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A Framework for an Intelligent Broker Model of Cloud Service Selection

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Abstract: Contemporary research in cloud federation faces challenges in selection of "best" cloud service among multiple cloud service providers. This study presents a novel architecture which incorporates the intelligent broking system for selecting the "best" cloud service among various cloud service providers. This research conducts investigation among various classification algorithms based on the cloud user requirement and select best classification algorithm to build an intelligent broker system. The evaluation of comprehensive experimental result is obtained using synthetic dataset. From the experiments, it is concluded that C4.5 classification algorithm outperforms well than any other classification approaches for most of the cloud user requirements.

Key words: Cloud service selection, data mining, classification, C4.5, synthetic dataset, service measurement index

INTRODUCTION

In the evaluation of distributed systems Web 2.0 and Grid Computing initiatives coined a new model named Cloud Computing. The subsequent Cloud Computing technology concretely envisioned the salient features like collaborative resource sharing, elasticity, pay-per-usage model. The most important three service provision models of Cloud Computing based on the IT customer application requirements are Software as a Service (SaaS), Infrastructure as a Service (IaaS) and Platform as a Service (PaaS). The SaaS is a software distribution model on basis of user payment and demand over the internet. The PaaS allow the users to run the applications without the need of required hardware and software infrastructure in local environment (Buyya *et al*., 2009). The IaaS provides virtual environment for resource computation. Among the three services, nowadays the SaaS service model growth is high over IaaS and PaaS due to traditional software usage.

The three services can be deployed in four models as public, private, community and hybrid cloud. The private cloud is operated only within a single organization and Community clouds are formed by several organizations jointly constructing and sharing the same cloud infrastructure. The Public clouds available in the public internet are used by the general public cloud consumers and hybrid cloud is the combination of two or more clouds. Currently single public cloud is prominent due to perceived benefits for startup and SME (Small and medium-sized enterprises) (Buyya *et al*., 2009) in saving capital investment on IT infrastructure and skilled manpower for maintaining them. To utilize the profits provided by cloud a majority of organizations are building their applications on the cloud Infrastructure. Cloud application development and porting existing application to the cloud has a number of challenges. The challenges arise while the application specific requirements are to be satisfied by the cloud provider. In near future everything as a service will be the de facto model due to lack of customer requirement satisfaction in traditional cloud.

The traditional cloud may not be the right choice for customer due to lifetime agreement of a single provider presents the difficulties like vendor lock in, limited choice, lack of control, etc. The Cloud providers come up with a broad range of features offered. On the other side numerous factors govern the decisions in migrating data and/or applications into the Cloud. The application specific requirements and characteristics of Cloud users are to be matched with the services offered by cloud providers. In some scenarios the exact user requirements cannot be met by a single provider. So a customer has to depend on multiple cloud service providers. As exponential increase in public cloud

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offerings, the main issue for customers is to find the appropriate cloud service providers that will meet Quality of Service requirements (QoS) (Buyya *et al*., 2009).

In this context, customers are in urge to identify best service providers. As each cloud service provider satisfies different set of functional and non-functional requirements, service levels of various cloud service providers evaluation become difficult. In addition to find various cloud service providers that satisfy the customer requirement, to provide suggestion about suitable cloud service provider is also essential. In this context, Cloud Service Measurement Index Consortium (CSMIC) has found metrics that are collective in the form of the Service Measurement Index (SMI), contributing comparative Cloud services evaluation. Customers can use these performance indices to compare various cloud services (Garg *et al*., 2013).

The process of QoS evaluation and selecting the best cloud service provider involves many challenges. The challenges are method of measuring SMI, dynamic nature of attributes and lack of measuring tools for precise measurement of SMI attributes. The proposed model devises precise metrics for each measurable attribute. The Selection of best provider is further complicated with functional and non-functional SMI attributes. The non functional attributes cannot be quantified with lack of metrics. The matching phenomenon involves rational intelligence which takes into account multiple criteria which are interdependent. Among various techniques in Multi Criteria Decision Making (MCDM) (Zeleny, 1982), an intelligent broker is developed which employs various efficient classification algorithms in a cognizant strategy to select cloud providers. The rest of the study is organized as follows:

