Personal Environment Service for Mobile Users

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***Abstract*—The *Personal Environment Service (PES)* configures user's computing and communication environmental based on the user's *Personal Organizer* profile, which stores the user preference data. *PES* then coordinates the reconfiguration of the user's physical environment, such as appliances, through the use of short-range wireless communications.**

Keywords-environment, personal, ubiquitous

I. INTRODUCTION

The rapid progress of radio communication technologies stimulated the introduction of new mobile communication services. Those services support ubiquitous access to computing and communications resources with the intent to provide convenient and easy to use interface for human operators. To accomplish this vision, communication devices and network protocols have been developed.

The main mode of *Human-to-Human* interaction is the traditional voice-based communication. This type of communication has reached its saturation level, and the number of *Human-to-Human* users in an environment remains relatively constant. On the other hand, *Human-to-Equipment* interaction, which is supported by data communication, such as Internet web surfing and Video-on-demand services, consists primarily of multimedia information. As the contents providers are able to provide newer, more interesting, and more valuable information, this type of traffic continues to expand. The most advanced mode of communication is the *Equipment-to-Equipment* interaction, which, for example, could be implemented by a widely deployed sensor network with context-aware data routing. In this mode of operation, through autonomous interchange of information, equipment continuously and undergoes (self-) reconfiguration, as to create a more convenient working environment for the users. Typically, modifications to the environment do not involve the user; rather, the function of the user is limited to the initial construction of the network of sensors and actuators of electronic equipment and the associated information databases. Elements of such an environment have been already studied: a home network of electronics, RFID for mobility management of users, and context-aware applications. However, those elements were not developed for integrated operation, but rather their designs are focused only on their respective functionality; e.g., the task of home network involves mainly communications between electronic equipments, while communication networks serve for exchange of information and for remote control; RFID has been used for indoors detecting and tracking users' locations; and context-aware routing is primarily employed for information acquisition. Consequently, the current application of *Equipment-to-Equipment* interaction is at the level of abstraction only and of very limited practical value.

Similarly to the above-mentioned different modes of interaction, support has also been developed for different modes of mobility (see Fig. 1). *Terminal Mobility* allows users with mobile terminals to travel during a conversation. Another mode of operation, *Personal Mobility*, allows a user to use any available terminal. Personal Mobility could be implemented, for example, through the use of a SIM (Subscriber Identity Module) card for GSM (Global System for Mobile Communication) or UIM (User Identification Module) for IMT-2000. The third mode of mobility support is *Service Mobility*, such as, for example, VHE (Virtual Home Environment) which support personally customized mobile phone services [1]. When a user roams to other than his network, the same user's interface is recreated in the visited network as the one in the user's home network.

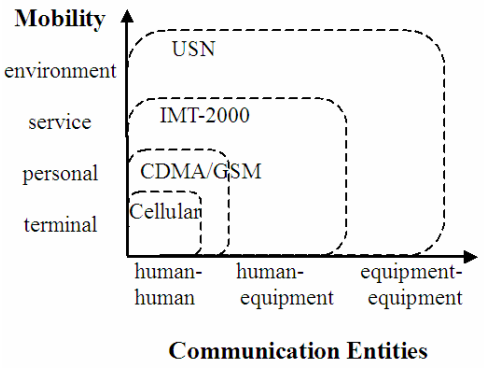

Figure 1. The progress in the development of mobile communication services for various communication mode

The new mode of support for a user of a mobile environment, which is proposed in this paper, is the *Personal Environment Service (PES)*. As a user moves around home, office, vehicle, or even outdoors, the environment's aspects (such as temperature, lighting, music, computing services, etc) are optimized and customized to the user and follow the user in their movements. In other words, the *PES* recreates the

aspects of the user environment in response to user's mobility. By leveraging the advances in communications and in mobile services, PES could very well become the next generation service of wireless networks.

In this paper, we propose the Personal Environment Service, and the network configuration and the service scenarios of PES are described.

