An Evaluation Approach of Trust Value and User Satisfaction Value Using Fuzzy Logic for Cloud Service Provider

Amit Saurabh, S. Durga, S. Jebapriya

Abstract- Cloud computing has recently come forward as a new and well-liked paradigm for organizing, managing and delivering a variety of services through a shared infrastructure and used by many individuals and organization globally. Demand of cloud service providers (CSPs) is increasing day by day due to it reduces capital expenditure as well as operational expenditure. More number of CSPs providing more well-versed choice for customers to choose. This paper portrays issues for having trusted cloud such as trust assessment and uncertainty in customer satisfaction assessment, and also developed a model, which consist trust assessment model and user satisfaction assessment model together based on fuzzy logic. This assessment helps users to make a well-versed choice towards selecting the appropriate CSPs as per their requirement, and also helps managers to perform gap analysis between existing level and the desired one.

Keywords: Cloud Service Provider, Cloud Analyst, Customer Satisfaction, Fuzzy Logic, Trust.

I. INTRODUCTION

Cloud computing has recently come forward as an emerging technology in this new developing era of internet. It delivers distributed information over the internet. However, the wide, multifaceted and self-motivated nature of cloud computing environments makes it challenging to provide flexibility against design faults, unexpected failures, unforeseen operating conditions and adversarial attacks. It creates extremely enormous change in saving the information and performing applied programs. The whole thing will be hosted on the cloud which consists some computers and server and can be offered through the internet instead of installing, organizing and managing the program on an individual PC. The security of information on the cloud is still a problem and no one can guarantee it [1]. Cloud-computing assigns to both the hardware and systems software in the data centers and the applications delivered as services over the Internet that provide those services. The services themselves have long been suggested to as Software as a Service (SaaS). Some service providers use words like IaaS (Infrastructure as a Service) and PaaS (Platform as a Service) to describe their products, but we stay away from these because accepted explanations for them still differ broadly. We suppose the two are more identical than different, and we judge them together.

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Most of the organizations are focusing on using the cloud in order to reduce capital expenditure as well as operational cost, there is aggressive growth in business for cloud adoption [2]. However, there are so many security issues and challenges for IT Management, which can be more costly for the organization to deal with, even considering the cost minimizing achieved by shifting to the cloud computing. Therefore, it is necessary for businesses to know their requirements before selecting various deployment models available on the cloud. The deployment models are private, public, community and hybrid cloud [3]. Cloud computing provides all the resources such as hardware, software and platform to the users over the internet in a pay-as-you-go manner. However, cloud computing is far away from being perfect, It needs appropriate instructions to manage standards and integrity. Since there is a common platform for all cloud vendors, it becomes progressively more complicated to manage security standards. The number of CSPs has increased rapidly in the last three years so that the customer has more well-versed choice based on a variety of parameters such as performance, security, policy, adoption, cost. We focus on SaaS providers (cloud users) and cloud service providers, which have received less attention than SaaS users [4]. This is not just an agreement issue. As a cloud service user, information on cloud that users do not own or manage, this introduces privacy issues and can minimize users control. Privacy issues are fundamental to user concerns about the adoption of cloud computing, and unless technological mechanisms to satisfy users, it will introduce the concerns, this may prove vulnerable for many different types of cloud services.

II. RESEARCH BACKGROUND REVIEW

All over the world, scientists and researchers have given a 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. It was a significant first step, but complete application infrastructure should be easily configured, deployed, dynamically-scaled and managed in a virtualized hardware environment to harness the power of the cloud is essential for companies. In order to discuss some of the issues surrounding the cloud concept, it is essential to place it in historical perspective. Looking at the Cloud's forerunners, and the problems they come across, gives the reference points to guide us through the challenges it needs to overcome before adopting it. In the earlier era of computing, researchers espoused a parallel and unified approach known as "grid computing," but cloud computing projects are more dominant and crash-proof than grid computing even in recent years. I examine cloud computing as a wide-array of internet based services, which allow users to obtain a broad range of functional capabilities on a "pay-as you-go" manner that previously required remarkable hardware/software investments and professional skills to get. Cloud computing is the understanding of the former ideals of utility computing without the technical complexities or complicated deployment worries. Cloud computing gives a way to enhance capacity or add capabilities on the cloud to reduce capital and operational expenditure as well as without training new personnel, or licensing new software, what always IT needs. Cloud computing expands IT`s existing capabilities, which includes any subscription-based or pay-per-use service that, in real time over the Internet.

