Ambient Intelligence: The Next Generation Technology

A Review

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Abstract:-Configuration of the computing and communications systems found at home and in the workplace is a complex system design that currently requires the attention of the user. Recently, researchers have begun to explore computers that would autonomously configure their functionality based on observations of who or what is surrounding them. By determining their context, using input from sensor systems distributed throughout the environment, computing devices could personalize themselves to their current user, adapt their behaviour according to their location, or interact to their surroundings. This field of intelligence is called Ambient Intelligence (AmI). There has been increasing interest in building networks with AmI, which incorporates the user-centricity and context awareness, or in short AmI is a new information paradigm where people are empowered through a digital environment that is "aware" of their presence, context and is sensitive, adaptive, responsive to their needs and requests. Users' environments are going to be disseminated of intelligent adaptive devices and sensors that will coordinate each other to help users in their activities with the help of AmI concepts and designs. This paper introduces the concept of AMI, explains the need for such an intelligence and also waves light over the different innovations done in this promising field of science and technology. This paper also addresses the topic of providing context aware services in smart environments. We review recent works in smart environments, and further defines and debates essential aspects concerning context-aware service supply. Future challenges for the research in context-aware smart environments are also discussed.

Keywords- Ambient Intelligence, Smart rooms, ubiquitous computing, Embedded Systems, Intelligent Class rooms, context- awareness

I. INTRODUCTION

AmI provides a vision of the future filled with smart and interacting everyday objects that offers a wide range of fascinating possibilities, developments and upgrades. AmI represents a new face for the life, made up of communicating devices and sensors, which further lead to a pervasive intelligence in the surrounding environment supporting the activities and interactions of the users [1]. Ambient Intelligence aims at producing a significant change in the way people live their life. Thanks to the growth of the digital technology, and the great availability of different kinds of devices. Nevertheless, the wide spread presence of electronic device does not create AmI, since these devices must coordinate and cooperate each other in order to support human activities and their corresponding reactions to armor the room with intelligence.

Ambient intelligence appears poised to cause remarkable changes in the way people live. With digital information, the ease of human computer interaction can be greatly increased by broadening the interface media available and allowing for mobile and portable communication free of inhibiting wires and stationary units [13]. Additionally, some forms of ambient intelligence allow computers to adapt to their user's preferences. The result of ambient intelligence is ultimately a more empowered computer with the benefits of added convenience, time and cost savings, and possibilities for increased safety, security, and finally entertainment. This technology has the potential to significantly impact business and government processes, as well as private life.

AmI emphasizes or mainly deals with user-friendliness, more efficient services support, user-empowerment, and support for human interactions. AmI builds on three recent key technologies: Ubiquitous Computing, Ubiquitous Communication and Intelligent User Interfaces – some of these concepts are barely a decade old and this reflects on the focus of current implementations of AmI. Ubiquitous Computing means integration of microprocessors into everyday objects like furniture, clothing, white goods, toys, even paint. Ubiquitous Communication enables these objects to communicate with each other and the user by means of ad- hoc and wireless networking policies. An Intelligent User Interface enables the inhabitants of the AmI environment to control and then interact with the environment in a natural and personalized way for example with the help of hand gestures. The term "ubiquitous computing", according to Mark Weiser (1991) who coined this term, refers to omnipresent computer systems that serve people in their everyday lives at home and at work, functioning invisibly and unobtrusively in the background and freeing people to a large extent from tedious routine tasks. The general working definition of ubiquitous computing technology is any computing technology that permits human interaction away from a single workstation. This includes pen-based technology, hand-held or portable devices, large-scale interactive screens, wireless networking infrastructure, and voice or vision technology [13].

At the front-end of an AmI system are a variety of tiny devices that can hear, see, or feel an end-user's presence/absence. At the back-end, wireless-based networked systems make sense of these data, identifying the end-user and understanding his/her needs and present requests. Wireless digital assistants, network-attached refrigerators, and smart houses are examples of pervasive or ambient computing. For example, think about a "virtual house" that updates its contents whenever you buy merchandise on the Net or in person, and that you can walk around with the aid of a virtual reality headset.

To get updated to AmI, the user must perceive the environment he/she is living in as intelligent, even if the environment individually is not intelligent at all. In fact, AmI does not imply that the environment (i.e., the environment components and or devices) must be endowed with a kind of artificial intelligence, but that it must be perceived as intelligent by the user, for example reacting and anticipating her actions on the basis of past events or her preferences by bringing the concept of probability or behaviour selective actions. In other words, AmI proposes to enhance the quality of life, offering to user's relevant services anywhere and at anytime, placing the users themselves at the centre of the system.

