Indian Journal of Science and Technology, *Vol 11(9), DOI: 10.17485/ijst/2018/v11i9/119843,* March *2018*
ISSN (Print) : 0974-6846
ISSN (Online) : 0974-5645

A Recommendation System for Cloud Services Selection based on Intelligent Agents

Abid Mahmood, Umar Shoaib and M. Shahzad Sarfraz

Faculty of Computer Science and IT,
University of Gujrat, Pakistan, 10021719-001@uog.edu.pk, abidonline6@hotmail.com

Abstract

Objectives: To provide a recommendation system for cloud services selection based on intelligent agents. **Methods/ Statistical Analysis:** There have been many assortments of research, frameworks, and systems that discussed in many kinds of literature for selection of most advantageous service to fulfill the requirements of consumers. QoS parameters in addition to cloud service related QoS parameters have been used, but an agent-based cloud computing system has been introduced now that facilitate the CSS for better usage and service for the consumer. In this study, we proposed a service selector system on computer trust merit of the cloud purveyor. In previous studies, the authors had used the QoS model to solve the problem of cloud service vendor selection in multidimensional technique but this was not practically approachable. But we implement the multi-agent system (MAS) approach where one agent is liable to intermingle with the client for unambiguous service. MAS have very supple and self-directed nature, due to this quality MAS is the very authentic approach for users. **Findings:** In this proposal a selection and recommendation methodology implemented using multi-agents paradigm, has been proposed that recommends the most aspirant service from similar grouped services. The experimental output confirms that the proposed methodology can effectively select an optimal required service for end users. Cloud computing system with the help of multi-agents offer better agent-based intelligent cloud solutions for complex computational tasks. **Application/Improvements:** Multi-agents can be employed as key components for the selection and recommendation of intelligent cloud applications, making cloud infrastructure more autonomous, adaptive, and flexible in resources management, services provisioning and in running large-scale applications.

Keywords: Cloud Service Selection, Intelligent Agents, MAS

1. Introduction

Clouds are defined as a computing system where users are connected to wide range of inter-linked distributed computing nodes to utilize the cloud shared resources or services.[1] Data and all other computing resources are available somewhere out there in interlinked nodes instead of local space of the connected user, local warehouse or repository.[2] Clouds provide an on-demand access to ultra-supercomputing power to its user. This user can be any computing entity like PC, laptop, mobile or any embedded device able to connect to Clouds.[3,4] Cloud computing systems deliver adaptable and flexible services with high performance and ultra-scalable data storage to a very large number of users.[1] The number of these cloud users is rapidly increasing with every passing moment of the day.[5] With increasing number of cloud users, new cloud services are also being introduced in the field of Cloud computing. A number of related and relevant services in increasing so it is becoming almost difficult to recommend or choose the best service among a group of available relevant or similar services. So there is a need for recommendation/selection system or agent.[1] At its first step, the agent will group together similar services based on the attributes of services and assigning a similarity index value to each service group. Then in the next step, the recommender agent will suggest the most appropriate services after comparing the criteria of the customer which is searching for an optimal service to use.[3]

**Author for correspondence*

Services in clouds is a combination of multiple enabling technologies like virtualization which enables cloud users to run and execute the services beyond the physical hardware limitations and provides the hardware illusion after emulating hardware infrastructure.[6] Multi-Agent System (MAS) consists of a group of I (Intelligent) A (Agents) interacting with the environment and with themselves.[7,8] Working of MAS shown in Figure 1 in section 37. Agents in MAS are often used to complete common tasks by using a distributed or decentralized policy, where all agents complete the assigned job by collaborating and cooperating with each other.[3] Intelligence is one of the major characteristics of agents in MAS which is embodied in them through some communal artificial intelligence (AI) method. This AI approach is accomplished through cooperation and collaboration among all agents of MAS, where agents can achieve high performance with low resource utilization by running on parallel or distributed infrastructure.[9]

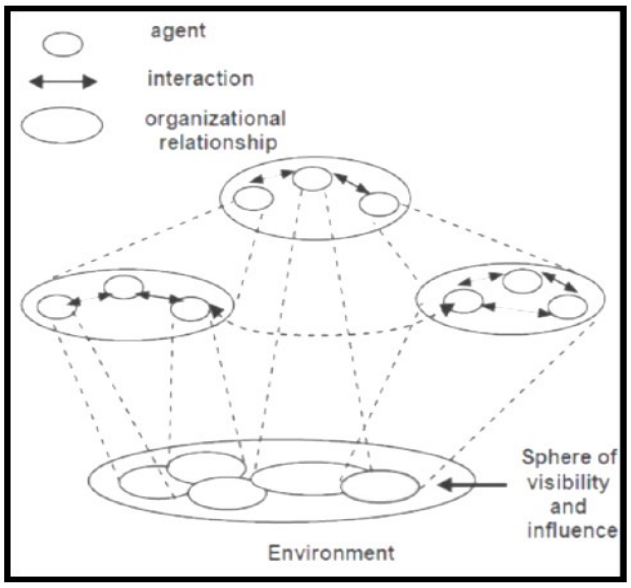

Figure 1. Multi-agent System in a Cloud Service.

