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Method of Profile Storage for Improving Accuracy and Searching Time on Ubiquitous Computing

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ABSTRACT

Users are able to use the information and service more free than previous wire network due to development of wireless network and device. For this reason, various studies on ubiquitous networks have been conducted. Various contexts brought in this ubiquitous environment, have recognized user's action through sensors. This results in the provision of better services. Because services exist in various places in ubiquitous networks, the application has the time of services searching. In addition, user's context is very dynamic, so a method needs to be found to recommend services to user by context. Therefore, techniques for reducing the time of service and increasing accuracy of recommendation are being studied. But it is difficult to quickly and appropriately provide large numbers of services, because only basic context information is stored. For this reason, we suggest DUPS(Dimension User Profile System), which stores location, time, and frequency information of often used services. Because previous technique used to simple information for recommending service without predicting services which is going to use on future, we can provide better service, and improve accuracy over previous techniques.

Keywords: Ubiquitous, Profile, Context prediction, Service recommendation, Personalization

1. INTRODUCTION

Today, the number of user's demanding information services, without time and location constraints, has increased due to the development of mobile devices and speed of networks[1,2]. For this reason, various studies on ubiquitous networks have been conducted. In this ubiquitous environment, context-aware information is collected by sensors located around users, and used to infer user's current situation, with personal information, such as user profile[3,4]. Because inferred context information is used to provide services appropriate for users, many academics are studying context-aware modeling, streaming data processing, service provision, context prediction, and context histories[5-11]. Also, recommendation techniques such as Case-based Reasoning, Collaborative filtering, Content-based filtering, Item-item filtering, have been studied in ubiquitous computing, on the web, and in other fields [12,13]. These techniques provide services with a way of using the personal profile and preference rating of users. However, previous techniques used for ubiquitous computing have not considered privacy problems and recommendation correctness by context. And because services exist in various places in ubiquitous networks, the application has the time of services searching. Therefore, we were suggested DUPS which stored location and time, frequency information of often used service, and put the serv-

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ices which expected to use in any location on time to storage. We can reduce use and search time of services through techniques and systems suggested in this paper, and are able to provide more accurate service than previous techniques.

2. RELATED WORKS

Ubiquitous is a word meaning 'anywhere and anytime' from Latin. In this computing environment, user can access to network regardless of wire and wireless environment, device. The subject of awareness in this ubiquitous which differ from previous computing environment is not human, but device[14]. This means that information of awareness is to be personalized. Because inference power of computer was not enough to understand human's action and thought. But because they actively have to provide various service and information to aware human's behavior and thought, there is need of definition, how expressed human's behavior and thought to context information. Also, because human's behavior and thought was individually differ, how understand personal inclination is important problem. For this problem solving on ubiquitous, it was inferred context which was able to understand human's behavior based situation information which collected from various sensors. And they are provided service and information to user through the inferred context. Generally, situation which arose around human was able to collect from sensor, but personal inclination and thought was not. Therefore, they used the method of personal information storage for analyzing inclination, such as personal profile, history, diary[15,16]. As mentioned above, user of ubiquitous was provided various services without human's recognization by ubiquitous devices in anywhere and anytime. So, we have to infer context for provide the services to users correctly. Therefore, there are studying about technique of context inference to use personal inclination and information. As it demanded personal inclination and information in context inference, using the user's profile for storing it, research about technique of profile was as follow:

UbiData project was suggested data process and synchronization in ubiquitous environment and addresses these three challenges using an architecture and sophisticated hoarding, synchronization, and transcoding algorithms to enable continuous availability of data regardless of user mobility and disconnection, and regardless of the mobile device and its data viewing/processing applications[17,18]. Furthermore, UbiData automates the task of maintaining currency (up-to-dateness) and consistency of data on mobile devices. For example, their Format-Independent Change Detection and Propagation (FCDP) algorithm allows users to edit and use different versions of the same document using multiple devices and word processing applications. Anthony Finkelstein was suggested customization technique that support context-recognization and propose the notion of customisation as the uniform mechanism to provide the necessary flexibility with respect to both contextaware computing and personalization[19]. Customisation is realized in terms of a reflective architecture consisting of context, profile and customisation rule management. Daisuke Morikawa was suggested framework that collected and updated profiles which created from various resources and propagate relative profiles[20]. Annika Hinze describe TIP (Tourism Information Provider) system, which delivers various types of information to mobile devices based on location, time, profile of end users, and their "history", i.e., their accumulated knowledge. The system hinges on a hierarchical semantic geospatial model as well as on an Event Notification System (ENS)[21].

