개인화된 유비쿼터스 웹 정보 서비스를 위한 웹 상호작용의 접근성 및 사용성 평가

(Estimation of Accessibility and Usability in Web Interaction for Personalized Ubiquitous Web Information Services)

김 영 복 †

(Yung Bok Kim)

요 약 웹 기반 정보 서비스는, 웹 정보 서버와 상호작용하는, 다양한 인터넷 웹-브라우징 기기들과의 접근성과 사용성을 위해서 평가되어야 한다. 다양한 웹-브라우징 장치로(예: 풀부라우징 휴대폰) 접근 및 사용가능하며, 신뢰할 수 있는 유비쿼터스 웹 정보서버는 유비쿼터스 웹 정보 서비스뿐만 아니라 개인화된 광고기반의 비즈니스 모델을 위한 통합센터가 되어야 한다. 개인화된 유비쿼터스 웹 정보 서비스를 위한 웹 상호작용의 접근성과 사용성을, 실시간 평가를 위한 메트릭으로서, 연구하였다. 시험용 웹 사이트('ktrip.net')와 1자 한글 도메인명(예: 김.net, 이.net, 박.net, 최.net, ㄱ.net, ㄴ.net, … ㅎ.net, ㅏ.net, … ㅐ.net, ㄱ.com, ㄴ.com … ㅎ.com)을 사용하여, 구현 및 한국, 일본 및 중국에서의 실험을 바탕으로 한 실험적 결과를 소개한다.

키워드 : 웹 상호작용, 접근성, 사용성, 웹 정보 서비스, 개인화

Abstract Web-based information services should be evaluated for accessibility and usability with various types of Internet Web-browsing devices, interacting with web information servers. A reliable ubiquitous Web information server, accessible and usable with a variety of Web-browsing devices (e.g. a full-browsing mobile phone), should be a unified center for personalized ubiquitous Web information services as well as for business models based on personalized advertisements. We studied an estimation of the accessibility and usability in Web interaction for personalized ubiquitous Web information services, as metrics for real-time estimation. We show empirical results based on implementation and experiments in Korea, Japan and China, using a test-bed Web site ('ktrip.net') and single-character Korean domain names (e.g. 김.net, 이.net, 박.net, 최.net, ㄱ.net, ㄴ.net, … ㅎ.net, ㅏ.net, … ㅐ.net, ㄱ.com, ㄴ.com … ㅎ.com).

Key words : Web interaction, Accessibility, Usability, Web Information Service, Personalized

1. 서 론

The Web with its contents including UCC (User Created Contents) has been revolutionarily in the variety of ways it has changed and affected the world in various ways. "Two breakthrough inventions have formed the foundation of the information society: computers and telecommunications, which are playing roles akin to those that the steam engine and electricity played during the industrial revolution" [1]. A hybrid technology of the aforementioned two inventions, the Internet penetrates deeply in normal life and business. Using two ways: wired Internet and mobile Internet, a ubiquitous Web information service for information access should be considered for efficient and effective interaction as well as for the integrity of consistent information in this knowledge and information society. We have considered a convenient

† 정 회 원 : 세종대학교 컴퓨터공학과 교수
yungbkim@sejong.ac.kr
논문접수 : 2007년 4월 3일
심사완료 : 2008년 6월 18일

정보과학회논문지: 소프트웨어 및 응용 제35권 제8호(2008.8)

mechanism for the simplification of information access interaction in an environment flooding with information; and as an example of specific application for users, we studied a ubiquitous Web information service for social networking [2] including the disabled and the elderly in the aged society.

The Web server is a role center in interaction for a ubiquitous Web information service; the client mobile devices for Web information access become very important for interaction in ubiquitous computing and the networking environment. For the performance of Web information access from the unified information Web server, we considered several aspects about the Web server for Web interaction. The performance of a worldwide web (WWW) server became a central issue in providing a ubiquitous, reliable, and efficient information network for ubiquitous Web information services. The performance issues in the worldwide Web servers were studied [3], and the mechanisms to reduce the number of packets exchanged in an HTTP transaction were presented. For wired Internet using HTML, for PCs, and for mobile Internet using WML or mHTML, for mobile phones, management of the Web server becomes more difficult; Hwang et al. [4] studied the case of WAP site from this point of view. The wireless, mobile Web promises to provide users with anytime, anywhere access to the same information; ubiquitous Web access should also facilitate greater acceptance of new services such as location-based shopping (based on personalized advertisements), which are specialized for mobile use [5]. We have studied the accessibility and usability of Web interaction for personalized ubiquitous Web information services as well as for the personalized advertisement, using the unified Web information portal with reliable Web server and mobile phones.

