

A review of Fuzzy Mechanisms for E-government Security

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ABSTRACT

Recently, e-government has become an important issue for citizens. Government services are provided using electronic media. The security of applications and infrastructures is a critical factor for e-government success. However, analysis of the various possible external threats and internal vulnerability in order to evaluate and develop solutions resolves them is needed. A huge number of Artificial Intelligence (AI) techniques have been proposed for this purpose; fuzzy is considered as the dominant approach in this area. This paper describes the security challenges in the context of e-government. Additionally, it reviews and discusses the comparison between variant fuzzy-based techniques. This paper has concluded that; Fuzzy set theory is very useful for evaluation of e-government security.

Keywords

E-government, security, fuzzy techniques

1. INTRODUCTION

The evolution of information and communication technologies (ICTs) has significant effects in daily services. This evolution not affects only in daily life of the people, but alter properties of interaction between the government and people. These changes are fast being converted into new forms of government, called electronic government (e-government). E-government is a special application area information network. It involves large number of confidential data and information, its role is to enable citizens to access government services in any time and any place through communication media [1]. Became the Internet and mainstream media for e-government to provide general information to the electronic text and others transactions, The importance of e-government is to provide a bridge to enhance the Communication and information access from government to citizens and back. However, it may leads to the existence of dangerous security vulnerability. As consequence, privacy and security are essential for any e-government applications. There are external threats and internal vulnerability that affect the security and privacy of e-government [2]. These threats are not limited to physical security, network security, system security, and application and management security. This paper focus in e-government security because it improves the trust of citizens and encourage them to use e-government, Improving the trust relationship in e-government, leads to the success of e-Government. In contrast, if the security of e-government, the trust towards the e-government weaken and this leads to the failure of e-Government. For all these reason security of e government become a crucial issue. We select studying the security in e-

government because it improves the trust of citizens to use e-government, and the success of e-government highly depends on success to gain the trust of clients. In contrast, the breakdown on poor e government system imposes sensitive information to the lost and network to the disaster attacked [3]. To solve such problems, many publications proposed the use of Ai techniques (Artificial intelligence) [4] was the part of computer science concerned with developing intelligent computer programs and artificial intelligence should not seek to merely solve problems, but should rather seek to solve the problem of how to solve problems, Artificial intelligence (AI) is the study of how to make computers do things at which, at the moment, people are better. Many Artificial Intelligence (AI) techniques have been employed in e-government security such as Bayesian Network, Neural Network, and Fuzzy, which are employed to deal with uncertainty in evaluation of government web sites. On the other hand Genetic algorithm as a random search optimization method based on the principle of natural selection and genetics has been used. Fuzzy techniques applied to secure e-government are the focus of this paper. Because it is able to deal with uncertainty and vagueness of human thought, simple to design, and easy understand [3].

This paper is divided into seven sections. Section two describes e-government as well as security issues within it. The fuzzy algorithm has been described in section three. Section four reviews the application of fuzzy in e-government security. Section 5 presents the analysis and discussions on the comparison's result. The conclusion presented in the last section and after the related work which has been described section 6.

2. LITERATURE REVIEW

Nowadays, the government institutions gradually provide its users a number of e-government services, and in turn, citizens represent a crucial factor in the success of e-government. E-government aims at increasing the convenience and accessibility of government services and information to citizens [5]. E-government information system is a human-machine decision support system based on computer network and another networks, aiming at supporting e-government administration and its services. The important of e-government is that it creates an optimizes relationship with its citizens-government directs to make smooth, convenient, transparent, and inexpensive interaction between government and citizens (G2C), government and business enterprises (G2B), and inter-agency relationships (G2G). Table 1 illustrates the relations between variant recipients and the supplier of services.

