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Evolution of the Next Generation of Technologies: Mobile and Ubiquitous Computing

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ABSTRACT: Mobile and Ubiquitous Computing technologies allow interconnected devices to be embedded unobtrusively in everyday appliances and environments, and to communicate and co-operate to provide information and services on behalf of their human users. The development of Mobile and Ubiquitous computing applications and systems has been identified by many visionaries as a key enabling prerequisite for the evolution of the next generation of technologies. The goal of Ubiquitous computing is to create ambient intelligence where network devices embedded in the environment provide unobtrusive connectivity and services all the time, thus improving human experience and quality of life without explicit awareness of the underlying communications and computing technologies.

KEYWORDS: Mobile Computing, Embedded, Ubiquitous Computing, Evolution, Next Generation, Technologies, Ambient Intelligence.

I. INTRODUCTION

The domain of mobile computing systems, which utilize advanced wireless communication technologies and offer personalized context aware services, is rapidly evolving so-called "smart spaces", such as "smart homes", "smart offices" and "smart cities", seek to seamlessly integrate these technologies.The goal of Ubiquitous computing is to create ambient intelligence where network devices embedded in the environment provide unobtrusive connectivity and services all the time, thus improving human experience and quality of life without explicit awareness of the underlying communications and computing technologies. In this environment, the world around us is interconnected as ubiquitous network of intelligent devices that cooperatively and autonomously collect, process and transport information, in order to adapt to the associated context and activity [1]. Sensor-based and context-aware systems are becoming readily established in all areas of daily life, ranging from transportation to healthcare and from environmental monitoring to education and entertainment.

The individual technologies that comprise the Mobile and Ubiquitous computing vision increasingly underpin modern Computing and Engineering practice [4]. In the long term, ubiquitous computing will take on great economic significance. Industrial products will become “smart” due to their integrated information processing capacity, or take on an electronic identity that can be remotely queried, or be equipped with sensors for detecting their environment, enabling innovative products and totally new services to be developed. However, an “informatized” world full of objects that can detect aspects of their environment and communicate with each other also has serious societal implications. The social and political challenges of the ubiquitous computing era will be characterized by an increasing dependence on technology, control over the information to which everyday objects are linked, and the protection of privacy.

II. THE TREND TOWARDS INVISIBLEAND UBIQUITOUS COMPUTERTECHNOLOGY

Given the continuing technical progress in computing and communication, it seems that we are heading towards an all-encompassing use of networks and computing power, a new era that Mark Weiser termed “ubiquitous computing” [10]. According to him, the computer as a dedicated device should disappear, while at the same time making its information processing capabilities available throughout our surroundings. Intrusive technology should make way for “calm technology”: “As technology becomes more imbedded and invisible, it calms our lives by removing the annoyances. The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it.” While Weiser saw the term “ubiquitous computing” in a more academic and idealistic sense as an unobtrusive, human-centric technology vision that will not be realized for many years yet, industry has coined the term “pervasive computing” with a slightly different slant [6]. Though this also relates to pervasive and omnipresent information processing, its primary goal is to use this information processing in the near future in the fields of electronic commerce and Web-based business processes. In this pragmatic variation – where wireless communication plays an important role alongside various mobile devices such as smartphones and PDAs – ubiquitous computing is already gaining a foothold in practice.

The vision of ubiquitous computing is grounded in the firm belief amongst the scientific community that Moore's Law, drawn up in the late 1960s by Gordon Moore [8] will hold true for at least another 10 to 15 years. This means that in the next few years,microprocessors will become so small and inexpensive that they can be embedded in almost everything not only electrical devices, cars, household appliances, toys, and tools, but also such mundane things as pencils and clothes. In fact, technology is expected to make further dramatic improvements, which means that eventually billions of tiny and mobile processors will occupy the environment and be incorporated into many objects of the physical world. All these devices will be interwoven and connected together by wireless networks

The effects of rapid progress in microelectronics and the convergence of communications and information technology can best be demonstrated using the example of mobile phones. A few years ago, mobile phones were still so big, expensive, and limited in their functionality that they didn'tsell very well and were often used more as a status symbol than a practical tool. This has changed very rapidly.