"When browsing information on large Web sites, users often receive too much irrelevant information. The vast amount of irrelevant information on most these Web sites can overwhelm users, leading to the study about personalized Web views for multilingual Web sources" was introduced by Liu et al. [6]. User navigation patterns were studied by modeling user navigation [7]. To avoid users browsing against over thousand of results, Ruvini [8] introduced the study of adapting to the user Internet search strategies.

Usability and Accessibility (U&A) guidelines have been set up to help designers in the process of creating usable and accessible sites [9]; W3C consortium recommendations for accessible Web sites, the Web Accessibility Initiative (WAI) recommendations, and the Web Contents Accessibility Guidelines. We studied accessibility and usability of personalized Web interaction with single-character multilingual (Korean) domain names (e.g. 김.net, 이.net, 박.net, 최.net, ㄱ.net, ㄴ.net, … ㅎ.net, ㅏ.net, … ㅐ.net, ㄱ.com, ㄴ.com … ㅎ.com) for personalized ubiquitous Web information services. We considered the simplification of the above complexity from the user's perspective, and moreover the user's viewpoint concerning services and contents for information access in this ubiquitous computing and networking environment.

In the following sections, we introduce the accessibility and usability of Web interaction in wired and mobile Internet, especially with user interaction at the user's perspective. We will discuss the accessibility and usability of personalized Web interaction with some metrics, and we will discuss our experience, got in Korea, Japan and China, with the empirical results based on implementation of a personalized ubiquitous Web information service. Finally, we will conclude our study with consideration of further research.

2. Backgrounds

In many countries, better access to Web services and Web administration is becoming an important issue; and a few action lines of improvement for the Web Content Accessibility Guidelines are suggested [10]. We considered the guidelines in our implementation of a ubiquitous Web information service, including the evaluation with KADO (Korean Agency for Digital Opportunity and Promotion) tool related to the above guidelines. The accessibility of the contents has become mandatory as a Korean regulation since April 2008.

Universal access implies the accessibility and

usability of Information Society Technologies (IST) by anyone, anywhere, anytime. It is important that the needs of the broadest possible end-user population are taken into account in the early design phases of new products and services. Universal Design in the Information Society has been defined as the conscious and systematic effort to proactively apply principles, methods and tools, in order to develop IST products and services that are accessible and usable by all, thus avoiding the need for a posteriori adaptations or specialized design [11]. Internet accessibility beyond disability was also studied by Hofstader [12]. The unified Web server for any user should be capable of showing the appropriate contents, i.e. the HTML contents for wired Internet as well as the mobile contents for many different kinds of mobile devices, e.g. WML, mHTML etc. We implemented a simplified and unified portal for personalized ubiquitous Web information services with wired Internet by PCs as well as with wireless Internet by mobile devices.

New approaches and related instruments are needed for capturing human requirements in the new reality. Appropriate architectural framework and development tools will also need to be elaborated in the age of the disappearing computer [13]. We considered the implementation of a ubiquitous Web information portal with good usability and accessibility for personalized Web interaction in this ubiquitous computing and networking environment.

Accessibility has been studied on the basis of quantitative metric such as time [second], however the usability has not been studied much with the quantitative metric instead of some qualitative evaluation. There is some correlation between accessibility and usability; we tried to use the time [second] metric for simplicity with the quantitative metric.

To pervasively and unanimously access the unified portal for every user in the real-time ubiquitous information network, the user interface for accessing the Web should be as convenient as possible even for typing-in the domain names or URLs with mobile phones because the first step for Web service with wired/mobile Internet (especially, with mobile Internet) is typing-in the URL of the targeted Web site offering the requested information.

For users in the real-time information network, even the input of a text-string becomes important for the retrieval of information or the registration of information with mobile phones, especially with keypads in the mobile phone for text-string URLs as well as information. To access the unified portal ubiquitously, the user interface for a user should be as convenient as possible even for typing-in the single-character multilingual (Korean) domain names (e.g. 김.net, 이.net, 박.net, 최.net, ㄱ.net, ㄴ.net, … ㅎ.net, ㅏ.net, … ㅖ.net, ㄱ.com, ㄴ.com … ㅎ.com), URLs, or information. For writing information in real-time way, the user's typing speed of text-string, e.g. Korean characters, is one of important performance factors, especially with mobile phones. Even for the simplest Korean character composed of one consonant and one vowel, pressing over four keys is required; that means inconvenient keypad-pressing is required for the mobile phone user for Web interaction. Therefore the personalized Web service based on the mobile phone is difficult with traditional schemes adapted for PCs. We considered the usability and accessibility of personal Web interaction with mobile phones as well as with PCs, especially using test-bed Web portal accessible with many simple Korean domain names.