Recommendation techniques, such as Case-based Reasoning, Collaborative filtering, Content-based filtering, Item-item filtering, were suggested[12, 13]. Annie Chen proposed a context-aware collab-

orative filtering system that can predict user preferences in different context situations, based on past user-experiences. The system uses what other like-minded users have done in similar context, to predict a user's preference towards an item in the current context[22]. Manuele Kirsch-Pinheiro proposed a context-based filtering process, aimed at adapting awareness information delivered to mobile users by collaborative web systems. This filtering process relied on a model of context which integrates both physical and organizational dimensions, and allows representation of the user's current context as well as general profiles. These profiles are descriptions of potential user contexts and express awareness information filtering rules to apply when the user's current context matches one of these rules. Given a context, these rules reflect user preferences. They describe how the filtering process performs in two steps, the first for identifying the general profiles that apply, and the second for selecting awareness information[23].

3. CHALLENGE

As mentioned above, the method of analyzing personal inclination for inferring the context on ubiquitous, such as profile, history, diary, was used.

The method of history stored all service information which used on context in particularly storage. As information about where, when used the information was included, this method has advantage which inferred to context correctly. But there are request a lot of storage size for storing all of user history, and as increase the data amount of history, take spent much time on search, and could not stored on personal device, such as PDA. It's able to issue that security accident was brought on ubiquitous which personal privacy was very important. Diary method has advantage that could predict the user's behavior, so is able to infer the context correctly. But, because ubiquitous computing preferred to sublate user's intervention, how predicted information constructed without user's intervention is very important. Also, processing method of context except on predicted context were shortage than other method. Profile method which simply stored information of inclination and personal has advantage that used and stored personal device, such as PDA, because size of the document is small. But detailed information which used and predicted on context is somewhat shortage than others. So, the challenge issue on ubiquitous for using the user's inclination was the following :

Storage size and Process time : In ubiquitous computing, many user requested service and information to ubiquitous service system. So the systems have to process a lot of data. Therefore, the size of data need to small for processing quickly.

Privacy : As where personal information stored, method of security is differ. Generally, user's device, such as PDA, is higher safe than server.

Prediction : Because we can provide service to predict what is happen, it is good method, but we need the way how systems could predict the context.

Accuracy of Inference : We must understand what users want for provide service and information to user. So how inferred the request is important.

Intervention : We must provide service and information without user's conscious behavior. So, there are need a way how user's behavior inferred without consciousness.

4. DUPS

We have to infer what service is fit to user well for serving various services to user based context-aware information which arose in ubiquitous environment. Generally, we stored profile for using

user's inclination and information. Also, because services that often used have high probability which continuously using, if the services stored in profile, we could reduce time of service using. Therefore, previous technique which information and time of often using services stored in profile was suggested. But there are need to information of user's location and time for providing more correct services. For example, we assume that A service was used 10 times on a day, and if time of service using is 3 P.M, we should infer that the service almost would use to afternoon. And time and frequency of information is important in ubiquitous. But location information is very important also. Even if services was same, frequency of service was different each other. Therefore we suggest technique that providing the service which demanded by user to store location information with time and frequency in profile and that put the service in location on time to using.

The system, which we were suggested, is consists of Agent and DUPS and User, service provider. And figure 1 shows how we structured DUPS system.

Agent is responsible for communicating user and DUPS, providing services to user. And DUPS is responsible for finding services and predicting, analyzing profile information, collecting information from sensors. Service provider is responsible for providing services to user. User is used to service in ubiquitous.

