A Cloud Service Providers Ranking System Using Ontology

K.Niha, Dr. W.Aisha Banu, Ruby Anette

Abstract— Cloud computing plays an important role in the access of infrastructure and application services on a subscription basis. As a result, several enterprises have started to offer different cloud services to their customers. Due to the vast diversity in the available cloud services, from the users point of view, it is difficult for them to choose the service that fits best into their requirements though there are ample number of system that help the users assist in choosing the appropriate service provider, they are still not completely satisfactory. This paper discusses an ontology based system that help the users evaluate the cloud service providers based on their requirements and quality of service by the providers. Here the system is designed as three phases, they are (i) processing of functional requirements (ii) processing of non-functional requirements and (iii) ranking of service providers. The using ontology with explicit meaning, making it easier to automatically process and integrate information available for comparison, selection and ranking of cloud service providers using Analytic Hierarchy Process (AHP) to prioritize the cloud services. This system also enables the service providers to improve their Quality of Services (QoS).

Index Terms— AHP, ontology, pattern matching, QoS attributes, ranking, RDF, web extraction.

1 INTRODUCTION

Cloud computing is a wide topic and many researches are focused on improving the technology and facilitating the use of the technology. One of the concepts that have evolved to felicitate the use of the Cloud technology is the Cloud services which are offered by different Cloud providers. They are mainly grouped into three categories [1] as, Infrastructure as a Service (IaaS) provides an environment for deploying, running and managing virtual machines and storage, Platform as a Service (PaaS) provides a platform for developing other applications on top of it, Software as a Service (SaaS) provides access to complete applications as a service, such as Customer Relationship Management (CRM) [2]. Due to this diversity of cloud offerings, an important challenge for user to discover exact cloud provider that can satisfy their requirements. Often, there may be trade-offs between different functional and non-functional requirements fulfilled by different cloud providers. This makes it difficult to evaluate service levels of different Cloud providers in an objective way. Therefore, it is not sufficient to just discover multiple Cloud services provider but it is also important to evaluate which is the most suitable Cloud service provider. This type of evaluations is done based on the processing of functional and non-functional requirements. Some examples of the functional requirements include the versions of the software that are supported like the 3ds max 2009, Maya 7.0 etc. , the render engines supported like the Mental Ray, V-Ray etc., Render node configuration etc.

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The non-functional requirements provides the holistic view of Quality of Service (QoS) attributes which include, Accountability, Agility, Assurance of Service, Cost, Performance, Security, Privacy and Usability. Currently Service Measurement Index (SMI) [10] is publicly available metrics which defines the Key Performance Indicators (KPIs) and compare Cloud service providers. In this paper, Ontology plays a major role. It provides a shared understanding of a domain of interest to support communication among human and computer agents. It contains a set of concepts and relationship between concepts, and can be applied into information retrieval to deal with user queries. Fig. 1 shows diversity of Cloud into three different levels Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS). "IaaS, PaaS, SaaS" are the subclass of "Cloud" and Cloud is the Subclass of "Thing". "Is a" is the instance which give description about the classes.

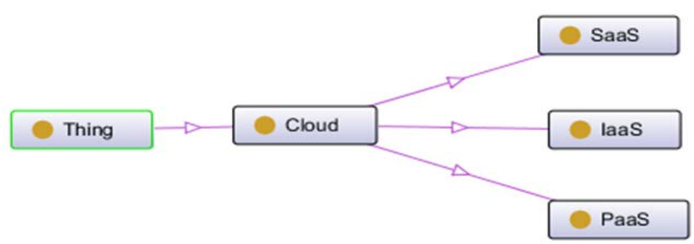


Fig1. Ontological representation of Cloud Service

Several techniques are already available to process functional requirements, among that web extraction and pattern matching is used on ontology for cloud service provider's based on functional and non-functional requirements. There are some challenges for evaluating non-functional requirements and ranking Cloud service providers. The first is how to measure various QoS attributes of a Cloud service provider. Many of these attributes vary over time. For example, the per-

ISSN 2229-5518

formance of Virtual Machine (VM) has been found to vastly vary from the promised values in the Service Level Agreement (SLA). However, without having precise measurement models for each attribute, it is not possible to compare different Cloud services or even discover them. Therefore, historical measurements are used to find out the actual value of an attribute for evaluating non-functional requirements and ranking cloud providers.

The second challenge is to rank the Cloud service providers based on these QoS attributes. Some of attributes cannot be measured easily. Attributes like security and user experience are not easy to quantify. Moreover, deciding which service provider matches best with all functional and non-functional requirements is a decision problem. It is necessary to think critically before selection as it involves multiple criteria and an interdependent relationship between them. This is a problem of Multi-Criteria Decision-Making (MCDM). Each individual parameter affects the service selection process, and its impact on overall ranking depends on its priority in the overall selection process. An Analytical Hierarchical Process (AHP) is used to address this problem based ranking mechanism by assigning weights to features considering the interdependence between them, thus providing a much-needed quantitative basis for the ranking of Cloud services provider.

