Applications of Fuzzy Logicin Cloud Computing: A Review

Gabriel Meelubari, Napoleon[1], Gabriel, Bariyira Christopher[2], Onuodu Friday E.[3]

[1,2]*School of Postgraduate Studies, Department of Computer Science, Faculty of Natural and Applied Science Ignatius Ajuru University of Education, Nigeria*

[3]*Department of Computer Science, Faculty of Science, University of Port Harcourt Choba, Port Harcourt. Nigeria*

Abstract:- **The objective of this paper is the analysis of various applications of Fuzzy Logic in Cloud Computing. This paper reviews the already available application areas of Fuzzy Logic in Cloud Computing. Methods/ Statistical analysis: Various studies on application areas of Fuzzy Logic in cloud computing systems have been considered. Relative analysis has been made to categorize these application areas. Findings: Cloud computing is web-based technology that has brought a lot of improvement in the field of Information Technology. It is a pay-as-you-go service model that delivers services on the basis of demand of users. Because of its capability to deal with uncertainties, Fuzzy Logic has given a good response in cloud computing. Various Fuzzy Logic based application areas in cloud computing are prevalent in the existing literature like Load balancing, Job Scheduling, QOS optimization etc. Results have shown that Fuzzy Logic helps in improvement in various areas in Cloud Computing. Application/Improvements: This research work is very useful for researchers working in the field of cloud computing with Fuzzy Logic.**

Keywords: **Cloud Computing, Fuzzy Logic, Job Scheduling, QOS, Reliability.**

I. INTRODUCTION: WHAT IS CLOUD COMPUTING?

Cloud computing is a general term for anything that involves delivering hosted services over the Internet. These services are broadly divided into three categories: Infrastructure-as-a-Service (IaaS), Platform-as-a-Service (PaaS) and Software-as-a-Service (SaaS)[1].

Cloud Computing is an emerging web-based technology where the information can be accessed by anyone anywhere. Cloud Computing attracts users by minimizing infrastructure investments and resource management costs while presenting a flexible and elastic service.

Cloud Computing makes possible the efficient utilization of resources by allocating and deallocating the hardware and software resources to the customers on demand. So, the customers need not to worry about the arrangement of computing resources. They can use these resources without making any costly investment by purchasing them. The customers use these resources on demand and when these are not needed, the customers can give these resources back to the resource providers. Customers will be charged only on the basis of usage.

What Is Unique About Cloud Computing?

A cloud service has three distinct characteristics that differentiate it from traditional web hosting.

- It is sold on demand, typically by the minute or the hour;
- it is elastic -- a user can have as much or as little of a service as they want at any given time;
- the service is fully managed by the provider (the consumer needs nothing but a personal computer and Internet access).

Classification of Cloud Computing

Cloud Computing is classified base on service provided and the kind of deployment:

- SOFTWARE AS A SERVICE (SaaS)**:** Software resources are offered by SAAS providers on request. The customers need not to bother about software purchasing cost and other maintenance tasks and related costs.Cloud applications allow the cloud to be leveraged for software architecture, reducing the burdens of maintenance, support, and operations by having the application run on computers belonging to the vendor. GMail and Salesforce are among examples of SaaS run as clouds, but not all SaaS has to be based in cloud computing.
- INFRASTRUCTURE AS A SERVICE (IaaS)**:** IaaS, gives business access to vital web architecture, such as storage space, servers, and connections, without the business need of purchasing and managing this internet infrastructure themselves.IaaS allows an internet business a way to develop and grow on demand.Choosing to use an IaaS cloud demands a willingness to put up with complexity, but with that complexity comes flexibility. Amazon EC2 and Rackspace Cloud are examples of IaaS.
- PLATFORM AS A SERVICE (PaaS)**:** clouds are created, many times inside IaaS Clouds by specialists to render the scalability and deployment of any application trivial and to help make your expenses scalable and predictable.The chief benefit of a service like this is that for as little as no money you can initiate your application with no stress more than basic development and maybe a little porting if

you are dealing with an existing app.Some examples of a PaaS system include: Mosso, Google App Engine, and Force.com.

