Assessing Level of Ubiquitous Computing Services for Ubiquitous Business Design

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Abstract We are entering into a new era of enterprise computing that is characterized by an emphasis on broadband convergence, knowledge sharing, and calm services. Some people refer to this as the "ubiquitous network" business model because its focus is on a high degree of connectivity between a company and its customers, suppliers, and channel partners. Moreover, immediate access to ideas, goods, and services will be of greater value than the traditional model of permanent and ponderous possession. This paper illustrates how ubiquitous computing technology can be combined with legacy computer-based information systems, along with thoughts on relevant issues of ubiquitous commerce. We also propose a model for how to assess levels of ubiquitous computing services.

Key words ubiquitous computing service; AHP; ubiquitous business

Methodologies for assessing the service levels and/or systems’ performance levels are still very rare. An approach for assessing the level of ubiquitous computing services is described. We have observed 23 service scenarios and then propose and discuss two criteria for evaluation criteria: level of ubiquity and level of usage. The level of ubiquity consists of personalization, context-awareness, intelligence, security&privacy, interface, and overall system level, whereas the level of usage consists of perceived usefulness, perceived ease of use, and task/technology fit. An analytical hierarchy process (AHP) model was developed as an assessment model. Evaluating levels of service is useful for analyzing who may be potential services users.

Today, the focus is dramatically increasing for applying ubiquitous computing technology to create innovative services. Ubiquitous business is a kind of business that is enabled by ubiquitous computing technology. The abilities of the technology allow the business to find potential demand from all over the world, to distribute business units and/or functionalities remotely, and to co-operate more efficiently with other companies. Mobile business also includes increased capabilities, such as mobility and portability. These increased abilities allow customers access to advertisements at a particular point of interest. For example, customers can enter an online marketplace any time, anywhere, with their own portable devices.

Although to date researchers have suggested several service scenarios and prototype systems that adopt ubiquitous computing technology, methodologies for assessing the service levels and/or systems’ performance levels are still very rare. Hence, this paper presents an approach for assessing the level of ubiquitous computing services. Until now, none was available.

The remainder of the paper is organized as follows. In Section 2, we provide an overview ubiquitous computing and services. Sections 3 and 4 discuss the evaluation criteria of ubiquitous computing services with technology-driven and utility-driven perspectives, respectively. In section 5, we describe the design of the assessment model. In Section 6, we review our general conclusions.

1 Ubiquitous Computing

Currently, researchers have proposed a variety of
ubiquitous services. In Ref. [1], we have selected 23 services from the literature and have classified them based on two dimensions: technical viability and business viability. As shown in Fig. 1, the services located in the lower left area of the graph are believed to be available shortly.

These services will be implemented in a similar manner as information systems. The current framework of computer-based information systems, despite its diversity, can be simplified as a combination of several components: data, model, knowledge, and dialog, with the help of networks. Based on the framework, an overall framework of ubiquitous service is shown in Fig. 2.

Despite the improved availability that ubiquitous services have in overall framework and example services, a methodology for evaluating service levels is so far quite rare. The business viability and technical viability are useful for identifying the priority of services in terms of commercialization. However, evaluating which factors fit which particular services, in order to improve that service’s level of market acceptance, is still a challenge. In other words, level of services need to be identified. Therefore, in this paper we propose a three dimensional view of ubiquitous computing services, including level of services, as shown in Fig. 3.

To begin building evaluation criteria for a ubiquitous computing service, we revisit the ideals that its initiator Marc Wesiser envisioned: “As technology becomes more embedded and invisible, it calms our lives by removing the annoyances while keeping us connected with what is truly important.” From the above sentence, we can extract some essential factors such as embeddedness, invisibility, and unobtrusiveness. Accordingly, in the next two sections, we propose and discuss two criteria for evaluation criteria: level of ubiquity and level of usage.

