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실시간 소셜 네트워크 서비스를 위한 사용 가능한-통합적-유비쿼터스 (U^3) 웹 서비스에서의 모바일 상호작용

김 영 복[†] · 김 철 수[††]

요 약

실시간 소셜(Social) 네트워킹 서비스를 위해서, 사용 가능한-통합적-유비쿼터스 (U3) 웹 서비스에서의 모바일 상호작용을 연구하였다. 실시간 소셜 네트워크를 위한 편리한 모바일 HCI로서, 또한 유비쿼터스 웹 서비스에서의 메타데이터 정보 색인 키로서, 다국어 한 글자 도메인 명(예, 김.net, 이.net, 가.net, ㄱ.net, ㄴ.net, ㅎ.net, ㅏ.net, ㅐ.net, ㄱ.com, ㅎ.com) 은 소셜 정보를 검색하고 또한 등록할 때 편리한 모바일 인터페이스이다. U3 웹 서비스의 예로서, 실시간 소셜 네트워킹 서비스 구현과 함께 모바일 상호작용을 위해 스케치된 디자인 목표와 한국, 일본, 중국에서의 모바일 상호작용 경험을 소개한다. 또한, 소셜 네트워킹과 센서 네트워킹 서비스에서 통합 정보관리를 위해, IP 기반의 센서네트워크(IP-USN)에서 메타데이터 디렉터리 서비스에의 응용 확장 가능성도 소개한다.

키워드 : 모바일 상호작용, 소셜 네트워크, 메타데이터, 디렉터리 서비스, 센서 네트워크

Mobile Interaction in a Usable-Unified-Ubiquitous (U^3) Web Service for Real-time Social Networking Service

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ABSTRACT

For real-time social networking service, mobile interaction in a usable-unified-ubiquitous (U3) web service was studied. Both as a convenient mobile HCI for real-time social networks and as indexing keys to metadata information in ubiquitous web service, the multi-lingual single-character domain names (e.g. 김.net, 이.net, 가.net, ㄱ.net, ㄴ.net, ㅎ.net, ㅏ.net, ㅐ.net, ㄱ.com, ㅎ.com) are convenient mobile interfaces when searching for social information and registering information. We introduce the sketched design goals and experience of mobile interaction in Korea, Japan and China, with the implementation of real-time social networking service as an example of U3 Web service. We also introduce the possibility of extending the application to the metadata directory service in IP-USN (IP-based Ubiquitous Sensor Network) for a unified information management in the service of social networking and sensor networking.

Key Words : Mobile Interaction; Social Network; Metadata; Directory Service; Sensor Network

1. Introduction

A social networkis a social structure made of nodes which are generally individuals or organizations. The maximum size of social networks tends to be around 150 people and the average size around 124 (Hill and Dunbar, 2002) [1]. Social networking also refers to a category of Internet applications to help connect friends, business partners, or other individuals using a variety of tools. These applications, known as online social networks,are becoming increasingly popular [2]. And, mobile social networking services, based on mobile interaction, are emerging as a result of the evolution of mobile communication technologyand multimedia mobile devices in the ubiquitous information society. We tried to find a unified concept and found an analogy between the social networking and sensor networking in terms of web-based metadata directory service for real-time information management.

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To better understand the concept of culture, and how it is related to human-computer interaction, Ford and Kotze [3] state that culture, being the patterns of thinking, feeling and acting, influences the way in which people communicate amongst themselves and *with computers*. We studied interaction with mobile devices as well as with sensors beyond *'with computers'* because of the proliferation of mobile devices and applications. We focused on mobile social networking service as a specific example among various mobile applications.

We studied usable methods for accessing web service in a unified and ubiquitous way for various social communities. Researchers have begun to examine user's findings, and have thus been able to redefine the behavior as well as the limitations of existing search technologies [4]. We should extend this concept of finding behavior with HCI concepts to access information for social networking services, especially in mobile Internet and ubiquitous web service. Special mobile phones for mobile Internet interaction, i.e. Apple iPhone, Google phone by LG, or Yahoo phone by Samsung, are already available or will be available in the near future.

Web browsing on small-screen mobile devices will continue to be a major constraint for mobile users [5], and we need to consider new requirements for using mobile devices [6]. Therefore, we need to study usable mobile interaction schemes and unified web-based directory services. The scheme and service should be appropriate for mobile Internet and ubiquitous web sites, especially for the unified interaction service for user/manager in the social networking as well as in the sensor network management.

