An Adaptive e-Service for Bridging the Cloud Services by an Optimal Selection Approach

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***Abstract*—The information technology industry designs various e-services based on the fast delivery, powerful computing and large storage capacity of cloud computing systems. Specifically, the service provider develops e-service markets within a cloud computing environment with which to provide the e-services. The use of information technology, insofar as helping people obtain reasonable e-service, provides challenges to innovative service providers. In this work, we propose an adaptive e-service for linking users and the cloud services. Our work is based on user profile, specifically, on a role-based access control model with which to identify the user and assign a specific role. A user with a specific role is then authorized to access the various e-services in the cloud computing environment. Then, the utility function and multi-criteria decision analysis model are deployed to optimize the e-service selection with regard to various cloud services. Our aim is that the proposed adaptive e-service will be able to assist people in obtaining e-services in cloud environments.**

***Index Terms*—adaptive e-service; role-base access control; utility function, multi-criteria decision analysis**

I. Introduction

Cloud computing is a powerful new service that provides fast delivery, powerful computation and increased storage capacity [7]. The service models of cloud computing include: *Software as a Service* (SaaS), *Platform as a Service* (PaaS) and *Infrastructure as a Service* (IaaS). In the SaaS and PaaS models, enterprises are able to use cloud computing techniques to deploy computing resources, integrate heterogeneous platforms and provide various cloud computing services for users [1]. Various software service portals, e.g., Apple app stores or Google Play, provide channels through which users are able to acquire software services from service providers [2]. Users are able to acquire cloud computing services in order to satisfy their specific requirements.

Challenges regarding the use of information technology in helping people obtain a specific e-service in cloud services environments currently require more attention. In this work, we propose an adaptive e-service for bridging cloud services. The service is based on user profile, mainly through a role-based access control model [10] to identify and assign a specific role. The purpose of access control centers on determining whether a user has permission to use or change a particular resource and on preventing users from abusing resources. The role-based access control model for assigning user permissions (based on roles) can reduce the instances of permission assignment and resetting. As such, this model reduces the complexity and cost of security management. The user with a specific role is authorized for adaptive access to the e-services in a cloud services environment [13].

Quality of service (QoS) is an important factor in evaluating an authorized e-service. User feedback regarding a negotiating process can be represented as a utility function reflecting the satisfaction a user reports after using an authorized e-service [11]. The user provides such a utility function [5][6] before committing to use an authorized e-service. Therefore, the user's utility function can be applied to the monitoring information in order to evaluate the authorized e-service's QoS. Notably, selecting a reasonable authorized e-service from a large number of candidate authorized e-services requires a multi-criteria decision analysis.

A multi-criteria decision analysis [3] is concerned with structuring as well as solving decision and planning problems involving multiple criteria. The purpose is to support decision makers facing such problems. Typically, since a unique optimal solution does not exist for such problems, it is necessary to use a decision maker's preferences to differentiate solutions [5]. Therefore, a multi-criteria decision analysis is required to formulate the selection order of the various candidate authorized e-services. The formulated selection order helps to optimize the user's ability to obtain a reasonable authorized e-service from various candidate e-services [6].

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The remainder of this paper is organized as follows. Section II reviews related works on cloud computing services, role-based access control, utility function and multi-criteria decision analysis. Section III introduces the functionality of the proposed adaptive e-service for bridging cloud services. In Section IV, we present our conclusions and indicate possible directions for future work.

II. RELATED WORKS

The related literature covers cloud computing services, role-based access control, utility model and multi-criteria decision analysis.

A. Cloud Computing Service

The volume of business data increases enormously when an enterprise grows, creating a need for powerful servers and enormous bandwidth capacities. Furthermore, software is revised continuously. Experts must be hired to manage this transformation and this recursive updating process consumes numerous resources [6]. Cloud computing is a new service which aims to reduce the cost of IT services, promote processing ability, reduce processing time and enhance reliability, usability and flexibility. A cloud computing [7] service enables enterprises to use remote platforms to obtain enormous amounts of computing power. Cloud computing services also provide relevant software services in order to reduce the cost of software construction and maintenance.