The features of websites that we visit regularly, that differentiate them from websites with the same purpose that we don't visit; Forrester did some research on this as follows: good content (75%), usability (66%), speed (58%), frequency of updating (54%), (the rest is noise: 14% and lower) [14]. According to Pemberton's comments, "device independence, accessibility and usability are surprisingly closely related." The definition of usability for mobile devices was referred [15] from of ISO 9241-11: "The extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use." A system for automatically evaluating the usability and accessibility of Web sites by checking their HTML code against guidelines has been studied by Beirekdar et al. [9].

Sutcliffe and Angeli [16] assessed interaction styles, i.e. traditional menu-based and interactive metaphors, in the Web user interface, and they

found that the menu-based interaction style was superior for usability and information quality. The usability of mobile devices and their applications is a key factor for the success of mobile computing. Betiol and Cybis [15] studied usability evaluation of mobile interfaces based on three different evaluation approaches; they mentioned the importance of the context of use of mobile devices in the usability evaluation, so that the traditional HCI evaluation criteria and methods should be reconsidered in order to meet the requirements of mobile interaction. There are now more browsers on mobile phones than on desktops, and there is a vast diversity in the types of devices; on top of this diversity, there is also the diversity required for accessibility, and Pemberton mentioned also that the Web interfaces landscape is turmoil at this moment [17].

Ford and Kotze [18] proposed that "the interface design characteristics required to design interfaces that accommodate high power distance, high uncertainty avoidance, masculinity and short-term orientation would provide a more usable interface to all users; and the user interfaces designed to accommodate the above cultural dimensions and collectivism provide better performance." We considered the collectivism in Web interaction with a unified Web site ('ktrip.net'), and also conceptually considered the above cultural dimensions with Korean domain names (e.g. 김.net, 이.net, 박.net, 최.net, ㄱ.net, ㄴ.net, … ㅎ.net, ㅏ.net, … ㅐ.net, ㄱ.com, ㄴ.com … ㅎ.com) to implement a ubiquitous Web information service; however we focused on the quantitative metric instead of qualitative metric. The metrics in Web interaction for personalized ubiquitous Web information services, i.e. accessibility and usability, are random variables, and should be estimated in real-time as we discuss in the following sections.

3. Accessibility and Usability in Web Interaction

The accessibility and usability for Web interaction at the user's viewpoint may be different from the conventional evaluation methodology. However, we should investigate a more effective approach, because the environment has changed significantly, especially in terms of the interactivity of users with mobile phones in the Web information system. In this paper, we considered the accessibility and usability of Web interaction with single-character multilingual (Korean) domain names (e.g. 김.net, 이.net, 박.net, 최.net, ㄱ.net, ㄴ.net, … ㅎ.net, ㅏ.net, … ㅐ.net, ㄱ.com, ㄴ.com … ㅎ.com) as keys for a ubiquitous Web information service, at the Korean user's viewpoint. The real-time application, getting required information as well as writing information in the wired and mobile Internet environment, was considered.

We studied the fundamental metrics for accessibility and usability of a personal Web interaction, from the user's perspective. We studied the metric, delay, not only with the time in the network and server, but also with the spent time by user and the input time on keypads for URL or information for notification in the personalized Web interaction. For example, in Fig. 1 for a mobile user, we assume that the random variable, the round-trip response time for a user's single interaction in a session, from a user to the contents in DB through wired/mobile Internet before next interaction with a mobile phone is $\mathbf{R}_1$. That is composed of the preparation time for any user in the ubiquitous computing and networking environment to get a mobile device for interaction in his hand is $\boldsymbol{U}$. The time spent by the user with the mobile phone to do appropriate interaction for service is $\boldsymbol{D}$. The aggregate interaction time to the Web server after the mobile device through wired/mobile Internet for mobile service is $\boldsymbol{S}$, and the network time is embedded here. The interaction time depending upon mobile contents is $\boldsymbol{C}$. We considered the accessibility as well as the usability for personalized Web information services on the basis of the real-time estimation of the aforementioned random variables related to Web interaction.

The session time of the Web interaction may be dependent on this content retrieval or registration, and there may be several back and forth iterations during the Web interaction. The returning round trip time in the Web interaction, from the content retrieval time to the requesting user through Web server and wired/mobile Internet using mobile

