MOBILE COMPUTING: THE EMERGING TECHNOLOGY, SENSING, CHALLENGES AND APPLICATIONS

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Abstract

The mobile computing is a computing system in which a computer and all necessary accessories like files and software are taken out to the field. It is a system of computing through which it is being able to use a computing device even when someone being mobile and therefore changing location. The portability is one of the important aspects of mobile computing. The mobile phones are being used to gather scientific data from remote and isolated places that could not be possible to retrieve by other means. The scientists are initiating to use mobile devices and web-based applications to systematically explore interesting scientific aspects of their surroundings, ranging from climate change, environmental pollution to earthquake monitoring. This mobile revolution enables new ideas and innovations to spread out more quickly and efficiently. Here we will discuss in brief about the mobile computing technology, its sensing, challenges and the applications.

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I. INTRODUCTION

The mobile computing is a category of computing where the computer and all necessary files and software are taken out into the field [1]. Several kinds of mobile computers have been introduced since the year 1990, including wearable computer, personnel digital assistant (PDA), enterprise digital assistant (EDA), smartphone, carputer and ultra-mobile personnel computer (UMPC). The mobile computing has three aspects, (i) the mobile communication (ii) the mobile hardware and (iii) the mobile software. The first aspect addresses communication issues in ad-hoc and infrastructure networks as well as communication properties, protocols, data formats and actual technologies. The second aspect focuses on the hardware, i.e. mobile devices or device components. The third aspect deals with the characteristics and requirements of mobile applications.

In the year 1972, American Telephone & Telegraph (AT&T) department submitted a proposal for cellular service to the Federal Communication Commission (FCC). The proposal had been approved in 1982. The project to create the first handheld mobile phone called the DynaTAC800X, was started by Motorola in December 1972 and took until 1983 [2, 3]. The first generation (1G) mobile phones which were developed in the year 1983 are analogue and used 824-894 MHz frequency band. The voice channel was 30 KHz wide and each channel had 2 frequencies, one for transmission and the other for reception of information separated by a frequency of 45MHz. The 2nd generation (2G) phone added compression and can accommodate 3-10 times more channels. There are 3 competing technologies for 2G phones, (a) the Frequency Division Multiple Access (FDMA) where each cell uses a separate frequency. This is mainly used in analogue phones, (b) the Time Division Multiple Access (TDMA) where each cell uses a certain portion of time on a given frequency. This provides three times the capacity of analogue system and is used by Global System for Mobile Communications (GSM). The GSM has encryption for security and uses the 900MHz and 1800MHz frequency bands in Europe, and much in Asia and Africa. It uses 850MHz and 1900 MHz in the US and Canada, (c) the Code Division Multiple Access (CDMA) where each cell uses a unique code and spreads the cell over the available frequencies [2]. It uses Global Positioning System (GPS) for timing. The 3rd generation (3G) mobile technology was designed for smart phones. In particular it increases the bandwidth and transfer rates up to 3Mbps, and accommodated web applications, audio and video files.

There are several access protocols including CDMA, Universal Mobile Telecommunications System (UMTS) who’s most common form is wideband CDMA, and Time - Division synchronous CDMA. The 4th generation (4G) is the name given to the next generation of mobile devices. There are two main contenders, (i) the worldwide interoperability for Microwave Access (WiMAX) [4] and (ii) the Long Term Evolution (LTE) [5]. They increase data speeds up to 100Mbps down and 50Mbps up, enhance security. It enables to carry High Definition Television (HDTV). They are intended for internet use on computers also. They are compatible to Internet Protocol (IP) packet switching and support IP version 6 (IPv6).
II. MOBILE COMPUTING DEVICES

There are various mobile computing devices developed by number of companies. The dashtop mobile equipment (DME) refers to a wireless mobile device mounted on the vehicle dashboard. The DME includes satellite radios, GPS navigation, OnStar, mobile TV, High Definition Radio (HDR), vehicle tracking system, motor vehicle event data recorder (MVEDR) and Broadband Wireless Access (BWA) devices [6]. Except for OnStar and BWA devices, most of them are in the stage of passive one-way communications equipment. However, fast-evolving mobile technology is on the threshold of turning dashtop mobile equipment into full-duplex multimedia gadgetry on the strength of fast-growing broadband infrastructure, including expanding WiMAX networks worldwide, with growing indications that convergence into an all-in-one dashtop mobile device is an ultimate destination [7, 8].

