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A Framework for Evaluating Cloud Computing User's Satisfaction in Information Technology Management

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ABSTRACT: Cloud computing is a new discussion in enterprise IT. It has already become popular in terms of distributed technology in some companies. It enables managers to setup and run the intended businesses by avoiding excessive spending on computers, software and hiring expert staff, which proves to be cost effective. Cloud computing also helps users pay for the IT services without spending massive amounts for integration, maintenance or management of the IT infrastructure. In this paper, we have tried to present a model for evaluating user's satisfaction in cloud computing. Therefore, a conceptual model has been constructed considering attributes such as (security, efficiency and performance, adaptability, and cost) to evaluate cloud computing user's satisfaction in an Internet Service Provider (ISP) companies in Iran. To avoid any ambiguities which are caused by linguistic methods, in this evaluation model we have used Fuzzy Inference System (FIS).

Keywords: *Cloud computing, Internet service provider, Fuzzy inference system, User's satisfaction*

INTRODUCTION

The growth in the number of applications and customers' demand for information security, fast processing, dynamic access and saving cost has made organizations use cloud computing to scale up their massive capacity as well as avoiding further investment on new infrastructure or staffing.

One vision of 21st century com-puting is that users would have to access Internet services over lightweight portable devices rather than through some descendant of the traditional desktop PC (Dikaiakos et al., 2009). In fact cloud computing is scalable and flexible style of computing and has the ability to provide services to customers through the internet. Cloud infrastructure provides organizations with more efficient use of software and hardware resources and makes a huge difference in storing data and running applications.

It also offers a simplified capital and expenditure model to compute services and to increase agility for cloud customers to expand and contract their IT services easily as business needs change. In cloud computing, any application and data on cloud consists of several computers and servers and users access them through the internet instead of their PC.

In IT enterprises there is no unique definition for cloud computing and most expertise and users define it based on their understanding. Totally, cloud computing is a concept for using the computing resources such as (programs, platform and infrastructure) over the internet. Cloud computing, in its simplest definition is "providing computer service on the internet" Instead of paying the expenses to manufacture for installations of information technology to keep the data and software; you may use the facilities of other companies as well (Pilevari and Arbabioon, 2011).These services are; software, data and computing resources, so storage and online data processing are done with cloud providers and the result is delivered to

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the customers. Therefore, in cloud computing we can store data, backup them and use applications.

According to the mentioned definition, some features of cloud computing are reliability, scalability and security. In cloud computing, the online services are conducted on a pay-as-you-use basis. It is not necessary to be in a long term contract with service providers. In this case, cloud customers can save large amounts of budget spent on operating, managing and transferring services. As cloud process done on machines and user does not have enough control on their data and equipment, it leads to mistrust of cloud computing like store location security risk, service interruption and data loss risk. Privacy issues are central to user concerns about adoption of cloud computing. The question we try to answer here is that what are the components and indicators of cloud computing user's satisfaction. The main contributions of this paper are investigating and analyzing the main requirements to establish an effective model for user's satisfaction in cloud computing. Cloud computing is not an innovation or completely new idea; it is a result of evolutionary development of different technologies such as utility computing, grid computing, virtualization and web2.0. Utility computing is a mean of computing and storage services that user pay base on their use and they have not an infrastructure of the services similar to a traditional public utility (for example, electricity and water).By virtualization technology, services in cloud computing are offered to the users over the internet with virtual services. Cloud computing is a development of grid computing technology and most cloud computing deployment uses it. Similarly, like grid computing, cloud computing is a complete system for organizations to use these services making computer power as easy to access that offers multiple geographically dispersed computation, data or service resources owned by different organizations.

Through Web2.0 technology on cloud computing, we can have information sharing, interoperability, user-centered design, and collaboration on the Internet.

In this paper, we found out determinants, which would affect user satisfaction in cloud computing like, security, adaptability, efficiency and performance and cost, and evaluate them through Fuzzy Inference System.

Cloud Computing Service Model

There are several types of services that can be provided through cloud computing. The concept of "everything- as- a- service" (EaaS) can be used for detachment type of service. Infrastructure resources such as (hardware, system software, storage and applications) are provided in EaaS. The resources of these services are virtualized, multi-tenant and available on-demand with pay-per-use models. (Aumueller, 2010).

The other type of cloud computing services model is Infrastructure as a Service (IaaS). Services in IaaS are in low level and it is near to hardware. IaaS enables consumers to have more control over the IT infrastructure. The famous suppliers in IaaS are Amazoon and Gogrid. Infrastructure as a service is a resource for computing, storage and communicating.

