An Efficient Method for Choosing Most Suitable Cloud Storage Provider Based on Multi-Criteria Decision Making

Mostafa El-Baz [1], Ibrahim El-Henawy [2]
[1,2] *Department of Computer Science, faculty of Computers and Informatics, Zagazig University, El-ZeraSquare, Zagazig, Sharqiyah, Egypt, Postal code: 44519*

Abstract *Cloud Computing has already changed the way that people think about and use the information technology services. Cloud data storage is one of such services in which data is stored, managed, remotely backed up and accessed by users over the Internet. when the organization need to depend on cloud computing solution as intelligent solution ,the first problem facing the organization is to choosing the appropriate provider between different providers available especially in the cases of confused portfolios which contain complex pricing models and different criteria's. for addressing this problem the thesis providing a multi-criteria algorithm which based on neutrosophic to help the organization to choose the best appropriate providers achieving high degree of security and privacy according their requirements map .*

Keywords— *Neutrosophic, cloud computing, cloud provider , multicreteria* **.**

I. Introduction

Cloud Computing has already changed the way that people think about and use the information technology services. Cloud data storage is one of such services in which data is stored, managed, remotely backed up and accessed by users over the Internet. whenzthe organization need to depend on cloud computing solution as intelligent solution ,the first problem faces the organization is to choosing the appropriate provider between different available providers, especially in the cases of confused portfolios, which contain a complex pricing models and different criteria's[1]. for addressing this problem , this paper provides an improved multi-criteria decision making method , which based on neutrosophic to help the organization to choose the best appropriate providers achieving high degree of security and privacy according their requirements map .

II. Neutrosophic Theory

In 1995, Smarandache starting from philosophy (fretted to distinguish between absolute truth and relative truth or between absolute falsehood and relative falsehood in logics, and respectively between absolute membership and relative membership or absolute non-membership and relative non-membership in set theory) began to use the non-standard analysis. Also, inspired from the sport games (winning, defeating, or tie scores), from votes (pro, contra, null/black votes), from positive/negative/zero numbers, from yes/no/NA, from decision making and control theory (making a decision, not making, or hesitating), from accepted/rejected/pending, etc. and guided by the fact that the law of excluded middle did not work any longer in the modern logics, Smarandache combined the non-standard analysis with a tri-component logic/set/probability theory and with philosophy[2,3].

III. Cloud Computing

Cloud computing can be defined as a new model for the dynamic provisioning of computing services without need to install them physically in the organization [4]. Cloud computing also enables their clients to use software and other resources remotely on demand services .Nowadays, cloud computing is one of the most intelligent solutions for organizations and clients.

Cloud computing provides five type of service model[5 ,6] ;The first service model is software as a service (SaaS) which enabling the organization to use the software online without needing to install it physically in the organization machines [7:11] ,This ability helps the organizations to reduce the cost of hiring software ,in addition to these the ability of improving the property of sharing knowledge ,maintenance ,support ,security and backup .The second service model is called platform as a service(PaaS) which enables the organization to run and test their work online without needing to install the platform or environment in the organization [11:13] , The third model is called infrastructure as the service(IaaS) which enable the organization to use the available resource as storage space or networking resources on line .the fourth service model is identity as a service (IDaaS) identity as a service offer management of user digital data and also helps in the process of authentication .The last model is a network as a service (NaaS) which helps the clients to access secured and protected network easily and on demand[11,12,13].

Choosing appropriate provider is one of the most important tasks for cloud computing customers.

Choosing appropriate cloud computing providers leads to great benefits for the customers such as improving security and performance and etc .Cloud computing customers depends on many factors in the process of evaluation providers such as accountability, Agiliabilty, Assurance, management, performance ,security and etc [14,15] .Because Security is one of most important factor for any customers or organization , so the organizations must depends on appropriate secured provider to secure their data ,improving their privacy ,and other security issues .In this chapter we uses improved neutrosophic multi criteria decision making method algorithm to choose appropriate cloud computing provider based on top ten risks as it was stated in (OWASP).

