The Future World of Ambient Intelligent Services - Mobile-phone-centric Perspective

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Abstract

This paper describes some possible use-case scenarios of mobile-phone-centric ambient intelligence services which are predicted to be soon a seamless part of our lives. Ambient intelligence (AmI) is a technologically advanced environment with a core emphasis on its natural outlook and use, with technological structure completely hidden from the user. The emergence of ambient intelligence has been made possible by parallel technological advancements in sensing, context recognition, embedded systems and communications. However the ambient use-cases are user-centric and not driven by the technology. This paper focuses on the vision of ambient intelligence, and its presence in the world, by defining and studying several use-cases. There already exist several proof-of-concepts of ambient intelligence for many different use-cases.

KEYWORDS: Ambient Intelligence, physical browsing, sensors and internet.

1 Introduction

The gap between the digital and physical world is narrowing by the development of smart sensor systems and services. Ambient Intelligence seems to strike out this difference totally. The device that can bridge the sensors and services is mobile phone. Mobile phone is the most intuitive choice for AmI applications for several reasons: it is one of the few things that people carry with them most of the time, it is digitally connected and it is foreseen to be present almost everywhere around the globe pretty soon. [1, 2].

One of the goals of ambient intelligence is to provide users with more natural ways of interaction with the machines. With AmI, the technology will disappear to the background, but intelligence features would be there, present almost everywhere in the environment and always awake [3]. This requires continuous power supply to the sensor system. Using large batteries or an external power supply does not fit the scenarios well for cost, size and environmental issues. Thus, sensors are required to have ultra-low power consumption, along with the technology for scavenging energy from the environment, like from solar cells, temperature differences, acoustic noise or mechanical movement, so that we can have indefinitely self-sustaining wireless sensor networks [4].

Context information of the user can play a crucial role in providing customized or needed services on the fly, referred to as just-in-time services. Beside the user location, the context information can include many things, such as lighting, noise level, user's current view and even the social situation. One of the enabling technologies for AmI is sensorized environment. This sensorized environment has to be robust enough to address concerns related with sensed object's mobility. The environment also needs to be integrated with wireless networks to provide AmI a platform to build upon.

AmI can be applied to almost every field of life ranging from everyday situations to health care, and thereby provide users with services in a more intelligent way. Research over the past fifty years has contributed much to human-computer interaction and what has been achieved in return is ease-of-use and convenience, but now people are so used to it that they for instance prefer to type something rather than writing it with a pen, it's possible that we end up losing many of our skills out choosing instead the comforts provided by the technology. This compels us to ask, if we are losing to technology and whether this a justifiable valid research goal for the coming decades?

In a computer environment, people tend to think of communication only as that between a person and computer but if we want to maintain a feeling of security and mental stability we need to ensure we maintain person-to-person communication, person-to-nature communication and person-to-universe communication. For example, to get knowledge about some tree, one can have it directly from the tree itself or say, if one points mobile phone towards some star in the sky,its information gets displayed on the screen. This is what ambient intelligence offers: an environment where people will not have the feeling of interacting with the digital world only, but where they will interact with a more developed real world in a natural way, with the technology hidden. The discussed future environment is being made possible with ambient intelligence [5]. This scenario has been depicted in, for instance the, e-Sense Project, as shown in Figure 1.

The design of AmI services is centered on user experience and many projects like Microsystems platform for Mobile Services and Applications (MIMOSA), working on the development of technology platform for the implementation of ambient intelligence, have followed this theme [7]. Development of AmI applications is user-driven and not technology-driven but, of course it is the technological advancement in many domains which is realizing these applications. Ambient intelligence seems to be very promising for users in many domains and greatly admired in the field of health care [8]. To be willing to accept AmI, the user needs to be in control