II. THE CONCEPT OF PERSONAL ENVIRONMENT SERVICE

In 1991, the concept of *Ubiquitous Computing* was introduced [2]. In [2], *ubiquitous* it is stated that "specialized elements of hardware and software, connected by wires, radio waves and infrared, will be so ubiquitous that no one will notice their presence." At that time, some ubiquitous services were already implemented, such as entrance control system and automatic data pulling from an individual's computer to a nearby computer using an RF badge. Later, the concept of *Ubiquitous Computing* has been recoined as *Pervasive Computing*, which is defined as combined and developed form of *distributed system* and *mobile computing* [3]. The basic idea behind all these concepts is to provide a user with a versatile and sophisticated form of computing services based on user's location [4].

Location Based Service (LBS) and *Location Aware Service* are systems where the supported services depends on the present location of a user. The operation of LBS can be of two types: user request type and trigger type. An example of the former is finding the nearest gas station, and an example of the latter is automatically providing user location information from cellular network in an emergency situation [5]. Location Aware Service is a computer application service that detects one's location and uses the information about the user's location to properly modify settings, user interfaces, and functions of the computer terminal [6].

Context Aware Computing (CAC) was initially discussed by Schilit [7]. In that paper, CAC was defined as software that adapts its use according to parameters such as the location of its execution, the collection of nearby users, hosts, and accessible devices, as well as to the changes in those parameters over time. A system with these capabilities can examine the computing environment and react to change to the environment. Context Awareness can be integrated with the concept of Ubiquitous Computing, but the Context Aware Computing focuses on information technology to impose real world characteristics [8]. Finally, the concept of Ambient Awareness is the procedure of personal computer that recognizes, processes, and executes the Context Aware Computing services by considering user's preference and mental state, without the user's active involvement [9].

According to the above discussion, the service concept is expanded from its initial definition of Ubiquitous Computing, to Location Aware and Location Based Service, to Context Awareness, and to Ambient Awareness (see Figure 2). Although the concept of Ubiquitous Computing in its various forms has been repeatedly considered by various papers, and some trial systems have developed, due to the lack of killer applications, the motivation to construct a communication infrastructure to support such services has been lagging behind. Furthermore, those applications which have been proposed are way too broad and too conceptual for those to be commercialized.

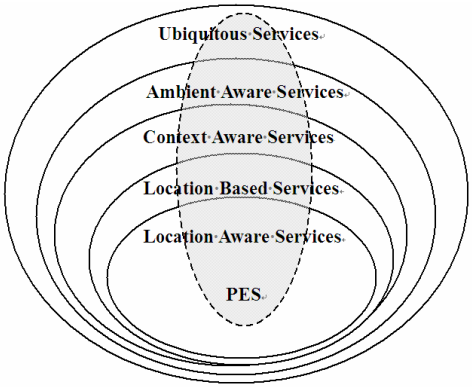

Figure 2. The position of PES among related services

Humans want their home and office environments to be set up according to their own and unique preferences and according to their current mental conditions. This usually allows the human to be comfortable and pleased, increasing the level of relaxation at home and the efficiency of a human's work in the office. It is important to realize that the desired settings of the environment are dynamically changing. Furthermore, those settings strongly depend on the location of the human; i.e., office, home, car. Additionally, as the user moves, the environment should be reconfigured (or recreated). This is the basic notion behind the *Personal Environment Service (PES)*.

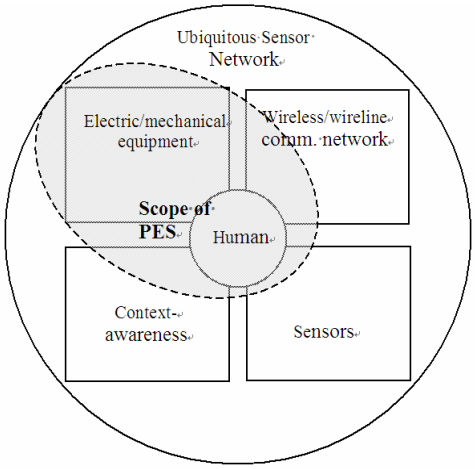

Figure 3. The position of PES in the Ubiquitous Sensor Network (USN) environment

The concept of PES is as follows. PES dynamically, automatically, and intelligently reconfigures the electronic, electrical, and mechanical equipment surrounding the user according to the user preferences (i.e., user's Service Profile) and based on the user's location and mental condition. The concept of PES, as proposed in this paper, is new and unique

mobile service, even though some elements of this concepts have been previously included in other concepts (see Figure 3). For example, while the main purpose of Context Awareness is to construct database systematically by sensing surrounding information, PES focuses on controlling the surrounding equipments. Also, the functions and performance of PES can be greatly expanded by maintaining (even intermittent) connection to wide area wireless/wireline communication networks.