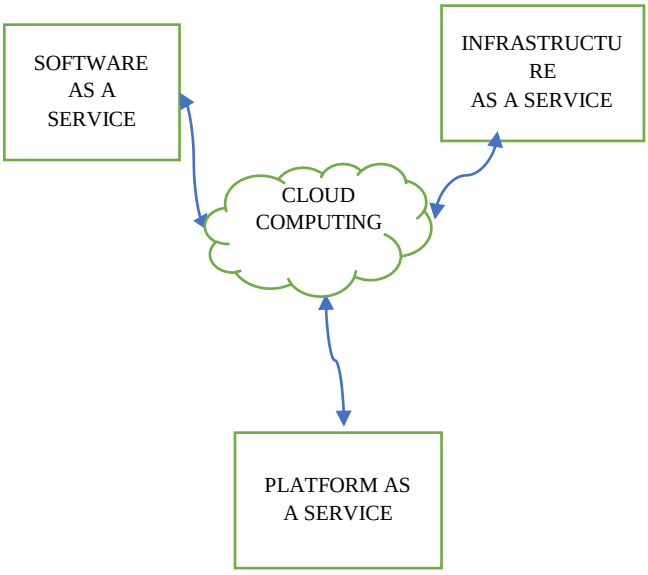

FIGURE 1: DIAGRAM SHOWING CLOUD COMPUTING SERVICES

On the basis of deployment models, Cloud is of four types:

- PUBLIC CLOUD:A public cloud sells services to anyone on the Internet. (Currently, Amazon Web Services is the largest public cloud provider.)In the public cloud model, a third-party cloud service provider delivers the cloud service over the internet. Public cloud services are sold on demand, typically by the minute or hour, though long-term commitments are available for many services. Customers only pay for the CPU cycles, storage or bandwidth they consume. Leading public cloud service providers include Amazon Web Services (AWS), Microsoft Azure, IBM and Google Cloud Platform.
- PRIVATE CLOUD:A private cloud is a proprietary network or a data center that supplies hosted services to a limited number of people. Private or public, the goal of cloud computing is to provide easy, scalable access to computing resources and IT services. services are delivered from a business's data center to internal users. This model offers the versatility and convenience of the cloud, while preserving the management, control and security common to local data centers. Internal users may or may not be billed for services through IT chargeback. Common private cloud technologies and vendors include VMware and OpenStack.
- HYBRID CLOUD**:** A hybrid cloud is a combination of public cloud services and an on-premises private cloud, with orchestration and automation between the two. Companies can run mission-critical workloads or sensitive applications on the private cloud and use the public cloud to handle workload bursts or spikes in demand. The goal of a hybrid cloud is to create a unified, automated, scalable environment that takes advantage of all that a public cloud infrastructure can provide, while still maintaining control over mission-critical data.
- COMMUNITY CLOUD**:** Where two or more organizations with common interest jointly share a common cloud.

II. INTRODUCTION: WHAT IS FUZZY LOGIC?

Fuzzy Logic provides a simple way to arrive at a definite conclusion based upon vague, ambiguous, imprecise, noisy or missing input information. It is a type of logic that recognizes more than simple true and false values [2]

Fuzzy Logic was proposed by zadeh in 1965 and now it has been widely used because it deals with imprecise and incorrect information. It is very close to human mind. In Fuzzy Logic, the human expertise is embedded into the system. Fuzzy Logic applies in various fields like Air Conditioners, Washing Machine,

Microprocessor, Microcontrollers, Image processing and many other real-world applications. In general, Fuzzy Logic consists of four components:

- Fuzzifier
- Rule Base
- Inference Engine
- Defuzzifier

Fuzzifier determines the input and output variables and maps them into linguistic variables with the help of membership functions [3].