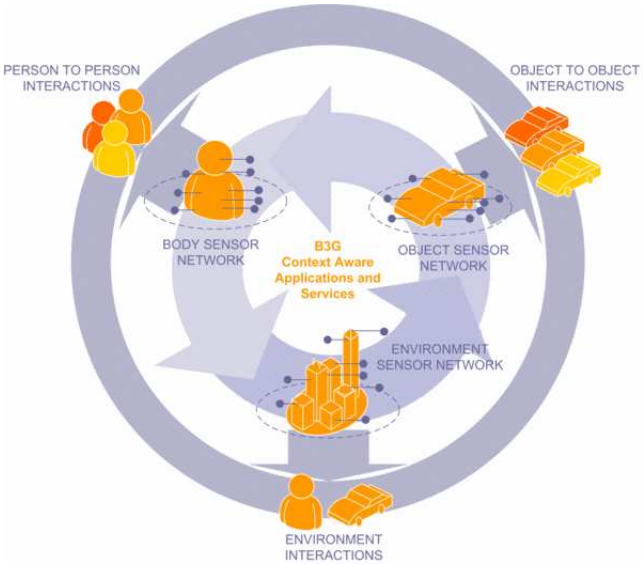

Figure 1: Ambient Intelligent Environment [6]

of the technology. Therefore, the usability of AmI services is going to be the deciding factor in the technology's success.

2 Related Research

Research in Ambient Intelligence is proceeding at a tremendous pace, but so far outcomes have been witnessed in specific domains and specific applications [3]. Various required technologies for ambient intelligence are already available, including smart mobile phones, sensors, ad-hoc networks, and computing, but still requiring some advancements in their integration and scalability [9]. Some technological advancements that are helping to realize ambient intelligence include energy scavenging wireless sensors, advancements in RFID technology by nanoelectronics, specialized low power radio for sensor communication like Ultra Low Power(ULP) Bluetooth and integration technology like MEMS [2]. Below is a brief description of the work done in the areas of physical selection, local and wireless sensor connectivity, context awareness, natural multimodal interfaces, and sensors connected to internet services.

2.1 Physical Selection/Browsing

Physical browsing is a term used to refer to a mechanism for accessing of digital information from the physical world. Users can access the information and services related to any real world object by physically selecting the object, e.g., by touching [10]. An enabling technology for physical browsing is radio frequency identification (RFID). It is a wireless automatic-identification technology, with two types of entities, RFID readers and RFID tags. An RFID reader is a device that interrogates RFID tags by sending radio waves which power the tags, and receives the waves that are bounced back by the tags. An RFID tag is a microchip combined with an antenna and packaged in a way so that, it can be easily attached to an object. Tags respond to the signal (radio waves) sent by the RFID reader and communication process begins. Tags have limited memory and computing power, and can store information and retrieve information through radio waves. RFID tags could be active, semi-passive or passive, depending on their power supply. Active tags have their own power supply, whereas passive tags first induce energy from RFID reader's signal and respond then. On the other hand, semi-passive RFID tags have their own power source, but it is not used for communication (responding to the reader), instead it is used for better sensing or other functions (powering chip circuitry).

To begin the process of selection the user needs a mechanism to select the tag he or she is interested in. This is done by a process known as physical selection [10], this includes several methods by which user tells the device which tag(s) to read. These RFID tags require RFID readers, the devices which are capable of extracting information from the tags.

RFID technology is being used commonly in the logistics and supply chain businesses. And it has also reached the consumer market in the forms of bus travel cards and e-passports. Although consumer RFID readers are still few but they have already started gaining momentum. There are mobile phones in the market like Nokia 6131 NFC that have Near Field Communication (NFC) type RFID reader functionality integrated. NFC is a short range radio technology having shorter set-up time compared to Bluetooth.

Previously, in the Cooltown project, they have demonstrated web presence for people, places and things, an approach for collecting links to points of web presence as one encounters them in physical world was depicted. In Cooltown Museum scenario, a visitor can receive web URLs from infrared beacons attached to the paintings and sculptures. Here standard IrDA technology, which is a commonly integrated feature in commercial mobile phones, laptop computers and PDAs, is used. The URLs then link to a web of information about the item, and by using web browser of a smart mobile-phone, the user can get information about the art and/or the artist. They have also experimented with RFID tags for service discovery [11]. There are several ways in which a user can select a tag these include pointing, selecting and touching. These are presented below [12].

2.1.1 Scanning

Scanning is very useful when the user (or user application) wants to discover services present in the environment. In this mode, all the services encoded in tags within the reading range of the user's mobile phone are sensed and displayed to the user on his mobile phone's display for selection or taken to use by some user-applications. The issue in the former use, could be the usability of the tags, because they should be named in such a way that they can be intuitively understood.

Use of scanned services by applications (on mobile-phone) might require some framework to understand semantics of scanned services and hence employ them automatically to the services or applications that are already being used by the user. For scanned device data, to be understood semantically, the framework might be transforming the sensor-observed data (or data observed from multiple sensors) to the application-specific data.