2 Related Work

The concept of ontology based service ranking is an explored concept in the area of web service [7], [15], [9] and the revolution of ontology play an important role in different domain. Many works has been published related to this concept [4], [6], [8], [14].

A notable work in ranking of Cloud computing services is done by S. K. Garg, S. Versteeg and R. Buyya called "SMICloud" which measure the quality and prioritize Cloud services [10] and A.Li, et al proposed "Cloudcmp" which compares the Quality of Services offerd by the popular cloud providers[3], [12], [13]. Ruby et al have also worked on ranking the cloud services [21], [22]. Though many of the works have concerned on the ranking of Cloud computing services, ontology based ranking is still an unexplored area.

3 Architecture Design

Fig. 2 represents the major phases of Cloud service providers ranking system. Initially, the functional requirements are obtained from the client by validating their identity. At the other end ontology is formed using the functional requirements provided by the cloud service providers which are extracted from the web using the extraction tool. Then the obtained functional requirements are matched with the extracted functional requirements and get the initial output as matched Cloud service providers. After functional requirement matching, the hierarchy structure for Cloud service providers based on QoS attributes are formed using ontology with respect to the output of matched functional requirements. Based on this requirements and their respective user's priority on non-functional requirements, the service providers are ranked using AHP.

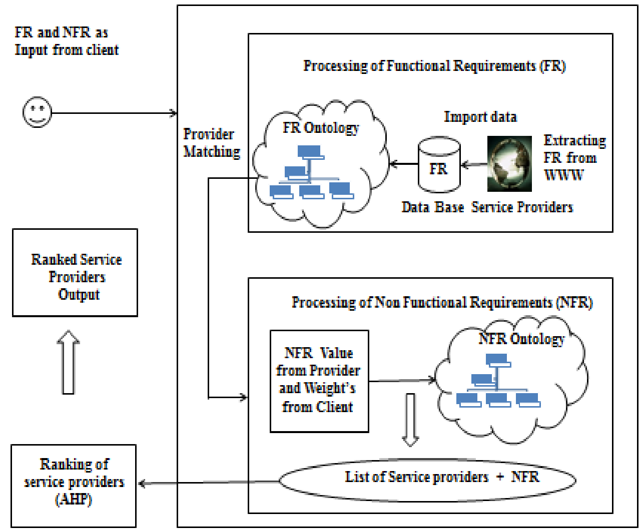
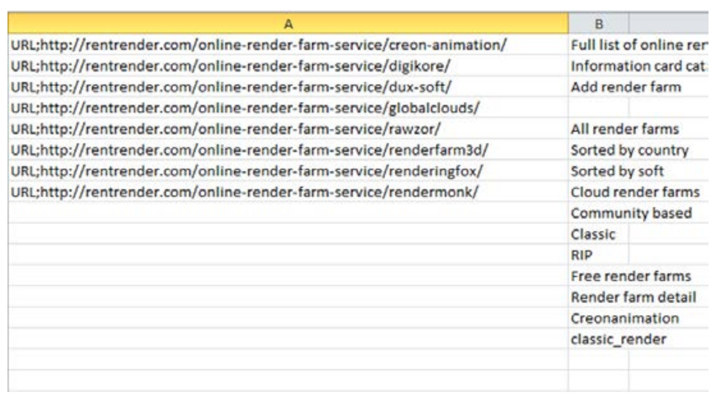


Fig2. Cloud Service Providers Ranking System

4 System Implementation

4.1 Processing of Funcitonal Requirements

In this phase after validating client, the required functional requirements from the client are obtained. The list of functional requirements provided by the Cloud service providers are extracted from the web using the extraction tool (Excel) which is a dynamic process. Fig. 3 shows an extracted unstructured data.



A	B
URL;http://rentrender.com/online-render-farm-service/creon-animation/	Full list of online rer
URL;http://rentrender.com/online-render-farm-service/digikore/	Information card cat
URL;http://rentrender.com/online-render-farm-service/dux-soft/	Add render farm
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URL;http://rentrender.com/online-render-farm-service/rawzor/	All render farms
URL;http://rentrender.com/online-render-farm-service/renderfarm3d/	Sorted by country
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URL;http://rentrender.com/online-render-farm-service/rendermonk/	Cloud render farms
	Community based
	Classic
	RIP
	Free render farms
	Render farm detail
	Creonanimation
	classic_render

Fig3.Example of Extracted unstructured data

After this process the unstructured data is converted to structured data to obtain the list of requirements along with the Cloud service providers name as shown in Fig. 4 and are imported in to the database for requirement matching with the help of Web Ontology Language (OWL) for ontology creation and SPARQL for matching. Finally, the matched Cloud service providers list is obtained as output.

