A COMPUTING MODEL TO BRIDGE A GAP BETWEEN REAL SPACE AND WEB SPACE

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Abstract: In this paper, we propose a computing model named ”symbiotic computing” to bridge an e-Gap between the real space (RS) and the web space (WS). The symbiotic computing is a post ubiquitous computing model based on an agent-based model to bring in social heuristics and awareness of the RS into the WS. The symbiotic computing is defined as a space of computing model spanned by three axes of the Ubiquitous computing, the Web computing and P/S computing, which consists of Perceptualware and Socialware. The last section of this paper describes a prototypical system of a symbiotic computing-based application of uEyes, which is a gentle watch over system for elderly people in an ubiquitous computing environment.

1 INTRODUCTION

Various kinds of computing models were proposed to develop more efficient and useful software system easily, such as the object-oriented computing, the Web computing and the ubiquitous computing (Lyytinen and Yoo, 2002). The technologies leaded the traditional society to the information network society where people can exchange information easily via the WWW efficiently. On the other hand, emergent problems also occurred with the Internet society, such as the digital divide, security, network-based crimes, and so on. These problems have been caused due to social and human difficulty rather than due to the computer and network technology. However, the technology should tackle these difficult problems by bringing in the sociality and humanity into computing models.

In this paper, we propose a computing model named ”symbiotic computing” which is formalized to bridge an e-Gap (eGAP-EU, 2006) between the real space (RS) we are living and the web space (WS) which is a cyber space constructed using the computer and network technology. We considered that the e-Gap which causes the problems was made because of the lack of mutual awareness between the RS and the WS. That is, people cannot receive its advanced services without IT skills, and the WS cannot provide a service suitable with a person depending on his/her situation. The WS also cannot provide a safe and secure service without heuristics on persons' activities in a society, such as custom, law, expertise and so on.

The symbiotic computing we proposed is defined as a space of computing model spanned by three axes of the Ubiquitous computing, the Web computing and the P/S computing. P/S computing is a methodology to acquire and process awareness of the RS and the WS using the Ubiquitous computing and to store social knowledge, persons' heuristics to live in a region and maps and facilities of the region, and to use the knowledge for people in the region.

The last section of this paper describes a prototypical system of a symbiotic-computing-based application of uEyes, which is a gentle watch over system for children and elderly people in the ubiquitous computing environment, using awareness and social knowledge.

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2 E-GAP PROBLEMS

Although a huge amount of social capital has been invested in the IT infrastructures and application systems, many of us in the Internet era still have not been able to reap satisfactory benefits from the services we have received in our daily lives. For example, the digital divide problem has blocked out unskilful people who has expected the useful helps form IT services.

Fig.1 explains cause of the phenomena in terms of an e-Gap which isolates the RS from the WS where various kinds of IT services and resources are installed. The RS has invested a huge amount of social capital and human resources to develop better services of the WS expecting that people can enjoy the satisfactory services in their daily lives and work places. However, due to the e-Gap, the people feel disappointed because they cannot receive satisfactory and suitable services they required. Therefore, we define the e-Gap by the differences between the expectation and the disappointments of the RS.

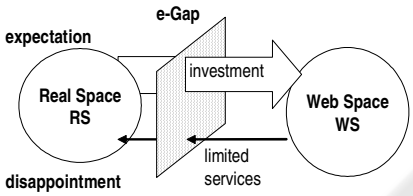

Figure 1: e-Gap Problem.

3 CONCEPT OF SYMBIOTIC COMPUTING

In order to bridge the e-Gap, we propose a computing model to construct an e-Bridge over the e-Gap which enable users to receive rich services of the WS. A basic concept of an e-Bridge is based on a concept of mutual awareness between the RS and the WS as shown in Fig.2(Pentland, 2005). The e-Bridge helps services of the WS recognize users' requirements and needs of help of people living and working in the RS. Then the e-Bridge can provide the adequate services automatically based on the recognition. The e-Bridge also helps each person find adequate services and resources in the WS as if he/she is familiar with them.