Scanning should be omni-directional, so that tags get

scanned in all the directions, to enhances usability, as user need not move the device in all the directions to scan all the tags in his mobile phone's reading range [12]. Wireless technologies such as Bluetooth, RFID technology (using omni-directional antennas) and WLAN have this feature.

2.1.2 Pointing

Pointing is used when user can see the tag him/herself and wants to access the information related to it. In this case, the natural way to select the tag is by pointing. For this purpose, an infrared beam could be used for selecting, but to make the technology more usable the infrared beam can be combined or replaced with a beam of visible light, such as a visible laser. However, a situation might occur where multiple tags get selected. In this case pointing should follow the same procedure as scanning and give a list of choices to the user for selection [12].

2.1.3 Touching

Touching means physically touching the tag with the reader (mobile phone) to select it. This does not even require the tags to be visible to the user and could be used when user knows which tag he wants to select or the user is too close to the tag. An example is a phonebook wall for an old person. The wall has photos of his/her relatives, with tags including phone numbers and a request to call underneath the photos. Thus, the elderly person does not need to remember phone number, nor names, nor how the phone is used or which buttons to press. He/she just touches the photo of the person he/she wants to call with his/her phone. This kind of calling mechanism could also be used in the developing mobile-phone markets where people may not have the literacy skills to operate the phonebook [12].

2.2 Communication with sensors

The first radio technology choice that comes to mind for communication with sensor radio nodes in ambient intelligence applications is Bluetooth because of its high availability in mobile phones and other handheld consumer electronics. Classic Bluetooth is, however, not well suited for communication with wireless sensors because of its relatively high power consumption. The ULP Bluetooth, previously known as wibree, the low end extension to Bluetooth can be used as an alternative to address the power concern of sensors and is specifically designed for sensor networks [2]. One could also use some other low-power radio technology, e.g., Zigbee which is specifically designed for wireless sensor networks and aimed to provide low-cost, low-bitrate, low-power and short-range RF datalink [13]. Extension of already existing radio Bluetooth to the ULP Bluetooth seems more feasible compared to the addition of a new radio technology like zigbee [2]. Also, amount of data-to-be-transfered, could be the deciding factor for radio-technology selection, which in case of large amount favors Bluetooth [14]. For communication with passive sensors or other passive information devices, NFC or other RFID technologies can be used.

2.3 Context Awareness

Context and context awareness are one of the vital factors in Ambient Intelligence. By using the context of the user, user can be provided with the right services at the right time and thereby possibly avoiding most of the user interaction and thus making the service more usable. For example, when one opens any navigation application it aligns map's directions(north,south,east or west) with his/her current position and directional view (direction to which user is currently looking). This can be done by sensor, sensing user's current head direction and sensing its movement. Navigation application (possibly on one's cell phone) can then utilize that sensor data, and update map's directions with respect to the user.

Dependability of the service on context demands the context information to be very precise, accurate, and updated in a real-time fashion as the user context changes. Research work on capturing of context information in an energy efficient way from multimodal inputs and transferring it in an invisible manner to the ambient intelligent systems has been undertaken in the e-Sense project [6]. The context-aware concerns of the services like context-aware adaption of the service and discovery, and management of context data, have been demonstrated in research projects like CoDAMoS and CROSLOCIS [15].

2.4 More Natural Interfaces

The concept of ambient intelligence has core emphasis on the need of multimodal and natural interaction mechanisms with the ambient environment. The concept is to establish a mechanism in which humans can interact with the environment in a way similar to how they interact with humans: by using multiple natural communication mechanism like speech, eye gaze, gestures and haptics [16]. To show the essence of ambient intelligence, in a project called "ambient intelligence", two multimodal prototype systems were developed: mushrooms that watch, listen, and answer questions and a Quizmaster Mushroom. These two systems work in real time using sound, speech, dialogue, and vision technologies [17].