The next computing service level after IaaS is PaaS. In this level, customers can put their applications in cloud infrastructure. In this level, users cannot manage or control network, servers and storage space, although they can have control on applications they put in PaaS. The example of this service is Google's App Engine that allows developers to write Programs and run on Google's infrastructure or platform. Some works done in Platform-as-a-Service are designing, modeling, development, programming and test. Finally, Software as a service is a type of cloud service model that end-user experiment it. In traditional approach, customers are forced to buy software and license that require large capital and finally spent expense for features and products but, when software as a service, is provided over the cloud, users pay the cost as much as they use services. In this case, cloud customers can save large amounts of budget spent on operating, managing and transferring services. In cloud computing utility computing and SaaS are provided in an integrated manner. (Slabeva et al., 2009).

Figure 1 show the hierarchical view of cloud services model.

Cloud Computing Development Model

All cloud computing deployment model are proper subset of internet as a global network. These models are Public, Private, Hybrid and Community cloud. Public and private clouds have some common feature such as scalability and virtualized IT infrastructure but there is a difference in term of access to the cloud and their implementation. Public cloud is available for all users and organizations can use services provide by

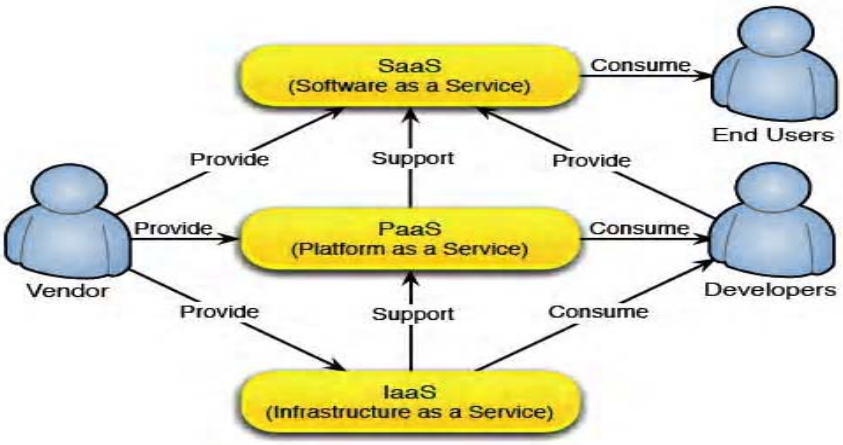

Figure 1: Cloud services to the consumer (Briscoe and Marinos, 2009)

other company. This allows companies to outsource their services and reduce their cost, but in Private cloud, services are available only for users of a specific company. In this model, there is more control on security of data. In fact, neither public nor private cloud may cover all needs of company, so organizations use hybrid cloud. As the name implies, this model is a mixture of two type of (public and private) cloud. Each of them has its specific features but can connect to the other by standardize or propriety technologies. In community clouds, some organizations having common need, share their resource and services.

Literature Review

From 2007 Researches on cloud computing began to find ways to use cloud computing in organizations. To help managers, to have better understanding about cloud computing, and to attain sustainable trust cloud, numerous studies have been made to discuss cloud computing in organizations. Table 1 provides various ways in which cloud computing has been defined.

Cloud computing user's satisfaction is one the important part of marketing research in organizations as it reflects the service quality of a company. User satisfaction is generally defined as a feeling or judgment by customers towards products or services after they have used them.

Many researchers provide conceptual overviews, different reference and mature models of cloud computing. For instance, (Alhamadet al., 2011) present the classification of cloud computing service requirements from the perspective of cloud consumers such as availability, scalability, response time, cost calculation, configuration of service and Security and privacy. (Alhamadet al., 2011) present a model for each of the dimensions for IaaS using fuzzy-set theory and then use the sugeno fuzzy-inference approach for developing an overall measure of trust value of the cloud providers.

(Abbadi, 2010) proposed a conceptual model this model is concerned about exploring and analyzing automated self-managed services for cloud's virtual resources. The model is in six categories such as System Architect, The resilience process, Adaptability, Scalability, Availability and Service Reliability. (Aumueller, 2010) in his master dissertation present a conceptual model mentioned principles and IT-compliance criteria such as Availability, Integrity, confidentiality and verifiability for Data Security in cloud computing. (Qin et al.,2010) present a model to evaluate user behavior trust and evaluation strategy in the cloud computing by using fuzzy Analytic Hierarchical Process (FAHP) to evaluate security behavior, identity re-authentication, expense behavior and contract behavior.

