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# Emerging Trends and Limitations in Technology and System of Ubiquitous Computing

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***Abstract:*** Ubiquitous computing(ubicomp), an advanced computing concept to make computing appear everywhere and anywhere, was coined by Mark Weiser around 1988. Since then humungous research is being carried out and applied accepting its best features. This paper discusses the origin and research works done in this field. Further exploring its concept, architecture and applications we provide words to the vision required and challenges it faces. Since, every coin has two faces, we not only highlight its benefits and effectiveness but study its limitations and understand how it is a risk to privacy of user and requires infrastructural changes. We also try to understand why Cyber Crime Research Center termed pervasive computing as a 'cyber crime'. Suggesting a mechanism (change in algorithm while designing ubiquitous environment) to overcome it we conclude this paper giving a glimpse of our further study and idea of development in this ever exciting and core field of development.

***Keywords:*** Ubiquitous Computing, Ubicomp, Pervasive Computing, Mobile Computing, Distributed Computing

## I. INTRODUCTION

Ubiquitous computing is an advanced computing concept where computing is made to appear everywhere and anywhere**. In now days, Ubiquitous computing are also called as pervasive computing** [16]. Ubicomp also phrased as pervasive computing, ambient intelligence, or everyware, touches on a wide range of research topics, including distributed computing, location computing, mobile computing, mobile networking, context-aware computing, sensor networks, human interaction and artificial intelligence. Ubiquitous computing neither being virtual reality nor a PDA or PC, supports a world of fully connected devices, ensuring information access everywhere and providing an intuitive, nonintrusive interface.

## II. ORIGIN & RESEARCH WORK

It is very important to highlight origin of ubicomp and move towards various research works done by various scientists till date because this will enlighten the trends of emerging trends in various sectors of pervasive computing. Mark Weiser around 1998, during his tenure as Chief Technologist of Xerox Palto Alto Research Center (PARC), along with John Seely Brown (Chief Scientist at PARC) wrote some earliest papers defining and portraying the subject.

Weiser with a goal of computing for everyday life started work in1988 and reported it in 1993[1].Inspired by the idea ignited by Wiser 14 well known researchers worked on his dream and presented their contribution all over the world. Gregory Abdowd with his doctoral students (Anind Dey, Jennifer Mankoff and Shwetak Patel)[2], Paul Dourish[3], Rebecca Grinter, Sumi Helal, Hiroshi Ishii, Natalie Jeremijenko, Elizabeth Mynatt, Eric Paulos, Alex Paul Pentland, Albrecht Schmidt, Thad Starner and many more researchers have been contributing tremendously since 1999.

Encouraging the idea of ubicomp, 4 research centers in various countries namely, Canada, Germany, Sweden and United Kingdom, have been set up till date.

## III. EXPLORING PERVASIVE CONCEPT

The basic idea was to construct an everyday thing focusing on physical affordance[5]. Even though technology was developing during 1993, it wasn't widely used (e.g. Wireless protocols were used only in labs). Chips at that time had no provision of powers saving modes and failed when underpowered [6]. Therefore, reduction in power consumption became an important goal.

Power =
Gate Capacitance*Voltage Supplied*Clock Frequency

To completely apply this, issues of wireless computing could not be ignored merely because of non-popularity. Weiser faced several issues like, FCC regulations and technology couldn't provide appropriate bandwidth, Narrow spectrum of technology of 1990, Reduction in power reduces media contention and avoided FCC regulations, IP was not designed to support mobility, display areas vary from one physical device to another [7].

Over past two decades the scenario has completely changed due to acceptance of technological changes and expansion of spectrum. These day ubicomp is widely used. Figure 1 illustrates layout of Ubiquitous computing suggesting physical layer as its first input allowing users to access internet via gateway by providing an infrastructure platform for application sector's services like banking, insurance, agriculture, health care, government, utility, manufacturing, transport and many others. Tools and techniques for dynamic reconfiguration and interloping of pervasive systems are

provided by mobile agent technology (employed to achieve interoperability among multiple interacting pervasive systems) and sensor networks (which support a considerable fraction of pervasive systems currently deployed)[11]. The figure depicts a layered structure employed these days.