	A	B	C	D
1	**Providers**	**Software**	**Engine**	**Plugin**
2	Astronomy.swin.edu.a	3ds Max	Mental Ray	FumeFX
3	Astronomy.swin.edu.a	Lightwave 3D	VRay	Krakatoa
4	Mirage		3delight	
5	Mirage		Renderman	
6	Creonanimation			
7	Digikore Studios	Maya	Mental Ray	
8	Digikore Studios	3ds Max		
9	Dux soft			
10	Global Clouds	3ds Max		
11	Global Clouds	Blender		
12	Global Clouds	Modo		
13	Rawzor	Blender	Luxrender	
14	Rawzor		YafaRay	
15	Renderfarm3d	3ds Max	VRay	
16	Renderfarm3d	Blender		
17	Renderfarm3d	Maya		
18	Rendering Fox	3ds Max	Mental Ray	
19	Rendering Fox	Maya	VRay	
20	Rendermonk	3ds Max	Maxwell	

Fig4. Example of converted data

4.2 Processing of non-functional requirements

After the functional requirement matching, the non-functional requirements attributes like the service suitability, availability, and elasticity etc., are obtained based on the International Organization for Standardization (ISO) standards by the CSMIC [18] consortium which is nothing but QoS attributes. It consists of a set of business relevant Key Performance Indicators (KPIs) that provide a standardized method for measuring and comparing business services.

By using these attributes with respect to the output of functional requirements, ontology for non-functional requirements are formed. Fig. 5 is an example of QoS ontology, in this the first layer is the analysis goals, which aims to find the relative service management index of all the Cloud service providers which satisfy the essential and non-essential requirements of the user. The second layer contains hierarchies of QoS attributes. The bottommost layer contains the values of all QoS attributes in the hierarchy presented in the second layer.

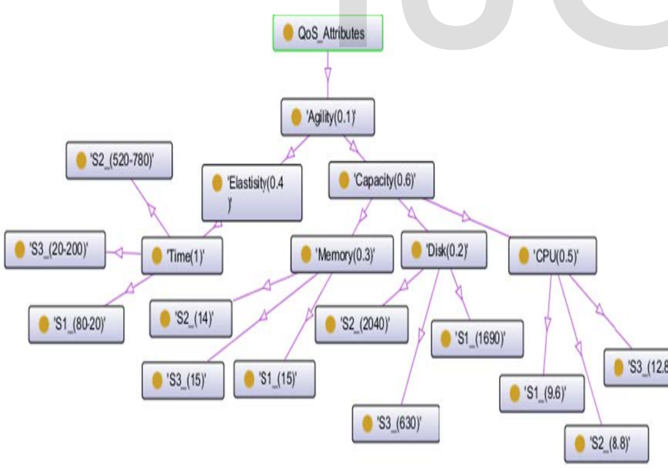

Fig5. Example of QoS Ontology

These values are obtained from the historical measurements and the weights are given in the brackets. Assign weights to these attribute is an important task to compare two Cloud services providers. For this, two types of weights are used.

1) The user can assign weights to each of the SMI attributes using values in some scale in the AHP method, to indicate the importance of one QoS attribute over another. This can be used to assign weights to all the QoS attributes. Users express their preferences for each attribute relative to other attributes.

2) A user can assign weights in their own scale rather than the one given by the AHP technique. In this case, the sum of all weights may not be more than 1 which is a requirement of AHP. For that normalize all the weights. Finally, the list of Cloud service provider with QoS attributes is obtained.

4.3 Ranking of service provider

Based on the matched Functional requirements and their respective user's priority on Non-functional requirements, the service providers are ranked using AHP by placing them in ontological format. As said earlier it is one of the most widely used mechanisms for solving problems related to multi-criteria decision making (MCDM) [17]. It simplifies complex, ill-structured problems by arranging the decision factors in a hierarchical structure. It is based on pairwise comparisons of decision criteria rather than utility and weighting functions. The pairwise comparison allows the decision maker to determine the trade-offs among criteria.

In addition, [19] AHP decomposes a decision problem into its constituent parts and builds hierarchies of criteria similar to KPIs in the SMI framework. It also helps to capture both subjective and objective evaluation measures. While providing a powerful mechanism for checking the consistency of the evaluation measures and alternatives, it reduces bias in decision making. Therefore, to rank Cloud services based on multiple KPIs, there are three steps in this process: problem decomposition, judgment of priorities, and aggregation of these priorities. It gives a very flexible way for solving such problems and can be adapted to any number of attributes with any number of sub-attributes.