(Khajeh-Hosseiniet al., 2010) analyze eight characteristics and quickly provide an indication of the cloud's suitability for a proposed IT system. Use a Technology Suitability Analysis to support decision makers in determining whether cloud computing is the right technology to support their proposed system. Technology Suitability Analysis comprises a simple checklist of questions to provide a rapid assessment

Table 1: Definition of cloud computing

No	Authors	Define of cloud computing
1	John Foley (2008)	cloud computing is the use of massively scaled offsite IT resources assembled virtually, accessed over the internet, used on demand in real time or near real-time on a pay-per-use or subscription basis, where the workloads are shared among multiple customers.
2	Vaquero et al. (2009)	Clouds are a large pool of easily usable and accessible virtualized resources (such as hardware, development platforms and/or services). These resources can be dynamically reconfigured to adjust to a variable load (scale), allowing also for an optimum resource utilization. This pool of resources is typically exploited by a pay-per-use model in which guarantees are offered by the Infrastructure Provider by means of customized SLAs.
3	Mell and Grance (2009)	Cloud computing is a model for enabling 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.
4	Gartner (2009)	Cloud computing is a style of computing in which scalable and elastic IT-enabled capabilities are delivered as a service to external customers using Internet technologies.
5	Marin Litoiu (2009)	Cloud Computing is an emerging computational model in which applications, data, and IT resources are provided as services to users over the Web.
6	Armbrust et al. (2010)	Cloud Computing refers to both the applications delivered as services over the Internet and the hardware and systems software in the data centers that provide those services.
7	Wenjuan Li and Lingdi Ping, Xuezeng Pan (2010)	cloud computing is a set of network enabled services, providing scalable, QoS guaranteed, normally personalized, inexpensive computing infrastructures on demand, which could be accessed in a simple and pervasive way.

of the potent suitability of a particular cloud service for a specific enterprise IT system.

The aggregation of above approaches can be criticized for ignoring the impact of enablers in assessing user satisfaction of cloud computing. In accordance to above literature review a conceptual model for mapping input space (tangible and intangible) to output space has been developed to assist companies in better achieving a user satisfaction in cloud computing. The proposed conceptual model has been based on the experiences of experts to evaluate cloud computing trust and satisfaction considering enablers and capabilities.

RESEARCH METHOD

To evaluate cloud computing user's satisfaction, two main stages should be carried out: Firstly, a conceptual model has been developed based on literature review and cloud computing experts to identify measurement criteria. Secondly, fuzzy inference system architectures have been designed to construct an input-output mapping based on both human knowledge in the form of fuzzy if-then rules with appropriate membership functions and stipulated input-output data based on evaluating cloud computing user's satisfaction. These two stages are investigated in some details in following sections.

RESULTS AND DISSCUSSION

Conceptual Model Construction

In this part, we have proposed a model of cloud computing user's satisfaction of internet service provider (ISP) company in Iran. In this stage, features of cloud computing have been used to define the user satisfaction in cloud computing and attributes and sub-attributes of cloud computing have been derived to finalize the structure of conceptual model.

A conceptual model which has been derived from expert's knowledge and literature is developed in four main attributes of cloud computing: security, efficiency, adaptability and cost (table2) and eleven sub-attributes (table 3) make up the basis of the conceptual model.

A. Security

Security is obviously essential in all systems dealing with potentially sensitive data and code. With cloud computing it is hard to control data, storage, networks and applications and users have to trust cloud provider to manufacture secure cloud. Users expect that the cloud provider will prevent unauthorized access to both data and code, and that sensitive data will remain private (Pilevari and Arbabioon, 2011).

Confidentiality: It means data should be accessible for those who have authority. The clients need to have assurance that they can control the privacy and confidentiality of their information at all times and have assurances that if needed, they can remove, destroy, or lock down their data at any time (Krautheim, 2010).

Availability and Usage Restriction: Availability means users have reliability to access data in specific time. Users expect to be able to access and use the cloud where and when they wish without hindrance from the cloud provider or third parties, while their intellectual property rights are upheld, and "mission-critical" applications expect clear delineation of liability if serious problems occur (Jaeger et al., 2008).

