

Fuzzy Trust Model for Cloud Environment using Simulators

Abdulkhaliq M. Alghamdi and Gamal F. Elhady

Department of Computer Science

College of Science and Humanities

Dawadmi, Riyadh. Shaqra University

KSA

ABSTRACT

Cloud computing has garnered popular support in a relatively short span of time. It is a new method of delivering distributed resources over the internet. A cloud consists of several elements such as clients, data centers and distributed servers, internet and it includes fault tolerance, high availability, effectiveness, scalability, flexibility, the reduced overhead for users, reduced cost of ownership, on-demand services and etc. Now the next factor is coming, the cost of Virtual machines on Data centers and response time. So this paper develops trust model in cloud computing based on fuzzing logic Algorithm, to explores the coordination between Data Centers and user bound to optimize the application performance, cost of Virtual machines on Data centers and response time using Cloud Computing Analyst.

Keywords: Cloud Computing, Cloud Analyst, Trust Model. Fuzzy Logic.

1. INTRODUCTION

Cloud computing is rapidly becoming a significant service in the Internet computing. Cloud Computing can be defined as a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction [1]. The services which offered by cloud computing are classified as: "X as a service (XaaS)" where X represents "Infrastructure", "Platform", "Software", "Database" etc. Among the various service models available in cloud, Infrastructure as a Service (IaaS) plays a vital role. IaaS is the delivery of computing resources as a service through APIs, which includes virtual machines, operating systems and other abstracted hardware[2]. The customer rents these resources which are dynamically scalable as per usage, rather than buying and installing them. Examples for IaaS include Amazon and service providers. Due to the large scale and openness of these systems, a customer is often required to interact with service providers with whom he has few or no shared past interactions. To assess the risk of such interactions and to determine whether an unknown service provider is trustworthy, an efficient trust mechanism is necessary.

Cloud is a highly agile and flexible utility computing paradigm that allows users to acquire virtualized computing resources in a pay-as-you go model [3]. Its merits, including no upfront investment, just-in-time resource provisioning, and fast deployment, is attracting more and more organizations to migrate their existing applications and develop new systems on cloud. Among all cloud service models, Infrastructure as a service (IaaS) provides the most flexible service for users trying to deploy their own applications. To realize the benefits of using IaaS cloud, users need to ensure the trading service providers can fully satisfy their applications' functional and non-functional requirements. However, there exists plenty of IaaS cloud providers offering similar services with different pricings and performances, which creates difficulty for users to find the most suitable service. Therefore, it is essential to develop automatic systems to dynamically identify satisfactory. IaaS services according to different application requirements [4]. Cloud services exhibit five essential characteristics that demonstrate their relation to, and differences from, traditional computing approaches such as On-demand self-service, Broad network access, Resource pooling, Rapid elasticity, and Measured service [5]. Cloud computing often leverages Massive scale, Homogeneity, Virtualization, Resilient computing (no stop computing), Low cost/free software, Geographic distribution, Service orientation Software and Advanced security technologies.

The main objective of this paper is to develop trust model in cloud computing based on fuzzy logic. This paper explores the coordination between Data Centers and user bound to optimize the application performance, cost of Virtual machines on Data centers and response time by using a tool called Cloud Analyst. This can help users make an informed choice towards selecting the appropriate (Cloud Service Provider) CSP as per their requirement (Performance and Efficiency, Cost, Adaptability, Time and Security).

The organization of this paper follows as: Section II, describes the previous related works and the proposed system in Section III. Simulation and results discussions are described in Section IV. Paper conclusion and future work are present in Section V.

2. PREVIOUS WORKS

Several number of ways are there for modeling (un-)certainty of trust values in the field of trust modeling in Cloud computing and internet based marketing system.[6, 7] But, these models have less capability to derive trustworthiness of a system which are based on knowledge about its components and subsystems. Different studies have been done in the area of cloud computing. Scientists and researchers in all over the world have a given different definition of cloud computing.