III. NETWORK CONFIGURATION OF PERSONAL ENVIRONMENT SERVICE

A PES system consists of *Personal Organizer (PO)*, electronic, electrical, and mechanical equipment, wide area wireless/wireline communication networks, and the *Service Agent*. Though the goal of PES is the user, the master of service operation is PO, which is carried by the user. The PO can be implemented as a stand-alone device, or can be integrated within a mobile phone. The PO includes short-range wireless communication module, and it can exchange information with equipments and sensor nodes surrounding the user. Rough information about the ranging of the user to the surrounding equipment can be obtained by intelligent signal processing techniques, and the service range of PES depends on the communication range of the PO. When the communication distance is too short, employing multi-hop communication technology can extend the service range. PO collects user's response data and environment data of the configured environment by using various physical user interfaces and by direct communication with sensor nodes. Using this information, the preference profile is then intelligently updated. When there are several users in the same environment, the PO negotiates the parameters' values of the joint configuration, while exchanging the PES profiles with the other users' POs.

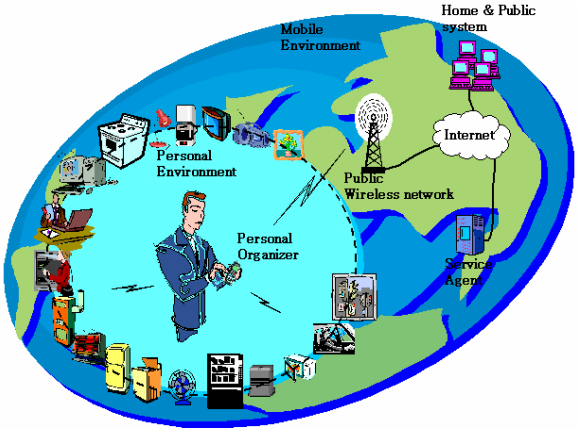

Figure 4. The overview of PES system

The electronic, electrical, and mechanical devices which exist in a communication environment are equipped with short-range wireless communication modules. These modules can exchange information with the sensor nodes around them and with the PO. The PO can control the function of the equipment and the equipment settings. Through a hook up to a wide area wireless or wireline network, the PO connects to the Internet. The Service Agent can then provide the PES with the profile management service and other PES related information from the home and public databases through the Internet. The Service Agent also monitors user's feedback information related to the configured environment, analyzes the information, and manages the environment. Eventually, the Service Agent recommends proper environmental services and parameters for the user. The Service Agent then reconfigures the environmental services in advance of the user's movement. Thus, the operation of the Service Agent is as a personal secretary. In order to continuously reconstruct the user's preferred environment as the user moves around, massive amount of data need to be communicated. For example, when user checks in into a hotel room, electronic displays on the walls would show the user's family pictures, the data of which could be stored in the PO or transferred from user's home storage through the Internet, from the Service Agent to the PO. Similarly, when the user use a computer in a business center of the hotel, the user's preferred application programs and the user's data files should transferred by the PO and the Service Agent to construct the user's familiar computing environment.