Table 1: The relations between variant recipients and the supplier of services

		Recipient of Services		
		Citizen	Government	Business
Supplier Of services	Citizen	Citizen to Citizen (C2C) Ex: Small advertisements internet pages	Citizen to Government (C2G) Ex: Tax declaration by single person of family	Citizen to Business (C2B) Ex: Job exchange by job seekers
	Government	Government to Citizen (G2C) Ex: Benefit processing	Government to Government (G2G) Ex: Transaction between PAs	Government to Business (G2B) Ex: procurement of PAs
	Business	Business to Citizen (B2C) Ex: Online order in shopping mall	Business to Business (B2B) Ex: Tax declaration by private organization	Business to Government (B2G) Ex: procurement through EDI

There are some reasons for using internet for public sector some of them are to enhance efficiency , optimize service quality, maintaining successful outcomes, encouraging economic policy goals, bringing further improvement in agenda, and building trust relationship, etc.

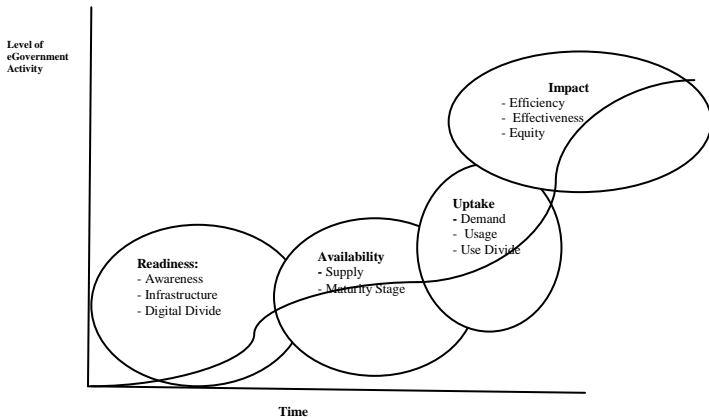


Fig1: The level of e-government activity

3. SECURITY IN E-GOVERNMENT

The security of e-government system is a major problem to reduce the building and development of e-government. The security in e-government's networks in the process of building e-government is one of the most important issues. The concern on security issues relating personal information have increased, as people rely increasingly upon the internet for the transfer of important and personal data.

As mentioned before, e-government runs a mass of data and information. These substances need protection which include confidentiality, integrity, credibility, controllability and non-repudiation. All above attributes represent the characteristics of security [6].

The main aims of software security are; the protection of the confidentiality, integrity, and availability of the information assets. In addition to that, the resources that the software creates, store, process or transmit, and the executing programs as well all are important issues in security domain. That means, Users in a secure system to have reasonable anticipations that are protecting their data from unauthorized access or modify their own data, which is still available, applications, and fixed. The Following are identification for some of the security attributes [7].

Confidentiality is the information published by e-government is only for authorized users, which cannot be revealed to unauthorized users. Integrity's-government information that is stored or maintained transmission cannot be modified.

Non-repudiation is the e-government information cannot be denied.

Controllability is the dissemination of the Internet information can be controlled.

Efficiency is a measure of speed and cost or is getting all you're testing done in the shortest time possible with the least amount of resources.

Effectiveness is it concern with high quality regardless of speed or time, "doing the right thing."

Accuracy is the state of being accurate; freedom from mistakes, this exemption arising from carefulness; exact conformity to truth, or to a rule or model; precision; exactness; nicety; correctness; as, the value of testimony depends on its accuracy. The public release of information must be released through the audit.

The security challenge in e-government is internal vulnerability and external threat to deal with such problems. Vagueness refers to things that are not clear, definitely expressed or stated, or not precisely determined or known. Researchers proposed the use of AI techniques to deal with this problem in the security domain.

Bayesian Belief Networks also known as Belief Network are the probability analysis and graph theory, a product of the combination in 1985, which was firstly put forward by Judea Pearl. It is a processing model which simulates the uncertainty of the causal relationship in the reasoning process. It has been used in e-government security to evaluation methods for e-government security risk assessment and the simulation results point that using the Bayesian network assessment has the same effect with the assessment of the experts. The algorithm is not only scientific and reasonable, but also be applied to the expert system to express the human being's knowledge [8]. The Bayesian Network is presented for uncertainty and complexity in the assessment process because it is used to solve the uncertainty problems, the papers are only a preliminary attempt to evaluate e-government security risk assessment and the results point that using the Bayesian network assessment has the same effect with the assessment and also be applied to the expert system to express the human being's knowledge of the experts. Number of researchers have applied Genetic Neural Network algorithm in risk assessment, also Dang Luo et al have tackled the problem that the randomness of the initial weights and thresholds of the BP neural network lead to the low network calculation accuracy and a fall into the local solution of the network easily, and Defines a model of e-government evaluation of the site based on genetic neural network algorithm [9]. in this paper investigate and discuss the evaluation e-government websites and e-government website evaluation is complicated system engineering, with many subjective and objective factors affecting the evaluation. The purpose of e-government website evaluation is to provide a reliable basis for e-government construction decisions. This model has fast speed of convergence and the result of the evaluation model is reasonable and a kind of effective method of e-government website evaluation, and also provides a new way of thinking for evaluation on e-government websites.