The functionality of mobile phones is currently expanding in different directions. So-called smartphones, for example, take on the role of Personal Digital Assistants, with notepad and appointment scheduling functions. Another option is to add localization functionality. Already now, mobile phones can be localized to within a few hundred meters. By using satellite-supported GPS systems or new 3G synchronization means, localization can be as exact as about 15 meters outsidebuildings. Providing mobile phones with additional short-range radio interfaces (such as WLAN, Bluetooth, or ZigBee) is yet another option. It means that other personal devices belonging to the user can also profit from the communication and localization abilities of the mobile phone. The mobile phone then becomes a personal base station and control center for a variety of other devices and “smart objects” nearby.

Recent developments in the field of materials science and solid-state physics are also important in that respect. They could give information appliances and computers of the future a completely different shape, or even mean that computers will no longer be recognizable as such because they will completely blend into their surroundings. One example in this context is light-emitting polymers, which enable displays consisting of highly flexible, thin and bendable plastic foils to be created. They offer many processing advantages, including the possibility of making large-area or curved displays capable of delivering high-resolution video-rate images at low power consumption, visible in daylight and with wide viewing angles [11]. Flat and very cheap screens that can be fixed to walls, doors and desks are conceivable. The displays could be configured to present information such as weather, traffic or sports results extracted from the Internet. Once configured, users could place these displays wherever they felt it was convenient. As humans, we are accustomed to looking in particular places for particular pieces of information [9]. This way, dynamic information would become much easier to find and assimilate

Laser projection from within spectacles directly onto the retina of the eye is another option currently being investigated as a replacement for traditional computer output media. Research is also taking place into “electronic ink” and “smart paper,” which will enable pen and paper to become fully functional interactive and truly mobile input/output media. Although there is still a lot of technical development work involved and a broad commercial application may be some years off, prototypes of smart paper and electronic ink already exist. If paper can be transformed into a computer or, conversely, computers into paper, the practical significance of such a development cannot be overestimated: just imagine carrying your calendar and contact list on a foldable piece of electronic paper, or pulling out a large screen from a mobile phone or a tubular scroll containing the remaining electronics of a PC! Combined with small GPS receivers, maps that display their exact location will then be a real possibility

The results of microsystems technology are also becoming more and more important. For example, they enable tiny integral sensors that can record a wide variety of different environmental parameters. One interesting development in this regard is radio sensors that can report their measured data within a few meters distance without an explicit energy source – such sensors obtain the necessary energy from the environment or directly from the measuring process itself.

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Electronic labels, so-called passive Radio Frequency Identification (RFID) tags, also operate without a built-in source of power they collect the energy they require to operate from the magnetic or electro-magnetic field emitted by a reader device. Depending on their construction, these labels are less than a square millimeter in area and thinner than a piece of paper [3]. What is interesting about such remote-inquiry electronic markers is that they enable objects to be clearly identified and recognized, and therefore linked in real time to an associated data record held on the Internet or in a remote database. This ultimately means that specific data and information processing methods can be related to any kind of object.

If everyday objects can be uniquely identified from a distance and furnished with information, this opens up application possibilities that go far beyond the original task of automated warehousing or supermarkets without cashiers. For example, an intelligent refrigerator may make use of the labels attached to bottles, which could be useful for minibars in hotel rooms. Even more intriguing are scenarios where prescriptions and drugs talk to a home medicine cabinet, allowing the cabinet tosay which of those items should not be taken together, in order to avoid harmful interactions. In a similar manner, packaged food could talk to the microwave, enabling the microwave to automatically follow the preparation instructions. With the emerging Near Field Communication (NFC) standard, mobile phones and other handheld electronic devices will be able to read RFID labels at short distances. The goal is to enable users to access content and services in an intuitive way by simply touching an object that has a smart label.
Significant technical advances have also been made in the field of wireless communications. GSM mobile phone technology has established itself extensively and next generation systems will allow higher bandwidth and better possibilities for data communications. Especially interesting arerecent short-range communications technologies (such as ZigBee) that need less energy and make smaller and cheaper products possible. Researchers are also working intensively on improved possibilities for determining the position of mobile objects. As well as increased accuracy, the aim is also to make the receiver smaller and reduce its energy requirement.

Another exciting development is the field of “Body Area Networks,” where the human body itself is used as a transmission medium for electrical signals of very low current. Simply by touching a device or an object, an individual identification code can be transmitted. This could be used for access controls, personalized device configuration, or the billing of services. Many of these technological developments can be used together or even integrated. For example, fully-functioning computers including sensors and wireless networking functionality will be developed on a single chip that can be built into any device or everyday object for control purposes.High processor speed is not as important as producing chips that are small, cheap, and save energy.