An EDA is a handheld computer which was adapted for extensive more robust use within the small to medium enterprise (SME) and enterprise business applications (EBA) as a data capture mobile device [9]. Over the years, these business applications have grown from simple batched data collection using Barcode readers to include extensive usage of other expanding business technologies within the areas of Wireless Local Area Networks (WLAN), Global Positioning Remote Sensing (GPRS), Edge Communications, Biometrics, Magnetic Stripe, Smart Card and Radio Frequency Identifier (RFID) data capture technologies. The EDA is also known as Data Capture Mobile Devices (DCMD) or Batch Terminals (BT) or Portables. The EDA has many uses in various types of business, e.g. (a) the warehouse management, (b) the inventory control and (c) in the Field Services etc. The EDA is available on a variety of different Operating System (OS) Platforms e.g. Windows CE, Windows Mobile, Windows Pocket PC, Windows XP Tablet Edition, Linux (Various), Palm, DOS and some proprietary OS Platforms. An EDA is designed to use in more harsh or hazardous environments. These rugged compact devices can deliver wireless Wide Area Network (WAN)/Local Area Network (LAN)/Personnel area network (PAN) voice and data communications, including voice over internet protocol (VOIP) functionality. The EDAs are available in a number of form factors, e.g. handheld or wearable and can be further extended to include figure barcode scanners, RFID panel antennas, swipe card readers, external Battery Packs and printer carry cases. The PDAs can be expanded to add-on data capture functionality, whereas the EDAs very often are designed without the need for additions and can include a combination of built in data capture functionality.

A smartphone is a mobile device that offers more advanced computing ability and connectivity than a contemporary basic feature phone [10]. Most of the feature phones are able to run applications based on platforms such as Java Micro Edition (JME) [11]. A smartphone allows the user to install and run more advanced applications based on a specific platform. The smartphones run complete OS software providing a platform for application developers [12]. It can be considered as a personal pocket computer (PPC) with mobile phone functions, although quite smaller than a desktop computer (DC). The growing demand for advanced mobile devices boasting powerful processors,
abundant memory, larger screens, and open OS has outpaced the rest of the mobile phone market for several years. According to a study by ComScore, over 45.5 million people in the United States of America (USA) owned smartphones in 2010 and it is the fastest growing segment of the mobile phone market, which comprised 234 million subscribers in USA [13]. Despite the large increase in smartphone sales in the last few years, smartphone shipments only make up 20% of total handset shipments, as of the first half of 2010 [14].

The Carputer is the predominant term used to describe a category of mobile computer designed and modified to specifically install and run in automobiles. Originally these were based on industrial PC technology. But as smartphones and PDAs have become more powerful, and have included useful technologies like GPS and Bluetooth, they become the predominant base platform for developing carputers [15]. The recent popularity of carputers has caused the creation of more advanced units that use touch screen interfaces, integrate with vehicles via On Board Diagnostics (OBD-II) link, and offer a variety of other add-ons like rear-view cameras and GPS.

Among PCs, UMPC is a term coined by Microsoft for a small form factor version pen computer running a licensed copy of Microsoft's Tablet PC OS [16]. With the announcement of the UMPC, Microsoft dropped the licensing requirement that Tablet PCs must support proximity sensing of the stylus. Originally, Codenamed Project Origami, a project launched in 2006 as collaboration between Microsoft, Intel, Samsung, and a few others. Despite prediction of the demise of UMPC device category according to Centre National d'Études des Télécommunications (CNET) [17] and the comparatively dominant sale of net books, the UMPC category appears to continue be in existence and may possibly see a rise in demand as a media consumption device as evidenced by the introduction of Apple iPad, Google Android, Google Chrome OS, BlackBerry Tablet OS, Nokia's upcoming MeeGo and HP's upcoming webOS 2.0.

![Fig. 1: (a) PDA: Palm TX, (b) Carputer: 2005 Dodge Magnum RT, (c) Smart phone: Blackberry curve 8052](image)

The fig.1 shows some of the common mobile computing devices recently in used.
III. MOBILE SENSING

While industry analysts predict that cell phones will become the “next PC”, it is believed that the cell phone has the power to become something much more than a scaled-down, connected Input Output (IO) and processing device. In addition to these standard PC characters, a cell phone is situated in an environment, mobile, and typically co-located with a user. These characters make the cell-phone ideally suited to track and understand the impact that the environment has on individuals, communities, cities, as well as understanding how humans effect their environment.

By attaching sensors to GPS-enabled cell phones, one can gather the raw data necessary to begin to understand how, for example, urban air pollution impacts both individuals and communities [18]. While integrating a sensor into a phone and transmitting the data that it gathers to a database is not very difficult, doing so at low cost, on a societal scale, with millions of phones providing data from hundreds of networks spread throughout the world makes the problem much trickier.