The cloud model initially has focused on making the hardware layer consumable due to exponential growth in demand of computing and storage capacity. Different studies have been done in the area of cloud computing. [8] have published a paper entitled "A Berkeley view of cloud computing", compares general clouds with private data centers and concludes their pros and cons. [9]. have published an article entitled "The Future of Cloud Computing and Server Platform", evaluates the performance of cloud and determines the impacts of cloud computing on organizational structure. [10] have published an article entitled "Cloud Computing: Today and Tomorrow", discussed few essential options for data policy in cloud computing. [3] published a paper entitled "outsourcing business to cloud computing services". They studied about different kinds of users who are using various types of cloud computing services. Finally, they introduced the architecture for businesses, which desire to use cloud computing services by outsourcing business. [11]. have published a paper entitled, "secure cloud" deals with the security issues and concerns in deploying cloud computing. [12] have published a paper entitled "A survey on trust and trust management in cloud computing", analyzes the trust management systems recommended for cloud computing by various researchers with an unusual emphasis on their capability, their implementation and their applicability in the practical heterogeneous cloud environment. [13] have published a paper entitled "A trust management model to enhance security of cloud computing environments", Discussed direct and recommended trust measurements based on fuzzy set theory. Their proposed model gives a helpful assess to improve security, robustness and fault tolerance of cloud computing. [14]. have published a paper entitled "A trust-evaluation metric for cloud applications", proposed a model for availability, usability, scalability and security parameters of trust for IaaS using fuzzy-set theory.

Fuzzy logic was used to provide trust in Cloud computing. Different types of attacks and trust models in service oriented systems, distributed system and so on are designed based on fuzzy logic system [15]. But it models different type of uncertainty known as linguistically uncertainty or fuzziness a very good model for E-commerce, which is based on fuzzy logic, is presented. But, this model also works with uncertain behavior. Belief theory such as Dempster-Shafer theory was used to provide trust in Cloud computing. But the main drawback of this model is that the parameters for belief, disbelief and uncertainty are dependent on each other.

In this paper, they developed an overall trust rating for a given CSP, based on mamdani fuzzy-inference system. We proposed a hierarchical model which extends the model described in [13], and rates the cloud service providers and their plans based on five parameters: Performance, Security, Elasticity, Time and Cost. In this model we developed the trust model in cloud computing based on Fuzzy Inference System. Fuzzy logic was used to provide trust in cloud computing. Different types of attacks and trust models in service oriented systems, distributed system and so on are designed based on fuzzy logic system [15]. A formal trust management model for Software as a Service (SaaS) based on the basics of the trust characteristics is presented in [2]. This model is capable to handle various cloud services access scenarios where an entity may or may not have a past experience with the service.

3. PROPOSED SYSTEM

Cloud computing is defined as "a type of parallel and distributed system consisting of a collection of interconnected and virtualized computers that are dynamically provisioned and presented as one or more unified computing resources based on service-level agreements established through negotiation between the service provider and consumers" [3].

For developing and exercising with our work, we have used a scenario from the field of cloud computing [16]. We have assumed that we are working to evaluate the trustworthiness of an organization or a simple office. We have worked mainly for the field of trade and business web pages. It has helped us to calculate the trust of the whole cloud computing system and also helped to make a system trustworthy to the user. In this section we define a framework of our proposed approach as the following Figure1.

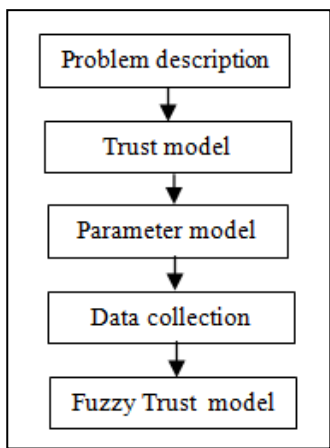


Figure 1. Framework of proposed system

A. Problem Description

On the cloud computing system, there is no framework which a cloud service consumer can make an intelligent trust-based decision regarding service selection from a service provider. Given the potential growth of cloud computing and the business implications, it is very important to have such architecture in place. The primary issues which are not investigated in the related literature are:

- The difficulties faced by cloud users when they want to sign online agreements with cloud providers; there is no clear and reliable method for selecting the most suitable parameters for the contracts.
- The lack of a trust model to calculate and estimate the cost for each level of the cloud architecture.
- Although trust and reputation systems have been widely proposed and implemented for various types of online services, no such models have been proposed for cloud computing; cloud users also need such systems in order to select the most trustworthy of services that are already being offered by cloud providers.