RS awareness in Fig.2 is a notion on recognizing the RS, using functions provided by e-Bridge, to capture users' requirements in real time, to recognize situation of the users, to acquire data of a region where users live, such as weather, traffic, position of each person, etc..

WS awareness is a notion on intuitive interface and visualization of WS to help users find adequate

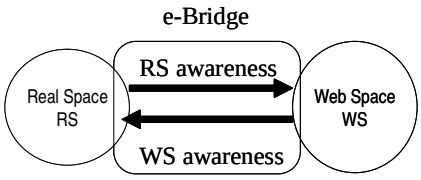

Figure 2: Mutual Awareness through e-Bridge.

resources in WS.

The concept of the symbiosis implies a biological terms of "the relationship between two different living creatures that live close together and depend on each other in particular ways, each getting particular benefits from the other" (Oxford, 2000). We are applying this concept to a relation between the RS and the WS, in order to bridge the e-Gap so that users and society easily get maximum benefits from the WS. The WS also gets principal investment from the RS when it recognizes that the investments brings richness and comfort to people living in it. The symbiotic computing provides models and technology to develop the e-Bridge which promotes the above symbiotic relationships.

The symbiotic computing we proposed is defined as a space of computing model spanned by three axes of the Ubiquitous computing the Web computing and the P/S computing as shown in Fig.3(Shiratori, 2005). (Symbiotic Computing, http://symbiotic.agent-town.com),

In this definition, the ubiquitous computing provides an interface between RS and e-Bridge, which is composed of embedded sensors, mobile devices, wireless LAN and so on, and the Web computing provides WWW services for the e-Bridge to compose services which users request. The P/S computing in Fig.3 is a model to develop functions to perceive the situations of users and communities in the RS, to acquire and save social knowledge and personal heuristics to live in a region and to provide context-adaptive(Coutaz et al., 2005) and social-aspect services(Hattori et al., 1999) for users using the above functions and services by WWW.

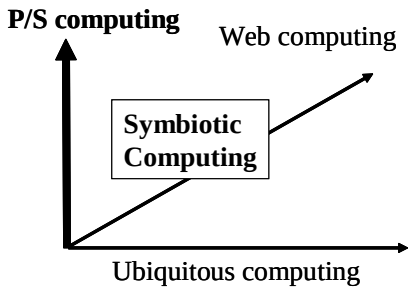

Figure 3: Symbiotic computing and P/S computing.

4 A MODEL OF E-BRIDGE

The symbiotic computing is a methodology to develop an e-Bridge between a community in a region and WS to make the community safe and comfortable, using the ubiquitous technology and Web technology. An e-Bridge is composed of Perceptualware and Socialware, as shown in Fig.4.

The Perceptualware is a collection of software and data for e-Bridge to perceive RS and WS through ubiquitous infrastructure and the web service interface(Billsus et al., 2002). The Socialware is a collection of software and data for e-Bridge to understand RS and WS, to save knowledge on RS and WS and to make decisions on how to support persons in RS properly and safely.

Functions of the Perceptualware is categorized into the followings, as shown in Fig.4,

(1) RS Perception

Functions of RS Perception are to transform signals and data from sensors and embedded devices into some data forms defined to perceive persons' activities, surrounding situation, climate, etc.. RS perception is categorized into (a)Location-based perception, (b)Event-based perception, (c)Vision-based perception, (d)Audio-based perception.

(2) RS Operation

Functions to operate mobile terminals, actuators and embedded devices in order to enhance person-system interactions and person-person communication in ubiquitous environment.

(3) WS Perception

Functions to perceive structure of Web Space and to transform web pages into data form which the module of "Recognition & Action" in Perceptualware can recognize. The model of perceiving WS is based on the model of Web Service(IBM, Webservices, 2006).

(4) WS Operation

Functions to maintain web pages which the e-Bridge provides for to WWW for persons in the region.

(5) Recognition and Action

Functions to recognize situation of RS and to make actions to solve problems collaborating with functions in the Socialware. This module recives data of lower level of perception from RS Perception ans WS Perception, and transfer them into higher level of perceptional representation on RS ans WS. This module also make lower level of decisions on reactive actions of e-Bridge.

