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### Ubiquitous Computing in Healthcare

<sup>1</sup>Barka Tatama Fori, <sup>2</sup>Ipole Nancy, <sup>3</sup>Lawal Ibrahim, <sup>4</sup>Onu Egena, <sup>5</sup>Maikori Jenom  
<sup>1, 2, 3, 4, 5</sup> Department of Computer Science, Bingham University, Karu, Nasarawa State, Nigeria

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Corresponding Author: **Barka Tatama Fori**

#### Abstract

Raising sophistication and cost in medicine and healthcare services is a major global issue, sophisticated ubiquitous computing also called pervasive computing applications are gearing up to this challenge, with sensors embedded into our daily devices it is becoming easier to put these devices in a computing grid and collect patient's data more frequently than performing a routine checkup. Ubiquitous computing can help manage critical cases because the patients will be

monitored more closely and emergency situations will be attended to a lot quicker and the medical experts and the system will be aware of any raising health issue. Ubiquitous computing allows patients records to be accessed anywhere anytime meaning an ambulance can be approaching a scene and pulling up the medical records of patient to act on the issue as it arises. This is could very well be the foundation for smart hospitals or smart healthcare.

**Keywords:** Ubiquitous Computing, Pervasive Computing, Smart Hospital, Smart Healthcare

#### Introduction

Ubiquitous computing is a system of computing where computing tasks are carried out from anywhere at any time using a grid of networked computing devices, this is in contrast to desktop computing where computing is carried out on a dedicated computer and virtual reality which simulates the real world. "The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it." Mark Weiser's seminal 1991 paper <sup>[1]</sup>. Mark Weiser who came up with the term ubiquitous computing believed the most advanced computing system will integrated seamlessly into our daily activities and lives that human computer interaction will be less intermittent.

Mobile and ubiquitous computing technologies offer promising solutions for archiving process, diagnostic conditions and proper care of patients in a patient-centered manner.

The adoption of this concept of ubiquitous healthcare requires an interdisciplinary approach, acquiring ideas and techniques from computing fields, such as Ubiquitous Computing, Context-aware Computing, Human-Computer Interaction (HCI) and Artificial Intelligence (AI) as well as the medical domain, nursing, public health, occupational therapy and health education. Healthcare environment requires a really deep knowledge of user's perspective. Furthermore, these kinds of setup enforce the need for design that considers multiple and non-technical users through easy and learnable means of use <sup>[2]</sup>. Many believe this to be the next stage after mobile computing, ubiquitous computing usually involves wireless networks and networking technologies, mobile devices, embedded systems, wearable computers, RFID tags, middleware and software agents. Internet capabilities, voice recognition and artificial intelligence are often also included <sup>[3]</sup>.

The rapid development of networked health care devices has been driven by a lot of factors. Data networks are becoming more reliable and are growing to include not only computing devices like desktop and laptop computers, but also health care electronics devices. Projecting this trend into the future, envision an explosion of interconnected small devices from watches to cars that make lives easier and more productive. An equivalent revolt deception in the network-enabling these persistent computing devices by providing transparent, ubiquitous admittance to e-business services <sup>[4]</sup>. It is the goal of Ubiquitous computing to exploit these networks to provide better and faster services in all works of life.

#### Medical information management

In terms of the computation model, conventional computing is combining acquired valid data, management and performing operations on this data, the processed data is then stored for further use. The efficiency of computing is heavily based on proper implementation of arithmetic and logic, meaning there is consistency in the results, a particular input should always return the same answer or result. However, a 5-A Model can be used to better rely ubiquitous computing ideology any data,

Any device, any network, anytime and anywhere. A user who knows how to interpret data using multiple devices via any network at anytime and anywhere will find the 5-A model easy to recognise<sup>[4]</sup>. Ubiquitous computing is usually seen as the de facto advancement from conventional computation techniques, where users take a network centered design and look into the integration of multiple networks. Some researchers on the other hand, take the data centered perspective and investigate the data flow and information collection, data processing and data storage problems of the systems. With the continuous raise of artificial intelligence it comes as no surprise that certain researchers are fusing there ubiquitous system with intelligence for smarter and better decision making further leading to ubiquitous intelligence<sup>[4]</sup>. Ubiquity goes a step further over traditional computing by introducing some form of intelligence which makes decision making easier and faster.