We introduce single-character multilingual domain names (e.g. 김.net, 이.net, ㄱ.net, ㄴ.net, 卜.net, 카.net, ㄱ.com, ㄴ.com …) for ubiquitous web service in online social networking based on wired and mobile Internet. We show the useful results from the implementation of ubiquitous web service for usable mobile interaction as well as the possibility for the metadata USN directory service. To pervasively access a unified portal for information access to online social communities, the mobile user interaction, especially with mobile phones for mobile social networking service, should be convenient for typing in the domain names or URLs as well as for typing in the contents with keypads on a mobile phone. We implemented the ubiquitous web portal accessible by mobile phone in Korea, Japan and China. The mobile interaction for real-time information access was successful both on hi-speed trains such as the KTX and Sinkansen at over 300km/hour and in the bus on the way to the Great Wall and other sites in China. In addition to the previous works, we studied further in China moreover, we tried to find a unified information managementboth for the social networking service and the sensor networking service in term of metadata directory service.

The mobile phone can be the sink node or the sensor node in a ubiquitous networking environment because the mobile service was available world-wide before the proliferation of sensor networks. The mobile device has several features that support the use in the middle of sensor networks [7]. Beside local connectivity with standalone sensor motes, connecting sensor networks to the Internet on a global scale creates endless opportunities for applications and services, as well as for new emerging models of operation. We studied the mobile interaction between a user and the unified IP-USN directory for highly evolved sensor web applications.

In the following sections, we will discuss the sketch of design goals for mobile interaction for a U^3 Web service. Then, we will discuss the convenience and the performance for usability metrics in accessing to a U^3 web site, and resource utilization for mobile interaction schemes considering mobile social networking service. Mobile (in Korea, Japan and China) interaction with a U^3 web service will be discussed on the basis of the implementation of a U^3 web site. Finally, we will conclude our study with a consideration of further research for a unified IP-USN directory service with metadata in the highly evolved sensor networking environment using COSMOS (Common System for Middleware on Sensor Network) [8] middleware that is developed by ETRI in Korea.

2. Sketch of Design Goals for Mobile Interaction

We need a sketching process to design experience or interaction as Buxton mentioned [9]. We sketched design goals for mobile interaction and application to a unified IP-USN metadata directory service to target usable and unified Web information service in ubiquitous computing and networking environments. Beyond social networking for humans, we are considering the highly evolved sensor networking for sensor nodes, because the concept of mobile interaction for social networking is similar to the highly evolved sensor networking of real-time information management for grouping of sensor nodes using web-based USN metadata directory service.

Most sensor network researchers would probably agree that we have placed too much attention on the network-

ing of distributed sensing and too little on the tools necessary to manage, analyze, and understand the data [10]. However, with standards in place for networking and other infrastructure-related issues, or at least an emerging consensus as to how to solve these issues, the demands for a sensor web revolve around questions of information management. In terms of service discovery, service discovery protocols are designed to minimize administrative overhead and increase usability [11].

The sketched design goals for a usable-unified-ubiquitous (U^3) web service must be considered on the basis of real service from a user's perspective. The primitive requirements for design goals are shown as follows. We need to consider usable mobile interaction for services in ubiquitous environments. We should consider a unified web-based directory service accessible with any device that provides unified information for universal services. For usability of real implemtation, the targeted design goal is for the real-time service for information retrieval within a few seconds as well as for the real-time service of information registration within a few minutes. The functionality for simple text-to-speech in a few seconds with inexpensive service as well as with inexpensive investment is required for various services including Telematics. The continuous removal of information-garbage after refreshment keeping W3C guidelines for web-contents accessibility is also one of our design goals. It should be both usable and accessible anywhere in the world by Koreans where mobile Internet service is provided. In terms of resource utilization, it should consume less memory for storing information and communication bandwidth. It should be usable with any mobile phones, PC, IPTV, etc. and be easy to backup a web-based directory. For ubiquity, it should be usable on express train at speeds of over300 km/hour (e.g. Sinkansen, KTX, etc). We need a web-based unified supra(i.e. super infrastructure) for various social networking of human beings as well as for sensor networking services for sensor nodesin the global perspective using IP-based Web. Pulling schemesfor information, instead of pushing and spam-style scheme, is required without addiction of service and should not be time-consuming for any user as a durable service. We don't need complex schemes for implementation. We need a service accessible to metadata information in convenient ways.

