Ubiquitous Architectural Framework for UbiSAS using Context Adaptive Rule Inference Engine

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Abstract - Recent ubiquitous computing environments increasingly impact on our lives using the current technologies of sensor network and ubiquitous services. In this paper, we propose ubiquitous architectural framework for ubiquitous sleep aid service(UbiSAS) in the subset of ubiquitous computing for refreshing of human's sleep. And we examine technical feasibility. Human can recover his health through refreshing sleep from fatigue. Ubiquitous architectural framework for UbiSAS in digital home offers agreeable sleeping environment and improves recovery from fatigue. So we present new concept of ubiquitous architectural framework dissolving stress. Specially, we apply context to context-aware framework module. This context is transferred to context adaptive inference engine which has service invocation function in intelligent agent module. Ubiquitous architectural framework for UbiSAS using context adaptive rule inference engine without user intervention is technical issue. That is to say, we should take sleep comfortably during our sleeping. And sensed information during sleeping is changed to context-aware information. This presents significant information in context adaptive rule inference engine for UbiSAS. This information includes all sleeping state during sleeping in context-aware computing technique. So we propose more effective and most suitable ubiquitous architectural framework using context adaptive rule inference engine for refreshing sleep in this paper.

Keywords: Ubiquitous Computing, Context-Aware Computing, Intelligent Agent, Ubiquitous Sleep Aid Service

1 Introduction

Ubiquitous computing environment is said to be embedding a computer at various things, and offers convenience to a user. Recent ubiquitous computing environments increasingly impact on our lives using the current technologies of sensor network and ubiquitous services. Ubiquitous computing provides a novel conceptual computing environment through the convergence of real physical space and virtual electronic space [1]-[5]. In the past, ordinary life and computing activities were separable; however, electronic information has become more influential owing to a rapid supply of widespread home network devices and sensor networks. These trends have brought ubiquitous computing to the attention of the public, not just for IT(Information Technology), but also for supporting a new information environment integrated with a new lifestyle. In this paper, we propose technological method for refreshing sleep aid service. At this time, we take advantage of suitable framework technology and can visualize its possibility as modeling this method. For examining realizable possibility, we design and implement ubiquitous architectural framework for technical composition and interaction.

2 Motivation

If we feel physical and mental fatigue, there are various changes in muscle, the circulation of blood, pulse, breath and brain wave etc. For taking advantage of his physical and mental maximum ability, we must dissolve, what we call, stress. That is such as fatigue, tension, fear, dyspeptic ailment. Ubiquitous architectural framework based refreshing sleep aid service model in digital home offers agreeable sleeping environment and improves recovery from fatigue. So we present new concept of ubiquitous architectural framework dissolving stress.

3 Related Research

Refreshing sleep aid service modeling without user intervention is technical issue. That is to say, we should take sleep comfortably during our sleeping. And sensed information during sleeping is changed to context-aware information. This present significant information in bedside sensor platform for refreshing sleep aid service. This information includes all sleeping state during sleeping in context-aware computing technique. And we should sense necessary parameter in our sleep. These sensing issues are technical issues for providing

refreshing sleep aid service. For satisfying these technical issues, following target scenario and requirements are needed.

4 Target Scenario

Refreshing sleep service scenario procedures are as follows.

1) In an early stage, sensors which are attached to bed are sensing and measuring fatigue using light and sound. In accordance with physical and mental fatigue, service model is decided to provide sleeper with agreeable sleeping environment.
2) The light is turned off and soundproofing function is operated for taking agreeable sleeping.
3) In case of mental fatigue, IR-based night vision camera is sensing the cerebrum activity level. According to distribution of red color, refreshing sleep service provides sleeper with aroma therapy. Also, in case of physical fatigue, pressure sensors are sensing and measuring blood pressure, pulse and the concentration of lactic acid in blood. According to above parameters, refreshing sleep service provides sleeper with agreeable sleeping environment.
4) Temperature and humidity sensors which are attached to bed are sensing and measuring body temperature and humidity of sleeper. Body position is sensed and measured by pressure point sensors which are attached to bed and by IR-based night vision camera. And sound sensors which are attached to bedside are sensing and measuring snore and apnea symptom of sleeper.
5) While sleeper is sleeping in a bed, computing system is gathering the information that is body temperature and humidity of sleeper. And the computing system is learning the gathered information. According to gathered information, computing system is inferring the fatigue of sleeper. Computing system provides sleeper with agreeable sleeping environment by inferred information.
6) For preserving agreeable sleeping environment, wave actuator generates delta wave.
7) According to fatigue of sleeper, computing system controls the device which screens the sunlight for agreeable sleeping environment

5 Requirements

The requirement of bedside sensor platform for refreshing sleep aid service is as follows.

- Requirement-1: Sensing method is used such as accurate sensing information using contact sensor and less accurate sensing information using non-contact sensor.
- Requirement-2: Sensing Information is used such as body temperature, pulse, body position, temperature/humidity/light/sound around bedside.
- Requirement-3: Feedback Service is used such as sensing information affects the composition of an environment for refreshing sleep.

