

Review

A model for evaluating cloud-computing users' satisfaction

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Cloud computing is a new discussion in enterprise information technology (IT). It is becoming popular in terms of distributed technology in some companies. It helps managers who intend to setup a business in cyberspace not to use high capital to buy computers, software and hire staff who are experts; instead, they can run their business with low cost. Cloud computing also helps users pay for their use of services without needing to spend massive amounts for integration, maintenance or management of the IT infrastructure. In this paper, we tried to present a model for evaluating users' satisfaction in cloud computing. Therefore, a conceptual model was constructed to consider attributes in order to evaluate the cloud computing of user's satisfaction in an internet service provider (ISP) company in Iran. To avoid any ambiguity caused by linguistic methods in this evaluation model, Fuzzy Inference System (FIS) was used.

Key words: Cloud computing, internet service provider (ISP), fuzzy inference system, user's satisfaction.

INTRODUCTION

One of the reasons why organizations are using cloud computing is that the growth of applications and customers require information security, fast processing, dynamic access and most importantly saving cost, that make organizations look for scale up to massive capacity and increase demands without having to invest in new infrastructure or hire new staff. One vision of the 21st century computing is that users would have to access internet services over lightweight portable devices rather than through some descendant of the traditional desktop or PC (Dikaiakos et al., 2009). In fact, cloud computing is a scalable and flexible style of computing and it 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 easily expand and contract their IT services as business needs change (Stanoevska-

Slabeva et al., 2009). 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 unit definition for cloud computing, 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 a manufacture, the information technology is installed to keep the data and software; the facilities of other companies may also be used (Pilevari and Arbabioon, 2011). These services are: software, data and computing resources, however, storage and online data processing are done with cloud providers and the result is delivered to the customers. Therefore, we can store data in cloud computing, back them up and use the applications. According to the aforementioned definition, some

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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 (Aumueller, 2010). In this case, cloud customers can save large amounts of budget spent on operating, managing and transferring services. Cloud process is done on machines, and if users do not have enough control on their data and equipment, it leads to mistrust of cloud computing like store location security risk, and service interruption and data loss risk. Privacy issues are the central concerns of users about the adoption of cloud computing. The question we tried to answer is that, what are the components and indicators of cloud computing to user's satisfaction? The main contributions of this paper was to investigate and analyze 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 web 2.0. Utility computing is a means of computing storage services that users pay based on their use and they have no infrastructure of the services similar to a traditional public utility, for example, electricity and water. Services in cloud computing are offered to the users over the internet with virtual services by virtualization technology. 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 to make computer power easy to access and offer multiple geographical dispersed computation, data or service resources owned by different organizations. Through Web 2.0 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, performance and cost, and evaluate them through Fuzzy Inference System.

CLOUD COMPUTING SERVICE MODEL

Services provided in cloud computing can be divided into several types. The concept of "everything- as- a- service" (EaaS) can be used for the detachment type of service. Infrastructural 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 service model is Infrastructure as a Service (IaaS). Services in IaaS are in low level and are close to hardware. IaaS enables consumers to have more control over the IT infrastructure. The famous suppliers in IaaS are Amazon 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. However, users cannot manage or control network, servers and storage space, although they can have control on applications they put in PaaS. An example of this service is Google's Application 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 models that end-users experiment. In traditional approach, customers were forced to buy software and license that require large capital and finally spend expense on 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 (Stanoevska-Slabeva et al., 2009). Figure 1 shows the hierarchical view of cloud services model.

