A Service Provision Model Based on Context Awareness for Ubiquitous Computing

Faqun Jiang\textsuperscript{1,2}, Jintao Li\textsuperscript{1}, Zhenmin Zhu\textsuperscript{1}

\textsuperscript{1}Ubiquitous Computing Research Center, Institute of Computing Technology, Chinese Academy of Sciences
\textsuperscript{2}Graduate School of the Chinese Academy of Sciences
Beijing, P. R. China
fqjiang@ict.ac.cn

Abstract

Ubiquitous computing environment has become more popular as a highly open, heterogeneous and service-rich domain, which makes it essential and important for end-users to build a reasonable service provision model. The critical issue for service provision is how to sense context information and provide personalized services according to current context and user’s requirement. This paper presents a service provision model based on context-awareness for dynamic ubiquitous computing environment called C-SPM. C-SPM provides context-aware service that is aware of context information, and uses intelligent provision mechanism to provide personalized services for users according to their context and requirements.

1. Introduction

Ubiquitous computing environment\cite{1} is a highly heterogeneous, service-rich domain which offer a wide range of services in many different types. On the one hand, the diversity of service has provided the probability of choice and new interaction for end-users. On the other hand it becomes more complicated and difficult to automatically present the appropriate services for end-users because services that end-users want and need are only a little part. At the same time, due to the mobility of end-users and the difference of ubiquitous terminals need to provide the appropriate services according to the user’s activity and intent. However, the traditional provider-centric service model(e.g., RPC-based client/server model, thin-client computing model, etc.) often results in dissatisfied users and inefficient service utilization for providers because it is not aware of context information related to current computing environment and user’s activity\cite{2}. So, how to build an appropriate service provision model in such an open, dynamic computing environment is a new challenge.

Based on our previous works, a service provision model based on context-awareness (C-SPM) is presented in this paper, which addresses the issues around how to effectively provide personalized services in a context-adaptive way.

2. Design of C-SPM

2.1. Basic definitions

In order to design an appropriate service provision model, ubiquitous computing environment needs to be abstracted.

\textbf{Definition 1}. Service $S$ is a function that is well defined, self-contained, which can be defined a triad, that is, $S=\langle S_N, S_D, S_A \rangle$, where $S_N$ represents the name of service; $S_D$ represents the descriptions of service; $S_A$ represents the attributes of service which can be defined a bi-tuple, that is, $S_A=\langle FA, NFA \rangle$, $FA$ represents the functional attributes of service, such as service interface, $NFA$ represents the non-functional attributes of service.

\textbf{Definition 2}. Effective Space is aggregation of all service available to users in ubiquitous computing environment, which denotes $E_S$.

\textbf{Definition 3}. Service Community $SC$ may be defined a bi-tuple, that is, $SC=\langle V_S, V_R \rangle$, where $V_S$ is the set of virtual service; $V_R$ is the set of semantic relationship of virtual service.

\textbf{Definition 4}. Abstract Space $A_S$ is the set of all service communities.

\textbf{Definition 5}. User Space is the set of all users’ service spaces that comprises of service interface, which denotes $U_S$. 

Definition 6. Context Space is the collection of context-aware components for environment and end-users, which denotes $\mathcal{C}_S$.

Definition 7. C-SPM may be defined a quaternion, that is, $\text{C-SPM} = \langle \mathcal{E}_S, \mathcal{A}_S, \mathcal{U}_S, \mathcal{C}_S \rangle$. Where, $\mathcal{E}_S$, $\mathcal{A}_S$, $\mathcal{U}_S$, $\mathcal{C}_S$ respectively denotes Effective Space, Abstract Space, User Space and Context Space. C-SPM is a model of distributed computation.

2.2. Context-aware service

In C-SPM, context could be seen as a higher-level abstraction of all static and dynamic data, stored in databases or produced by dynamic acquisition tools and sensors.

The forming process of high-level context needs use several collaborating components: context wrapper, context aggregator, context knowledge base, context reasoner and context query interface. Context wrappers obtain raw data, static or dynamic information from various sources such as hardware sensors and software programs. There are various context wrappers such as location context wrapper, environment context wrapper, etc. Context aggregator is responsible for discovering context wrappers and gathering context markups from them. Context knowledge base provides persistent context knowledge storage. Context reasoner infers abstract, high-level contexts from basic contexts. Context query interface is responsible for handling queries about both low-level context and high-level context.

2.3. Intelligent provision mechanism

To adapt user’s personalized requirement and the characteristic of ubiquitous computing environment, intelligent provision mechanism is presented. The service provision process in the C-SPM paradigm can be broken into the following three steps:

1) Preprocessing phrase. In this phrase services in service communities will be filtered according to user’s basic information (e.g., user authority, user identity) while user login. Thus, the initial set of services will be obtained.

2) Recommendation phrase. The recommendation rating of service in the initial set will be computed according to the context information related to current computing environment and user’s activity. In order to take into the consideration the contextual information, multidimensional recommendation model[3] is applied to solve the problem of service recommendation. The multidimensional recommendation model is defined as follows:

$$R: \mathcal{C}_1 \times \mathcal{C}_2 \times \ldots \times \mathcal{C}_n \rightarrow \text{Rating} \quad (1)$$

Where, $\mathcal{C}_i$ denotes the input information which represents context, such as user’s location, network bandwidth and so on; Rating is the output of recommendation result, which indicates the degree that service meets the preference of user.

3) Selection phrase. In this phrase, the optimal service will be selected from candidate services according to user’s requirement. Since QoS is an important factor for service selection, we use QoS-aware approach which is similar to the approach in [4]. To support the service selection based on QoS constraints that include cost, reputation and reliability, we define a utility function $Q_s$ to represent the degree that service’s QoS attributes meet user’s QoS requirement.

$$Q_s = \sum_{j=1}^{i} (\omega_j \times q_j) \quad (2)$$

Where $\omega_j \in [0,1]$ represents the weight by the end-user to the j-th quality criterion $q_j$ and $\sum_{j=1}^{i} \omega_j = 1$. End-users express their preferences regarding QoS by providing values for the weight $\omega_j$. The computing process of $Q_s$ includes two phases: normalization phase and weighting phase.

3. Conclusions

In order to better meet user’s personalized demand and the characteristic of ubiquitous computing environment, this paper presents a service provision model based on context-awareness, which called C-SPM. It provides context-aware service and intelligent provision mechanism to provide personalized services for users. It has been applied in “R&D Infrastructure and Facility Development of China” that comprises a lot of heterogeneous interactive GUI services (e.g., legacy applications, web services, etc.).

4. References