International Journal of
Advances in Scientific Research and Engineering (ijasre)

E-ISSN : 2454-8006

DOI: http://dx.doi.org/10.7324/IJASRE.2018.32611

Volume 4, Issue 2
February-2018

Ubiquitous Computing: A Primer

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ABSTRACT

Ubiquitous computing is an emerging research area which is due to the rapid evolution in smart devices, as well as tremendous advances in wireless networks and mobile computing. It is a technology, in which invisible computers are embedded and connected with all things enabling using computers anywhere at any time. It facilitates the anywhere anytime communication. It allows services and devices become aware of each other without explicit human administration. This paper provides a primer on ubiquitous computing.

Key Words: Ubiquitous Computing, Pervasive Computing, Calm Technology.

1. INTRODUCTION

The need for using different devices that surround humans to communicate with each other at any time and any environments has introduced ubiquitous computing. Ubiquitous computing (ubicomp) is about computers everywhere surrounding humans, communicating with each other, and interacting with people and environments. It is the next wave in computing evolution. It seeks to embed computers into our everyday lives in such ways as to render them invisible and allow them to be taken for granted. It aims to revolutionize the current paradigm of human-computer interaction. It will have a profound effect on the way we interact with computers, devices, environment, and other people. Unlike desktop computing, ubiquitous computing can occur using any device, in any location, and in any format. Devices that use ubicomp have constant availability and are always connected.

Ubiquitous computing is also known as pervasive computing. Ubicomp environment is marked by anywhere, anytime and anyone-based characteristics. The terms "ubiquitous computing" and "pervasive computing" are used interchangeably but they are conceptually different. Ubiquitous computing uses the advances in mobile computing and pervasive computing to present a global computing environment. Pervasive computing is invisible to human users; ubiquitous computing aims to provide pervasive computing environments to a human user as he moves from one place to another [1,2].

The word "ubiquitous" means present everywhere at the same time. The term "ubiquitous computing" was coined by the late Mark Weiser around 1988 while at the Electronics and Imaging Laboratory of the Xerox Palo Alto Research Center. Mark Weiser is widely regarded as the father of ubiquitous computing. He had a vision of computing technology weaving itself in to the very fabric of everyday life. He identified ubiquitous computing (many computers, one person) as the third generation of computing, following the first generation of mainframe computing (one computer, many people) and the second generation of personal computing (one computer, one person). A fourth generation of computing, known as collective computing, has emerged over the past decade [3-6].

2. BASIC FEATURES

The basic features of ubiquitous computing include [7]:

- C**o**mputing elements are not integrated in a single workstation, but distributed as everyday **o**bjects in user's w**o**rk environment
- The context-aware feature of ubiquitous environments is also called "situatedness." It requires adapting behavior based on information sensed from the physical and computational environment.
- Use of inexpensive processors, thereby reducing memory and storage requirements
- Capturing of real-time attributes
- Totally connected and constantly available computing devices

- Improvised and dynamic interactions among applications
- Relies on converging Internet, wireless technology, and advanced electronics

The purpose of these features is to allow users to perform their tasks more effectively and efficiently. Ubiquitous computing is not just the omnipresence of computational systems; it represents new ways of thinking about human–machine interaction. We now live in a world where the number of computers exceeds the number of humans and are entering a many-to-one computer/human relationship. This is one of the hallmarks that characterize the ubiquitous computing era [8].

3. UNDERLYING TECHNOLOGIES

Ubiquitous computing suggests embedding countless tiny, wirelessly intercommunicating microprocessors into objects. The underlying technologies supporting ubiquitous computing include:

- operating systems, Internet, microprocessors, artificial intelligence, RFID (Radio Frequency Identification)
- mobile devices and mobile networking
- middleware and software architecture
- wireless sensor networks
- machine-machine communication and human-machine interface
- user interfaces

Ubiquitous computing is an enabler of numerous devices, such as embedded systems, computers, digital communication equipment, electronic sensors, novel ways of interaction, and also dedicated services. Ubicomp devices include mobile phones, PDAs, tablet PCs, ipods, as well as reading appliances, pad-type appliances, interactive whiteboards, and telepresence boards. Mobile phones have grown beyond being perceived as more than just conversion tools; they are now movie players, gaming platforms, cameras, etc. Tablet PCs share many of the main characteristics of a nomadic information environment. They are highly mobile and allow users to multi-task.

4. APPLICATIONS

Ubiquitous computing applications will have a discernible impact on organizations and societies. Ubiquitous computing has advanced to such a level that it has led to unprecedented applications. Common applications include education, commerce, healthcare, and home.