Backup and Recovery: Users are expected to classify and correct their data and know how and where data are stored. Even when we do not know where the data is cloud provider tell us what happened to our data.

Table 2: Attributes of the conceptual model

Attribute	Reference List
A. Security	Aumuler, 2010; Jing and Jian-jun, 2010; Chowhan and Saxena, 2011; Alhamad, Dillon and Chang, 2011; Pilevari and Arbabioon, 2011
B. Efficiency and Performance	Kaiqi, Xiong and Harry Perros, 2009; Iosup et al., 2011
C. Adaptability	Abbadi, 2010; Nawaz et al., 2010; Ristola, 2010.
D. Cost	Nawaz et al., 2010.

Table 3: Sub- attributes of the conceptual model

Sub-attributes	Reference
Confidentiality	Aumuler, 2010;Ristola, 2010.
Availability and Usage Restriction	Abbadi, 2010; Aumueller, 2010; Ristola, 2010; Nawaz et al., 2010; Alhamad, Dillon and Chang, 2011; Pilevari and Arbabioon, 2011.
Backup and Recovery	Aumuler, 2010; Alhamad, Dillon and Chang, 2011.
Response time	Alhamad, Dillon and Chang, 2011.
Usability	Muhammad Nadeem Faisal, 2009; Alhamad,Dillon and Chang, 2011.
Customization	Alhamad, Dillon and Chang, 2011.
Flexibility	Ristola, 2010; Abbadi, 2010; Nawaz et al., 2010.
Interoperability	Chen-Tung Chen andKuan-Hung Lin, 2009; Aumuler, 2010.
Scalable storage	Michael Armbrust et al., 2009.
Hardware cost	Chen-Tung Chen and Kuan-Hung Lin, 2009.
Software cost	Chen-Tung Chen and Kuan-Hung Lin, 2009.

B. Efficiency and Performance

By using cloud computing, the efficiency is improved greatly and Performance is generally tied to an application's capabilities.

Response time: Cloud computing accomplishes a better response time in most cases than your standard server and hardware. Users want to complete their process quickly and receive the process.

Usability: The usability is defined as "the effectiveness, efficiency and satisfaction with which specified user can achieve the specified goals in particular environment." by the international standardization organization (ISO) and other authors. The usability evaluation is to test the system and services for users approaching and measure how effectual, resourceful and satisfied are the users in their interactions (Nadeem Faisal, 2009).

Customization: Virtually any type of hardware, software or idea can be integrated into the cloud computing model it is the most customizable networking / computing solution that has ever been created. What is even more astounding is the fact that despite its high marks in terms of overall customizability, it is still the most affordable way to incorporate the highest possible level of features. A classic example that demonstrates just how customizable cloud computing really is would be how quickly a new cloud network is able to provide and reconfigure capacity, storage and servers (especially when compared with traditional networks).

C. Adaptability

Today, by increasing the service requests, customer demands and security requirements, user expect that system be able to react by these changes.

Flexibility: With Cloud Computing flexibility, user can scale the businesses up or down as needed ultimately saving cost of equipment, operations, installation, staffing, training and investment for security precautions.

Interoperability: because cloud computing offer in different deployment models such as private, public etc, interoperability makes integration between models.

Scalable storage: The main reason why anyone should use cloud computing paradigm is scalability. Three properties whose combination gives cloud computing its appeal: short-term usage (which implies scaling down as well as up when demand drops), no upfront cost, and infinite capacity on demand while it is straightforward what this means when applied to computation, it is less clear how to apply it to persistent storage.(Armbrust et al., 2009).

D. Cost

Most important factor in user's satisfaction is the cost of services. They prefer to use low expense services.

Hardware cost: In cloud computing, it is not necessary to pay high cost to purchase a system with high computing power. In this model, hardware cost include Central processing units, LANs, disk storage, peripherals, wide area network, PCs, portables, local servers (Jäätmaa, 2010).

Software cost: With cloud computing, it is not essential to buy expensive software and we can use software through internet (figure 2).