The inference engine uses If-Then rules defined in the rule base and on the basis of that it arrives at the fuzzy output. This fuzzy output is converted into a single crisp value with the help of defuzzifier.

Because of its wonderful response in various applications and its capability to deal with uncertainty, Fuzzy Logic is also used in Cloud Computing[4] In Cloud Computing, it is widely used in various areas which we will explain in the next section.

III. APPLICATIONS OF FUZZY LOGIC IN CLOUD COMPUTING

On the basis of existing literature, we have identified various fields in Cloud Computing where Fuzzy Logic applies: On the basis of existing literature, we have identified various fields in Cloud Computing where Fuzzy Logic applies:

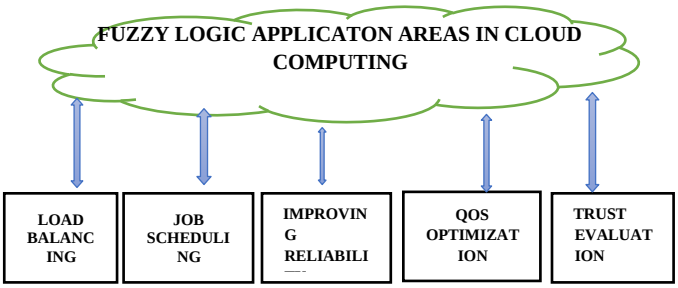

FIGURE 2: DIAGRAM SHOWING FUZZY LOGIC APPLICATON AREAS IN CLOUD COMPUTING

3.1 Load Balancing

Load balancing is a technique of dividing the traffic between the servers so that data can be sent and received with minimum response time [5], simultaneously removing a condition in which some nodes are overloaded while some others are under loaded[6]

A Load Balancing model has been proposed for the public cloud by using Cloud partitioning concept that simplifies the concept of load balancing and also improves the performance and maintains stability [7]

A Fuzzy Logic based Firefly algorithm for efficient load balancing in Cloud Computing also has been proposed. Firstly, the cloud is partitioned into heavy and least loaded nodes. With this algorithm, the best suited partition for the cloud is selected and the firefly algorithm helps the load to get attract towards that partition. Fuzzy Logic is employed for handling uncertainties in time. The proposed algorithm is compared with genetic algorithm. The result shows that the algorithm consumes less execution time, incurs less execution cost, can handle much heavier load, and balances a good amount of arrived load then genetic algorithm [8]

Another Fuzzy Logic based algorithm for efficient Load Balancing also has been proposed. The researcher has taken two input variables for fuzzification i.e. assigned load and processors speed. Rules have been defined to measure the balanced load as output. The proposed algorithm is compared with round robin load balancer and the results have shown that the proposed technique helps in balancing the load by minimizing response time, minimizing processing time and maximizing resource utilization and in real life applications it can be used more efficiently [9]

3.2 Job Scheduling

Scheduling is a method by which thread or process are granted access to computer resources [10]

A fuzzy neural network-based job scheduling algorithm has been proposed where the Fuzzy Logic is used to convert the classified inputs into linguistic variables. The genetic algorithm in neural network is used for mapping the system resources with the tasks. Defuzzification process is used to convert the linguistic variables to the crisp values. The proposed algorithm is implemented on CLOUD SIM and compared with the traditional Berger model. The result shows that the proposed technique results in reduction in bandwidth utilization and completion time thereby enhancing performance [11].

A Job Scheduling Algorithm is also proposed which allocates the resources on the basis of job length. Genetic Algorithm along with the Fuzzy Logic is used. Fuzzy Logic is used to modify the standard genetic algorithm. The proposed approach is compared with ACO and MACO algorithms in terms of make span and degree of imbalance. The results have shown that the system performance is improved by minimizing execution cost and execution time [12]

A Fuzzy Logic based multi queue job scheduling has been proposed for cloud computing and this technique helps in reduction of waiting time and response time as compared to existing technique [13].