In the first phase, the ranking of a complex problem is modeled in a hierarchy structure that specifies the interrelation among three kinds of elements, including the overall goal, QoS attributes and their sub-attributes, and alternative services. The second phase consists of two parts: a pairwise comparison of QoS attributes is done to specify their relative priorities; and a pairwise comparison of services based on their QoS attributes to compute their local ranks. In the final phase, these weights define the relative performance of each service based on the values of the lowest level attributes. The process of assigning weights is not straightforward since the lowest level attributes can have various types of values.

For example the value of 'certifications' for a particular cloud provider will be a list or a set. While the value of 'elasticity' will be a numerical value, values of some attributes may not be known. Therefore, the challenge is how to assign weights to each of the attributes when they are not quantifiable. To address this issue relative weights are used.

Here the [9] relative weight metrics consider two types of QoS requirements of Cloud users, i.e. essential and non-essential. Compare both values for each cloud service provider. First make sure that the dimensional units of both values are the same. Secondly compare the two values based on their types. Thirdly compare non-functional attributes for each alternative service provider and the relative local ranks of all criteria are aggregated to generate the global ranking values

ISSN 2229-5518

for all the service providers and finally ranked cloud service providers are obtained. For example, based on the data given in Fig. 3, the Agility has two QoS attributes which are further subdivided into sub-attributes. The Relative Service Ranking Matrix (RSRM) for elasticity will be:

$$\text{RSRM}_{\text{elasticity}} = \begin{pmatrix} & S1 & S2 & S3 \\ S1 & 1 & 80/520 & 80/20 \\ S2 & 520/80 & 1 & 520/20 \\ S3 & 20/80 & 20/250 & 1 \end{pmatrix}$$

Its Relative Service Ranking Vector (RSRV) is given by RSRV $_{\text{elasticity}}$ = [0.34700 0.1991 0.4538]. For each sub-attributes, i.e., CPU, memory and disk, RSRVs are given by

RSRV $_{\text{CPU}}$ = [0.3076 0.41020 0.2820]

RSRV $_{\text{memory}}$ = [0.3409 0.3181 0.3409]

RSRV disk = [0.3623 0.4373 0.2002]

Combining RSRV vector of sub-attributes, i.e. CPU, memory, disk the RSRM for Capacity is obtained.

$$\text{RSRM}_{\text{capacity}} = \begin{pmatrix} 0.30769 & 0.34090 & 0.36234 \\ 0.41025 & 0.31818 & 0.43738 \\ 0.28205 & 0.34090 & 0.20026 \end{pmatrix}$$

Next, compute the RSRV for Capacity,

$$\text{RSRV}_{\text{capacity}} = \begin{pmatrix} 0.30769 & 0.34090 & 0.36234 \\ 0.41025 & 0.31818 & 0.43738 \\ 0.28205 & 0.34090 & 0.20026 \end{pmatrix} \begin{pmatrix} 0.5 \\ 0.3 \\ 0.2 \end{pmatrix}$$

Therefore,

RSRV $_{\text{capacity}}$ = (0.3286 0.3881 0.234)

Similarly, compute the RSRV for each top level QoS attributes i.e., Assurance, Cost and Performance. Finally, aggregate all RSRVs of all the QoS attributes to get the relative service ranking matrix for obtained providers. To get the final RSRV, multiply the above RSRM with the weights of the top level QoS attributes.

$$\text{RSRM} = \begin{pmatrix} 0.25 & 0.336 & 0.3812 & 0.1619 & 0.2846 & 0.25 \\ 0.5 & 0.3125 & 0.2671 & 0.1308 & 0.1181 & 0.5 \\ 0.25 & 0.3516 & 0.3517 & 0.7073 & 0.5973 & 0.25 \end{pmatrix}$$

Therefore, the relative ranking of all the Cloud service providers can be decided based on the resultant RSRV. Based on the user requirements, this system ranked the Cloud service providers.

5 Conclusions and Future Work

Cloud computing has an important role in IT organization and currently many Cloud providers offering different Cloud services. It has become a challenge for the Cloud customers to find the best Cloud service provider based on their QoS requirements. To choose appropriate Cloud service provider customer need to have a way to identify and measure QoS attributes that are important to their application. Therefore, the Cloud service providers ranking system is proposed. This system has three phases, they are (i) processing of functional requirements (ii) processing of non-functional requirements and (iii) ranking of service providers. Initially, the functional requirements are obtained from the client by validating their identity and allow access to them. Then the obtained requirements are matched with the details already exists in ontology and with respect to non-functional requirements the weights are assigned to them. Finally, the service providers are ranked using AHP based on that weight and values of QoS attributes. This ontology based system have information with explicit meaning, making it easier to automatically process and integrate information available for comparison, selection and ranking of cloud service providers which make a significant impact and will create healthy competition among Cloud providers to satisfy their Service Level Agreement (SLA) and improve their Quality of Services (QoS). In future, this system will extend to cope with variation in QoS attributes such as performance by adopting fuzzy set.

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