Fuzzy Model

Fuzzy set theory is a suitable system for modeling uncertainty arising from mental phenomena, which are neither random nor stochastic. In this paper, we use fuzzy inference system (FIS) to evaluate the cloud computing users satisfaction A fuzzy inference system is a rule based system with concepts and operations associated with fuzzy set theory and fuzzy logic. This system is a rule based system which is mapping input spaces to output spaces. Therefore, they allow constructing structures to be used to generate responses (outputs) by certain simulations (inputs) based on the stored knowledge of how the responses and simulations are related. The knowledge is stored in the form of a rule base, that is, a set of rules that express the relation between inputs of a system and expected outputs. In this paper Mamdani approach has been used for aggregating rules; we have member function in Mamdani approach. A "membership function" is a curve that defines how the value of fuzzy variable is mapped in a degree of membership between 0-1.In this paper to evaluate cloud computing user's satisfaction three steps have been done. In step one,

membership functions are used to calculate the degree of fuzzy user's satisfaction in different values expressed by linguistic term such as low, low to medium, medium, medium to high and high (figure 3).

IF-THEN expression is the most common way for representing human knowledge. This form generally is referred to as deductive form. It means that if we accept on a fact (premise, hypothesis, antecedent), then we can infer another fact called conclusion (consequent). The fuzzy inference system is a popular way for wide range of science and engineering. In step two, for making rules the verbal options of experts regarding the effects of different factors such as security, efficiency and performance, adaptability and cost are gathered and processed for generating a rule base and using them as inputs of our fuzzy inference system. For example following rule has been used: If security is A, efficiency and performance are B, adaptability is C, and cost is D then cloud computing user's satisfaction will be E. For evaluating cloud computing user's satisfaction four attribute have been used as proposed inference system inputs, but in most steps there are several rules for evaluating so in the last step we need an algorithm to aggregate the result of the rules to derive a final evaluation. The process of deriving overall conclusion from the individual consequents contributed to each rule in the rule base is known as aggregation of the rules.

The proposed methodology has applied to company to evaluate user's satisfaction. In order to carry out the assessment procedure, a committee of experts has been formed. The decision team is asked to determine

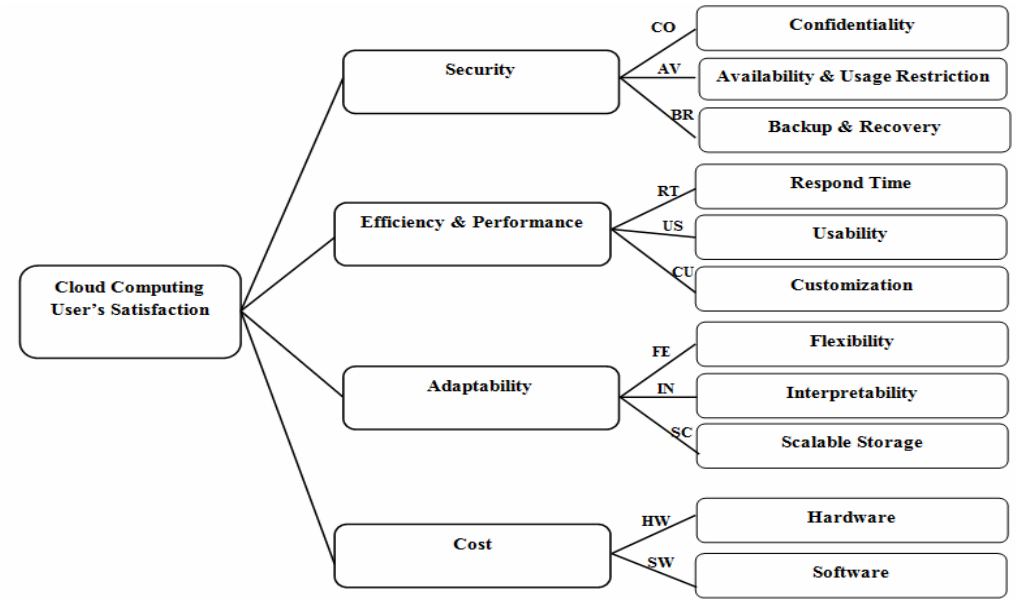

Figure 2: Cloud computing user's satisfaction conceptual model

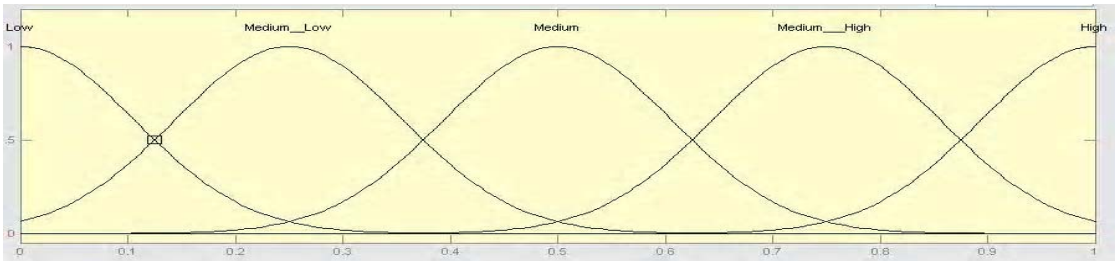

Figure 3: Mamdani fuzzy scale for evaluating

the shape of the "membership function" based on subjective judgment about the magnitude of satisfaction attributes in influence diagram that is shown in figure2.

