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Information System Meta-Synthesis Research Based on SOA

Shibin He*, Juhui Cao and Yi Zhang

Department of Military Engineering, Logistics Engineering University, Chongqing, China

Abstract: This paper is to about the main contents and basic working principles of information system meta-synthesis based on SOA. In the anterior part of the paper, we explained the current situations of the information system management and working conditions, and pointed out the reasons why we had to think over the disadvantages and advantages of information system meta-synthesis. In the middle part of the paper, we point out the basic principles of SOA, and introduced the layers of the SOA structure. And then, we created a probable architecture of the information system meta-synthesis based on SOA. In order to explain more clearly of this structure, the papaer described the mapping relationships between task requests and services by using nodes network structure, and some mathematics methods or models were used to analyze. Some formulas were also used to express the longest and the average distance of the services responding time. Three main physical layers were created in this architecture, public core service layer, service construction layer and service application layer. Each layer contained different services and achieved different functions. Finally, we took a certain area information system as an example to illustrate the main contents of this structure, and analyzed the relationships among those layers. In the end of the paper, we summed up all the advantages and superiorities of information system meta-synthesis based on SOA, and proposed the research keynotes in the future.

Keywords: Information system, interface, meta-synthesis, SOA, web service.

1. INTRODUCTION

With the development of computer science, each branch in information system becomes mature both in theory and practice. The traditional way that considering application subsystem, organizational structure and procedure flow separately leads to more and more problems and difficulties. Consequently, when systems engineering is applied to such complex systems as social, economic and environmental problems, it is found that due to characteristics of systems – uncertainty, multi-dimension, multi-goal and multi-mechanism, in the process of system modeling a lot of new problems arise, which are related to social economy, environment and politics and whose factors are difficult to describe in a quantitative way [1]. However, traditional application sub-system can only play a limited even no role in some parts in the organization. Therefore, people start to reflect on system itself and system approaches in order to find a way out from the basis. Hence the deep research on ideology and theory of system science and approach of system engineering [2].

Research on system science gives arise to many implications. Can disperse sub-systems play their roles continually and to what extent? Can function modules in use be restructured to form a comprehensive large-scale system? Answers to these questions above are principles of system meta-synthesis, which in fact is a process of integrating various disperse elements or units into a more harmonious one and sharing internal resources to lead better results to the whole system [3]. As for information system meta-synthesis, in the definition of Information Technology Association of America (ITAA), it is a process in which a variety of products and technologies, as required by a complex information system or subsystems, are connected into a solution.

Rapid development of society demands efficiency, flexibility and dynamic reorganization of the information system, which then depends on new theories and approaches. Currently, research on intelligentization of the complex large-scale system (including the integrated information large-scale system) is a fast-developing brand-new field. Integrated information system is bound to develop into intelligent information system. Service-oriented Architecture (SOA), which is of loose coupling, supports efficient meta-synthesis of application system and procedure flow changes in accordance with needs, provides a new concept and practical approach for the information system meta-synthesis [4]. Many researchers have concentrated their focuses on this subject and have got some achievements, like the enterprise integration information system. Many big companies have got their own integrated information systems which support the main functions and daily businesses.

When the information system is meta-synthesized with SOA, grid information infrastructure used as a platform, original system components are re-developed and encapsulated per the standard interfaces and protocols, system resources are connected accordingly and service is combined and reused quickly, so that system's requirement for "plug-and-play" can be met and system meta-synthesis can be achieved [5]. Ability for such dynamic reorganization and redistribution greatly improves the overall flexibility of the organization.

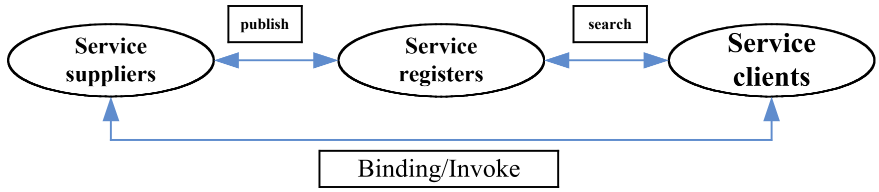

Fig. (1). Web service structure model interaction schematic.