DUPS was consists of 3 module, such as Service manager, Agent manager, Inference engine, and each modules consist of sub-modules. Service manager is responsible for finding the service and the predicted service which user will use in other place from service provider. And then stores the predicted services in service storage. If users request the predicted service to DUPS, we will directly search it on service storage without searching works. So it is more quickly find service which user requested, and is able to provide it to user. Analyzer within inference engine is responsible for analyzing context with profile and sensor information to provide suitable service for user. And predictor estimates services which user is going to use service on other place. Location and context model database was stored location information anywhere user could stayed in a place and context model information how we infer to context. Sensor information database was stored sensor data which was received from DUPS manager. Agent manager is responsible for receiving information from DUPS manager on agent, and then send to inference

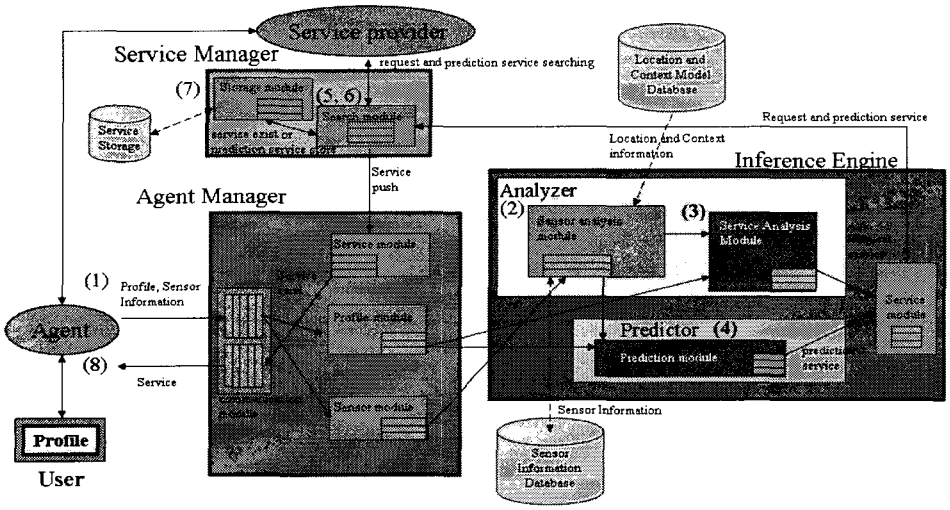


Fig. 1. Architecture of DUPS.

engine. Also, it is send services which was find from service provider to service handler on agent.

4.1 Profile Structure

4.1.1 Defining User Profiles

A user profile specifies information of interest for an end user. So user profile was structured user information part and service information part. User information part was stored user's information such as user's name, inclination, hobby and Service information part was stored services which we were used such as service name, service provider etc. structure of user profile was follow:

- User Information : User name, User ID, Personal inclination, hobby, etc
- Service Information : Service Name, Service Provider, Service context, Service frequency value, etc

Because profile stored how much the service information used, stored not only used service, but also information when, how, where used. Also, there are stored the information about what context used.

4.1.2 User Profile Manipulation

We assumed that the services will use this place and time next time, if service was demanded in specific location and time. So, we used the information of time, location, frequency to provide services to user more correctly and suggested DUPS technique which using recently access time, access time, frequency of access, location value, weekend value. And the values stored in DUPS profile.

- recently access time(t) : This value stored time when service used recently, and use for finding service which not used for a long time.
- access time(a) : This value have to 24 from 0, and if service was used on 1 P.M, it's value has 13.
- frequency of access (f) : This value stored frequency of service how many user used the service.
- location value(l) : This value have unique number of place where service was used. For example, if user used A service in house and office, location value of A service which used in house is 1, other is 10.
- weekend value(e) : This value have to 7 from 1, if service used on Monday, weekend value is 1. Generally, people's life pattern was repeated per week. So we use the value for analyzing service frequency of user per week

And we represented frequency of access to 3-Dimension graph which have three-coordinate values(access time, location value, weekend value). For example, if user demand A service at 7 A.M, Monday on bathroom, an then weekend value(monday·is mean 1 in the location model) has 1, access time has 9, location value has 1. So frequency of A service is represent at coordinate (7, 1, 1) and has 1 value. If user will demand A service at same time and place, frequency of A service which has coordinate (7, 1, 1) will become 1 by increasing. Also, we find location information of service which has most high value of frequency which place on responding coordinate among it, and put it in service storage which user will use the service. And then user can use the service which they demanded more quickly.

4.1.3 Location Information Model

In case of using the service, we need location information where service used for inferring user's inclination and context efficiently. So, we simply classified location information which has a unique value, such as the following :

- Home : Bathroom(1), bedroom(2)
- Office : Lobby(3), elevator(4), floor(5), office room(6), conference room(7)

- Other : Street(8), Car(9), etc

4.2 Service Analysis and Prediction

4.2.1 Matching User Profile

This section describes the profile handled in DUPS as well as the way to deliver relevant service to the user. For the formal definition of profiles, we use a notation inspired by Event-Condition-Action(ECA) rules on XML by logical operators: ON-event IF condition DO action. We use the notation given in table 1 to refer to the various data sources.