Human activities can be supported by a digital environment, reducing time wasting and leading to a simpler life in every-day actions, or even improving results in enterprise activities by using the concept of AmI. In fact, AmI is not tied to a specific human activity/environment, but can be applied to different scenarios, context and situations. Thus for example we can find AmI systems for the management of school class rooms and healthcare in general [11], and in enterprises as well [12], where AmI can both support worker activities and allow enterprises to be a part of several networks at the same time without the need of deep changes. Furthermore, since AmI proposes to improve and allow the participation of individuals in the society, it can be applied also to an e-government scenario [13]. This paper is a review of the fascinating development of AmI. A brief historical introduction is given, followed by a discussion on present works done in the field.

The rest of this paper is organized as follows. Section II explains about the different smart environments like conference room, class rooms [4], offices and home [23] .In section III, we have explained some advancements in AmI other than smart homes. In section IV we conclude the work by explaining the future advancements possible in this amazing field of science and technology. The paper drops details about the advancements in AmI only over the past 18 years.

II. SMART ROOMS / ENVIRONMENTS

Technological progress, particularly in the domains of sensor networks, computer vision and artificial intelligence (AI) has enabled the construction of augmented "*smart environments or smart rooms*". The concept of smart home was introduced to the scientific community when Mozer [21] developed one of the first intelligent home environments at the University of Colorado. The Adaptive House has been implemented in an actual residence that was renovated in 1992, at which time the infrastructure needed for the project was designed and developed into the house architecture. These environments are equipped with numerous sensors and interaction devices, permitting to sense, interpret and react to human activity, like movement/gestures, in the scene. Real context-awareness constitutes a major challenge for engineers of smart environments/smart rooms and goes beyond simply sensing and reacting to human actions. Issues like intelligibility, scrutability and trust need to be considered when realizing a useful context-aware system.

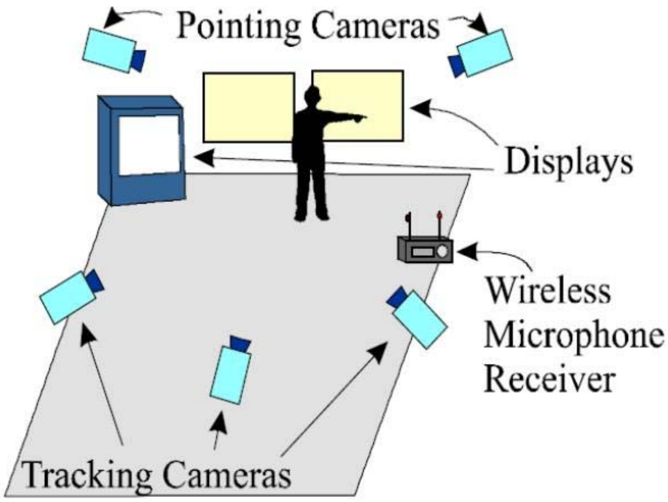

Fig 1
Smart Environment: An example for an AmI integrated room in MIT (a picture from [14])

The integration of computing devises like cell-phones, desktop computers into every-day environments has been one of the predominant trends over the last decade. Apart from this WLAN networks have become part of almost every organization [10]. This trend enables computer everywhere in the environments. This was the scenario which gave birth to smart rooms or an intelligent environment where these computing devices had an option to communicate with other devices and make the life better. Coen [15] defined the term of intelligent environments as spaces in which computation is seamlessly used to enhance ordinary activity. The objective is to make computers not only user friendly but also invisible to the user. Interaction with them should be in terms of forms that people are naturally comfortable with.

One of the very first intelligent environments, the Intelligent Room [15], has been realized at Massachusetts Institute of Technology (MIT) AI Laboratory. The Intelligent Room is laid out like an ordinary conference room, with a large table surrounded by chairs (Figure 1). Mounted at various places in the conference area are 12 video cameras, which are used by computer vision systems. Two video projectors, several video displays as well as audio devices and wireless microphones further augment the environment. The objective of the intelligent room was to experiment with different forms of natural, multi-modal human computer interaction during what is traditionally considered non-computational office activity. Numerous computer vision, speech and gesture recognition systems are used to detect what inhabitants are doing and saying.