Functions of the Socialware are categorized into the followings,

(1) Situation Understanding

Functions to understand activities and, surrounding situations of each person, collaboration among persons, etc. using the perceived data form provided by the RS Perception functions.

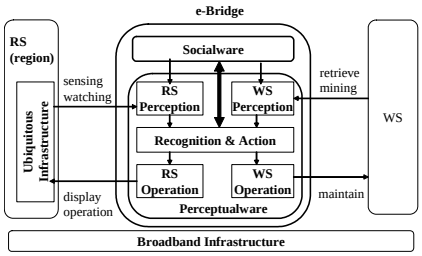

Figure 4: Architecture of e-Bridge.

(2) WS Understanding

Functions to understand information and services which are provided for in WS and create new information from them to meet person's request.

(3) Social Knowledgebase

Functions to store knowledge and common social heuristics in order for persons to use/reuse.

(4)Region-Directed Knowledgebase

Functions to store the region-directed knowledge and information which are acquired by the function of the Situation Understanding and the WS Understanding.

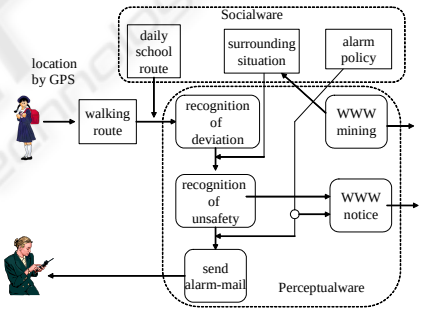

Figure 5: Simple Example of e-Bridge of Watch-over-support for children.

An example of an e-Bridge that we are developing in order to watch over children in a region is illustrated in Fig. 5. Th e-Bridge watches over children's walking routes using location data acquired by GPS, referring to map information of the region, which is stored in a Region-directed knowledgebase. When a module of "detection of deviation" detects a deviation from the child's daily school route stored in the Region-directed knowledgebase, a message of the detection is sent to a module of "detection of unsafety" in "Recognition and Action". If the module decides that the child may be in a dangerous situation, using the surrounding situation provided by the Socialware, it activates "send alarm-mail" module in RS Operation and "WWW notice" module in WS Operation.

These modules are installed using an agent framework described in the next section.

5 AN AGENT FRAMEWORK

We are developing the functions in Fig.4 using an agent framework of ADIPS along with the technologies of the Ubiquitous computing and the Web computing. The ADIPS framework was proposed and implemented to develop functions of flexible networks (Shiratori et al., 1996).

We have developed network middleware and distributed applications (Suganuma et al., 2003; Sugawara, 2005) using ADIPS framework. Features of ADIPS framework are described as follows (Kinoshita and Sugawara, 1998);

(1) Agentfication of resources in WS and devices in RS

An ADIPS agent is an autonomous module consisting of programs and devices, which is generated based on the wrapping approach as shown in Fig.6. An agent consists of a wrapper module and a resource consisting programs, devices, web pages, databases, knowledge bases, actuators, and so on. The wrapper in Fig.3 enables an agent communicate with other agents through Agent Communication Language (ACL). The wrapper also controls a resource based on algorithms, a production model, BDI model , which was implemented using Java based on the ADIPS framework(Kinoshita and Sugawara, 1998).

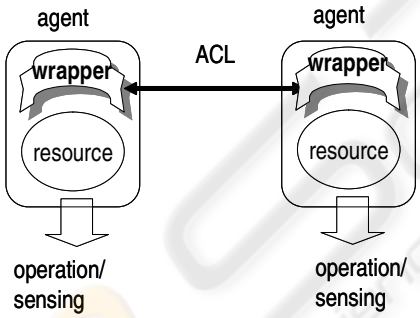

Figure 6: Wrapper-based Agentification of Resources.

(2)Agent Virtual Machine (AVM)

AVM supports agents to be generated, to run, to communicate, to be uniquely named and to be persistent.