Table 1. Notation used in this paper

Variable	Description
L	Location information in context
T	Access time in context
W	Weekend information in context
SI	Sensor Information
S	Set all of Service
RS	Request Service
PS	Predicted Service
CS	Context Sensor
UP	User Profile
DUPS	Dimension User Profile System
F	Frequency of service

The methods used for the profile are shown in table 2.

And manipulation processing of Service analysis and prediction which used method of ECA notation was the following :

(1) Service analysis

Analyze and recommend what service is fit to user based inferred context to use the information of location, time, weekend in user profile. And we find service which frequency (f(f)) of service is the highest.

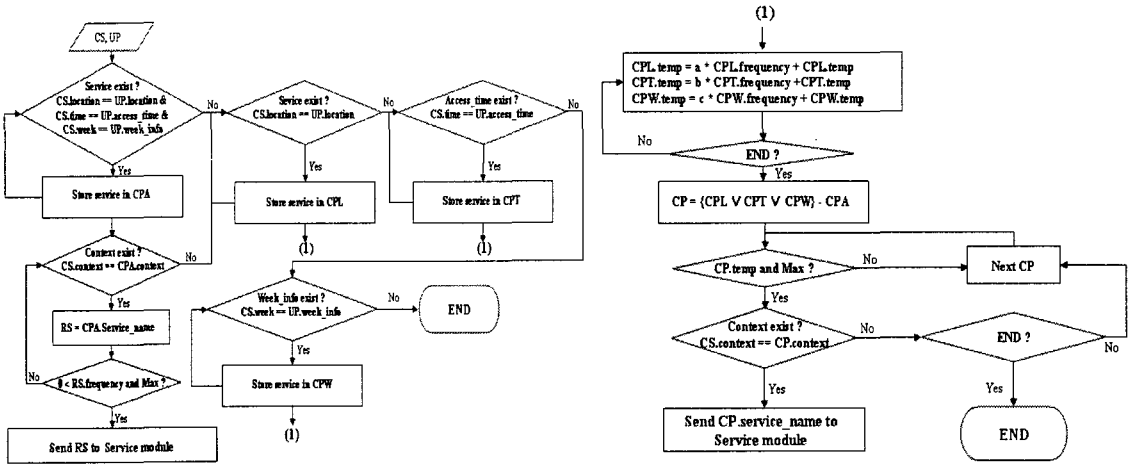
Flow chart of figure 2 is show how service analysis can process on DUPS, and notion of ECA is the following:

ON request event DUPS.request

IF $\exists l \in L$: match(UP.location, CS.location) $\wedge$

Table 2. Methods used for profile

Method	Description
Match (object1, object2)	true if the object1 same the object2, false otherwise
Analysis (context, l,t,w)	analyze the user's context and then recommend the service with location, time, weekend information
Prediction (l,t,w)	predict the user's service with location, time, weekend information



(a) (b)

Fig. 2. (a) Flow chart of service analysis process, (b) Flow chart of service analysis process.

∃t ∈ T : match(UP.access_time, CS. Access_ time) ∧ ∃w ∈ W : match(UP.Week _Info, CS.week_ info) ∧ ∃f ∈ N : ∀max ∈ N : max < f -> ∃ f(f) ∈ F

DO Analysis(c,l,t,w)

And if requesting service is existed in service storage, we could not need the searching process. Because we are already stored the information of service in service storage, we just have only to request it from service storage, and then provide the service to user. So, we are able to reduce the searching time of request service.

(2) Service prediction

Predict what service is going to use based inferred context to use the information of location, time, weekend in user profile. And we find service which frequency(f(f)) of service that appeared on prediction time(j) after current time(t) is the highest.

