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Goal-Based Cloud Broker for Medical Informatics Application: A proposed goal-based request and selection strategy

Mohamad Izuddin B Nordin[1], Azween B Abdullah[2], and Mahamat Issa Hassan[3 +]

Department of Computer & Information Sciences
Universiti Teknologi PETRONAS
Bandar Seri Iskandar, 31750 Tronoh, Perak, Malaysia

Abstract. Medical informatics application nowadays combines computer technology and clinical medicine to improve health care, medical education, and medical research. For many years, people debated about existing processes in collecting patient's important data with a great deal of work to discover, select, and analyze the information. To reduce treatment delay and errors in retrieving data, resource broker technology can be used to provide good indexing metadata. Existing resource broker are mostly applied in grid computing and widely used in business environment. In this paper, we proposed a goal-based cloud broker as a solution to improve the current broker technology. Our solution is based on the concept of goal which enables users in defining required resources and to optimize the usage of resources in the cloud. Several contributions by this research include enhancing resource brokers by using goal-based request to maximize resources allocation within the cloud environment and to assist user in selecting the best suitable resources in cloud by minimizing user intervention in resources discovery.

Keywords: broker, cloud computing, goal-based, medical informatics, resources discovery, resources selection.

1. Introduction

Medical informatics [1-2] is practically an interdisciplinary field of study that combines computer technology and clinical medicine to improve health care, medical education, and medical research. It consist a variety of medical information and applications which need to be organized and managed properly. For many years, people have debated about existing processes in collecting patient's important data that need a great deal of labour work to discover, select, and analyze the information [3]. At first glance, it may seems like patient's medical record is handled carefully and properly but these processes are usually slow and could lead to errors. Various types of current applications are widely used in medical field such as collaborative decision making system [4], content-based image retrieval system [5], medical information system [6], etc. People failed to notice that current medical informatics data and applications are placed in distributed locations and thus time consuming to discover them [7] thus hindering the interest of non-technical users to use these applications.

In medical field, accurate record keeping is vital [8] and medical practitioners must ensure that medical information for patient or client is in accurate account of treatment, care planning and delivery. Other than that, large data archive is needed to accommodate huge clinical data record [9]. Record such as image, media technology and operation video need a large volume of data storage for storing application-dependent information produced by radiologist or clinician. Besides of having good data archive, medical informatics application need a high speed computation and data management. Several software used by clinicians to perform radiotherapy require an extremely high level of accuracy to calculate area of infection in cancer

+ Corresponding author. Tel.: +605-3687423
E-mail address: mohamad.izuddin@gmail.com[1], azweenabdullah@petronas.com.my[2], mhtissa@gmail.com[3]

treatment [10]. Recently, users required a service that can retrieve application and resources on demand regardless where the information have been stored and located [11]. To bridge these gaps, resource broker technology must be put in place as well as providing good indexing metadata [12]. By having this kind of technology, medical practitioner or clinician would be able to discover medical information and suitable application accurately and faster than previous process.

The solution is presented to improve the processes by proposing goal-based cloud broker. Our solution is based on the concept of goal which enables users (e.g. medical practitioner, radiologist and clinician) to define required resources and to optimize the use of resources in the cloud environment [13]. We examined how medical informatics can share its data and applications through distributed environment and determined how users can discover available resources from heterogeneous machines to use that particular data and applications. With cloud computing, resources can be administered properly on centralized facilities managed by third party compute and storage utilities [11, 14].

In current distributed computing, cloud computing has been receiving more attention than grid and cluster computing. Clouds generally offer users to access resources on demand anywhere in the world [15]. The information and resources in clouds are available from where it can be accessed by resource broker and/or distributed to medical expert for diagnostics and analysis.

Based on aforementioned solution, our contributions in this research are divided into two. First, we demonstrate enhanced resources broker by using goal-based request to maximize resources allocation in cloud environment. Then, we assist user to select the best suitable resources in cloud by minimizing user involvement in resources discovery.

The rest of this paper is organized as follows: Section 2 provides several related works. Section 3 presents our propose solution by describing goal-based cloud broker architecture and resource selection strategies. Section 4 presents resource selection strategy for selecting the best meet-requirement resource in cloud infrastructure. Section 5 concludes this paper with some recommendations of future work.

2. Related Works

There is several related works which include recent technologies regarding resource broker that envision similar clarification. We are focusing on the functionalities and techniques applied in discovering and selecting resources, scheduling techniques and also algorithms that are implemented.

In [16], they proposed two algorithms to search and discover in any cluster that can be merged with medical application within the time limit in distributed environment. The techniques applied in it provide some requirements to our works. Nevertheless, one of the algorithms can only cater for small number of resources. Complications arise if large amount of resources are involved.

Venugopal et al. [17] introduced Gridbus Broker that consist a strategy on resource scheduling in data grid by focusing on adaptive scheduling algorithms. However, the results shown in this work may be considered high when it comes to not considering the location of data.

