

# Ubiquitous Computing: A New Era of Computing

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**Abstract** - This paper deals with the introduction of ubiquitous computing, challenges and a few applications. Ubiquitous computing also known in many other ways such as pervasive computing, calm technology, ambient intelligence has the concept of one person many computers. The literal meaning of 'ubiquitous' is omnipresent or found everywhere. The real world implication of it being, there are computers everywhere. It has applications in various fields such as mobile computing, location computing, mobile networking, context-aware computing, smart learning, sensor networks, human-computer interactions and artificial intelligence. The key elements of ubiquitous computing are Nanotechnology, Wireless computing, Context awareness and Natural Interactions; it is a powerful set to help in achieving the goals of ubiquitous computing. Challenges that are being faced are privacy, reliability, energy requirements, data mining etc. This paper helps in giving a brief introduction for those interested in researching on this topic and which could help them dive further into this vast domain.

**Keywords** Context-aware computing, Data Mining, Ubiquitous learning, Incentive Compatibility, Natural Interaction, Machine Learning

## I. INTRODUCTION

Ubiquitous computing, or Ubicomp, is essentially an advanced computing concept where computing is made to appear everywhere and anywhere for the user's convenience. In contrast to desktop computing, it can occur using any device, in any location and in any format. The underlying technologies to support ubiquitous computing include Internet, advanced middleware, operating system, mobile code, sensors, microprocessors, new input-output user interfaces, networks, mobile protocols, location and positioning, new materials, etc.

It is the term given to the third era of modern computing. The first era was defined by the mainframe computers, a single large time-shared computer owned by an organization and used by many people at the same time. Then second, came the era of the PC, a personal computer primarily owned and used by one person, and dedicated to them. The third era is ubiquitous computing, which we are now transitioning into, is characterized by the explosion of small networked portable

computer products in the form of smart phones, personal digital assistants, and embedded computers built into many of the devices we own—resulting in a world in which each person owns and uses many computers. Each era has resulted in progressively larger numbers of computers becoming integrated into everyday life.

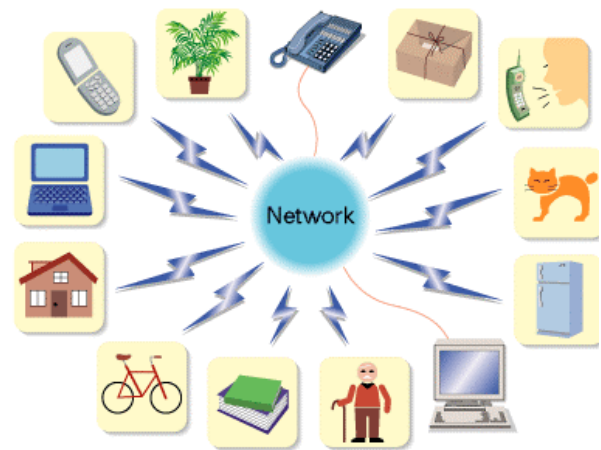


Fig 1: All devices are linked to each other connected to a common network  
Courtesy: <http://astrodynamics.net>

This new paradigm is also described as pervasive computing, ambient intelligence, invisible computing or, more recently, "everyware". Pervasive means to be present and apparent to us. Ambient intelligence refers to electronic environments that are sensitive and responsive to the presence of people [10]. It is also referred to as invisible computing because computation could be integrated with common objects that you might already be using for everyday work practices, rather than forcing computation to be a separate activity. If the integration is done well, you may not even notice that any computers were involved in your work.

The key elements of Ubiquitous computing are: Nanotechnology, Wireless Computing, Context awareness and Human computer interactions.

#### A. Nanotechnology

The trend towards miniaturization of computer components down to atomic scale is known as Nanotechnology. Nanotechnology involves building highly miniaturized computers from individual atoms or molecules acting as transistors, which are the heart of the computer chip. Therefore, nanotechnology's extreme miniaturization of transistors allows for impressive levels of computing power to be put into tiny packages [9].

#### B. Wireless Computing

Wireless computing refers to the use of wireless technology to connect computers to a network. Wireless computing is required for ubiquitous computing because it allows workers to escape from the tethers of a network cable and enable them to access network and communication services from anywhere within the reach of a wireless network [9].

