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Mobile Ad Hoc Networks Performance Analysis Based On The Fuzzy Network Method

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Abstract: With the constant development of ad hoc networks, the problem of mobile ad hoc networks hasbecamegradually serious, people are beginning to study mobile ad hoc networks performance analysis, it is very important of correctly understanding and analyzing mobile ad hoc networks. Therefore, it is an important topic of study. In this paper, we seek to use the Fuzzy analytical network process (FANP) for analysis of the mobile ad hoc networks performance and selecting the best strategies for improving it.The method is validated using the structural validation approach.

Key words: Mobile, Ad Hoc Networks, Fuzzy Analytical Network Process (FANP), Management.

INTRODUCTION

The problems of mobile ad hoc networks performance are recently faced as one of the main problem in the mobile networks.Under the condition of technology growth, how to use ad hoc networks efficiently is particularly important. An ad hoc network consists of a collection of radio units with a wireless interface forming temporary connections. No fixed infrastructure is involved in the communication. Instead, two radio units establish a communication link, if the signal to noise ratio is high enough. Two radio nodes far away from each other may communicate, if the nodes between them are participating in the ad hoc network, and are willing to forward packets for them (called the multi-hop functionality) (K.-W. Chin, 2002). This type of network is often referred to as multi-hop radio networks in military command and control systems, for which it is often not feasible to install any permanent communication infrastructure. In recent years, there is a growing interest in other applications of ad hoc networks, such as peer-to-peer computer communications, and communications between mobile sensors and transferring multi-media packets and use Real-time applications in these networks (J. Crowcroft, 2005; P. De, 2005; D.S.J. De Couto, 2002).

It needs to study and to analyze these problems; we should be able to answer some basic questions: What mobile ad hoc networks performance type should be used? And also provides conditions for output quality and also provides conditions for improvement network quality. What factors affected on the conditions of improvement of mobile ad hoc networks performance, and how they can identify and provide the appropriate response to them? It needs to select the best strategy based on the suitable method. There are various decision-making techniques. However, algorithm presented in this paper is based on the FANP; because of it can measure a relationship between the strategic factors that can make good such as AHP, ANP methods based on the independence factors. The AHP technique cannot measure to exist dependence between the factors, because the AHP compared to factors completely independent, and finally this method cannot effectively be an appropriate method considers assessing the effect of internal and environmental factors (K.-W. Chin, 2002; P. De, 2005; D.S.J. DeCouto, 2003).

The study is set seven major sections; the second part presents related works. The third part presents research methodology. The forth part describes the proposed algorithm based on the FANP method. The fifth part is expressed case study, and in the next sections, it will be discussed analysis and presentation of research findings and suggestions for future research results.

2. Related Works:

Our research work is guided and convoyed by many other works in the past, which have given us a strong background and motivation for modeling the proposed scheme. Before we commence with the design and implementation descriptions of our solution, we offer a brief review of the prominent works that exist within the scope of our problem.

In an ad-hoc network, since all stations share a single channel by multiple access protocol, unconstrained transmission may lead to the time overlap of two or more packet receptions, called collision, resulting in damaged useless packets at the destination. Collided packets increase the system delay and decrease the throughputof flows because they must be retransmitted. Therefore, the ad hoc network performance analysis must be scheduled to avoid any collision, that is, collision-free transmission should be guaranteed (Crowcroft, 2005; DeCouto, 2003; Farago, 2001). The problem of link ad hoc networks has been tackled for a long time (Draves, 2004; Flynn, 2001; Ganesan, 2002). These works address the problem in an isolated fashion (Flynn, 2001) or jointly with routing and topology/power control (DeCouto, 2003; Girod, 2004).

MANET is aggregated by a group of mobile nodes attached with wireless signaling devices. Mobile nodes exchange information by relaying packets from their sources to destinations. MANET can be used in many scenarios, such as in military, disaster recovery and home networking applications. MANET uses broadcasting (flooding) because it is simple

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and immediate. However, flooding introduces the broadcasting storm problem (Draves, 2004 Garcia-Luna-Aceves, 2001; Girod, 2004). Because the flooding broadcast requires each receiver node to relay and forward a broadcast message to all of its one-hop neighbors, the number of broadcast packets grows exponentially.

Mobile ad-hoc networks (MANETs) enable mobile users to communicate without the use of a fixed infrastructure. These networks can be used, e.g., to extend the range of access points, to allow communication in disaster areas or to realize intervehicle communications. There are a lot of technical challenges in designing MANETs, and for a lot of those challenges, solutions have been presented (Gomez, 2003).