Cloud computing services significantly reduce enterprise costs and increase the effectiveness of business processes [1]. Enterprises are able to use cloud computing techniques to deploy computing resources, integrate heterogeneous platforms and provide various cloud computing services for consumers [2]. The service models of cloud computing include: *Software as a Service* (SaaS), *Platform as a Service* (PaaS) and *Infrastructure as a Service* (IaaS). In the SaaS and PaaS models, enterprises are able to use cloud computing techniques to deploy computing resources, integrate heterogeneous platforms and provide various cloud computing services for users [1]. Various software service portals, e.g., Apple app stores or Google Play, provide channels through which users are able to acquire software services from service providers [2]; users can acquire cloud computing services to satisfy their specific requirements.

B. Role-Based Access Control (RBAC)

The purposes of access control are to determine whether a user has permission to use or change a particular resource and to prevent users from abusing resources. Notably, traditional access control directly assigns access responsibilities to a user. Therefore, access permissions must be set for each user. When a user's access permission is changed, the authorized permission must be reset. In 1996, Sandhu et al. proposed a *Role-Based Access Control Model* (RBAC Model), which consists of four basic elements: *users*, *roles*, *permissions* and *sessions* [10]. Figure 1 presents the model structure.

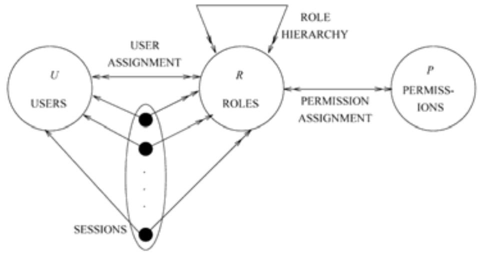

Figure 1. Role-Based Access Control Model [10]

The base model adds roles between users and permissions. The user is not directly granted permission but is assigned an appropriate role according to which s/he obtains the appropriate permission. Each user can be assigned different roles and each role can be assigned to multiple users. Specifically, the relationship between role and permission is similar. Therefore, the access control model for assigning user permissions based on roles can reduce the number of instances of permission assignment and resetting. Notably, roles have hierarchical relationships. Roles are able to inherit permissions and constraints from other roles to reduce the number of roles and the complexity of role-permission assignments. Here, an active RBAC [13] is combined with the active database. This model solves the real-time processing problem of the RBAC models. It authorizes appropriate access operations for the demand of an automated management system insofar as providing the effective service architecture.

C. Utility Model and Multi-criteria Decision Analysis

QoS is an important factor in evaluating a service. The user feedback of an evaluation process can be represented as a utility model reflecting the satisfaction gained from choosing a service [11]. The user provides such a utility model [5][6] before committing to take an action. Service information analysis can quantify all of the influences of the various factors and their relationships to consolidate the utility model. Therefore, the user's utility model can be applied to the monitoring information in order to evaluate the service's QoS. The user will get the expected value of the issue of interest by choosing a service.

Multi-criteria decision making (MCDM) [3][5][6] approaches have played important roles in solving multi-dimensional and complicated problems. MCDM is concerned with structuring and solving decision-planning problems involving multiple criteria. The purpose is to support decision makers facing such problems. Typically, since a unique optimal solution does not exist for such problems, it is necessary to use a decision maker's preferences when differentiating solutions.

ELECTRE (Elimination Et Choice Translating Reality) is a family of multi-criteria decision analysis methods. ELECTRE methods are developed in two main phases. In the first phase, the outranking relations are constructed for a comprehensive comparison of each pair of actions. In the second phase, the recommendations are elaborated upon from the results obtained by an exploitation procedure from the first phase. The nature of the recommendation depends on the problems, i.e., choosing,

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ranking or sorting. The evolutions of ELECTRE methods include: ELECTRE I, ELECTRE Iv, ELECTRE IS, ELECTRE II, ELECTRE III, ELECTRE IV, ELECTRE-SS and ELECTRE TRI. Each method is characterized by its construction and exploitation procedure. ELECTRE I, ELECTRE Iv and ELECTRE IS were designed to solve choice problems. ELECTRE II, ELECTRE III, ELECTRE IV and ELECTRE-SS were designed for solving ranking problems. ELECTRE TRI was designed for solving sorting problems.

III. THE FUNCTIONALITY OF AN ADAPTIVE E-SERVICE FOR BRIDGING CLOUD SERVICES

This section introduces the functionality of an adaptive e-service for bridging cloud services, including personal data characterization, the active role-based access control model, authorized e-service formalization by a utility function and determining the selection order of authorized e-services through the modified ELECTRE method [3].