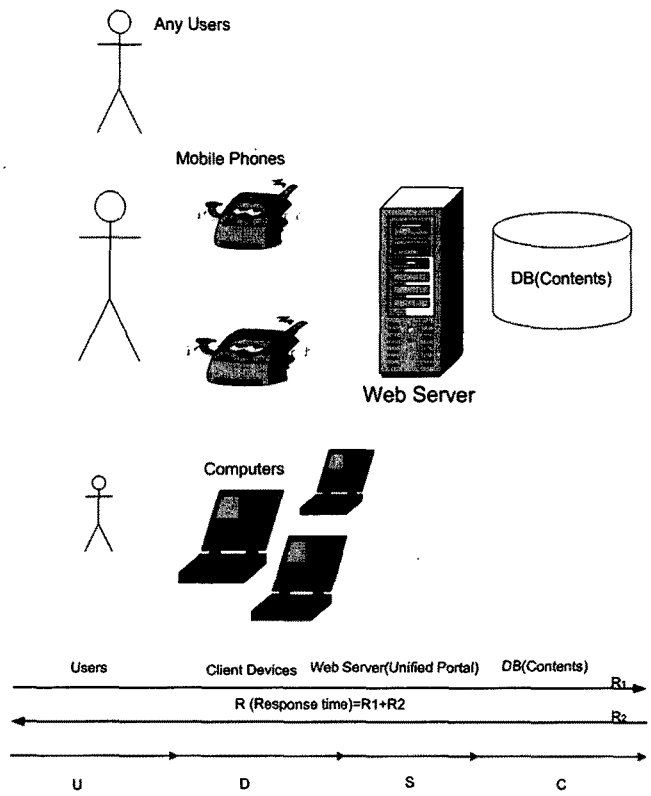

Fig. 1 Metrics for Accessibility and Usability of Personal Web Interaction

device, is $\mathbf{R_2}$. We estimated the random variables of metrics after implementation of Web-based information service with a test-bed Web site: http://ktrip.net [19]. The previous works for computer networking has been mainly focused on the analysis of the random variable time S, but we suggest the average overall metric for estimation of accessibility and usability in Web interaction.

For the real-time application using wired and mobile Internet, the dominating factor and the variance of that averaged random variable should be bound within the deterministic response time. To be deterministic for a real-time application, each user should be skilled, the Web interaction with device should be convenient, the network should be stable if possible, the Web server should be efficient and have high performance for the dedicated application, and finally the contents for Web interaction should be as simple as possible with a simplified and efficient format. We also considered the packet size to be independent from the network traffic conditions as well as the simple service in the Web server to be independent from the load of the Web server in a personalized ubiquitous Web information service for a user.

As an example for multilingual applications, let's consider the average keypad-press number in the case of Korean handheld phone model, discussed before; this is related to the device time Mean ($\boldsymbol{D}$). Based on the assumption of a single Korean character composed of one consonant and one vowel; this is analyzed at the user's viewpoint. For writing the information in real-time way, the user's typing speed of Korean character is one of important performance factors in any mobile Internet services for Korean users with the mobile phone. For example with the simplest Korean character composed of one consonant and one vowel, several Korean handheld phone models showed that the average number of keypad pressing is approx 4-5 for the mentioned single Korean character and around 2-3 for single English alphabet, including

shift key for next character. This is also critical dominating factor related to the time, ***D***, especially for writing contents of information with a mobile phone.

In Fig. 1, we showed a simple example for accessibility with a single iteration, however there may be actually several iterations in a session as shown in Fig. 2; we expanded our prior work [20] for mobile interaction to the *accessibility* as well as the *usability*. We found that a service/product should be *accessible* if the service/product needs to be *usable; accessibility*, that is a necessary but not sufficient condition for *usability*, is a subset of *usability*. We discuss the *accessibility* in a session then we will discuss the *usability* based on the *accessibility*. We tried to find a fundamental metric based on time [second] for simplification. The stochastic estimation of the random variables for the *usability* and the *accessibility* was studied on the basis of time series analysis.

In Fig. 2, the time delay for personal Web interaction in a session by several elements (i.e.