Phanse *et al.,* (2005) review Design and demonstration of policy-based managementin a multi-hop ad hoc network. In this paper, they propose a policy-based framework for the management of wireless ad hoc networks and briefly describe a characteristics-based taxonomy that provides a platform to analyze and compare different architectural choices. They develop a solution suite that helps achieve our goal of a self-organizing, robust and efficient management system. One of the main contributions of this work is the prototype implementation and testing of the mechanisms and protocols comprising our framework in a multi-hop ad hoc network environment. Experiments are conducted using both an emulated ad hoc network test-bed and a true wireless test-bed. Degradation in management system performanceis observed as the number of hops between a policy server and client increases. Their proposed k-hop clustering algorithm alleviates this problem by limiting the number of hops between a server and client. They demonstrate the operation of their prototype implementation, illustrating QoS management in a multi-domain ad hoc network environment using the proposed cluster management, redirection, and policy negotiation mechanisms. Wang *et al.,* (2009) present A game-theoretic approach in Throughput-oriented MAC for mobile ad hoc networks (Girod, 2004; Gomez, 2003).

Appani *et al.,* (2007) present an adaptive transmission-scheduling protocol for mobile ad hoc networks (Gray *et al.,* 2004; Hartenstein, 2003; Yeo *et al.,* 2002) present An efficient broadcast scheduling algorithm for TDMA ad-hoc networks. In this paper, they propose an efficient algorithm to end a collision-free time slot schedule in a time division multiple access frames. In order to minimize the system delay, the optimal schedule must be defned as the one that has the minimum frame length and provides the maximum slot utilization. The proposed algorithm is based on the sequential vertex-coloring algorithm. Numerical examples and comparisons with the algorithm in previous research have shown that the proposed algorithm can end near-optimal solutions in respect of the system delay (Heissenbu¨ ttel, 2005; Herms, 2005; Y.-C. Hu, 2002).

3. Research Methodology:

Research methodology of this paper has been based on the analytical and descriptive research using FANP Method. This analytical and descriptive type research has been carried out using the questionnaire as the research tool for gathering the required data. Data's gathering involved both reference material and a questionnaire survey. Sampling was simple random sampling and the data-gathering instrument was the questionnaire. The author had already undertaken research in this field, which had stimulated the decision-making techniques used to analyzethis case study, based on FANP Method.

In November 2008 a request for interviews and questionnaires was sent to a number of the managers (80 persons, 30% Male and 70% Female, 70% over 10 year’s experience) and the staff (50 persons, 35% Male and 65% Female, 65% over 20 year’s experience) in the ad hoc network Company. Prior to the interview and fill the questionnaire, the author explained the purpose of the research and made it clear that this information would be in the public domain, so any confidentiality concerns could be noted. The interview and questionnaire, from December 2009 to April 2010, lasted ten hours per week. The interview and questionnaire were semi-structured in nature, starting with general questions on the mobile ad hoc networks performance management to put the respondent at ease. To ensure internal validity the interview and questionnaire were transcribed and sent to the experts for check that no commercially sensitive information had been included.

4- Fuzzy Analytical Network Process:

The FANP is a generalization of the Like AHP, while the AHP represents a framework with a unidirectional hierarchical AHP relationship, the FANP allows for complex interrelationships among decision levels and attributes. The FANP feedback approach replaces hierarchies with networks in which the relationships between levels are not easily represented as higher or lower, dominant or subordinate, direct or indirect (DeCouto, 2003; Flynn, 2001; Garcia-Luna-Aceves, 2001) Figure 1 presents Structural difference between hierarchy (a) and network (b).

FANP is considered comprehensive and explanatory for multipurpose decision-making discussions and also for solving complex decision-making issues. Studies by Yüksel and Dagˇdeviren used ANP to select information system projects that are internally dependent. These studies saw no requirement for doing an ideal zero and one programming. Karsak,Partovi and Corredoira have used ANP in quality activity development (Girod, 2004; Gomez, 2003). A system with reflective state can be explained by a network. The structural difference between the hierarchy and the network is depicted in Figure 1. The existent element in each cluster can affect all or some of the other cluster elements. A network may contain main clusters, middle clusters, and final clusters. Arrows show the relationships in the network and their direction shows the dependence. The dependence among clusters can be named external dependence and the internal dependence among elements of a cluster can be called circle dependence (Girod, 2004; Gomez, 2003; Hartenstein, 2003). The network model used in this research is presented in Figure 2.