IV. METHODOLOGY

In this paper, we introduce an improved neutrosophic decision making algorithm for choosing the appropriate provider according the organization needs. The algorithm is used to rank the cloud computing providers according the requirements of the customers. The improved neutrosophic decision making method allows the degree of satisfaction, non un-satisfaction and indeterminacy of each alternative with respect to a set of criteria to be represented by neutrosophic sets, respectively. It allows the decision maker to assign and adjust the degree of satisfaction, un-satisfaction, and indeterminacy of the criteria to a vague concept .importance of criteria

Algorithm 1. An improved neutrosophic multi criteria decision making method

Input number of available Provider P
Input number of features F
Build the evaluation matrix
For i from 1 to p
For j from 1 to F
Build the scoring matrix
Build accuracy matrix
Calculate the weighted matrix
End For
End For
For I from 1 to F
Build weighted matrix for features
End For
Calculate the coefficients based on weighted matrix of features
Use coefficient, to create equation
Compute the weight for each provider by solving the equation using linear programming
Ranking provider according their weight

After conducting an evaluation for the experts, the algorithm builds an evaluation matrix contains the result of the evaluation ,then build the evaluation matrix using Equation 1.the result of this equation present two values ,the first values shows the degree about how the result of evaluation satisfies the requirements of organization , the second value measures the degree of dissatisfaction.

$$\text{Min}((T+I)/2, (1-F+I)/2), \text{Max}((T+I)/2, ((1-F+I)/2)) \quad (1)$$

The algorithm uses the evaluation matrix to calculate scoring, accuracy, and weighted matrix respect with equation 2, 3 and 4. The algorithm uses equation 2 for scoring each alternative, uses equation 3 to evaluate the degree of the accuracy of the neutrosophic, and uses equation 4 to build the weighted matrix. The next step it to compute the coefficient by summing the weight of each feature from weighted table then build the linear programming equation. The result of the linear programming equation can be use as a weight of each feature. The final step is to multiply the weighted matrix by the weight of each feature and sort the result.

$$2(\text{Max}((T+I)/2,((1-F+I)/2))-\text{Min}((T+I)/2,((1-F+I)/2))) \quad (2)$$

$$(((T+I)/2+((1-F+I)/2))/2 \quad (3)$$

$$\textit{Weighted matrix} = \textit{Square (Scoring matrix)} - [(1-\textit{accuracy matrix})/2)] \quad (4)$$

Case Study

In this case study, the organization tries to compare between the most used provider as stated in (IEEE COMSEC) in 2017 Table 1.in this case study ,we depends on improved neutrosophic multi criteria decision making method to get the most secured provider according **(OWASP)** . In this case study, we start with conducting a survey to get the opinions of some IT employees who are aware by cloud computing security features. Each employee in survey can accept or refuse or doesn't judge if he doesn't have enough knowledge about feature in each provider. The result of the survey as the table 2. The first number refers to the degree of employees who accept the feature, the medium number refers to the amount of employees who doesn't judge, and the last number is the degree of refuse. The second step is to feed the model with survey result .

Provider identity	Provider name	Abbreviation
1	Amazon	P1
2	Microsoft Azure	P2
3	Google cloud platform	P3
4	IBM cloud	P4
5	Vmware Vcloud	P5
6	Rackspace	P6
7	Century link	P7
8	Veriation cloud	P8

Table 1. Most used provider as stated in (IEEE COMSEC)