2 Level of Ubiquity: the Six Technology-Driven Evaluation Criteria for Ubiquitous Computing Services

2.1 Personalization

In terms of service levels, three levels of services have been proposed[2]: personalization, passive context-aware, and active context-aware services. In the personalization service level, users manually provide profile, preference and contextual data. The
passive context-aware service automatically captures the user’s context from the federated sensors. The service, however, is activated by events triggered by the user. For example, when a user clicks a menu in the interface, the service displays some recommendations about the restaurants. An active context-aware service not only describes applications that autonomously change their own content, but it can also trigger itself for proactive service. In this scenario, the user does not need to initiate any actions to start the service, nor is there a need to manually input personal or contextual data. Browns and Jones call the active context-aware service “proactive”[3]. The “push” approach described by Chevist et al. also uses the same “proactive” concept[4], while passive context-aware and personalization services are described as the “pull” approach [5]. Proactive ubiquitous services that are based on an active context-aware service in turn can be classified as pull-based, push-based, and push-based automated modes.

2.2 Context Awareness

Most of the legacy context-aware services [6~8] depend simply on location, providing location-based services. To overcome this limitation, we will use four kinds of context that Abowd previously classified[9]: TILE—Time, Identity, Location, Entity. The context of time can be acquired when mobile devices such as PDAs or Bluetooth Service Provider Machines communicate with each other for a synchronized service. Identity context is information on other people around whom the current user is located. Using location context is one of the fundamental activities of the legacy context-aware system and tends to be co-leveraged with other contexts in order to derive internal context, rather than using location information directly on its own. Entity context is the data of sensed objects that Bluetooth hardware detects within the vicinity of the user’s current location. Meanwhile, context-aware services may involve a variety of context, which can consist of both primitive and composite contexts. Composite context data are acquired with at least one kind of primitive context, which can be sensed by various sensors.

2.3 Intelligence

The state that describes the maturity of the ubiquitous computing technology is known as calmness, following Weiser’s original description. Learning, reasoning, and autonomy capabilities are selected to assess the level of intelligence.

2.4 Security & Privacy

One key hurdle to ubiquitous computing, aside from technical advances, are concerns about users’ privacy. According to the vision of ubiquitous computing known as “disappearing technology” or “calm technology”, the invisibility must be found in the goal state of the ubiquitous computing services. However, invisibility can be an inhibitor of ubiquitous computing service usage due to security and privacy concerns. Hence, service providers must be attentive to these security and privacy concerns in order to effectively increase levels of service.

2.5 Overall Service Level

Since ubiquitous computing is a type of information system, or at least adopts the typical evaluation criteria of information systems such as response time, scalability, correctness, extendibility, etc., these should all be included in the assessment.

3 Level of Usage: the Usage Driven Evaluation Criteria of Ubiquitous Computing Services

Systems’ levels of information technology or system have long been regarded as determinants of its overall effectiveness. In this paper, we advocate a more socio-technical approach to ubiquitous computing services as information systems. The outstanding research models on IT usage are task acceptance model (TAM) and task/technology fit (TTF) models.

Perceived usefulness

In Ref. [10], perceived usefulness is defined as “the degree to which a person believes that using a particular system would enhance her/his job performance”. This notion is known as a determinant of some user performance measures such as user participation, user involvement, and user attitude[11].

Perceived ease of use

Perceived ease of use is the degree to which a
person believes that using a particular system would be free of effort\textsuperscript{12}. Perceived ease of use is thought to be determined by intrinsic motivation, control, and emotion\textsuperscript{13}. In many literatures\textsuperscript{5,12,14–21}, the concept has been regarded as crucial when deciding if an information technology would be acceptable to an individual or an organization. Perceived ease of use is also adaptable to test how an information system is acceptable by the enterprise\textsuperscript{22}. These discussions naturally lead us to consider perceived ease of use to assess the level of ubiquitous computing services.

**Task/technology fit**

Goodhue explored Task/Technology Fit (TTF), which suggests that better outcomes (i.e., performance) will result when there is a match between the task and the technology used\textsuperscript{18}. Items assessed by the Task/Technology Fit model include the quality, currency, relevance and ease of determining what data is available and where, ease of use of the system\textsuperscript{10}, response time, user satisfaction\textsuperscript{23}, and how the data displayed is readable and usable\textsuperscript{24}. The measures could be subjective or objective.

**4 An Assessment Model**

By the two categories of the criteria—level of ubiquity and that of usage—an AHP model to assess the level of ubiquitous computing service is developed as shown in Fig. 4.