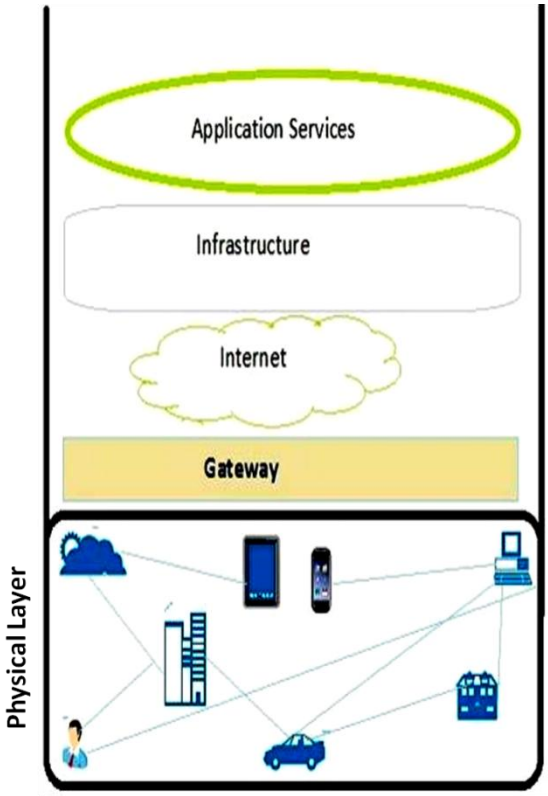


Figure 1: Various layers of Ubiquitous Computing layout.

## IV. VISION & CHALLENGES

Practical realization of pervasive computing requires us to solve many difficult design and implementation issues. For successfully completing purpose of ubicomp tracking user intent is crucial. Today's systems are poor in grasping and judging user's intention. In fact, it is impossible to determine which system actions will help than hinder users[19]. Applications in today's era, designed to help users, end up offering little support for adaption and proactively [9].

To make today's hardware smaller, lighter and have long battery life, their computing capabilities are compromised. To meet the ever growing expectations of users, computing beyond lightweight service architecture [12] with long battery life is required. Compiling these requirements is difficult, but not impossible. To empower this computing we require a client that can guide applications in changing their behavior to minimize resource utilization, a client to interact with environment and a client to suggest a corrective action to the user. These challenges can be overcome by developing a vision of high level energy management client thickness.

Figure 2 explains that distributed computing, arising due to intersection of personal computing and local area networks, and mobile computing, appearing as full function laptop computers and wireless LANs combining together to form pervasive computing. Mobile computing led researchers to resolve the problems in building distributed system with mobile client. Hence, research agenda of ubicomp subsumes that of mobile computing. Pervasive computing incorporates additional research thrusts into its agenda likes distributed systems, mobile computing, reconfigurable computing [24], smart environments, technology etc. as pictorially represented in the below figure.

