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Original Article

Generic-distributed framework for cloud services marketplace based on unified ontology

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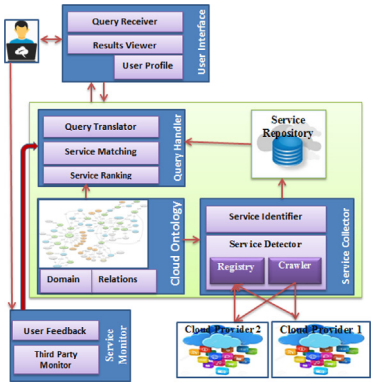
GRAPHICAL ABSTRACT



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ABSTRACT

Cloud computing is a pattern for delivering ubiquitous and on demand computing resources based on pay-as-you-use financial model. Typically, cloud providers advertise cloud service descriptions in various formats on the Internet. On the other hand, cloud consumers use available search engines (Google and Yahoo) to explore cloud service descriptions and find the adequate service. Unfortunately, general purpose search engines are not designed to provide a small and complete set of results, which makes the process a big challenge. This paper presents a generic-distrusted framework for cloud services marketplace to automate cloud services discovery and selection process, and remove the barriers between service providers and consumers. Additionally, this work implements two instances of generic framework by adopting two different matching algorithms; namely dominant and recessive attributes algorithm borrowed from gene science and semantic similarity algorithm based on unified cloud service ontology. Finally, this paper presents unified cloud services ontology and models the real-life cloud services according to the proposed ontology. To the best of the authors' knowledge, this is the first attempt to build a cloud services marketplace where cloud providers and cloud consumers can trend cloud services as utilities. In comparison with existing work, semantic approach reduced the execution time by 20% and maintained the same values for all other parameters. On the other hand, dominant and recessive attributes approach reduced the execution time by 57% but showed lower value for recall.
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Introduction

Cloud computing is considered the fifth utility [1] after water, electricity, telephone and gas based on pay-as-you-use model. There are three abstract delivery models for cloud services: (SaaS, PaaS, and IaaS) [2]. In Software as a Service (SaaS), consumers use applications running on providers' infrastructure. In Platform as a Service (PaaS), consumers deploy applications onto providers' infrastructure. Finally, in Infrastructure as a Service (IaaS), consumers deploy arbitrary software and have a full access to the operating system. Cloud service providers advertise cloud service descriptions on websites and portals. Advertisement contains flat text descriptions, images, tables and files. Cloud service discovery and selection process becomes a significant challenge because of exponential growth in the number of cloud service providers. Nowadays, finding the appropriate cloud service is a time-consuming and tedious task. Consumer uses the available search engines like (Google, Bing and Yahoo) with appropriate keywords to find all cloud provider websites, then they make a list of all available services with their features. Finally, the consumer selects the best appropriate service and uses it. Unfortunately, available search engines are not designed to give a small set of exactly matching cloud services. On the contrary, existing search engines show all websites that have the search keywords without any semantic matching like (ParkCloud, CurrencyCloud [3]). Buyya et al. [4] wrote in 2013 that "the discovery of cloud services is mostly done by human intervention: a person (or a team of people) looks over the Internet to identify offerings that meet his or her needs. We imagine that in the near future it will be possible to find the solution that matches our needs by simply entering our request in a global digital market that trades cloud computing services." They added: "In this cloud marketplace, cloud service providers and consumers, trading cloud services as utilities". Techniques used for web service discovery and selection [5] cannot be adopted for cloud services because of their special characteristics. This work presents a generic framework that serves as a template for cloud service marketplace. In this marketplace consumer can submit a request for cloud service and get a ranked list of the best matching services. The proposed framework is divided into six subsystems and thirteen components. Academic and industrial bodies can create instances of this framework by adopting different methods and approaches for each component. Additionally, this work presents a domain ontology for cloud services to create a shared understanding of the cloud environment and model the real-life cloud services according to the proposed ontology. Furthermore, this work implements two instances of generic framework by adopting two different matching algorithms. The first one is the dominant and recessive attributes algorithm borrowed from gene science, and the second one is the semantic similarity algorithm based on unified cloud service ontology. The contributions of this paper are:

- Presenting a generic framework for cloud service marketplace.
- Presenting cloud service domain ontology.
- Modeling the real-life cloud services according to domain ontology.
- Presenting percent distance similarity algorithm for cloud services matching.
- Building two instances of cloud services marketplace and compare them with existing work.

The rest of this paper is organized as follows: Section 2 surveys the existing researches in cloud service discovery and selection domain; Section 3 presents generic framework for cloud services marketplace; Section 4 presents cloud service domain ontology; Section 5 presents experiments and results; and Section 6 is a conclusion of the work.

Related work

Researches in the area of cloud service discovery and selection process can be divided into the following categories:

Multi-criteria decision making approaches

Multi-Criteria Decision Making (MCDM) is a set of methodologies used to select the best matching in case of multiple alternatives with multiple attributes [6]. Park and Jeong [7] proposed a model for cloud service discovery based on MCDM approach with six criteria: Functionality, Reliability, Usability, Efficiency, Maintainability and Business. Godse and Mulik [8] presented an approach to select SaaS based on Analytic Hierarchy Process (AHP) and expert survey respondents. The problem with MCDM approach is completely ignoring the relationships between the different parameters.

Performance analysis approaches

Qu et al. [9] presented a cloud service selection system based-on user's feedback and performance analysis. The proposed system aggregates the feedback from cloud users and the objective performance measurement from a third party. Rehman et al. [10] presented cloud services monitoring system based-on user experience feedback approach. System assumption is a cloud service that satisfies existing applications with specific usage profiles similar to new application, which is the best cloud services for new application. Unfortunately, Performance indicator may not be enough to judge the best matching cloud service and there is no way to check the reliability of users' feedback.

Agent based approaches

Maheswari and Karpagam [11] presented an agent base and multilayered architecture to facilitate service discovery in cloud environment. Reshma and Balaji [12] proposed agents model for cloud service publication, discovery and selection, where clients can submit requests and matching attributes through user interface. There is no concrete approach for cloud service discovery and selection process in these two proposed works. Sim [13] developed cloud services discovery system based on Multi-Agents and search engine. This work doesn't consider QoS parameters.

Semantic approaches

Tahamtan et al. [14] introduced a semantic framework that provides query capability based on unified cloud ontology and business service ontology. However, service matching is done based on SPARQL that need experienced users. Afify et al. [15] developed a unified ontology that serves as semantic based repository to facilitate SaaS publication, discovery and selection processes. This work focused on SaaS only and didn't consider PaaS and IaaS. Hasan et al. [16] proposed service discovery system based on hierarchal ontology. This work assumed the existence of local ontology in each cloud provider which is not applicable in the real world.

Other approaches

Zhang et al. [17] presented two-level cloud service directories for cloud services discovery. Unfortunately, this assumption is not applicable in the real world. Somu et al. [18] presented architecture for cloud services discovery based-on Hyper-graph Computational Model (HGCM) and Minimum Distance-Helly Property (MDHP) algorithm [19]. This work didn't provide a clear

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