**Ubiquitous computing systems in healthcare**

Progressively autarkic, multifunctional, scaled down and networked medical software in pervasive computing offer an extensive variety of potential outcomes for checking the soundness of the sick and the elderly in their own homes, and in addition for smart implants<sup>[5]</sup>. The achievement of ubiquitous computing rests with the best possible merger of different parts that communicate to each other and carry on as one. Fig 1 shows such a setup. At the base of the stack is a "Physical" layer. Small sensors are connected (conveyed, worn, or installed) to individuals, machines, homes, automobiles, and fields. Today, some cell phones carry a large group of sensors that catch different bits of data from the environment. Apart from the cameras, and microphones smart phones also come with ambient light sensors, gyroscope, accelerometer, compass and so on<sup>[18]</sup>.

Ubiquitous computing comprises of numerous devices like smart watches, desktop computers, GPS devices, fitness bands as so on, for this study the focus will be on smart phones, for ubiquitous technology to really permeate real life and feel seamless it relies heavily on sensors to for data generation this is built on top of the embedded computing model where we have sensors like cameras acting as sensory devices passing data called stimulus to a sensor control for data processing which in turn triggers an action via an actuator, ubiquitous computing relies on foundation of such system.

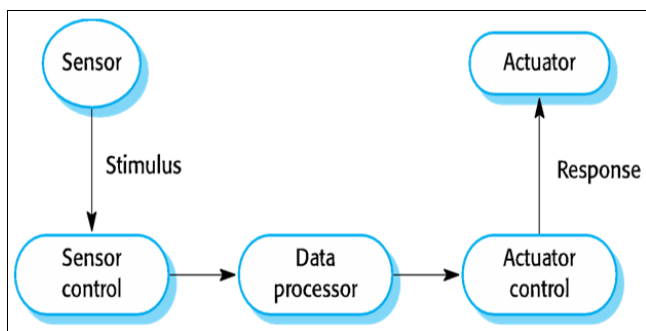


Fig 1: A simple model of an embedded system. (Embedded system)<sup>[28]</sup>

Smart phones are now equipped a lot of sensors to make health care easier and better, an example is a phone equipped with pedometers which can be used to estimate

how many steps a user takes and how many calories are burnt, with access to an API a medical doctor can get this information at certain intervals or on demand. Irregular reading can also trigger emergency response without the patient acting on anything, diagnosis can also be carried-out based on readings and updated to the patients records, this process is shown in Fig 2.

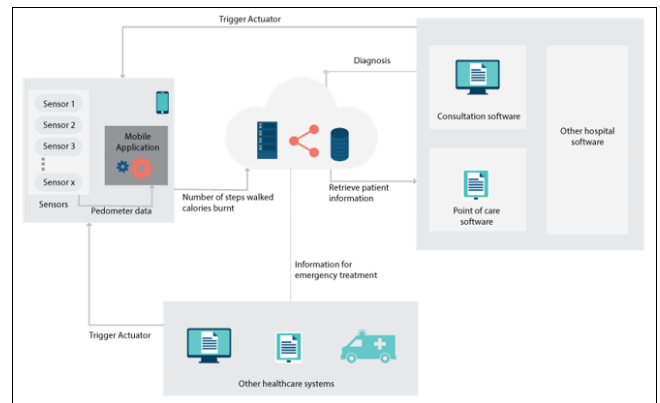


Fig 2: A simple model of a ubiquitous healthcare system. (Embedded system)

Sensors get data also called stimuli from the patient and his environments and is processed by the mobile application for interpretation of the data after process the information is then uploaded to an online server that can be accessed by anyone with granted access to the patients records and medical personnel can trigger alerts for the user to take certain precautions or take note of certain habits.

Ubiquitous computing is seen less as a discrete field of innovation, but instead as a rising use of data and networking innovation that blends into the regular world like never before. The objective is to meet the claim of "everything, always, everywhere" for information preparing and transmission through the universality of ICT frameworks<sup>[5]</sup>.

Sandy Pentland led a group of researchers from MIT discovered that information about a patient's location, communication and navigation data from mobile phones can provide enough information to identify flu and gastrointestinal cases before they get out of hand<sup>[6-8]</sup>.

At UC San Diego SMART systems take advantage of SMS and social media applications for positive topics to drive weight loss campaign amongst adolescents and this was engineered by Kevin Patrick<sup>[9]</sup>.