We have used Fuzzy Tech Software to derive final aggregated result by Mamdani (max-min) inference method, and also to find a crisp value for the aggregated output, center of gravity. Mamadani method is the most prevalent and physically appealing defuzzification methods. That is given by algebraic expression:

$$\bar{y} = \frac{\sum_{j=1}^{m} y_j \prod_{i=1}^{n} \mu_{A_i}(x_i)}{\sum_{j=1}^{m} \prod_{i=1}^{n} \mu_{A_i}(x_i)}$$

The proposed fuzzy model consists of five main rule blocks and eleven inputs (CO, AU, BR, US, RT, CU, FE, IN, ST, HW, and SW), four intermediates (security, efficiency and performance, adaptability and cost) and the output of the main fuzzy inference system is the cloud computing user's satisfaction.

CONCLUSION

By following the steps that are mentioned in the proposed methodology and also by using fuzzy model of satisfaction assessment User's satisfaction in ISP company is evaluated and mentioned in tables 4-8 and the results have been shown in table 9.

By matching selected membership function for satisfaction variable with crisp output (0.645) the cloud computing user's satisfaction of the company can be labeled "medium to high satisfied". And also to analyze the system's performance, we can use surface to represent the mapping from inputs to satisfaction. Figure 4 shows the output surface (satisfaction) with different inputs. Surface is used to display the dependency of output on any inputs.

This evaluation helps information technology managers to perform gap analysis between existent level and the desired one. Gap analysis helps to identify

Table4: Survey security attribute in cloud computing user's satisfaction

Security	BR	AU	CO
0.718	0.6	0.5	0.8

Table 5: Survey efficiency attributes in cloud computing user's satisfaction

Efficiency	CU	US	RT
0.833	0.8	0.7	0.5

Table 6: Survey adaptability attributes in cloud computing user's satisfaction

Adaptability	ST	IN	FE
0.555	0.6	0.5	0.7

Table 7: Survey cost attributes in cloud computing user's satisfaction

Cost	HW	SW
0.351	0.5	0.1

Table 8: Survey cloud computing user's satisfaction

Customer satisfaction	Cost	Adaptability	Efficiency	Security
0.645	0.351	0.555	0.833	0.718

Table 9: Fuzzy model's inputs and output values

Sub-Attributes	Values
CO	0.8
AU	0.5
BR	0.6
RT	0.5
US	0.7
CU	0.8
FE	0.7
IN	0.5
ST	0.6
HW	0.1
SW	0.5
User's Satisfaction	0.645

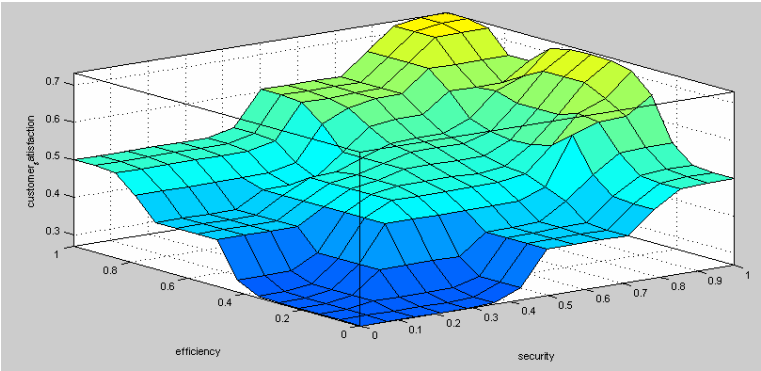

Figure 4: Output surface with obstacles and adaptation as inputs

obstacles within the organization that could block cloud computing user's satisfaction achievement. This methodology provides more informative and reliable analytical results and also facilitates rapid decision making for managers. The model can facilitate systematic continuous quality improvement; it provides the means for manager to devise an improvement plan. Further research is necessary to compare the efficiency of different models for measuring user's satisfaction.

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