In order to accommodate the new development situations of information system, this essay is meant to describe the main contents and basic principles of the information system meta-synthesis based on SOA [6]. The first research keynote will focus on the mapping relationships between the task requests and services description, which will sharply affect the efficiency of the information transportation between different function parts. Some parameters and formulas will be made to describe the longest and the average distance of the services responding time. The second research keynote comes to the architecture and the model. In the back part of the essay, brief and basic architecture of the information system meta-synthesis based on SOA will be introduced. The architecture will contain the main physical parts and function parts, which will play different role in information system integration construction. Physical parts will be made up of public core service layer, service construction layer and service application layer. Function parts will include security service, index service, storage service, transfer service and other encapsulated services. Encapsulated services and function areas are connected through service application layer [7].

A certain designated information system model will be created in the following part, and four layers are to be made, included sporadic small-scale systems layer, encapsulated web services layer, UDDI registration center and customer use layer. Each layer plays an independent role in the system network and connects with each other through different interfaces and mapping relationships. In a word, this essay will figure out the current situations and disadvantages in information system integration construction, analyze the reasons and point out the basic solutions [8]. For further research, this essay will also put forward some mathematical methods and system meta-synthesis architectures for the future development.

2. PRINCIPLES AND ADVANTAGES OF SOA

SOA (Service-Oriented Architecture) is a systematic structure orienting service, which aims at reusing service in the application to the greatest extent in order to improve adaptability and efficiency of software [9]. Given the standardization and assemblability of SOA, the key technology based on SOA resource integration is encapsulating original resources into service and then combining new developed service and original of service encapsulation, which results in the integration of information resources.

Compared with traditional modes, SOA has accurately-defined standard interfaces, is a coarse-grained and loose-coupled service structure and can be well encapsulated and integrated. SOA has flexible and powerful service layers and integrates most of services which are coarse-grained and can be passively dynamically discovered and bound. These services can be realized with different technologies and methods in different platforms. With these services, application system which is loose-coupled and of the ability to process information across platforms can be established. Furthermore, SOA is irrelevant to platforms and languages, so there is no need taking platforms and equipment in which application is realized into consideration [10].

3. PRINCIPLES OF INFORMATION SYSTEM META-SYNTHESIS BASED ON SOA

The principle of information system meta-synthesis based on SOA is to utilize the technology of Web Service to integrate information system resources, in order that these resources can be interconnected, integrated and coordinated *via* Web service for resources being integrated and software being reused [11]. Web Services provides a new mechanism to integrate information system and meanwhile a whole set of solutions for definition, publishing and access of local and remote services. The structure model of Web Services is based on interaction of three roles, that is, service suppliers, service registers and service applicants [12]. Interaction involves such operation as publishing, search and binding, and these roles together with the operation act on Web Service modules, as shown in Fig. (**1**).

As shown in Fig. (**1**), the model consists of the following three roles: 1) service suppliers, who publish data and service in the required format, and respond to service requirement; 2) service registers, who register published service and provide such service as classification and search; 3) service clients, who search for and acquire needed service through the service registration center [13]. These roles complete operation of publishing, searching and binding of services with standard service description, communication protocol and data format.

If an interacting mode is needed to perform the three kinds of operation – publishing, searching and binding, what must be determined is who supplies these services, how to verify these service and how is the quality. Therefore, information system meta-synthesis based on SOA needs to extend protocol regulations of Web Service [14]. Introduced service-description extending layers and service combination layers are shown in the following (Fig. **2**) graph. Service extending layer is focused on describing service access limitation by information system characteristics, service performance cost and service context information, in order to improve security, reliability and efficiency of service integration [15]. And service combination layer aims at task demands and perform dynamic combination of services to complete the meta-synthesis of information system.