Different studies have been done in the area of cloud computing. Armbrust et al [4] have published a paper entitled "A barkeley view of cloud computing", compares general clouds with private data centers and concludes their pros and cons. Nuno Santos [5] have published a paper entitled "towards trusted cloud computing", deals with designing a platform under the name of TCCP in order to enhance the security. Jaesun Han [6] 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. Kim Won [7] have published an article entitled "Cloud Computing: Today and Tomorrow", discussed few essential options for data policy in cloud computing. Bryan Stephenson [8] in 2009 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. Fang Hao [9] have published a paper entitled, "secure cloud" deals with the security issues and concerns in deploying cloud computing. Suhaidi Hassan [10] 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 heterogenous cloud environment. Xiaodong Sun [11] 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. Tharam Dillon [12] 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. In this paper, they developed an overall trust rating for a given CSP based on sugeno fuzzy-inference system.

Cloud Service Measurement Index Consortium [13] has proposed a framework using common characteristics of cloud services. The aim of this consortium is to define each of QoS parameters given in the framework and provide a method for computing a relative index for comparing different cloud services. Cloud Service Measurement Index Consortium has developed the Service Measurement Index (SMI), which consists a set of Key Performance Indicators (KPI) that helps to regulate the measurement of business services. SMI Cloud - A work published by Garg [14] have proposed a framework to measure the quality of CSPs and prioritize them, which will create healthy competition among cloud providers to satisfy their Service Level Agreement (SLA) and improve their Quality of Services (QoS). SMI Cloud, systematically measures all the QoS attributes proposed by Cloud Service Measurement Index Consortium and rank the cloud services based on these attributes. Thus, cloud computing has opened up a new frontier of challenges and the problem of trusting cloud computing is of ultimate concern for most enterprises. In order to address a few of these issues, related to trusting the Cloud Service Providers, we propose a model which can help the users of cloud to make a well-versed choice to meet the user satisfaction.

III. MODEL DESCRIPTION

In this paper, we have developed two model, a model for trust assessment a model for user satisfaction assessment based on Fuzzy Logic.

In a social context, trust is defined as one party (trustor) is willing to rely on the actions of another party (trustee), It is strongly connected with confidence. It implies some degrees of uncertainty, fuzziness and randomness. There are mainly two types of trust, Direct trust and Recommended trust. Direct trust, essentially based on direct experiences and recommendation trust, an evidence based relationship, can be accurately described, reasoned and verified. Trust can be divided into Inter domain and Intra domain, based on the location or limit within which the trust can be estimated. In addition, I would like to explain user satisfaction, the service provided by CSPs should satisfy users in every facet.

A. Model Parameters

In order to form a conceptual model, some attributes has been used, Which is defined by Service Measurement Index (SMI). These include security, policy, obstacles of cloud computing, adoption, accountability, agility, performance, financial and usability. 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 frame the attributes in evaluating the trust and user satisfaction. We discussed policy issues, security, Adoption issues, obstacles, performance, financial and agility in this paper. Table 1 shows the factors and there KPI.

Table 1 Factors and their KPI

Factors Impacting Degree of Trust and Users Satisfaction	*KPIs of corresponding attributes*
Policy	Reliability, Liability, Security privacy, Access and usage restriction
Obstacles	Performance predictability, Scalable storage, Bugs in large distributed system
Adoption	Compliance, vendor luck in
Security	Data location, Recovery
Performance	Accuracy, Functionality, Stability, Interoperability, Service Response Time
Agility	Adaptability, Capacity, Elasticity, Extensibility, Flexibility, Portability, Scalability
Financial	Acquisition and training cost, Ongoing cost, Profit or Cost Sharing

B. Trust Model

The Trust Model concentrates on the assessment of trust value based on Direct and Recommended information, for CSP in Inter Domain and Intra Domain. Figure 1 shows The trust model architecture of the trust assessment.