2.5 Local sensors connected to internet services

With the vision of ambient intelligence and development of sensors from short range wireless nodes to video capturing devices, sensors are getting common in the environment. But the data captured from them is mostly used for providing some specific services and is not globally available for general use. The reason for this seems to be the dynamic nature of data and unavailability of any common framework for sharing it to public and making it more useful [18]. Sharing sensor data through the internet can be very useful. One interesting scenario is having sensors in vehicles publishing real time traffic data on the internet, to be then utilized by applications, e.g., in other vehicles to avoid traffic congested areas. A framework for effectively publishing, browsing, and analyzing sensor data over the Internet has been developed known as Web-based Intelligent Sensor

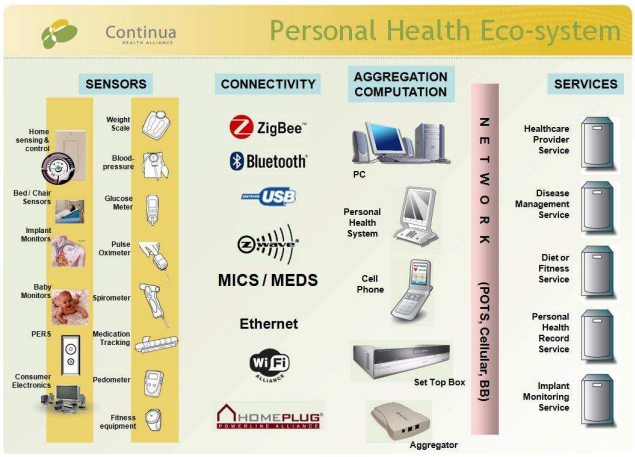

Figure 2: Personal health eco-system [21]

Explorer (WISE) [18]. From architectural and communication protocols point-of-view the Embedded Internet Architecture (EIS) for internet protocol enabled devices has also been proposed. The concept realized in the research was to equip sensors with radio technology for communication with internet-enabled devices, feasibly a mobile phone, thus routing sensor data to global servers in the Internet [19].

3 World full of Ambient Intelligent Services

Several possibilities of AmI services exist, how people can interact with them and their impact on our lives. I will visualize ambient intelligence services in the real world, by describing the possible use cases.

No need to memorize

It has been observed that mostly what people like to carry with them while leaving certain place are keys, money (wallet) and a cell phone [1]. People need not to worry that they will forget things they typically carry with them most of the time, because they will get notified of the things, if they are being forgotten at some place. With ambient intelligence, objects are tagged with RFID, hence they can be tracked with one's cell phone (tag reader). This will also work for the cases, when things fall off unnoticed. It appears to person like everything one owns has a sense of loyalty to him/her [20].

Non-smoking zone

Whenever one enters a non smoking zone one gets notified by one's cell phone, and a navigation application can then, depending on one's preferences, show the nearest smoking zone. Similarly while entering a meeting room one's cell phone can automatically go to silent mode.

Health Tele-monitoring

Health services at hospitals could use a link to patients home via a mobile phone to health sensors, for example, during recuperating from an operation or during long-term treatment of some disease, e.g. cancer, as shown by the Continua Health Alliance's Personal Health Eco-system vision in figure 2.

Clothes sensing weather

One's cold weather clothes could have an RFID tag which contains information about their weather suitability. While leaving residence, an application on his/her mobile phone fetches the real-time weather data from a service over web and then it could sense the clothes for their weather suitability by sensing the information on them and warns if it is too cold for the clothes worn, or if one is forgetting umbrella at home and it is forecasted to rain sometime.

Food wrappers indicating quality

Food wrappers could have sensors [22], which could detect the quality of food and notify one through one's cell phone that the food has expired or is soon going to rot

Intelligent Physical Browsing

Whenever a person spends some time over something at some location, the location gets added to her favorites list by her mobile phone and whenever she is in the vicinity of things similar to those in her list, she gets notified

Virtual Presence everywhere

Split families can get virtually connected. If a person is out of her home for some reasons, even then she can make her presence feel back home on any occasion or she can look after her elderly/sick people back home. She just needs to install "ambient sharing" systems at both of her homes, by doing so she does not need to focus on something or connect to some device, or ask the person to face some device, they can watch each other's routine activities at home anytime. This mode can be turned on and off between extended home [23]. This can further be extended to keep a tele-watch on one's property like farm house or farms.

Environment learns from a person's past and doesn't let her feel down

It is observed by the environment sensors that one is feeling sad. And whenever she feels sad and lonely, she hears the voice of her loved one and what she used to love to eat with her loved ones or some similar reminders to some great memories, as observed by the environment to cheer her up [24].