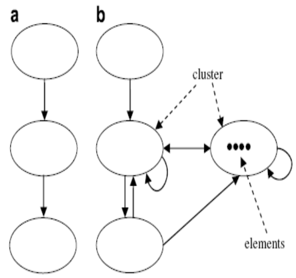

Fig. 1: Structural difference between hierarchy (a) and network (b).

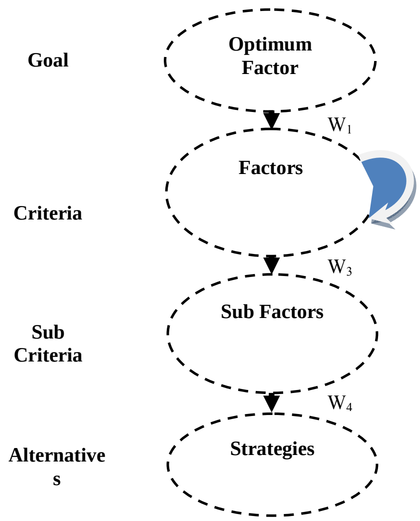

Fig. 2: Network model structure.

The proposed algorithm is derived as follows.

Step 1: Determine the element sub-factors and strategic options according to sub-factors.

Step 2: Establish the triangular fuzzy numbers.

Step 3: Assume that no dependencies among element factors exist, and then the importance degree of element factors is shown by the fuzzy scale.

Step 4: Determine the element factors of the internally dependent matrix by the fuzzy scale, and consider other factors by schematic view and internal dependencies among them (W2 calculation).

Step 5: Specify the internal dependencies' priorities, that is, calculate $w_{factors} = W_2 \times w_1$.

Step 6: Specify the importance degree of element sub-factors using the fuzzy scale.

Step 7: Specify the importance degree of sub-factors.

Step 8: Specify the importance degree of strategic options, considering each sub-factor, on the fuzzy scale.

Step 9: Calculate the final priority of strategic options derived from the internal relationships among element factors and defuzzification its. $w_{alternatives} = W_4 \times w_{sub-factors\ (global)}$

5. Case Study:

This section presents an illustration of the proposed approach summarized in the previous section.The proposed algorithm is as follows:

Step 1: First, the issue is depicted as a hierarchical structure, which contains the strategic options and sub-factors for the next calculations using FANP. (See Figure 3) The goal is chosen at the first level of the FANP Model and the element factors are determined at the second level. The third level contains the sub-factors. Furthermore, 3 strategic options are given in the fourth level. The strategic options are as follows:

A-B:improvement mobile ad hoc network performance

A-C: Investment on the mobile ad hoc networks

B-C: cost recovery

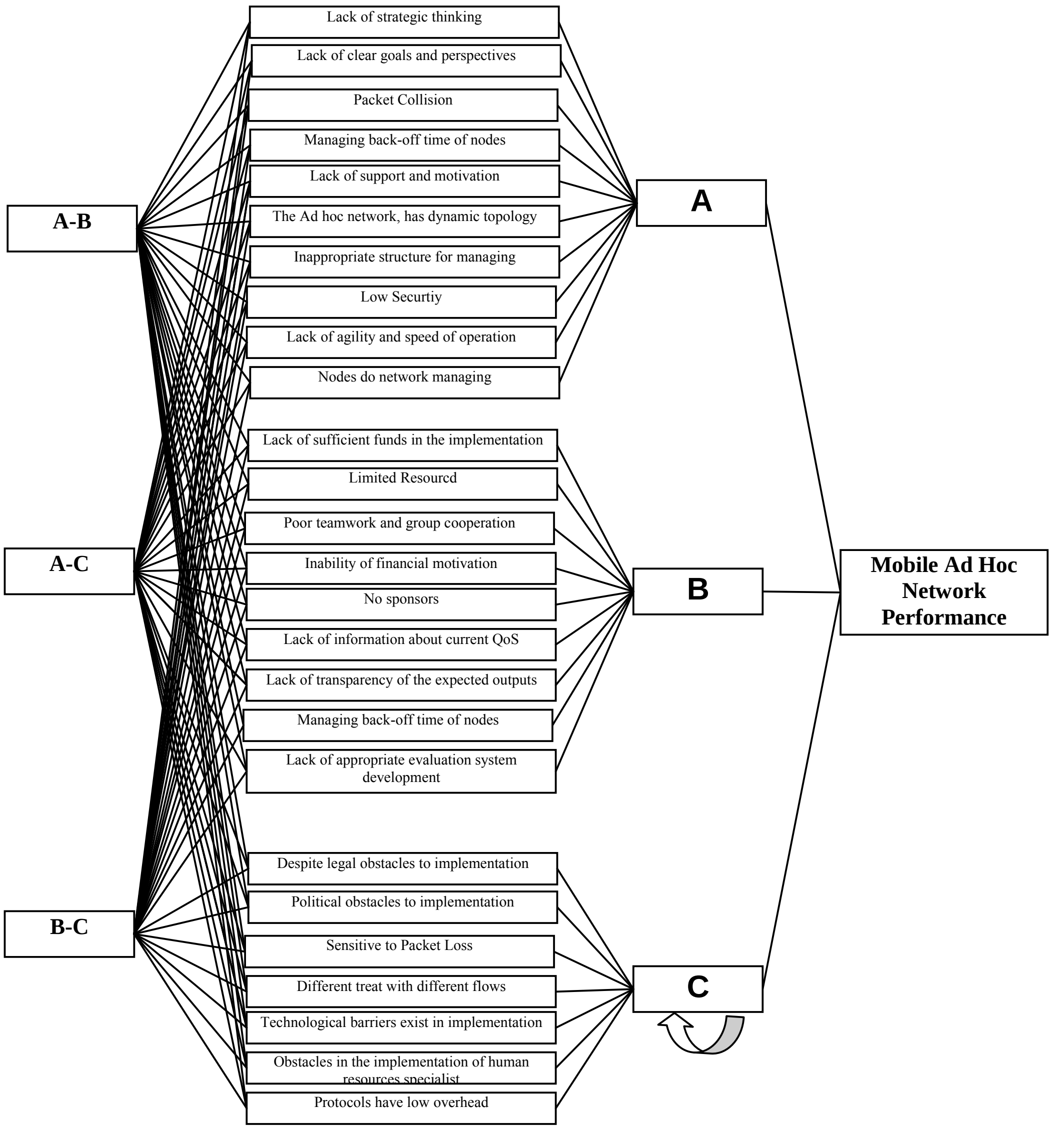

Fig. 3: strategies influencing on the mobile ad hoc networks performance .

Step 2: Establish the Triangular Fuzzy Numbers. A triangular fuzzy number (TFN) is shown in Figure 4.

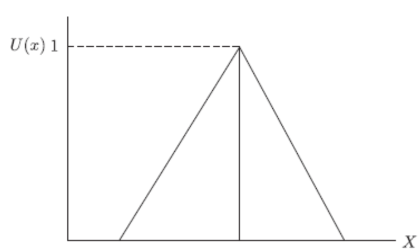

Fig. 4: Triangular Fuzzy Numbers.

Since each number in the pair-wise comparison matrix represents the subjective opinion of decision makers and is an ambiguous concept, fuzzy numbers work best to consolidate fragmented expert opinions. A TFN is denoted simply as (L, M, U). The parameters L, M and U, respectively, denote the smallest possible value, the most promising value and the largest possible value that describe a fuzzy event as shows in formulae (1) to (5). The triangular fuzzy numbers u_{ij} are established as follows:

$u_{ij} = (L_{ij}, M_{ij}, U_{ij})$, (1)
$L_{ij} \leq M_{ij} \leq U_{ij}$ and L_{ij}, M_{ij}, U_{ij} ε[1/9, 9], (2)
$L_{ij} = \min (B_{ijk})$, (3)
$M_{ij} = n\sqrt{\prod B_{ijk}}$, (4)
And
$U_{ij} = \max (B_{ijk})$, (5)

Where B_{ijk} represents a judgment of expert k for the relative importance of two criteria C_i-C_j.

Step 3: Assume that there is no dependency among the element factors. Determine the factors' pair comparison matrix using the numerical scale of 1 to 9. (See results in Table 2) All the pair comparisons are completed by a team of experts. The pair comparison matrix (Table 2) is analysed using Expert Choice software and the following special vector is obtained. In addition, a final inconsistency coefficient is shown at the end of the table.

$$W_1 = \begin{bmatrix} A \\ B \\ C \end{bmatrix} = \begin{bmatrix} .528 \\ .140 \\ .332 \end{bmatrix}$$

Table 1: Pair wise comparisons (independent status).

