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Resources discovery in the cloud environments using collaborative filtering and ontology relations

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ABSTRACT

Nowadays, cloud services have been providing a wide source of information and yet the expansion of these services has led to their own particular problems in this subject. Discovering of the appropriate resources or services is a major challenge in the cloud computing. Therefore, many methods are proposed to tackle this problem. Also, in the cloud environments, ontology is a description of the concepts and relationships that can exist for a cloud service or group of services. On the other hand, for a certain item, user's interest according to the information of their profiles are predicted by collaborative filtering. It uses a collection of users with similar interests to predict interesting information for target users. However, despite the importance of the semantic relations among the cloud services, a few papers consider these relations to discover the proper resources. Therefore, this paper aims at proposing a method to discover the cloud services via semantic concepts and collaborative filtering. The obtained results from experiments have illustrated that the presented approach improves the efficiency of service discovery in the cloud computing and obtains fewer execution times against the current approaches.

1. Introduction

Cloud computing as a recent technology has been growing in the pool computing resources as a pay per use fashion (Aznoli and Navimipour, 2016; Milani and Navimipour, 2016a,b). It consists of deploying groups of remote servers and software in the shared network which allows huge repository and availability of computing services or resources for online user's accessing (Milani and Navimipour, 2016a,b; Singh and Chana, 2016). An extremely available, scalable, accessible, and flexible computing platform is provided by cloud computing for a variety of applications (Chiregi and Navimipour, 2016a,b). Therefore, it caused good profit to organizations and users such as cost reduction (Navimipour et al., 2015; Fouladi and Jafari Navimipour, 2017). In addition, the cloud computing is utilized to enable ubiquitous, convenient, and on-demand network accessing to a shared repository of resources such as software design languages, networks, applications, servers, storages and vast databases which they are prepared and distributed easily (Mell and Grance, 2011; Azad and Navimipour, 2017; Milani and Navimipour, 2017). Cloud services are delivered by the cloud providers using the Internet and they are available to the users through web-portals (Keshanchi et al., 2017). There are four classes of virtualized resources in the cloud computing which named Software as a Service (SaaS) (van de Weerd et al., 2016; Vázquez-Poletti et al., 2017), Infrastructure as a Service (IaaS) (Madni et al., 2016; Ngo et al., 2016; Tao and Gao, 2017), Platform as a Service (PaaS) (Itani et al., 2013; Bassiliades et al., 2017) and Expert as a Service (EaaS) (Ashouraie and Jafari Navimipour, 2015; Hazratzadeh and Jafari Navimipour, 2016; Fouladi and Jafari Navimipour, 2017).

Furthermore, one of the most important issues in any distributed systems like grid and cloud computing is discovering the proper services based on user's request according to their needs (Souri and Navimipour, 2014; Aznoli and Navimipour, 2017). To gain the best efficiency for both human users and programs, an effective and automated search and choice of relevant and proper services are necessary (Navimipour and Milani, 2015). Also, the identical or similar functionalities can be delivered and provided by service providers in the cloud environment using different keywords, information or even knowledge (Charband and Navimipour, 2016; Navimipour and Charband, 2016). Therefore, it is difficult to find the suitable and relevant services for requesters from the pool of shared services. Hence, it is a challenge to recommend a proper service to do a user's needs from many services (Lin et al., 2014), especially when different service providers use dissimilar data and keywords for similar services. For overcoming this issue,

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ontology, and semantic relations are used. Ontology is an obvious description of the concepts and relationships which can exist for an agent or a community of agents (Ma et al., 2011) where is used to support relationships between users and programs (Sminia and Stuckenschmidt, 2002). It can be used for giving semantic meanings to information and corresponding concepts in the same domains (Liu et al., 2016; Villalonga et al., 2017). On the other hand, collaborative filtering uses a group of users with similar interests to forecast interesting information for target users (Herlocker et al., 2000). It has three main categories which they are named: user-based, item-based, and hybrid of these. The user-based algorithm is exploited for predicting an item which a current user interest in via the neighbor's ratings. Rating value is a quantitative measurement which is given to an item by a user. Henceforth, the items which have great predicted scores are recommended to the target user (Wang et al., 2008). Item-based methods use the similarities to evaluate between items. Then the similarities of items are applied and the ratings are forecasted by finding items which are alike to other items that the users have previously accessed. Eventually, the items are recommended to the target users which have high predicted scores (Wang et al., 2006; Lin et al., 2014).