Plants request attention when they feel un-noticed

If a person loves gardening, he can be notified in case if his plants are out of water and are getting dried or have grown ugly and need some brushing.

Locating things and places

If directive signs to a certain place or to a certain thing are all typically RF ID tags, then a user can be easily routed to that place by an ambient intelligence application running on her cell phone. For example, if one want to locate a coffee vending machine in any building, one can be routed to the machine by just pressing a button on his/her mobile-phone and specify the thing a person is looking for.

Incompatibility Warnings

When things which can be apparently connected physically but have different power ratings, resulting in a possible damage can be sensed and read by the reader (mobile phone) while one is connecting, possibly generating a warning and signaling the device to a discontinuous supply mode. For example if a person buys a laptop from US (120 Volts and 60 Hz) and tries to plug it in Finland (230 Volts and 50 Hz) can be warned against possible hazard.

Monitoring and collecting health data

Different sensors related to user's possessing like watch, t-shirt or shoes can sense blood-pressure and glucose level in the blood periodically and collect the data and transmit it to health services through some mobile-phone health monitoring application. In case, if some threshold has been sensed an emergency call to hospital can also be made [20].

Restricting access for children and pets for their safety

Clothes or other wearings of the children and pets can have their identity tagged with RFID. They can be warned to leave or enter some regions, like they can be asked to stay at home or don't go to the garden in the evening. If they cross the limits set by their guardian, it can be detected the by the sensors monitoring their tags and location tags inside the home. This can generate an alert on guardian's mobile phone.

Locating known people incidentally and/or intentionally

It is quite often that many known people to a person are at a smaller distance to him/her, but no one of them probably knows about each other's presence. This distance can be bridged if one could get notified about the presence of his friends or family in his vicinity and about his presence to them. But this requires both the parties have consent on using such application and sharing their context. This can be done by the radio technologies (like Bluetooth) and detection of the relationship between the people. One possibility of detecting relationship between the people is figuring out their presence in their mobile phonebook or matching their contact data from social network web sites. Such application could be quite useful in public places and increase social acquaintances.

Family memories are being recorded

Consider an example of a mushroom shaped hypothetical device which is an intelligent ambient device. The device has lived with some family for quite a long time like a pet and has observed all their family happenings. The device is now residing with a grandmother living alone. The mushroom has read the grandfather's will which states that his wife should not be left to live alone. So whenever she feels to be tired or lonely, mushroom speaks up the voice of grandfather, "hey, let's have a tea break", and shakes the wedding ring which is beside grandfather's photo. This might remind grandma of her forgotten wedding anniversary. This ambient technology understands human feelings [24]. Another example is of a grandchild living abroad. She is listening to a song and is loving it. The mushroom beside, knew from the family database that this song is also liked by her grandfather. So, the device lets her know about this coincidence and connects to her grandfather back home. One's family memories are being recorded and giving the feeling to family of being always connected [25].

Belongings identification

It often happens when one lays off his/her slippers (or shoes) while entering certain places (common practice at sacred places like mosques and temples). It would not be surprising then, if he/she comes across many similar looking slippers while returning. With RFID tagged slippers, identification then would be a matter of just hovering one's mobile phone over them and one can easily find out his/her slippers. And even if one mistakenly wore stuff other than his/her, he/she gets notified. Moreover, the direction to the stored slippers can also be indicated by the mobile phone, given a suitable technology.

4 Conclusion

Ambient Intelligence is foreseen to be present everywhere in the future world and to ease human living. It has a vision to build an environment which will be natural, informative and caring from human perspective. Research in this domain is also going at a tremendous pace and outcomes are very promising. Sensor networks are being built into the environment, which is a sign of progress for AmI. Besides, context-aware applications are already in business. Middlewares and frameworks for context-aware applications are further evolving, enabling secure and efficient context capture. Moreover, mobile phone is bridging the gap between sensor networks and Internet. Thus services are getting connected digitally, which enhances their ability to leverage more usefulness to the user.

Development in AmI is user-centric. This might require advancements in user interfaces, as compared to the past technology-driven development. One such area of development is multimodal interfaces, where more enhancements are required to unleash the true potential of AmI. However, several successful AmI implementations and prototypes have been observed in some domains. AmI is on the verge of reality and it would not come as a surprise if the future environment we talked of, becomes part of the world fairly soon.

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