We tried to satisfy the aforementioned design concept for the implementation of a web-based directory portal for mobile interactionbetween human beings and service agents in a web-based directory server. We are trying to improve satisfaction for thedesign goals. Thus, we introduce the current status of our research to apply the insight of social networking to the advanced sensor networking for the u-City (e.g. Sejong City in Korea) in the future, especially in the COSMOS project. The test-bed Web site is 'http://ktrip.net' (accessible with 김.net, 이.net, ㄱ.net, ㄴ.net, ㅏ.net, ㅐ.net, ㄱ.com, ㄴ.com …) has been implemented to satisfy the design goals. We studied the application to the unified IP-USN directory service based on metadata information management.

3. Consideration for a U^3 Web Service

Ford and Kotze [3] proposed that the interface design characteristics required to design interfaces that accommodated high power distance, high uncertainty avoidance, masculinity and short-term orientation would provide a more usable interface to all users. The user interfaces designed to accommodate the above cultural dimensions and collectivism provide better performance.

Considering usable mobile interaction, the usefulness of the multilingual domain names for ubiquitous web service for online social networking was studied, especially on the basis of the convenience of single-character multilingual domain names for mobile social networking service. For fast and convenient service, the time needed to type long and complex URLs will be one of the dominating factors in terms of usability and performance for mobile phone users. In previous work, the performance and UI (User Interface) issues in ubiquitous information networks were studied [12, 13], additionally we studied further with the application of sensor networking for the unified concept. This concept is applicable to the manager's mobile interaction for the metadata IP-USN directory service with metadata information management.

For usable mobile interaction, the user interface to type in the domain name for access to web service for wired Internet as well as mobile Internet should be as simple as possible. Single-character multilingual domain names (e.g. 김.net, 이.net, ㄱ.net, ㄴ.net, ㅏ.net, ㅐ.net, ㄱ.com, ㄴ.com …) satisfy the convenient user interface for the mobile Internet and wired Internet. The scheme for multilingual domain names has been standardized world-wide by IETF (Internet Engineering Task Force) and has been approved by ICANN (Internet Corporation for Assigned Names and Numbers). The auto-conversion functionality for standardized multilingual domain name service has been embedded in the Web browsers as a built-in functionality, e.g. from the version of MS IE7.0 and Firefox,

Opera, etc.

For information retrieval and access to online social networking services, the performance of ubiquitous web service with mobile Internet is important to provide QoS (Quality of Service) with cost-effective and inexpensive system solutions. We studied the requirement for performance of mobile interaction and its metrics in ubiquitous computing and networking environments. We introduce a social networking service, based on single-character multilingual domain names, and we show also the useful results of implementation of ubiquitous Web site for online social networking. We study the application of our concept to the unified metadata USN directory service in the COSMOS project [8] for Web-based sensor networking such as IP-USN.

For consistency of information when using online social networking services, in addition to usable user interfaces, we need a unified and ubiquitous web service for wired Internet and mobile Internet. Fast and convenient access to information as well as notificationis required for online social community service including mobile social networking service. We need to write the information in the ubiquitous web site and make it accessible with single-character multilingual domain names (e.g. 김.net, 이.net, ㄱ.net, ㄴ.net, ㅏ.net, ㅐ.net, ㄱ.com, ㄴ.com …) instead of long URL strings for convenient web-based information management.

The complexity involved with providing consistent information access from portals or community sites has been increasing and the inconvenience of user interaction for information access has become challenging for even skilled users. We suggest a ubiquitous web service for usable mobile interaction, which is based on 'hand-board' with meaning of online white**board** service using **hand**-sized information in PC or **hand**held phone, accessible with simple single-character multilingual domain names as a convenient mobile UI.

For ubiquitous information portalfor social networking service, the unified information service is indispensable in online social networking. The ubiquitous Web server should have the capability of showing the unified contents, i.e. the HTML contents for wired Internet as well as the mobile contents for many different kinds of mobile Internet and various contents using different mobile markup languages, e.g. WML (Wireless Markup Language) and mHTML (mobile Hypertext Markup Language). Easy typing of the URL is also important especially for usable mobile Internet interaction. The single-character multilingual domain names (e.g. 김.net, 이.net, ㄱ.net, ㄴ.net, ㅏ.net, ㅐ.net, ㄱ.com, ㄴ.com …), which could become the indexing key character for information retrieval from ubiquitous web server and for information registration into ubiquitous web-based directory, were considered as a convenient mobile user interface for online social networking services as well as in the metadata IP-USN directory services.