Mehdi Fasanghari ET al have proposed the use of Fuzzy Numbers [10], their approach aims to assess the performance of e-government as the traditional models evaluate the performance of e-government is generally very subjective and imprecise. This research introduced a fuzzy TOPSIS technique for assessing the performance e-government. Lingual expressions, for example, are satisfied and fair, is not satisfied, and the natural representation of preference or provision. These characteristics indicate the applicability of fuzzy set theory in capturing the structure of decision-makers' preference.

Uncertainty is the obstacle of evaluation when experts present their opinions in vague information such as verbal language variables. To encounter this problem, fuzzy sets and its applications as fuzzy numbers can be used. And they used the traditional TOPSIS widely in ranking problems, therefore, the researchers proposed fuzzy TOPSIS to handle ranking problems, and they implement triangular fuzzy number for their method since the triangular number is easy to use and another reason for using triangular fuzzy numbers in fuzzy TOPSIS, modeling the decision makers opinion is intuitively easy through fuzzy triangular numbers where the information available is subjective and inaccurate. The main benefit of this method is that it can be used for qualitative and quantitative criteria. The results demonstrate that this model has the ability to be flexible and be applied in assessing the performance of e-government. In the next section we introduce

the Fuzzy technique and its application in e-government security.

4. FUZZY ALGORITHM

Fuzzy logic emerged in 1965 by fuzzy set theory has been implemented in many areas such as control theory and AI, The fuzzy set theory as it deal with reasoning that is estimated rather than constant and precise has been proposed by LotfiZadeh in 1965. The main advantage of Fuzzy Logic analysis was its ability to quickly process the subsequent survey responses and produce a ranked list for management. In logic there are sequences of statements which are either 0 or 1. Fuzzy Set Theory presents a framework to model the problem in an uncertainty environment. It is a mathematical method to handle uncertainty, as well as it supplies the technology to deal with details and accuracy of information. Fuzzy logic is not the solution to all the technical challenges, however to manage problems in which the simplicity and speed of execution is essential then fuzzy logic is a suitable choice. Fuzzy logic is used to deal with both logic and probability theory, and allows handling several types of uncertainty in the conceptual framework. In the next session we will introduce some of fuzzy application that applied to evaluate e-government security.

Mathematically probabilistic and Fuzzy logic are same – together have truth values between 0 and 1 – however theoretically dissimilar, due to different explanations. Fuzzy logic applies IF - THEN rules and fuzzy methods may produce uncertainty and reduce ambiguity may generate more certainty. Fuzzy Theory can be applied broadly in the field of information gathering, modeling, analysis and optimization, and control and decision-making and supervision [10].

5. APPLICATION OF FUZZY ON E-GOVERNMENT SECURITY

Using fuzzy in evaluation process is critical due to the security and lack of knowledge; researches have proposed the combination of fuzzy with other methods.

Jun Fei ET al have proposed the use of fuzzy with AHP [11], this approach aimed to the evaluation of public satisfaction as it's an essential issue to the construction of e-government. Evaluation models for public satisfaction and fulfillment are usually subjective and imprecise, and they used Fuzzy Analytic Hierarchy Process based on trapezoidal fuzzy numbers (FrFN) as an evaluation method. The fuzzy is used because of the uncertainty and imprecision on subjective judgments of the decision-maker, and AHP seems to be insufficient and imprecise to capture the right judgments of decision maker so Fuzzy and AHP were combined together. Also, the Fuzzy with AHP were employed in this paper to develop a fuzzy multiple-attribute decision-making (FMADM) model. The main benefits of such methods are to be used for qualitative and quantitative benchmarks. From their results we can notice that, the model has the ability to be adapted and implemented in the evaluation of e-government satisfaction. The fuzzy AHP technique can be expanded to a variety of evaluations such as human subjectivity.