- A detailed research study of cloud service selection is presented
- A novel architecture is proposed for selecting “best” cloud service provider for which makes use of data mining approach
- Investigation of cloud service selection is made by using various classification algorithms
- Evaluation of experimental results

Cloud service selection: The major problems in selecting best cloud services by using performance indicators are:

- There are many cloud service providers available with huge pool of services in the market. The task of acquiring the cloud services among these cloud service providers for solving consumer’s business problem is a cumbersome job
- Many of the parameters changes over time. So, it is not possible to compare different cloud offerings without having accurate measurement models for each attribute
- We have consider both functional and non-functional parameters to make decision for selecting the cloud service

Moreover, selection of cloud service involves multiple criteria and dependency between the QoS parameters. To evade these problems, the system needs to be devised to consider Multi-Criteria Decision-Making (MCDM) (Zeleny, 1982). The proposed architecture utilizes one of the MCDM approach called classification algorithm, uses historical information and it includes both functional and non-functional parameters.

Data Mining is the algorithmic process of extracting useful patterns from the transaction databases. Different kinds of patterns are mined from the databases. For example, Association Rule Mining (ARM) is used to find the relationship among the items in the itemset. Classification algorithms are used to allots items in a group to target categories or classes. Clustering algorithms are used to group the set of objects in such a way that objects in the same group. Outlier analysis is used to mine the data that do not comply with the general behavior or model of the data. Data mining is used in wide variety of applications such as retail industry, financial analysis, intrusion detection, biological data analysis, telecommunication and many other applications.

In this study, we propose a novel framework that uses classification analysis to suggest the user for selecting the suitable cloud service provider based on both functional and non-functional parameters.

Literature review: In the related work, previous findings for cloud service selection and its limitations are discussed. Garg *et al.* (2013) proposed a framework entitled Service Measurement Index Cloud (SMICloud) which makes use of metrics identified by CSMIC and measures the quality and prioritize cloud services. It is used by the cloud service consumer to compare different cloud offerings and select cloud service providers according to their priorities and various dimensions. Goscinski and Brock (2010) proposed a technology, constructs possible service publication provisions, discovery and selection based on dynamic attributes that convey cloud services state and resources characteristics.

Their implementation allows the cloud user to use webpage for effortless publication, find, select and use of an available cluster.

Salama *et al*. (2012) presented a mathematical model to select a best cloud service provider using optimization problem based on QoS guarantees. They discussed that the model is efficiently matches with the characteristics of market-oriented platforms covering a wide range of service provider selection problems with the simulation studies. Selection of best cloud service based on security and privacy requirements is a major issue in recent years. Mouratidisa *et al*. (2013) addresses this issue by delivering the efficient and controlled approach that permits the user to find best cloud service provider based on security and privacy requirements. This framework understand the organizational context in terms of identifying goals, actors, tasks, resources and plans that helps to spot and analyze security, privacy constraints, security and privacy goals, threats and vulnerabilities relevant to a cloud based system. This system is explained with the help of a real case study called electronic-point-of-sale (EPOS).

Manvi and Shyam (2014) have identified some of the issues in resource management such as resource provisioning, resource allocation, resource adaptation, resource mapping, resource modeling, resource estimation, resource discovery and selection, resource brokering and resource scheduling. They provided a comprehensive review on some of the aforementioned issues. Nowadays, there is a need of decide whose services user should use and what is the basis for selecting the cloud services. Dergan and Dhindsa (2013) presented a usage pattern based mechanism for the selection of cloud services. In this research, selection of services is based on characteristics such as performance, reliability and cost, ranking and integrity are also considered. This research utilizes the synthetic test data consists 600 records to perform experimental evaluation.

Zeng *et al*. (2009) expresses the cloud service architecture and key technologies for service selection algorithm. They also proposed the optimized service selection algorithm. Pawluk *et al*. (2012) designed a cloud broker service. In that work, Services offered by multiple cloud service providers (Amazon Ec2, Rackspace) has been identified and various optimization techniques have been used to automate the selection of application topology which was based on requirement specification. Deployment and dynamic management of selected cloud application which was provided by STRATOS broker service. Badidi (2013) proposed a framework for software as a service selection and provisioning. In this framework, cloud service selection algorithm is proposed to rank SaaS providers by using linear aggregate utility function to match services offered by the SaaS provider with requirements of service consumer. SLA negotiations of selected service are done by cloud service broker instead of service consumer and also monitor SLA compliance.

