/Pervasive Computing

Assem Abdel Hamed Mousa
Ecommerce Technical Support Systems Manager, Cairo, Egypt

Abstract:
2013: The year of the Internet of Things; The Internet of Things probably already influences your life. And if it doesn't, it soon will, say computer scientists; Ubiquitous computing names the third wave in computing, just now beginning. First were mainframes, each shared by lots of people. Now we are in the personal computing era, person and machine staring uneasily at each other across the desktop. Next comes ubiquitous computing, or the age of calm technology, when technology recedes into the background of our lives. Alan Kay of Apple calls this "Third Paradigm" computing.
Ubiquitous computing is essentially the term for human interaction with computers in virtually everything.
Ubiquitous computing is roughly the opposite of virtual reality. Where virtual reality puts people inside a computer-generated world, ubiquitous computing forces the computer to live out here in the world with people. Virtual reality is primarily a horse power problem; ubiquitous computing is a very difficult integration of human factors, computer science, engineering, and social sciences.
The approach: Activate the world. Provide hundreds of wireless computing devices per person per office, of all scales (from 1" displays to wall sized). This has required new work in operating systems, user interfaces, networks, wireless, displays, and many other areas. We call our work "ubiquitous computing". This is different from PDA's, dynabooks, or information at your fingertips. It is invisible; everywhere computing that does not live on a personal device of any sort, but is in the woodwork everywhere. The initial incarnation of ubiquitous computing was in the form of "tabs", "pads", and "boards" built at Xerox PARC, 1988-1994. Several papers describe this work, and there are web pages for the Tabs and for the Boards (which are a commercial product now):
Ubiquitous computing will drastically reduce the cost of digital devices and tasks for the average consumer. With labor-intensive components such as processors and hard drives stored in the remote data centers powering the cloud , and with pooled resources giving individual consumers the benefits of economies of scale, monthly fees similar to a cable bill for services that feed into a consumer's phone

1.Definitions

Ubiquitous computing is the method of enhancing computer use by making many computers available throughout the physical environment, but making them effectively invisible to the user
– Mark Weiser
Ubiquitous computing, or calm technology, is a paradigm shift where technology becomes virtually invisible in our lives.
-- Marcia Riley

2.Ubiquitous Computing (Ubicomp)

It is a post-desktop model of human-computer interaction in which information processing has been thoroughly integrated into everyday objects and activities.
This paradigm is also described as **pervasive computing**, ambient intelligence, or, more recently, **everywhere**,] where each term emphasizes slightly different aspects. When primarily concerning the objects involved, it is also **physical computing**, the Internet of Things, hap tic computing, and things that think. Rather than propose a single definition for ubiquitous computing and for these related terms, taxonomy of properties for ubiquitous computing has been proposed, from which different kinds or flavors of ubiquitous systems and applications can be described.
Three Waves of Computing

- Mainframe computing (60's-70)
  Massive computers to execute big data processing applications
  Very few computers in the world

- Desktop computing (80's-90)
  One computer at every desk to help in business related activities
  Computers connected in intranets to a massive global network
  (Internet), all wired
- Ubiquitous computing (00's?)

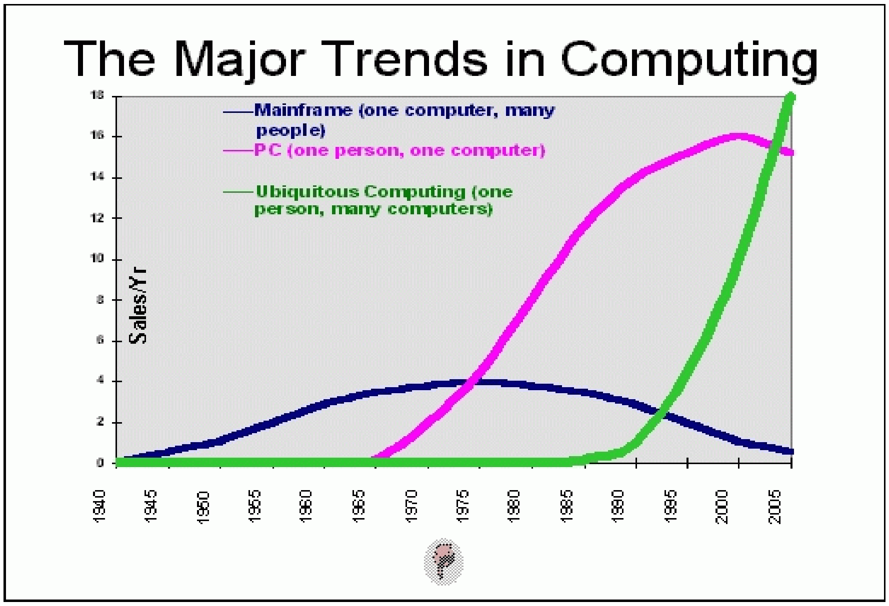

Figure 1

– Tens/hundreds of computing devices in every room/person, becoming
"Invisible" and part of the environment
Tangible interface).