Guangfu Wei ET al have proposed the use of Fuzzy AHP and Artificial Neural Network model [12], The authors firstly has

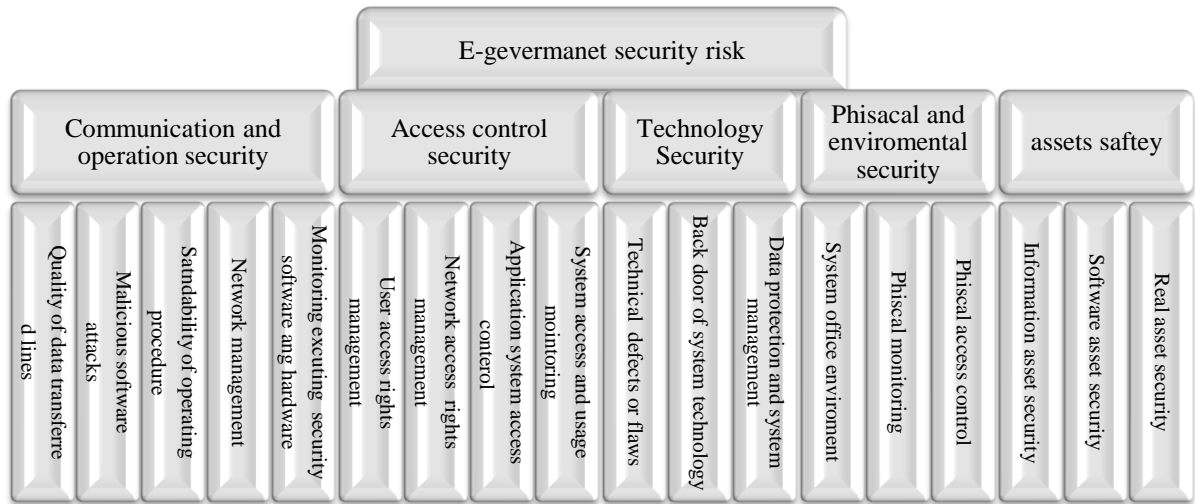


Fig2: E-government information security risk evaluation index

established a hierarchy structure index system for E-government information systems, security risk assessment based on the operationally critical threat, assets and vulnerability evaluation and also proposes a new security risk assessment method based on FAHP and ANN. This method aimed to decrease time and cost using ANN method without decreasing the accuracy of the result. And he used this index to assess e-government information system for evaluating an efficient and effective. The improvement of the index system and the assessment method gradually to make the assessment results more accurate and efficient is mentioned as a future research work.

Irfan Syamsuddin ET el have proposed the use of A New Fuzzy MCDM Framework [3] Because of constant threats and vital to the security of information and one government, policy makers require to assess the information on the security strategy to bring reliable and e-government services. This research produced information security evaluation framework depend on novel fuzzy multi criteria decision making (MCDM) to assist policy makers to perform comprehensive evaluation of e-government security strategy. This research tries to introduce a holistic method from managerial decision making viewpoint by merging all relevant features of security to generate a framework used to assess e-government security plan. Fuzzy set theory is used to supplement the framework to handle fuzziness in the form of inconsistencies and vagueness coming from subjective judgments by decision makers.

