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# Estimation and Evaluation of Pervasive Computing

Chanchal Arun Marathe and Reshma T. Satpute
*M.G.M College of Computer Science & Information Technology, Parbhani*
*e-mail: chanchalmarathe@gmail.com, rashmisatpute@rediff.com*

***Abstract—Pervasive computing is a rapidly developing area of Information and Communications Technology (ICT). The term refers to the increasing integration of ICT into people's lives and environments, made possible by the growing availability of microprocessors with inbuilt communications facilities. Pervasive computing has many potential applications, from health and home care to environmental monitoring and intelligent transport systems. This briefing provides an overview of pervasive computing and discusses the growing debate over privacy, safety and environmental implications. Pervasive computing will not only replicate the standard functionality of the Web in embedded devices, but it will also offer the services provided by such devices to other entities on the Internet.***

***Keywords:** Pervasive computing, Ubiquitous, Communication, Devices.*

## I. INTRODUCTION

Pervasive computing is the trend towards increasingly ubiquitous connected computing devices in the environment, a trend being brought about by a convergence of advanced electronic - and particularly, Wireless technologies and the Internet. Pervasive computing devices are not personal computers as we tend to think of them, but very tiny - even invisible - devices, either mobile or embedded in almost any type of object imaginable, including cars, tools, appliances, clothing and various consumer goods - all communicating through increasingly interconnected networks. Pervasive computing brings the technology closer to the users by enabling the users to use daily-life devices (mobile phones, TVs, touch screen walls, etc.) for controlling their environment and accessing information virtually anywhere. Interacting with such devices does not remind users of classical computers and enables them to more naturally interact with the controlled system, if user interface is designed properly. These devices usually operate in networked environments with every controlling and controlled device connected to a central hub. Bringing easy-to-use applications to such environments faces the challenge of highly heterogeneous, dynamically changing environment and necessity to deploy applications to controlling devices with very different features (display size, input methods, operating systems, etc.). The goal of research is to create a system that is pervasively and unobtrusively embedded in the environment, completely connected, intuitive, effortlessly portable, and constantly available. Among the emerging technologies expected to prevail in the pervasive computing environment of the future are wearable computers, smart phones and smart buildings.

## II. PERVASIVE COMPUTING HISTORY

Pervasive computing is the third wave of computing technologies to emerge since computers first appeared:

- First Wave - Mainframe computing era: one computer shared by many people, via workstations. Many people serving one computer dominated the first wave of computing, from the 1940s to the early 1980s.
- Second Wave - Personal computing era: one computer used by one person, requiring a conscious interaction. In the early eighties the personal computer evolved and allowed the symbiosis between a single person and a computer. Users largely bound to desktop.
- Third Wave – Pervasive (initially called ubiquitous) computing era: one person, many computers. Millions of computers embedded in the environment, allowing technology to recede into the background. The third wave was introduced with the invention of the World Wide Web in the early nineties.

## III. PERVASIVE COMPUTING TECHNOLOGIES

Pervasive computing involves three converging areas of Information & Communication Technology ICT:

- Computing ('devices')
- Communications ('connectivity')
- User interfaces

### *A. Computing ('Devices')*

Pervasive Computing System (PCS) devices are likely to assume many different forms and sizes, from handheld units (similar to mobile phones) to near-invisible devices set into 'everyday' objects (like furniture and clothing). These will all be able to communicate with each other and act 'intelligently'. Such devices can be separated into three categories:

- Very Small Screen Devices (up to 4 inches)
- Small Screen Devices (up to 8 inches)
- Medium Screen Devices (up to 15 inches)

Discriminating devices based solely on their screen size seems at first questionable. But the screen size of the device typically correlates with the computational resources like memory and processor and the type of wireless connection. In addition the size of the screen determines the types of possible interactions. The reason for this correlation is that the size of the screen (being the larges part of the device) determines the available space for the other parts. As the screen size grows there is more space in the back of the unit for other parts. Consequently small screens lead to less computational resources and vice versa. In the following a brief overview of the different devices is given.

*1. Very small screen devices*

Among the many mobile and wireless connected devices those with very small screen seem at first useless. The user is limited to a typically four-line colorless LCD display. The devices offer a simple keyboard that allows a simple interaction. Typical examples of these devices are the web enabled mobile phones (WAP), and the popular Blackberry device of RIM.

Fig. 1: RIM's Back Berry Device


Fig. 2: WAP Phones: Present (Siemens C35i) Future

The main characteristic of these devices is that they allow the user to send and receive virtually everywhere text messages and/or text-based web content. They offer only minimal computational resources and a set of preinstalled applications (e-mail, text only HTTP-client). They are small, continuously connected ultra-thin clients.