Table 1. Comparison between legacy and proposed system

	Legacy System	Proposed System
Sensing Method	Contact	Contactless
Sensing Data Processing	Numerical Result	Conversion to Context Information
Method for Making Sleeping Environment	User Intervention	Context Awareness
Measuring Method	Uncomfortable	Comfortable
Providing Service	Result Analysis	Feedback for User Customized Service

We propose the model that is using contactless sensing unit. This is less accurate in comparison to using contact sensing unit. But it is more comfortable to use without user intervention in ubiquitous network of digital home. That is advantage of using this model. Table 1 is comparison between legacy and proposed system. Therefore, Figure 1 is the proposed Ubiquitous Architectural Framework for UbiSAS.

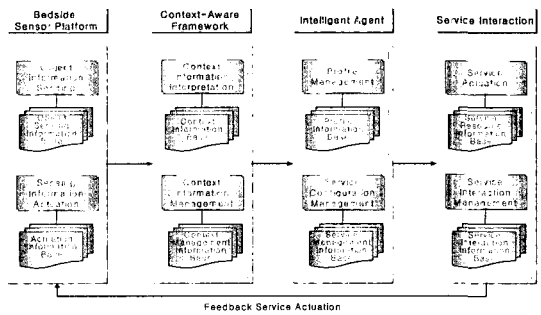

Figure 1. Ubiquitous Architectural Framework for UbiSAS

6 UbiSAS Architectural Framework

6.1 Bedside Sensor Platform Module

Sensing method for sleeping state is using sensors attached to bed. Sensing information is body temperature, pulse rate, the temperature, the humidity and the illumination of bedside. Pressure sensor is attached on bed by 5 by 5 cm unit for finding body position. Sleeping person doesn't recognize it. Sensing information is delivered to system by second unit. Bedside sensor platform module consists of sensor node and sensor coordinator. It is connected with wire between sensor and sensor node. Each sensor node is also connected to sensor coordinator with wire. Sensor coordinator is gathering information at each sensor node. Sensor coordinator

delivers gathered data to system. Figure 2 is Bedside Sensor Platform Module.

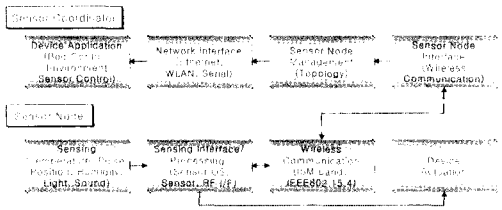

Figure 2. Bedside Sensor Platform Module

Sensing block is sensing real data from environment. Sensing Interface/Processing block is interfacing and processing between sensor and device actuation. Wireless Communication block is interfacing to Sensor Node Interface in Sensor Coordinator. Device Actuation block is to control the device. Sensor Node Interface block is interfacing to Wireless Communication in Sensor Node. Sensor Node Management block is managing sensor node topology. Network Interface block is providing communication interface such as Ethernet, WLAN and Serial. Device Application block is to control command such bed control and environment sensor control.

6.2 Context-Aware Framework Module

Gathered sensing information is changed to context information. Context information which is gathered from the real world is classified to a kind of pattern of context. And it is changed to significant context information by binding sensor node which transmits context information with time information which is transmitted. It is required to present all sensing information to be integrated and to configure context information schema. Context information schema configures context. And it must be added to sleep and health information from sleeper. The Figure 3 is Context-Aware Framework Module.

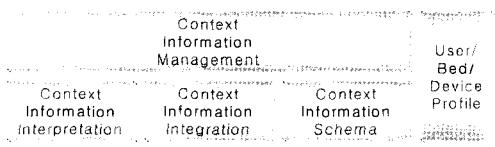

Figure 3. Context-Aware Framework Module

Context Information Interpretation block is converting sensed data from real world to context and interpreting context which is suitable for computing system. Context Information Integration block is integrating all context information. Context Information Schema block is classifying context information. User/Bed/Device Profile block is configured with attribute of user/bed/device. And Context Information Management block is managing all context information which is presented as status of context.

6.3 Intelligent Agent Module

Intelligent agent using context information, which is converted from sensed information, checks the status of sleeper. Intelligent agent uses context information to define providing service. If sensor node detects increment of body temperature of sleeper, intelligent agent controls networked device around the bed and decreases temperature and humidity of bedside with inferring from healthy information of sleeper's. Doing by this, each sleeper is provided with adaptive sleeping service. In this module, service decision is concluded with environment for refreshing sleep. The Figure 4 is Intelligent Agent Module.

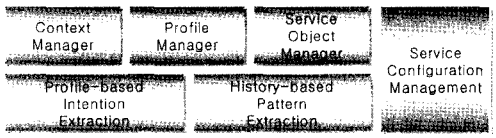

Figure 4. Intelligent Agent Module

Profile-based Intention Extraction block is managing a pattern of sleeper. History-based Pattern Extraction block is managing accumulative pattern of sleeper. Context Manager block is managing context from context-aware framework for service decision. Profile Manager block is managing status of profile in according to user/bed/device. Service Object Manager block is managing service invocation. And Service Configuration Management is managing a sequence of providing service.