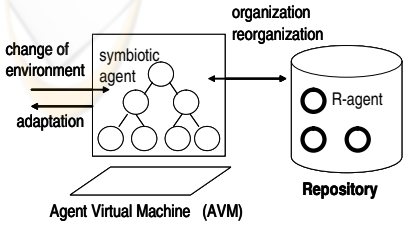

Figure 7: Repository-based Programming and self-organization.

(3) Repository-based programming

System developers programs R-agents and save them into a repository as class agents in Fig.7. An R-agent is transformed into an instance agent onto an AVM according to a request from the AVM.

(4)Repository-based Self-Organization

A multi-agent system working on an AVM or on distributed AVMs has a property to adapt its functions to change of the social/system's requirements easily and rapidly (Fujita et al., 1998). This property gives the WS a cost-effective evolutional mechanism to serve the RS progressively. Fig.7 shows a framework of developing functions having the above properties. This repository-based framework generate a multi-agent system from a repository consisting of R-agents which produce agents in a socialware(Hattori et al., 1999; Sugiyama et al., 1999), perceptualware and networkware.

6 SYMBIOTIC APPLICATION

6.1 An Overview of eEyes

Building a gentle watch over system for children or elderly people in the ubiquitous computing environment has led to a big challenge(Helal et al., 2005). Due to the lack of context awareness of devices, software and networks around the user, they cannot provide appropriate watching services to the user. Furthermore users are losing sense of ease and conveniences in the watching because of lack of user-oriented aspects in operation and quality of service (QoS) of the system. In this chapter, we explain a prototypical system to watch over elderly people developed based on the symbiotic computing-based approach. In this system, multiple contexts including user's presence, location, detailed requirements for watching, device status, available bandwidth of network etc, in both watched site and watching site, are comprehensively considered for quality control of the live video streaming, based on the concept of Symbiotic Computing. We build an application of watching over system to provide support for elderly people in home, and show the effectiveness of the idea with some initial experiments with the prototype system.

Fig.8 shows an overview of uEyes and the structure of e-Bridge in uEyes. Socialware is a set of programs, heuristics, data regarding watching over elderly people, which are developed and acquired based on the socialware (Hattori et al., 1999).

Perceptualware is a set of programs and data to process RS awareness and WS awareness based

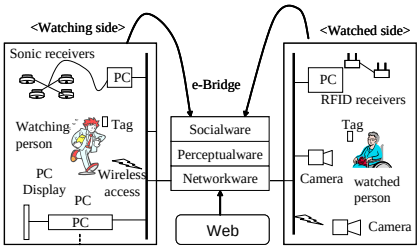

Figure 8: An Overview of uEyes and Components of e-Bridge.

on the Perceptualware using ubiquitous devices described in the next section.

Networkware is a set of programs to support communications among agents and resources in WS based on the flexible network model.

6.2 Ubiquitous Devices Used in uEyes

Fig.9 shows a snapshot of example of user terminal for the prototypical system of uEyes. The user terminal is a device which watching persons always carry with them. Although this terminal can receive video streaming in low quality, users can check roughly situation of their family anytime and anyplace. This terminal also becomes a sensor to acquire the data of their location and becomes an anytime-anyplace interface with agents in the socialware.

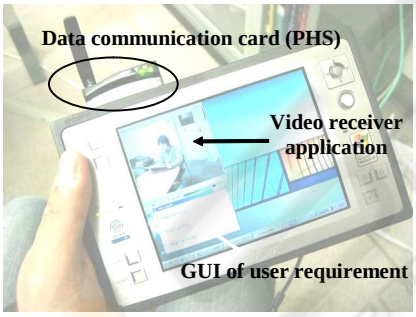

Figure 9: User Terminal.

In this prototypical system, we use a handheld PC Sony VAIO type-U (Windows XP, Celeron M 900MHz, 256MB memory) for the device. It is connected to the network with a CF type data communication card (PHS) that provides a link of 128 kbps bandwidth.