Flow chart of figure 3 is show how service prediction can process on DUPS, and notion of ECA is the following:

ON request event DUPS.request

IF ∃l ∈ L : match(UP.location,CS.Location)∧ ∃t ∈ T : match(UP.access_time,CS.access_time) ∧ ∃w ∈ W : match(UP.week_info, CS.week_ info) ∧ ∃t ∈ N : ∀j ∈ N : t < j < 24 -> ∃ t(j) ∈ T ∧ match(t(j), UP.access_time) ∧ ∃f ∈ N : ∀max ∈ N : max < f -> ∃ f(f) ∈ F

DO prediction(l,t(j),w, f(f))

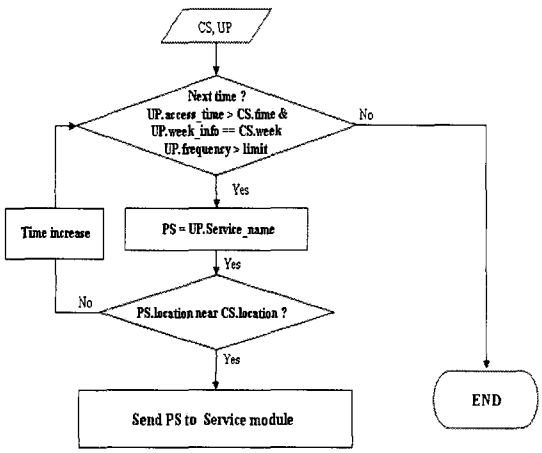


Fig. 3. Flow chart of service prediction process.

5. COMPARATIVE ANALYSIS

Figure 4 shows accuracy of recommendation in DUPS, COMPASS, Annie Chen. In this figure, technique, which annie chen was suggested, had a high accuracy on the whole, but our system had a low accuracy at beginning part, after this, it is increased. COMPASS system had a low accuracy on the whole. The DUPS system that we were suggested had low accuracy relatively by reason of rack of information about personal inclination. So our system wasn't able to an accurate recommend. But because our system was increased accuracy after collecting a information of personal inclination, in case of using the same services at the same time and location, our system has a good performance on processing time and recommendation accuracy.

Table 3 shows comparative analysis of each other, such as UbiData, TIP, DUPS. UbiData system suggest to use the profile with priority method

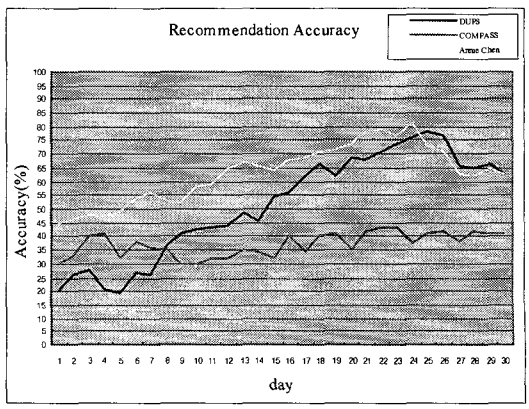


Fig. 4. Recommendation Accuracy.

Table 3. Comparative analysis of each method

	UbiData	TIP	DUPS
Information	File	Information	Service
Context	Frequency	Location, Time	Location, Time, Frequency
Personal inclination storage	Profile	Profile, History, Diary	Profile
Prediction	+	++	+
Accuracy	+	++	++
Data size	++	-	++
Privacy	-	+	++
Data Process time	++	-	++
Intervention	++	--	++

how user often used file. But as prediction of using file was decided by simple frequency value, this has a drawback that important element of ubiquitous, such as location, time, was not considered. TIP system that used information of location and time for providing user's interesting information. This system provided surrounding information to user, after compute how closed current user's location to location which stored in their history. But this system could not relatively consider time but mainly used information of location.

As shown table 3, DUPS that suggested by our has good performance as a whole. Especially, DUPS was able to improve than previous profile method in performance of prediction. In this table 3, (++) is mean very good, (+) : good, (-) : not bad, (--) : bad.

6. CONCLUSION AND FUTURE WORKS

In this paper, we suggest to DUPS which stored location and time, frequency information of often used service among various services, and put the service which will expect to use in any location. The system used a profile made in the form of an XML document, and classified information, which was used by users when context arose with elements such as location, time, date(week), and frequency. If the user is located at a specific place, our system provide service to the user through location, time, date(week), and frequency information, which is stored in the user's profile. The processing of similarity assessment between current and past context was very simple and fast, and more accurate than previous techniques. Therefore, we can reduce the recommending time of service, and are able to provide more accurate service.

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