In spite dissimilarities in multi-agent systems and Cloud Computing Systems, both systems also share multiple common attributes like distributed computing paradigm. Thus both systems, with integrated features or with integrated, collaborative and cooperative practices, can be utilized to resolve or identify common problems or to obtain shared benefits.[10] The main focus of Cloud Computing is to provide efficiently computing infrastructure as services include hardware, software, storage and platform with less cost and more benefits like virtual resource allocation to multiple users connected to same physical resource.[11]

The main focus of Cloud Computing is an efficient use of computing infrastructure provided partially or as whole as service.[12,13,4] On the contrary, the main research focus in the MAS is an intelligent aspect of agents and their use to complete tasks inside complex application systems.[14] So in both systems, the major problem is associated with issues such as simulation of complex systems, computing-intensive systems, distributed computing systems and collaborative learning and editing systems.

An agent, in the domain of computer science, is a computer system, program, software component or process that performs independent and intelligent actions continuously and autonomously on behalf of its owner or user in a particular dynamic environment.[15] The agent interprets its design objectives itself, instead of complete and repeated involvement of its user or owner learns from the environment and updates its knowledge repository for future decisions. The agent environment is typically inhabited by other agents as well where collaboration and communication between agents are also involved. The agent works as an autonomous entity or cooperates with another agent(s) to meet its design objectives. Agent encompasses one or more characteristics such as learning, mobility, collaboration, communication, intelligence, adaptability, scalability, and flexibility.[16]

2. Research Methodology

There have been various researches on web service vendor selection as well as cloud service providers selection. Various frameworks, techniques, and systems have been discussed in the literature for selection of best and an optimal cloud service fulfilling the consumer's requirements.[9,13,17] For example, the author introduced the idea of integrated Quality of Service (QoS) model to solve the problem of cloud service vendor selection by using a multi-dimensional QoS technique to evaluate the available services and recommend the cloud service searcher the best service.[6] The proposed technique has only been validated based on results from computer-based system simulation and there is no practical deployment of this system.

Another cloud service promising system has been developed by combining existing cloud architectures with

network virtualized resource techniques.[2,1] The proposed solution uses sane performance and modeling technique as used by network virtualization resources to provide a solution for cloud service selection. Although the main focus is to use network QoS parameters as well as Cloud service related QoS parameters for Cloud service selection there is less focus on QoS parameters related to cloud vendor and service providers.

The authors in paper have proposed a service selector based on computer trust worthiness of the Cloud vendor where the trust parameters have been collected from the users of the specific cloud service.[11] The system has been implemented using a multi-agents approach where one agent is responsible to interact with user searching for specific service. While the second agent's main responsibility is to collect the attributes, feedback, and responses socially from other consumers who got any past or present experience in using that specific service. Based on collected feedback the framework is able to recommend a service based on the computed trust of a service.[18]

Due to autonomous and flexible nature, MAS is the most appropriate approach for user authentication, authorization, access negotiations, service usage allocation, resource management and allocation, automation of services and resources discovery, configuration, dealing and marketing of cloud-related assets.[19] So a new arena, labeled as agent-based cloud computing, has been established to provide agent based cloud solutions which enable CCS to improve cloud computing usage and service. Self-governing agents can enhance the collaboration and interactions of the services in CSS to make them smarter computing and processing.[20] As various proposed system from literature has been discussed that assist the consumer to find the cloud service. However, to the best of my knowledge, there is no prose or an implemented solution like the proposed solution that solved the problem of service selection by helping the end user to search or find the Cloud service based on clustering technique and also provide the consumer with not only the specific service but also some alternatives.[21]