Similar smart environment was designed by a team a research engineers from Microsoft named "*The New Easy living Project*" [17]. The concept was to design a complicated architecture for building intelligent environments that facilitate the unencumbered interaction of people with other people, with computers, and with devices. They are concentrating on applications where we can make computers easier to use for more tasks than the traditional desktop computer. It maintains an awareness of its occupants through computer vision, responds to voice and gesture commands, knows its own geometry and capabilities, and can be easily extended. The technology will enable a home's resident to make a phone call by simply speaking his intentions from anywhere that he happens to be. The home will keep track of children and pets automatically. It will allow a user to move from room to room while still maintaining an interactive session with the computer, with the user interface migrating along. The project explains extensively on the sensing and modeling issues associated with a smart environment. Apart from this user interface, computing issues, architecture for extensibity is also discussed. The focus of Easy Living laid on technologies for middleware (to facilitate distributed computing), geometric world knowledge and modeling (to provide location-based context), perception (to collect information about environment state) as well as service abstraction and description. Input devices can include an active badge system, cameras, wall switches, and sensitive floor tiles. Output devices can include home entertainment systems, wall-mounted displays, speakers, and lightening. Stereo computer vision tracking is used to derive the location of people in the environment as well as to maintain their identity while they are moving around. Radio-frequency (RF) wireless-LAN-enabled mobile devices were also used.

At MIT Media Lab, Bobick et al. [20] constructed another intelligent entertainment environment with better algorithm. It's called the Kids Room. The Kids-Room was a perceptually-based, interactive, narrative play space for children. The environment/room, which resembles a children's bedroom, uses 2 large back projected video screens, 4 speakers, theatrical lightening for ambient atmosphere, 3 video cameras, and a microphone array to perceive and to interact with the children. Computer-vision algorithms on the video images of the scene are used to identify the activity of several children. Constant tracking of the positions of up to 4 children and a strong story context are used to limit the number possible children's activities to reduce the complexity of the algorithm. Images, music, narration, light and sound-effects generated by the system guide the children through the story. The strong story context defines the possible children's activities at the actual state of the play and the appropriate reactions to be taken by the system. The objective of the Kids-Room was to explore the design of interactive spaces and to develop suitable computer vision techniques.

The Concept of intelligent classroom has been an area of interest for many researchers. Many research institutes like Cairo University and Georgia Tech has extensively funded research proposals in the field of intelligent class rooms. These funded Researches have resulted in design of the "*iClass*" by Rabie A. Ramadan [4]. He presented three different directions including the utilization of RFID technology, interacting with the user via speech and developing intelligent agents to learn the user behaviour and adapt to its change over short and long time intervals for providing AmI to the class room. AmI techniques and algorithms have been utilized in many of smart environments research. For instance, at university of Essex [23] the authors tried to achieve the vision of ambient intelligence by embedding intelligent agents in the user environments so that they can control them according to the needs and preferences of the user.

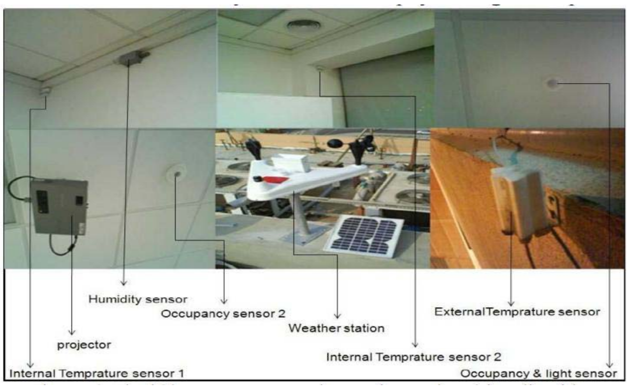

Fig: 2
Smart Environment: An Intelligent Classroom
(A picture from [4])

The "*eClass Project*" [19] (formerly known as Classroom 2000 Project) concerned the development of an intelligent education environment at Georgia Tech. The project developed a prototype classroom environment and the necessary software infrastructure to seamlessly capture much of the rich interaction that occurs in a typical university lecture hall. The classroom is augmented with single audio- video stream recording facilities, electronic whiteboards, and personal pen-based interfaces. Further, software and WWW access facilitate automatic capture and content-based access of multimedia information in the educational setting. The objective of the eClass Project was to automate the capture of individual and group activity in the classroom and to provide an easily accessible interface that integrates this information together.

The "*Smart Classroom Project*" [22] constructed an intelligent class-room environment at Tsinghua University. The augmented classroom has two wall-size projector screens, one on the front wall and the other on a side wall, and several cameras that are deployed in the environment (Figure 3). Additional cameras are installed on the computers of remote students. The teacher wears a wireless headset microphone to capture his or her speech. A touch sensitive board further enhances the room. Voice-recognition, computer vision techniques and activity recognition are used to permit the simultaneous instruction of local and remote students. The objective of the Smart Classroom Project was to seamlessly integrate tele-education and traditional classroom activities. The system turns a physical classroom into a user interface for tele-education.