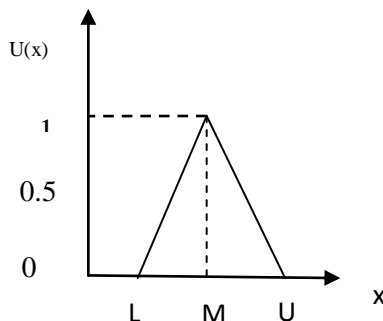


Fig3: Fuzzy triangular membership function

Assume A as triangular fuzzy number with a triplet (L, M, U). We can identify the membership value as follows

$$u_A(x) = \begin{cases} \frac{x - L}{M - L}, & L \leq x \leq M \\ 0, & \text{Otherwise} \end{cases}$$

Ouranian I. Markaki ET el have proposed the use of Fuzzy Analytic Hierarchy Process [13] this approach develops an evaluation framework that overcomes the problem of ambiguity by using triangular fuzzy numbers and also adopts Fuzzy Analytic Hierarchy Process. A fuzzy multiple attribute decision making approach, is used to evaluate the quality features of e-government websites. FAHP is implemented to offer a fuzzy weight for each features used in the selection procedure. Finally this approach may provide e-government administrators with an important reference for assessing the quality of e-Government implementation.

6. COMPARATIVE AND DISCUSSION

6.1 Comparative

This section demonstrates the results of comparison between five different approaches use Fuzzy techniques to evaluate e-government security. The criteria used in this evaluation are; effectiveness, efficiency, vagueness, accuracy, and inconsistency. In our comparative effectiveness refers to concern with high quality regardless of speed or is doing the job right. Efficiency means is a measure of speed and cost or is getting all you're testing done in the shortest time possible with the least amount of resources, vagueness indicates the things is not clearly, precisely, or definitely expressed or stated or not precisely determined or known; uncertain. Accuracy represents the state of being accurate; freedom from mistakes, this

Table 2.The comparison between the techniques

Criteria	effectiveness	efficiency	vagueness	Accuracy	inconsistency
Fuzzy AHP(2009-2010)	No	No	Yes	yes	No
Fuzzy AHP and Artificial Neural Network(2010)	Yes	Yes	Yes	No	Yes
Fuzzy numbers and statistics(2010)	No	Yes	Yes	No	Yes
A new fuzzy MCDM(2010)	No	No	Yes	No	Yes
Fuzzy Group Analytic Network Process(2011)	No	No	No	Yes	No

exemption arising from carefulness; exact conformity to truth, or to a rule or model; precision; exactness; nicety; correctness; as, the value of testimony depends on its accuracy.
, and finally inconsistency is the fact or state of being inconsistent or an inconsistent element or an instance of being inconsistent. As illustrated in Table 1, if the feature is supported by the technique then it denoted by “Yes”, else it donated by “No”.

In Fuzzy AHP (2009-2010), there is lack of efficiency, effectiveness and inconsistency. The technique has a good accuracy rate and vagueness. Fuzzy AHP and Artificial Neural Network (2010), there is lack of accuracy. The technique has a good efficiency, effectiveness, vagueness and inconsistency rate. Fuzzy numbers and statistics (2010), there is lack of effectiveness, accuracy and inconsistency. The technique has a good efficiency and vagueness.
The new fuzzy technique, MCDM (2010) has lack of efficiency, effectiveness and accuracy. The technique has a good vagueness and inconsistency. Fuzzy Group Analytic Network Process (2011), there is lack of efficiency, effectiveness, vagueness and inconsistency .The technique has a good accuracy rate. Next section presents the result and discussion of the comparative between the five approaches.

6.2 Analysis and Discussion

Refereeing to table 2, we discuss the use of fuzzy techniques in approaches to evaluate of e-government security. It is clearly observed that, most approach combined Fuzzy with other technique. As mentioned before Fuzzy assists to overcome the problem of uncertainty that obstacle the evaluation when experts describe their views in unclear information such as vocal language. Fuzzy AHP demonstrated vagueness, accuracy and inconsistency. However, the method fails in evaluating the effectiveness and efficiency of e-government. While, the technique uses Fuzzy AHP and Artificial Neural Network, verifies vagueness, inconsistency, effectiveness and efficiency, but it needs more concern in the evaluation of the accuracy. The Fuzzy numbers and statistics method verifies vagueness, inconsistency and efficiency but also fail to evaluate accuracy, effectiveness and inconsistency. The new fuzzy MCDM takes care of vagueness and inconsistency, although it requires more concern to evaluate effectiveness, efficiency and accuracy. The Fuzzy Group Analytic Network Process verifies accuracy but needs to deeply concern about the performance.