If you summarize these technology trends and developments – tiny, cheap processors with integrated sensors and wireless communications ability, attaching information to everyday objects, the remote identification of objects, the precise localization of objects, flexible displays and semiconductors based on polymers, electronic paper it becomes clear that the technological basis for a strange new world has been created: everyday objects that communicate and that are in some respects “smart,” without actually being “intelligent.”

III. EVERYDAY OBJECTS BECOME “SMART” AND NETWORK THEMSELVES

The “creeping revolution” induced by the sustained technological progress is leading to a situation where there will be a plentiful supply of computing power. Smart cards that become worthless after being used in the form of telephone cards, or electronic labels that act as a substitute for bar codes are the first indicators of a new wave of single-use or disposable computers.

This likely saturation of our world with information processing capacity heralds a paradigm shift in computer applications tiny, cheap processors embedded into many everyday objects can detect their surroundings via similarly integrated sensors, and they can equip “their” object with both information processing and communications capabilities. This adds a completely new dimension to such objects they could, for example, find out where they are, what other objects are in their vicinity, and what had happened to them in the past. They may adapt to the environment, behave in a context-sensitive manner, and provide useful services in addition to their original purpose. They will be equipped with spontaneous network capabilities and will thus be able to communicate and cooperate with other smart objects and to access all sorts of Internet resources. Connected together and exchanging appropriate information, they will form powerful systems.

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Future smart devices will come in various shapes and sizes and will be designed for various task-specific purposes. Their user interface may be based on speech recognition, gesture recognition, or some other advanced natural input mode technology that is appropriate for their purpose, size, and shape. Ideally, all these devices will be so highly optimized to particular tasks that theywill blend into the world and require little technical knowledge on the part of their users they should be as simple to use as calculators, telephones or toasters [12].

Wearable computing devices will be used to keep people informed, connected, and entertained. The expectation here is that the computer functionality and the devices that incorporate it should not only be "portable," but also, to a certain degree, become part of our clothing and be worn more or less directly on our bodies. An appropriate comparison might be between a "portable" pocket watch, which has to be taken out and opened up if needed, and a "wearable" wristwatch, which can be read at any time. Since its sensors are located close to the body, a wearable computer is also suitable for reinforcing the user's sensory perception or for monitoring his or her health.

Localization technologies also have great application potential. In the future, it may be virtually impossible to lose valuable things, or it may be possible to relocate lost objects, because the objects will know where they are, and can communicate this if necessary. Localization modules which, for example, use the GPS system are still too large, expensive, and imprecise, and consume too much energy for many applications. But continuing progress is being made on all four parameters. As localization technology progresses, simpler things will also profit from this possibility. Parents might appreciate it, for example, if their children's shoes and coats revealed their whereabouts

Many more applications are imaginable. The limits are less of a technological nature than an economic one. Initially, it will be the higher priced appliances, tools and other objects that benefit from ubiquitous networking and "artifact intelligence". Sensor-supported information processing and communications capabilities will provide objects with substantial added value.

IV. UBIQUITOUS COMPUTING GAINS GREAT ECONOMIC SIGNIFICANCE

Together with the possible resulting applications, the new basic functions resulting from the progress of information and communications technology in general, and the development of ubiquitous computing in particular, are set to gain great economic significance in the medium to long term. This can be illustrated using the example of remote identification. A whole range of constantly improving techniques exists for identifying objects over a distance of a few meters. In addition to options that are not yet suitable for general use, such as purely optical recognition, there are the smart labels or RFID tags mentioned above. A smart label is a small, low-power microchip combined with an antenna. In some systems, the antenna is replaced by conductive ink. The substrate of the labels is usually paper or plastic, yielding a paper-thin and flexible label, which can be self-adhesive and be printed on. The smart labels can be stuck onto objects or integrated into them during the manufacturing process. Each label has a unique serial number and can contain other programmable information, on some types of tags it is also possible to store a limited amount of information. Their big advantages are that individual products rather than whole product groups can be differentiated, and that they do not have to be placed in the line of sight of the reading devices – in particular, they work through plastic, wood, and other materials. The RFID reader transmits a radio signal to the labels and recognizes their unique radio echoes, which works for distances of up to a few meters. Smart labels have been prototypically used to optimize warehousing and production processes. For example, parts boxes on vehicle assembly lines can automatically control their own stock and transmit a signal to the warehouse and supplier as soon as they need replenishing. Using this method, suppliers receive precise information regarding the requirements and can deliver the necessary parts just in time.Until now, most pilot applications for smart labels have been found in the automobile, logistics and transport industries. More recent application examples come from the retail sector. An example is a pilot application of a supermarket chain, where electronically labeled recyclable containers for perishable products are resulting in a reduction in the supply chain lead time and therefore increasing the time products spend on the supermarket shelf. This involves detectors automatically identifying every box and recognizing the expiry date of the contents in the warehouse and at the retail store. Simple ubiquitous computing applications are limited to basic functions such as identification, localization, and tracing, where by technologies such as RFID only the identifier is stored locally on the object [7]. More complex applications are increasingly using sensors for the decentralized collection of data from the environment and working with what are known as notification services in other words, smart objects report automatically if a specified condition occurs or if a preprogrammed rule is violated. The ultimate goal are "self-aware", smart products. A smart product can on the one hand automatically download the latest information such as a destination or updated user