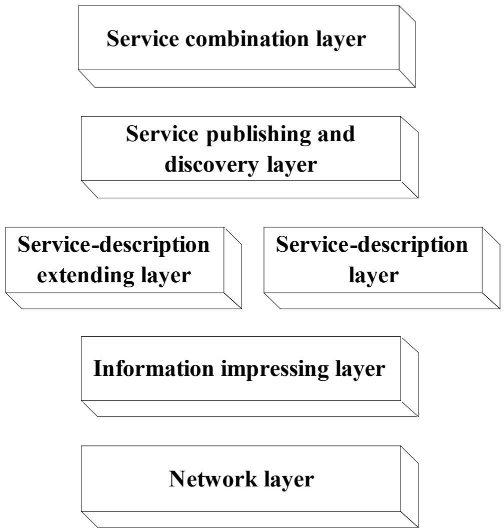

Fig. (2). Web service layers schematic.

3.1. Service-Description Extending Layer

Service-extending layer generally consists of performance information, original data information and service context information. Among them, performance information mainly describes non-functional index such as service quality – duration to finish service, service level and service security; original data information mainly describes regulations for service registering and publishing as well as service function description to facilitate publishing and search of service [16]; service context information mainly describes relationship between each other service and in most cases, it indicates the assigned contexts and relationships when service is running and being combined and, by recording successful service combination case, provides further support for service discovery and combination.

3.1.1. Service Combination Layer

Meta-synthesis of information system is an integrated comprehensive system, which is not only extension of individual function, but also flexible, interactive and dynamic integration based on task requirement. Consequently, it is necessary to combine each individual task to generate the service which is more complicated and more powerful in functions to support various demands [17]. And service combination layer is the main layer in this process. Service combination process is shown in Fig. (**3**), in which it can be found that the process is divided into three phases: service generation phase, combination phase and performing phase. In service generation phase, model description base of service is generated with characteristics of each function module; in combination phase, algorithm is synthesized based on service to match task requests and service models; and in performing phase, combination service is performed and task request result is returned.

3.1.2. Information System Synthesis Frame Based on SOA

Normally, the packaged services contain multiple types, and there types include a plurality of similar services. When a certain task request occurs, after completing the semantic description, interpretation, and processing of the task request. We can match this task request with queue service through services may be in the waiting idle state. How to accomplish the match involves mapping relationship between service and task requests [18]. In other words, this is a one to many type mapping problem.

In order to understand mapping relationship between task requests and services more clearly, we could consider the matching process of the task requests and services as a network structure. Nodes in the network represent services in the queue. Attributes of the nodes include types of the services, capability and the idle state. The connection between the nodes represents the link of the various types of services. As shown in Fig. (**4**).

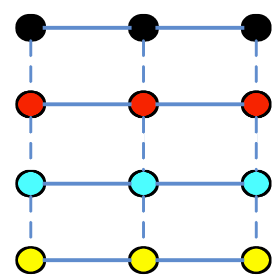

Fig. (4). Various types of services in the queue.

In Fig. (**4**), the node of the same color represents the same type of services. The connection between the nodes represents the coupling relationship between the services. The solid line indicates a high coupling relationship between services, that is relations between the same type of services. The dashed line indicates a low coupling relationship between services, that is relations between the different types of services.

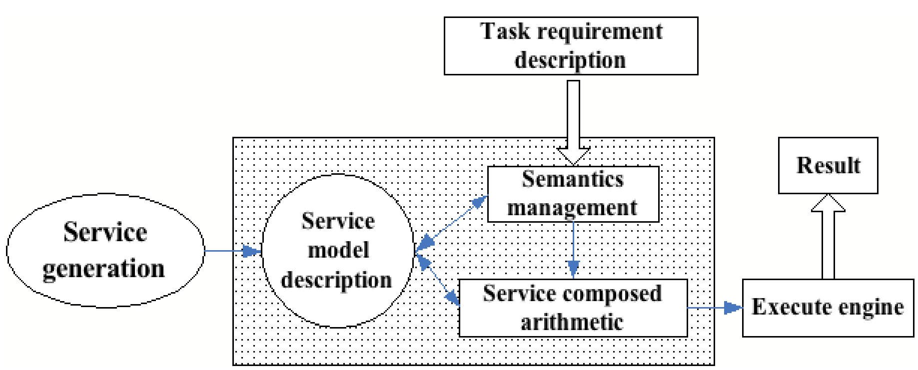

Fig. (3). Service combination frame.