2.1 Multi-Agent System in a Cloud Service

As Cloud computing is attaining much reputation in software development as well as in hardware infrastructure proving vendors domain. To facilitate a broad range of consumers, it is also providing a great array of Cloud services, specially tuned for a specific purpose like storage, medical consultation, computing, monitoring and many others.[22] As the number of these being introduced services in gaining in total count, the selection of an optimum service is also becoming a challenge for Cloud users or consumers. In this paper plan a selection and recommendation methodology, implemented using multi-agents paradigm, has been proposed that recommends the most aspirant service from similarly grouped services.[23]

The core objective of this research is to select the most aspirant Cloud services among a group of services having similar services clustered together based on their features, implementation, availability and other general service related features and QoS attributes. The whole mining of existing services is being carried out using multi-agents. The first step, the grouping or clustering of similar services is done based on features or attributes of Cloud Services.[24] Selection or recommendation phase is then carried out by comparing the defined criteria of the end user who wants to use the specific service, with the class or group of filtered services. For final experimental phase, the proposed methodology will be evaluated for end-user seeking a medical consulting service as shown in Figure 1.

3. Proposed Solution

In order to solve the service selection problem, a Cloud Service Selector (CSS) solution is proposed which basically consists of two main modules. Both modules facilitate the CSS use by working in a number of phases as explained to select the best optimal service based on user parameters criteria. One module (another name agent) is based on Graphical User Interface that is used with a search engine. This module gets data as an input, and not used the selection structure. The other module is clustering agent that is the main module of this research. This module gets all parameters and CSP characteristics privately and publically s indicated in Figure 2.

1. CSS user inputs or selects the feature, attributes, and other related properties, from the provided user-interface, for the intended service to search for his use.
2. Clusters knowledge base construction based on the attributes/features of available Cloud services using the multi-agents architecture that builds a QoS knowledgebase.

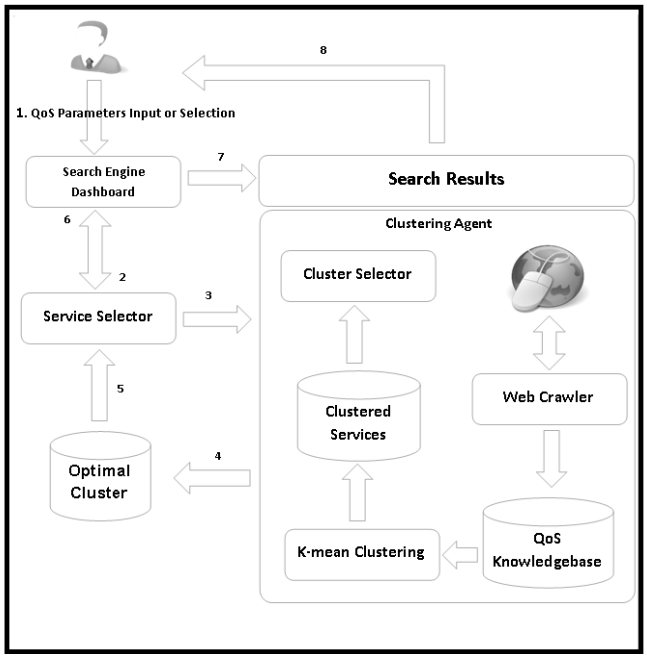

Figure 2. Proposed Solution.

3. Using k-means clustering techniques of data mining which is used for data bearing no class labels[13,15], the services will be grouped or clustered together based on their similarity values, means how much the services are related to each other and should be in a group or cluster with properties common to all members of the group.
4. The best and optimal group will be selected based on the criteria of the user.
5. From filtered or selected group, further selection will be done based on the comparison of attributed to each service with the criteria attributes of user requirements.
6. Testing will be performed using a case study for the user seeking medical consultation and/or a cloud storage service.

A general model of the proposed system has been described below, as depicted in Figure 3. CSS comprises of two main modules. The first one is Searching Dashboard UI, where the user is represented with available service general features and groups of services like the service belong to computing, storage, security, web, e-commerce or online-development category. The user can input the QoS parameters for the required service and request the CSS system to represent the response with optimal service as well some alternatives services, if available. The first module or agent is a graphical user interface (GUI) with a search engine as it's backed. It represents user wither with available QoS options to select or direct input from the user instead of selection. The QoS parameters are passed to search engine which after filtering collaborates with other agent or module to give the query response for the specified criteria.[25]

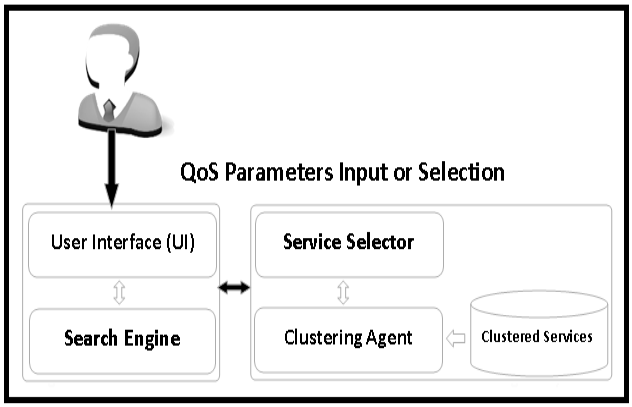

Figure 3. General model of cloud service selector based on Multi-agent system.