Dou *et al*. (2015) composition of cloud services from various cloud service provider results in Big Data processing. Some private cloud service provider will not reveal their QoS parameters to maintain privacy. So they proposed a method to evaluate cloud service based on history of QoS records. Ghosh *et al*. (2015) proposed a cloud service selection framework to provide guaranteed quality service by combining reliability and capability to calculate interaction risks where reliability can be measured based on feedback of the users. Zhou *et al*. (2016) proposed a workflow as service model to reduce the cost of workflow execution in IaaS. Mostly cloud environments are dynamic in performance which is created by interferences. In WaaS, outbound bandwidth price will be calculated in dynamic based on workflow execution. Tajvidi *et al*. (2014) proposed a framework for cloud service selection based on fuzzy logic application on user requirements.

A framework was proposed by Yan *et al*. (2012) using Policy Implementation Engine (PIE) to help enterprises to select the cloud service subscription based on the policy-based service selection and rating-based service recommendations on account of user requirements and specifications offered by cloud platforms. The framework consists of four modules, cloud service modeling and feature extraction, here the cloud services as classified to catalog and the catagorized features are extracted. Quantitative metrics of cloud services, here the services are quantified to measure each feature and the performance scores are further normalized to facilitate comparison among the criteria. Policy Implementation Engine checks automatically for the conflicts based on user requirement when conflict is detected a form is generated to assist the users to quickly understand the conflict and resolve it. Cloud intelligence assesses the solution from PIE based on multiple criteria like quantitative metrics for cloud services, collective intelligence from intranet and social media, internal user's rating and feedback and individual user's preferences.

A service brokering and recommendation mechanism was proposed by Gui and coauthors for providing better cloud service selection. It automatically collects the heterogeneous cloud information and depicts a uniform information model, generates solutions for specific configurations, by leveraging multiple selection criteria it evaluated and recommends cloud solutions. The architecture consists of a unified cloud information model this is essential to combine and predict heterogeneous cloud information. Collecting and managing cloud service information by gathering cloud service information and storing and updating them. Service filtering using an operable service classification model based on six dimensions of the model such as flexibility, scope and performance, reliability and trustworthiness, service and management addresses, IT security and privacy and

cost/price. Solution generating with an application dependent requirement description schema, based on hardware requirement, application features and rental preference. Preference-aware solution evaluation mode which has six criteria like fee cost, VM computing capacity, SLA (service level agreement), feedback, customer service, software ecosystem.

QuARAMRecommender is a service recommendation system proposed by Soltani *et al*. (2014) which maintains a case base of previous selections which helps to select the best match cloud provider based on customer requirements and preferences. Through a user interface customer submits the application requirements, preferences and constraints. The architecture contains the knowledge bases in this system are application case base from where the queried attributes are retrieved. Adaption case base contains knowledge about the adaption of retrieved solution. Providers' knowledge base contains list of different providers offering VM instances. Next is case base memory model in which the case base is organized in a manageable structure and the model can be catagorized into three classifications such as flat/linear memory model, hierarchical memory model and network- ased memory model. Next is retrieval in which the flat memory model uses K-Nearest Neighbour (KNN) and the footprint model uses proprietary retrieval model. Finally, adaption where it adapts the target problems of retrieved solutions. In this study dataset is collected from 260 different available Amazon Machine Images (AMI).

MATERIALS AND METHODS

Proposed novel architecture: In this study, a novel architecture is proposed which aids cloud consumers to select best cloud service provider and therefore can initiate SLAs (Service Level Agreements). Existing frameworks makes use of rank based mechanism, provides cloud service selection features which are based on functional parameters only. This architecture offer features such as cloud service selection based on both functional and non-functional QoS parameters. It makes use of intelligent decision making tool called decision tree classification that utilizes historical information to assess the cloud service in terms of user requirements. Figure 1 shows some key components of the framework.