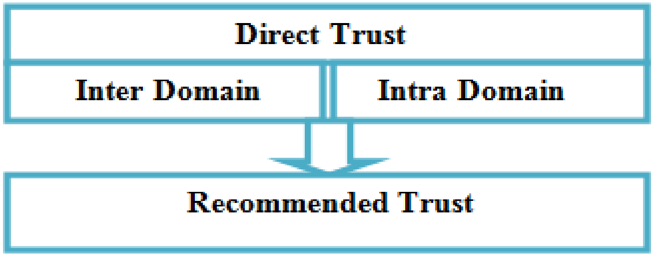

Fig. 1 The Trust Model

In this paper, we have simulated a framework using the Cloud Analyst toolkit and focused on the assessment of Inter Domain trust value for CSP based on the direct trust.

Cloud Analyst is developed by Bhathiya Wickremasinghe [15] at the CLOUDS Laboratory. 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

Step I. Configuring and defining User Bases.

Step II. Configuring and defining Data Centers

Step III. Allotment of VMs in Data Centers.

Step IV. 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 computation and communication. Figure 2 shows the snapshot of the Cloud Analyst configuration window.

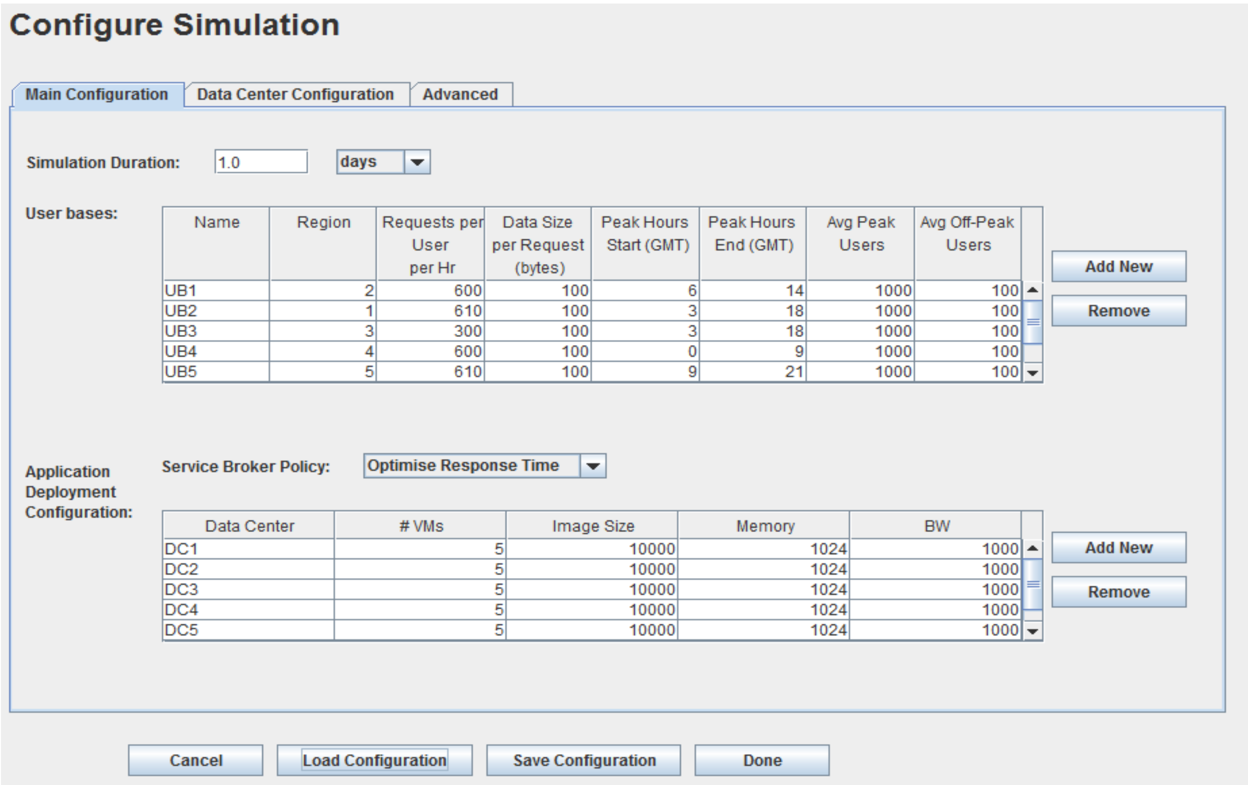

Fig. 2 CloudAnalyst Configuration Window

C. The User Satisfaction Model

The User Satisfaction Model concentrates on the assessment of user satisfaction value based on Fuzzy Logic for cloud computing users. In this model, we have taken four parameters separately, which fulfill users requirement completely. They are policy, obstacles of cloud computing, adoption and security. Figure 3 shows the user satisfaction model architecture of the user satisfaction assessment.