The core module is clustering agent that has a couple of tasks to perform before and after it is provided with QoS parameters from the user. The web service searcher or collector gathers all the related parameters, features, cloud service provider characteristics and all the related attributes attached to a specific cloud service provided publically. QoS parameters have been collected by requesting private cloud providers to build a knowledge base. After data is gathered and saved in knowledge-based, some pre-processing steps like filling missing info, removing duplicate and incorrect info and other inconsistencies from the collected data are performed to make the collected data ready for processing. After applying the k-mean clustering technique data grouped into clusters having similar services grouped together having inter-cluster differences more than the intra-cluster differences WRT to features and attributes.[26,27] All clusters of the services are saved in cluster knowledgebase. The Service Selector then select either a single service a group of similar services with descending order of matching user criteria to select a prime cloud service. Finally, the user is provided with query response having either a single service as the required service or more than one service ordered according to the specified user QoS parameters or input criteria.[28]

4. Discussion

Numerous benefits are associated with agent-based cloud service selection. As the whole service selections are totally automated and have a huge impact on cloud service providers as well as cloud service users.[29] Some of the advantages are listed below:

- Transferring of research work into practice by providing an implemented system to assist the user searching for specific cloud service.
- Beneficial for cloud service providers as well, because cloud service provider can evaluate their services.[30]
- Cloud service providers can compare their services with other services from other vendors.
- The end user can visualize the similar services together and have an option to select alternative service.
- The user is not limited to one specific service, as he is provided with alternatives.
- As the most similar services are grouped together, so the comparison between services is easy and provided the end user with options.

5. Conclusion

We proposed a service selector system and we concluded that MAS is practically applicable to solve the problems of cloud service vendor selection in multidimensional techniques. This system is most beneficial and it is the most authentic approach for a client. It is very helpful for the solution of complex computational tasks. MAS are a direct in itself as the agent is accountable to interact with a client for the explicit system. This is a key component in selection and recommendation of intelligent cloud application. The main purpose of cloud computing is an effective to use of computing infrastructure provided as a whole service.

6. References

1. Sim K. Agent-based Cloud Computing. IEEE Transactions on Services Computing. 2012; 5(4):564–77. crossref
2. Bedi P, Kaur H, Gupta B. Trustworthy Service Provider Selection in Cloud Computing Environ-ment. 2012 International Conference on Communication Systems and Network Technologies; 2012. p. 714–9. crossref
3. Jackson KR, Muriki K, Canon S, Cholia S, Shalf J. Performance analysis of high performance computing applications on the Amazon Web services Cloud. 2010 IEEE Second International Con-ference on Cloud Computing Technology and Science; 2010. p. 159–68. crossref
4. Dubey S, Agrawal S. Methods to Ensure Quality of Service in Cloud Computing Environment. International Journal of Advanced Research in Computer Science and Software Engineering. 2013; 3(6):405–11.
5. Hoang DB, Chen L. Mobile Cloud for Assistive Healthcare (MoCAsH). IEEE Asia-Pacific Ser-vices Computing Conference; 2010. p. 325–32.
6. Bhattacharya A. Mobile agent based elastic executor service. Ninth International Conference on Computer Science and Software Engineering (JCSSE); 2012. p. 351–6. crossref
7. Prieta FD, Rodríguez S, Bajo J, Corchado JM. A Mul-tiagent System for Resource Distribution in-to a Cloud Computing Environment. Advances on Practical Applications of Agents and Multi-Agent Systems; 2013. p. 37–48.
8. Dinesh Kumar RC, Ashwin R. Multi-Agent based Cloud Services. International Conferences on E Governance & Cloud Computing Sevices (EGov '2012), Proceedings published by International Journal of Computer Applications (IJCA); 2012. p. 1–4.
9. Sundareswaran S, Squicciarini A, Lin D. A Brokerage-Based Approach for Cloud Service Selec-tion. IEEE 5th International Conference on Cloud Computing; 2012. p. 558–65.
10. Salama M, Shawish A, Zeid A, Kouta M. Integrated QoS Utility-Based Model for Cloud Compu-ting Service Provider Selection. IEEE 36th Annual Computer Software and Applications Confer-ence Workshops; 2012. p. 45–50.
11. Jung G, Sim KM. Agent-Based Adaptive Resource Allocation on the Cloud Computing Environ-ment. 40th International Conference on Parallel Processing Workshops (ICPPW); 2011. p. 345–51. PMCid:PMC3106168
12. Kang J, Sim KM. Towards Agents and Ontology for Cloud Service Discovery. International Con-ference on Cyber-Enabled Distributed Computing and Knowledge Discovery Cy-berC; 2011. p. 483–90.
13. Huang J, Liu Y, Duan Q. Service provisioning in virtualization-based Cloud computing Modeling and optimization. International Conference on Global Communication; 2012. p. 1728–33. crossref
14. Nikolopoulos V, Mpardis G, Giannoukos I, Lykourentzou I, Loumos V. Web-based decision-support system methodology for smart provision of adaptive digital energy services over cloud technologies. IET Software. 2011; 5(5):454–65.crossref
15. Wei Y, Blake MB. An Agent Based Services Framework with Adaptive Monitoring in Cloud En-vironments. Workshops on Enabling Technologies Infrastracture for Collaborative Enterprises; 2012. p. 4–9.

