ISSN No. 0976-5697

Volume 3, No. 3, May-June 2012

International Journal of Advanced Research in Computer Science

REVIEW ARTICLE

Available Online at www.ijarcs.info

A Study on the Technologies Used in Ubiquitous and Pervasive Computing

A.Kanagaraj*
PhD Scholar,
Department of Computer Science
NGM College, Pollachi-642 001, India
a.kanagaraj@gmail.com

Dr. Antony Selvadoss Thanamani
Associate Prof & Head,
Dept of Computer Science
NGM College, Pollachi-642 001, India
selvdoss@yahoo.com

Abstract - This paper presents the survey of Ubiquitous and Pervasive computing. Pervasive computing is a fastest developing area, where we can make day to day using objects as an intelligent, easily accessible and connected to an increasingly ubiquitous network infrastructure. The term Ubiquitous means everywhere; Pervasive means "spread out in every part of." Pervasive computing is an integration of information and communication technology everywhere for everyone.

Keywords - Ubiquitous Computing, Pervasive Computing, applications, Wireless Sensor Networks

I. INTRODUCTION

Pervasive computing is the growing trend, where microprocessors are embedded in everyday objects and make them to share information. The words pervasive and ubiquitous mean "existing everywhere." Pervasive computing devices are completely connected and constantly available. Pervasive computing is a third era, from when computer first appeared (see Fig 1):

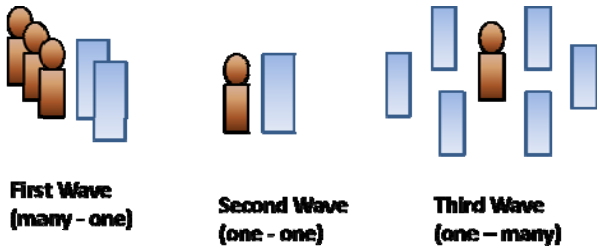

Figure 1. Computing Evolution

First era – It is a Mainframe computing era. In this time one computer shared by many people, via workstations. Second era – It is a personal computing era. In this time each person handled an individual system. Users where largely bound to desktop. Third era – It is a Pervasive computing era. In this current era each person handling many computers. Millions of computers embedded in environment, allowing technology to shrink back into the background.

Pervasive computing is a combination of wireless technologies, advanced electronics and the Internet. The goal of researchers working in pervasive computing is to create smart devices that communicate unobtrusively. The devices are connected to the Internet and the data they generate is easily available. One practical example of pervasive computing is the replacement of old electric meters with smart meters. Previously, electric meters had to be manually read by a respective person, but now a day's smart meters made this process automatic, by reporting usage of power through internet.

The "authorized access to anywhere, anytime, any network, any device, and any data", the 6As model of pervasive computing propose a new paradigm in convergence and networking [3]. It makes user's life more easy and convenient, by sharing information among PC or a Palm or cell phone of email, Internet, etc. This paper presents a detailed survey about pervasive computing.

II. TECHNOLOGIES USED IN PERVASIVE COMPUTING

Pervasive computing is not an independent technology rather than it shows the performance characteristics of approach for processing, sensor and communication technologies become a part of any environment, object or device. A smart object might be embedded in a house or any device from house might send information to smart device. This clearly describes pervasive computing means not always same, rather than different combination of technologies might be used in pervasive computing. Peter Gabriel et al. [5] in his paper, clearly identified eight technology fields and its realization of six characteristics in pervasive computing (see Table I)

A. Wireless Sensors In Pervasive Computing:

Wireless pervasive computing is a fastest developing area that has attracted significant attention in recent years because of its ubiquitous deployment throughout our society. It is widely accepted that pervasive computing is having a tremendous impact on the way we live our life, conduct businesses, communicate with each other, and many other areas of life. Most of the technology enablers that make wireless pervasive computing feasible have been deployed with little consideration to the energy they consume during their operations.

The development of wireless sensor networks was originally motivated by military applications such as battle field surveillance. However based on the survey we found wireless sensor networks are now a day's used in various areas such as Information access, Text retrieval, Multimedia document retrieval, Automatic indexing, Pervasive devices, Palm top computers, Smart badges, Electronic books, User sensitive devices, Mobility and networking, Device discovery, Wireless protocols, Security, Voice and video over IP, Perceptive interfaces, Biometric person ID, Speech recognition, Gesture recognition etc [1][2].