A. Personal data charactrization

Personal user preferences and operational data forms the user profile [5][6]. Information retrieval techniques [9] are used to extract key terms from a user's personal data. The extracted key terms form a profile to represent the informational needs of users in regard to acquiring cloud services. Moreover, the profile can be generated according to the context of the user operation, e.g., searching for, selecting and rating cloud services. According to certain contexts, the key terms are also recorded in a user profile. This work is based on the user profile, mainly through the RBAC model to identify and assign the specific role [13]. The user with a specific role is authorized adaptive access to the e-services in the cloud services environment.

B. Active database and role-based access control(RBAC)

The *events-condition-action* rule (ECA rule) is the most common method with which to construct the active database [4][8]. Each rule is composed of three parts. When an event occurs (*on event*), in accordance with the pre-set conditions (*if condition*), the active database responds by performing actions according to the reactions that are implemented by the system manager (*do actions*). Events are caused by user operations, the system, regular action, or responses to derivative action. When an event satisfies the conditions in the set rules, it is known as the trigger. The rules that can be divided are regular or reactive. A regular rule is usually based on time; it refers to events at a specific time or in a fixed time interval. A reactive rule is used to identify user-generated events. Therefore, through the enforcement of ECA rules, the system not only monitors context to enable unexpected events to be processed immediately, but also has the capacity to respond without human intervention [12][13].

An active RBAC model [13] is combined with the active database. This model solves the real time processing problem that is associated with the previous proposed RBAC models. It authorizes appropriate access operations for the demand of an automated management system insofar as providing the effective service architecture. The ECA rules replace the session element of the traditional RBAC model [14]. Based on an identified user operation event, the proposed model receives the request to authorize. Based on the application of the rules, an appropriate role is assigned to the user. Finally, the model considers the organizational policy to assign permission to the user. The model reviews and changes user permissions based on an identified event that has been altered in the environment.

C. Authorized e-service formalization by an utility function

The authorized e-service formalization is the initial and an essential task in the selection approach. This paper refers to a utility-based reputation model [5][6][11] to formalize an authorized e-service's QoS items in order to reinforce the utility function.

Let $X = \{x_1, x_2, \ldots, x_n\}$denote the set of authorized e-services, and $x \in X$. Let SP denote the set of e-services providers, $b \in SP$, and function S: $SP \rightarrow P(X)$ denote the solutions provided by an e-service provider, where P represents the power set operator. Let SW denote the set of user of the system and $u \in SU$. Each authorized e-service has associated issues of interest, denoted by set I, which users are interested in monitoring, and $i \in I$. Function IS represents the set of issues of interest for an authorized e-service: $IS : X \rightarrow P(I)$. Function O^u: $X \times SP \times I \rightarrow R$ denotes the expectation of the user u for the authorized e-services they undertake, where R denotes the real numbers. Notation $v_{s,i}^{u,b}$ represents the expectation of user u on issue i concerning authorized e-service s supplied by provider b.

In a cloud service environment, a potential issue of interest could be the QoS. Based on their expectations, a user can develop a utility function which reflects the satisfaction they perceive from choosing an e-service.

D. Determining a selection order of authorized e-services through the modified ELECTRE method

For the second task, the modified version of the ELECTRE method [3][5][6] is used to determine the optimal selection order of an authorized e-service. To calculate the weighted normalization decision matrix, a weight for each QoS item must be set to form a weighted matrix (W). The multiplication of a normalization matrix Q by a weighted matrix W obtains the weighted normalization decision matrix V ($V = QW$). Compare arbitrary different row i and row j in the weighted normalization decision matrix V to verify the concordance and discordance sets, respectively.

If value v of row i is higher than value v of row j, the component k can be classified as the concordance set C_{ij}, or the discordance set D_{ij}. The sum of each component's weight forms a concordance matrix C. A discordance matrix can be presented as $D = [d_{ij}]_{m \times m}$. The reverse complementary value is used to modify D to obtain the modified discordance matrix D'. To show the large

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component value of the candidate solution when the expected value is larger, we combine each component C_{ij} of the concordance set with the discordance matrix to calculate the production and obtain the modified total matrix A.

Obtain the maximum value a_j of each column from the modified total matrix. The purpose is to determine the modified superiority matrix. To ensure a reasonable solution, we have to rank a_j from small to large: a_1, a_2, …, a_m. The threshold $\bar{a}$ is set behind the smallest value $a_1^{'}$ and the next smallest value $a_2^{'}$. If the value a_{ij} is smaller than threshold $\bar{a}$, it is replaced by 0 or 1. Then, we get the modified total superiority matrix.