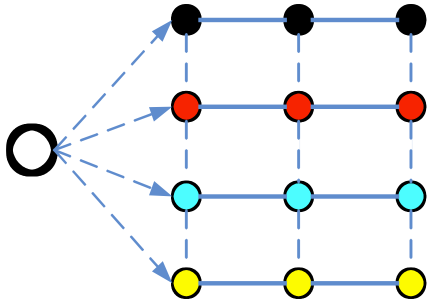

Fig. (5). Task requests and task mapping relationship.

There is a one to many type mapping relationship between a certain task request and the services in the queue after completing the semantic description, interpretation, and processing of the request. As shown in Fig. (**5**).

The one to many type mapping relationship between tasks and services reflects a phenomenon, that is we always could match a packaged service in the system with a task request when it occurs. This service may be in a busy or idle state. When a task request is matched to services in the busy state, it will select the same type of other services in the idle state. Sometimes for the sake of getting timely services, it also could choose different types of idle services with similar properties when all the services of the same type are in the busy state. When a task request is matched to services in the idle state, it can be served immediately [19]. The one-to-many type mapping relationship is to fully meet the request of each task, meanwhile the request could get the services closest to its needs.

This matching process of tasks and services is actually an infinite approximation of a feedback process, and it will end until a most suitable match is made of the tasks and services.

So as to ensure matching efficiency, this feedback process can be determined by calculating the path between nodes. Assuming the shortest path between the node n and m is d_{mn}. In the network structure of the tasks and services, we name the maximum distance between any two nodes the diameter of the network. It is called D, and it can be indicated as follows:

$$D = MAX\ d_{mn} \tag{1}$$

Network diameter D indicates the maximum distance between two nodes in the network. That is the maximum feedback distance between any two packaged services in the network. In other words, network diameter D represents the longest response time from the first selected service to the second one when there is a task request. D is a value to measure changing option services in the network. When the value of D is more higher, the time of changing option services in the network is more longer, and the difficulty is increase. When the value of D is more lower, the time of changing option services in the network is more shorter, and the difficulty is decrease.

The average distance between any two nodes is called the average path of the network, and it is called L. It can be indicated as follows:

$$L = \frac{1}{\frac{1}{2}N(N+1)} \sum_{m \geq n} d_{mn} \tag{2}$$

Thereinto, N indicates the number of network nodes, that is the number of services in the queue. Normally, the average path of the network stands for the matching process of the tasks and services. When the value of L is more higher, there are more difficulties in matching tasks and services in the network. When the value of L is more lower, there are less difficulties in matching tasks and services in the network. Thus, L is an important value to measure the difficulty of matching tasks and services.

It follows that, both the network diameter D and the average network path L could reflect the mapping relationship of task requests and network structure of services from different aspects. There must be some relations of them, because both are a measure of the distance between two nodes in the network structure. The network diameter D describes a maximum, while the average network path L describes a mean. Obviously, the level of the average network path L will influence the level of the network diameter D. The distance between any two nodes in the network is longer, if L is at a higher level, and the level of network diameter D will be higher. Conversely, the distance between any two nodes in the network is shorter, if L is at a lower level, and the level of network diameter D will be lower.

Obviously, the maximum distance, the shortest path and the average network path have the following relationship among each other:

$$D \geq d_{mn} \geq L \tag{3}$$

As we know, for the normal services responding speed, the longer node distance, the longer service responding time. Assuming the shortest service responding time between the node n and m is t_{mn}, we name letter Trepresenting the maximum responding time between any two nodes. It can be indicated like:

$$T = MAX\ t_{mn} \tag{4}$$

Like the express way of the average distance, the average services responding time can be expressed in the same way. We name letter H representing the average responding time between any two nodes. It can be indicated like:

$$H = \frac{1}{\frac{1}{2}N(N+1)} \sum_{m \geq n} t_{mn} \tag{5}$$

N still indicates the number of network nodes. Normally, the average services responding time stands for the matching process of the tasks and services. When the value of H is more higher, there are more difficulties in matching tasks and services in the network. When the value of H is more lower, there are less difficulties in matching tasks and services in the network. Thus, H is an important value to measure the difficulty of matching tasks and services.