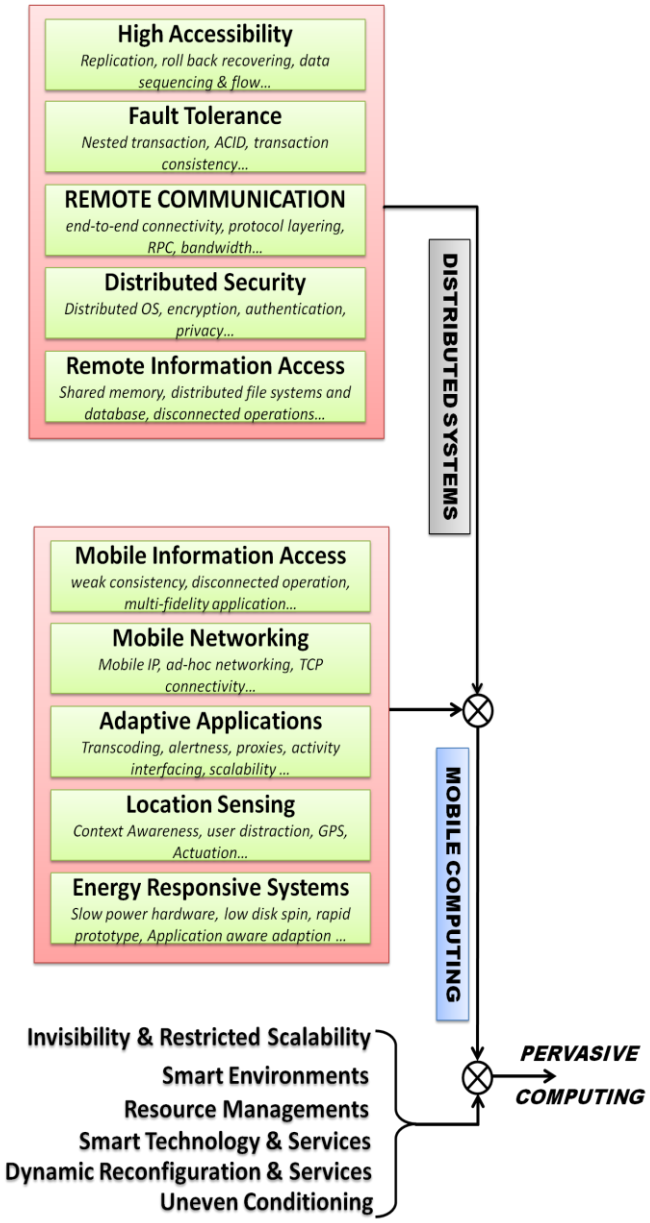


Figure 2. Foundations of pervasive computing.

## V. CHARACTERISTICS OF PERVASIVE COMPUTING

Pervasive computing being situated in human centered personalized environment, interacts less obtrusively with humans. This system is a part as well as uses the physical environment, thus being able to adapt, act and control it. There are three key features of such a smart system specifically, transparency, openness, and user interface. Access of Ubicomp is hidden and integrated to the environment. 'Invisibility' being the general term used does not mean one cannot see the technology but rather its presence does not intrude into workplace environment, either in terms of physical space or activities being performed.

Openness allows system to avoid having to support all their functions at design time, avoiding closed implementation. Basically, openness is the amount of functionality Ubicomp allowing for users to manipulate. GUI, command line or menu driven computing is inappropriate and inadequate to the

ubiquitous case. Pervasive computing allows distributive composition of services [21].

## VI. APPLICATIONS & REQUIREMENTS

Due to wide spectrum of ubicomp as suggested by its alias "everyware", it has an even wider spectrum of applications or employment[8]. Following examples quoted by Stefan Poslad[15] in his book "Ubiquitous Computing"[13] highlight the range of benefits and challenges for Ubiquitous Computing. Personal memories scenario focuses on users recording audio video content, automatically detecting user contexts and annotating the recordings. A 21st century scheduled transport services are adapting their preset plans to the actual status of the environment and distributing this information more widely. Foodstuff management system focuses on how analogue non electronic objects such as foodstuffs can be digitally interfaced to a computing system in order to monitor their human usage [23]. A fully automated foodstuff management system could involve robots which can move physical objects around and is able to qualify the level of a range of analogue objects. A utility management scenario focuses on how to interface electronic analogue devices to an Ubicomp system and to manage their usage in a user centered way by enabling them to cooperate to achieve common goals.