Pervasive computing may consist of several types of sensors such as thermal, magnetic, visual, radar and acoustic which can able to sense in different conditions that includes;

humidity, temperature, lightning condition, soil makeup, pressure, noise levels, mechanical stress levels on attached objects etc.

Table 1. Pervasive Computing Characteristics with Necessary Technologies Fields

	Mobility	Embedded	Ad-hoc-networks	Context Awareness	Energy autarky	Autonomy
Micro Electronics	√	√				
Power Supply	√		√		√	√
Sensor Technology			√	√		√
Communication Technology	√		√	√		√
Localization Technology	√			√		√
Security Technology		√	√	√		√
Machine to machine communication		√	√	√		√
Human to Machine Interface		√		√		√

B. Power Supply:

One of the important requirements for pervasive computing is power supply. Devices using for pervasive computing is very small. Due to this reason, it consumes low power and it provides high performance. Lithium-ion batteries came in to use, it provides power supply for long-term. Current research is going on how to consume more power. Batteries are recharged by using thermo generators, photovoltaic's, miniature piezo generators or other converters, without plug into a power supply line [10]. Plenty of methods are there for supplying power to electronic devices. The choice is based on how shortly can able to load and how to improve the life time of batteries.

C. Microelectronics:

Electronics devices are the one of the main technology which is using for pervasive computing. So while speaking about devices, size plays a key role. Micro level electronics are mainly using in medical field, automotive industry and in consumer electronics fields etc. Currently microelectronics works with smaller than 90 nanometers. The problem in manufacturing these kinds of devices are; it took more time and high cost. Current research in nanotechnology is how to reduce more size and make it more mobilize the micro electronics.

D. Communication Technology:

Based on the survey, the experts accessed communication technology is a key factor for pervasive computing. Generally communication technology is combined with information technology in order to emphasize the overlap between two fields. Normally data communication between two objects occurs using radio technology or via cable. Currently wireless technology becomes very popular because of its mobility and less requirement of infrastructure.

E. Localization Technology:

Generally pervasive computing uses transmitters and receivers which interact with objects to enable localization. Currently there are three types of localization systems are in use; there are cellular supported, satellite supported and indoor localization systems. Compare to all other technologies, Localization technology is an least relevant to pervasive computing.

F. Security Technology:

Data communication is an main feature in pervasive computing. While communicate data's between objects, security plays a major role. It should allow only authorized person/device to share information. Generally wireless network is using for data communication in pervasive computing. Lack of security is an current problem regarding with pervasive computing.

G. *Machine to Machine communication:*

Pervasive computing is a distributed system which interacts with thousands of components. Standard is very important to be followed in machine to machine communication. In machine to machine communication: technology, architecture and software's are the three facts which build upon each other. Compare to other technology relevance with machine to machine and pervasive is an average.

H. Machine to Human communication:

Human machine interaction an major role in all makers of electronics and computer systems today. A smart object of pervasive computing expects more contribution of human interface. Movements capturing by the sensors, hand writing recognition and voice commands recognition are some of the examples for machine to machine communication.

III. AREAS OF PERVASIVE COMPUTING APPLICATIONS

Pervasive computing aims to pervade and interconnect all areas of our life [5]. Wireless internet access, handheld computer and mobile internet etc are the evidence of information exchange is already in routine. But in future pervasive computing will bring a new style of information exchange and processing of data. In future using this technology most of the process will happen automatically. Depending upon the area the development of these applications will differ. In this survey 8 application areas were selected, in where pervasive computing is already in use.

A. Logistics:

In logistics pervasive computing is using for track the object. The logic behind this is, the data carrier is affixed in an object, so that we can able to track the object throughout the logistic supply chain. But now a days, still in logistics barcode is using for identification purpose [5]. There are plenty of drawbacks are there in this system. Scanner is needed in a direct sightline to read a barcode. It seems that it is like a manual process. In addition the barcode label cannot read if it is damaged or dirtied.