In this paper, we will concentrate on how to develop and evaluate the trusted cloud providers model in such a way that users of cloud can easily understand and start.

B. Trust Model

A trust model based on virtual machines, with two considerations is proposed [17]. First, a timeliness strategy is introduced to ensure the response time and also to minimize the idle time of servers. Second, the linear trust chain by differentiating the trust of the platform domain and user domain is extended. Besides, a fuzzy theory based method to calculate the trust value of cloud service providers is developed.

Trust is strongly connected to confidence and it implies some degrees of uncertainly, hopefulness or optimism [18]. The Trust Model concentrates on the measure of trust value based on direct experience which is considered as direct trust and Recommended information which is, for CSP in Inter Domain and Intra Domain. Figure 2, shows the trust model architecture of the trust assessment.

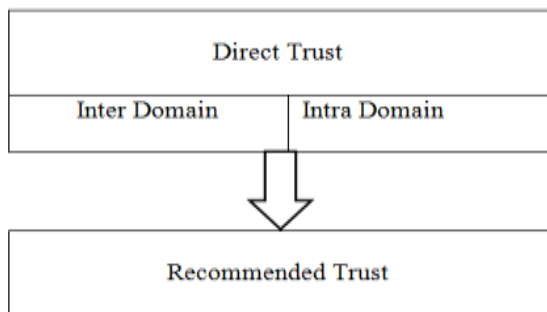


Figure 2. Trust Model

In our paper, we have simulated an environment using Cloud Analyst and focused on the estimation of Inter Domain trust value for CSP based on the direct relationship. Cloud Analyst is developed by [19]. It is built on top of CloudSim and separates the simulation experimentation from a programming task enabling one to concentrate on the simulation parameters rather than the technicalities of programming. Simulation in Cloud Analyst involves the following steps:

1. Defining and configuration of User Bases.
2. Defining and configuring Data Centers
3. Allocating of Virtual Machines in Data Centers.

4. Review and Adjustment of various other parameters such as Packet size, No of packets, Bandwidth, and Load balancing policies

The Cloud Analyst enables us to model different scenarios of CSPs and User Bases, and provides a comprehensive output detailing the response time, Data Center processing time and total cost involved in the communication and computation.

C. Parameter Model

Some attributes are used to be performing parameter model this attributes are defined by Service Measurement Index (SMI). As the following: Security, Elasticity, Performance, Cost and Time. Each of these attributes consisting a set of Key Performance Indicators (KPIs), which explain the data to be collected for measurement. KPIs are experimental measurements, agreed to earlier, that reveals the vital success factors of an organization. They will fluctuate depending on the organization. Based on the KPI that frames the attributes in evaluating the trust and user satisfaction. We discussed performance, cost, elasticity, security and time in this paper. Table 1 shows the Factors Impact of Trust Degree (FITD) and there KPIs Attribute [10].

Table 1. PARAMETERS MODEL

FITD	KPIs Attribute
Performance and efficiency	Accuracy, Functionality, Stability, Interoperability, Service Response Time
Adaptability	Elasticity, Capacity, Extensibility, Flexibility, Portability, Scalability
Cost	Acquisition and training cost, Ongoing cost, Profit or Cost Sharing
Time	User Base Response Time. User Base Request Serving Time.
Security	Data location, Recovery

D. Data collection

Data collection is considered one of the most important step in the development of fuzzy-based control system. So, the model with a fuzzy inference approach must be trained with training data that represent the greatest possibilities of application [20]. In our study, we use the data which was collected from cloud computing experts and cloud users. By an online-based survey was developed in order to collect more data sets from different locations. The survey with the designed research questions was conducted to collect values for the most important variables which had already been selected to present the trust value in a cloud-based application.