CLOUD COMPUTING DEPLOYMENT MODEL

All cloud computing deployment models are a proper subset of the internet as a global network. These models are: public, private, hybrid and community cloud. Public and private clouds have some common features, such as scalability and virtualized IT infrastructure, but there is a difference in terms of access to the cloud and their implementation. Public cloud is available for all users, and organizations can use services provided by 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 the needs of a company, so organizations use hybrid cloud. As the name implies, this model is a mixture of two types (public and private) of 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, researchers on cloud computing began to find a way to use cloud computing in organizations to help managers have better understanding about cloud computing and to attain sustainable trust cloud. Numerous studies were carried out to discuss cloud computing in organizations. Table 1 provides various ways in which

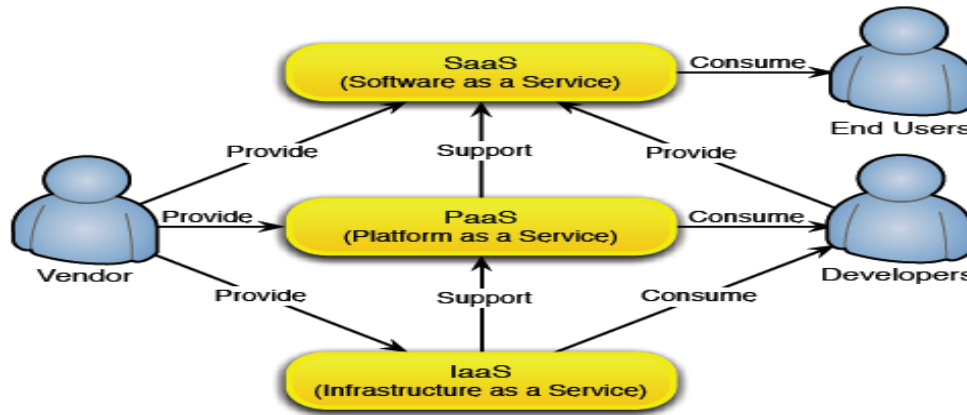


Figure 1. Cloud services to the consumer (Briscoe and Marinos, 2009: 2).

Table 1. Definition of cloud computing.

Authors	Define of cloud computing
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.
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.
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.
Gartner (2008)	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.
Litoiu (2010)	Cloud Computing is an emerging computational model in which applications, data, and IT resources are provided as services to users over the Web.
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.
Wenjuan et al. (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.

cloud computing was defined.

Cloud computing user's satisfaction is one of the important parts of marketing research in organizations and is able to reflect service quality of a company. Customers generally defined user satisfaction as a feeling or judgment towards products or services after they have been used (Jamal and Naser, 2003).

Many researchers provide conceptual over views,

different references and mature models of cloud computing. For instance, Alhamad et al. (2011) presented 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. They presented a model for each of the dimensions for IaaS using fuzzy-set theory and then use the sugeno fuzzy-

Table 2. Attributes of the conceptual model.

Attribute	Reference list
Security	Aumuler (2010), Chowhan and Saxena (2011), Alhamad et al. (2011), Pilevari and Arbabioon (2011) and Jing and Jian-jun (2010).
Efficiency and performance	Iosup et al. (2011) and Xiong and Perros (2009)
Adaptability	Abbadi (2010), Nawaz et al. (2010) and Ristola (2010)
Cost	Nawaz et al. (2010)

inference approach for developing an overall measure of trust value of the cloud providers.

Imad (2010) proposed a conceptual model that 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 Masters' dissertation presented a conceptual model and mentioned the principles of IT-compliance criteria such as availability, integrity, confidentiality and verifiability for data security in cloud computing. Li-qin et al. (2010) presented 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, and identity re-authentication, expense behavior and contract behavior.

Khajeh-Hosseini et al. (2010) analyzed eight characteristics and quickly provided an indication of the cloud's suitability for a proposed IT system. A Technology Suitability Analysis was used to support decision makers in determining whether or not 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 of the potential suitability of a particular cloud service for a specific enterprise IT system.

The aggregation of the earlier mentioned approaches can be criticized for they have not considered the impact of enablers in assessing user satisfaction in cloud computing. According to the aforementioned literature review, companies are assisted in better ways to achieve a user satisfaction in cloud computing, a conceptual model, which has been developed for mapping input space (tangible and intangible) to output space. The proposed conceptual model was based on the experiences of experts to evaluate cloud computing, trust and satisfaction considering enablers and capabilities.