B. Motor Traffic:

Automobile is another important area where pervasive computing is in use. In today's luxurious cars contains a plenty of driver assistance systems for safe drive. For

instance if car contains rain sensor, it will automatically turn on the wipers if rain came. Another type of sensor is fixed to check whether seat belt is fastened or not. So the main goal of driver assistance system is make them comfort to drive in everyday traffic. So most of the driver assistance functions are accepted by drivers. The car itself becomes a smart object [5].

C. Inner/External Security:

Identification systems such as smart cards and newly introduced electronic passports are an example for inner pervasive computing security. Secret services and armed forces are the some of the main external security application areas [5]. In these security systems networking and surveillance plays a major role. The actual goal of inner and external security is to protect the public life.

D. Electronic Commerce:

Another application area where pervasive computing is in use is logistics and production. The use of mobile terminals for business transactions and financial services are comparatively widespread. Currently three trends are emerging in pervasive computing for electronic commerce [5]. For car, real estate and other capital intensive products, renting and leasing are common business today. In future no more products may purchase, but rented by paying amount according to a usage. So pervasive computing will be used to trace products. Similar to the e-commerce over the internet, experts see commerce in pervasive computing by offerings new products and services as well as by cost savings [5].

E. Health Applications:

In medical side pervasive computing is used to provide interface for the disabled, integrated patient monitoring and tracking and to monitor the doctors and patients inside the hospital [5]. Using this technology doctors can able to monitor the patients from home. So patients can able to save money as well as time. However, the increased use of pervasive computing in medical technology is expected to take it into the positive growth.

F. Environmental Applications:

Some environmental applications of pervasive computing includes tracking the movements of birds, small animals, and insects; monitoring environmental conditions that affect crops and livestock; irrigation; macro instruments for large-scale Earth monitoring and planetary exploration; chemical/biological detection; precision agriculture; biological, Earth, and environmental monitoring in marine, soil, and atmospheric contexts; forest fire detection; meteorological or geophysical research; flood detection; bio-complexity mapping of the environment; and pollution study.

G. Home Applications:

Home automation is an area where pervasive is in use. Pervasive computing connects all the devices in a home and retrieves information by using sensors connected with networks. These devices internally can interact with each other and with an external network through internet. So these allow end-users to control home devices locally and remotely.

IV. EMERGING PERVASIVE COMPUTING TECHNOLOGIES

Pervasive computing is a term for the strongly emerging trend towards; 1) Numerous, casually accessible, often invisible computing devices 2) Frequently mobile or embedded in the environment 3) Connected to an increasingly ubiquitous network structure.

Some of the emerging pervasive technologies are [3];

A. 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 [3].

B. Peer-to-Peer (P2P) Networking:

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.

C. 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 [3]. 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.

D. The tapestry of Distributed Computing and Voice 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.

E. Wireless Technology:

Wireless Internet connection helps access the Net through cellular phones, Personal Digital Assistants (PDAs) 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 [3].

V. PERVASIVE COMPUTING DEVICES

Pervasive computing devices are not personal computers, 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 interconnected networks. Expert predict pervasive computing in future will become so naturalized within the environment that people will not even realize that they are using computers. The difference between traditional, networking and pervasive computing are;

These connections are fundamentally unlike those we associate with networks. Rather than using the network to connect computers that are being used directly by people, these appliances communicate over networks such that people do not directly monitor the communication between machines and programs. The majority of these communications will occur in an end-to-end structure that does not include a human at any point. Unlike traditional Desktop Computers and existing networks, the new devices will have the following characteristics: 1) Many will have small, inexpensive processors with limited memory and little or no persistent storage. 2) They will connect to other computing elements without the direct intervention of users. 3) Often, they will be connected by wireless networks. 4) They will change rapidly, sometimes by being mobile, sometimes by going on and offline at widely varying rates. Over time, they will be replaced (or fail) far more rapidly than is now common. 5) They will be used as a source of information, often sending that information into the center of the network to which they are attached [4].

VI. CHALLENGES

The most serious impediments to pervasive computing advances are systems challenges. The immense amount of distributed system elements, limited physical access to them, and this regime's extreme environmental dynamics, when considered together, imply that we must fundamentally reexamine familiar layers of abstraction and the kinds of hardware acceleration employed—even our algorithmic techniques[6].