Understanding the raw data gathered from the network of cell-phone-attached sensors presents significant challenges as well. The cell phone users are mobile, are unlikely to calibrate their sensors, typically put their phone in their pocket or handbag, thus obstructing the sensor from airflow, spend significant time indoors or in cars, and typically charge their phone at most once per day, often much less frequently. Even if users did calibrate their sensors, the very low-cost sensors intended to use drift over time and environmental conditions. Without knowing the location of a sensing event, automatically calibrating the sensors in the phone, detecting the environment of the phone, and intelligently managing power, the data gathered by the phones will be next to useless.

The economics of mobile phones also provide a unique opportunity for developing countries in particular. Since mobile phones tend to first find markets in the highly industrializes world, and then secondary markets in less industrialized areas either in the form of used devices or low priced overstock, if devices are manufactured with sensors integrated into them, they are almost certain to find their way to all corners of the globe.

Even today, the low cost of mobile phone-based computing offers the opportunity for scientists in developing regions with modest budgets to deploy sensing in their communities or areas of study. Integrating sensing into mobile phones is increasingly straightforward and common. The mobility of the phone also provides some important opportunities. At the expense of sampling a given location continuously, a sensor in a user’s phone can provide significant geographic coverage. The mobile sensors will be heavily biased towards location in which people congregate, so for human-centre applications, sensing in mobile phones will often provide coverage exactly where it is needed most. In over-samples locations, the precision of the sensing system can be increased by carefully averaging the readings from several nearby sensors. Also, sensors close to one another can be automatically calibrated, especially if there is some “ground truth” reference sensors are also situated in the environment.
The Computer scientists in the University of Southern California (USC) have found a way to combine smartphone resources with a novel application that allows the phone users to help in monitoring air quality [19]. The application is provisionally titled, "Visibility". According to Gaurav Sukhatme, the computer science professor of USC who documented the paper work, the basic principle of the Visibility app is simple. The user takes a picture of the sky while the sun is shining, which can be compared to establish models of sky luminance to estimate visibility. The visibility is directly related to the concentration of harmful "haze aerosols," tiny particles from dust, engine exhaust, mining or other sources in the air. Such aerosols turn the blue of a sunlit clear sky gray. Fig.2 gives a glimpse of the application. The system has been tested in several locations, including Los Angeles and in Phoenix, Ariz. The USC rooftop camera has a built-in "ground truth" test - it is near a conventional air pollution monitoring station. So far the results are promising, but they indicate that several improvements are possible [19].
IV. APP INVENTOR FOR IMPLEMENTING MOBILE APPLICATIONS

The App Inventor is a prototype programming tool for Android that lets someone easily create mobile applications and customize existing applications. With the support of Google University Relations, a faculty group is working together to pilot courses where beginner students, including non-computer science majors, can create Android applications that incorporate social networking, location awareness, and web-based data collections [20]. App Inventor could change the nature of introductory computer science by making it less dissociated and more about people and their interactions with the world around them. The educational perspective that motivates App Inventor holds that programming can be a vehicle for engaging powerful ideas through active learning. As such, it is part of an ongoing movement in computers and education that began with the work of Seymour Papert and the Massachusetts Institute of Technology's (MIT) Logo Group in the 1960s [21].

The blocks editor uses the Open Blocks Java library for creating visual blocks programming languages. The Open Blocks visual programming is closely related to the Scratch programming language, a project of the MIT Media Laboratory's Lifelong Kindergarten Group. The open blocks is distributed by the MIT’s Scheller Teacher Education Program and derives from thesis research by Ricarose Roque.

The compiler that translates the visual blocks language for implementation on Android uses the Kawa Language Framework and Kawa's dialect of the Scheme programming language, developed by Per Bothner and distributed as part of the Gnu OS by the Free Software Foundation [22]. The beta version of the Web site for App Inventor for Android went live from Google Labs with a video demonstrating how easy it is to make App, including a number of ideas for Apps people can make themselves. To use App Inventor, one does not need to be a developer. According to the websites, the App Inventor requires no programming knowledge. Software code is written by App Inventor software, while users are given options on what to include in the App. The site offers several suggestions in App creation, including use of the handset's GPS function for location, creating SMSs for friends, or building apps that link to other services, such as Twitter. The new software tools should give Google's Android mobile software a leg up against rival smartphone software, including Apple's iPhone OS. The App Inventor site lets anyone become an App creator, giving people the power to design software specifically for their own needs. That's not so easy in iPhone. Anyone interested in using App Inventor to start making Android Apps will need a few things, including a Gmail account, a computer and an Android-based handset. Today smartphones let us carry computing with us, have become central to servicing our communication and information needs, and have made the web part of all that we do [23].
V. CHALLENGES

Integrating sensors into mobile phones have several practical advantages. For many applications, the most significant challenges that face traditional wireless sensor networks are power management and network formation and maintenance. Among these, power management is greatly simplified in mobile computing, because user charges their phone regularly. The network formation is also largely solved. Also, a shortage of real-world, practical applications have limited the number of wireless sensor network nodes that get manufacture, and thus the price of a node remains relatively high. With the number of mobile phones sold in the year 2010 on track to surpass 1.2 billion, cell phones obviously have enormous economies of scale that will be hard to replicate in the near term [24]. Thus the mobile phone platform has several significant advantages as a sensor that will allow relatively simple and massive deployments.