6.4 Service Interaction Module

If sleeping environment is well constructed during providing service, system watches changes from above sensing information to context information. And if there is a change in context information, another service is continuously provided to sleeper for agreeable sleeping. Finally, sleeper can take agreeable sleeping. The Figure 5 is Service Interaction Module.

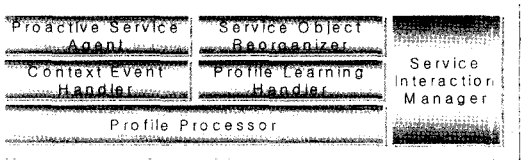

Figure 5. Service Interaction Module

Profile Processor block is processing profile information for providing service from Profile Manager in Intelligent Agent. Context Event Handler block is handling changed context information. Profile Learning Handler block is learning the existing changed profile. Proactive Service Organizer block is managing service priority. Service Object Reorganizer block is managing invocated service. And Service Interaction Manager block is managing service interaction in according to service priority.

6.5 Context Adaptive Rule Inference Engine

Context-awareness in ubiquitous network of digital home is context adaptive estimation and decision using rule based inference engine. In general, rule based inference engine extracts rule of problem area from human expert. And according to the rule, we implement rule-base. So computing system infers solution from rule-base. Context adaptive rule inference engine organizes context of digital home into rule. And according to the context, computing system provides service without user intervention. This engine is included in service configuration management of intelligent agent module. Rule structure is divided into two parts. One is condition part(IF) and the other is execution part(THEN). So we call it production rule. In production rule, we can adapt context to condition part and service to execution part in digital home. And we must consider cases to be happened in digital home. The Figure 6 is Rule Hierarchy of UbiSAS in Digital Home.

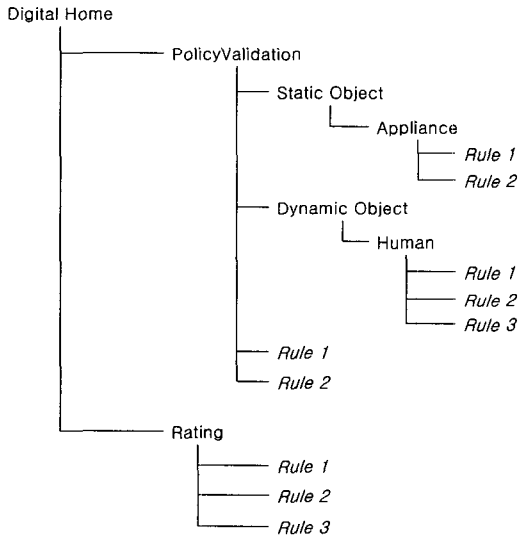

Figure 6. Rule Hierarchy of UbiSAS in Digital Home

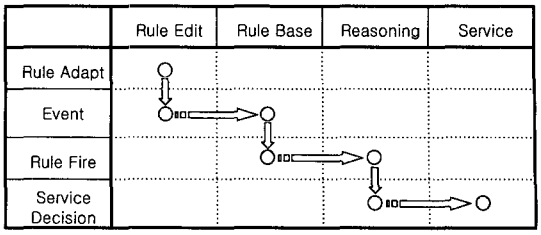

Figure 7. Rule Adaptation Flow in Event Processing

When sleeper lies in bed, the event is inputted to context adaptive rule inference engine in intelligent agent module. And when the event is accepted, computing system infers service from generated context. The Figure 7 is Rule Adaptation Flow of Event Processing.

7 Conclusions

Ubiquitous architectural framework for UbiSAS consists of bedside sensor platform, context-aware framework, intelligent agent and service interaction modules. Bedside sensor platform is gathering sleeping information. And device is controlled by sensing information through service interaction. Intelligent agent decides service for sleeping person using context adaptive rule inference engine which organizes context into rule and defines service estimation without user intervention. This model is able to take concrete shape in refreshing sleep aid service system.

References

[1] Manuel Romn, Christopher K. Hess, Renato Cerqueira, Anand Ranganathan, Roy H. Campbell, and Klara Nahrstedt, "Gaia: A Middleware Infrastructure to Enable Active Spaces," IEEE Pervasive Computing, Oct.-Dec. 2002, pp.74-83.

[2] A.K. Dey, G.D. Abowd, and D. Salber, "A Context-based Infrastructure for Smart Environments," Proceedings of the 1st International Workshop on Managing Interactions in Smart Environments (MANSE '99), 1999, pp.14-128.

[3] H. Liberman and T. Selker, "Out of Context: Computer Systems That Adapts to, and Learn from Context," Vol. 39, NOS 3&4, IBM Systems Journal, 2000, pp.617-632.

[4] A.K. Dey and G.D. Abowd, "Towards an Understanding of Context and Context-Awareness," 1999.

[5] D. Salber, A.K. Dey, and G.D. Abowd, "The Context Toolkit: Aiding the Development of Context-Enabled Applications," in Proceedings of CHI'99, 1999, pp.434-441.