E. Fuzzy based Trust Model

A fuzzy mathematics-based trust model is proposed for cloud services. It works on the success & failure interaction of the cloud entities so that the fuzzy direct trust relation is calculated in the light of direct experiences between clients and cloud service providers. Also, the substances can manufacture a fuzzy indirect trust relation with each other through their acquaintances. Simulation results demonstrate that the proposed model equipped for recognizing frauds and the performance of whole cloud will be improved. [21]. To estimate the trust value of the cloud service providers using fuzzy logic model is described in [13]. This model is used as to extend the mathematics ontology in certain method with fuzziness in order to help make an intelligent decision [22].

The proposed fuzzy logic method in this paper uses three fuzzy sets for the input factors and four fuzzy sets for the parameters of output. The three fuzzy sets which are low (L), medium (M) and high (H) are used to characterize the fuzzy value for each input which are Performance, cost, security, Elasticity and Time. The fuzzy sets that represent the output parameters are: poor (P), good (G), very good (VG) and excellent (E). In this model, Security was considered as important parameter which is requirement for the users of the cloud since when a company outsources its confidential data to another company or a cloud; it needs assurance that the service provider has used “reasonable security” to protect those data [6]. In order to evaluate the trust value for CSP comprises of two stages as shown in Figure 3.

The first stage is the implementation with the help of Mamdani Fuzzy Inference System (http://www.mathworks.com/help/pdf_doc/fuzzy/fuzzy.pdf” Fuzzy Logic Toolbox™ User’s Guide). It takes Performance, Cost, Elasticity and Time as inputs and produces a range of values which could be easily fed as input to the next level of processing. The Performance attribute can be evaluated by Processor Speed and Number of Processors as inputs to the Mamdani FIS. Cost attribute is calculated with the following inputs: Virtual Machine (V.M) Cost, Memory Cost, Storage Cost, Data Transfer Cost. Elasticity attribute has number of Physical Units, Memory Size, number of V.Ms as its inputs. Time attributes are User Base (UB) Response Time, User Base (UB) request and servicing times as inputs. Finally, Security attribute include Data Location and Recovery as inputs to the Mamdani Fuzzy based Inference System.

The second stage is the implementation using also Mamdani FIS. It takes the output of the first stage and helps to obtain the trust rating for the CSP. For the Mamdani FIS, the membership values for performance, Cost, Elasticity, Time and Security, parameters are assumed as low, medium, high and very high as per the requirement. For example, certain input parameters can have values only in a short interval while some may vary over larger range. The above two stages are implemented hierarchically using the fuzzy logic blocks in Simulink of Matlab (http://www.mathworks.com/help/pdf_doc/fuzzy/fuzzy.pdf Fuzzy Logic Toolbox™ User’s Guide).