Many devices will be embedded in the environment in places that are inaccessible or expensive to connect with wires, making the individual system elements largely unattended, and resource constrained. Much communication will be wireless, and nodes will have to rely on onboard and harvested energy (such as from batteries and solar cells) [6]. Inaccessibility, as well as sheer scale, implies that they must operate without human attendance; each piece is such a small part of the whole that nobody can reasonably lay hands on all of them.

VII. SECURITY ISSUES IN PERVASIVE COMPUTING

Security or privacy with pervasive computing is a major issue now days. Pervasive Computing has an ability to retrieve/store information from large databases. Chances are there to theft personal stored information from database. Pervasive Computing system could be embedded in private places and can able to record personal information with the risk of breaking of privacy. So pervasive computing may mean data's can be collected without person's knowledge. This activity is against the information protection law.

Now a day's data mining activities fully related with pervasive computing system. Data mining concentrates on working with large quantities of data to provide a pattern. In terms of consumer data it is very useful to lead to attain successful marketing. So sometimes it is violating the information protection law by proving unknown relationships in data. Now a day computing technologies becoming more pervasive, due to these reason government agencies, consumers and service providers etc getting more benefits. So there is a debate over how to provide all possible benefits from pervasive computing without breaking the information protection law [7].

VIII. ADAPTIVE ARCHITECTURE

Hardware and architecture are the first area to research for providing efficient pervasive computing system. This system refers to computing environments consists of large number of computing devices embedded in our everyday environment. Building infrastructure for individual pervasive applications is a tedious job in terms of money and time. To overcome this problem Simon Dobson et al. [8] developed open-source infrastructure architecture (see Fig 2) for pervasive computing system. It provides best spread technique for pervasive computing. This system acts as a middleware platform between sensors and services.

Wang-Chien Lee [9] points out two important aspects of pervasive computing in his research namely infrastructure and model. Because of mobile and transient services in a pervasive computing environment special attention is needed on modeling, dynamic and recursive composition of services and infrastructures that match requests to services in a scalable manner are needed.

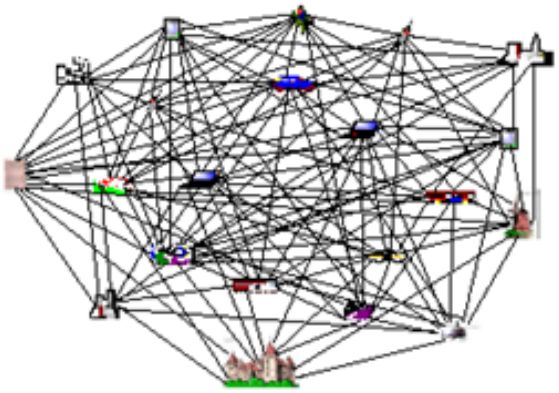

Figure 2. Data from various sensors collected and shared by nodes

IX. CONCLUSION

Pervasive computing provides a great future for computing system. In this wireless world we no need to sit in front of the PC to get access to information. Through wireless we can able to access information and the services instantly. To access information with devices such as Spy Pen, video Phone, GPS installed in a car, TV Remote control watch, Wearable glass monitor, Watch Phone, Match box computer etc we can able to do by linking all devices in to a single network and making them to allow us to connect anytime and anywhere to accomplish our tasks.

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Short Bio Data for the Author

***Mr. A.Kanagaraj** M.C.A., M.Phil has around two years of experience in software industry. He has published five papers in national / international conferences. He has presented three seminars at national level. He is a member of Indian Science Congress. Now he is pursuing PhD Computer Science in Dr. Mahalingam center for research and development at NGM College, Pollachi, India.

****Dr Antony Selvadoss Thanamani** is presently working as professor and Head, Dept of Computer Science, NGM College, Coimbatore, India(affiliated to Bharathiar University, Coimbatore). He has published many papers in international/national journals and written many books. His areas of interest include E-Learning, Software Engineering, Data Mining, Networking, Parallel and Distributed Computing. He has to his credit 25 years of teaching and research experience. His current research interests include Grid Computing, Cloud Computing, Semantic Web. He is a life member of Computer Society of India, Life member of Indian Society for Technical Education, Life member of Indian Science Congress, Life member of Computer Science, Teachers Associates, Newyork.