The maximum responding time, the shortest time and the average responding time have the following relationship among each other:

$$T \geq t_{mn} \geq H \tag{6}$$

Apparently, the parameters of distance and time express the same meaning of task-service matching situations. But, between the two kinds of parameters slight differences can be tell easily. The distance parameters can not reflect the real responding time totally. When the distance between any two nodes is confirmed, services in the queue are informed to respond the tasks. But there are two special situations. The first one is that more than two services are ready to respond the same task at the same time. Which one to respond in the end is a big question. The second one is that more than two tasks are waiting to be serviced, but only one service is in the queue. To service which task for the unique service could be another question.

In order to analyze this question clearly, another parameter should be introduced. Letter S represents the fitting extent between tasks and services, which would determine the services responding order early or late. Obviously, letter S is a dynamic parameter. It will change with the step of tasks. We introduce the letter v represent regular responding speed without any influence. Here is the relationships between them:

$$D = S \cdot vt_{mn} \tag{7}$$

In this formula, letter S plays a role of coordinator between nodes distance and services responding time. When certain task and regular responding speed are confirmed, nodes distance changes with parameter S and services responding time.

$$L = S \cdot vH \tag{8}$$

Same situation in this formula, letter S still plays a role of coordinator between nodes distance and services responding time. From the formulas above, parameter S will be the key in the task-service responding process. Simply speaking, the higher matching extent between tasks and services, the quicker task-service responds. When the value of S is high, usually represents the high matching extent between tasks and services, and the task will be serviced in a very short time by the closest service. When the value of S is low, usually represents the low matching extent, and the task will be waiting for another service. In this situation, responding time will be longer.

Currently, in the process of construction of information system in various fields in China, a set of inter-industry interfaces and regulations have been initially established. However, such problems as poor openness, high complexity of integration, high cost and poor flexibility still exist in the meta-synthesizing process of information system. Therefore, it is necessary to, with the concept of being service-oriented; establish an integrative system structure model based on SOA, for the purpose of encapsulating each functional module into plug-and-play service to supply operation unit and operators [20]. SOA provides a standardized frame and a technical access to integration of information resources, that is, with no great change of the current system, each subsystem resources and function of operation are converted or encapsulated to individual services, and these services can be both independent on each other and combined with each other, resulting in great reduction of costs caused by not being reused and then efficient combination of information resources in each field. As shown in Fig. (**6**), integrative information system synthesis frame based on SOA is divided into public core service layer, service construction layer and service application layer.

The main functions of public core service layer is such public core service as service register, publishing, search, service security strategy and information storage, which facilitate service publishing, discovery, organizing and management. Service construction layer, composed of existing application systems and encapsulated services, for existing systems, can follow related protocols to encapsulate functions provided to the outside into services. Service application layer, aimed at demanded tasks, mainly organizes and manages services in operational procedure and in accordance with specific rules, in order to match services and demands to meet different users' demand.

4. DATA ANALYSE AND PROTOTYPE ARCHITECTURE

The following is an example about information system meta-synthesis in a specific field. We divide the main struc-