Finally, the matrix E' indicates that authorized e-service i is better than authorized e-service j. We can eliminate authorized e-service j and show it as: $A_i \rightarrow A_j$. The relationships between the QoS items of the candidate authorized e-services as well as the optimal selection order for all authorized e-services are obtained. The authorized e-service is the solution provided by an e-service provider. The user can follow the selection order to obtain a reasonable authorized e-service.

IV. Prototype System Demonstration

A prototype system was developed to demonstrate the effectiveness of the proposed adaptive e-service. The server side implementation was conducted using several software tools: Windows 7 32bit, AMD Athlon(tm) IIX2 245 Processor 2.90GHz, system memory is 2 GB, Hard Drive is 320GB. This paper uses a mobile device as the client side to send cloud service requests to the server side. The adaptive e-service executed on the server side in the prototype system bridges the clients' requests and cloud services. The application developed for the client side uses software tools which include: the Android SDK version 4.0.3, *Android Development Tools* (ADT) version 20.03, *Java Development Kit* (JDK) version 1.7, Eclipse Classic 4.2.1, and SQLite. The testing mobile device is an Asus Eee Pad Transformer TF101, the operating system is Android version 4.03, system memory is 1GB and data storage capacity is 16GB, supported by WLAN 802.11b/g/n protocols of communication.

The proposed adaptive e-service uses the RBAC model to assist in cloud services bridging. This paper uses a healthcare e-platform as a demonstrative case. Users are assigned different roles based on the RBAC model. After login, the user with one or more specific roles may want to fetch the reasonable healthcare cloud services with which to enforce the jobs. An example of an RBAC model designed for doctors is shown as Fig. 2. The user-role permission is defined by XML tags which illustrate the doctor's abilities. The RBAC model in an e-platform helps the proposed adaptive e-service to filter out the cloud services that the user has no permission to use.

Additionally, the proposed adaptive e-service uses a utility model to evaluate each authorized cloud service's expected utility value. The expected utility values of candidate cloud services are used by a multi-criteria decision analysis to obtain an optimal selection order. The selection order optimizes a user's ability to make an appropriate decision. The selection order also helps the user to access the cloud services. Notably, the proposed adaptive e-service is easy to implement and deploy in a modern e-platform bridging cloud services

```xml
<role>
    <name>主治醫生</name>
    <cardinality>1</cardinality>
    <permission>
        <record id="1" name="病歷記錄" set="讀" />
        <record id="2" name="用藥記錄" set="讀" />
        <record id="3" name="診斷記錄" set="讀/寫" />
        <record id="4" name="飲食記錄" set="讀" />
        <record id="5" name="巡訪記錄" set="讀" />
        <record id="6" name="生理數據記錄" set="讀" />
        <record id="7" name="電子處方簽" set="讀/寫" />
    </permission>
    <constraint>
        <role id="1">藥師</role>
    </constraint>
</role>
```

Figure 2. The RBAC module is implemented using XML tags

Fig. 3 illustrates the user waiting for the cloud service contents bridged to the proposed adaptive e-service. The case use shows that users want to get healthcare cloud service files based on their role and permissions; they can access the healthcare cloud service file content. Fig. 4 illustrates the user acquiring the cloud service contents bridging from the proposed adaptive e-service. The case use shows that users obtain two cloud service "電子處方簽" files of a specific patient based on their role. Then, the user can access the cloud service files to enforce their role permissions to read or modify the cloud service file content.

Figure 3. An adaptive e-service for bridging cloud services

Figure 4. User gets the reasonable cloud service contents

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V. Conclusions

We have proposed an adaptive e-service for bridging cloud services. It is based on the user profile, mainly through the RBAC model to identify and assign specific roles. The user with a specific role is authorized access to the various e-services in a cloud services environment. As stated, QoS is an important consideration in evaluating an authorized e-service. With this in mind, user feedback from a negotiating process can be represented as a utility function reflecting the satisfaction a user obtains from using an authorized e-service. Then, a selection method is used to optimize the process. The contribution of this work is such that the proposed adaptive e-service can assist people in obtaining authorized e-services in cloud services environments.

Future work includes intelligent binding of e-services and negotiation between e-services based on service level agreements. Notably, E-service binding requires huge levels of computing power and intelligent tuning which limits current abilities. However, well-designed algorithms can allow the binding process to take place quickly in cloud service environments. Determining an effective negotiation process between user and service provider is also an important research topic for bridging cloud services.

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