We use the following three kinds of location sensors to obtain location information of uses in the room, (1) ultrasonic-based sensor system in Fig.11 which measures location, moving velocity and direction, direction of sight line, (2) passive type RFID systems, and (3) an active type RFID system using 315MHz radio frequency., which can recognize location of the tag that is located within 2 meter from receiver, in minimum setting.

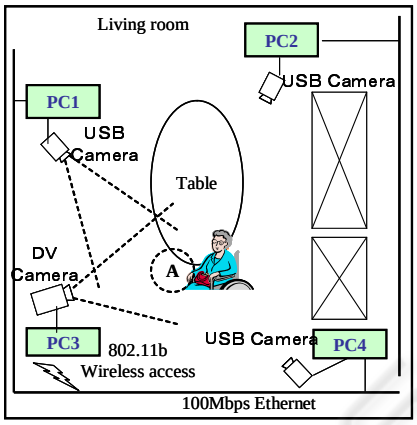

Figure 10: Sensing Devices in Watched Side.

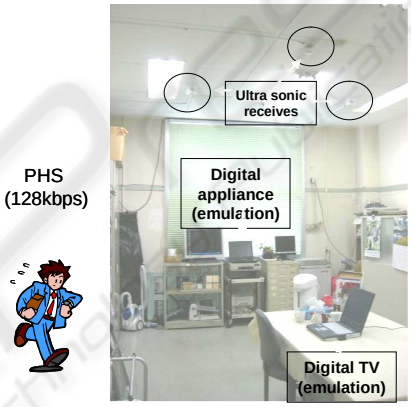

Figure 11: Sensing Devices in Watched Side.

6.3 Agent-based Architecture of e-Bridge in uEyes

An e-Bridge in the prototypical uEyes in Fig.8 is being implemented using the ubiquitous-directed ADIPS agent framework named AMUSE. The e-Bridge was designed as a distributed agent system working on the distributed PCs as shown in Fig.10 and 11. The networkware in Fig.8 is an agent-based middleware to control QoS of multimedia communication between PCs which controls multimedia devices such as cameras, microphones, displays. Elderly people never want to be watched over always by camera if they are in good health. However, they may want to be watched over with high quality of multimedia information captured by camera and microphones if they are in badly illness. They may choose certain level of the QoS of the multimedia information if they feel vague anxiety or loneliness in order to tell the feeling with their family implicitly. The networkware connects data channel among multimedia devices in the uEyes system, controls QoS of every communication channels, and keep the important channel even if

the troubles happens in the network system used by uEyes.

The perceptualware of uEyes is a multi-agent system to perceive situation and health condition of watched persons and to control the networkware based on a decision instructed by a designated agent in the socialware.

For example, an agent in the perceptualware of which roll is to count a pulse-beat and check blood pressure notifies an agent in the socialware, of which roll is to manage the health information of the person, of abnormal state in the persons health. If the health information management agent in the socialwaere know that it is very dangerous situation for the person according to a medical instruction by a personal doctor, the agent in perceptualware notifies multimedia QoS agents of setting multimedia channels to his/her family and doctors in the highest QoS.

The socialware of uEyes consists of agents to store the social knowledge and heuristics for taking care of elderly people, to store information of families such as jobs, daily routine, roles in family, to know map of the region and facilities in the region. A socialware agent designated to the elderly person inform persons who take care the watched person of prescribed alam and data based on the contract between the agent and the persons.

7 CONCLUSION

In order to bridge the e-Gap, we propose a computing model named symbiotic computing to construct an e-Bridge over the e-Gap which enables users to receive rich services of the WS. An e-Bridge is composed of Perceptualware and Socialware which are working in web servers.

The Perceptualware is a collection of software and data for e-Bridge to perceive RS and WS through ubiquitous infrastructure and the web service interface. The Socialware is a collection of software and data for e-Bridge to understand RS and WS, to save knowledge on RS and WS and to make decisions on how to support persons in RS properly and safely.

Based on the above concept, we prototyped an experimental system of uEyes which watch over elderly people. An advantage of uEyes to the conventional approach of the ubiquitous computing is that it can watch over more gently because the system tries to keep both of their privacy and safety based on the social knowledge to take a warm watch.

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