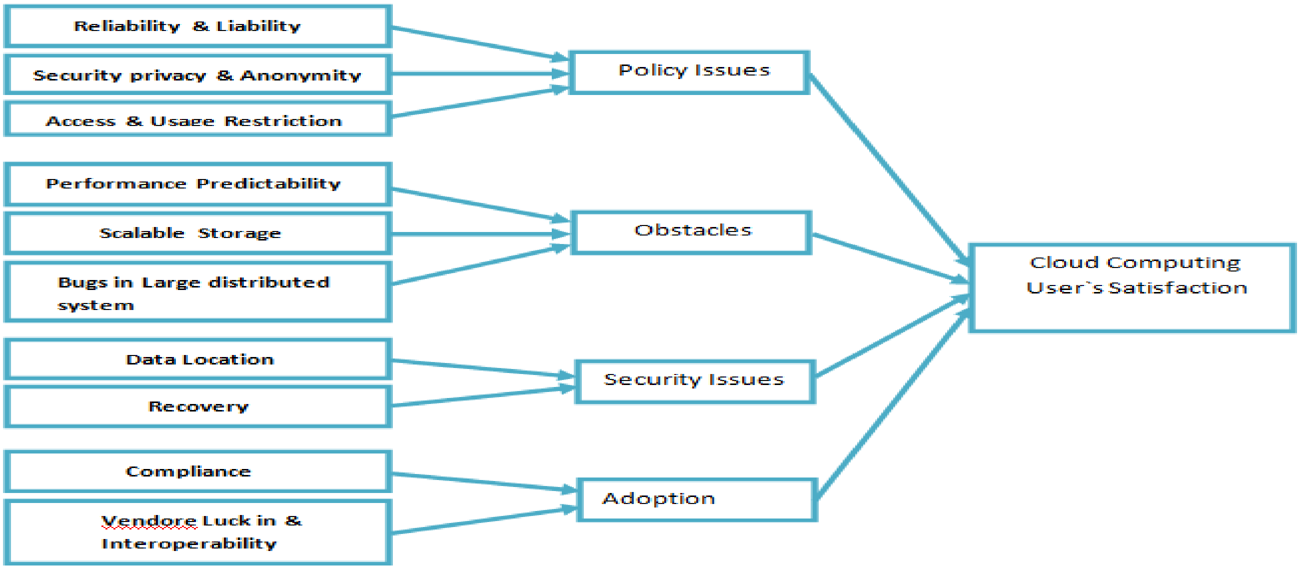

Fig. 3 The Overall Architecture of User Satisfaction Model

D. The Conceptual Model

In this model, finally we combined both the model together and proposed a new conceptual model. The evaluation of the trust value for CSP as well as evaluation of user satisfaction for cloud computing users, comprises of two stages as shown in Figure 4. The first stage is the implementation with the help of Mamdani Fuzzy Inference System [16]. It takes policy, obstacles of cloud computing, adoption issues, security issues, performance, financial and agility as inputs and produces a range of values which could be easily fed as input to the next level of processing. The second stage is the implementation using Sugeno FIS. It takes the output of the Mamdani FIS and helps to obtain the trust rating for the CSP as well as user satisfaction rating for cloud computing users.