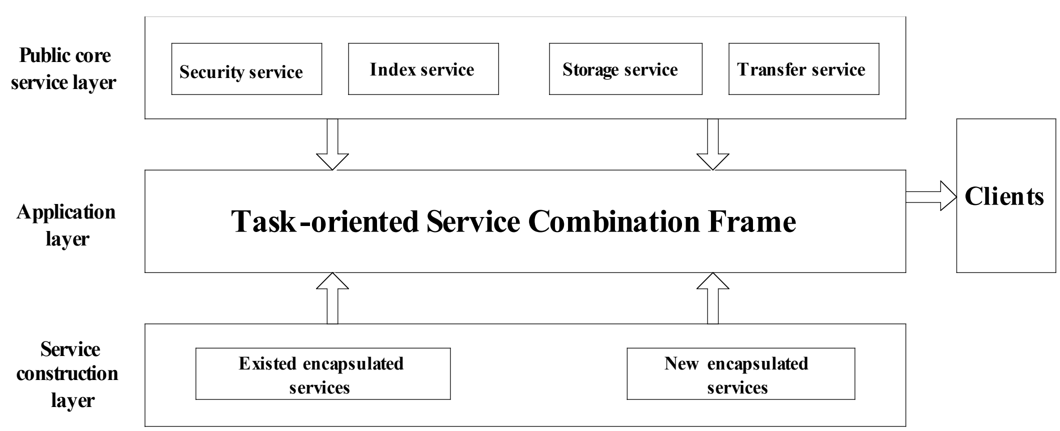

Fig. (6). Information system synthesis frame based on service.

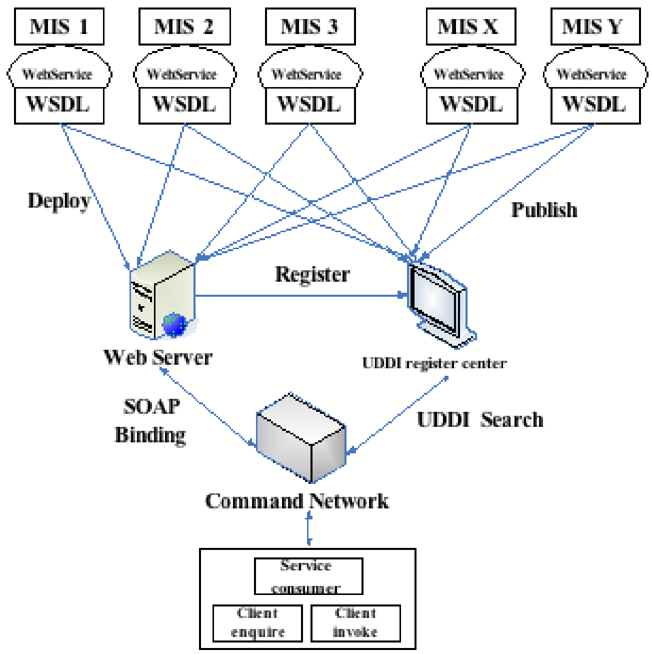

Fig. (7). Information system synthesis frame based on SOA in a certain field.

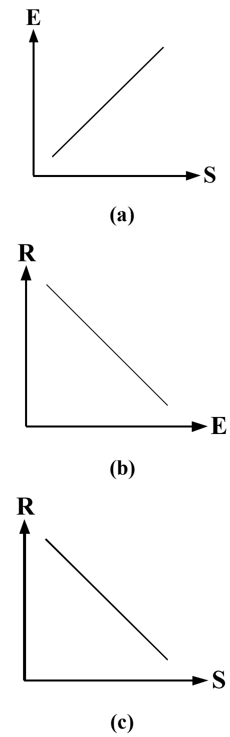

Fig. (8). The relationship between task description, service encapsulation and service responding.

ture into several layers: sporadic small-scale systems layer, encapsulated web services layer, UDDI registration center and customer use layer.

Thereinto, the sporadic small-scale systems layer is made up of different small-scale and simplex function systems which are different from each other in edit languages, develop platforms, develop technologies and data structures, and these small-scale systems play different roles in functions structure. Encapsulated web services layer will finish encapsulation and transformation of these sporadic small-scale systems, and also describe them into unified standard WSDL documents in order to circulating among the inside interfaces. UDDI registration center is obligated to register and manage various types of web services which have finished encapsulation and paraphrase, and after all of this a services warehouse will be formed by various types of web services which have close relationships among each other [21]. Once there is a new task request visiting the whole meta-synthesis system, the service warehouse could easily and quickly choose appropriate services which matches well to serve.

Thus, we come back to the concept of one-to-many type mapping relationship mentioned before, it illustrates that information system meta-synthesis question will change into the tasks-and-services mapping relationship in any situations.