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instructions; and on the other hand it can independently supply its informational counterpart, which resides somewhere on the Internet, with sensor data such as its location

Generally speaking, the new technologies of ubiquitous computing are automating the process of linking the real world with everyday objects, products, and means of production with the virtual world of the Internet or e-commerce and supply chain management systems; in many ways, they are replacing man as the mediator between the real and the virtual world. As a consequence, this is facilitating new business processes that bring additional benefits to manufacturers, suppliers, and clients. These technologies are helping to reduce lead times, warehouse inventories, risks, and error rates [9]. They can contribute to new solutions in the fields of maintenance and repair, security and liability, quality assurance, waste disposal and recycling, and ultimately create a variety of new services such as the consistent individualization or personalization of goods throughout the entire life cycle.

In the longer term, the process of remotely identifying objects along with wireless information access, mobile communications technology, and "wearable computing" pave the way for possibilities that go far beyond the optimization of business processes mentioned above and, to some extent, amount to an information of the world. To give an example, imagine everyday objects such as furniture, packaged food, medication, and clothing being equipped with a label that contains a specific Internet address as digital information which, to put it simply, points to the home page of the object [5]. If you then read this Internet address with a device similar to a mobile phone just by pointing it at the object, the mobile phone can, independently and with no further assistance from the object in question, access and display the corresponding homepage or some other related information via the mobile telephony network.

It seems to be clear that ubiquitous computing in general will, in the long run, have dramatic economic effects: many new services are possible that could transform the huge amount of information gathered by the smart devices into value for the human user. The maintenance and ongoing development of the global infrastructure necessary for cooperating and communicating smart everyday objects – including the measures required to meet the increased need for security and privacy in such an environmentmight eventually even occupy a whole industry, similar to today's energy and telecommunications enterprises.

V. SOCIAL AND POLITICAL CHALLENGES

While a technical analysis may be able to predict what the future could bring, the question of what the future is allowed to bring can only be answered by means of a social process. Many other questions are generated by the information of the world, only a few of which are touched on here: if many objects can only function properly if they have access to the Internet or a similar infrastructure, this results in a far-reaching dependency on those systems and their underlying technology. If these fail, for whatever reason design errors, material defects, sabotage, overloading, natural disasters etc..., then it could have catastrophic consequences on a global scale. If the correct functioning of the information technology infrastructure is vitally important to society and individuals, not only do we have to have appropriate security mechanisms, but the systems have to be designed from the outset with this in mind.

Last but not least, we should pay particular attention to the protection of privacy. This is of course a primary concern when devices or smart everyday objects can be localized and traced, and when various objects we use daily report their state and sensor information to other objects. Whereas until now only a relatively limited view of a person could be obtained by rummaging around in data, in a future ubiquitous computing world a much more comprehensive picture can be painted of this person and his day-to-day behavior. It seems clear that, without effective data protection measures, the technology of ubiquitous computing could be used to create a surveillance infrastructure that would render ineffective many existing laws and privacy protection mechanisms. Therefore basic legal considerations and new technical approaches, as well as much social and organizational effort, will be required in order to prevent this brave new world of smart, interconnected objects becoming an Orwellian nightmare.

VI. PERSPECTIVES

The technology trend is pointing quite clearly towards a continued informatization of the world. It is clear, however, that we are moving only gradually towards the ultimate vision of ubiquitous computing where inanimate everyday objects communicate and cooperate. Much remains to be done and already from a technical viewpoint there are many

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challenges to consider – the energy supply for smart objects, communications standards, and much more besides. Furthermore, a considerableinfrastructure would have to be implemented before the vision could become a reality.