4. Performance Metrics for Usability

For typing the information in a fast and convenient way, the user's typing speed is an important performance factor related to the interaction of information retrieval for online social networking services, especially with the mobile phones. Depending upon the keypad stroke number, the level of convenience of mobile interaction could be estimated as a convenience metric as one of many usability metrics, which need further research for metadata directory service. Considering the convenience metric, i.e. defined as the keypad stroke number for a moment, we may understand the usability of the single character domain names instead of long URL-strings for access to unified and ubiquitous web service, especially in a mobile Internet environment. For a ubiquitous information network, even the input interaction of characters is important for retrieval interaction from a unified web-based directory. To access the unified web-based directory ubiquitously, the mobile interaction for information retrieval should be as convenient aspossible for typing in the domain names or URLs for searching the right community web site and accessing to information in ubiquitous Web-based directory.

We can access dynamic information in a unified and ubiquitous web-based directory with multilingual single-character domain names as root nodes in information tree for usable mobile interaction in online social networking as well as in metadata IP-USN directory service for sensor networking. With multilingual single-character .net domains (e.g. 김.net, 이.net, ㄱ.net, ㄴ.net, … ㅎ.net, ㅏ.net, ㅑ.net, ㅐ.net …), we can access the required information, especially the unified and consistent information in a ubiquitous information network. If we looked at the mobile interaction for handheld phones for mobile information service, and even for the URL typing interaction for information access in the wired Internet. Multilingual single-character is very convenient and usable because it is like a root node in the tree of information-access hierarchy in web-based directory to generate any multilingual domain names or words for in-

formation access in China, Japan, Korea, and other countries using multi-lingual domain names.

Considering usable mobile interaction for mobile Internet for mobile social networking services, the development and application environment are very different from existing wired Internet environments, i.e. mainly based on MS Explorer as an Internet browser. Most web pages today are designed for desktop PCs, and viewing them on mobile web browsers is extremely difficult. Chen et al. [14] studied the adaptation of web pages for small-screen devices. It (e.g. mini-homepages, blogs, club, café, etc.)is very difficult to browse with mobile phones, thus we need to consider ubiquitous web service with usable mobile interactionand unified (for PC and mobile devices) online directories, i.e. so called 'hand-board' for text-based information adequate for fast TTS (text to speech) application.

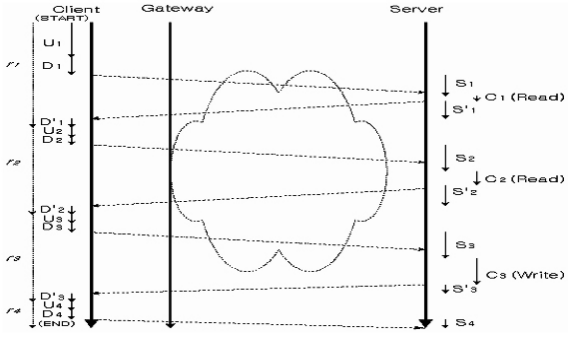
We need to consider the accessibility to ubiquitous web-based directory sites as well as the performance of the mobile interaction for a U^3 web service. We used a single web server for metadata information access as a unified service for simplicity of information management and for cost-effectiveness in this study. We plan to implement the redundancy scheme to check the reliability of aunified USN directory service for the COSMOS project [8]. This method gives effectiveness and efficiency for the access of information and the utilization of resources, in terms of the bandwidth for communication and the size of disk storage tobuild ubiquitous web sites for mobile social networking service as well as for metadata IP-USN directory service.

We studied the important performance metric, e.g. delay, at the user's perspective. We studied the performance metric, e.g. delay, not only with the time in the network and server, but also with the spent time by user and the input interaction time with keypads for URLs or metadata information for notification/registration interaction with the web site for mobile social community services as well as for the metadata IP-USN directory service.