## VII. LIMITATIONS

Despite the wide role in creating and sharing data, ubiquitous computing has certain limitations and constraints. Since ubiquitous computing involves a range of devices and components that were produced by different manufacturers and service providers and as each service provider implements his own protocols, suited for their components so, integration fails during assembling ubiquitous components. Administration is really a tough job to implement. It is often difficult for a wearable system to sense beyond the user's local area. NIR exposure, Physical contact and use of active implants cause health hazards. New form of human machine interaction causes more stress due to poor ergonomics. Change in public health sector caused a rapid increase in health care cost. Pervasion of everyday life by ICT to reduce the digital divide created restrictions on consumer's freedom of choice. Ubiquitous information access led to economy of attention to dominate culture and loss of social contacts, and isolation. By watching everything a user do, these systems have the potential to leak out all our actions, preferences, and location to others unknown to us, now or in future. Unfortunately, it seems to be truism that the most useful information is also the most personal. Network topologies crashes frequently as system Just as smart rooms re ill-suited for personalized information, wearable computer systems have trouble in maintaining localized information [18]. These limitations can still be accommodated in near future but a few that are in dire need of accommodation are:

- Always a sophisticated environment like newly constructed buildings are required to support the infrastructure of ubiquitous computing which is practically not possible at all times.
- It is often difficult to maintain personalized ubiquitous computing system. In worst case, every time a new person joins a work-group or community, his personal profile needs to be added to every device. Even if all devices and environments on a campus share a personal profile database, profile needs to be updated every time a person moves to a new site.

## VIII. CONSEQUENCES

Several experiments at Xerox PARC, EuroPARC, and Olivetti Research Center used active badge systems to support location based information and collaboration. In these systems, participants wear badges that broadcasted their location to sensors positioned in each room. The researchers suggested a combination of both technical and social mechanisms to help address this problem. However as Foner points out sometimes good security and strong privacy policy are not enough to protect a person's privacy[4]. Central databases are prime targets for subpoena, and the more places where sensitive information resides the more potential places that are to compromise that information.

There is always a situation where someone should not trust the environment to keep his/her information secure. One case is in customer- provider relationship, where we already have seen a large interest in logging customer profile and buying habits to increase sale. Another is the case when entering a hostile environment. For example, if a businessman is entering a competitors company to negotiate a contact, he probably would not like all his personal information to automatically be uploaded to their system where it might be viewed to gain an unfair advantage[10].

According to Cyber Crime Research Center [25], "The incidence of cyber-crime (e.g., successful and attempted security breaches, theft, financial fraud, and virus detection) continues to rise, according to the annual Computer Crime and Security Survey conducted by the Computer Security Institute (CSI), a San Francisco-based association of information security professionals. The survey reveals significant financial losses due to security breaches and information theft.

The mission of the survey, conducted in collaboration with the San Francisco Federal Bureau of Investigation's Computer Intrusion Squad, is to determine the pervasiveness of computer crime in the U.S. and to raise the level of awareness regarding security concerns. The 503 participants in the survey consisted of computer security professionals from U.S. corporations, government agencies, financial institutions, medical institutions, and universities. The following are some of the general survey results:

- 90 percent of respondents detected computer security breaches.
- 80 percent reported financial losses due to security breaches.
- 44 percent quantified their financial losses, reporting a total of US$455,848,000 in losses.
- Information theft and financial fraud contributed to the most serious financial losses.
- 74 percent of respondents reported their Internet connection as a frequent point of attack.
- 33 percent reported their internal systems as a frequent point of attack.
- 34 percent of respondents reported these intrusions to law enforcement.

This was not a part of vision of Mark Weiser. In computer network, firewalls protect devices and users against any intrusion or misbehavior. Users are authorized to work with only well defined interconnections and trusted computers. Lightweight Directory Access Protocol (LDAP) or Active Directory (AD) is used to control resources and to affect rights to every component that wishes to connect to the network or utilize its resources. Access control (AC), Role Based Access Control (RBAC) being most predominant scheme, in pervasive networks usually relies on the right management matrices, which define roles, rights and context [22].