If technical progress means more and more everyday objects are becoming "smart" and therefore behaving unconventionally towards humans, then this will ultimately lead to a different world from that to which we are accustomed. The changes won't happen overnight; instead, this process will be more of a creeping revolution. Taken to its logical conclusion, a world which is literally permeated by information technology will sooner or later bring with it major social and economic consequences [2], adding a political dimension to ubiquitous computing and its technologies.

It is therefore clear that the 21st century will be characterized less by major technological structures such as moon colonies, underwater cities, and 10 atomic cars, than by the application of tiny, practically invisible technology that is therefore easy to replicate and distribute. It is certainly already now worth thinking about the economic prospects and the social consequences ubiquitous computing.

VII. CONCLUSION

Ubiquitous middleware are becoming the nowadays trend in the development of ubiquity in computer science fields. Ubiquitous applications rely upon this layer, to profit from the diverse functionalities it has to offer. Ubiquitous environments brought more constraints and challenges to mobile environments. The main constraints come from, the environment's heterogeneity and dynamics, and the variable connectivity of the devices coming and leaving. The main challenges are in maintaining the computing smartness, scalability, invisibility and pro-activity for the users in these environments. The study of this research field with artificial intelligence and autonomic computing leads to the development of the ambient intelligence, the future evolution of ubiquitous computing.

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BIOGRAPHY

Javed Mohammed was born in Hyderabad, India, in1990. He received the Bachelor's in Engineering in Computer Science from the University of Allahabad, Uttar Pradesh, India, in 2012, and Master's Science inComputer Science from NewYork Institute of TechnologyAbout to pursue PhD in Computer Science from CUNYat Stonybrook University. Presently taking advancedcourses in Computer Science from Massachusetts University of Technology(MIT) & Harvard University.

In 2014, he worked on various multi-disciplinary projects in Computer Science, Geospatial Intelligence projects. His current research interests include Nanotechnology, Cyber Security, Cryptography, Database Management, Cloud Computing and Big Data, Software Systems, Modeling and Simulation of Water Quality at Hydrofracking operations, Mobile and Wireless Computing, and Programming Languages.

He is currently serving on the editorial board of " International Journal of Computer Science, Engineering and Applications (IJCSEA); as a Technical program committee member of "4th International Conference on Advances in Computing, Communications and Informatics"; as a Program committee member of "Fifth International conference on Computer Science, Engineering and Applications"; as judge for peer-reviewed presentations at prestigious International Conferences; and was invited to White House AAPI <WhiteHouseAAPI@ed.gov> to attend the Asian American and Pacific Islander (AAPI) Heritage Month Opening Ceremony. Mr. Mohammed also organized a Presidential Initiative on "Second Annual National Day of Civic Hackathon".

He is a member program volunteer for climate change, Clinton Global Initiative, 2014-PRESENT; a program co-ordinator with Lions Club International (a volunteer non-profit grant making organization), especially that fund health based programs serving low-income communities; a program volunteer with Rotary International Hicksville-Jericho at the The Hicksville Boys and Girls Club on a STEM Research grant from Hofstra University sponsored by the National Science Foundation and will be collaborated with the US Department of Energy's Brookhaven National Laboratory and The Center for Advanced Study in Education at The Graduate Center at The City University of New York. As a volunteer will be actively providing innovative and engaging academic challenges designed to encourage an interest in the fields of engineering and design, as well as an understanding of how science, technology, engineering and math skills can translate into careers; Volunteer in the New York Institute of Technology's TUES (Transforming Undergraduate Education in Science, Technology, Engineering and Mathematics) program sponsored by the National Science Foundation's focuses on enhancing the Electrical and Computer Engineering (ECE) curriculum by integrating applications of Wireless Technology, Volunteer of STEM program and REACH HIGHER program (Initiative of the First Lady Michelle Obama) at the NYIT, Old Westbury Campus.

Mr. Mohammed is a member of Association for Computing Machinery (ACM) ;Ground Water Protection Council (GWPC); National Society of Professional Engineering; SAS Data Management; Association of Environment and Engineering Geologists (AEG); Information System Security Association (ISSA); American Society of Administrative Professionals (ASAP); Big Data Innovation Group; and Fracfocus;