For both the FIS, the membership values of policy, obstacles of cloud computing, adoption issues, security issues, performance, financial and agility 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 a larger range.

The above two stages are implemented hierarchically using the fuzzy logic blocks in Simulink of MATLAB [16].

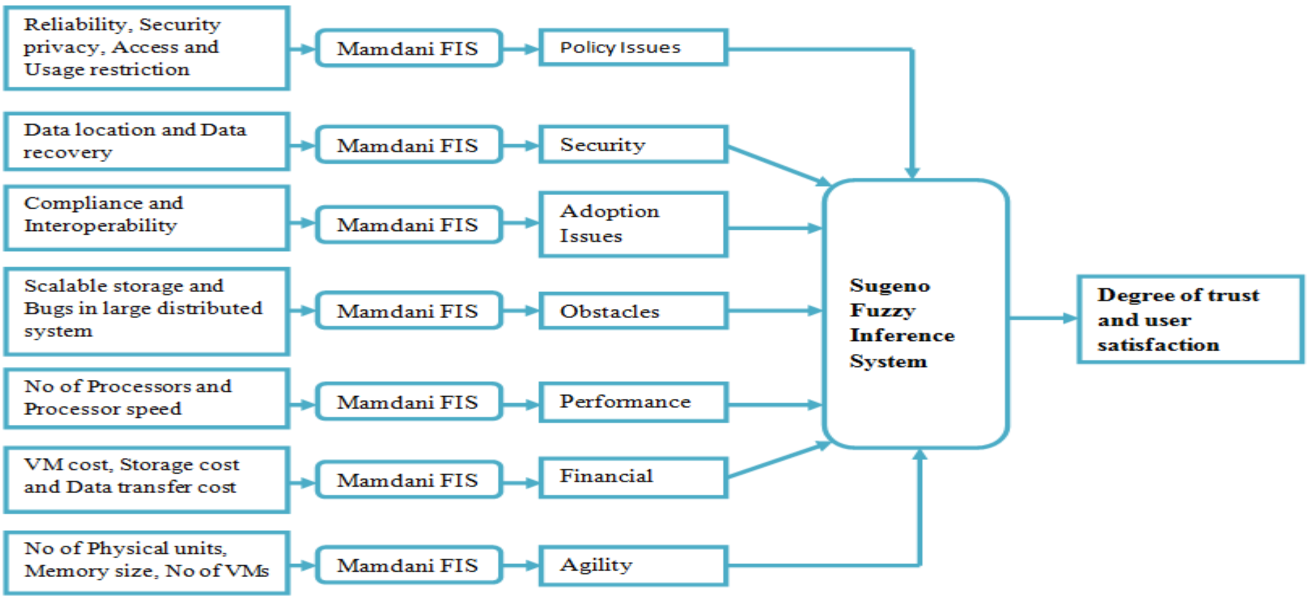

Fig. 4 The Conceptual Model

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IV. IMPLEMENTATION AND RESULTS

The implementation consists of two stages. First is simulating the cloud environment, next is using the parameters from the simulation in Fuzzy Logic toolbox to obtain the trust rating as well as user satisfaction rating.

A. Simulation Setup

In Cloud Analyst, the scenarios are setup in such a way as to represent user bases across the globe. The user bases remain constant across the scenarios whereas the CSPs setup 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 five different CSPs each with unique setting representing the geographic diversity, the cost factor, and the processing capabilities.

Table 2 describes the values which are taken to simulate the cloud environment using Cloud Analyst. So, five different simulations are running and each produces an output report detailing the Response time, Data Center processing time and the total cost.