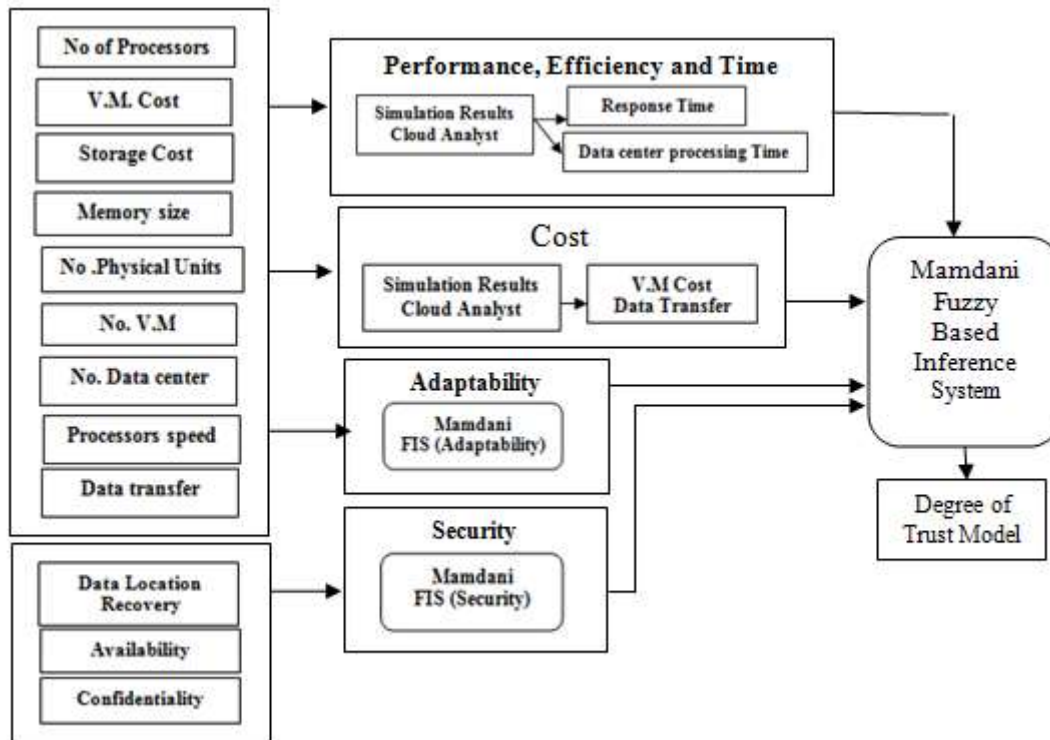


Figure 3. Fuzzy Based Trust Model

4. SIMULATION AND RESULTS DISCUSSIONS

In this section we show our apprpehe for verifying the proposed trust calculation model for cloud-based online services. In this section, the implementation of the proposed model is provided with the final results of the experiment.

A. Cloud setup Simulation

To perform the simulation some of the User Bases, Cloud Service Providers and data center at different region are to be set. We define six user bases representing the six main regions of the world with parameters are described in Table 2. The simulation depend on a given parameters such as: cost , Time and virtual machine.

Table 2. User base region

User base	CSP _s	Region
UB1	CSP-A	0 – N. America
UB2	CSP-B	1 – S. America
UB3	CSP-C	2 - Europe
UB4	CSP-D	3 - Asia
UB5	CSP-E	4 - Africa
UB6	CSP-F	5 – Ocenia

Many of scenarios are used to setup cloud simulation. The user bases remain constant across the scenarios whereas the CSPs setup can be changes. So for the same amount of user load we are able to determine the performance of various CSPs. We take an example scenario with six different CSPs each with unique setting representing the geographic diversity, the cost factor, and the processing capabilities. Table 3, show the values which are taken to simulate the cloud environment by Cloud Analyst. So, six different simulations are running and each produces an output report detailing the Total Cost, the Response time, Data Center Request Servicing Times and the User Base Request Servicing Times.

Table 3. SIMULATION SETUP

Cloud Service Provider	Virtual Machine		Cost				Data Center			
	# VMs	Memory (MB)	Cost Per BW (Data transfer) (\$/GB)	Cost Per Storage (\$/s)	Cost Per Memory (\$/s)	Cost Per VM (\$/Hr)	#Physical units	Processor Speed	# processors per machine	Region
CSP-A	200	512	0.15	0.15	0.05	0.4	6	100000	24	0-N.America
CSP-B	150	1024	0.09	0.25	0.05	0.1	3	120000	400	1-S.America
CSP-C	50	1024	0.02	0.08	0.05	0.05	6	80000	68	2 - Europe
CSP-D	5	512	0.05	0.25	0.05	0.8	7	10000	12	3 - Asia
CSP-E	30	1024	0.2	0.15	0.05	0.5	3	60000	4	4 - Africa
CSP-F	125	512	0.09	0.1	0.05	0.3	3	160000	16	5 - Oceania

Figures 4, 5 are showing the simulation in progress during running and after simulation complete running. In this figures, UB represents User Bases and DC represents Data Centers.