Cloud Service Broker (CSB): After referring SLAs, user supplies the requirements to select the best cloud service. This request will be forwarded to Cloud Service Broker (CSB). It gathers all requirements of a user and perform discovery of best cloud service using other element called Intelligent Discovery Component (IDC).

IDC: This component makes use of transaction databases to extract invaluable cloud service using Decision Tree Classification (DTC) algorithm. DTC element outputs classification rules which will be stored in Knowledge Base (KB). The requirements obtained from the user are supplied to the IDC component. The IDC component recommends best cloud service to the cloud consumer with the help of KB.

Dispatch Unit (DU): This component collect best cloud service provider suggested by the CSB. With the help of Deltacloud, user can interact with cloud service provider to complete their business service. The main purpose of Deltacloud is to provide one unified REST-based API that can be used to manage services on any cloud.

Investigation of cloud service selection by various classification algorithm: In this research, we investigates various Classification Algorithms like Decision Strump, Naïve Bayesian Classification(NBC), NBTree, FT, C 4.5, BFTree, Kstar, etc. that supports both nomial and categorical data.

An intelligent cloud service selection algorithm: A general flow of proposed cloud service selection algorithm is represented pictorially in Fig. 2.

Step 1; collection of data: Dataset is constructed synthetically due to the fact that there are no benchmark data available for this problem. While constructing the dataset, various parameters that define the cloud services are considered i.e., both quantifiable and non-quantifiable parameters like User Rating, Base Plan Cost, Inbound Bandwidth Price and Outbound Bandwidth Price, etc. For the synthesized dataset construction, various cloud service providers like windows azure, Amazon, gogrid, etc.

Step 2; preprocess the data: In this step, selection of relevant attributes (i.e., parameters for choosing the cloud

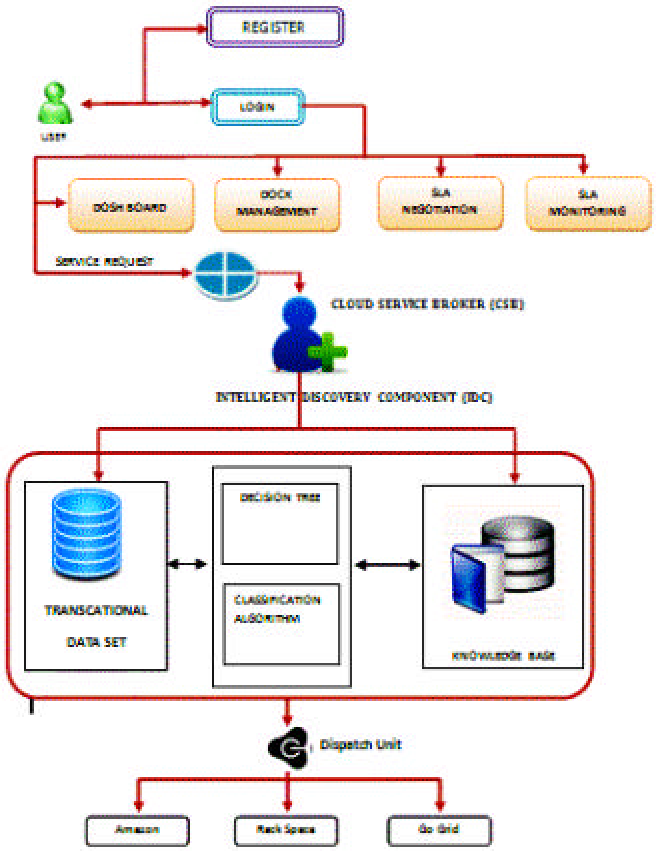

Fig. 1: Proposed architecture for intelligent cloud service selection

service) is done for constructing the decision tree model. Existing works pertaining to the cloud selection approaches focuses only on the quantifiable QoS parameters. In this research, the focus is done to take both quantifiable and non-quantifiable parameters to select best cloud service provider using intelligent technique. Decision tree algorithm prunes the irrelevant parameters based on user requirements and also some missing data is replaced with constant value.