Table 2 Simulation Setup

Cloud Service Provider	No of Data Center	No of Physical Unit	Memory Size (GB)	No of VMs	No of Processors	Processor Speed in MIPS	Cost ($)		
							VM	Storage	Data Center
CSP A	6	6	6	30	24	100000	0.4	0.15	0.15
CSP B	3	17	1.5	15	68	80000	0.1	0.25	0.09
CSP C	6	6	3	30	24	120000	0.05	0.08	0.2
CSP D	2	40	4	50	400	160000	0.8	0.25	0.05
CSP E	3	3	6	150	12	60000	0.5	0.15	0.09

Table 3 Results of Cloud Analyst Simulations

Cloud Service Provider	Response Time (ms)		DC Processing Time (ms)		Total Cost ($)
	Min	Max	Min	Max	
CSP A	37.12	387.69	0.16	13.34	830.26
CSP B	37.58	385.93	0.16	13.34	361.36
CSP C	36.89	385.61	0.14	11.26	759.01
CSP D	37.27	628.36	0.06	7.09	1140.76
CSP E	41.46	821.02	2.08	209.18	2125.37

Table 3 summarizes the results of the Cloud Analyst for the assumed scenario in Table 2. The Response times and D.C Processing times along with the cost factor in $ listed here show that CSP B is cheaper compared to other CSPs. Section 4.2 describes the estimation of trust value from these results for each CSP using Fuzzy Logic.

B. Fuzzy Logic Implementation

Agility- The agility model has three input parameters mapped to one output. Each of the input parameters in Figure 4 has different membership functions. "Physical units" has two member functions while "Memory", "V.M" and output "Agility" 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 "Agility" has 3 member functions low, medium and high. When the input related to CSP A is fed to the Matlabs FIS, the Agility comes out as Medium. Similarly for CSP B it is medium, CSP C-low, CSP D-medium, CSP E-medium. Figure 5 shows the sample Rule Viewer when implemented in Matlab.

Policy- Policy has three input values namely reliability & liability, security privacy & anonymity and access & usage restriction. Each of the input parameters in figure 4 has three member function. The output "policy" has five member function low, low to medium, medium, medium to high and high. The outputs obtained from the FIS are CSP A- Low to Medium, CSP B- Medium, CSP C- Low, CSP D- Medium to High, CSP E- High.

Security- Security also has two input values namely data location and recovery. Both of the input parameters in figure 4 has three membership function. The output "security" has three membership function low, medium and high. The outputs obtained from the FIS are CSP A- Low, CSP B- Medium, CSP C- Low, CSP D- High, CSP E- High.

Obstacles- Obstacles has three input values namely performance predictability, scalable storage and bugs in large distributed system.

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Each of the input parameters in figure 4 has three membership function. The output "obstacles" has five membership function low, low to medium, medium, medium to high and high. The output obtained from the FIS are CSP A- Medium to High,CSP B- Medium, CSP C- Medium to High,CSP D- Low to Medium, CSP E- Low.

Performance- Performance has two input values namely number of processors and the processor speed as shown in Figure 4. Both have three member functions each. The output "performance" has four member functions low, medium, high, and very high. The outputs obtained from the FIS are CSP A-Low, CSP B-Medium, CSP C-Medium, CSP D- High, and CSP E-Very High.

Financial- The financial block also comprises of three inputs namely V.M cost, Storage cost, Data Transfer cost. The "V.M cost" input has three member functions whereas "storage cost" and "Data transfer cost" have two member functions each. The output "financial" has three member functions low, medium and high. Here a total of nine rules are written. Given the values of CSPs to the financial model we get results as CSP A-High, CSP B-Medium, CSP C-Medium, CSP D-High and CSP E-High.

Adoption- Adoption has two input values namely compliance and vender luck in & interoperability. Both have three membership functions each. The output "Adoption" has five membership function low, low to medium, medium,medium to high and high. The outputs obtained from FIS are CSP A- Low to Medium, CSP B- Medium, CSP C- Low, CSP D- Medium to High, CSP E- High.