7. RELATED WORK

Fuzzy logic has been applied to many fields from different area, from control theory to artificial to a cross section of applications that have successfully used fuzzy control includes:

M. Monitto has proposed the use of [14] the decision on production system acquisition for the automotive industry is very critical, given the number of different aspects to be considered. Indeed different automated solutions are feasible and evaluation techniques that take into account all the critical issues are needed to make a selection. In this study a complete, precise and value driven Decision Support System is presented to support the selection of the best Automated Manufacturing System. The evaluation problem is solved using a Fuzzy Analytic Hierarchy Process (AHP) method able to manage uncertainty and to consider productivity and flexibility issues. Economic and financial performance and the effects on human resources due to the investment decision are also investigated. AMS to produce a new part in a complex and turbulent environment has been presented. Three alternative solutions have been considered (RTL, FMS, MFP).

Uncertainty of market demand and technological content of the considered part are modeled within the proposed method. In particular, uncertainty due to the unpredictable environment has been managed relationships among vague parameters related to the uncertain events and performance measures of the alternative solutions.

Furthermore, fuzzy evaluation of intangible criteria and an outcome interpretation based on EEM function have been proposed. The developed decision support system allows firm management to define the best AMS considering personal perception of intangible aspects, environment uncertainty and risk inclination. A future development will be devoted to the introduction of correlation among fuzzy variables, considering joined membership functions. In addition, other innovative production paradigms could be introduced within the alternative solutions.

Tien-Chin Wang et el have proposed the use of [15] this method develops an evaluation approach based on the Technique for Order Performance by Similarity to Ideal Solution (TOPSIS), to help the Air Force Academy in Taiwan choose optimal initial training aircraft in a fuzzy environment where the vagueness and subjectivity are handled with linguistic terms parameterized by triangular fuzzy numbers. This study applies the fuzzy multi-criteria decision making (MCDM) method to determine the importance weights of evaluation criteria and to synthesize the ratings of candidate aircraft. Aggregated the evaluators' attitude toward preference; then TOPSIS is employed to obtain a crisp

overall performance value for each alternative to make a final decision. This approach is demonstrated with a real case study involving 16 evaluation criteria, seven initial propeller-driven training aircraft assessed by 15 evaluators from the Taiwan Air Force Academy. Several alternatives must be considered and evaluated in terms of many different conflicting criteria in an optimal initial training aircraft selection problem, leading to a large set of subjective or ambiguous data. Current aircraft selection methods rely on panels of experts to provide the evaluation, disregarding human subjectivity and the requirements of

Drillmasters and trainees. Hence, an effective evaluation approach is essential to improve decision quality. This study, presenting a scientific framework to assess initial training aircraft, uses triangular fuzzy numbers to express linguistic variables that consider the subjective judgments of evaluators and then adopts fuzzy multiple criteria decision-making approach to synthesize the group decision. TOPSIS extended to a fuzzy environment is utilized to determine overall performance value and rank of the aircraft. The importance weight ranking of the evaluation criteria demonstrate that the Taiwanese pilots are very concerned about the technological performance criteria, such as power plant, stalling speed when flameout, maximum operating speed, maximum G limits and fuel capacity, of initial training aircraft. This information improves the understanding of government procurement agencies better understand about the critical performance criteria that should be considered when purchasing initial training aircraft. The ranking of the seven initial training aircraft addressed herein reveals that KT-1 is the best performing aircraft. Because of the extreme concerns about national security and international political isolation that may cause supply interruption, the Taiwanese government has been always defense-oriented seldom considering the economic sector (Chiang, 1997). Simultaneously, owing to the difficulty of collecting qualitative data of initial training aircraft, this study focused primarily on technical performance of airplanes as the basis for evaluation criteria, and neglected other characteristics such as procurement & maintenance cost, logistics capability, reliability, armament capability, avionics and safety. Future studies can consider these factors when evaluating initial training aircraft. And also we used fuzzy to represent subjective belief