Step 3; construct decision tree using training dataset: A decision tree is a learning tool which looks tree-like model of decisions and their possible outcomes, including event outcomes probability. Construction of decision tree has the following steps:

- The selection of the division in our synthesized datasets
- The decisions based on gini index to announce a node terminal or to further division
- The assignment of class to each terminal node

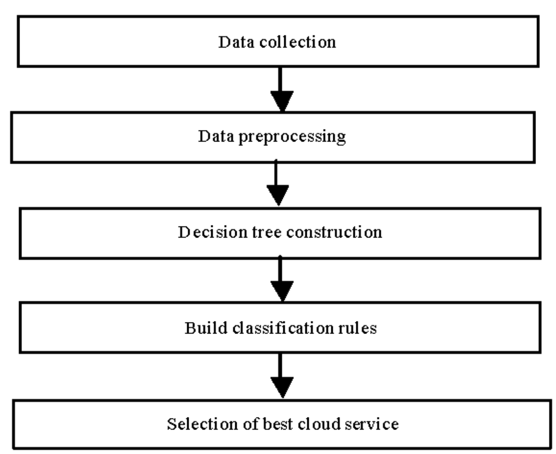

Fig. 2: Flow of proposed cloud service selection algorithm

In this research, numerous decision tree algorithms are experimented to decide on which algorithm achieves better accuracy and performance for the purpose of selecting best cloud service.

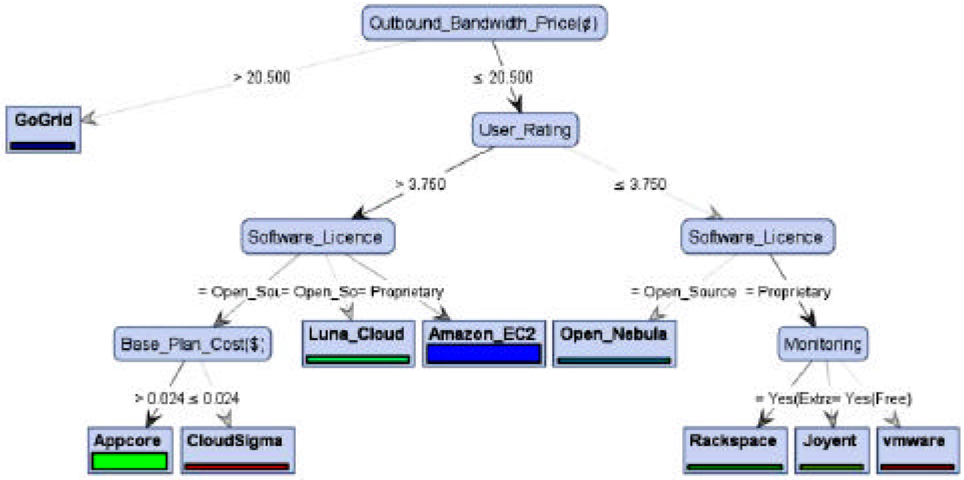

Fig. 3: Decision tree

Step 4; Build classification rules with the help of decision tree: Set of useful if-then rules are extracted by using decision tree model. These rule set are kept in knowledge base. Constructed decision tree is shown in Fig. 3. It considers only the relevant parameters to the user request. Based on user requirement decision tree is constructed.

Step 5; select best cloud service using classification rules: Cloud users request have the requirement of Outbound_Bandwidth price is <20,500$, then GoGrid is the right option. Otherwise we have to consider other parameters like user_rating, software_licence, Base_plan_cost, etc. Classification rule is generated based on user request. Intelligent broker make use of these rules to select best cloud service provider for cloud users. Sample Classification rule is given below:

- IF Outbound_Bandwidth_Price($) >20,500$ and User_Rating>3,750 and Software_Licence= Proprietary THEN Amazon_EC2
- IF Outbound_Bandwidth_Price($) >20,500$ and User_Rating>3,750 and Software_Licence=Open_Source THEN Luna_Cloud
- IF Outbound_Bandwidth_Price($) >20,500$ and User_Rating>3,750 and Software_Licence=Open_Source and Base_Plan_Cost($)>0.024 THEN Appcore
- IF Outbound_Bandwidth_Price($) >20,500$ and User_Rating>3,750 and Software_Licence=Open_Source and Base_Plan_Cost($)=<0.024 THEN CloudSigms
- IF Outbound_Bandwidth_Price($) >20,500$ and User_Rating<=3,750 and Software_Licence=Open_Source THEN Open_Nebula
- IF Outbound_Bandwidth_Price($)>20,500$ and User_Rating<=3,750 and Software_Licence= Proprietary THEN Monitoring=YES THEN Rackspace