Provider	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10
p1	(.8,0.1,0.1)	(.3,.2,.5)	(.3,.2,.5)	(.2,.2,.6)	(.5,.1,.4)	(.1,.1,.8)	(.1,.1,.8)	(.3,.2,.5)	(.5,.1,.4)	(.5,.1,.4)
p2	(.4,0.2,0.4)	(.3,.2,.5)	(.2,.1,.7)	(.3,.2,.5)	(.5,.1,.4)	(.3,.2,.5)	(.2,.3,.5)	(.5,.1,.4)	(.3,.2,.5)	(.5,.1,.4)
p3	(.2,.2,6)	(.3,.2,.5)	(.3,.2,.5)	(.2,.1,.7)	(.5,.1,.4)	(.2,.2,.6)	(.1,.1,.8)	(.2,.2,.6)	(.3,.4,.3)	(.3,.2,.5)
p4	(.3,.2,.5)	(.2,.1,.7)	(.2,.1,.7)	(.3,.2,.5)	(.2,.2,.6)	(.5,.1,.4)	(.2,.3,.5)	(.2,.2,.6)	(.2,.2,.6)	(.3,.2,.5)
p5	(.7,0,.3)	(.3,.2,.5)	(.2,.1,.7)	(.2,.2,.6)	(.2,.2,.6)	(.3,.2,.5)	(.2,.1,.7)	(.2,.1,.7)	(.3,.3,.4)	(.3,.2,.5)
p6	(.6,.2,.2)	(.3,.2,.5)	(.3,.2,.5)	(.3,.2,.5)	(.2,.2,.6)	(.1,.1,.8)	(.5,.1,.4)	(.2,.1,.7)	(.5,.1,.4)	(.2,.1,.7)
p7	(.2,.1,.7)	(.2,.1,.7)	(.5,.1,.4)	(.5,.1,.4)	(.2,.1,.7)	(.2,.3,.5)	(.5,.1,.4)	(.2,.1,.7)	(.2,.1,.7)	(.3,.3,.4)
P8	(.3,.4,.4)	(.2,.1,.7)	(.5,.1,.4)	(.3,.2,.5)	(.2,.1,.7)	(.5,.1,.4)	(.5,.1,.4)	(.2,.1,.7)	(.1,.8,.1)	(.2,.1,.7)

Table 2 Survey Result table

According Table 2 and equation 2 the scoring matrix is

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10
P1	0.1	0.2	0.2	0.2	0.1	0.1	0.1	0.2	0.1	0.1
P2	0.2	0.2	0.1	0.2	0.1	0.2	0.3	0.1	0.2	0.1
P3	0.2	0.2	0.2	0.1	0.1	0.2	0.1	0.2	0.4	0.2
P4	0.2	0.1	0.1	0.2	0.2	0.1	0.3	0.2	0.2	0.2
P5	0	0.2	0.1	0.2	0.2	0.2	0.1	0.1	0.3	0.2
P6	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1
P7	0.1	0.1	0.1	0.1	0.1	0.3	0.1	0.1	0.1	0.3
P8	0.3	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.8	0.1

According equation 3 the Accuracy matrix is

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10
P1	0.475	0.3	0.3	0.25	0.325	0.125	0.125	0.3	0.325	0.325
P2	0.35	0.3	0.175	0.175	0.325	0.3	0.325	0.325	0.3	0.325
P3	0.25	0.3	0.3	0.3	0.325	0.25	0.125	0.25	0.45	0.3
P4	0.3	0.175	0.175	0.175	0.25	0.325	0.325	0.25	0.25	0.3
P5	0.35	0.3	0.175	0.175	0.25	0.3	0.175	0.175	0.375	0.3
P6	0.45	0.3	0.3	0.3	0.25	0.125	0.325	0.175	0.325	0.175
P7	0.175	0.175	0.325	0.325	0.175	0.325	0.325	0.175	0.175	0.375
P8	0.425	0.175	0.325	0.325	0.175	0.325	0.325	0.175	0.65	0.175