Using the level of ubiquitous computing services, the next question is to estimate potential demand: who will be the buyers of the service? To do this, a variety of methods can be suggested. In this paper, we propose a relative level of service approach to demand identification. The underlying assumption is that the potential buyer would compare a particular ubiquitous computing service with legacy services to determine if she/he would better replace the legacy service with the new service. Hence, the buying decision is subjective and relative. Factors of each criterion for determining level of service (LoS) are listed in Tab.1.

**5 Concluding Remarks**

In this paper, we have proposed a method to assess ubiquitous computing services and systems in terms of level of service. AHP is adopted to represent the assessment model, which includes both technology-driven and utility-driven criteria. One of the main contributions of this paper is that we include both behavioral aspects, as well as technical aspects, for consideration in the assessment. We have included a broad range of each: criteria for five technical aspects and three behavioral aspects.

Evaluating levels of service is useful for analyzing who may be potential services users. We believe that ubiquitous computing technology’s commercial success would rely on how the level of service itself is suited to the user’s level, as well as conventional business success factors such as financial planning.
### Tab.1 Criteria of estimating level of service of ubiquitous computing services

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Factors</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personalization</td>
<td>User preference</td>
<td>none, hard-coded, shared to some, shared to all</td>
</tr>
<tr>
<td></td>
<td>User profile</td>
<td>none, hard-coded, shared to some, shared to all</td>
</tr>
<tr>
<td></td>
<td>User context</td>
<td>none, hard-coded, shared to some, shared to all</td>
</tr>
<tr>
<td>Context-awareness</td>
<td>Location tracking</td>
<td>none, manual, pull, push</td>
</tr>
<tr>
<td></td>
<td>Time tracking</td>
<td>none, manual, pull, push</td>
</tr>
<tr>
<td></td>
<td>Identity tracking</td>
<td>none, manual, pull, push</td>
</tr>
<tr>
<td></td>
<td>Entity tracking</td>
<td>none, manual, pull, push</td>
</tr>
<tr>
<td></td>
<td>Seamlessness</td>
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</tr>
<tr>
<td></td>
<td>Composite context</td>
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</tr>
<tr>
<td></td>
<td>Context reusability</td>
<td>none, hard-coded, shared to some, shared to all</td>
</tr>
<tr>
<td></td>
<td>Service coverage</td>
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<tr>
<td>Intelligence</td>
<td>Learning</td>
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<tr>
<td></td>
<td>Reasoning</td>
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<td>Autonomy</td>
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<td></td>
<td>Ad hoc collaboration negotiation</td>
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<td></td>
<td>Standardization</td>
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<td>Security &amp; Privacy</td>
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<td></td>
<td>Authorization</td>
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<td>Interface</td>
<td>Usability</td>
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</tr>
<tr>
<td></td>
<td>Pull &amp; push</td>
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</tr>
<tr>
<td></td>
<td>End user’s device</td>
<td>none, bounded, yes pull only, push only, all {PDA, cellular phone, multimodal, etc.}</td>
</tr>
<tr>
<td></td>
<td>Response time</td>
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</tr>
<tr>
<td></td>
<td>Conversion efforts</td>
<td>Not satisfactory, so so, satisfactory</td>
</tr>
<tr>
<td></td>
<td>Scalability</td>
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</tr>
<tr>
<td></td>
<td>Extensibility</td>
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<tr>
<td></td>
<td>Reconfigurability</td>
<td>Not considered, considered</td>
</tr>
<tr>
<td>Overall service level</td>
<td>Overall service level</td>
<td>Not considered, considered</td>
</tr>
</tbody>
</table>

The assessment model proposed here is not yet validated yet. Some significant criteria might be unconsidered and omitted. The correctness of the AHP model depends on the correctness of the relative importance of the criteria. The Delphi method will be useful to identify the relative importance of the criteria for further evaluation of actual services.

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### References


**Brief Introduction to Author(s)**

KWON Ohbyung is an associate professor of college of management and international relations in Kyunghee university, Korea. He received the B.S. degree in business administration from Seoul National University and M.S and Ph.D. in management information system from Korea Advanced Institute of Science and Technology. In 1996, he has worked for Yanbian University, Jilin, China. His current interests include: decision support systems, agent-based technology, ubiquitous computing services, and mobile commerce.