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Ubiquitous Computing and Its Applications

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ABSTRACT: Ubiquitous computing is a concept in computer science where computers will provide information and assistance for people effortlessly by embedding intelligence and computing capabilities into everyday objects. Ubiquitous computing was introduced by Mark Weiser and is made up of nanotechnology, wireless computing, context awareness, and natural interaction. Ubiquitous computing can be applied to many fields like robotics and sensor networking. There are several concerns to ubiquitous computing, like privacy and cost, but the ubiquitous computing trend will continue to expand through software development and reach many industries.

Ubiquity is the concept of a presence to have the capacity to be everywhere at every time. This idea of ubiquity can be applied to many fields, especially that of computer science. Ubiquitous computing is the idea that computers will fade into the background, providing information and assistance for people effortlessly by embedding intelligence and computing capabilities into everyday objects. The International Journal Of Innovative Research And Development defines ubiquitous computing as the "…method of enhancing computer use by making many computers available throughout the physical environment, but making them effectively invisible to the user" (Mousa 276). Ubiquitous computing is also known as ubicomp, pervasive computing, ambient intelligence, and calm technology and is made up of several important factors. The key aspects of ubiquitous computing are nanotechnology, wireless computing, context awareness, and natural interaction. These elements are used to incorporate ubiquitous computing into many different applications. Some of the most significant applications of this concept are robotics and sensor networking. Ubiquitous computing is an important computing concept that will most likely be vital in the future development of software engineering.

To begin, to understand the concept of ubiquitous computing one must know how the idea came to be. Ubiquitous computing was introduced in 1988 at Xerox's Palo Alto Research Center by computer scientist Mark Weiser and his colleagues. Weiser is known as the father of ubiquitous computing and he believed that the purpose of computers is to make the user's life simpler. Weiser explains in his article, The Computer for the 21st Century, that the "… most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it…" (94). He goes on to further explain that ubiquitous computing devices can come in three different forms to better suit each task they are

assigned. The first form is a tab device that is inch-scale and wearable. Pads are the next form of ubiquitous device that are larger in size and act like a sheet of paper or a book. The third form of device is a board, they come in larger displays and act like a blackboard. Weiser also attempted to create a ubiquitous computing environment during his time at Xerox PARC. In one of the earliest ubiquitous computing experiments, they installed a string to act as a live wire. This string was connected to a small motor and controlled by a LAN connection. When network activity would occur the string would move, the movement would indicate that there was traffic happening nearby. Weiser referred to this experiment as an example of calm technology. Mark Weiser would go on to become Xerox's chief technology officer before unfortunately passing away from cancer in 1999. However, his legacy as the father of ubiquitous computing will continue in the development for new and better user centered software.

Additionally, the development of ubiquitous computing devices and environments are based on the essential aspects of nanotechnology, wireless computing, context awareness, and natural interaction. Nanotechnology involves shrinking down the computers to an atomic scale. The miniaturized computers are built from individual atoms or molecules that will act as transistors. These transistors are described as the heart of the computer chip and the amount of transistors in a single chip is an indication of how powerful the chip can be (Mousa 279). Nanotechnology allows for a great degree of power to be incorporated into very small packages. This is an important part of ubiquitous computing because these packages can be put away so that they can act unobtrusively and blend into their environments. This is important in the development of devices like wearable tabs. Another essential part to ubiquitous computing is wireless computing. In wireless computing involves the use of wireless technology to connect computers to a network. Wireless computing is important because it allows for people to free of cable and wire

restraints and it allows for communication services to function from anywhere and anytime as long as there is a wireless network nearby (Mousa, 279). This is critical part of ubiquitous computing because it allows for devices to function from anywhere and anytime without the need to restrict access due to a cabled connection. The next key part of a ubiquitous computing environment is context awareness. In context awareness, a computer should be able to "…understand enough of a user's current situation to offer services, resources, or information relevant to the particular context" (Mousa 279). In a ubiquitous computing environment, the attributes that make up a device's context awareness should differ widely, including the user' s locations, roles in life like mother or coach, past activity, affective state, and must go beyond the user to include the current date and time. For instance, a ubiquitous device with context awareness could use the information that the user is away from home, has no appointments, and that the time is late to determine and create the timing for the user's upcoming needs. After using this information, the device could decide that it is time for dinner and inform the user of nearby restaurants. The final part of ubiquitous computing is natural interaction. In natural interaction, the ubiquitous computing device must "… 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 them" (Mousa 279). This is important because it allows the user to be free from doing several tasks at once, they will not be preoccupied with trying to use the device and get the services they need. Ubiquitous computing devices with natural interaction, will allow for the job to get done without the instrument getting in the way. All in all, the development of proper ubiquitous computing environments relies on these factors to evolve and advance the software industry.