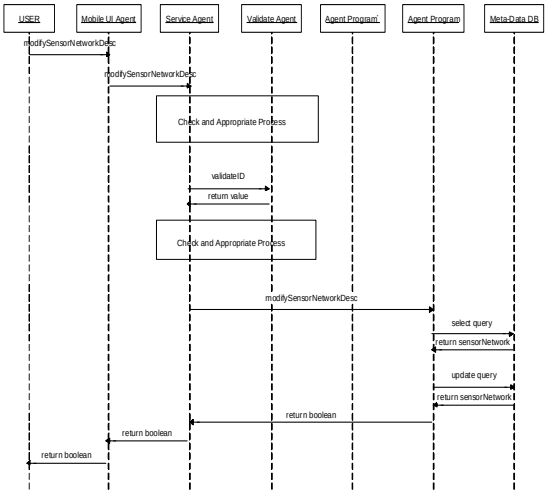
As *performance metrics* for usable mobile interaction, we assume that the random variables, the round-trip response time for a user's single interaction in a session, from user to the contents in DB or directory through wired/mobile Internet before next interaction with mobile phone is $\boldsymbol{R}$. That is composed of the preparation time for any user in online social networking to get mobile phones in the user/manager's hand for interaction is $\boldsymbol{U}$. The time spent by the user/manager with mobile phone to do appropriate interaction for service is $\boldsymbol{D}$. The aggregate interaction time to the Web-based directory server after the mobile device through wired/mobile Internet for mobile service is $\boldsymbol{S}$. The interaction time depending upon mobile contents in the metadata directory DB is $\boldsymbol{C}$.

For pulling service, we may order the dominating factors in the overall performance of mobile interaction at the user's perspective as follows. In general, the relationship between delay metrics for mobile interaction with mobile phone could be $\boldsymbol{U>D>S>C}$. Here, we need to decrease the major interaction times $\boldsymbol{U}$ and $\boldsymbol{D}$ for pulling service, as well as the network and server interaction time $\boldsymbol{S}$ (or interaction time to contents or metadata in DB, $\boldsymbol{C}$). We need to decrease the times $\boldsymbol{U}$ and $\boldsymbol{D}$ for pulling service in the mobile Internet for usable mobile interaction.

In (Fig. 1), the overall time delay of several elements (i.e. user, device and Web-based directory server) are shown and discussed as follows: user's preparation time, U_1 time with user/manager's device, D_1 and D'_1 time in network and Web-based directory server, S_1 and S'_1 user's time for understanding and readiness, U_2 time with client's device, D_2 and D'_2 time in network and Web-based directory server, S_2 and S'_2 time for reading contents or metadata in Web-based metadata/information DB, $C_{1(\mathrm{Read})}$ time for writing contents or metadata in the web-based DB, $C_{1(\mathrm{Write})}$ user's preparation time for understanding and readiness, U_3 time for writing contents or metadata with user's device, D_3 and D'_3 time in network and web-based directory server, S_3 and S'_3 user's preparation time for understanding and readiness, U_4 time for finishing the session with user's device, D_4 time in network and web-based directory server, S_4. The random variables: *U, D, S, C* will be discussed in the following section based on experience in Korea, Japan and China.



(Fig. 1) Mobile Interaction Time for Sessions with a Mobile Device



(Fig. 2) Mobile Interaction Time for a Metadata Update Session of a Sensor Network

To be time-deterministic for application with QoS (Quality of Service) in metadata IP-USN directory service, e.g. searching of required metadata in one minute, the mobile interaction with device should be usable, the web-based metadata directory server should be efficient and have high interaction performance for the dedicated directory service, and the metadata for interaction should be simplified in efficient format. The user's preparation time for metadata access, or ubiquity metric, U will be decreasing (i.e. being improved) depending upon the proliferation of ubiquitous computing and networking environments. The average keypad-press number for mobile phones is related to the interaction time related to the mobile UI agent. The aggregate interaction time is related to the convenience metric and *performance metric*, (as one of usability metrics) which can be improved with simple user interface and Web-based metadata USN directory for sensor Web, especially for usable mobile interaction in a U^3 web service. Fig.2 shows the detailed session for the metadata update for a sensor network, as one example among many of the different types of sessions such as registration, deletion, update and search in the USN Directory Service Component in the COSMOS [8] middleware. To accomplish detailed interactions, we will estimate random variables including mobile interaction time between agent processes to further study performance metrics for QoS.