A prototype built in a research project of [12] investigates how the services model could overcome the weaknesses in an enterprise-based system. Nonetheless, it restricts the usage of services provided to the certain number of data which has permission to see. It is totally opposite with the rule of cloud computing which data can be retrieved on demand.

Based on aforementioned related works, we concluded that none of the analyzed work applies their broker in medical application in cloud infrastructure. Most of the broker works only concern to grid infrastructure. Therefore, we proposed this cloud resource broker with applying goal-based concept.

3. Goal-based Cloud Broker

This section gives an overview of goal-based cloud resources broker for medical informatics application. Goal-based request initially presents as new strategy in optimizing the use of resources in the cloud. The formation of this goal-based cloud broker is motivated from earlier work on [13] where the concept of goal is applied. Goal, mediator and web service must be well-defined using inbuilt keywords in order to reduce syntax burden for semantic web service (SWS) developer. Similarly, in cloud broker, user needs to define the

goal in their request, and broker will act as a mediator while cloud resources represent the web services. In this paper, goal-based cloud broker architecture was proposed to fulfil the concept of goal-based request. Discovery and selection algorithm in resource broker will be enhanced to achieve research objective. Details of the propose architecture is illustrated in Fig. 1.

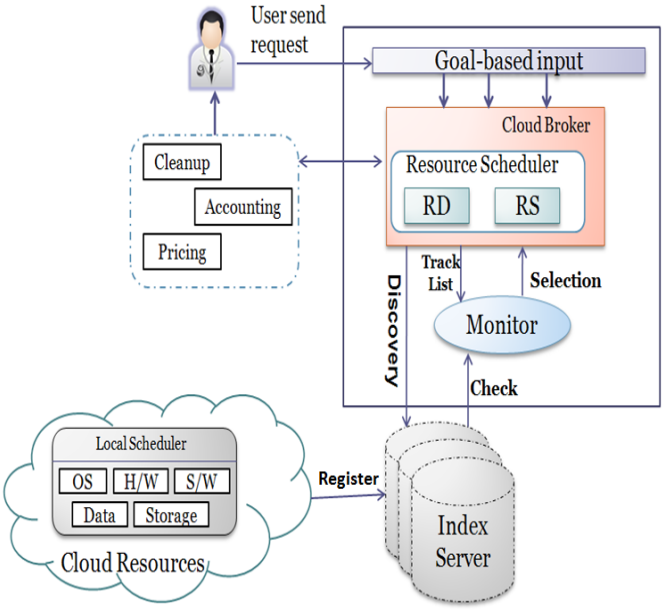

Fig. 1: Goal-based cloud broker architecture.

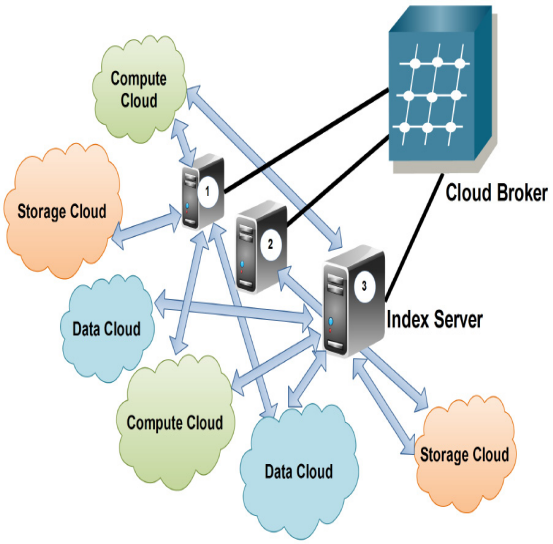

Fig. 2: Registered cloud resources in index server.

Goal-based input **–** This component will act as front end to the user to insert desired resources they need in treatment process by mentioning specific attribute of each resources.

Resource Discovery (RD), Resource Selection (RS) – By using goal-based input, a cloud broker will discover possible relevant resources, monitor whether user requirements are met or not, mediate any mismatch requirements, and select the best resources that match with incoming request.

Cloud broker – It comprises of two functions, **RD** and **RS** which handled by resource scheduler. This broker will act as a middle component between users and resources. It tries to search the best resources which best fit to user requirements.

Resource scheduler – This component will execute RD by transmitting job to index server which is close (provide high accuracy of resource allocation) to available cloud resources to minimize the number of data involved when submitting the jobs [17].

Index server – It will act as interface between resources provided in cloud and cloud broker to discover what cloud resources are available. As depicted in Fig. 2, every cloud resource must be registered in one or more index servers [18] as the broker can easily identify nearest source of data which capable to meet user requirements through monitoring component.

Monitor – It has been assigned to check whether the resource available is similar or not with attributes that have been set by user earlier in goal-based request. If user requirements are met, scheduler will perform RS by selecting resource that best matches user requirements and send the selected resource to the respective user [19].

Cloud Resources – In medical informatics, we divide cloud resources into three categories which are compute cloud, storage cloud and data cloud. Compute cloud consists of resources like hardware, software, CPU and operating system while storage cloud provides database and large capacity hard disk to store digital images from radiology department located at different places. All information regarding digital images and patients can be retrieved from data cloud as the data will come from experiment from research universities and collaborative decision making systems.