RESULTS AND DISCUSSION

The data utilized in the experimental result is synthetically generated which consists 35,000 transactions and 24 functional and non-functional QoS parameters. In Table 1, it is shown various quantifiable and non-quantifiable QoS and it's description, parameter value, type, CSMIC SMI(v2.0) category and KPI's category.

The experiment was conducted by using various well-known classification algorithms which supports both nominal and categorical data in the data mining literature.

Execution time and accuracy of various algorithms are recorded by extensive evaluation and that is shown in Table 2. Synthesized dataset is divided into training data and testing data. We have created dataset in proper distribution.

Accuracy and Execution Time of various Classification Algorithms is shown in Fig. 5 and 6. Even though the following classification algorithms NBTree, LADTree, LMT, C4.5, BFTree and Kstar gives >80% accuracy, C4.5 algorithm results in high performance among those six algorithms.

With these results, it has been found that C4.5 algorithm resulted best performance in terms of accuracy and execution time. Thus we have selected C4.5 classification algorithm to build intelligent broker model in our proposed architecture.

Table 1: List of QoS parameters

	Parameters					
PID	Name	Description	Value type	Values	CSMIC SMI(v2.0)	KPI's
Functional parameters						
1	User rating	Rate given by user based on their opinion	Range	1-5	Performance	Accuracy
2	Processor	Processor architecture supported by the cloud service provider	Numeric	32, 64 bits		Functionality
3	Base plan cost	Cost of the base plan provided by the cloud service provider	Range	0-6$	Financial	Cost
4	Inbound bandwidth price	Incoming data transfer Price per GB	Numeric	0$		Billing process
5	Outbound bandwidth price	Outgoing data transfer Price per GB	Range	0.0-0.29$		Billing process
6	Guaranteed network availability	The minimum network availability which is guaranteed are described in the service level agreement	Range	0%-100%	Assurance	Availability
7	Virtual CPU cores	Multiple logical core on a single physical CPU	Range	1-8	Agility	Capacity
8	RAM	Main Storage Area	Range	1-16 GB		
9	Disk space	Secondary Storage Area	Range	1-30 GB		
Non functional parameters						
10	Software license	The software license refers to the user's agreement for the software usage in cloud	Boolean	Proprietary, Open Source	Accountability	Ownership
11	Control interface	It is a software interface used by cloud subscriber to access their data on the cloud	Unordered set	Command Line, GUI, API, Web based Application	Performance	Functionality
12	Subscription Plan	It tells how often and how much to charge customers to utilize cloud services	Unordered set	Hourly Rate, Monthly/Fixed Rate, Free Plan, Spot Instance, On Demand Self Services	business Accountability	Provider stability
13	Free Security Features	Security features given by the cloud service provider for free	Unordered set	Advanced Firewall, Critical Data Privacy, Custom/Secure Permission Failover Features.	Security	Privacy and data loss
14	Paid Security Features	Security features given by the cloud service provider upon payment	Unordered set	Backup storage, critical data privacy, data protection, snapshot backup	Security	Retention
15	Auto scaling	Ability to be automatically enlarged	Boolean	Yes/No	Agility	Elasticity
16	Virtual Private Servers	A Virtual Private Server is a logically dedicated server for each user which runs on physical server	Boolean	Yes/No	Security	Security and Privacy
17	Root Access	Whether cloud service provider permits root access or not	Boolean	Yes/No	Security	Physical and Environmental
18	Load Balancing	Whether cloud service provider balanced the load in cloud for the user process	Boolean	Yes/No	Quality	Availability (fault tolerance)
19	Monitoring	Whether cloud service provider provides monitoring facility or not	Boolean	Yes/No	Security	Access Control
20	File Hosting Service	Availability of file hosting service with cost or without cost	Boolean	Yes/ No	Quality	Serviceability (service continuity)
21	Web Hosting Service	Availability of web hosting service	Boolean	Yes/ No	Quality	Serviceability (service continuity)
22	Compatible OS	List of operating system supported by the cloud service	Unordered set	Cent OS, Redhat, Windows, Debian, Fedora, ubuntu	(usability- Quality	Effectiveness operability)
23	Free Support	Cloud service provider offers free support or not for user services	Boolean	Yes/No	Serviceability	Supportability
24	Support Services	Different way of providing assistance to the users for their convenience	Unordered set	Phone, forums, 24/7, urgent responses, diagnostic tools, online responses, support videos, knowledge base, online guide	Serviceability	