#### C. Context Awareness

The general trend of computing is to have the devices integrated into the life of the users and have the services readily available whenever and wherever needed. Context awareness is a component of the Ubicomp environments that senses the physical environment and adapts their behavior accordingly [7]. Context is any information that characterizes the situation entity such as location and temperature. Applications that use context to provide relevant information are said to be context-aware. It emphasizes on delivering the right services at the right time. Context-aware systems start with gathering of raw, low-level contextual data; interpret the raw contextual data into high-level interpreted context. Then they reason the interpreted context to derive implications and adapt the application behavior on the basis of the implications [1]. For example, a context aware health kit senses the changes in the body temperature, variations in blood pressure etc., to provide assistance such as the need to visit the doctor, home remedies etc.

The use of context allows the application to be tailored to the users' specific situation providing increased benefits. The goal of context awareness is to use context to enrich the impoverished interaction from humans to computer, making it easier to interact with the computer. Context information is distributed and arrives from heterogeneous sources. Sensors are used by the devices in detecting the elements of context. Sensor is a device used to measure the physical quantities and

convert them into services as required by the user. Consider a scenario in which a context map utilizes the information that the user is leaving to Chennai and gathers information that there are heavy rains at Chennai, warning is provided by the device to take umbrella.

A few parameters of Context Awareness:

- **Location:** The location of the user is one of the parameters of context awareness in which location of the user is the context. For example, if a person is away from his house and it is lunch time the device suggests him the restaurants nearby where he may choose to go.
- **Time:** Depending upon the time, various decisions might have to be taken considering the user's schedule. For example, at a particular time the user has certain appointments it should alert the user so that appropriate planning can be done by the user.
- **Temperature:** Decisions can be taken by the devices after analyzing the temperature of the surroundings to lower or increase the temperature. In case the temperature is around 30°C, the air conditioner automatically lowers it to an optimum value like 22°C.
- **Lighting:** Sensing the mood in the room or the surrounding, the lights should dim or increase its brightness or if no one is present it should automatically switch off.

#### D. Natural Interactions

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 those [9]. In this way, the user is not preoccupied with the dual tasks of using the computer and getting the services, resources, or information.

## II. LITERATURE SURVEY

#### A. History

Mark Weiser first articulated the idea of Ubiquitous computing in 1988 at the Xerox PARC's (Palo Alto Research Center) Electronic and Imaging lab. It started with the idea of fabricating a large wall sized, flat panel computer display which also functioned with help of electronic pens, this opened the idea of spreading computers ubiquitously throughout i.e. many computers shared by each of us. This

was a way of computing that was considered different from the usual computers as they are invisible and focus can be placed more on the actual tasks.

The experiments that were conducted on implementation of Ubiquitous Computing between 1988 and 1994 at PARC were Tabs, Pads and liveboards. A tab was a device which incorporated a small display that could simultaneously serve as an active badge, calendar and a diary. It also acts as an extension of computer screens. Pads were the cross of 'a sheet of paper' and laptops which could potentially handle hundreds of devices per room per person. They did not have an identity of their own. Liveboards are large sized displays that are used in conferences, meetings and open areas and also as bulletin boards. An electronic chalk was used that could work either keeping it in contact or from a distance [3]. Liveboards were also proposed to serve as bookcases from which texts could be copied to the tabs or pads. Relaxing the size, form and display an additional system was proposed at PARC. Dust: Miniature devices without display. Skin: Fabric based light emitting polymers, organic polymers and Clay: Numerous smart dusts shaped into a real world object [3].



Fig 2: Liveboard as a bulletin board displaying the necessary information [12]

### B. An Example Scenario

- Anamika wakes up at 6a.m. in the morning; her smart bed sends a message to the electric heater and the alarm about this.
- The electric heater switches itself on while the alarm switches itself off.
- A display at the kitchen indicates her maid to prepare a cup of coffee.
- While she brushes, a display on the mirror shows "Talk on UbiComp, BMSIT at 9a.m."
- While she sits in the balcony drinking her coffee and reading the newspaper, she comes by an interesting article on UbiComp and wants to add it to her slides for the presentation.

- She uses a smart pen and copies the marked content of the article onto its memory and later on copies it on to her PC.
- After a quick glance, she loads the presentation on to her PAD and moves on to get ready.
- While Anamika is ready to start, her car driver is informed to keep the car ready to leave to BMSIT.
- As she starts, a tiny display on the window suggests her nearby restaurants for breakfast. She decides to have her breakfast.
- As Anamika approaches towards the campus gates of BMSIT, smart cameras inform organizers about her arrival and the seminar hall computers boots itself getting ready for the presentation.
- While she enters the hall, the presentation is copied from her PAD onto the live board at the seminar hall.
- After the presentation is complete, a message is sent out to her car driver to keep the car ready to start back.