The Human Computer Interaction (HCI) presents new challenges, like the introduction and widespread adoption of the internet [25]. It is taken for granted that the most common way to access the Internet will soon be through mobile devices and that everyone, even those who never wanted to use a computer, will embrace the use of mobile services. However, if HCI aspects of mobile technologies are not properly addressed, the above mentioned scenario is not so likely to come true. Users will not enthusiastically adopt mobile computing devices if we are not able to prevent the pains and complexities of interacting through very limited input and output facilities. The mobile services will not be successful if we do not understand mobile users and design for their contexts, which are very different from the ones traditionally studied in HCI [26].

The society stands to impact significantly from advances in mobile computing. Improved efficiency in business may see less time spent in working, with more time for leisure. In other professions, this may see more opportunities to travel, with businesses based nationally and globally. The world will potentially communicate mainly in an online environment, changing the way we interact and engage. The theory of anywhere anytime connection may mean we are never uncontactable, adjusting our public and private lives. The mobile computing presents new challenges as well as new advantages, and must be tailored to suit the needs of the individual and organization.

The mobile computing faces many challenges on the path the mass acceptance and use. The initial costs of setup and maintenance prevent many businesses from making the change. McKimmy asserts that wireless networking setup, access restrictions, power supply, and file storage are all issues to contend, with careful planning required for maintenance and piloting [27]. The power is another critical issue with laptops

The security is another major challenge in mobile computing. The miss-configured wireless networks present a security hazard. Anyone with a wireless computer could have full access to a LAN unless restrictions are implemented [27]. This can be prevented by establishing Message Authentication Code (MAC) addresses, a unique number that identifies its Network Interfacing Card (NIC). Unknown computers can then be denied access if their MAC address is not on an authorized
list. Other alternatives such as a virtual private network (VPN) also exist. Other limitations related to connection speeds and access points. The WiFi has seen some success, however it is hoped that the introduction of WiMax will see a greater number of users adopt mobile computing practices. Norman (The Invisible Computer) in Goldstein, Nyberg and Anneroth suggests that getting each tool to perform effectively presents yet another challenge [28]. In order to ensure good enough usability, each tool should be tailored to fit the task and the interface should be as transparent as possible to the user.

VI. APPLICATIONS

Some of the applications of mobile computing are education and research, healthcare sector, pollution monitoring, tourism industries, airlines and railway industries, transportation industry, manufacturing and mining industries, banking and financial institutions, insurance and financial planning, hospitality industry etc. The internet can be accessible from business, homes, and hot spots cyber cafes, available on cell phones. It is a critical business requirement, such as the oceanic fibre cuts that may result in loss of revenue and severe disruptions in networks. The required speeds have moved for supporting simple text terminals to email, the web, audio and video, requiring orders of magnitude increases in performance. It is no longer to a salesman come door to door for selling shelves full of dictionaries and encyclopedias. Rather one can use the search engines such as Google, online dictionaries, Wikipedia etc. The written word is increasingly enhanced and replaced with graphical images, sound clips and videos.

New software technology allows cell phone and PDA users to download their medical records, making them quickly accessible in case of emergency, creating rooms for accessing the information about the status of airline or railway tickets. The new software to be available in years to come which can even display animated 3D scans. The computer scientists predict that the technology will also enable students to do research using their portable devices.

Social networking has also taken off with applications such as Facebook, Twitter and so on. The freedom of information via Google, blogs, photos, video (YouTube), Twitter, Wikileaks are some good examples, or police brutality are often reported first by individuals. Intellectual property, e.g. the music industry’s protective stand, or how much does say Facebook or Google know about you, who your friends are, where you live, where you work, for searches made, or mining all the emails etc. The smart phones bring mobility to the internet user.

VII. DISCUSSION & CONCLUSION

The mobile computing is the technology which is emerging as a next generation significant tool for computing. It will have tremendous impacts on the field of education and research of our society. Considering all the advantages of a mobile computing system as discuss here, it points to a new opportunity to build the largest scientific instrument ever built. The instrument will consist of
millions or billions of sensors, aggregating data on an unprecedented scale. The instrument could be truly societal scale, reaching across economic, social, geographic and political boundaries, and illuminating the corners of human activity, how our environment affects us, and how we affect our environment [29].

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