RESEARCH METHODOLOGY

Two main stages were carried out in evaluating cloud computing user's satisfaction. Firstly, a conceptual model

was developed to identify measurement criteria based on literature review and opinions of cloud computing experts. Secondly, fuzzy inference system of architecture was 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 evaluation of the cloud computing users' satisfaction. These two stages were investigated in detail as follows:

Conceptual model construction

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

A conceptual model, which was derived from experts' knowledge and literature was developed in four main attributes of cloud computing: security, efficiency, adaptability and cost (Table 2), and eleven sub-attributes (Table 3) which are the basis of the conceptual model.

Security

Security is obviously essential in all systems dealing with potentially sensitive data and code (Schubert, 2010). With cloud computing, it is hard to control data, storage, networks and applications, and users have to trust cloud providers to manufacture secure cloud. Users expect that cloud providers 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).

Table 3. Sub-attributes of the conceptual model.

Sub-attributes	Reference
Confidentiality	Aumuler (2010) and Ristola (2010)
Availability and usage restriction	Alhamad et al. (2011), Abbadi (2010), Aumueller (2010), Ristola (2010), Nawaz et al. (2010) and Pilevari and Arbabioun (2011)
Backup and recovery	Alhamad et al. (2011) and Aumuler (2010)
Response time	Alhamad et al. (2011)
Usability	Alhamad et al. (2011)
Customization	Alhamad et al. (2011)
Flexibility	Ristola (2010), Abbadi (2010) and Nawaz et al. (2010)
Interoperability	Aumuler (2010) and Chen and Lin (2009)
Scalable storage	Armbrust et al. (2010)
Hardware cost	Chen and Lin (2009)
Software cost	Chen and Lin (2009)

Availability and usage restriction: Availability means users have reliability to access data in specific time. Users are expected 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; however, “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 the data are stored; even when the users do not know where the data are stored, cloud provider tells them what happened to their data.

Efficiency and performance

By using cloud computing, the efficiency was greatly improved and performance was generally tied to application’s capabilities.

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

Usability: Usability is defined by the international standardization organization (ISO) and other authors as “the effectiveness, efficiency and satisfaction with which specified users can achieve specified goals in a particular environment.” The usability evaluation is applied to test the system and services for approaching users, and measure how effectual, resourceful and satisfied the users get while they interact with it (Nadeem, 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 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.

Adaptability

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

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

Interoperability: Because cloud computing offers different deployment models such as private, public, etc, interoperability makes integration between models.

Scalable storage: Scalability is the main reason why anyone should use cloud computing paradigm. Therefore, there are three properties whose combination gives cloud computing its appeal: short-term usage (which implies scaling down and up when demand drops), no upfront cost and infinite capacity on demand; what this means is that when applied to computation, it is less clear on how to apply it to persistent storage (Armbrust et al., 2010).

Cost

Cost of services is the most important factor in users’

satisfaction. Users prefer to employ service in low expense.

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, and local servers (Jäättmäa, 2010).

Software cost: With cloud computing, it is not essential to buy expensive software, in that any software can be used through the internet.

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 used the fuzzy inference system (FIS) for evaluating satisfaction of cloud computing users. 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 expresses the relationship between inputs of a system and expected outputs. In this paper, Mamdani approach was used for aggregating rules. In Mamdani approach, we have member function. A "membership function" is a curve that defines how the value of fuzzy variable is mapped in a degree of membership between 0 and 1. In this paper, membership functions are used to calculate the degree of fuzzy users' satisfaction in different values expressed by linguistic terms 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 refers to a deductive form; it means that if we accept 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. 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 for our fuzzy inference system. For example, the following rule has been used: If security is A, efficiency and performance is 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 attributes were

used as proposed in the inference system inputs, but in most steps, there were several rules for their evaluation. Therefore, in the last step, we need an algorithm to aggregate the result of the rules to derive a final evaluation. The process of deriving the overall conclusion from the individual contributed rules in the rule base is known as aggregation of the rules.

The proposed methodology was applied to companies to evaluate user's satisfaction. In order to carry out the assessment procedure, a committee of experts was formed. The decision team was asked to determine the shape of the "membership function" based on subjective judgment about the magnitude of satisfaction attributes in the influence diagram that is shown in Figure 2.