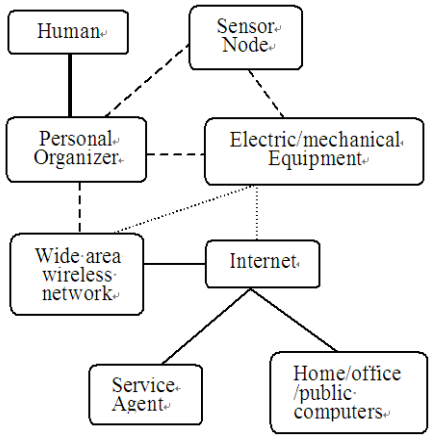

Figure 5. PES network configuration (bold solid: direct contact, solid: wired connection, dashed: wireless connection, dotted: optional)

The network configuration of PES system is shown in Fig. 5. The PO consists of the user preference information module, a short-range wireless communication module, and an authentication and security module. The electric and mechanical equipments consists of a short range wireless communication module, the personal preference recognition module, an authentication module, and an optional Internet connection module. Sensor nodes are composed of a sensing module and of short-range wireless communication module. Service Agent consists of service coordinator module, which is used to construct the user-preferred environment by cooperation with the PO, and of the LBS module, which traces user's location and support LBS.

A human user and his/her PO are connected by several methods. The user can input data into the PO directly, or the data about the user can be collected through the sensing points on the body of the user, such as a mobile phone, a watch, or

special sensors (for example, blood pressure meter, electrocardiogram, etc.). The PO, sensor nodes, and electronic equipment continuously exchange environmental information among them.

Fig. 6 shows timing diagram of communication among the system components for a basic configuration of PES. Firstly, preference data of the user's environment is stored in the PO by the user, and the PO continuously collects environmental data from electronic, electrical, mechanical equipment, and sensor nodes surrounding the user. When the user activates the PES, the PO connects to the equipment, authenticating each other. The level of authentication and security depends on the type of the equipment and the service. The PO controls the surrounding equipment according to environmental parameters for the user preference, and collects feedback data, which indicates on the level of the user's satisfaction. The information is analyzed and the service profile of the user is updated according to the user's status, location, time, and the environment. The PO continues to optimize the user environment by exchanging information with equipment and with sensor nodes, and by obtaining feedback data from the user.

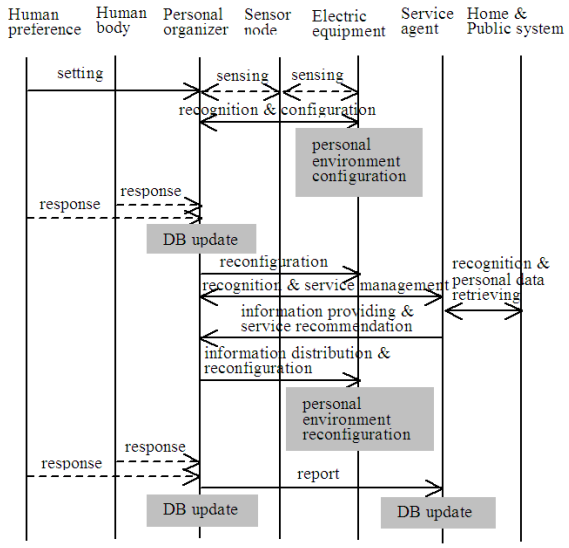

Figure 6. Timing diagram of basic PES

The PO provides current status and location information to the Service Agent, which is used by the PO to manage the user services. If it is necessary, Service Agent connects to the user's computer or public data server collects the necessary environmental data, and provides the data to the PO. Finally, optimized parameters and information for each user should be stored in the database of the PO and the Service Agent.

Several PES users can co-exist in the same area. In this case, competition on resources and unfairness of the use of the environment could occur. To avoid this problem a negotiation process between the users' POs is needed to decide on the proper settings of the value of the environment. Additionally, it is important not to overload the resources, as to avoid critical situation for the safety of users. This process is shown in Fig. 7.

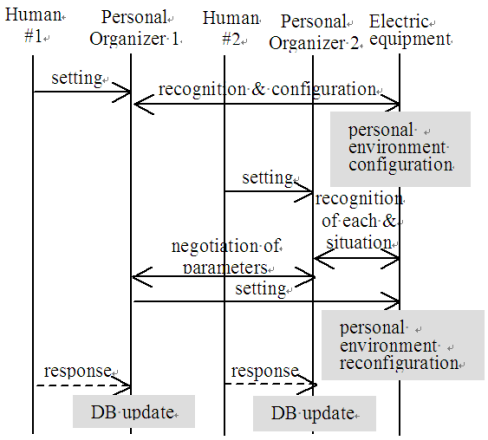

Figure 7. Timing diagram of PES for negitiation

GPS(Global Positioning System) cannot be used indoors for location determination due to the lack of direct line-of-sight to the satellites. Also, it would be very expensive to construct extra indoor tracking system. Instead of determining the exact location indoors, rough ranging technology using received signal strength is feasible for PES; i.e., what is of interest to the PO is the detection of equipment within some range. If the equipment has a unique location, which is stored in advance, then LBS can also be used. The PO can get location information from the equipment, and Service Agent can get the location information of the user through the PO. Fig. 8 shows timing diagram of PES system for LBS service.