In Fig. (**7**) we can tell the task or services description, web services encapsulation and task request part clearly. In early chapter of the essay, we know that task or services description is the first step of a certain task occurring, and it is the basis of the service responding and task implementation which will affect the process and result of the task implementation. In order to show the relationship between the two, we analyze the matching level, efficiency and accuracy rate by drawing curve graphs. In a huge information system meta-synthesis, we use letter *S* represents the services description, letter *E* represents encapsulated web services, letter *R* represents service responding. Absolutely, the three parts are related closely each other, and in the following graphs the relationship of them will be showed.

Fig. (**8**) includes three graphs which show different relationship among those three parts. The first graph shows that the higher accuracy rate of the services description, the higher degree of the service encapsulation. The second graph shows that the higher degree of the service encapsulation, the shorter time of the service responding. The third graph shows that the higher accuracy rate of the services description, the shorter time of the service responding.

As shown in Fig. (**7**), no matter how heterogeneous language, platform, technology and data structure in existing information systems are, as long as they are encapsulated or converted at the outlet interfaces with a unified object model Web Service, by manually or automatically defining Web Service interface description WSDL documents for each resource system and mapping what the documents describe to UDDI database to be managed in different categories, various Web Services are registered in the UDDI registration center.

When users access resources systems through the portal web site, there is no need considering its internal mechanism. If users log in the authentication system of portals, they should first search for WSDL documents corresponding to user interface in the UDDI user registration center, and then accordingly transfer the user management module in the system to acquire the user authentication and access the system after authentication passes. When users request for sharing data and transferring operations, they should first go to UDDI registration center to access Web Service registration information of the required service, and then access corresponding Web Services interface description WSDL documents and generate a local agent object. Thereafter, required operations, *via* this agent object, exchange information resources with Web Services and transfer operational functions. If changes occur to Web Services' internal structure and performance, as long as WSDL description is modified and interface maintains the same, the entire system needn't get changed.

In the process, the following four stages are of great importance: service description, service registration, service discovery and agent implementation. Service description refers to using WSDL documents to describe Web Service functions, including interface transferring methods, factors and return values. Service registration provides publishing and searching of service description WSDL documents to UDDI. For service discovery, a specific implementation (Service) comes from the Model which corresponds with same port Type. And for agent implementation, with sought WSDL documents, service consumers can dynamically generate agent objects and transfer corresponding Web Services [21].

CONCLUSION

Traditional integrating methods for information system resources can not ensure the integration of heterogeneous system in a convenient and low-cost way and adapt to demand from changes of modern information resources operations. SOA frame is irrelevant to software and platform, and is loosely coupled, which enables it to provide a service mode for solving the problem of "isolated information islands" between system resources, without changing existing software system frame. With SOA frame, the integration of information resources in systems and the reusage of software can be realized, accelerating the informationizing process of industry. In this sense, integration frame based on SOA will have a bright future and is a significant developing trend for future information system establishment and information system integration.

CONFLICT OF INTEREST

The authors confirm that this article content has no conflict of interest.

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ABOUT THE AUTHORS

Shibin He (Sichuan, China, 1986.03), male. Doctor of Management, study in Logistics Engineering University in Chongqing, the major field is military barracks management, and the main research area is about the military information system management. Master degree is on military informational engineering which was granted in 2011, also in Logistics Engineering University in Chongqing. He used to be a member of some information system explorations, and joint in the information system practices and publish. At the same time, his research key point has transferred to the military information system management on barracks fields, and he has made some practical surveys by contacting with other real departments.

Juhui Cao (Hunan, China, 1964.12), male. Professor of Logistics Engineering University. He got the doctor degree in Chongqing University on material science in 2004, and he studied in France for two years from 1994 to 1996 and visited USA as a member of military environment protection experts team in 2006. His main research area is military barracks management and military materials science. These years he published many monographs and essays on military logistics management, especially US military barracks management. He has engaged in military materials recent two years and has got some well-marked achievements.

Yi Zhang (Sichuan, China, 1981.08), female. Lecture of Logistics Engineering University. She graduated from Logistics Engineering University both of her undergraduate course and postgraduate course, and the major research orientation were western culture. Now she is a doctor of military management in Logistics Engineering University and her main research area is US military logistics and barracks ensurements.

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