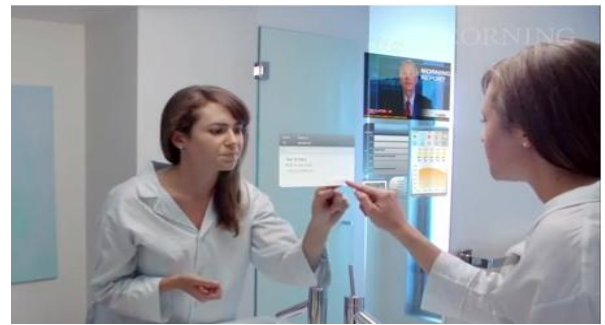


Fig 3: A smart mirror showing the day's schedule along with weather report [11]

### C. Applications

A few applications of Ubiquitous computing are Smart Memories, Smart Pen, Smart Wardrobe, Smart class, Smart Table, Smart Bed, Smart Green house, Ubiquitous learning environments, Smart Wall etc [5].

Smart memories is an application in which the atmosphere transmission system has the capacity to record its own memories of living patterns and the preferred lighting, sounds, images and smells. It can then access these memories in order to create the appropriate atmosphere in the smart house.

Smart pen offers a way of finding the meaning of a word or even lets you remember important phrases from books or documents. All we need to do is to run the pen over the text and it translates or saves the text.

Smart Wardrobe digitally looks up to the weather forecast for the day so that they can comfortably choose what they wear in coordination to the outside environment.

Smart Bed with the use of sensors comprehends the person is awake and sends this information to the alarm so that the alarm can switch off itself and sends a message to the heater to keep the water ready for bath.

Smart Greenhouse is a natural air purifying system that utilizes plants that have naturally powerful air purifying qualities in a mini greenhouse in the house providing fresh air and pleasant natural scent. It automatically also adjusts the climate to provide adequate freshness according to the contamination level in the house.

Smart Table incorporates an interactive touch screen which allows us to access all parts of the network with a touch and can be used to communicate messages and create tasks in case of an emergency .

Ubiquitous learning environment (ULE) is a setting of omnipresent learning. A ubiquitous learning environment provides an interoperable, pervasive, and seamless learning architecture to connect, integrate, and share three major dimensions of learning resources: learning collaborators, learning contents, and learning services. It is characterized by providing intuitive ways for identifying right learning collaborators, right learning contents and right learning services in the right place at the right time [8]. Education is happening all around the student but the student may not even be conscious of the learning process.



Fig 4: Smart table which loads on it the required documents [12]

### III. CHALLENGES

There are various challenges and issues faced in the implementation of Ubiquitous computing. The challenges include:

- Data mining

- Energy requirements
- Context aware computing
- Privacy/Security and Reliability
- Incentive compatibility
- Machine Learning

**Data mining:** Generally, data mining (sometimes called data or knowledge discovery) is the process of analyzing data from different perspectives and summarizing it into useful information [6]. With respect to ubiquitous computing, it deals with the segregation of data as needed by the respective devices and which devices need to access the information. Since there are many devices in a single place large amount of data is generated and this data must be specifically be directed to the devices concerned only.

**Energy Requirements:** A large amount of devices are involved and each device requires a significant amount of energy for computation, hence energy requirement is a concern for the successful implementation of Ubiquitous computing.

**Context aware computing:** The interpretation of context and adaptation of service behaviour is a prime challenge of context-awareness. Most of the tools are task specific. Standard and support tools are yet to be developed [1].

**Privacy/Security, Reliability:** Since all the devices can access the network there is a possibility of trailing the devices and information may get leaked. A single rouge tab in room can track all the activities happening hampering the privacy and security of the users [3]. There are a lot of devices and relying on a network is of concern.

**Incentive compatibility:** Incentive compatible is a mechanism to facilitate the trustworthiness evaluation in ubiquitous computing environments [2]. It is based on probability theory and supports reputation evolution and propagation. With the implementation of incentive compatibility, the security can be improved. Various algorithms are being developed to improve this aspect.

**Machine Learning:** It is a branch of artificial intelligence that is concerned with the construction and study of algorithms and systems that can learn from data [4]. These algorithms process large amounts of data, discover patterns in data, and construct predictive models for a desired task. Machine learning is time consuming and improvement of its algorithms can prove to be a very helpful task for context aware computing under Ubiquitous computing.

#### IV. CONCLUSION

This paper therefore gives an introduction to Ubiquitous computing, discussing about its history and a few applications. It also presents a few challenges to the implementation of Ubiquitous computing along with an example scenario. This paper helps in getting to know the basics of Ubiquitous computing and gives an opportunity for people who may be interested in carrying out further research regarding this topic.

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