UCLA researcher William Kaiser was able to build healthcare software to keep constant check on stroke patients for diagnosis and treatment. This has drawn funding for over 300 subjects from more than 20 countries<sup>[10]</sup>.

**Concerns for ubiquitous system**

The power ubiquitous computing guarantees convey with it huge dangers. One such problems is related to the measure of privacy that must be relinquished to see the advantages of really useful computing. Another is that early, "front line" uses of ubiquitous computing will end up being more aspiring than compelling, driving some to rashly assume that the concept has failed<sup>[11]</sup>.

Ubiquitous computing isn't simply discussing one gadget for one individual. Ubiquitous computing implies somebody can bring some ubiquitous computing device sand

furthermore should be utilized as a part of an expansive area. This innovation isn't at present ready to ensure the pace for such circumstances since it can be insufficient if not bolstered with wireless technology improvement that can give the required speed [12]. In location detection agent, ubiquitous computing often produces data with a reference to the place of the event happened. The issue of tracking people is linked to the debate about privacy problems on social media platforms [13] to the extent that these social media track user locations consistently and in real time [14]. Maintaining anonymity during commuting or movement is important because with enough computing power and skill certain organisations can figure out information about who the tracked person is with from thereon gain information about people whose privacy shouldn't be invaded upon [14, 15].

Safety and security of children and particular patients is enhanced true tracking of these persons. Tracking poses a huge security threat as most people will prefer not being tracked for privacy reasons, so who should be tracked and the purpose of tracking has to be properly documented with the person being tracked [16]. Having enough information on a patient could lead to serious security and privacy issues and standards have to be put in place to make sure this information is not exploited and used for the wrong reasons.

### The need for security and privacy

Security and Privacy concerns are one of the fundamental issues while in adopting ubiquitous frameworks. Regular clients are normally not overly security and privacy burdened and would give away some private information to acquire certain rewards. Notwithstanding, it has a tendency to be evolving. That implies, that organizations sending a safe and security mindful UbiComp frameworks will probably have business accomplishment than the other people who have not put resources into security and security.

When the framework is made, it is moderately simple to convey the framework (i.e. set people up with sensors) since "singular ventures pay instantly" (consider a case of conveying development to the auto part ("more personal") and to the railroad one ("more public")). In this way, a framework with a decent protection and security administration instruments is more probable to be acknowledged by the larger part and can be sent generally simple and be economically fruitful, despite the fact that extra interests in protection and security of the framework were made.

### Benefits of ubiquitous computing to healthcare

Regardless of the concerns related to ubiquitous computing it does have a great potential in modern healthcare. Ubiquitous computing offers a variety of potential for building intelligent healthcare services as integral parts of future care ideas [19], which are challenges posed by our ageing community.

**Smart Health:** A term coined by fusing concepts from ubiquitous computing and intelligent systems applied to the future P4-medicine ideas, thus tightly integrated into concept of healthy living [20, 21], inclusion of medical sensors to read stimuli from the patient and actuators to observe the patient and gather numerous data will lead to efficient health status prediction and diagnosis.

**Smart Hospital:** A concept of a completely ubiquitous run healthcare environment equipped with state of the art ubiquitous devices [22], ubiquitous healthcare has drawn attention of large companies like Google, Siemens, IBM etc, mainly due to the potential it holds in reducing the overall cost healthcare systems globally making this a strategic move for these companies [22]. As with everything trying to drive change there are challenges and these are technological challenges like mobility, visibility (smart wearable devices like watches, clothes [23], glasses [24], etc.), natural methods of interaction with the systems like sound and gesture based interaction rather than keyboard or mouse and most of all grow and understand complex situations, as those two important issues "adaptive behavior in context" are key for "intelligence" i.e., being able to react to strange and unique problems with flexibility and intelligence. Integrating such daily technology into health will create an atmosphere of constant observation of a patient's health. Keeping up with increasing medical data is becoming increasingly difficult to keep up with by experts [25] ubiquitous computing will help provide a layer of processing to make this data consumption by experts faster. A clear example is Jesus Favel and his groups smart hospital software that estimates hospital staff behaviour and mapping important information for the user's activity [26].

### Conclusion

This paper touched the basics of ubiquitous technology and its viability in healthcare and despite some concerns of security and privacy it is clear that with ever increasing production wearable and smaller technological devices that permeate into our daily lives the more feasible it becomes to adopt ubiquitous technology and leverage the benefits it has to offer.

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