Table 2: Record of execution time and classifier accuracy of various algorithms on synthetic dataset

Name of the algorithm	Execution time (sec, %)	Accuracy
Naïve Bayesian	30.00	2.92
Random Forest (RF)	66.67	12.00
Random Tree (RT)	33.33	1.80
Decision Stump (DS)	33.33	3.91
NBTree	90.00	193.00
REPTree	33.33	2.00
LADTree	80.00	792.00
LMT	85.00	3795.00
FT	33.33	522.00
C4.5	97.00	1.00
BF Tree	79.00	111.00
Addesr	77.00	1.50
Kstar	92.00	6649.00
Lbr	80.00	123.00
C 4.5 graft	75.00	2.00

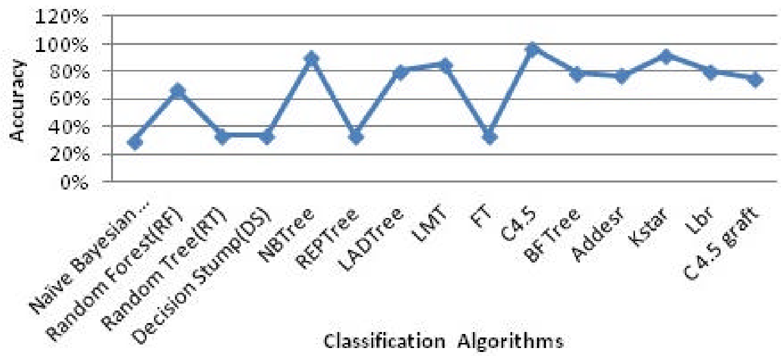

Fig. 4: Accuracy of various classification algorithms

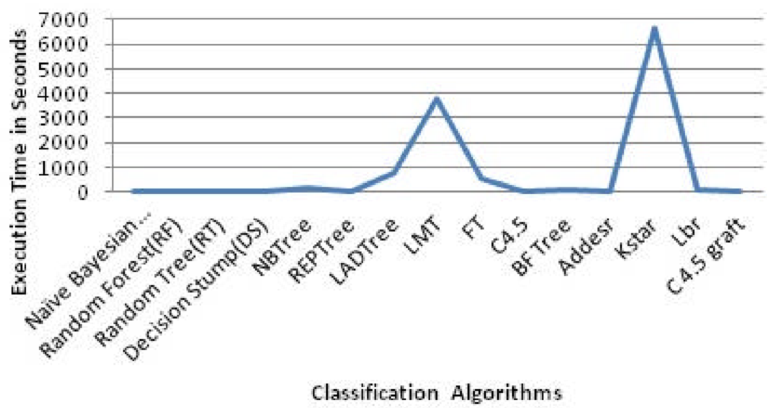

Fig. 5: Execution time of various classification algorithms

CONCLUSION

Selection of cloud service providers for different needs (IaaS, PaaS and SaaS) of the user is a major issue. To avoid this problem, a novel architecture for an intelligent cloud service selection approach is proposed. A comprehensive analysis of cloud service selection is done by using various classification algorithms in data mining literature. Experimental evaluation shows that C4.5 algorithm produces better accuracy and responses quickly when compared to other classification algorithms for the most common user requirements. Cloud users need not verify manually to choose best service provider in terms of Quality and Cost. This research presents a framework to select a best cloud service provider based on Intelligent Broker Model which uses both functional and non-functional QoS parameters on Windows Azure, Amazon and Go Grid. In our future work, usually customer requirements suits with multiple cloud service providers, for that we will propose a model to suggest Cross Cloud service selection.

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