Keywords: Ubiquitous Computing (UC), Evaluation, Quality Characteristic.

Abstract: One of the main problems with the evaluation of ubiquitous computing (UC) is that we do not have standards guidelines, or metrics, even though there have been many researches on the individual technical aspects of ubiquitous systems. UC systems differ from standard applications in many ways. Therefore, it is very hard to apply the current working standards or metrics to the evaluation of UC system, which leads us to develop a desirable way to deal with this. This paper suggests the evaluation issues of service and system software to provide ubiquitous computing. Also, we investigate how equally the evaluation scopes we have suggested and the quality characteristics could be matched with the current technological feasibility of the ubiquitous computing systems, so we can see what benefits and the deficiencies of the proposed evaluation scopes would be. Two case studies are considered and these can be seen as the most-likely applications in the current ubiquitous computing environment.

1 INTRODUCTION

For decades, the improvement of communications technologies has brought computing environment evolved into human from machine. This is called a ubiquitous computing environment, initially introduced within the computer systems world by Weiser in the early 1990s (Weiser, 2002), comprehends the ability to exist everywhere at the same time. Ubiquitous environment consists of innumerable number of computing devices embedded in almost everything around us, platforms and networks that interconnect them, and user devices that make use of and act on the available information. The system software in this domain, it is a key issue to provide satisfied UC services to users without intrusion among heterogeneous devices with different capabilities and protocols. The ubiquitous computing has environmental problems such as wireless channel fading and mobility. As these problems have possibilities to affect the performance of a network and application, it is often proposed that quality-of-service (QoS) be handled at the ubiquitous system software level (Tokunaga et al, 2004).

This paper proposes evaluation issues of services and the system software running on the ubiquitous computing environment. And we investigate the feasibility for application of the proposed evaluation scopes through considering two case studies.

2 UBIQUITOUS COMPUTING ENVIRONMENT

A general ubiquitous computing system environment has four entities; User, I/O artefact, Service, Ubiquitous System Software as shown in Figure 1 (Cha et al., 2005).

When the receptive events are triggered by users’ activities, sensors or some physical input artefacts carry out the operations of reception and integration of the user’s activities. Examples of some physical input artefacts are switches mounted to a grip, trackballs, and mobile phone, gesture and speech recognition or context awareness facilities. The receptive function accepts the user’s activities and act upon it, while the integrated function takes into account the states of the several sensors as well as the input artefacts at the same time, delivering the information to the ubiquitous service. Once the sensors or the physical input artefacts locate a detectable event, the ubiquitous services act upon it to process the integrated event.

Most of the ubiquitous application modules receive a lot of data from other input artefacts or theirs and interpret this data to fit into the context of the user’s activities. The context awareness in the ubiquitous services is of great importance (Asim, 2004). A very significant part of the context is to know or be able to infer the user’s intent. For instance, Global
Positioning Systems (GPSs) give us location context. Some good sensing networks provide environmental context, and clever service design can support some levels of intent inference, i.e., situational context.

Ubiquitous system software controls all the data processing for these individual entities in the ubiquitous system and coordinates the contextualization between services so that the services can make intelligent decisions on how to interpret events.

The output artefacts formulate expressive functions upon contextual events triggered from the ubiquitous service. Finally, users evaluate the expressive events from output artefacts e.g., large-wall-mounted display, lights, sound or even haptic interfaces, in the system.

In a UC environment, service not only provides configuration of integrated event (or data from the sensors or physical devices) but also contextualization with regard to the information that the ubiquitous computing system has to provide. The system should provide for the correct translation between data types and representations of the outputs generated by one service that are to be used as the inputs to another. Therefore, service and system software can usually be chained together to form a complicated task.

3 EVALUATION ISSUES FOR SERVICE AND SYSTEM SOFTWARE

Under the UC environment, we must consider the one person-to-many computing interaction. This paper figures out main function and quality characteristics for service and system software entities.

Table 1 and Table 2 delineate evaluation scope with the checklist examples and metrics for each entity.

3.1 Service

The UC service refers to the applications that perform computation or action on behalf of users in a ubiquitous computing environment.

We have found several issues crucially important for the successful deployment of services in the UC environment: Functionality, service quality, smartness and security. These are the key characteristics to make UC possible.

Functionality

The ubiquitous computing service has the features necessary to support the requirements. The general purpose of functionality testing is to verify if the product performs as expected and documented.

Developers creating a new product start from a functional specification, which describes the product’s capabilities and limitations. Software functionality test engineers utilise this specification as a guideline for expected product response. Tasks are exercised to test specific features or functions, and the results of the tasks are verified to be in compliance, suitability and accuracy with the expected response.

Service Quality

For varying application computation and communication demands and for a varying quality offered by the ubiquitous computing environments, the ubiquitous system has to provide multiple grades of service quality and maintain a number of agreed-upon or negotiated service qualities. Technically, quality of service (QoS) can be guaranteed through bandwidth, ratio frequency and response time requirements. In terms of evaluation objectives, several characteristics of service quality should be considered as followings: efficiency, resource availability, reliability, maturity, fault tolerance, fault recovery, maintainability and adaptability.
Smartness

Smartness is often referring to Smart house or smart room where small sensors, such embedded processors are used to detect their surroundings and equip human with both information processing and communication capabilities. A smart house is a truly interactive house using the latest information and communication technology to link all the mechanical and digital devices available today. Humans could communicate and cooperate with other smart objects and, theoretically, access all sorts of Internet resources. Objects and appliances could thus react and operate in a context-sensitive manner and appear to be smart. Five aspects of smartness should be considered for evaluation purpose: location awareness, environment awareness, situation awareness, user recognition and personalization.