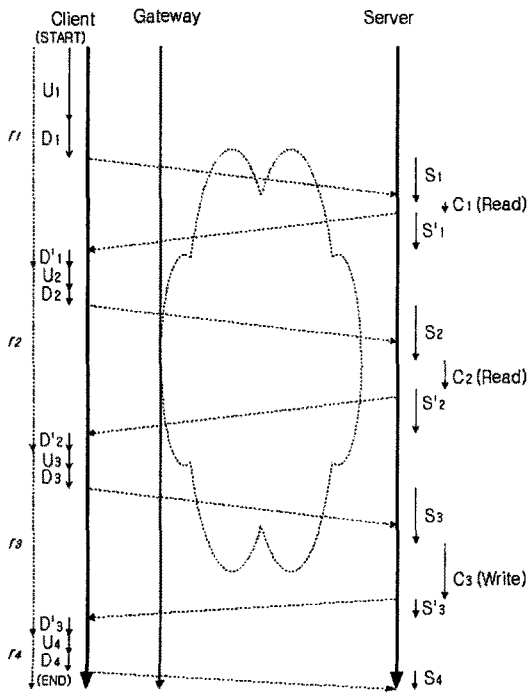

Fig. 2 Personal Web Interaction in a Session with Mobile Internet (Web) Phone

user, device and Web server) are shown and broken down as follows; user preparation time for interaction, U_1; interaction time with client's device, D_1 and D'_1; interaction time in network and Web server, S_1 and S'_1; user interaction time for understanding and readiness, U_2; interaction time with client's device, D_2 and D'_2; interaction time in network and Web server, S_2 and S'_2; interaction time for reading contents in the DB server, $C_{1(\text{Read})}$; interaction time for writing contents in the DB server, $C_{1(\text{Write})}$; user preparation interaction time for understanding and readiness, U_3; interaction time for writing contents with user's device, D_3 and D'_3; interaction time in network and Web server, S_3 and S'_3; user's preparation interaction time for understanding and readiness, U_4; interaction time for finishing the session with user's device, D_4; interaction time in network and Web server, S_4.

From Fig. 2, a metric for estimation of the accessibility and usability, the response time for i_{th} interaction at the user's viewpoint, $r_i = U_i + D_i + D'_i + S_i + S'_i + C_i$; and the overall metric for evaluation, i.e. the overall interaction delay for a session in information access is $R = \sum_{i=1}^{n} r_i$. The ***R***, that is the response time in Fig. 1, is defined as the *accessibility* [second] of a session in our discussion. For real-time estimation the session time should be estimated on the basis of easy implementation in the programs (such as ASP, JSP, or PHP) running in the Web information server.

$$\textbf{\textit{Accessibility}} = R = \sum_{i=1}^{n} r_i \quad [second] \qquad (1)$$

In this session during Web interaction, the dominating factor is U_i and D_i in normal network and server, considering the recent stable network. We considered the packet size to be independent of the network traffic condition, and the simple service in the Web server to be independent from the load of the Web server during personal Web interaction.

For real-time interaction using wired and mobile Internet, the dominating factor and the variance of that averaged random variable should be bound with the deterministic response time. To be deter-

ministic for real-time Web interaction, the user should be skilled, the user interface of device should be convenient, the network should be stable if possible, the Web server should be efficient and have high performance for the dedicated application. Finally the contents for a ubiquitous Web information service should be as simple as possible with a simplified and efficient format for interaction. The bandwidth requirement for wireless or mobile Internet should be as low as possible to be immune to the network traffic conditions for Web interaction with text-string; also that will be good against degradation caused by the other rich multimedia contents. The user's average preparation time for interaction, Mean(***U***), will be shortened depending upon the proliferation of ubiquitous devices for Web interaction, i.e. mobile phones for a ubiquitous Web information service.

The *usability*, which should be estimated in real-time as a quantitative metric, could be defined with the equation, $\sum_{j=1}^{f} R_j$, where f is the number of sessions by the same or different users, i.e. frequency, per a day (i.e 24 hours); the f is random variable. R_j is the accessibility in j_{th} session in a day and we can use the notation A_j [second] for accessibility of the j_{th} session, therefore the usability is the summation of the accessibility of each session during a day, as follows:

$$\textbf{Usability} = \sum_{j=1}^{f} A_j \approx \overline{A} * \overline{f} \quad [second] \qquad (2)$$

The *usability* could be approximated with the multiplication of the mean of *accessibility* and the mean of daily usage frequency, f. For simplicity in our discussion, we assumed as follows. The shorter the value of *accessibility* [second] is, the better the *accessibility* is; the longer the value of *usability* [second] is, the better the *usability* is.

The real-time estimation for statistics of random variables (e.g. ***U, D, S, C, R, A, f***) for mission-critical application service was considered. For *real-time estimation*, we used an exponentially weighted moving average model with the appropriate smoothing parameter a to get the mean value of the random variable x_k, which may be related to any random variable among the discussed random variables (e.g. ***U, D, S, C, R, A, f***). To find and eliminate the statistical outlier we required deviation ststistics, and we used the mean absolute deviation (*MAD*) model to reduce the complexity of real-time estimation. The *mean* value of each random variable (such as ***R, A, f***) required for real-time estimation can be estimated as follows.

$$\overline{x_k} = a x_k + (1-a)\overline{x_{k-1}} \text{ where } 0 < a < 1 \qquad (3)$$

In the time-series analysis, the statistical outliers can be eliminated considering the standard deviation and the current value of the random variable; however the calculation of the standard deviation is not efficient in the real-time estimation. We use the *mean absolute deviation (MAD)* model in our real-time estimation of the *accessibility* and *usability*.