The "*MavHome Project*" [23] developed a smart home environment at the University of Texas at Arlington. The MavHome acts as an autonomous intelligent agent that perceives its environment through the use of sensors, and can act upon the environment with the help of actuators. Perception is managed through light, humidity, temperature, smoke, gas, infrared motion, and switch sensors deployed in the environment. Main actuators are the control of lightening and blinds, water heater, different video and screen displays, sprinkler and VCR. Location-based media control and tracking is also provided. The objective was to manage the home automatically in a way that maximizes productivity and comfort of its inhabitants, minimizes the costs of operating the home, and ensures the maximum security of the home and collected/personal data.

III. Developments in AMI

Computing systems should "*stay out of the way*", while providing useful and enriching services. In the context of smart environments and smart rooms there are two types of service behaviour: system-oriented, importunate smartness and people-oriented, empowering smartness. System-oriented, importunate smartness enables the environment to take certain self-directed actions, while people-oriented, empowering smartness focuses on empowering the users to make decisions and take responsible actions.

The system services are to be supplied without interrupting the user's current task and activity. In addition, they should be predictable for the user. These services will not replace human-computer interaction itself because depending on the complexity of the current task of the user, deriving user behaviors, intent, or need may be too difficult. The main purpose of AmI is to reduce the communication workload of the use in his tasks. Obviously necessary actions may be automated and so the user can concentrate on essential work and human-computer interaction tasks. [2] is a very good example for as an application of this concept in AmI. It describes application of a combination of wireless sensor networks, ambient intelligence and Control Area

Network (CAN) and Human machine Interface for monitoring freight and truck status are seen as a future solution in Fleet Management Solutions. This setup monitors a multitude of aspects related to intermodal transport and transmits the processed information to Fleet Management Systems (FMS) Control Centre via GSM and GPRS. It will focus on the design, implementation and validation of a pervasive intelligence architecture based on heterogeneous sensor networks. It introduces intra-vehicular sensor networks and the way to improve transport road services by using these technologies. The design of an architecture based on FMS legacy solutions combined with heterogeneous sensor networks is proposed. Furthermore, implementation details and tests carried out are described

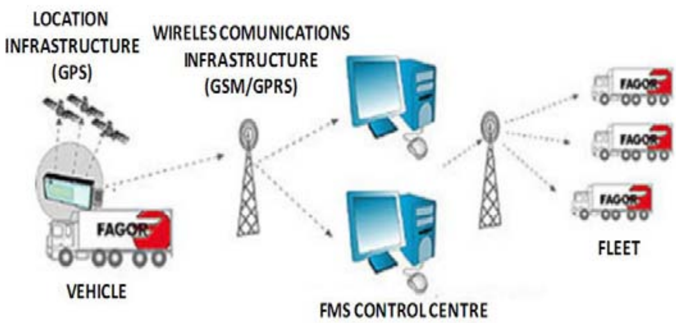

Fig 3
Fleet Management system Architecture Proposed by [2].
(a picture from [2])

Social and interactional aspects of context must also not be neglected. Individual behaviour may not be the correct unit of analysis. Evidence shows that about 40 % of the variance in human behaviour may be attributable to non-linguistic social context. Research further high lights the interactional nature of context. Contextuality is a relational property that holds between objects and activities. Context is particular to each occasion of activity or action; the scope of contextual features is redefined dynamically. Context is not just a fixed part of the environment, but context arises from human activity.

LAICA [7] stands for "*Laboratorio di Ambient Intelligence per una Città Amica*" (in English means: Laboratory of Ambient Intelligence for a Friendly City), and it is a regional project that involves universities, industries and public administrations. The main aim of the LAICA project is to define innovative models and technologies for Ambient Intelligence in an urban context, with particular regard to security issues, enabling AmI even at an enterprise level. The main application of LAICA is to control the human and vehicles flow across streets and crosswalks, in order to both control that flow (e.g., appropriately activating traffic lights) and to keep into account security issues (e.g., understanding if a danger situation happens, activating appropriate alarms, etc.). To this purpose, LAICA propose architecture with different components. The sensor agents are agents in charge of managing information acquired by devices. For instance, we make use of video cameras to acquire information about the traffic in the streets of the city.