3.Core concepts

At their core, all models of ubiquitous computing share a vision of small, inexpensive, robust networked processing devices, distributed at all scales throughout everyday life and generally turned to distinctly common-place ends. For example, a domestic ubiquitous computing environment might interconnect lighting and environmental controls with personal biometric monitors woven into clothing so that illumination and heating conditions in a room might be modulated, continuously and imperceptibly. Another common scenario posits refrigerators "aware" of their suitably tagged contents, able to both plan a variety of menus from the food actually on hand, and warn users of stale or spoiled food.

Ubiquitous computing presents challenges across computer science: in systems design and engineering, in systems modeling, and in user interface design. Contemporary human-computer interaction models, whether command-line, menu-driven, or GUI-based, are inappropriate and inadequate to the ubiquitous case. This suggests that the "natural" interaction paradigm appropriate to a fully robust ubiquitous computing has yet to emerge - although there is also recognition in the field that in many ways we are already living in an ubicomp world. Contemporary devices that lend some support to this latter idea include mobile phones, digital audio players, radio-frequency identification tags, GPS, and interactive whiteboards.

Mark Weiser proposed three basic forms for ubiquitous system devices, see also Smart device: tabs, pads and boards.

- Tabs: wearable centimeter sized devices
- Pads: hand-held decimeter-sized devices
- Boards: meter sized interactive display devices.

These three forms proposed by Weiser are characterized by being macro-sized, having a planar form and on incorporating visual output displays. If we relax each of these three characteristics we can expand this range into a much more diverse and potentially more useful range of Ubiquitous Computing devices. Hence, three additional forms for ubiquitous systems have been proposed:

- Dust: miniaturized devices can be without visual output displays, e.g., Micro Electro-Mechanical Systems (MEMS), ranging from nanometers through micrometers to millimeters. See also Smart dust.
- Skin: fabrics based upon light emitting and conductive polymers, organic computer devices, can be formed into more flexible non-planar display surfaces and products such as clothes and curtains, see OLED display. MEMS device can also be painted onto various surfaces so that a variety of physical world structures can act as networked surfaces of MEMS.

- Clay: ensembles of MEMS can be formed into arbitrary three dimensional shapes as artifacts resembling many different kinds of physical object (see also Tangible interface).

In his book The Rise of the Network Society, Manuel Cast ells suggests that there is an ongoing shift from already-decentralized, stand-alone microcomputers and mainframes towards entirely pervasive computing. In his model of a pervasive computing system, cast ells uses the example of the Internet as the start of a pervasive computing system. The logical progression from that paradigm is a system where that networking logic becomes applicable in every realm of daily activity, in every location and every context. Cast ells envisage a system where billions of miniature, ubiquitous inter-communication devices will be spread worldwide, "like pigment in the wall paint".

Ubiquitous computing may be seen to consist of many layers, each with their own roles, which together form a single system:

- Layer 1: task management layer
  Monitors user task, context and index
  Map user's task to need for the services in the environment
  To manage complex dependencies
- Layer 2: environment management layer
  To monitor a resource and its capabilities
  To map service need, user level states of specific capabilities
- Layer 3: environment layer
  To monitor a relevant resource
  To manage reliability of the resources

4.Examples

One of the earliest ubiquitous systems was artist Natalie Jeremijenko's "Live Wire", also known as "Dangling String", installed at Xerox PARC during Mark Weiser's time there. This was a piece of string attached to a stepper motor and controlled by a LAN connection; network activity caused the string to twitch, yielding a peripherally noticeable indication of traffic. Weiser called this an example of calm technology

Ambient Devices has produced an "orb", a "dashboard", and a "weather beacon": these decorative devices receive data from a wireless network and report current events, such as stock prices and the weather, like the Nabaztag produced by Violet Snowden.

The Australian futurist Mark Pesce has produced a highly configurable 52-LED LAMP enabled lamp which uses Wi-Fi named MooresCloud after Moore's Law

The Unified Computer Intelligence Corporation has launched a device called Ubi - The Ubiquitous Computer that is designed to allow voice interaction with the home and provide constant access to information.