Local scheduler – It will be located in every cloud resource as it schedules user task by finding available resource (i.e. free processor or available amount of storage) to send it back to the user [19].

Accounting, Pricing – These two components are actually not in this research focus point but they still have their own function in deciding how service request are charged [15].

4. Resource Selection Strategy

Based on the aforementioned components, we came out with nine steps in selecting required resources, inspired by [20] in utilizing goal-based cloud broker architecture. Then, we anticipated producing goal-based request algorithm to select the best meet-requirement resource available in cloud infrastructure.

1) ***Authorization filtering***: Users are supposed to submit a request which capture a goal or desired resources via an interface (goal-based input). The interface is used as security where only authorized users from medical field can access the resources provided. It is better for cloud computing to include authentication before any users can submit a job into a cloud.
2) ***Application Specification***: The user need to specify a set of resources they required based on concept of goal. They can choose as many as attributes they want to optimize resource discovery and resource selection.
3) ***Minimize requirement filtering***: As stated in previous discussion, cloud broker comprise of two functions, resource discovery (RD) and resource selection (RS) which are handled by resource scheduler. The scheduler will execute RD by transmitting job to nearest index server comprises the highest registered meet-requirement cloud resources to minimize the number of data involved.
4) ***Information Gathering***: RD will perform its task by discovering the best fit resources which match the goal-based request set by user.
5) ***Resources Allocation***: When user requirements are met, scheduler will perform resource selection (RS) by selecting resource that best matches user requirements set in goal-based request.
6) ***Advanced Reservation***: Index server will act as interface between cloud resources and cloud broker to discover what cloud resources are available. Every cloud resource must be registered in one or more index servers as the broker can easily identify nearest source of data which capable to meet user requirements through goal-based monitoring.
7) ***Monitoring resources***: This cloud resource broker is not excluding from applying error checking by determining similarity among entities from requirement list and selected resources list. The monitor will check whether the resource available is similar or not with parameters that have been set by user in goal-based request.
8) ***Job completion***: Local scheduler will be located in every cloud resource as it schedules user task by pointing out any available resource to be sent back to the user. Once the highest similarities achieved between the goal and resources, the resources will be allocated to respective users. Then, users have two options whether to accept or to reject it.
9) ***Cleanup***: If user accepts the selected resources, the bill will be out based on specified amount and charge the user. Otherwise, accountant system will close transaction and cleanly close down the use of resources. This last step is necessary in general cloud usage but we are not giving much attention to this step as it is out of research scope.

From these nine steps, we present the outline of proposed goal-based request algorithm (Algorithm 1) which focusing on scheduling (Algorithm 1.1) and monitoring (Algorithm 1.2) mechanism in selecting the best available resources in cloud. By looking at this kind of algorithm, one method (fastest search algorithm) will be proposed to select the best index server which is closer to available cloud resources.

Algorithm 1: Goal-based request.

```
Require: Specific type of (OS, Data, CPU, S/W);
         Specific size of (storage, memory)
Ensure: Return selection resources
    1. Discovered=Null
    2. Selected=Null
    3.   For discovering available resources and index server
    4.     Refer algorithm 1.1
    5.   End For
    6.   For selecting best resources
    7.     Refer algorithm 1.2
    8.   End For
    9.   Return selected resources
```

Algorithm 1.1: Scheduling.

```
Require: Job Request (retrieved from 1st algorithm);
Ensure: Resource Discovery
    1. For each job request do
    2.   Sort out index server that do not fill job requirement/goal
    3.   Repeat with another index server
    4.     If cloud resource registered to index server Then
    5.       Dispatch job to index server (close to available cloud resources)
    6.       If local scheduler find available resource in cloud
    7.         (available resource = true)
    8.     Else
    9.       Discard the index server
   10.     End If
   11.   Until job dispatches or no available/registered index are left to try
   12. End For
   13. Return discovered resources
```

Algorithm 1.2: Monitoring.

```
Require: Parameters set in goal-based request (retrieved from 1st algorithm);
Ensure: Resource Selection
    1. Selected = Null
    2.   While (Cloud Resource = registered in index server)
    3.     If(Resources available = parameters)
    4.       Scheduler select resources that best match user requirements
    5.       Selected = Resources
    6.     End If
    7.   End While
    8. Return Selected
```

5. Conclusion

In this paper we have shown the ongoing research in cloud computing in relation to medical informatics field. We presented goal-based cloud broker architecture as a potential solution in optimizing resource discovery and resource selection in cloud infrastructure by taking out user involvement in this proposed broker. This cloud broker shall also maximized resource allocation through application of goal-based concept enabling users to define the only required resources.

For future works, we intend to simulate this resource selection strategy by determining similarity between entity class from goal-based request and best available resources. In addition, we intent to apply fastest search algorithm in selecting the best index server that have registered resources to best fit user requirements.

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