Furthermore, the concept of ubiquitous computing can be applied to many fields but one of the most important is robotics. With the recent increase in new ubiquitous computing

technologies, robotic systems have also been able to develop further. The ubiquitous robotic companion is a networked robot that are integrated into the ubiquitous computing environment to provide users with services they need at anytime and anyplace. These robots are designed and implemented through an infrastructure called the ubiquitous robotic service framework. The authors of the article, A Robotic Service Framework Supporting Automated Integration of Ubiquitous Sensors and Devices, explain that this framework "… enables automated integration of networked robots in ubiquitous computing environments in a service-oriented way" (Ha et. al. 658). The ubiquitous robotic service framework uses Semantic Web Services and an artificial intelligence planning methodology to provide automated interoperation between the robots and ubiquitous computing devices in the service environment (Ha et. al. 658). Semantic web services are a web technology that allow for machine-to-machine interaction through the internet. In the experiment done by the article, they use the semantic web service called, Web Ontology Language for Services also referred to as OWL-S. The ubiquitous robotic service framework is made up of a robotic agent, a device web service, and an environmental knowledge repository. The robotic agent acts as a service requester agent and has the main role in the automated integration procedure of the framework. The device web service is an implementation of web services for the ubiquitous devices in the service environments. The environmental knowledge repository is used for the registration and the discovery of knowledge from the service environment. Using these factors, the framework gets information about the environment to create a ubiquitous robotic companion that can respond to the tasks asked of it. The development of this ubiquitous robotic companion is an example of ubiquitous computing because it involves weaving in the environment with the device to provide an easier and simpler experience between

the user and their surroundings. This application of ubiquitous computing shows how the concept can be utilized to bring forth new devices that can embedded into the environment.

Moreover, another application of ubiquitous computing that is important are sensor networks. A ubiquitous sensor network is made up of many small computing devices. Each device has a sensor, a wireless radio, a processor, and a power source. The devices are deployed unobtrusively into the physical environment to monitor their surroundings. These ubiquitous sensor networks can connect any object with another by detecting, storing, processing, and integrating information gathered by the sensors. These sensors use motion detection, speaker identification and facial recognition, all of which are important for the context awareness aspect of ubiquitous computing described previously. The most common ubiquitous sensor network is a radio frequency identification tag, also referred to as RFID. RFID technology allows for contactless object identification, so they can be placed in the environment of ubiquitous sensing (Changyoon et. al. 159). An RFID system is made up of tags called readers and antennas that come as passive and active. Active tags have their own power source to reflect radio waves from the RFID reader and passive tags are activated by the RFID reader itself. These tags collect data and by identifying objects through low power radio waves (Changyoon et. al. 160). A ubiquitous sensor network that uses RFID tags can be used to in many environments to encourage ubiquity. In the article, Ubiquitous Sensor Network for Construction Material Monitoring, the authors conducted an experiment by attaching RFID tags to a construction site to track materials. By the end of the experiment, the RFID tags were able to identify a wide range of construction materials and were able to transfer the information to an end user. These ubiquitous sensor networks are vital for ubiquitous computing environments because they can be incorporated into objects for

unobtrusive sensing. This application of ubiquitous computing to sensor networks can prove to be very beneficial for future software development.

Ultimately, ubiquitous computing is an innovative computing concept that will have a significant effect on how people interact with computers, devices, physical spaces, and even other people. It was developed decades ago and has still managed to evolve and impact the development of technology. Ubiquitous computing is made up of nanotechnology, wireless computing, context awareness, and natural interaction. These elements are used to incorporate ubiquitous computing into many different applications. Ubiquitous computing can be applied to many fields but some of the most important applications are the fields of robotics and sensor networks. As beneficial as ubiquitous computing seems, it does have its downsides. Creating ubiquitous computing devices requires sacrificing privacy to ensure that they work. These ubiquitous environments require complete knowledge about their surroundings and that includes the user. Any opponents to ubiquitous computing might sight privacy concerns as a reason not to implement them. Another possible disadvantage to ubiquitous computing is the operating costs associated with it. Total ubiquitous environments require great amounts of resources and money to maintain. Despite these shortcomings, that has not stopped the development of ubiquitous computing in industries like energy, entertainment, healthcare, logistics, and the military. These industries are currently dedicating time and money on future research to create more ubiquitous computing environments where most tasks will be automated by a ubiquitous computing device. The concept of ubiquitous computing will continue grow and incorporate into the future of software development to create more helpful environments.

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