3.3 Improving Reliability

An algorithm is proposed by using Fuzzy Logic for scheduling resources to improve the reliability of cloud computing. Three linguistic variables i.e. cost, length and trust are taken and fuzzified. The output of the system is the priority which will be assigned to the task that needs to be scheduled. The proposed system is compared with other algorithms like FIFO and MAXMIN. The results have shown that there is also an improvement in waiting time, turn-around time, accuracy and reliability [14]

A conceptual model is proposed for assessment and prioritization of risk that may occur if the company is thinking to rent out resources from resource providers in Cloud Computing. Risk assessment and prioritization in Cloud Computing is very much essential to reduce and manage the risk and to enjoy the unlimited services of Cloud Computing. Here Fuzzy Logic is used to deal with uncertainties and estimate the risk rate with probability and impact of risk. The results is discussed by using various entities and show that decision taken using Fuzzy Logic is more beneficial in risk assessment and management process [15]

3.4 QOS Optimization

A Fuzzy Logic technique is also proposed in the behavior, load and performance prediction model by taking imprecise information. The data is fuzzified and the defuzzified value is generated for scale control module that scales up and down the use of VMs. The proposed approach is compared with conventional rule set and the results showed that with this approach, the scaling process of VMs can be improved thereby minimizing SLA violation and thus improving QOS parameters [16]

Another researcher has taken the concept of different service providers providing different levels of qualities in services offered. Also, there is difference in requirements of users. So, it is very difficult for customer to select best service from the best service provider that fit into their quality of cloud service (QOCS) requirement i.e. high availability, timeliness, reliability etc. So, in this paper, the researcher has proposed an evaluation approach for measuring QOCS in Cloud Computing. Firstly, the cloud service providers are evaluated as per user requirements on the basis of the level of services provided with the help of Fuzzy Logic model. Secondly, the researcher has taken a cloud model to calculate the uncertainties in the services provided by them on the basis of QOCS data. Finally, the output of personalized evaluation module and uncertainty evaluation module are used to calculate QOCS evaluation value. Comparisons have been made with "QOSC" and "SLC" which are existing techniques. Results have shown that proposed approach is better than existing approach in terms of accuracy and time cost [17]

3.5 Trust Evaluation

An evidence-based trust evaluation model is proposed for relying on the cloud-based services. The Fuzzy Logic model is used to obtain the trust value. Various attributes like CPU utilization, Data in, Data out, Disk Read Throughput and Disk Write throughput are taken. At every request these attributes of services are measured and stored in database at various time slots and then they are normalized. These normalized values are fuzzified and defuzzified value represents the trust value for the time slot. Using IOWA (Induced Weighted Aggregating Operator), the global trust value is calculated. Also, weights are assigned to the time slots to tackle the instable performance of cloud service. The calculated trust value is used to ascertain the trust-worthiness on service and fuzzy logic is used to handle the uncertain nature of attributes in dynamic cloud-based services [18].

3.6 Power Monitoring System

A researcher has designed and implemented power monitoring and control system using Fuzzy Logic and Cloud Computing. This system is responsible for automatically adjusting the working time of electrical appliances which we use in our day to day life. The Fuzzy Logic part helps in calculating the working time of appliances as output by taking humidity and temperature of the environment as inputs. With the help of Cloud Computing, various computers and handheld devices can be used to access the information about power consumption of electrical appliances through internet. The results of experiment have shown that the proposed system helps in efficient utilization of energy, thereby helps in power saving [19].

IV. CONCLUSION

We have identified key areas of applications of Fuzzy Logic in Cloud Computing. This study gives a review of various applications areas of Fuzzy Logic in Cloud computing. We hope that this work willprove useful for the researchers and students doing research in the field of Cloud Computing with Fuzzy Logic

REFERENCES

[1]. Margaret R.Cloud Computing, Retrieved from https://searchcloudcomputing.techtarget.com/definition/cloud-computing

[2]. Endo PT, Rodrigues M, Gonçalves GE, Kelner J, Sadok DH, Curescu C. High availability in clouds: systematic review and research challenges. Journal of Cloud Computing. 2016 Dec 1;5(1):16.