Fuzzy Tech Software was used to derive the final aggregated result by Mamdani (maxmin) inference method and to find a crisp value for the aggregated output center of gravity. Mamadani method is the most prevalent and physically appealing defuzzification methods. This is shown in the algebraic expression:

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

The proposed fuzzy model consists of five main rule blocks, eleven inputs (CO, AU, BR, US, RT, CU, FE, IN, ST, HW, and SW), and 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

Following the steps mentioned in the proposed methodology and using the fuzzy model of satisfaction assessment, user's satisfaction in ISP company is evaluated and the results is shown in Table 4.

By matching the 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". Therefore, 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. However, the output surface was used to display the dependency of output on any input. This evaluation helps managers to perform gap analysis between existent level and the desired one. Gap analysis helps to identify obstacles within the organization that could block the achievement of cloud-computing user's satisfaction. This methodology provides more informative and reliable analytical results, and also facilitates rapid decision

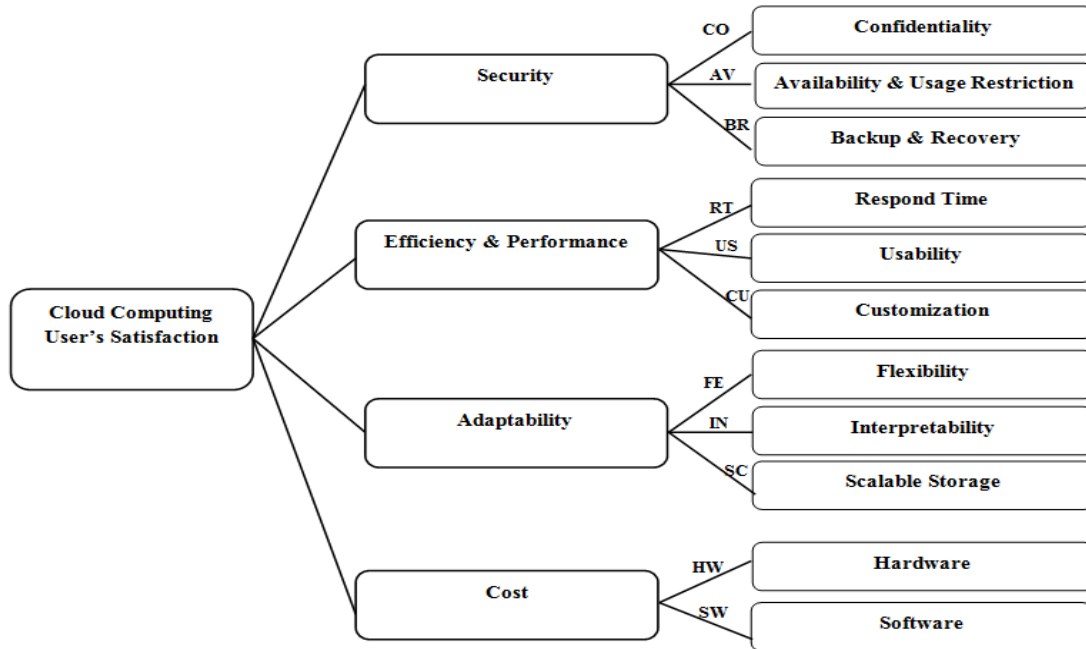


Figure 2. Cloud computing user's satisfaction conceptual model.