Weight	C	B	A	Factors
0.528	2	3	1	A
0.140	1/3	1		B
0.332	1			C

CR=0.03

Step 4: The internal dependency among element factors is determined by comparing the effect of each factor on other factors. As mentioned in the preface, considering independence among the element factors is not always possible. Suitable and realistic results are obtained from the FANP technique and element analysis. An analysis of internal and external environment elements reveals the element factors' dependencies as shown in Figure 4. The results obtained from the special vectors are depicted in the last column of Tables 1 to 5. The internal dependency of the element matrix, based on the calculated relative importance weights, is shown by W2. While opportunities are only influenced by strengths, a pair comparison matrix cannot be formulated for the opportunities. Internal dependency of factors is defined in Figure 5.

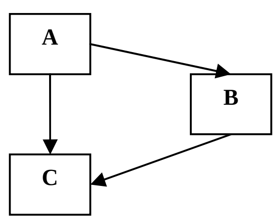

Fig. 5: Internal dependency of factors.

Internal dependency matrix of factor A is defined in Table 2.

Table 2: Internal dependency matrix of factor A

WEIGHT	C	B	A
0.667	2	1	B
0.333	1		C

CR=0.00

Internal dependency matrix of factor B is defined in Table 3.

Table 3: Internal dependency matrix of factor B.

WEIGHT	C	A	B
0.9	9	1	A
0.1	1		C

CR=0.00

Internal dependency matrix of factor B is defined in Table 4.

Table 4: Internal dependency matrix of factor C.

Weight	B	A	C
0.857	6	1	A
0.143	1		B

CR=0.00

$$W_2 = \begin{bmatrix} 1 & .9.857 \\ .667\ 1\ .143 \\ .133\ .11 \end{bmatrix}$$

Step 5: Priorities for internal dependencies among the factors are calculated as follows:

The significant differences observed in the above results when compared with those in Table 1 are due to the lack of information about internal dependencies. Factor priority results including A, B, C have changed from 0.528 to 0.495, from 0.332 to 0.221, from 0.140 to 0.284

Step 6: Local priorities of sub-factors are calculated using the pair comparisons matrix. The priority vector is defined. According the priorities, it defines vector of sub factors.

$$W_{sub-fdactors-A} = \begin{bmatrix} 0.218 \\ 0.192 \\ 0.151 \\ 0.133 \\ 0.108 \\ 0.095 \\ 0.062 \\ 0.031 \\ 0.008 \\ 0.002 \end{bmatrix} \quad W_{sub-fdactors-B} = \begin{bmatrix} 0.297 \\ 0.196 \\ 0.148 \\ 0.137 \\ 0.117 \\ 0.082 \\ 0.023 \end{bmatrix} \quad W_{sub-fdactors-C} = \begin{bmatrix} 0.207 \\ 0.175 \\ 0.135 \\ 0.126 \\ 0.108 \\ 0.096 \\ 0.076 \\ 0.044 \\ 0.033 \end{bmatrix}$$

Step 7: General priorities of the element sub-factors are calculated by multiplying the internal dependency priorities, obtained in Step 4, by the local priorities of element sub-factors, obtained in Step 5. The results are depicted.

Vector $w_{\text{sub-factors (global)}}$ which is obtained from the general priority amounts in the last column of table.

$$W_{sub-fdactors-GLOBAL} = \begin{bmatrix} 0.107 \\ 0.095 \\ 0.075 \\ 0.066 \\ 0.053 \\ 0.047 \\ 0.031 \\ 0.016 \\ 0.004 \\ 0.001 \\ 0.084 \\ 0.055 \\ 0.042 \\ 0.038 \\ 0.034 \\ 0.024 \\ 0.007 \\ 0.046 \\ 0.039 \\ 0.030 \\ 0.028 \\ 0.024 \\ 0.021 \\ 0.017 \\ 0.010 \\ 0.007 \end{bmatrix}$$

Step 8: The degree of strategic options' importance is calculated from each element's sub-factor viewpoints. Special vectors are calculated from the analysis of this matrix and matrix W4.