- *Education*: This has been a major force in the adoption of ubicomp technology. It results in ubiquitous learning (or U-learning) which aims at accommodating learners in their learning style by providing adequate information at anytime and anywhere for various educational materials [9]. This is the convergence of electronic learning (e-learning), mobile learning (m-learning). Massively open online courses (MOOCs) are often combined with social networking services so that students across the globe can learn collaboratively. Personal, portable, and wirelessly networked technologies are becoming widely used by learners, and social media has created new ways of participating in educational activities [10]. Students will have the privilege of gaining access to information resources in a timeless and limitless way.
- *Commerce:* Ubicomp technologies are finding their way into commercial information systems. Applications in retailing are based on the use of cheap RFID transponders, which handles automatic registration, identification of goods deliveries, automatic recording of the inventory, etc. Ubiquitous computing facilitates always-on processes, where customers can access any information-based service at any time.

- *Health care:* The Internet allows individuals to gather health information. Ubiquitous computing opens up possibilities for a better quality of health care. It finds applications in diagnostic, therapeutic, nursing, and the automatic remote and self-monitoring and diagnosis of patients. Ubicomp allows rapid communication of health issues between interested parties. However, since medical data are very sensitive personal data, introduction of ubiquitous computing in the healthcare environment is difficult [11].

- *Smart Home:* Ubiquitous computing promises to increase comfort in the private home area and make the home smarter. This is a desirable technology for home networks where the home owner acts as an administrator and home devices and appliances are integrated to work together effectively. Ubiquitous computing is making inroad into the kitchen to improve health or safety [12].

Other applications of ubicomp include the military high-performance computing, laboratory environments, manufacturing, emergency care, crime prevention, social games, logistics, and Internet messaging [13].

5. BENEFITS

The following are the benefits of ubiquitous computing as it impacts our lives [14].

5.1 ***Invisibility*****:** One of the objectives of ubiquitous computing is to enhance computer use by making many computers available throughout the physical environment, but making them effectively invisible to the user. By invisibility, we mean that the tool does not intrude on your consciousness; we focus on the task, not the tool. To achieve invisibility, our systems should be as free as possible from explicit human administration. "Smart" environments will be embedded with computing technologies that will be mostly out-of-sight. An important aspect of invisibility is seamless integration.

5.2 ***Socialization*****:** Ubiquitous computing will enhance physical integration, connecting computers to the physical reality in which they are used. Interactions with environments will be more social in nature. There will be social groups as winners and losers in ubiquitous computing. The elderly and persons with little experience with technology can benefit from ubiquitous computing.

5.3 ***Decision-making*****:** As computers ubiquitously embed themselves in our environments, sensors and actuators will create "smart" environments, which will help users make better choices as they go about their everyday lives.

5.4 ***Multimedia***: Communications incorporates all types of media, from continuous media to application sharing. Much of the ubicomp environment will be supplemented with interconnected digital technologies and such interconnectivity will allow for a new type of "sharing."

6. CHALLENGES

Ubiquitous computing presents several challenges across computer science, engineering, and user interface design. Conventional human-computer interaction models, such as menu-driven and GUI-based, are not suitable for ubiquitous computing. Contemporary devices that support interaction with ubiquitous computing include mobile phones, digital audio players, radio-frequency identification tags, and GPS [15,16].

When ubiquitous computing achieves ubiquity, there is a major concern on privacy. Privacy is the most often-cited challenge facing ubiquitous computing and may be the greatest barrier to its long-term success. Ubiquitous systems may threaten privacy and create questions surrounding user consent. What is regarded as private depends on cultures, eras, and individuals. The right level of privacy is commonly considered as where consumers trade their privacy for useful services [17]. Although people may not have a complete understanding of the threats to their privacy, they do not have enough confidence in privacy management procedures to hand-over management of their privacy preferences. Privacy concerns may likely to be highly situation-dependent. Another associated issue is trust. There are legal challenges in the protection of users' information.

Scalability, heterogeneity, integration, invisibility, context awareness, context management, and mobility are all challenges to be addressed. Ubicomp environment is heterogeneous because computation can take place using a wide variety of computing platforms, interfaces, networks, and services. The need for a new class of standard software still hinders this field's development [18].

Another challenge for ubiquitous computing is bridging the gap between captured context data and the different levels of interpretation needed by applications. Deploying ubiquitous computing applications is costly and requires a lot of work.

6. CONCLUSION

Ubiquitous computing has been successful in view of the fact that Mark Weiser's vision of an individual making use of tens or hundreds of embedded devices networked together is now a reality. It is gradually changing the way we live and interact. It is poised to be a disruptive cultural force with great potential for good or ill.

Educators at all levels are obligated to articulate constructive visions for ubiquitous computing. More and more schools are offering classes on ubicomp [19]. At graduate level, such classes may require students to have background knowledge in several areas such as communication networks, distributed computing, and software engineering [20].
More information on ubiquitous computing is available in [21,22] and other books in Amazon.com.

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