Trust and User Satisfaction- The Trust and User Satisfaction FIS is the final Fuzzy model which takes the output of the previous seven blocks and gives the Trust rating and User Satisfaction rating as output. However the fuzzy model chosen here is Sugeno FIS, so the output is a crisp value i.e. one of the five: very poor, poor, good, excellent, and outstanding. This has considerably a large number of rules compared to the previous values due to the increase in number of member functions of input as well as output.

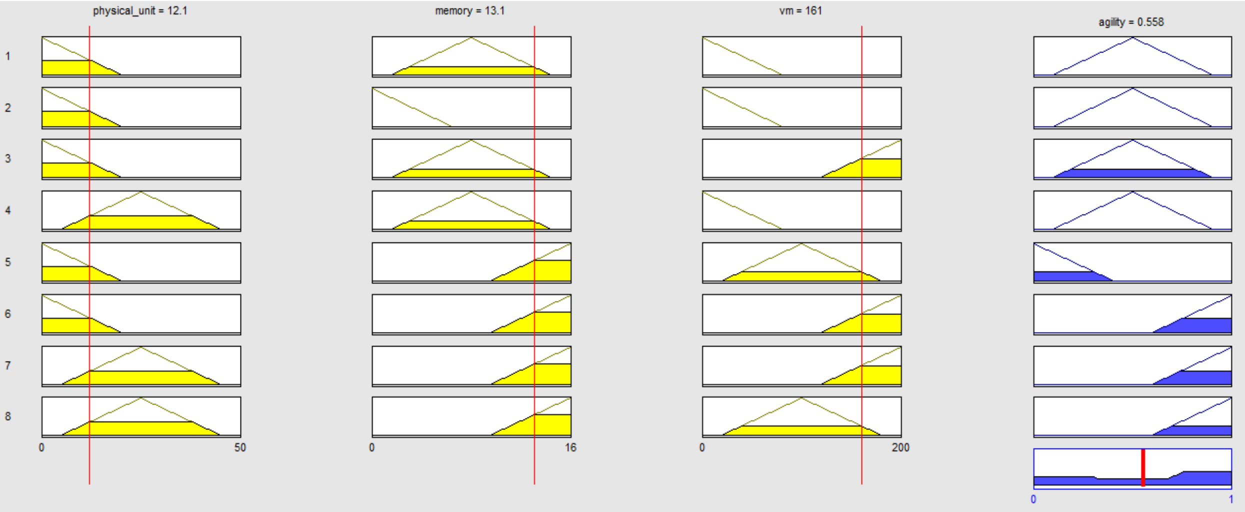

Fig. 5 Rule Viewer

The two fuzzy models: Mamdani and Sugeno are combined together using FIS blocks of Simulink, which on execution provide a trust rating as well as user satisfaction rating using the rules. Assuming equal weights for all the rules the trust values and user satisfaction value estimated for each CSP from above described conceptual model are classified in Table 4.

Table 4 Trust rating and User Satisfaction Rating

Cloud Service Provider	Agility	Policy	Security	Obstacles	Performance	Financial	Adoption	Trust and User Satisfaction Rating
CSP A	0.45	0.374	0.287	0.636	0.347	0.856	0.423	Poor
CSP B	0.451	0.45	0.512	0.578	0.448	0.5	0.587	Good
CSP C	0.151	0.185	0.217	0.764	0.446	0.6	0.236	Very Poor
CSP D	0.45	0.768	0.823	0.234	0.8	0.857	0.761	Excellent
CSP E	0.451	0.85	0.9	0.178	0.85	0.9	0.898	Outstanding

V. CONCLUSION

I have shown that it reduces capital expenditure as well as operational expenditure and also helps managers to perform gap analysis between existing level and the desired one. I took an example scenario with five different CSPs each with unique setting representing the geographic diversity, the cost factor and the processing capabilities. So, five different simulations are run using cloud analyst and each produces an output report detailing the response time, data center processing time and the total cost. Based on this report the response times and D.C processing times along with the factor in $ presenting that CSP B is cheaper Compared to other CSPs.

Also, I have revealed that Inter Domain direct trust value and User Satisfaction 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.

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