Table 1: Evaluation Scope of the UC Service.

<table>
<thead>
<tr>
<th>Functionality</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Security</td>
<td>Accessible</td>
</tr>
<tr>
<td></td>
<td>Privacy</td>
</tr>
<tr>
<td></td>
<td>Personalization</td>
</tr>
<tr>
<td></td>
<td>Location</td>
</tr>
<tr>
<td></td>
<td>Environment</td>
</tr>
<tr>
<td></td>
<td>Situation</td>
</tr>
</tbody>
</table>

Security

The security of UC service refers to establish mutual trust between infrastructure and device in a manner that is minimally intrusive. Security can be implemented in heterogeneous components such as firewalls, different computer operating systems and multiple databases. Authentication is one of the most important characteristics of ubiquitous computing security. Authentication provides confirmation of user access rights and privileges to the information to be retrieved.

3.2 System Software

UC device hardware is not simply limited to handheld devices. There is also a large amount of fixed-infrastructure hardware that may be incorporated into a system. The software that runs the hardware devices, and coordinates the usage of the physical resources is of paramount importance. The UC systems software and networks have two orthogonal aspects: configuration and coordination.

Coordination

Coordination describes the system software’s ability to coordinate a user request operating across the ubiquitous computing system. We sub-divide this category into resource coordination, mobility, reliability and distributed systems support.

Table 2: Evaluation Scope of the UC System Software.

<table>
<thead>
<tr>
<th>System Software</th>
<th>Criterion</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Security</td>
<td>Accessible</td>
<td>Must support the secure operation of the UC system and the UC service, including the transmission of the data over the network.</td>
</tr>
<tr>
<td></td>
<td>Privacy</td>
<td>Must ensure the confidentiality, integrity, and availability of user information.</td>
</tr>
<tr>
<td></td>
<td>Personalization</td>
<td>Must ensure the personalization of the service to the user.</td>
</tr>
<tr>
<td></td>
<td>Location</td>
<td>Must ensure the location awareness of the service.</td>
</tr>
<tr>
<td></td>
<td>Environment</td>
<td>Must ensure the environment awareness of the service.</td>
</tr>
<tr>
<td></td>
<td>Situation</td>
<td>Must ensure the situation awareness of the service.</td>
</tr>
</tbody>
</table>

4 CASE STUDY

We consider two case studies and investigate the propriety of the proposed evaluation scopes for UC service and ubiquitous system software.

4.1 Mobile Banking Service

The main applications of the ubiquitous service would be via mobile phones. SK telecom and Telecom NZ
introduced the mobile banking service in 2004. The customer can use the service anywhere without distorting or blocking the signal. Service provider’s global network allows the mobile banking to be sued around the world using their roaming service (Maintainability – Service Quality). One of the major banks in New Zealand, ASB bank has introduced mobile banking service, taking security seriously and offering the security of a secure 128 bit encrypted connection. Furthermore, the customers are required to enter their personal access code and passwords to sign on the system (Security – Service). They also provide some emergency situation control such as battery discharges while doing banking service. All of the banking transactions the customers made before their phone battery discharged should have done through. Once battery is recharged, customers can check the balances and the record of the last transactions the customers made. Alternatively, because all the online service are real time, the customers can also check the balanced and last transactions through internet banking or telephone banking service (Reliability – Service Quality and Coordination). In addition, as the customers’ accounts will be displayed on the screen of the mobile phone, so the customer can access their accounts quickly without fuss when they are on the move (Functionality – Service). This service is also designed to cope with a large number of users and has a back-up system (Scalability – Configuration).

### 4.2 Location-Awareness Service

As another application of the ubiquitous service via mobile phones, Vodafone Germany (2000) introduced the first location awareness services based on the WAP portal in the world. All location-based services offered so far to mobile phone users are always pull-services, say; the user has to explicitly request information relevant to her current location. This is particularly annoying if the user always has to establish a WAP connection before he can use such services. It takes a lot of time, which limits the values of the service to the user, and it is also very costly as the user usually has to pay for the online time. Thus, this service should be very easy to use, therefore must offer a simple, yet powerful interface, be robust, and error-tolerant, covering the reasonable service region (Reliability – Service Quality and Coordination, Resource availability – Service Quality). The location-awareness service must also be secure and private to the users. The user should be able to turn on/off the service to actively confirm her wish for localization for privacy reasons (Privacy – Service). The most important technical concern of this service is the high accuracy location enabler across all environments (Location awareness – Smartness). However, in order to realize the proper location awareness service, information has to be automatically delivered to the user (Functionality, Adaptability – Service). The system architecture for tracking location should also not be restricted to or depend on specific kinds of trackers. It must allow adding new trackers (perhaps even newly developed trackers) and including them easily in the overall architecture (Extensibility, Scalability – Configuration).

### 5 CONCLUSION

This paper outlines the issues to be considered in terms of UC service and system software evaluation. We also apply the proposed evaluation scopes to two case studies. However, these are not a full evaluation scope but some important things. We expect that these issues can be the beginning point to make the systematic UC system evaluation model along with the present software evaluation model such as ISO/IEC 9126 or 12119. Our work raises the need of framework development and opens a new discussion for the UC evaluation.

### REFERENCES