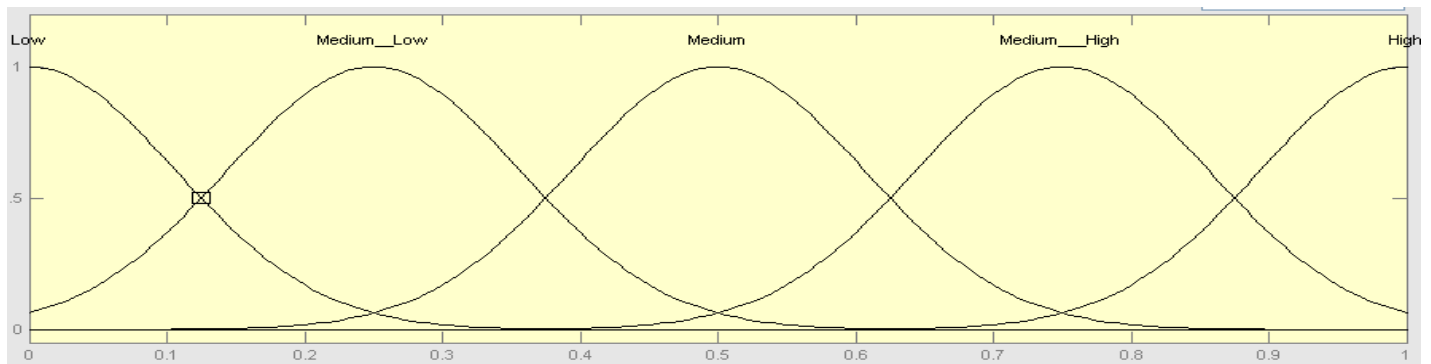


Figure 3. Mamdani fuzzy scale for evaluation.

Table 4. 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

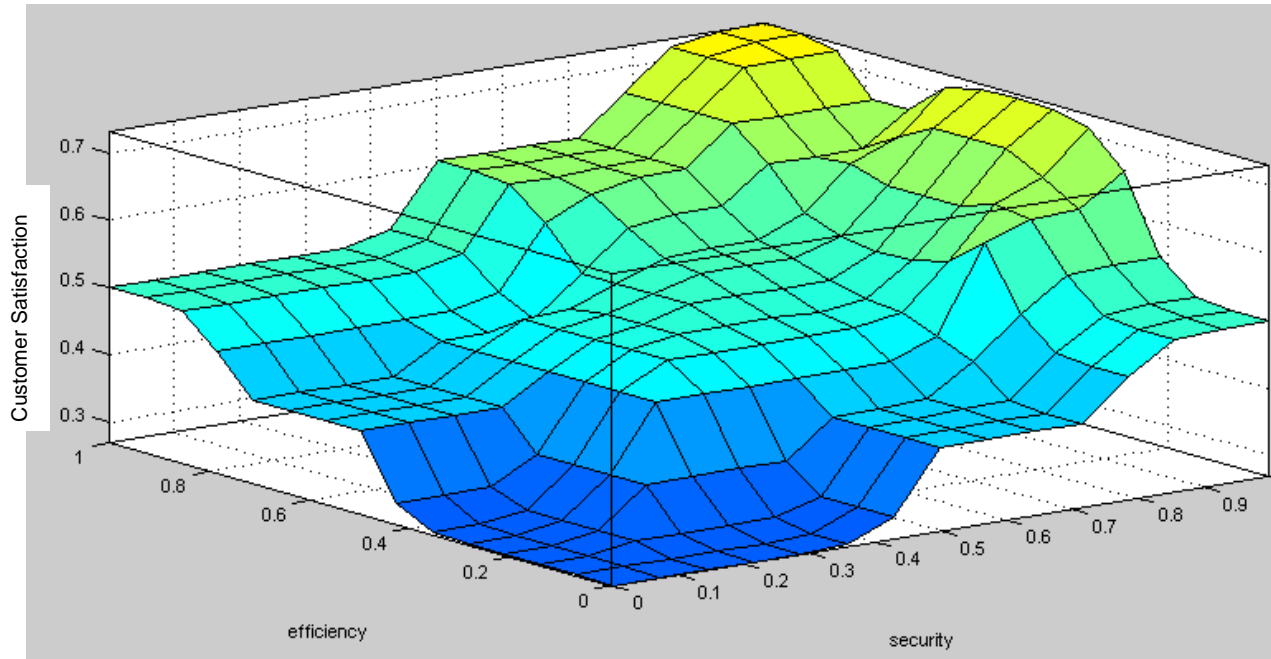


Figure 4. Output surface with obstacles and adaptation as inputs.

making for managers. The model can facilitate systematic continuous quality improvement; it provides the means for managers 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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