5. Resource Utilization for Mobile Interaction Schemes

We used a single web-based server for the simplicity of management and the cost-effectiveness of implementation for text-based web information portals for mobile social networking services. This helps with the reliability of duplicated web-based directory servers, which will be implemented in the near future. We considered the effectiveness and efficiency of the management of web-based information and utilization of resources for social networking, in terms of the bandwidth for communication and the size of Web DB for usable mobile interaction in a U^3 Web service. Most commercial portals provide rich-media content for the community, e.g. UCC (user created contents), mini-homepage, blog, club, and café therefore the resource requirement for web services are continuously increasing with more advanced devices as well as with higher network bandwidth, e.g. mobile blog and mobile UCC with WCDMA, HSDPA, WiBro (WiMax), and 4^{th}G service. The investment of resources for multimedia Web service is so huge when we compare to our text-based approach, and it is self-evident even without further analysis moreover the finding of right information in most commercial portals is very difficult and is becoming worse with mobile devices in the mobile Internet environment.

First, we analyzed resource consumption for interaction based on commercially available services, e.g.SMS or e-mail service, mini homepage, blog, UCC, mobile UCC, **'hand-board'** services related to social networking service, as follows. With the push-style interaction service (sometimes it becomes **spam-style** service, we use the subscript s) of information notification based on SMS (short message service) or e-mail service, the disk size of the message server is $S_s = \sum_{i=0}^{n-1} d_i = nd$, where d is assumed as a disk/memory space required for every message of n users.

In the sensor network, the distributed and broadcasting scheme for dynamic metadata management is similar to this type of resource consumption. If we consider the information access for a social networking service based on a **pulling-style** interaction scheme (we use the subscript p), then the equation becomes $S_p = d$ for a centralized Web-based metadata directory server. If we consider the consumed bandwidth is proportional to the number of packets transmitted, $B_s = \sum_{i=0}^{n-1} p_i = np$, where p is assumed as the number of packets for each message. In the case of the suggested method based on the pulling interaction scheme, e.g. mini homepage, blog, UCC, **'hand-board'** services, $B_p = \sum_{i=0}^{r-1} p_i = rp$, where r is assumed as the num-

ber of requesting/pulling users, and $r \le n$, sometimes the r is negligible.

If we consider the sensor network, instead of the distributed and broadcasting scheme, the centralized Web-based scheme is similar to this type of resource consumption, i.e. with less resource consumption. Also we need to consider the time spent by many message users to browse and delete the messages, $T_s = \sum_{i=0}^{n-1} t_i = nt$. However, the time for information management for online social networking with the pulling interaction scheme is $T_p = \sum_{i=0}^{r-1} t_i = rt$, and $r \le n$, sometimes the r is negligible. In general, we can assume the relations: $S_s > S_p$, $B_s > B_p$, and $T_s > T_p$.

We considered mostly the server-side resource S_s, ignoring the client-side resource, for the cost-effective Web-based directory server and we considered the complexities of consumed resources R_s and R_p (s means *pushing* interaction scheme like *spam*, p means *pulling* interaction scheme) for *pushing* and *pulling* interaction scheme respectively, as follows.

$$O(R_s) = O(S_s * B_s * T_s) = O(np * nb * nt) = O(n^3)$$
$$O(R_p) = O(S_p * B_p * T_p) = O(d * rp * rt) = O(r^2).$$

In general, we can assume $n > r$, and we can derive the relationship where: $O(n^3) > O(r^2)$.

We need to form an efficient way for resources to interact with cost-effective web-based DB using pulling interaction schemesinstead of push-style interaction scheme in online social networking service as well as in the information management for directory service. This concept will also be important for unified IP-USN directory services in the ubiquitous sensor networking services because of real-time characteristics and QoS.

W compared the pulling interaction schemes, e.g. mini homepage, blog, mobile, UCC, mobile UCC, **'hand-board'** services in terms of the resource consumption for interaction, i.e. telecommunication bandwidth and disk space. As a scheme for '1 to many' interaction service (i.e. one information provider notifies social information to many participants or customers) the above pulling interaction scheme seems to satisfy, even though the levels of efficiency and effectiveness are very different. The resource consumption for interaction is also different from an interaction scheme to other interaction schemes. We don't need to analyze each interaction scheme in detail instead we can differentiate the above services into two interaction schemes as follows. One scheme is based on multimedia contents, i.e. mini homepage, blog, mobile blog, UCC, mobile UCC services, and another interaction scheme is using only text-based contents with limited size, i.e. our proposed **'hand-board'** interaction service. We chose the **'hand-board'** interaction service because of the efficiency and effectiveness of resource utilization and TTS functionality for mobile social networking service with hand-held mobile devices, especially for usable mobile interaction. This concept is applicable to the metadata USN directory service for static or dynamic metadata information management.