The *mean absolute deviation (MAD)* is defined by

$$MAD = \frac{1}{N} \sum_{i=k-N+1}^{k} \left| x_i - \overline{x_k} \right| \qquad (4)$$

where the chosen sample size for statistics is N, *that is, the number of samples to be stored in memory for estimation*, the samples have values x_i, the mean is $\overline{x_k}$ $(k > N-1)$ and $N \approx \frac{1}{a}$. If the smoothing parameter a is too small, N becomes larger. For many sessions, if N_s is the number of sessions in a Web information server, then the memory size for real-time estimation becomes $N_s * N = N_s * \frac{1}{a}$. The right place for real-time estimation may be chosen on the basis of requirements and kind of server program, for example the *global.asa* in ASP server may be considered for implementation of real-time estimation.

4. Implementation

The personalized ubiquitous Web information services, here the Korean information network, as an example of Web-based information services using multilingual applications, is based on wired or mobile Internet, many single Korean character domain names (e.g. 김.net, 이.net, 박.net, 최.net, ㄱ.net, ㄴ.net, … ㅎ.net, ㅏ.net, … ㅖ.net, ㄱ.com, ㄴ.com …

ㅎ.com) for Web interaction. The required information or advertisement for a user can be registered in any time and any place using wired or mobile Internet in the unified Web server for the personalized ubiquitous Web information service, i.e. the 'http://ktrip.net'.

As an example for personalized ubiquitous Web information services with various mobile phones serviced by many mobile service operators, we used the following service program based on Microsoft IIS Web server and DBMS for various mobile phones of a user. With this program for Web information interaction by a member in a user, the information portal, 'http://ktrip.net' can be accessed in a unified way by different mobile phones.

```
<%   'Information of Mobile Phone Header for IIS Web Server and ASP Program
agent = Request.ServerVariables("HTTP_USER_AGENT")
subno = Request.ServerVariables("HTTP_X_UP_SUBNO")
accept = Request.ServerVariables("HTTP_ACCEPT")
        If InStr(agent,"SK") >= 1 Then   'for Mobile Phone: SKT
                response.Redirect "http://ktrip.net/listwml.asp"
        ElseIf InStr(subno,"ezweb") >= 1 and inStr(agent,"UP.Browser/4.1") >= 1 Then
                response.Redirect "http://ktrip.net/listwml.asp"   'for Mobile Phone: LGT
        ElseIf InStr(subno,"itouch") >= 1 or InStr(subno,"ezweb") >= 1 Then
                response.Redirect "http://ktrip.net/listhdml.asp" 'for Mobile Phone: LGT
        ElseIf InStr(agent,"MSMB") >= 1 Then   'for Mobile Phone: KTF
                response.Redirect "http://ktrip.net/listm.asp"
        ElseIf InStr(agent,"KUN") >= 1 Then   'for Mobile Phone: KTF
                response.Redirect "http://ktrip.net/listm.asp"
        ElseIf InStr(accept,"xhtml") >= 1 Then   'for xHTML device
                response.Redirect "http://ktrip.net/list.asp"
        ElseIf InStr(accept,"wml") >= 1 Then   'for WML device
                response.Redirect "http://ktrip.net/listwml.asp"
        ElseIf InStr(agent,"Mozilla") >= 1 Then   'for other Browsers: Mozilla
                response.Redirect "http://ktrip.net/list.asp"
        End If
        Else 'for other Browsers with wired Internet and full-Browsing Phone
                response.Redirect http://ktrip.net/list.asp      %>
```

Considering the accessibility of the unified portal, we could make the Web interaction time deterministic in the Web server for contents. For the usability we will modify ASP programs to get the usage frequency of sessions. The deterministic time was possible with the deterministic size of packet for WAP service. The average response time with mobile phone Internet is around 12 seconds with about 2 second standard deviation, similarly in Korea, Japan and China. Considering the performance of the unified portal in the information network, we made the interaction time deterministic in the Web server for contents; we got the relationship between S and C.

Referring to Fig. 1, the empirical performance with various mobile phones by 50 students, the average interaction delay of D (the typing time of a URL, i.e. 'ktrip.net') is about 30 [sec] with Standard Deviation (14.3 [sec]). The average of $S_{(ktrip.net)}$ is about 9 [sec] with Standard Deviation (6.4 [sec]), the average of $S_{(operator's\ portal)}$ is about 7.9 [sec] with Standard Deviation (5.8 [sec]). The average time of reading-content is about 6.8 [sec] with Standard Deviation (7.3 [sec]).

We need to continuously try to decrease the interaction times U and D. We can also consider speech technology (instead of pressing keys in the automobile) to decrease the interaction time D. The 'Pen Phone' introduced by Siemens reduced the device interaction time D. Standardization for UI of mobile phone is important, and service providers and manufacturers of mobile phones have been attempting it in Korea. This will be also helpful to reduce the device time D. The maturity of speech technologies represents a great opportunity for people working with other or/and with a piece of information through Interactive Voice Systems; and the research with the VoiceXML technology was considered for the universal access paradigm by speech for the new generation of interactive systems [21].