The effectors agents are agents that can perform actions on the ambient where they live. For instance, such agents can control traffic lights, alarms, and so on. All interesting information data is recorded in a database, which is in charge of keeping track of whatever happens. The Web portal is an important component of the LAICA architecture. From one hand, it allows to control the whole system by means of a technology that is well-established, wide spread, user friendly, and usually allowed by firewalls. On the other hand, it enables the publishing of different kinds of information about the city and the current situations. Finally, the operating central is the core of the architecture, in charge of instrumenting all other components in a fruitful way. Note that, even if this is a centralized component, the intelligence of the whole ambient infrastructure is spread among the agents and the middleware.

Security for ambient systems had been an interesting topic for the past few years. Many interesting papers had been submitted in this topic mainly [8]. Considering its security problem, distributed nature of ambient intelligent environments has both advantages and disadvantages. Advantage is that attacking one node does not disclose the complete system. The disadvantage is that every node and the system as a whole need protection. A denial of service attack is by flooding the network with requests. Similar attacks exist in the Internet also. But the main difference is that for sensor networks, energy will be drained and the nodes can die irrevocable while in general networks the performance will drop or stop, but is usually restored after the source of attack is removed. Also the devices are physically accessible at every node. A certain percentage of the nodes right is compromised. Any protocol needs to be investigated for its computation resources and its communication requirements, i.e. radio transmission and reception. Attacks on the communication channels by placing a jamming device in the proximity of the sensor network can be encountered by re-routing information, or by introducing sufficient redundancy in the network or solutions such as using a frequency hopping system.

Researchers from NUS have come up with a sophisticated method by introducing a new layer in OSI model called User Layer [10]. This paper mainly concentrates on the concept of a new architecture for ―user model‖ in TCP/IP protocol for AMI. The paper suggests a better model than the OSI model for the existing TCP/IP protocol by introducing a new element in the protocol called user layer. The User Layer empowers the end-users to influence network performance based on their interaction activities with the networks. We adopt the Model Human Processor (MHP) approach for building the User Model. The networks with Ambient Intelligence (AmI) emphasize on user-centricity and context awareness, where the interaction between the end-user and the networks becomes most crucial. Many interesting papers give details about how to reduce power consumption in AmI systems [9].

IV. CONCLUSION

The introduction of AmI in a home environment will have an impact on personal lives in several ways. The time gained will allow people to spend more time with their family and friends. Convenience, money, time savings, security, safety and entertainment reduce the stress leading to an overall higher quality of life. However, the ability to prepare or complete more and more everyday tasks such as shopping or banking at home, potentially leads to reduced face-to-face interaction between people or, at least, to selective interaction restricted to mainly family and friends.

Research must, therefore, focus on developing user-friendly low-cost solutions with a high level of network security. Managers of the various companies intending to produce and sell AmI technology must agree on common networking standards, which are a major factor determining future success or failure. Managers intending to employ AmI in their companies must ensure that the expected benefits exceed the cost of implementation and that the organization fits the technology, which will in many cases require structural changes. Individuals and organizations will be affected by AmI in various ways and it is the end-user's responsibility to gain the greatest benefits from AmI while preventing or minimizing its potential negative effects as far as possible.

Organizations are exploring ways to incorporate gaze tracking, emotion detection, speech recognition, and gesture recognition in a "smart" computer, that in the future will often be invisible, with an intuitive user interface. The current phase of AmI/pervasive computing, in which computers are already being embedded in many devices, has begun to affect our everyday lives in ways we do not even notice:

- computing is spread throughout the environment
- users are mobile
- information appliances are becoming increasingly available
- communication is made easier-between individuals

The next step in the evolution of computing involves the move toward ubiquitous computing, in which computers will be embedded in natural movements and interactions with environments, both physical and social. Ubiquitous computing will help organize and mediate social interactions wherever and whenever these situations might occur. Researchers predict that during the next 20 years, ubiquitous computing will come of age and the challenge of developing ubiquitous services will shift from demonstrating the basic concept to integrating it into the existing computing infrastructure and building widely innovative mass-scale applications that will continue the computing evolution. The main challenges in ubiquitous computing originate from integrating large-scale mobility with pervasive computing functionality. The key technical hurdles in an AMI are, making computers see, hear, speak and understand language. The size of the potential market for such applications, especially in the home, is far from clear.

The stumbling blocks that might hinder the widespread adoption of AmI in the home environment are costs and risk of intrusion. In the business field, potential employee resistance, legal and ethical restrictions, and risks associated with high system complexity are additional major hurdles that have to be overcome before AmI can be successfully implemented. If companies succeed in offering AmI technology at a price that people are willing and able to pay for the associated benefits, AmI can turn into an entirely new market. More companies are investing considerable sums on research and development of AmI in anticipation of market expansion

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