5.What Ubiquitous Computing Isn't

- A Mobile Computer – even if you have access to “everything” you do it only through one access point.
- Multimedia Computing – while it may employ sound and video it should fade into the background rather than demand the focus of your attention.
- Virtual reality - where virtual reality puts people inside a computer-generated world, ubiquitous computing forces the computer to live out here in the world with people.

5.1.Related Fields

- Sensor networks
- Human-computer interaction
- Artificial intelligence
- Sensor Networks
- A sensor network consists of a large number of tiny autonomous computing devices, each equipped with sensors, a wireless radio, a processor, and a power source.
- Sensor networks are envisioned to be deployed unobtrusively in the physical environment to monitor a wide range of environmental phenomena
- E.g., environmental pollutions, seismic activity, wildlife
- Human Computer Interaction (HCI)
- HCI is the study of interaction between people (users) and computers.
- Goal of HCI: to improve the interaction between users and computers by making computers more user-friendly and receptive to the user's needs.
- Long term goal of HCI: to design systems that minimize the barrier between the human's cognitive model of what they want to accomplish and the computer's understanding of the user's task.
- Artificial Intelligence
- AI can be defined as intelligence exhibited by an artificial (non-natural, manufactured) entity.

- AI studies in overlapping fields of computer science, psychology and engineering, dealing with intelligent behavior, learning and adaptation in machines, generally assumed to be computers.
- Research in AI is concerned with producing machines to automate tasks requiring intelligent behavior.
- In the Ubiquitous learning campus atmosphere Individualized Learning Environment can also be supported using RFID enabled learning where in RFID tagged Labs, Library etc. enable the learner with awareness as well as elaborate learning in that specific area. RFID enabled monuments in any location help in acquiring detailed knowledge pertaining to them. Similarly for a science student with a specialization in botanical sciences

6.Ubiquitous Computing: The Basics

Ubiquitous computing (often abbreviated to “ubicomp”) refers to a new genre of computing in which the computer completely permeates the life of the user. In ubiquitous computing, computers become a helpful but invisible force, assisting the user in meeting his or her needs without getting in the way. The industrial-organizational psychologist 45 on his web site (http://www.ubiq.com/hypertext/weiser/ubihome.html), xerox parc’s mark weiser, the originator of the term “ubiquitous computing,” described it this way: “… [ubiquitous computing] highest ideal is to make a computer so imbedded, so fitting, so natural, that we use it without even thinking about it.”

7.Nanotechnology and Wireless Technology

If computers are to be everywhere, unobtrusive, and truly helpful, they must be as small as possible and capable of communicating between them. Technological movements supporting these goals are already well underway under the rubrics nanotechnology and wireless computing.

8.Nanotechnology

The trend toward miniaturization of computer components down to an atomic scale is known as nanotechnology. Nanotechnology involves building highly miniaturized computers from individual atoms or molecules acting as transistors, which is the heart of the computer chip. The number of transistors in a chip is indicative of its power. Therefore, nanotechnologies extreme miniaturization of transistors allows for impressive levels of computing power to be put into tiny packages, which can then be unobtrusively tucked away.

9.Wireless Computing

Wireless computing refers to the use of wireless technology to connect computers to a network. Wireless computing is so attractive because it allows workers to escape the tether of a network cable and access network and communication services from anywhere within reach of a wireless network. Wireless computing has attracted enormous market interest, as witnessed by consumer demand for wireless home networks, which can be purchased for several hundred dollars. The second author has a three-computer
Wireless network in his home.

10.Context-Awareness and Natural Interaction

Small computers that communicate wirelessly provide a necessary infrastructure for ubiquitous computing. However, infrastructure is only half of the battle. As noted above, the ubiquitous computing movement aims to make computers more helpful and easier to use. Indeed, computers should be able to accurately anticipate the user’s needs and accommodate his or her natural communication modes and styles. These themes are captured with- in the ubiquitous computing movement’s focus on context-aware computing and natural interaction.

11.Context-Awareness

The promise of context-awareness is that computers will be able to understand enough of a user’s current situation to offer services, resources, or information relevant to the particular context. The attributes of context to a particular situation vary widely, and may include the user’s location, current role (mother, daughter, office manager, soccer coach, etc.), past activity, and affective state. Beyond the user, context may include the current date of context may include any combination of these elements. For example, a context-aware map might use the information that the user is away from home, has no appointments, and that the time is 6:00 in the evening to determine and time, and other objects and people in the environment. The application that the user could soon be interested in dinner. It would then prepare to offer the user guidance to nearby restaurants should he or she make such a request.