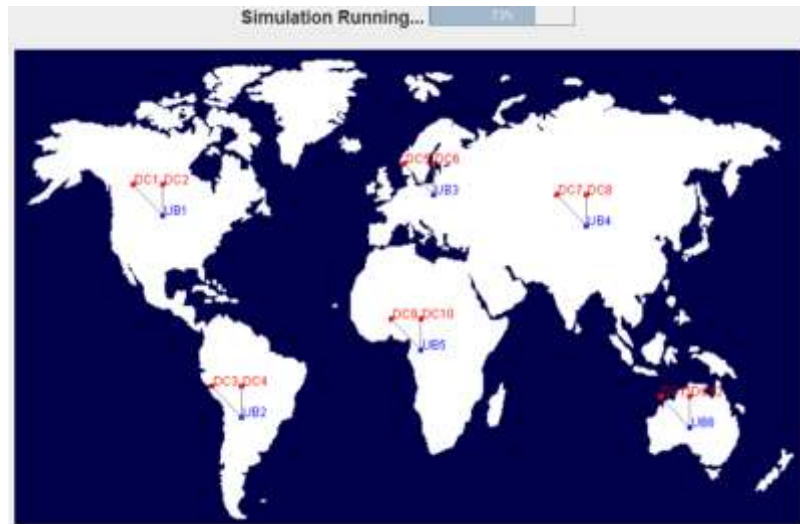


Figure 4. The Cloud Analyst Simulator during Running



Figure 5. The Cloud Analyst Simulator after Running

The results of the Cloud Analyst for the assumed scenario can be summarized in Table 3. The Response times and Data Center Request Processing times, User Base Request Servicing Times with the Total Cost factor in \$. Table 4, show that CSP-C is cheaper compared to other CSPs.

Table 4. Cloud Analyst Simulations Results

Cloud Service Provider	Response Time (ms)		DC Request Servicing Times (ms)		UB Request Servicing Times (ms)		Total Cost \$
	Min (ms)	Max (ms)	Min (ms)	Max (ms)	Min (ms)	Max (ms)	
CSP-A	42.03	63.83	0.01	2.08	0.02	3.11	160.52
CSP-B	39.36	61.52	0.01	1.03	0.02	1.63	30.75
CSP-C	37.77	63.76	0.02	0.86	0	1.54	5.52
CSP-D	36.36	64.61	0	0.77	0.02	1.72	8.82
CSP-E	37.75	64.4	0	0.77	0.19	2.17	31.61
CSP-F	39.03	64.02	0	0.77	0.01	1.55	47.11

The fuzzy logic toolbox of Matlab is used to design and implement our model. This toolbox includes ready functions and calculation methods to implement one type of fuzzy inference systems such as the Mamdani inference system. In our model, we use the Mamdani fuzzy methods with gbell membership function for inputs and output.

B. Fuzzy Logic Implementation

Performance and efficiency: Performance and efficiency are uses two input values number of processors and the processor speed as shown in Figure 3. Both have three member functions each, low, Medium, High. See figures, 6, and 7.

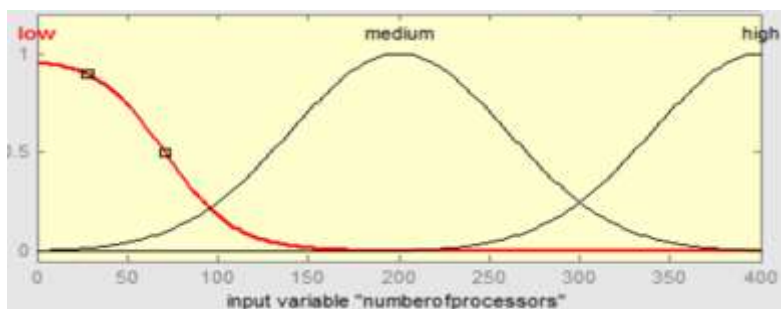


Figure 6. Input variable "number of processors"

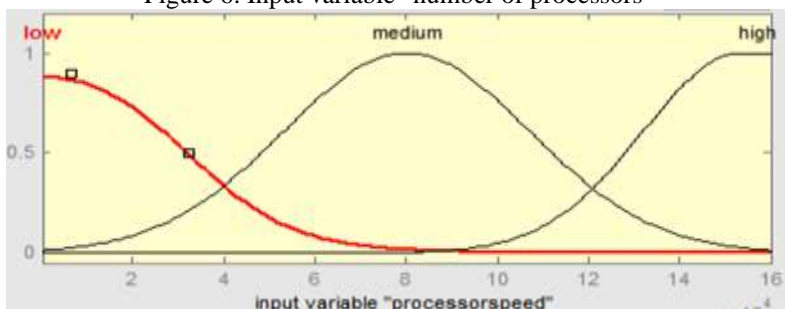


Figure 7. Input variable "processor speed"

The output of "Performance and efficiency " has five member functions: very low, low, medium, high, and very high. The outputs obtained from the FIS are CSP A-Low, CSP B-Medium, CSP C-Medium, CSP D- Medium, CSP E- Very High and CSP F-Low. The total of nine rules is written. Figure 8, shows the sample Rule Viewer when implemented in Matlab [23].