We considered resource utilization for sensor networking as follows. With a different DB table for metadata IP-USN directory service, the manager or user components for web-based USN directory service can manage the metadata information efficiently. The resource utilization for sensor networking is very important, because the performance for the unified USN directory service is heavily dependent on the scheme of the web-based metadata directory service for IP-USN.

6. Experience of Mobile Interaction with a U^3 Web Service

For mobile interaction with a U^3 web service, the implemented system is based on wired or mobile Internet, many multilingual single-character domains (e.g. 김.net, 이.net, 가.net, ㄱ.net, ㄴ.net, ㅎ.net, ㅏ.net, ㅐ.net, ㄱ.com, ㄴ.com, ㅎ.com …) for fast access to mobile social networking service. We completed the development of this application as a specific example among various applications including the unified IP-USN directory service in development with the analogy. The required information or advertisement can be registered anytime or anywhere using wired or mobile Internet with multilingual single-character domain names. We considered the cultural dimensions, proposed by Ford and Kotze [3], in our implementation of the design goals for usable mobile interaction. To accommodate high power distance, high uncertainty avoidance, masculinityand short-term orientation and collectivism, we implemented a U^3 Web service for lecture group, i.e. composed of around 120 students (high power distance, short-term orientation), and alumni association, i.e. composed of around 60 members (low power distance, longer-term orientation), among various social networking services. We focus on the social networking, then, we applied sensor networking.

We measured the time to type-in the 'ktrip.net' as a simple example to show the critical time in terms of performance. We measured also the aggregate time spent by web site and network, and we observed the time to read the right content after click the title in the displayed information list on the screen of mobile phone. We observed that the typing time for full domain names or long URL-string with mobile phone was serious in terms of interaction performance. Therefore, we need single-character domain names instead of long URL-string for mobile Internet UIwith mobile phones as discussed. The typing time was faster than 3 seconds in most cases while multilingual single-character was completed in 1 second.

In terms of packet cost for interaction, one packet, i.e. 512 Bytes, costs 0.5 Cents (U.S.), the minimization of delivered packet number from the ubiquitous Web DB to the mobile phone is important for cost-effective interaction service with ubiquitous Web-based directory service. We considered both the cost-effectivepacket size and the number of packets for delivery in our implementation of the ubiquitous web portal for usable mobile interaction in mobile social networking service; and moreover the TTS (text to speech) functionality in interaction service was easy to be implemented because of the tiny size and text-based 'hand-board' contents for usable mobile interaction.

We did some experimental research with students as a mobile social network in a lecture group as follows. The number of students was around 800 over 7 semesters, i.e. around 114 students in each semester over 4 month period. This is similar to the number (124) of the averaged social network size [1]. They used a bulletin board or 'hand-board' using the site 'ktrip.net'that is also accessible with a multi-lingual domain name: '망.net'. The cumulative number of clicks was around 47,000. This means that the average click number in one semester for one student was around 14 clicks per month. Therefore, each student clicked around 3~4 times a week. As an example of web services for online/offline social networking service, special application for information registration/retrieval from/into ubiquitous web-based metadata DB can be done with the notification bulletin board so-called 'hand-board' for alumni association in social networks; here the size of association members may be from tens of members to a couple of hundred members in online/offline social networking. In the deployment of real sensor networks, the appropriate group size of sensor nodes for each sensor network as well as the appropriate group size of sensor networks for the unified IP-USN directory service will be realized depending upon the application service such as u-City.

The pulling of metadata in the directory can be considered similarly to the sampling theorem, the pulling frequency $f_{poll} \geq 2 * f_{notify}$, where f_{poll} is the frequency of pulling the ubiquitous record in the metadata DB table, i.e. a searched Web site for mobile social networking service, and f_{notify} is the frequency of notification in 'hand-board' by the association for mobile social networking service. In the IP-USN directory service, the pulling rate by manager or components for the updated metadata information of a sensor network or a sensor node will be very similar to the above concept and it will be helpful for the queuing analysis within the above arrival rate, i.e. as a practical pulling rate, for the IP-USN directory service for further research.