12.Natural Interaction

Currently, using the computer is part of the task we are attempting to accomplish—something else to focus on, learn, or do in order to accomplish a goal. The idea behind natural interaction is for the computer to supply services, resources, or information to a user without the user having to think about the rules of how to use the computer to get them. In this way, the user is not preoccupied with the dual tasks of using the computer and getting the services, resources, or information. Donald Norman, a well-known
Researcher in human–computer interaction, once said that he doesn’t want a word processor; he wants a letter writer—something that will allow him to get the job done by writing a letter, without the instrument getting in the way.

13.The Promise of Ubiquitous Computing in the Workplace

The elements of ubiquitous computing—nanotechnology, wireless computing, Context-awareness, and natural interaction—offer a powerful set of Tools to achieve the promise of ubiquitous computing. To provide a better sense of what this future holds, let's take a look at how ubiquitous computing Might play out in the workplace.

14.The Desk Job

It's the beginning of the day and Elaine has a major presentation to work on for a sales call. Two weeks ago, when the meeting was set up, she instructed her calendar to schedule two additional meetings with her team to 46 April 2002 volume 39 number 4 prepare for the presentation. It is about time for the second meeting, and she walks into the conference room that her calendar had reserved. The display on the conference room door lists the title of the meeting and checks off attendees as they enter. The giant "work board" on one wall of the room has preloaded all of the documents related to the presentation and is waiting for input. When everybody has arrived for the meeting, the display on the conference room door lists the meeting as "in progress" and dims the window to minimize distraction from the busy hallway outside.

As the team reviews the presentation, Elaine spots a section that flows poorly. After discussing it with the team, she calls to the work board and tells it to move the section on product features to just before the section on optional services. The meeting covers several additional topics and then disbands 10 minutes early. The work board automatically saves the updated files as the attendees exit the room. On the way back to her desk, Elaine stops by her friend roger's desk to ask him a question. Sensing her approach, roger's computer works in the background to load documents that the two of them have worked on together in the past 2 weeks, should any of them be required. Elaine is greeted excitedly by roger, who is rushing to a meeting of his own? "We really need your input on pricing for this service ," says Rogers. "Can you join us?" Elaine can spare some time, so she elects to participate in the meeting.

When Elaine enters the conference room, her calendar automatically updates to include the new meeting. After roger introduces the topic, Elaine says, "my team came up with a template to determine pricing for a slightly

Different service. Maybe we can use it as a starting point." Elaine approaches the work board and a list of her public files appear. The files are sorted in alphabetical order, with the files whose contents are related to the topic of the meeting highlighted. Elaine touches the template file, and the document opens. After some discussion, the template is modified and is ready for testing. Meeting attendees pitch different "what-if" scenarios, which are automatically entered into the template and processed, with the final price displayed. Once everyone is satisfied with the revised template, the meeting breaks up.

To thank Elaine for her help, roger offers to buy her lunch at the cafeteria. Elaine accepts the invitation, saying that she'll be ready as soon as she checks her video mail. As she approaches a nearby public communications portal, the screen shows the four new video mails waiting for her. One video mail is from a longstanding client. She touches the message and watches as

The client recounts a story of superior service received from one of Elaine's direct reports, Dave. Elaine tells the video mail system to add the message to her file on dave, and records a thank-you message to the client. Business done, Elaine and Roger take the elevator down to the cafeteria.

15.Concerns

The power ubiquitous computing promises carry with it significant risks. One such risk is associated with the amount of privacy that must be sacrificed to see the benefits of truly helpful computers. Another is that early, "bleeding edge" applications of ubiquitous computing will turn out to be more ambitious than effective, leading some to prematurely conclude that

The idea is a failure. We address each of these concerns below.

16.Privacy Issues

Simply put, the more software tracks users, the more opportunities exist to trample on their right to privacy. To some degree, these issues have already been argued in the contexts of corporate e-mail snooping and the use of it software that can track user activity down to the level of individual keystrokes. However, factoring in the idea of software that can track and act upon a user's physical presence and form of activity leads to the privacy concerns of a magnitude beyond those currently debated. The privacy implications

Of ubiquitous computing implementations must always be accorded the most careful consideration. Without powerful standards surrounding user privacy, the future world of ubiquitous computing may very well shift from one of ease and convenience to one where each of us has an inescapable sense of being watched, at best, and no control over our personal information, at worst. Such prospects are clearly far from desirable.

