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Filtering Technique on Mobile Cloud Computing

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Abstract

Mobile Cloud Computing has become as a new IT paradigm because of the growth of mobile device like smartphone and appearance of Cloud Computing environment. This mobile cloud environment provides various services and IT resources according to users' requests, so an effective providing of service and IT resources is required. Hence, this paper filtering approach based on resource usage frequency in mobile cloud computing in order to provide distributed IT resources and services to users based on context-awareness information. We also apply the context of usage location and time to it for improving recommendation.

Keywords: Filtering; Mobile Cloud Computing; Context-aware

1. Introduction

The market of mobile recently has been evolving rapidly and cloud computing is spreading into mobile as well. That is why mobile cloud computing is becoming a new issue today. Cloud computing is the computing that provides virtualized IT resources as a service by using Internet technology. In cloud computing, a user lends IT resources (software, storage, server, network) as needed, uses them, get a support of real-time scalability according to service load, and pays as he/she goes. Especially the cloud computing environment distributes IT resources and allocates according to user's request, so there should be a study on technology that manages these resources and effectively deals with it[1].

Mobile cloud computing creates a new chance for IT industry because it allows the superiority and economic of cloud computing to meet the mobility and convenience of mobile and draws a synergy effect for both. Also mobile cloud computing refers to an infrastructure that data storage and data processing is done outside mobile device by using cloud computing in the regardless of kinds of mobile devices.

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Mobile devices used in the mobile environment include personal information and enable to provide the environment that collects a variety of context-aware information. Users' demand on service types suitable for the individual situation has been increasing.

Therefore, context-aware reasoning technique has been studied to provide a suitable service for user by using user' context and personal profile information in mobile environment[2-9]. Also, various techniques of recommendation have been studied to provide services which fitted to user's situation. But, many techniques of recommendation are mostly based on Web. For example, they are various with researches on techniques to offer personalized recommendations, content, and services to user, and researches to solve problems related to legacy techniques of recommendation. Recently many researches based on ubiquitous environment are progressing. These researches introduce context into legacy filtering techniques. The legacy filtering techniques utilize two dimensions such as user and item information for recommending. And context is used various elements like time, location, companion, condition, and etc. It is used to perform the recommendation estimation about item.

These techniques improve certainly the recommendation accuracy. However they were passing over resource's usage frequencies. It indicates how often a specific resource is used. We are able to know how much user like a specific resource through this fact. Our main idea is that a preference resource is frequently used. Sometimes a preference resource may be not always used frequently. In this paper, we propose a recommendation technique through resource usage frequency is collected in mobile cloud computing. Also it applies context such as location and time.

2 Related Works

Mobile platform is mainly referred to mobile middleware what lets users operate the optimized contents or service on mobile and it provided a formed interface to UI and service by using RTOS (Realtime OS) and hardware function. There are Windows Mobile, iPhone, Android, Symbian, etc. as these mobile platform.

There are Context-aware information modeling techniques such as Key-value model, Markup scheme model, Graphical model, Object oriented model, and ontology based model which are used in the existing ubiquitous environment and Web environment. Ontology model, a Context-aware model which has been studied mostly recently, enables to express concepts and interactions easily. Recently ontology model has been studied lively related to Semantic Web study based on OWL(Web Ontology Language) and there is a movement to adapt ontology-based model in a variety of context-aware framework. One of the early methods of context modeling using ontology was proposed by Otzturk and Aamodt. Van Heijst divided ontologies into Structure Type and Concept Issues in the study for ontology. Structure Type is classified as Knowledge Modeling Ontology, Information Ontology and Terminological Ontology. Concept Issues is divided as Domain Ontology, Application Ontology, Representation Ontology and Generic Ontology[10]. Guarino classified ontologies according to general level to represent context of different kinds [11]. Top-level Ontologies describe general concepts like space, time, matter, object, event and action. Domain Ontologies and Task Ontologies describe the vocabulary related to a generic domain or a generic task or activity by specializing the terms introduced in the Top-level Ontology. Application Ontologies describe concepts depending both on a particular domain and task, which are often specializations of both the related ontology. These concepts correspond to roles played by domain entities while performing a certain activity. Context modeling in context-awareness needs to acquire context initially. Then it is necessary to process modeling to enable acquired context to use. Many projects have used context model with their certain type. Context Toolkit[12] suggested middleware layers that serve to convey to application after acquiring original information and transforming it into any type that application can be understandable. Hydrogen was developed by Hofer[13]. This system is based on