According equation 4 the weighted matrix

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10
P1	-0.2525	-0.31	-0.31	-0.335	-0.3275	-0.4275	-0.4275	-0.31	-0.3275	-0.3275
P2	-0.285	-0.31	-0.4025	-0.31	-0.3275	-0.31	-0.2475	-0.3275	-0.31	-0.3275
P3	-0.335	-0.31	-0.31	-0.4025	-0.3275	-0.335	-0.4275	-0.335	-0.115	-0.31
P4	-0.31	-0.4025	-0.4025	-0.31	-0.335	-0.3275	-0.2475	-0.335	-0.335	-0.31
P5	-0.325	-0.31	-0.4025	-0.335	-0.335	-0.31	-0.4025	-0.4025	-0.2225	-0.31
P6	-0.235	-0.31	-0.31	-0.31	-0.335	-0.4275	-0.3275	-0.4025	-0.3275	-0.4025
P7	-0.4025	-0.4025	-0.3275	-0.3275	-0.4025	-0.2475	-0.3275	-0.4025	-0.4025	-0.2225
P8	-0.1975	-0.49	-0.49	-0.46	-0.49	-0.49	-0.49	-0.49	0.14	-0.49

By summing each Colum in weighted matrix, the coefficients are

-2.3425,-2.845,-2.955,-2.79,-2.88,-2.875,-2.8975,-3.005,-1.9,-2.7

We can create linear programming equation using these coefficients,

Maximize P=-2.3425X1-2.845X2-2.955X3-2.79X4-2.88X5-2.875X6-2.8975X7-3.005X8-1.9X9-2.7X10 ,now we must calculate the score matrix of the features depends on the next table which is the result of survey.

Feature	F1
F1	(.1,.3,.5)
F2	(.4,.2,.4)
F3	(.2,.2,6)
F4	(.3,.2,.5)
F5	(.4,.1,.5)
F6	(.5,.3,.2)
F7	(.2,.1,.7)
F8	(.3,.4,.4)
F9	(.2,.1,.7)
F10	(.3,.4,.4)

Table 2 importance of features to each other

From table 2, we can use equation 1to calculate the intervals of each feature to create the constraints of the linear programming equation .

.2<=X1<=.4, .3<=X2<=.4, .2<=X3<=.3, .25<=X4<=.35, .25<=X5<=.3, .15<=X6<=.2, 15<=X7<=.2, .35<=X8<=.5, .15<=X9<=.2, .35<=X10<=.5, now we can build the equation as

Maximize P=-2.3425X1-2.845X2-2.955X3-2.79X4-2.88X5-2.875X6-2.8975X7-3.005X8-1.9X9-2.7X10

Subject to .2<=X1<=.4, .3<=X2<=.4, .2<=X3<=.3, .25<=X4<=.35, .25<=X5<=.3, .15<=X6<=.2, 15<=X7<=.2,.35<=X8<=.5, .15<=X9<=.2, .35<=X10<=.5.

Using simplex method ,we can get
X1=0.2,X2=0.3,X3=0.2,X4=0.25,X5=0.25,X6=0.15,X7=0.15,X8=0.35,X9=0.15,X10=0.35
The final step is to calculate the final weight, by multiplying the weight of each feature by the weighted matrix.

The next table shows the final result.

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	Final weight
P1	-0.0505	-0.093	-0.062	-0.08375	-0.08188	-0.06413	-0.06413	-0.1085	-0.04913	-0.11463	-0.77163
P2	-0.057	-0.093	-0.0805	-0.0775	-0.08188	-0.0465	-0.03713	-0.11463	-0.0465	-0.11463	-0.74925
P3	-0.067	-0.093	-0.062	-0.10063	-0.08188	-0.05025	-0.06413	-0.11725	-0.01725	-0.1085	-0.76188
P4	-0.062	-0.12075	-0.0805	-0.0775	-0.08375	-0.04913	-0.03713	-0.11725	-0.05025	-0.1085	-0.78675
P5	-0.065	-0.093	-0.0805	-0.08375	-0.08375	-0.0465	-0.06038	-0.14088	-0.03338	-0.1085	-0.79563
P6	-0.047	-0.093	-0.062	-0.0775	-0.08375	-0.06413	-0.04913	-0.14088	-0.04913	-0.14088	-0.80738
P7	-0.0805	-0.12075	-0.0655	-0.08188	-0.10063	-0.03713	-0.04913	-0.14088	-0.06038	-0.07788	-0.81463
P8	-0.0395	-0.147	-0.098	-0.115	-0.1225	-0.0735	-0.0735	-0.1715	0.021	-0.1715	-0.991

Table 3 Final result

Now, we can sort the provider according the final weight.