17.Growing Pains

Systems that can act as subtle as those described will not come without a substantial developer learning curve. As system developers learn from their mistakes, there will undoubtedly be at least one premature declaration that truly ubiquitous computing is an impractical ideal and that the interim efforts are too riddled with problems to be usable. We cannot guarantee that ubiquitous computing will fulfill its promise. However, we would argue that it ought to do so, based on the strong trend we have observed toward more powerful, more usable software. The first author recalls a word processor from about 1984 that required the manual entry of printer codes for boldface and italic fonts. Advanced ideas like templates and styles—and, come to think of it, tables—were far from considering as features. Modern word processors are very powerful, flexible, and easy to use compared to anything that has come before. Usability is definitely a recognized goal in software design, and much has been learned to make new software—even unique, New applications—very easy to use. It should only get better.

18.The Transition To Ubiquitous Computing

Obviously, in a world where one still encounters the occasional landline phone, fax machine and pager, simply having the technology to enable ubiquitous computing does not automatically result in its universal adoption. Over the next year or so, a number of other advances will serve as benchmarks for the spread of the ubiquitous computing revolution.

"A thing to look for is when your healthcare data goes into the cloud. That will be kind of a watershed moment. And in another year or two, when cars start communicating with each other," Patterson said.

Similarly, just as the Kindle constantly communicates with the Amazon cloud to preserve what page readers last read across all the Kindle platforms, so too will all mobile devices start communicating with the cloud, without the user realizing it, to sync up data across different media, said Brown.

Bit by bit, over the coming months, twenty years worth of laboratory research and industry development will filter out of the hands of scientists and into the pockets of general consumers, filling out the final gaps in the transformation of computing. Soon, a digital device tied to one spot, designed for multiple uses, with a limiting interface, will seem as archaic as a computer without internet connectivity does today.

Your computer is disappearing. And when it goes, you won’t even notice it's gone. "It's the opposite of less is more? Ubiquitous computing is more is less," Buxton said.

"Computing in the right place, in the right form, means less technology in between the user and the task they want to accomplish."

19.Final Thoughts

The promise of ubiquitous computing is of a life in which our endeavors are powerfully, though subtly, assisted by computers. The idealistic visions painted by the ubiquitous computing movement stand in stark contrast to what we see when we boot up our computers each day. There is an immediate barrier because you have to know how to use a computer to use a com-50 april 2002 volume 39 number 4 the industrial-organizational psychologist 51 putter. If you sat down in front of a computer without knowing how to use a mouse, would you be able to get anything done? It’s unlikely. The computer won’t help you, either, since you have to know how to use the computer to ask it for help on how to use it! When computers do offer assistance, it still tends to fall short of the mark. Much application software tries to cater to new users and power users alike by offering simple, task-focused “wizards” and detailed help systems. Unfortunately, the wizards are often too limited to offer sufficient power for day-to-day use, and the help systems often don’t cope well with the many ways in which a user can express a need for a given piece of information. The next step, of course, is to go down to the local bookstore and buy a book that is four inches thick and weighs five pounds and that promises to give straightforward instruction on how to use the program in question. Most of us get by just fine on the tasks we are well-used to performing. However, there should be an easier route. We are still a long way away from seeing the promise of ubiquitous computing fulfilled. Yet, physical barriers to ubiquitous computing are falling, thanks to technological advances such as nanotechnology and wireless computing. Further, as we have argued, software is getting easier to use all the time. As the themes of context-awareness and natural interaction are adopted by hardware and software makers, we will begin to see successive approximations of ubiquitous computing. There are many issues to resolve and a steep learning curve to face as we consider this close integration of computers into our lives. As i-o psychologists, we will benefit ourselves and our field by carefully examining the promises and implications that ubiquitous computing holds for us, and then adapting our products, services, and policies appropriately.

20.Conclusion

"[Ubiquitous computing] is a world where computers are all around us, but we don’t realize they're there. It's a conceptual jump," said Donald Patterson, director of the Laboratory for Ubiquitous Computing and Interaction at the University of California, Irvine. "You'll know you’ll have your phone with you, and you’ll know you'll be in your car, but you won't think about all the different computers that make those things work. To you, it just feels like you're using your phone or driving your car. If ubiquitous computing is successful, you won’t even realize its happening." With digital devices unobtrusively distributed all around us — and empowered with as much computing muscle as possible — ubiquitous computing also allows for data collection on an unprecedented scale.

Additionally, ubiquitous computing will drastically reduce the cost of digital devices and tasks for the average consumer. With labor-intensive components such as processors and hard drives stored in the remote data centers powering the cloud , and with pooled resources giving individual consumers the benefits of economies of scale, monthly fees similar to a cable bill for services that feed into a consumer’s phone, television and car will replace expensive electronics purchases. Basically, all the consumer needs to purchase upfront is screened of the size they want, be it travel–sized like a tablet, or the movie - screen sized like a TV, Patterson told TechNewsDaily.

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