hierarchical architecture. This model's representation ability is admirable because it represented model with object-oriented method. But the representation formality is incomplete. Karen's context information model is based on object-oriented method. This modeling concept provides a formal basis for representing and reasoning about some of the properties of context information such as its persistence and other temporal characteristics, its quality and its interdependencies[14]. He attempted to model using both the Entity-Relationship model and the class diagrams of UML. CASS(Context-Awareness Sub-Structure)[15] is a framework for context-aware mobile application designed with middleware approach. By separating into application and context inference, this middleware can be able to infer context without recompiling. CONON(the Context Ontology)[16] is divided as Upper Domain and specific Sub Domain. The context model is structured around a set of abstract entities, each describing a physical or conceptual object including Person, Activity, Computational Entity and Location, as well as a set of abstract sub-classes. This model supports extensibility to add specific concepts in different application domain. It also supports the use of logic reasoning to check the consistency of context information, and to reason over low-level, but it's difficult to represent diverse context with upper context restricted selectively. However, these context models not sufficient on mobile cloud computing. Therefore, this paper proposes context model in order to manage resources more effectively by using personal context information and do modeling context-aware information in mobile platform and reason.

And, recommender system performs a role to help users with selection of items that they do not previously experience[20, 21, 22]. To do so, we recommend an item that user can like. For this, recommender system is based on rating for items. But in the case of an item that user does not experience, there is no rating for the items. Therefore, recommender system should be able to estimate rating for unrated item. Rating for unrated items can be estimated with various methods. Content-based filtering, collaborative filtering, and hybrid filtering can be classified according to method of rating estimation and method of recommendation generation [17].

Many current content-based systems focus on recommending items containing textual information, such as documents and Web sites URLs[18, 22]. For generating recommendation about textual information, Term Frequency/Inverse Document Frequency(TF-IDF) measurement was proposed to estimate the weight of keywords[22]. It is based on the frequency of keywords. Also Bayesian classifiers and other techniques are used in content-based recommendation[26]. These techniques calculate utility predictions based on a model learned from the underlying data using statistical learning and machine learning techniques. Collaborative filtering systems try to predict the utility of items for a particular user based on the items previously rated by other users. This is the difference with content-based recommendation methods. More formally, the utility u(c,s) of item s for user c is estimated based on the utilities u(cj,s) assigned to item s by those users(cj C) who are "similar" to user c. For example, in a movie recommendation application, in order to recommend movies to user c, the collaborative recommender system tries to find other users that have similar tastes in movies. Then, only the movies that are most liked by the "peers" of user c would be recommended. Collaborative recommender systems are applied in various applications such as GroupLens, Video Recommender and Ringo. Collaborative recommendations can be grouped into two general classes: memory-based and model-based. Memory-based algorithms essentially are heuristics that make rating predictions based on the entire collection of previously rated items by the users[18, 23]. Model-based algorithms use the collection of ratings to learn a model, which is then used to make rating predictions[23, 24, 25]. Several recommendation systems use a hybrid approach by combining collaborative and content-based methods, which helps to avoid certain limitations of content-based and collaborative systems[17, 19, 27, 28].

3 Technique of Recommendation

Most of recommender system provides recommendation about users and items. And the recommendation space is two dimensions(users and items). Similarity of user groups and ranking of items are appropriate criteria as recommendation. However, for the accuracy of recommendations, more information and processing technique is needed. In this paper, we research improving recommendation accuracy by adding a context and resources on mobile cloud computing. So, we propose a technique of recommendation that is added additional recommendation space. Additional recommendation space is the context about location and time, resource.

3.1. Information Aggregation

Mobile cloud computing network is consisted of wireless embedded sensor devices and exchanges information in wireless communication. It adheres RFID(Radio Frequency IDentification) to everything. And it is able to detect the situation through context awareness and generate real-time connection for managing information. Consequently mobile cloud computing means the environment that is able to communicate anytime, anywhere and anything. We will aggregate the data for recommending services in this environment.

In this paper, data is defined all used information by user. For example, trousers, mobile phone, PDA, watch, shoes, classes, bag, software, CPU, storage, network and etc are available information. RFID can be embedded in these items. Item's identification information and current user's location and time can be aggregated from them. Location is derived information from sensed data. Time is sensed time.

We can know users context through item's id, location and time information. Location is not user's current location. It means the kind of location. Since we need only user preference, fined-grained information about location is not needed.

Aggregated information is able to use for recommending services. To do so, we have to analyze resource's usage frequency. We can obtain users preference through the analysis of usage. This information is context and filtering criteria.

3.2. Profiling of Aggregated Information

Aggregated information means user's information. To analyze user's taste, data modeling procedure is needed. It transforms data into more consistent form. Mostly modeling is used the profile or database. Specially, in mobile cloud computing, context-aware information which can be used is user's profile, services that user was used, resources for providing services. And we need to techniques of recommendation in order to manage resources more effectively on mobile cloud computing, multimodal techniques for supporting convenient user's interface, inferring user's intention more accurately. So, we include entity such as provision, activity. Figure 1 shows each entity and relational property.