Provider2, Provider 3, Provider 1, provider 4, provider 5, provider 6, provider7,

V. CONCLUSIONS

The improved neutrosophic multi criteria decision making method is a simple and easily model to choose the provider according the organization's requirements .the model is simple and easy to implement by any programming language and doesn't need hard programming skills to implement .The model is also open the door for cloud researcher to use the neutrosophic in many areas in cloud computing

REFERENCES

[1] Parnia Samimi and Ahmed Patel, Review of Pricing Models for Grid & Cloud Computing, IEEE Symposium on Computers & Informatics

[2]Florentin Smarandache,Neutrosophy, A New Branch of Philosophy, Multiple Valued Logic An International Journal, USA, ISSN 1023-6627, Vol. 8, No. 3, pp. 297-384, 2002.

[3] A. A. Salama, S. A. Alblowi, Generalized Neutrosophic Set and Generalized Neutrosophic Topological Spaces, Computer Science and Engineering

[4] Ahmed Shawish and Maria Salama, Cloud Computing: Paradigms and Technologies , Inter-cooperative Collective Intelligence: Techniques and Applications

[5] Imran Ashraf, An Overview of Service Models of Cloud Computing, International Journal of Multidisciplinary and Current Research, ISSN: 2321-3124

[6] Ch Chakradhara Rao , Mogasala Leelarani , Y Ramesh Kumar, Cloud: Computing Services And Deployment Models, International Journal Of Engineering And Computer Science ISSN:23197242 Volume 2 Issue 12, Dec.2013 Page No. 3389-3392

[7] Santosh Kumar and R. H. Goudar, Cloud Computing – Research Issues, Challenges, Architecture, Platforms and Applications: A Survey, International Journal of Future Computer and Communication, Vol. 1, No. 4, December 2012

[8] Ahmed Shawish and Maria Salama, Cloud Computing: Paradigms and Technologies , Inter-cooperative Collective Intelligence: Techniques and Applications

[9] Imran Ashraf, An Overview of Service Models of Cloud Computing, International Journal of Multidisciplinary and Current Research, ISSN: 2321-3124

[10] Ch Chakradhara Rao , Mogasala Leelarani , Y Ramesh Kumar, Cloud: Computing Services And Deployment Models, International Journal Of Engineering And Computer Science ISSN:2319-7242 Volume 2 Issue 12, Dec.2013 Page No. 3389-3392

[11] K.Kavitha, Study on Cloud Computing Model and its Benefits, Challenges, International Journal of Innovative Research in Computer and Communication Engineering, Vol. 2, Issue 1, January 2014

[12] Dimiter Velev, Member, IACSIT, and Plamena Zlateva, A Feasibility Analysis of Emergency Management with Cloud Computing Integration, International Journal of Innovation, Management and Technology, Vol. 3, No. 2, April 2012

[13] Solanke Vikas , Kulkarni Gurudatt , Maske Vishnu , Kumbharkar Prashant , Private Vs Public Cloud, Solanke Vikas et al, International Journal of Computer Science & Communication Networks,Vol 3(2), 79-83

[14]pedro costa ,joao correia, Evaluation Criteria for Cloud Services, Cloud Computing (CLOUD), 2013 IEEE Sixth International Conference on

[15] Pedro Miguel Almeida Carvalho Costa, Evaluating Cloud Services using Multicriteria Decision Analysis