16. Haresh MV, Kalady S, Govindan VK. Agent based dynamic resource allocation on federated clouds. Recent Advances in Intelligent Computational Systems; 2011. p. 111–14. crossref
17. Rehman ZU, Hussain FK, Hussain OK.Towards Multi-criteria Cloud Service Selection. Proceed-ings Fifth International Conference on Innovative Mobile and Internet Services in Ubiquitous Computing; 2011. p. 44–8. crossref
18. Zhou Y, Yang Y, Liang L, He D, Sun Z. An Agent-based Scheme for Supporting Service and Re-source Management in Wireless Cloud. Grid and Cooperative Computing (GCC), 2010 9th Inter-national Conference; 2010. p. 34–9.
19. Sim KM. Complex and Concurrent Negotiations for Multiple Interrelated e-Markets. Systems Man and Cybernetics; 2010. p. 1–16.
20. Navimipour NJ, Rahmani AM, Navin AH, Hosseinzadeh M. A Cloud-based framework to share the knowledge and skills of human resources. Computers in Human Behavior. 2015; 46:57–74. crossref
21. Sim KM. Agent-based Cloud commerce. IEEE International Conference on Industrial Engineering and Engineering Management; 2009. p. 717–21. crossref
22. Aversa R, Di Martino B, Rak M, Venticinque S. Cloud Agency: A Mobile Agent Based Cloud System. International Conference on Complex, Intelligent and Software Intensive Systems; 2010. p. 132–7. crossref
23. Zhang Z, Zhang X. Realization of open cloud comput-ing federation based on mobile agent. IEEE International Conference on Intelligent Computing and Intelligent Systems. 2009; 3:642–6. crossref
24. Pan L. Towards a framework for automated service negotia-tion in cloud computing. IEEE Interna-tional Conference on Cloud Computing and Intelligence Systems (CCIS); 2011. p. 364–7.
25. Huang H. A Multi-agent Minority-game based Demand-response Management of Smart Buildings towards Peak Load Reduction. IEEE Transactions on Computer-Aided Design of Integrated Cir-cuits and Systems. 2017; 36(4):573–85. crossref
26. Talia D. Clouds Meet Agents: Toward Intelligent Cloud Services. IEEE Internet Computing. 2012; 16(2):78–81. crossref
27. Sim KM. Agent-Based Cloud Computing. IEEE Transactions on Services Computing. 2012; 5(4):564–77. crossref
28. Dashora G, Awwal P. A hybrid firefly based approach for data clustering. International Research Journal of Engineering and Technology (IRJET). 2015; 2(4):1–3.
29. Sundararajan S, Karthikeyan S. An efficient hybrid approach for data clustering using dynamic k-means algorithm and firefly algorithm. ARPN Journal of Engineering and Applied Sciences. 2006; 9(8):1–6.
30. Yang SY, Hsu CL, Lee DL. An ontology-supported ubiq-uitous interface agent for cloud computes — Example on Bluetooth wireless technique with Java programming. International Conference on Machine Learning and Cybernetics (ICMLC). 2010; 6:2971–8.