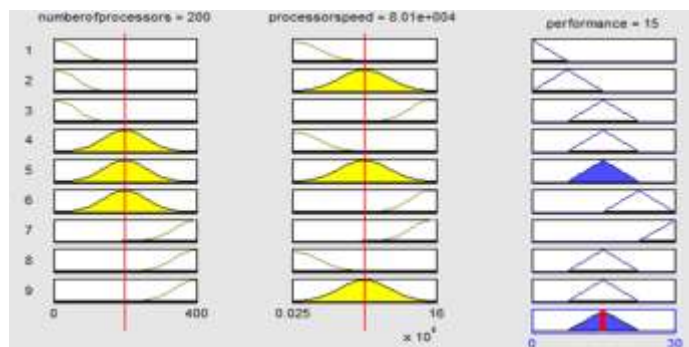


Figure 8. Performance Rule Viewer

Cost: The block Cost also comprises of four inputs V.M cost, Storage cost, Data Transfer cost and Processing Cost. The output of "Cost" has three member functions low, medium and high. Here a total of thirty four rules are written see figure 9.

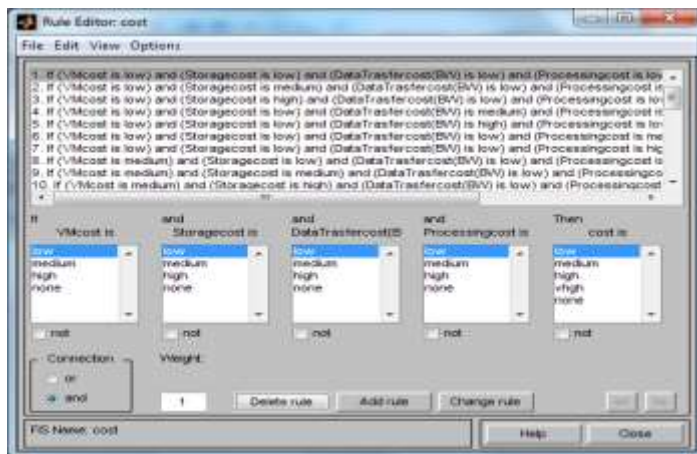


Figure. 9. Costs Rules Viewer

At given values of CSPs to the Cost model we get results as CSP A-High, CSP B-Medium, CSP C- High, CSP D-High, CSP E- High and CSP F-Medium.

Adaptability: the Adaptability model has three input parameters mapped to one output. Each of the input parameters in Figure 5 has different membership functions. "Physical units" has two member functions while "Memory" and "V.M" have three member functions each. The range of member functions is chosen based on the actual range of values used. A total of eight rules are written. The output of "Elasticity" has 3 member functions low, medium and high. When the input related to CSP A is fed to the Matlab FIS, the Elasticity comes out as Medium. Similarly for CSP B it is medium, CSP C-low, CSP D-medium, CSP E-medium, CSP F-medium.

Security- Security also has two input values namely data location and recovery. Both of the input parameters in figure 5 have three membership functions. The output "security" has three membership functions low, medium and high. The outputs obtained from the FIS are CSP A- Low, CSP B- Medium, CSP C- Low, CSP D- Low, CSP E- High, CSP F- High.

Time: Time has two input values namely User Base Response Time, and User Base Request Serving Time. Both have three membership functions each. The output "Time" has three membership function low, medium, and high. The outputs obtained from FIS are CSP A- Low, CSP B- Medium, CSP C- Low, CSP D- Medium, CSP E- Medium, CSP F- High.