[3]. Singh B, Mishra AK. Fuzzy Logic Control System and its Applications. International Research Journal of Engineering and Technology (IRJET). 2015 Nov;2(8).

[4]. Prasath V, Bharathan N, Lakshmi N, Nathiya M. Fuzzy logic in cloud computing. Int. J. Eng. Res. Technol. 2013;2(3):

[5]. Hayat B, Kim KH, Kim KI. A study on fuzzy logic-based cloud computing. Cluster Computing. 2017:1-5.

[6]. DoddiniProbhuling L. Load balancing algorithms in cloud computing. computing. 2013;2:4.

[7]. Begum S, Prashanth CS. Investigational Study of 7 Effective Schemes of Load Balancing in Cloud Computing. International Journal of Computer Science Issues. 2013;10(6).

[8]. RajeshirkeNikhil,SawantRoahn,SawantSumeet,HasibShaikh.Load Balancing In Cloud Computing.International Journal of Recent Trends in Engineering and Research(IJRTER).2017 March;3(3)

[9]. Technologies in Web Intelligence. 2014 Nov 1;6(4):43540.

[10]. Sethi S, Sahu A, Jena SK. Efficient load balancing in cloud computing using fuzzy logic. IOSR Journal of Engineering. 2012 Jul;2(7):65-71.

[11]. Kumari R, Sharma VK, Kumar S. Design and Implementation of Modified Fuzzy based CPU Scheduling Algorithm. arXiv preprint arXiv: 1706.02621. 2017 May 26.

[12]. Kumar VV, Dinesh K. Job scheduling using fuzzy neural network algorithm in cloud environment. Bonfring International Journal of Man Machine Interface. 2012 Mar 1;2(1):1.

[13]. Javanmardi S, Shojafar M, Amendola D, Cordeschi N, Liu H, Abraham A. Hybrid job scheduling algorithm for cloud computing environment. InProceedings of the Fifth International Conference on Innovations in Bioinspired Computing and Applications IBICA 2014 2014 (pp. 43-52). Springer, Cham.

[14]. Singh I, Arora A. Fuzzy Based Improved Multi Queue Job Scheduling For Cloud Computing. International Journal of Advanced Research in Computer Science. 2015 May 1;6(5).

[15]. Singh I, Arora A. Fuzzy Based Improved Multi Queue Job Scheduling For Cloud Computing. International Journal of Advanced Research in Computer Science. 2015 May 1;6(5).

[16]. Amini A, Jamil N, Ahmad AR, Sulaiman H. A Fuzzy Logic Based Risk Assessment Approach for Evaluating and Prioritizing Risks in Cloud Computing Environment. In International Conference of Reliable Information and Communication Technology 2017 Apr 23 (pp. 650-659). Springer, Cham.

[17]. Frey S, Lüthje C, Reich C, Clarke N. Cloud QoS scaling by fuzzy logic. InCloud Engineering (IC2E), 2014 IEEE International Conference on 2014 Mar 11 (pp. 343-348). IEEE.

[18]. Wang S, Liu Z, Sun Q, Zou H, Yang F. Towards an accurate evaluation of quality of cloud service in service-oriented cloud computing. Journal of Intelligent Manufacturing. 2014 Apr 1;25(2):283-91.

[19]. Selvaraj A, Sundararajan S. Evidence-Based Trust Evaluation System for Cloud Services Using Fuzzy Logic. International Journal of Fuzzy Systems. 2017 Apr 1;19(2):329-37.

[20]. Su TJ, Wang SM, Vu HQ, Ku DY, Huang JL. An Application of Fuzzy Theory to the Power Monitoring System in Cloud Environments. InComputer, Consumer and Control (IS3C), 2016 International Symposium on 2016 Jul 4 (pp. 350-354). IEEE.