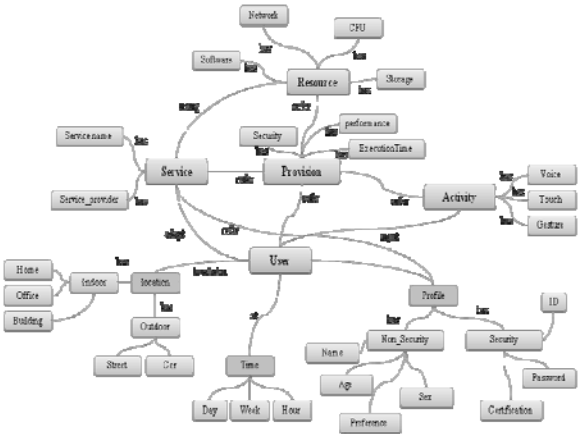

Fig.1 Context model Suggested platform architecture

In this paper, generic ontology is user, service, resource, provision, activity. And they are connected with each other through relational property(eg. Locatedin between User and location). Individual generic ontology includes domain ontology as a detailed material and immaterial entity(eg, User and location). Consequently, it provides extensibility and formal representation ability by hierarchical ontology classification.

3.3. Recommendation Generation Process

Context data is not applied directly for recommending services because context is only situation. To apply context, recommender system requires user's preference that is derived from context. Therefore we propose context analysis technique for generating preference. This technique analyzes separately location and time, resources information. It makes a result that means resource usage frequency. Resource usage frequency(RUF) is consisted of three part, RUF_t(time), RUF_l(location), RUF_r(resources).

The analysis processes are consisted of four steps. Each operation is performed by recommender system. First, system extracts context from resource usage database. Second, it divides context by location or time, resources. Third, it estimates one item's frequency based on location and time and resources. The results are $IUF_{i,l}$ and $RUF_{i,t}$, $RUF_{i,r}$. Finally, it estimates $RUF_{i,l,t,r}$ using $RUF_{i,l}$ and $RUF_{i,t}$, $RUF_{i,r}$.

We can take any item's RUF depending on location and time and resources through the above analysis procedure. The mid-result $RUF_{i,l}$ means how frequent an user uses services i in any location. And $RUF_{i,t}$ means how frequent an user uses services i in any time. $RUF_{i,r}$ means how frequent an user uses services i on any resources.

3.4. Estimating Resource Usage Frequency

All resources can denote a set. It is consisted of several sets. That is, $I=\{il_1,t_1,r_1, il_2,t_2,r_2 \ldots il_n,t_n,r_n\}$. An element of resources set il,t,r means that it is a location, time, resource when an services are used. One service's $RUF_{i,l,t}$ is defined like below:

$$RUF_{i,l} = \frac{if_{i,l}}{if}, \quad RUF_{i,t} = \frac{if_{i,t}}{if}, \quad RUF_{i,r} = \frac{if_{i,r}}{if}$$

$$RUF_{i,l,t} = \frac{RUF_{i,l} + RUF_{i,t} + RUF_{i,r}}{3}$$

if is the total appearance frequency of an services. if_l is the appearance frequency where location is *l*. if_t is the appearance frequency when time is *t*. if_r is the appearance frequency what resources is *r*. RUF is able to be denoted as R(*i*, $RUF_{i,l,t}$, *location, time*).

4 Conclusions

Context modeling in context-awareness needs to acquire context initially. And then it is necessary to process modeling to enable acquired context to use. In this paper, we have proposed context model to provide users with suitable services and manage resources effectively by using context information in the Mobile Cloud environment. We have also defined context for modeling through diverse context definitions. We have classified ontology and represent hierarchically. The proposed context model by the paper is expected to help have the optimized personalized service and effective IT resources management in the Mobile Cloud environment. And we proposed a novel recommendation approach based on aggregated information. This approach classifies aggregated information into location and time and resources and writes them to profile. And then recommender system analyzes them for generating context. The analyzed context is resource usage frequency.

Our approach is not main filtering approach. That is, it's role is the assistance for improving the legacy filtering approach and expanding recommendation environment into mobile cloud computing. Therefore our future work is to integrate our approach to legacy filtering approach and to perform sufficient experiments on mobile cloud computing. Also, we will include additional function for inference. Also we will try to progress in a study that interpret and inference the high level context, and study the resources management technique that manages distributed IT resources effectively by using context information, and the part that examines the performance and tests after embodying the actual platform proposed.

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