The main models for the fuzzy logic system are shown in figure 10. We used FIS editor in Matlab to develop the model. The proposed model was implemented with five input factors: Performance, Cost, Elasticity, Security and Time. These five inputs are directed as inputs to the fuzzy inference system implemented with the Mamdani method. The Mamdani fuzzy model using FIS, and rules to execution and provide a trust rating. Assuming equal weights for all the rules the trust values estimated for each CSP, from above described conceptual model are classified in Table 5.

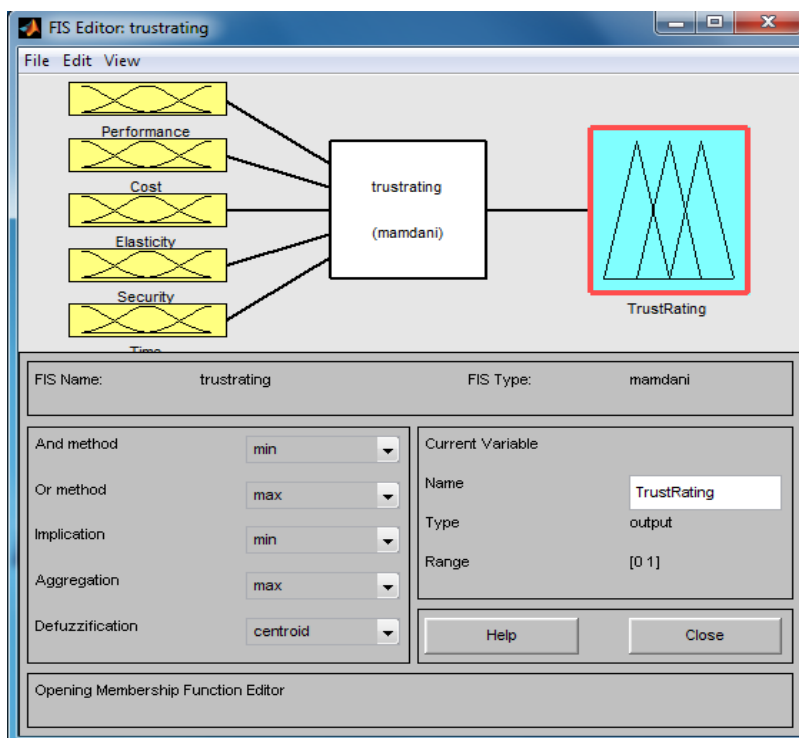


Figure. 10. FIS Editor Interface.

Table 5. Trust Values of CSPs

Cloud Service Provider	Five Parameters in Direct and Recommended Trust					Trust result	
	Performance	Cost	Elasticity	Security	Time	Trust values	Trust rating
CSP-A	0.499	0.222	0.321	0.050	0.350	0.456	Good
CSP-B	0.999	0.441	0.642	0.525	0.500	0.910	Excellent
CSP-C	0.749	0.343	0.481	0.787	0.500	0.682	V Good
CSP-D	0.350	0.156	0.225	0.367	0.400	0.364	Poor
CSP-E	0.399	0.445	0.258	0.525	0.306	0.406	Good
CSP-F	0.649	0.511	0.417	0.682	0.650	0.638	V Good

To verify the efficient of our proposed model, the experimental results are done for comparison between our model and other model described in [11]. The proposed model more than efficient and accuracy, where, we uses five parameters such that, Performance, Security, Elasticity, Time and Cost than other model uses three parameters, Agility, Financial and Performance for developed the trust model in cloud computing based on Fuzzy Inference System

5. CONCLUSION AND FUTURE DIRECTIONS

This paper used to developed trust model to evaluation the trust values based on fuzzy logic system. This method enables cloud users to evaluate the trustworthiness of cloud services providers. I took an example scenario with six different CSPs each with unique setting representing the geographic diversity, the cost factor and the processing capabilities. So, six different simulations are run using cloud analyst and each produces an output report detailing, the response time, data center processing time, user base request servicing time and the total cost with the factor in \$. Based on this report the CSP C is cheaper Compared to other CSPs. Also, I have revealed that Inter Domain direct trust value for CSPs can be estimated using fuzzy logic tool box, which can serve as an indicator for the users to choose a CSP as per their requirement. Our future work can be extends to others parameters and User Bases at different region

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