The speed of on-line registration for advertisement/notification as well as the speed of access to special information with ubiquitous web DB is fast enough for real application. Moreover, the effectiveness of web DB usage for mobile social networking services can be anticipated if we consider the applications for various communities, mini-homepages, clubs, blogs, mobile blogs, UCC, and mobile UCC services based on rich media as far as the consumed disk storage and cost for operation and administration related to mobile social networking are concerned.We study the performance for real-time registration and search of sensor networks or sensor nodes, in the similar mobile Internet environment before proliferation of USN including IP-USN.

We implemented the Text to Speech (TTS) functionality for usable mobile interaction because the simple and text-based information used for 'hand-board' services was easy to implement TTS functionality based on speech synthesis. We will study the TTS application for the manager of metadata directory service in the highly evolved u-City such as Sejong City. The conversion time of 1 Kbytes text-based information was around 1 second. In most cases, the information/metadata size for mobile social networking service and the record size in the metadata DB table for unified IP-USN directory service is enough within around 1 Kbytes on the basis of our experience and metadata design for a metadata IP-USN directory. This TTS functionality for interaction will be very helpful for the elderly. Also, the telematics service for auto drivers will be applicable with usable mobile interaction for listening to the contents in 'hand-board' with

transformed audio contents.

According to the empirical results from the implementation of social networking services using wired Internet, the time S may be considered a rather short period (around 5~30 msec with Ping, which is related to the S. However, for a 5Kbytes web page, PC response time is around 2~3seconds, which is related to the S and C, here C is much longer than S). Since mobile phones use mobile Internet (for short packets below 1.5Kbytes and even around 5Kbytes), the response time is around 12 seconds with little deviation through the WAP gateway. Thus, the time S is longer than C, where S includes the elapsed time at the gateway for the mobile Internet.

From the experiment of Web-based directory service based on the mobile Internet in Japan, with roaming service, we observed that the response time for awired PC is rather fast and stable with little deviation as in Korea. The average response time for mobile phones for the first access to 'ktrip.net' was around 12[sec] with little deviation from what was observed in Korea. After the initial connection to 'ktrip.net', the reading time of registered information was around 2~3[sec]. The results in the Forbidden City and the Summer Palace as well as on the way to the Great Wall in China were similar to the results in Japan and Korea. To conclude, the critical time the device time $D$with mobile phone in our experiment as found in Korea. The sum (S+C) was around 2~3[sec] and was not comparable to the time D that is at least over 30~60[sec] depending upon the amount of text-based information for writing with keypads during registration of information. The inconvenient interface for writing URLs or information with keypads caused a major bottleneck in degradation of overall performance for U^3 web information service. This experience is applicable to the manager for real-time information management of metadata IP-USN directory service in the u-City.

We are also considering location-based service for mobile social networking services as well as sensor networking services for the U-City, using mobile phones. Then, the listed metadata information related to that specific location will decrease tremendously for usable mobile interaction in U^3Web service. The convenience and usefulness of multilingual single-character domain names will be remarkable for accessibility to the ubiquitous web sites for mobile social community service as well as for the metadata IP-USN directory service. With any mobile devices, the directory service for social interaction as well as for the sensor networking will be feasiblein ubiquitous computing and networking environments for real-time information management.

7. Conclusions

Mobile interaction for a usable-unified-ubiquitous (U^3) web service was studied by considering the applications for social networking as well as metadata for IP-USN directory service. As a convenient and usable mobile HCI for mobile web service foronline social networks, the multi-lingual single-character domain names (e.g. 김.net, 이.net, 가.net, ㄱ.net, ㄴ.net, 호.net, ㅏ.net, ㅐ.net, ㄱ.com, ㄴ.com, 호.com …) as indexing keys to social information in ubiquitous web service are convenient mobile interfaces that allow one to search for social information andto register information. We studied to apply to the metadata directory service because of the analogy. The convenience of multilingual single-character domain-names and the tiny 'hand-board' for usable mobile interaction was discussed with empirical results based on the implementation of a U^3 web service. We studied the design goals and experience in Korea, Japan and China for mobile interaction with the implementation of mobile social networking services, as an example of a U^3 web service.

We introduced the extended application of social networking to future sensor networks with metadata IP-USN directory service because of the analogy of real-time information management. The results of this implementation showed usable mobile interaction with multilingual single-character domain names for usability and accessibility for a U^3 web service. The reliability of a U^3 web service for IP-USN using mobile Internet should be studied in the future. Also, U^3 web sites for the u-City will be studied for a unified USN directory service for COSMOS.

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