We studied the dominating factors in the overall performance at the user's perspective as follows. In general, in Fig. 1, the relationship of mean interaction time in mobile Internet with mobile phone is Mean(U) > Mean(D) > Mean(S) > Mean(C). We have tried to decrease the interaction times Mean (U) and Mean(D) in the time-critical Web information service for a user. As Internet URLs for unified Web services, we used over 200 single-character Korean.net (e.g. 김.net, 이.net, 박.net, 최.net, ㄱ.net, ㄴ.net, … ㅎ.net, ㅏ.net, … ㅐ.net, ㄱ.com, ㄴ.com … ㅎ.com) as simple URLs to find information as well as to notify information in real-time way and ubiquitously for ubiquitous Web information services. Speech recognition technology would also decrease the interaction time, Mean(D), instead of

time-consuming keypad-press interaction.

The handheld phone model SCH-X600D manufactured by Samsung was used for testing of the international roaming service and mobile Internet service days in 2006 in Japan as well as in 2007 in China. In Tokyo, Kyoto, Osaka, and Beijing, the primitive experiment of a ubiquitous Web service for real-time access to information, i.e. reading and writing information in anytime and anywhere, was studied. Even on the Japanese express train, the 'Sinkansen', driving over 300Km/hour, the registration of personalized Web information was possible. The reading of ubiquitous Web information, of course, was easy and took similar amount of time as in Korea. On the Korean express train 'KTX' (i.e. Korea Train eXpress) the reading and writing of ubiquitous Web information has been possible for two years with the same model of SCH-X600D as well as since six months ago with 'Viewty Phone' serviced by LGT. The interaction time U is almost negligible because we carry always our handheld phones being able to connect to mobile Internet, as ubiquitous computing and networking environment prevails. From the experiments in Japan and China, we observed that the interaction time with wired PC is rather fast and stable with a little deviation as in Korea.

Table 1 shows the *accessibility* statistics for accessing to some portals in the KTX (between Seoul-Daejeon/KwangJoo) after eliminating statistical outliers; we used the 'Viewty Phone' serviced by LGT, and the URLs of the portal sites were registered in the favorite folder in advance. The accessing time was the latency time *from* the click on the URL of the portal in the favorite folder to the displaying of the main page on the 'Viewty Phone' screen. Therefore the '$S+C$' time metric was estimated without U and D. We will implement to get the *usability* statistics using the usage frequency. Fig. 3 shows demonstrations of ubiquitous Web information service with PCs and mobile phones. We will study the *usability* on the basis of the estimated *accessibility* and the usage frequency in our further research; applications of the *accessibility* and *usability* to personalized u-healthcare services will also be studied.

Table 1. Accessibility Statistics for Accessing Portals

	Portal A	Portal B	Portal C	ktrip.net
Min [sec]	23	17	11	11
Mean [sec]	35	20	15	12
Max [sec]	45	25	25	13

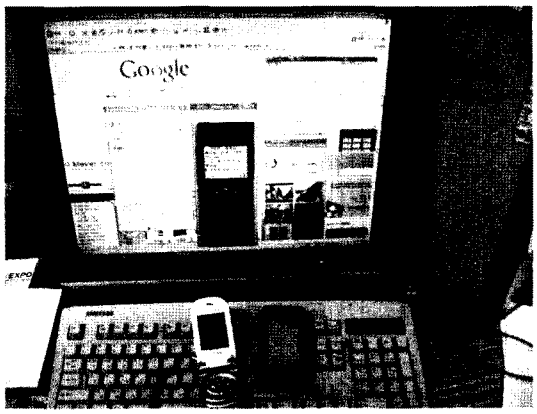

Fig. 3 Demos of Ubiquitous Web Information Service with PC and Mobile Phones

5. Concluding Remarks

The accessibility and usability of mobile interaction was studied for personalized ubiquitous Web information services. The overall evaluation for Web interaction in the real-time ubiquitous computing environment from the user's perspective was studied for assuring the *accessibility* and *usability* of personal interaction with the unified portal, with the statistical analysis based on the empirical results. We showed empirical results based on the implementation in Korea, Japan and China. With a more ubiquitous computing environment (i.e. the decrease of user preparation time for service), the interaction time in the device will become more critical. Thus we need a more efficient user interface (e.g. 김.net, 이.net, 박.net, 최.net, ㄱ.net, ㄴ.net, … ㅎ.net, ㅏ.net, … ㅐ.net, ㄱ.com, ㄴ.com … ㅎ.com) for personalized ubiquitous Web information services, especially using mobile Internet with mobile phones. For future works, the practical applications based on the *accessibility* as well as the *usability* of personal mobile interaction will be studied for real-time personalized advertisements. We will implement the real-time estimation of the *accessibility* and the *usability* in our Web information server;

we will also apply the concept of *accessibility* and *usability* to u-healthcare service.