## IX. SUGGESTIONS & EMERGING TRENDS

In view of above mentioned problems, we would like suggest that only creating documents of terms and conditions won't do the job of ensuring security of private information, we need a change in algorithm employed for pervasive computing. The change may increase the complexity at initial levels but would surely benefit consumer and justify the vision on Mark Weiser. Changes should be such that a user can judge what to be displayed and what not to another user or unknown person whether belonging to the group or not. Personal details should be encrypted by user's server before transferring to administrator of the network so that nobody can have unauthorized access to private information. Data security must be assigned higher priority because other issues may harm users but data leak may scare the user.

NIR radiations also required to be tackled with serenity to get best out of Ubiquitous computing without affecting health of anyone [17]. This demands a new technology which would be more environmental friendly. Some current research projects are Cool Town HP with the aim of making wireless- web enabled world, in that every entity in physical world whether electronic or not has a web page. It provides architecture for nomadic computing. Cyborg 2.0 is a surgical implant in Kevin Warwick lower arm that could send signals back and forth between Warwick nervous system and a computer. He was able to remotely control an electronic wheelchair and an artificial hand without using his arm. Project oxygen is a project by MIT which aims at making computing available as oxygen. It deals with making self governing, nomadic computing with computational and hand held devices. Smart dust and Tiny OS micro fabrication and integration of low cost sensors, actuators and computer controllers, MEMS enable devices to be small enough to be sprayed or scattered in air, to embodied through digital environment, creating a digital skin that senses a variety of physical and chemical phenomenon. Easy living and SPOT, a project Microsoft which aims at developing intelligent environment which allow the dynamic aggregation of diverse I/O devices into a single coherent user experience. It facilitates flexible I/O operations between different devices [14].

In near future, some more technologies like, Smart refrigerator "aware" of the suitably tagged contents, able to both plan a variety of menus from food actually on hand and warn users of stale or spoiled food, Smart windscreen that is able to show the traffic updates, speedometer, and route maps on windscreen itself without looking off from the road, Smart toothbrush can contain cameras and sensors so that they automatically guide themselves or show the view to user to assist users in which parts of the teeth need to be specially cleaned, Smart pillows that can read any book of your choice to you at bedtime and can play your favourite music to drift off when you start to get sleepy , Smart chairs to take information about a sitter's behaviour and adapt it, Smart traffic lights automatically synchronizes according to traffic rather than a timer, Smart mirrors can automatically optimise the field of vision, example, near side wing mirrors of cars to automatically face downwards to see the kerb when reversing into the kerb, Smart buses-to inform passengers how late they are to remote passenger and at what time they would reach, Smart camera-capture an image when you glance at something new for more than 3 sec, and a lot more would be worked upon[20]. Xerox took first step to implement smart environments in their research laboratory thereafter paving a way for more research projects as well as commercial initiatives. But wistfully, focus is mainly on applications like smart shopping environments and do not incorporate further prospects of using an open approach. Thus we need to have equal focus and emphasis on enhancing the tool incorporated by father of ubicomp.

## X. CONCLUSION & FUTURE ACTIONS

In this paper we discussed, how Ubiquitous computing started, what was its goal, what effects it created in research and applied societies, focusing on milestones we are yet to cover to achieve the desired computing anywhere , everywhere and for all. We explored the concept of ubicomp mentioning its applications, highlighting current and future projects being worked and discuss upon at various renowned research laboratories. Paying heed to limitations of ubicomp we discussed how to tackle privacy issues being the core reasons of coining ubicomp as 'cyber crime'. We conclude this paper leaving a glimpse of our future research, i.e. to develop universally compatible model accommodating a new layer in existing model to ensure privacy and avoiding infrastructural changes by designing a user friendly algorithm for pervasive computing. A work in direction to enhance hardware life without compromising with computing capabilities is expected to be present soon.

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