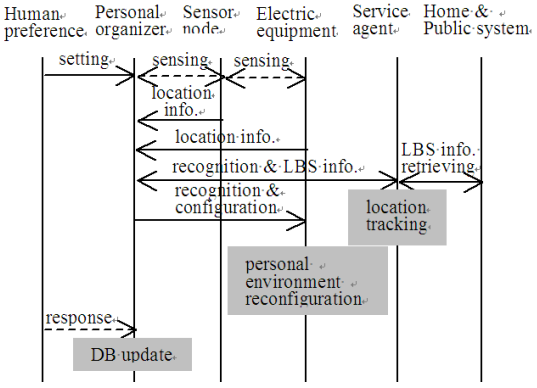

Figure 8. Timing diagram of PES for LBS

For implementation of the PES, the communication protocol and the structure of database should be defined first, and then services can be expanded step by step. Also, by updating the software in the electronic, electrical, and mechanical equipment, incremental the evolution of the PES can be made possible.

IV. PERSONAL ENVIRONMENT SERVICE SCENARIO

PES is the environmental service for human users, so the service scenario can be presented for any environment in which the user could reside; for example, home, office, restaurant or café shop, vehicle, and outdoor place like a street. For each place, though the environmental object to be achieved may be different. Some of the scenarios are already known as Ubiquitous Services, but the service integration and focus on the environment under the concept of Personal Environment Service has the great synergy effect to be realized and commercialized.

A. Services in the home

- automatic air conditioning: configuring temperature, humidity, air purity, and ventilation as proper to user
- decoration control: kind of light and intensity, content of electric picture frame
- favorite group selection: TV channel, music, cooking method
- auto configuration of computer: power on/off, favorite web site addresses, Internet home page, login name, password, monitor theme, application program porting, user attributes for application program, volume control, e-mail configuration
- mood control: calm mood, exciting mood, sleeping mood, cold mood - According to the environment profile, the set of environmental components such as temperature, light intensity, music selection and volume, communication function (like filtering incoming calls), the content of electric picture frame, food selection, and cooking method are configured properly

B. Services in the office and other indoor places

- private assistant: pulling conference material from user's computer to the meeting place, personal gateway – Portable devices like notebook PC, MP3 player, Internet radio, and digital camera can be connected to Internet through the PO
- favorite beverage and food selection at vending machine or store
- location identification: indoor location identification, automatic destination guide from the display at the entrance or corridor, elevator control, LBS
- automatic recognition: attendance check, entrance control

C. Services in the vehicle

- automatic air conditioning: temperature, ventilation
- automatic driving mode control: seat position, handle position, mirror angle, pedal sensitivity, maximum speed alarm
- favorite music or broadcasting station selection
- in-vehicle navigator control: menu configuration, favorite geography information, geography information update and Telematics services through the PO

D. Services in an outdoor space

- travel and location information service: When user stands in front of the electric display guide, it shows the information about destination, geography, transportation, and shopping in user's language
- automatic street lamp control

V. CONCLUSION

In this paper, we proposed the concept, the related network configuration, and the service scenario of the Personal Environment Service (PES) in the Ubiquitous Service environment. In this concept, each person is associated with his/her own PES service profile, which stores one's attributes and preferences. PES is a new service paradigm of mobile service and is based on several technologies of short-range wireless communication, such as ad hoc and sensor networks. To realize PES, a few compelling service scenarios should be specified and implemented and standardization effort should commence with the participation of the relevant home appliance companies. Personal Environment Service will concretize the concept of Ubiquitous Service and Ubiquitous Computing.

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