*2. Small screen devices*

This category of devices is characterized by displays that range between 5 and 8 inches. Typically these devices expect the user to interact using a special pen (stylus). Clicking on the screen and recognizing the user's handwriting offers a simple & efficient interaction. Typical examples of small screen devices are the Palm, Visor, and the Windows CE Pocket PCs. The small screen devices offer between 2 and 32 MB of RAM, and an energy efficient but often slow processor. They all can be equipped with additional programs and offer as a standard communication device a simple Infrared port. Data exchange between the devices is simple and reliable as long as the distance between the devices is only a few inches. To enhance the usability of these devices all of them support wireless modem-connection and/or a wireless Ethernet connection (802.11b).

Fig. 3: Palm Computer


Fig. 4: Honeywell's WebPad

*3. Medium screen devices*

Devices with screens between 9 – 15 inches as are considered medium sized. Two types of devices are found in this category, notebook computers and web-pads. While the notebook computer tends to be a miniaturized version of a desktop machine, the web-pad represents a new development. Web-Pads can be described best as notebooks without keyboard and other external devices. Using a touch sensitive display and a good wireless Ethernet connection (802.11b) these devices are typically far lighter and thinner than notebooks. Unlike the notebook that can be configured anyway the user pleases, the Web-pad is typically a thin HTTP-client. Offering energy efficient processor and up to 32 MB of RAM the web-pad is not designed as a platform to run applications. It is a truly thin web-client that depends on a good Internet connection.

The most interesting feature that distinguishes the web-pad from the notebook computer is that it targets users with no or only minimal computer experiences. Web-pads are in a way a kind of hardware version of a standard http browser. The advantage of limiting a machine to being only a browser is that such a device can be switched on and off without any harm. Unlike a PC that needs typically minutes to boot up, the web-pad is instantly ready and can be switched off safely at any

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moment in time. Web pages are light, compact and relatively robust. The touch-screen allows for interactivity, and the size of the screen allows it to be used as a convenient, nearly normal size keyboard. Thus the web-pad represents the long promised web-pc.

*B. Connectivity*

Pervasive computing systems will rely on the interlinking of independent electronic devices into broader networks. This can be achieved via both wired (such as Broadband

(ADSL) or Ethernet) and wireless networking technologies (such as WiFi or Bluetooth), with the devices themselves being capable of assessing the most effective form of connectivity in any given scenario. The effective development of pervasive computing systems depends on their degree of interoperability, as well as on the convergence of standards for wired and wireless technologies it includes the following technology.

*1. Peer-to-peer (P2P) networking*

Napster popularized the application of P2P (peer-to-peer networking) products and now the same technology has begun to sing a business melody. The basic idea behind it being the sharing of files and programs and communicating directly with people over the Internet, without having to rely on a centralized server. What it does is to create private workspaces for sharing files, exchanging information, creating databases and communication instantly. Companies can now participate in B2B marketplaces, cut out intermediaries and instead collaborate directly with suppliers. Peers on desktop PCs can share files directly over a network. Renting computing power can solve resource problems in smaller companies, thus improving the power of web applications.

*2. Nano technology*

We've seen science fiction flicks where miniature machines get into the human body and track cell patterns and behavior like those of cancer cells and exterminate them. Molecule sized computers can be manufactured to create new materials that can replace steel in all its properties and even withstand temperatures of 6,500 degree Fahrenheit. It is predicted that these materials will soon be used to build automobiles and office buildings. 'A la' - an invisible infrastructure!

*3. Chips and the net*

Net-ready chips are a low cost method of getting on to the Internet. They follow all the necessary. Internet Protocols and can be embedded in home appliances that can then be easily connected to the Internet. They function as tags that possess comprehensive information about the object that it is tagged on to and include details like the date and place it was manufactured.

*4. Wireless technology*

Wireless Internet connection helps access the Net through cellular phones, Personal Digital Assistants (PDA's) and Wireless laptops and this technology proposes enormous business opportunities. The sales force can avail real-time access to inventory records; price lists, order and customer account status and can book a sale almost instantaneously. Constant communication with wireless gadgets (that cost many degrees lesser than a laptop) can ensure that there is a constant feedback loop thus ensuring a new way of reaching customers.

*5. The tapestry of distributed computing*

Distributed computing is the processing power of thousands of PCs aggregated to create a super computer. A centralized server subsidizes a large computing task in to smaller bits. It then assigns those bits to thousands of desktop computers, each of which does a small task and returns the results to the server. Specialists in content delivery, pharmaceuticals, biotechnology and financial services will see the use of distributed computing capabilities soon. A classic example of how it is being used today is in the SETI@home project. This project is about searching for extraterrestrial using radar arrays that look for intelligent patterns of radio waves among the background radiation. Thousands of volunteers have downloaded the SETI@home screen saver and when their machines are sitting idle, they get data from the project and do some data crunching and send it back for analysis.