Chin-Tsai ET al have proposed the use of [16] this study applies a fuzzy analytic hierarchy process (AHP) to evaluate service performance of foreign travel intermediary (destination tour operator, DTO) through the host travel agency's vision. Service performance is a composite of various attributes, including many intangible attributes difficult to measure. Therefore, the present research adopts an AHP method and further integrates a fuzzy set theory into the service performance measurement to overcome the problem. This work

Collected evaluation criteria from thirty-six senior travel managers'

Opinions, using the critical incident technique (CIT) and fifty-six general managers from different travel agencies to weight and rank the overall criteria by applying fuzzy AHP. Research results could help DTOs increase service performance and quality, and provide Asian travel agencies with objective standards in evaluating the most suitable business cooperators. This study makes two main empirical contributions to the

travel marketing and tourism distribution literature. The first explores DTOs' service quality evaluation criteria conducted by business customers of tourism distribution. The second uses the fuzzy AHP to measure DTO service performance. The evaluation procedures consist of the following steps: (1) identify the evaluation criteria for DTOs service performance; (2) assess the importance of each criterion by fuzzy AHP over all the respondents; (3) ranking of each criterion.

8. CONCLUSION

Fuzzy logic has been widely used in real world especially in automation and process control, fuzzy logic is best solution and much appropriate for work with indefinite information. In context of evaluation the security of e-government and according to the criteria used, it was obviously observed that, policy makers require assessing the information on the security strategy to produce reliable and e-government services. In this paper we have investigated and reviewed the application of Fuzzy algorithms in the field of e-government security. A comparison between five approaches based on Fuzzy has been described, a result, and discussion has been presented. We conclude that there is need for new evaluation methods to obtain the good performance particularly in the evaluation of effectiveness and efficiency. Although the current approaches that use Fuzzy offers the opportunity to better evaluate security of the e-government, but still there is an effort required to come up with technique that satisfy the above discussed features. Our future work is focus on developing hybrid approach to ensure the effectiveness as well as the efficiency of evaluation.

9. ACKNOWLEDGEMENT

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10. REFERENCES

- [1] ZHANG Bo-ping ET al "Research on E-Government System Network Security Based on Immune Agent "2010 IEEE
- [2] Wu Zhong et al" A Study on E-government System Security based on Fuzzy Analytic Hierarchy Process "2009 IEEE
- [3] Irfan Syamsuddin ET al "A New Fuzzy MCDM Framework to Evaluate E-Government Security Strategy "2010 IEEE
- [4] Evolutionary Computation, Third Edition. By David B. Fogel Copyright © 2006 the Institute of Electrical and Electronics Engineers, Inc.
- [5] Jun fei Et al "Public Satisfaction Evaluation of E-government with Fuzzy AHP "(2009)IEEE.
- [6] Wu Zhong et al" A Study on E-government System Security based on Fuzzy Analytic Hierarchy Process "2009 IEEE.
- [7] WU Zhong" Research on E-Government Security Model "2010 IEEE

- [8] Aiyue Xia "Research of E-government Security Risk Assessment Method Using Bayesian Network "2009 IEEE
- [9] Dang Luo et el "Evaluation on E-government Websites Based on Rough Set and Genetic Neural Network Algorithm"2010 Academy Publisher
- [10] Mehdi Fasanghari ET el "E-Government Performance Evaluation with Fuzzy Numbers "2009IEEE
- [11] Jun Fei ET el "Public Satisfaction Evaluation of E-government with Fuzzy AHP "2009IEEE
- [12] Guangfu Wei ET el "Research on E-government information security risk assessment "2010 IEEE
- [13] Ourania I. Markaki ET el" Application of Fuzzy Analytic Hierarchy Process to Evaluate the Quality of E-Government Web Sites"2010 IEEE
- [14] M. Monitto "A new Fuzzy AHP method for the Evaluation of Automated Manufacturing Systems2002".
- [15] Tien-Chin Wang et el "Application of TOPSIS in evaluating initial training aircraft under a fuzzy environment2006" .
- [16] Chin-Tsai ET el "Using Fuzzy AHP to Evaluate Service Performance of Travel Intermediary2009".