References

[1] Cellary, W., "The Profession's Role in the Global Information Society," IEEE Computer, pp. 122-124, September 2003.

[2] Kim, Y.B., "A Ubiquitous Social Community Portal Service for Social Networking with Convenient Accessibility," ICCHP 2006, LNCS 4061, pp. 263-270, 2006.

[3] Erich Nahum, E., Barzilai, T. and Kandlur, D.D., "Performance Issues in WWW Servers," IEEE/ Transactions on Networking, Vol.10, No.1, pp. 2-11, February 2002.

[4] Hwang, G.J., Tseng, J.C.R and Huang, Y.S., "I-WAP: An Intelligent WAP Site Management System," IEEE Transactions on Mobile Computing, Vol.1, No.2, pp. 82-95, April-June 2002.

[5] Pashtan, A., Kollipara, S. and Pearce, M., "Adapting Content for Wireless Web Services," IEEE Internet Computing, pp. 79-85, September-October 2003.

[6] Liu, Z., Ng, W.K. and Lim, E.P., "Personalized Web Views for Multilingual Web Sources," IEEE Internet Computing, pp. 16-22, July/August 2004.

[7] Herder, E., "Modeling User Navigation," UM2003, LNAI 2702, pp. 417-419, 2003.

[8] Ruvini, J.D.: "Adapting to the User's Internet Search Strategy," UM2003, LNAI 2702, pp. 55-64, 2003.

[9] Beirekdar, A., Keita, M., Noirhomme, M., Randolet, F., Vanderdonckt, J. and Mariage, C., "Flexible Reporting for Automated Usability Evaluation of Web Sites," INTERACT, LNCS 3585, pp. 281-294, 2005.

[10] Duchateau, S., Boulay, D., Tchang-Ayo, C. and Burger, D., "A Strategy to Achieve the Accessibility of Public Web Sites," ICCHP 2002, LNCS 2398, pp. 58-60, 2002.

[11] Stephanidis, C.and Emiliani, P.L., "Universal Access to Information Society Technologies: Opportunities for People with Disabilities," ICCHP 2002, LNCS 2398, pp. 8-10, 2002.

[12] Hofstader, C., "Internet Accessibility: Beyond Disability," IEEE Computer, pp. 103-105, Sep., 2004.

[13] Stephanidis, C., "The Disappearing Computer: Emerging Opportunities and Challenges for Disables and Elderly People," ICCHP 2002, LNCS 2398, pp. 41-48, 2002.

[14] Pemberton, S., "Usability, Accessibility and Mark-up," http://www.w3.org/2005/Talks/11-steven-usability-accessibility/, 2005.

[15] Betiol, A.H. and Cybis, W.A., "Usability Testing of Mobile Devices: A Comparison of Three Approaches," INTERACT 2005, LNCS 3585, pp. 470-481, 2005.

[16] Sutcliffe, A. and Angeli, A.D., "Assessing Interaction Styles in Web User Interface," INTERACT 2005, LNCS 3585, pp. 405-417, 2005.

[17] Pemberton, S., "The Future of Web Interfaces," INTERACT 2005, LNCS 3585, pp. 4-5, 2005.

[18] Ford, G. and Kotze, P., "Designing Usable Interfaces with Cultural Dimensions," INTERACT 2005, LNCS 3585, pp. 713-726, 2005.

[19] A Ubiquitous Web Information Service Portal: http://ktrip.net

[20] Kim, Y. and Kim, C., "Mobile Interaction in a Usable-Unified-Ubiquitous (U3) Web Service for Real-time Social Networking Service," KIPS, Vol. 15-B, No.3, 2008.

[21] Privat, R., Vigouroux, N., Truillet, P. and Oriola, B., "Accessibility and Affordance for Voice Interactive Systems with VoiceXML Technology," ICCHP 2002, LNCS 2398, pp. 61-63, 2002.

김 영 복

1978. 2: Seoul National University, Electrical Eng. (BSEE). 1981, 2: KAIST, Electrical Eng. (MSEE). 1990, 5: Illinois Inst. of Technology, Electrical & Computer Eng. (Ph.D.) 1983~1998 Hyundai Electronics Industries, Media R&D Center, Director. 1999~Present Sejong University Computer Engineering Dept./Venture Business Incubation Center, Professor/Director. Interested Area: Computer Network, Mobile Internet, Performance Analysis, Ubiquitous Computing & Networking, u-Healthcare Service & Technology, RFID/USN Application Service & Technology