*6. Voice computing: tell your computer to switch on!*

Voice recognition software will soon allow users to switch on their computers by just talking to them. Even documents can be edited through voice commands. We'll finally be reaching out to the frontier where man will be able to talk to all his machines and command them to do as he wishes.

*C. User Interfaces*

User interfaces represent the point of contact between ICT and human users. For example with a personal computer, the mouse and keyboard are used to input information, while the monitor usually provides the output. With PCS, new user interfaces are being developed that will be capable of sensing and supplying more information about users, and the broader environment, to the computer for processing. With future user interfaces the input might be visual information – for example recognizing a person's face, or responding to gestures. It might also be based on sound, scent or touch recognition, or other sensory information like temperature. The output might also be in any of these formats. The technology could 'know' the user and tailor the physical environment to meet specific needs and demands. However, designing systems which can adapt to unforeseen situations presents considerable engineering challenges.

## IV. Applications for Pervasive Computing

Pervasive computing could have a range of applications, many of which may not yet have been identified. Applications in healthcare, home care, transport and environmental monitoring are among the most frequently cited, as discussed below.

### *A. Healthcare*

Pervasive computing offers opportunities for future healthcare provision for both treating and managing disease, and for patient administration. For instance, remote sensors and monitoring technology might allow the continuous capture and analysis of patient's physiological data. Medical staff could be immediately alerted to any detected irregularities. Data collection on this scale could also provide for more accurate pattern/trend analysis of long-term conditions such as heart disease, diabetes and epilepsy. Wearable sensors may offer greater patient mobility and freedom within hospitals and save both time and money by reducing the need for repeated and intrusive testing. Hospital administration could also be transformed. Patients might be tagged with wristbands containing digital photographs and medical notes. These wristbands would allow patients to be traced more effectively through hospital administration systems, reducing the risk of misidentification and treatment errors.

### *B. Environmental Monitoring*

Pervasive computing provides improved methods to monitor the environment. It will allow for continuous real-time data collection and analysis via remote, wireless devices. However, this poses significant challenges for PCS developers. Devices may be required to withstand harsh environmental conditions (such as heat, cold and humidity). There is also a risk that devices, once deployed, may prove too costly or impractical to recover; thus they will have to be cheap and, where possible, environmentally sensitive. Power is also a challenge as systems will need to operate over long periods of time, requiring high levels of energy efficiency and robust energy supplies.

### *C. Intelligent Transport Systems*

Traffic congestion and accidents cost billion a year in lost productivity and wasted energy. Pervasive computing technologies are being employed in the development of intelligent transport systems to try to alleviate these costs. Such systems seek to bring together information and telecommunications technologies in a collaborative scheme to improve the safety, efficiency and productivity of transport networks. Electronic devices could be directly integrated into the transport infrastructure, and into vehicles themselves, with the aim of better monitoring and managing the movement of vehicles within road, rail, air and sea transport systems. Computers are already incorporated into modern cars via integrated mobile phone systems, parking sensors and complex engine management systems. Intelligent transport systems take this process further by introducing 'intelligent' elements into vehicles. Vehicles could become capable of receiving and exchanging information 'on the move' via wireless technologies and be able to communicate with devices integrated into transport infrastructure, alerting drivers to traffic congestion, accident hotspots, and road closures. Alternative routes could be relayed to in-car computers, speeding up journey times and reducing road congestion. This would bring added coordination to the road transport system, enabling people and products to travel more securely and efficiently. Greater communication and coordination between different transports sectors (road, rail, air, etc.) may help fulfill integrated transport policies.

## V. Conclusion

Pervasive computing provides an attractive vision for the future of computing. We will no longer be sitting down in front of a PC to get access to information. In this wireless world we will have instant access to the information and services that we will want to access with devices, such as Smart Phones, PDA's, boxes, embedded intelligence in your automobile and others, all linked to the network, allowing us to connect anytime, anywhere seamlessly, and very importantly, transparently. Computational power will be available everywhere through mobile and stationary devices that will dynamically connect and coordinate to smoothly help users in accomplishing their tasks. Some of the implications of this new revolution may seem far-fetched, but they really aren't. Technology is rapidly finding its way into every aspect of our lives. Whether it's how we shop, how we get from one place to another or how we communicate, technology is clearly woven into the way we live. Indeed, we are hurtling towards computing that pervades our realities, computing that is everywhere.

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