In this paper, to discover proper and relevant services in the cloud environment, a new cloud service discovery mechanism is proposed which uses both semantic discovery and collaborative filtering concepts. The proposed method utilizes the ontology reasoning for offering the services to user's queries in a cloud environment. In addition, for queries and services classification the collaborative filtering is applied in the proposed method. Briefly, the major contributions of the proposed method are mentioned as below:

- Discussing the recent service discovery methods in cloud computing and outlining their main advantageous and disadvantageous;
- Proposing a new service discovery mechanism using the collaborative filtering and semantic relations among service providers and users;
- Designing the relevant open issues and giving some hints to deal with current obstacles in this area.

The structure of the article is organized as follows. Section 2 reviews some related work in the field of service discovery in the cloud environments. In Section 3, we describe a suggested conceptual framework and detailed design for efficient service discovery mechanism using ontology and collaborative filtering approach. Section 4 depicts the implementation of the proposed approach to obtain the experimental results. Finally, the paper is concluded and also future work are introduced in the last section.

2. Related work

The state-of-the-art studies in the service discovery are analyzed and reviewed in this section. Most of these papers use the ontology concept for discovering cloud services.

In (Han and Sim, 2011), cloud services are discovered from the Internet to the users. In this method, ontology idea is exploited to define the similarities between the provided services. They also introduced a system which is used the agent-based discovery to meet an ontology for retrieving cloud services. Furthermore, the agent of a cloud service reasoning provides the cloud service discovery system for reasoning the relations of cloud services and ranking the seeking results. Moreover, in order to determine the relations of cloud services via similarity, equivalent and numerical service reasoning methods, a cloud ontology is proposed that contains a taxonomy of cloud services ideas to enable the reasoning of cloud service agent. Obtained results have shown that using the cloud ontology, the cloud service reasoning agent is getting better to find cloud services which are near to the users' needs.

Ma et al. (2011) have proposed a method to assign demanded services from cloud users to the proper cloud resources. To do this, it suggests job assignment based on ontology concept to do reasoning regards to the semantic meanings. The current resources evoking is depended on consumer needs and the received task is assigned to the most appropriate resource based on Service Level Agreement (SLA). This method can define the concepts and describe their relations using the cloud ontology. Henceforth, complex queries can search the cloud resources. In order to assess the efficiency of the method, some experiments are done which compared the proposed method against the current resource management algorithms. The obtained results have indicated that the suggested approach has better results in term of efficiency in the cloud environments.

Furthermore, Chen et al. (2011) have proposed a method to develop the semantic cloud services that are marked based on ontology. This method uses the annotations for the semantics-based discovery of proper cloud services. The method can be efficiently used to retrieve similar or correlated cloud services in the cloud environment. Finally, an algorithm is suggested for the semantic discovery of cloud services which uses the functionality of the service as the main criterion for searching the similarity between the clusters.

In (Sangers et al., 2013), a semantic service discovery framework using natural language approach is proposed to discover semantic services. This algorithm searches and finds matched services that related to the user's query keywords searches and finds. Keywords are specified in the goal searching and end-users do not require any information in semantic languages, which this method helps to discover the eligible semantic services. In the proposed approach, part-of-speech tagging, lemmatization, and word sense disambiguation techniques are exploited to match keywords with semantic service descriptions. The experimental results have depicted that the proposed algorithm can execute the matching process and approximate matching.

Zhang et al. (2016) has assumed two types of resources which they were manufacturing machine as an advance idea of the examination of multi-granularity resource configuration procedure. In order to model data of resources, information and sensor techniques are approved that comprise static properties, real-time data construction, and data evaluation. Obtained results based on real-time conditions have illustrated that the service providers by using the service proactive discovery mechanism quickly answer to the requests and submit demands to execute jobs proactively. Henceforth, service providers are improved in responsiveness and initiative. Thus, potential services are discovered efficiently. Finally, a case study has shown the effectiveness of the suggested mechanism.

In (Chen et al., 2017), a new measure of semantic similarity integrating multiple conceptual relationships (SIMCR) for service discovery is proposed. The presented measurement method has a more precise service-request comparison by handling various conceptual relationships in ontologies. In this method, a service or request is shown via vectors of words which describe the interface signature and textual description. The proposed algorithm calculates entire semantic similarity as a weighted aggregation of interface similarity and description similarity.

The cloud service discovery system (CSDS) (Han and Sim, 2011) is the earliest effort in constructing a cloud service discovery system to help users in searching for cloud services more efficiently. The CSDS for initial searching mechanism utilizes existing search engines to collect information about the cloud services. In the next