$$W_4 = \begin{bmatrix} 0.653 & 0.578 & 0.637 & 0.472 & 0.253 \\ 0.282 & 0.350 & 0.051 & 0.453 & 0.107 \\ 0.065 & 0.072 & 0.312 & 0.075 & 0.640 \end{bmatrix}$$

$$\begin{matrix} 0.078 & 0.285 & 0.774 & 0.444 & 0.148 & 0.573 & 0.547 & 0.118 & 0.450 \\ 0.137 & 0.577 & 0.161 & 0.508 & 0.571 & 0.238 & 0.223 & 0.335 & 0.250 \\ 0.785 & 0.138 & 0.065 & 0.048 & 0.281 & 0.189 & 0.230 & 0.547 & 0.300 \end{matrix}$$

$$\begin{matrix} 0.578 & 0.637 & 0.472 & 0.253 & 0.078 & 0.285 & 0.774 \\ 0.350 & 0.051 & 0.453 & 0.107 & 0.137 & 0.577 & 0.161 \\ 0.072 & 0.312 & 0.075 & 0.640 & 0.785 & 0.138 & 0.065 \end{matrix}$$

$$\begin{matrix} 0.444 & 0.148 & 0.573 & 0.547 & 0.118 \\ 0.508 & 0.571 & 0.238 & 0.223 & 0.335 \\ 0.048 & 0.281 & 0.189 & 0.230 & 0.547 \end{matrix}\Bigg]$$

Step 9: Finally, the general priorities of strategic options are calculated considering the internal dependencies of element factors, as follows:

$$w_{alternatives} = \begin{bmatrix} A-B \\ A-C \\ B-C \end{bmatrix} = W_4 * w_{sub-factors(global)} = \begin{bmatrix} 0.456 \\ 0.269 \\ 0.275 \end{bmatrix}$$

The results of FANP analysis show that the most important strategy for the mobile ad hoc networks is strategy A-B or QoS supporting, network has different treat by different flow, in the other words, a network has good treat by flows with high priority, proposed protocols have low overhead and don't sensitive to packet loss and improvement and management on the mobile ad hoc network performance whose score is 0.456.

6- Discussion:

This study faced many challenges in its model validation test. The first is that the FANP model's factors are not naturally quantitative. FANP is a technique for solving multi-criteria decision making by using the dependence among quantitative and qualitative factors. However, it is not always possible to apply numerical and quantitative amounts to elements in decision-making. It is also that for each calculation, different amounts resulted. This may be due to the different viewpoints among the experts who evaluated the matrix. Thus, it seems impossible to obtain similar amounts based on the data obtained from different studies. These limitations are exacerbated by the nature of decision making. It is natural that in different circumstances, there are different priorities. It should be noted that the existent differences among the pair comparison amounts, which are due to the differences in expert viewpoints, are not sufficient reason for rejecting the proposed model's validity in FANP discussions (T. He, 2004; Heissenbu¨ ttel, 2005). Another problem is that the validity of this model has not been tested using the latest data and that is because those data are available only to special managers. The comparison matrix which is the input for the proposed model was composed under definite conditions; hence, results may differ due to the pair comparison matrix's composition in different time periods (Herms, 2005). This model may be improved as the factors and sub-factors keep changing. Each management team should apply these strategies to the model according to the strategic factors in play. Second, the amount of dependence among factors and sub-factors may vary based on the management type. For example, in The Tehran Provice, only the dependence among important element factors is evaluated. The inconsistent ratio resulting from the pair comparison matrix also co-organizations this model. The inconsistent ratio or CR is based on the inconsistency index and Random index. Inconsistency index or CI can be obtained through the following formula: $CI = (\lambda_{\max} - n)/(n-1)$

Where $\lambda_{\max}$ is the highest special amount and n is the matrix dimension. Inconsistency ratio (CR) is composed of two parameters: inconsistency index (CI) and Random index (RI). The relationship between RI and n is as follows:

$$RI = 1.98 * [(n - 2) / n]$$

Where 1.75 is the ratio of average amount of all numbers for n=3 till n=15, each having been multiplied by (n-2)/n. The calculated amount for the inconsistency ratio in FANP should not be less than 0.1. The inconsistency ratio of the pair comparison matrix is calculated using Expert Choice. All inconsistency ratio amounts are less than 0.1. The proposed model is the first of its kind and is hence considered unique. The results were re-rating of the experts who confirmed that 79.5 percent, and it suggest for reliability. Validity of the model is used the Cronbach' alpha value was 88.2 percent, which indicates validity of the model.

7. Conclusion:

We have defined and classified the effective factors of the mobile ad hoc networks performance management and analysed them using FANP. The mobile ad hoc networks performance is one of the most powerful elicitors of subjective emotion, yet it is not clear whether emotions elicited by the mobile ad hoc networks performance management are similar to emotions elicited by visual stimuli. It presents the best strategy influence on the mobile ad hoc networks performance. Consequent to this analysis, we have presented strategies for improving the mobile ad hoc networks performance, which were verified and validated in a case study.

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